CG-273-15
(Volume 1)

INSTRUCTION BOOK

for

LORAN TIMER SET AN/FPN-30

Volume 1 of 2 Volumes

ITT *Federal Division*

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

Clifton, New Jersey, U.S.A.

FORMERLY

FEDERAL TELEPHONE AND RADIO COMPANY

TREASURY DEPARTMENT

U.S. COAST GUARD

Dwight M. Grimes

NOTICE

This manual incorporates amendments 2 and 3 to AN/FPN-30 Technical Manual, publication number CG-273-15.

CG-273-15
(Volume 1)

INSTRUCTION BOOK

for

LORAN TIMER SET
AN/FPN-30

Volume 1 of 2 Volumes

ITT *Federal Division*

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

Clifton, New Jersey, U.S.A.

FORMERLY
FEDERAL TELEPHONE AND RADIO COMPANY

TREASURY DEPARTMENT
U.S. COAST GUARD

Contracts: Tcg-38701(CG-20,181-A)
Tcg-39263(CG-27,298-A)
Tcg-40020(CG-35,798-A)
Tcg-41083 (CG-44,327-A)

Approved by C. G. Headquarters:
16 October 1959

LIST OF EFFECTIVE PAGES

PAGE NUMBERS	CHANGE IN EFFECT	PAGE NUMBERS	CHANGE IN EFFECT
Title	Revised	3-58 to 3-78	Original
A	Revised	3-79	Amend 2
B to C	Original	3-80	Original
i to xxii	Original	4-1 to 4-9	Original
xxiii	Revised	4-10	Amend 2
1-0	Amend 2	4-11 to 4-12	Original
1-1	Original	4-13	Amend 2
1-2	Amend 2	4-14 to 4-60	Original
1-3	Original	5-1 to 5-11	Original
1-4	Amend 2	5-12	Amend 2
1-5 to 1-7	Original	5-13 to 5-31	Original
1-8	Amend 2	6-0 to 6-1	Original
1-9 to 1-12	Original	6-2	Amend 3
1-13	Revised	6-3 to 6-9	Original
1-14	Original	7-0 to 7-180	Original
1-15	Revised	7-181 to 7-182	Amend 3
1-16 to 1-17	Original	7-183 to 7-184	Amend 2
2-0 to 2-26	Original	7-185 to 7-194	Original
2-27	Amend 2	7-195 to 7-198	Amend 2
2-28 to 2-46	Original	7-199 to 7-202	Original
2-47	Amend 2	7-203 to 7-204	Amend 2
2-48 to 2-69	Original	7-205 to 7-206	Original
2-70	Amend 3	7-207 to 7-208	Amend 2
2-71 to 2-81	Original	7-209 to 7-210	Original
2-82	Revised	7-211 to 7-212	Revised
2-83 to 2-89	Original	7-213 to 7-214	Original
2-90 to 2-92	Amend 2	7-215 to 7-216	Amend 2
2-93 to 2-129	Original	7-217 to 7-228	Original
2-130 to 2-131	Amend 2	7-229 to 7-232	Amend 2
2-132 to 2-142	Original	7-233 to 7-240	Original
3-1 to 3-55	Original	i-1 to i-6	Original
3-56 to 3-57	Amend 2		

UNITED STATES COAST GUARD

ADDRESS REPLY TO:
COMMANDANT
U. S. COAST GUARD
HEADQUARTERS
WASHINGTON 25, D. C.

EEE
19 May 1955

LETTER OF PROMULGATION

1. CG-273-15 is the Instruction Book for Loran Timer Set, AN/FPN-30, and is in effect upon receipt. The two copies furnished with the equipment are parts thereof and shall always accompany the basic equipment.

2. Extracts from this publication may be made to facilitate the preparation of other instruction books and handbooks.

3. Copies of this publication may be obtained by requisition to the Commanding Officer, U. S. Coast Guard Supply Center, Jersey City, N. J.

4. Corrections to this publication will be made by serially numbered amendments. They shall be entered promptly by the responsible personnel.

K. K. Cowart

K. K. COWART
Rear Admiral, U. S. Coast Guard
Engineer-in-Chief
By direction of the Commandant

RECORD OF CORRECTIONS MADE

CHANGE NO.	DATE	SIGNATURE OF OFFICER MAKING CORRECTION

TABLE OF CONTENTS

SECTION 1—GENERAL DESCRIPTION

SECTION 2—THEORY OF OPERATION

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

SECTION 3—INSTALLATION AND INITIAL ADJUSTMENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

SECTION 4—OPERATION

TABLE OF CONTENTS (Cont'd)

SECTION 5—OPERATOR'S MAINTENANCE

SECTION 6—PREVENTIVE MAINTENANCE

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

LIST OF ILLUSTRATIONS

SECTION 1—GENERAL DESCRIPTION

SECTION 2—THEORY OF OPERATION

LIST OF ILLUSTRATIONS (Cont'd)

LIST OF ILLUSTRATIONS (Cont'd)

SECTION 3—INSTALLATION AND INITIAL ADJUSTMENTS

LIST OF ILLUSTRATIONS (Cont'd)

LIST OF ILLUSTRATIONS (Cont'd)

LIST OF ILLUSTRATIONS (Cont'd)

LIST OF ILLUSTRATIONS (Cont'd)

LIST OF ILLUSTRATIONS (Cont'd)

LIST OF ILLUSTRATIONS (Cont'd)

LIST OF ILLUSTRATIONS (Cont'd)

LIST OF ILLUSTRATIONS (Cont'd)

LIST OF TABLES

SECTION 1—GENERAL DESCRIPTION

SECTION 2—THEORY OF OPERATION

SECTION 4—OPERATION

SECTION 5—OPERATOR'S MAINTENANCE

SECTION 6—PREVENTIVE MAINTENANCE

SECTION 7—CORRECTIVE MAINTENANCE

LIST OF TABLES (Cont'd)

GUARANTEE

The Contractor guarantees that at the time of delivery thereof the articles provided for under this contract will be free from any defects in material or workmanship and will conform to the requirements of this contract. Notice of such defect or nonconformance shall be given by the Government to the Contractor within two years of the delivery of the defective or noncomforming article, or within one year of the date it is placed in service, whichever expires first. To the extent the equipment, including all parts and spare parts, as defined above, is of the Contractor's design or is of a design selected by the Contractor, it is also guaranteed, subject to the foregoing conditions, against defects in design with the understanding that if ten percent (10%) or more of any such said item, but not less than two of any such item, of the total quantity comprising such item furnished under the contract, are found to be defective as to design, such item will be conclusively presumed to be of defective design and subject to one hundred percent (100%) correction or replacement by a suitably redesigned item. If required by the Government the contractor shall with all possible speed correct or replace the defective or nonconforming article or part thereof. When such correction or replacement requires transportation of the article or part thereof, shipping costs, not exceeding usual charges, from the delivery point to the Contractor's plant and return, shall be borne by the Contractor; the Government shall bear all other shipping costs. This guaranty shall then continue as to corrected or replacing articles or, if only parts of such articles are corrected or replaced, to such corrected or replacing parts, until one year after redelivery. If the Government does not require correction or replacement of a defective or nonconforming article, the Contractor, if required by the Contracting Officer within a reasonable time after the notice of defect or nonconformance, shall repay such portion of the contract price of the article as is equitable in the circumstances.

REPORT OF FAILURE

Report of failure of any part of this equipment, during its entire service life, shall be made to the Commandant via channels in accordance with current instructions using form DD–787 (revised). The report shall cover all details of the failure and give date of installation of the equipment.

INSTALLATION RECORD

Contract Number Tcg–38701 (CG–20,181–A)	Date of Contract 14 November 1951
Contract Number Tcg–39263 (CG–27,298–A)	Date of Contract 20 March 1953
Contract Number Tcg–40020 (CG–35,978–A)	Date of Contract 14 September 1955
Contract Number Tcg–41083 (CG–44,327–A)	Date of Contract 12 May 1959
Serial Number of Equipment....................	
Date of acceptance by the Coast Guard....................	
Date of delivery to contract destination....................	
Date of completion of installation....................	
Date placed in service....................	

Blank spaces on this page shall be filled in at the time of installation. Operating personnel shall also mark the "Date Placed in Service" on the date of acceptance plate located below the model nameplate on the equipment, using suitable methods and care to avoid damaging the equipment.

ORDERING PARTS

All requests or requisitions for replacement material should include the following data:

1. Standard Navy Stock Number.
2. Name and short description of part.

If the appropriate stock number is not available the following shall be specified:

1. Equipment model or type designation, circuit symbol, and item number.
2. Name of part and complete description.
3. Manufacturer's designation.
4. Contractor's drawing and part number.
5. JAN or Navy type number.

SAFETY NOTICE

THIS EQUIPMENT EMPLOYS VOLTAGES WHICH ARE DANGEROUS, AND WHICH MAY BE FATAL IF CONTACTED BY OPERATING PERSONNEL. EXTREME CAUTION SHOULD BE EXERCISED WHEN WORKING WITH THE EQUIPMENT. While every practicable safety precaution has been incorporated in this equipment, the following rules must be strictly observed:

KEEP AWAY FROM LIVE CIRCUITS:

Operating personnel must at all times observe all safety regulations. Do not change tubes or make adjustments inside equipment with high voltage supply on. Under certain conditions dangerous potentials may exist in circuits with power controls in the off position due to charges retained by capacitors. To avoid casualties always remove power and discharge and ground circuits prior to touching them.

DON'T SERVICE OR ADJUST ALONE:

Under no circumstances should any person reach within the equipment for the purpose of servicing or adjusting it without the immediate presence or assistance of another person capable of rendering aid.

DON'T TAMPER WITH INTERLOCKS:

Do not depend upon door switches or interlocks for protection but always remove power from the equipment. Under no circumstances should any access gate, door, or safety interlock switch be removed, short-circuited, or tampered with in any way, by other than authorized maintenance personnel, nor should reliance be placed upon the interlock switches for removing voltages from the equipment.

WHERE 1,000 VOLTS OR MORE, TAKE NOTE:

NEVER MEASURE POTENTIALS IN EXCESS OF 1,000 VOLTS BY MEANS OF FLEXIBLE TEST LEADS OR PROBES.

RESUSCITATION

AN APPROVED POSTER ILLUSTRATING THE RULES FOR RESUSCITATION SHALL BE PROMINENTLY DISPLAYED IN EACH RADIO, RADAR, OR SONAR ENCLOSURE. POSTERS MAY BE OBTAINED UPON REQUEST TO THE COAST GUARD SUPPLY CENTER, JERSEY CITY, NEW JERSEY.

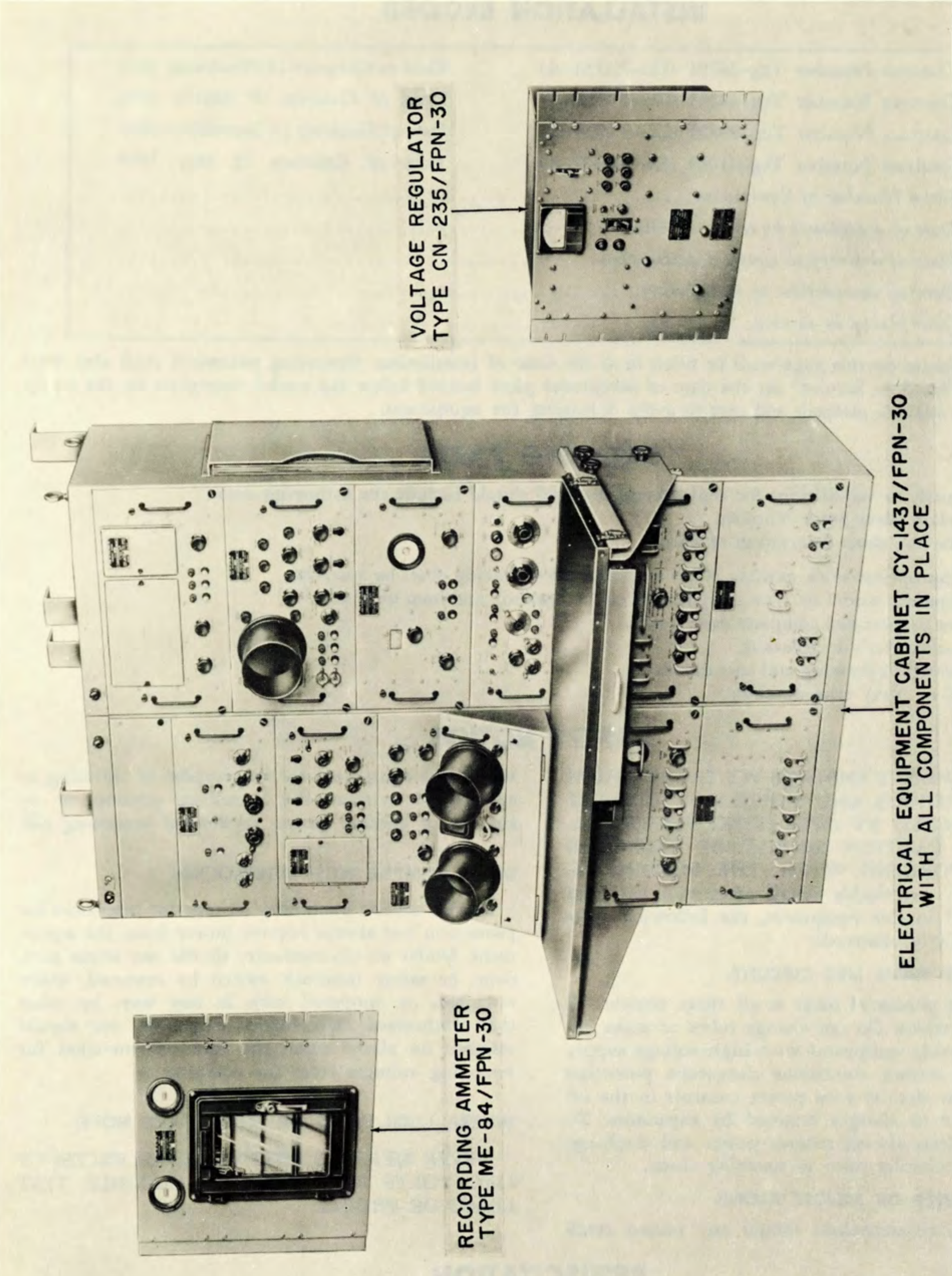


Figure 1–1. Loran Timer Set AN/FPN–30, Front Oblique View Showing All Units Comprising an Equipment

CG-273-15
(Volume 1)

INSTRUCTION BOOK

for

LORAN TIMER SET
AN/FPN-30

SECTION 1
GENERAL DESCRIPTION

ITT *Federal Division*
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION
Clifton, New Jersey, U.S.A.
FORMERLY
FEDERAL TELEPHONE AND RADIO COMPANY

TREASURY DEPARTMENT
U.S. COAST GUARD

Contracts: Tcg-38701(CG-20,181-A)
Tcg-39263(CG-27,298-A)
Tcg-40020(CG-35,978-A)
Tcg-41083 (CG-44,327-A)

Approved by C. G. Headquarters:
16 October 1959

General Description
Section 1

TABLE OF SECTIONS

Section	*Title*	*Volume*
1	General Description	1
2	Theory of Operation	1
3	Installation	1
4	Operation	1
5	Operator's Maintenance	1
6	Preventive Maintenance	1
7	Corrective Maintenance	1
8	Parts Lists	2

SECTION 1
GENERAL DESCRIPTION

1. INTRODUCTION.

Loran Timer Set AN/FPN-30 is one of the basic components of a loran transmitting station. It is the function of this book to supply all the information necessary for the installation, operation, and maintenance of the timer set. The general appearance and arrangement of the timer set are shown in figure 1-1.

2. THE LORAN SYSTEM.

To assist in understanding the nature and purpose of the timer set, a brief description of the loran system follows.

a. PURPOSE OF LORAN.—Loran is a navigational system for determining positions by means of radio. The term is derived from the initial letters of the words "LOng RAnge Navigation" and consequently implies that the distances involved are greater than those obtained by the familiar radio direction finding methods. Ordinarily, over sea water, ranges may be expected of from 500 to 900 nautical miles during the daytime and up to 1,400 nautical miles at night. For the latter, however, so-called "sky wave" transmission is employed, which is not quite as reliable as daytime ground wave transmission.

b. PRINCIPLE OF OPERATION, PAIRED PULSES.—The principle of operation is based on the difference in travel time (in millionths of a second) to the point of observation of radio signals from two transmitting stations spaced several hundred miles apart. Assume that pulse signals are transmitted at exactly the same instant from the two transmitting stations. Refer to figure 1-2. It is evident that along the perpendicular bisector of the base line connecting the two stations, the two pulse signals will arrive at exactly the same time, since any point along this bisector is equally distant from the two transmitters. For observation points on either side of the bisector, the signal from the nearer station arrives ahead of the other and the loci for observation points of given time differences are represented by hyperbolas with the two transmitting stations at the two foci*. The hyperbolas on the side of the bisector toward transmitting station, let us say, "A" correspond to pulses from "A" arriving first. On the other side of the bisector is a similar set of hyperbolas corresponding to pulses from transmitting station "B" arriving first.

c. TIME DELAY FOR IDENTIFICATION.—Since the pulses from the two transmitting stations are essentially identical in shape, it is not possible to tell whether the pulse which arrives first originated at station "A" or station "B". This results in an ambiguity as to which of two hyperbolas—one on each side of the bisector—is the true line of position. To overcome this ambiguity and at the same time simplify the measurement method, the pulses from the two transmitting stations are not transmitted simultaneously but those from one station are delayed a finite amount in order that the pulse from that station will always arrive last. This delay is called the *coding delay.* The amount of this delay needs to be at least equal to or slightly more than the travel time of the radio signal between the two transmitting stations, Actually, it is much more than that. However, as long as it is always a definite amount, proper allowances can always be made.

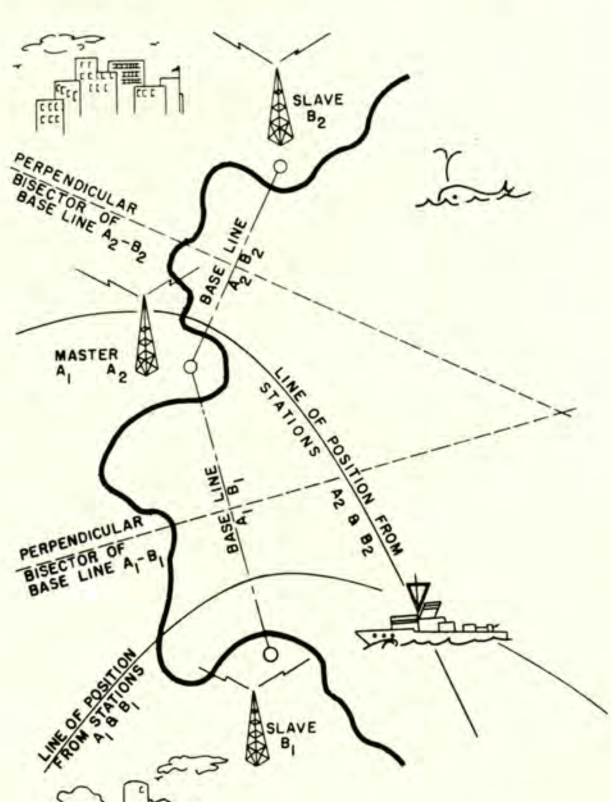


Figure 1-2. Sketch Illustrating How a Loran "Fix" is Obtained

* A hyperbola is a mathematical figure which may be drawn by plotting a path of points having a constant difference in distance from two fixed reference points. These reference points are the foci of the hyperbola. In the loran system the two transmitting stations are the foci for a family of hyperbolas which form lines of position used to obtain a navigational "fix". The constant distance difference is measured in terms of constant time difference, since radio signals travel a given distance in a known amount of time.

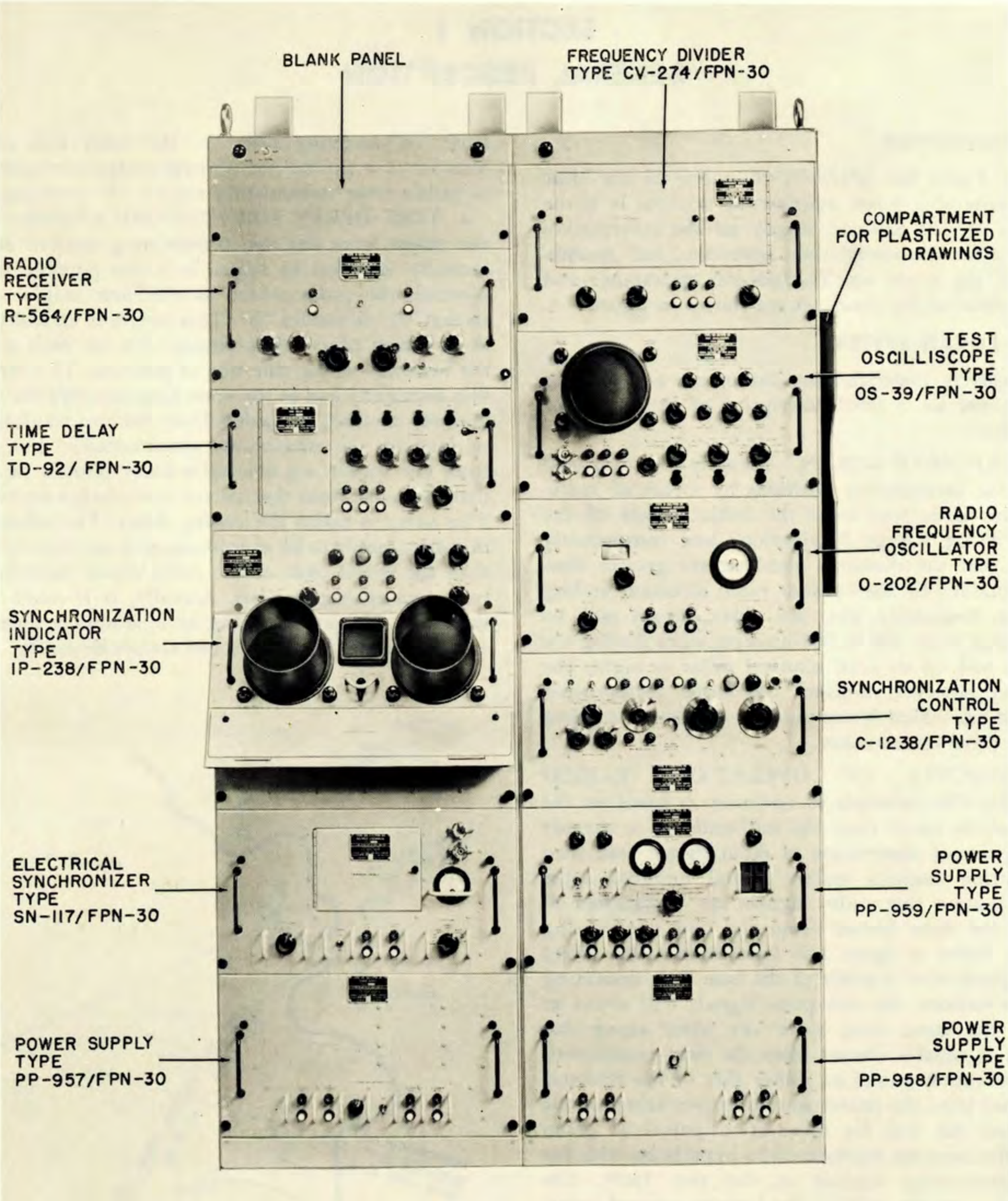


Figure 1–3. Loran Timer AN/FPN–30, Front View of Main Cabinet Showing Component Units, Operator's Table Removed

The transmitted signals are not random pulses, first from one transmitter and then the other, but a series of carefully timed pulses from each which are properly interspaced. The time interval between each station's pulses is constant for a given pair of stations but differs for various pairs as a means of identification and to avoid interference of other loran signals. These recurrence periods vary from about 30,000 microseconds to 50,000 microseconds.

d. "MASTER" AND "SLAVE" STATION.—It was previously stated that the interval between the pulses from one transmitting station and the corresponding ones from the second station must be carefully timed with respect to each other. Any adjustment required should be made at only one station to avoid confusion. This station is termed a "slave" station, whereas the other is the "master" station.

e. RECEIVING EQUIPMENT.—On the ship or aircraft a loran receiver-indicator is used to determine the difference in times of arrival between the related pulses from the "master" and from the "slave" station to within a microsecond. This measurement determines the line of position as indicated on specially prepared charts (or tables). A similar measurement made on a second pair of loran ground stations provides a second line of position. The intersection of two or more lines of position determines the location of the ship or plane.

f. TRANSMITTING STATION EQUIPMENT: THE TIMER.—It is evident that, in addition to the radio transmitter, power supply, antennas, and associated accessory equipment usually found in a radio transmitting station, a loran station must also include equipment for timing the pulses accurately. The timing equipment must: (1) establish the pulse interval, or pulse recurrence rate, at any one of a number of standard rates; (2) establish the delay between master and slave to any specified value; (3) permit constant monitoring of the pulse transmissions for correct timing, delay, etc.; and (4) provide a means of maintaining synchronism between stations by making minor corrections at one of the two stations. The last function, by convention, is performed only at a slave station although, technically, it could be done equally well at either.

Because the functions of the timing equipment are basically similar at a master and a slave station, identical timers are used. In other words, the same type of timer is used at each station, the small differences in operational requirements being met by appropriate adjustment.

Loran Timer Set AN/FPN–30, shown in figure 1–3, is such a timing equipment and, as mentioned above, it can be used as a master or a slave station timer. In the latter case, automatic synchronization may be employed in lieu of manual operation.

g. BASIC TIMING CONSIDERATIONS.—The timing intervals mentioned above are measured in microseconds (millionths of a second) by means of several series of timing pulses ("markers") spaced at various intervals ranging from one microsecond to 1,000 microseconds. The infinitesimal passage of time represented between these markers, or even the greater pulse interval (30,000 to 50,000 microseconds) between transmissions of the loran signals, is almost inconceivable compared to the more familiar time units of seconds and minutes. Yet this timing equipment must measure and portray these small bits of time so accurately and consistently that, if added up for several years, the sum would not differ by more than one second from the actual elapsed time. This precision is essential in the loran system, in which microseconds of time difference measured at the ship or plane become miles of difference in position when plotted on the chart by the navigator.

Such precise timing can be accomplished only by specially designed electronic circuits which will retain their precision in spite of varying atmospheric and other conditions. In Loran Timer Set AN/FPN–30 the accuracy is maintained within a few parts in a billion. However, even this slight deviation could build up an error in loran reading of many microseconds in an hour unless compensated. Therefore, it is necessary to correct constantly (at the slave station) for the slight difference which accumulates between the errors of two timers working together as slave and master. Correction must also be made periodically (at the master station) by comparison with a primary standard of frequency, such as the United States Bureau of Standards' standard frequency station WWV or WWVH.

3. BASIC FUNCTIONS OF THE TIMER.

The primary purpose of a loran timer is to control (trigger) the pulses generated by the transmitter, spacing them with absolute uniformity and with precisely timed reference to the pulses received from a second transmitter located several hundred miles away. Several functions, performed by the various units of the timer, are co-ordinated to accomplish this purpose.

Principally the timer:

a. Generates the excitation (trigger) pulse which actuates the local transmitter periodically.

b. Generates a very accurate timing signal for the control of the transmitter trigger pulse.

c. Converts the timing signal of *b*, above, into large, small, and intermediate time units which can be used for measuring the time relationship of the local and distant loran pulses.

d. Receives the pulse signal generated by both the local transmitter and the other ("remote") transmitter.

e. Provides a visual indication (on cathode-ray oscilloscopes) of the remote pulse, the local pulse, and the time units (marker pulses) so that the time interval between the two pulses can be determined and

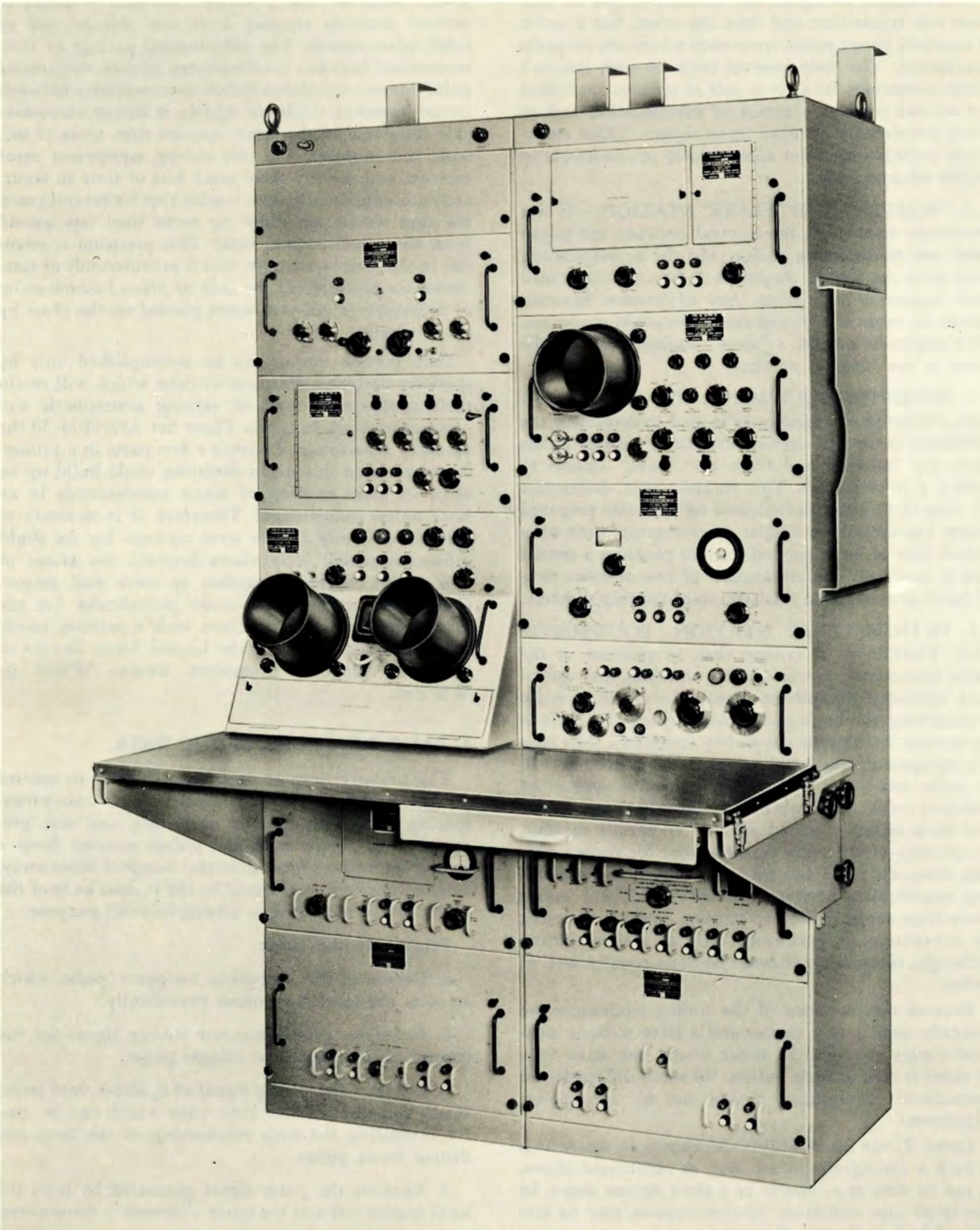


Figure 1–4. Electrical Equipment Cabinet CY–1437/FPN–30, Front Oblique View, Showing Components of Loran Timer Set AN/FPN–30 in Place

maintained. (Maintaining the proper time difference, or "delay", as seen on the scopes, is called "synchronizing". This is the timer operator's principal duty.)

f. Provides manual facilities for establishing, and later correcting, the time interval between remote and local pulses and also for correcting the basic timing signal (of *b*, above) which controls that time interval (synchronizing).

g. Provides automatic facilities for correcting and maintaining the basic timing signal which controls the time interval of *f*, above.

h. Provides 100-kc phase-controlled signal for use in generating the local transmitter carrier, where required.

4. DESCRIPTION OF MAJOR UNITS.

a. ELECTRICAL EQUIPMENT CABINET CY–1437/FPN–30: OVER-ALL CONSTRUCTION. (*Figure 1–4.*)—All but two of the major units of Loran Timer Set AN/FPN–30 are housed in a single two-section cabinet. The units are supported on slides so that removal, either partially or completely, is possible from the front. Several of the units incorporate a tilt mechanism so that they can be withdrawn to the safety stop (chassis completely forward of the panels) and then tilted upward (see figure 3–5). This permits tests and adjustments to be made below the chassis deck while the timer is in operation. (Because of an electrical interlock arrangement provided for each unit, except the oscillator and one power supply, service will be interrupted when a unit is withdrawn from the cabinet. A "cheater" arrangement, on each interlock, permits service to be restored, once the unit has been withdrawn.)

The units are held in place by the combined action of panel catches and thumb screws. A blank panel, providing space for contemplated timer equipment, is located at the upper left side of the front of the cabinet. This panel is held in place by means of ordinary screws; however, provision has been made to allow the same type of thumb screws as used on all major units to be used for securing the contemplated equipment.

An operator's table is supplied with the cabinet. It extends forward 20 inches and is 30 inches above the base. It fits snugly below the synchronization indicator unit whose sloping panel protudes several inches beyond the front of the cabinet. The table is supported at both ends by brackets which are secured to the cabinet sides. Luggage-type fasteners hold the table on the brackets during normal operation. If required, the table may be lifted off the brackets to permit access to those units mounted in the lower half of the cabinet. The supporting brackets may be removed from the cabinet, by loosening three locking knobs on either side of the cabinet. A drawer is mounted on the underside of the right-hand half of the table and is used for storage of timer accessories. Space is also provided for the operator's log pad.

Hinged doors, one for each section, are provided at the rear of the cabinet for access to the cabling, etc. The doors operate safety interlocks which are connected into the previously described interlock circuit. Slip hinges are used so that the doors may be removed completely.

A temperature control system is contained in the cabinet. Space heaters, at the bottom of the cabinet, are energized when the timer is shut down. They keep the cabinet temperature above ambient and thereby reduce the possibility of moisture condensation when the timer is idle. No attempt is made to regulate the temperature while the space heater is energized. During operation the space heaters are inoperative, the heat supplied by the units themselves being more than sufficient to keep the temperature at the desired level. A thermostatically controlled blower system is used to reduce the temperature rise within the cabinet. Two blowers are used, one in each cabinet section. They exhaust air through screened ports at the top rear of the cabinet. The thermostat is centrally located in the cabinet and is provided to turn the blowers on if temperature rises above 10°C.(50°F.) and shut them off if temperature falls below −1.2°C.(30°F.).

The wiring from chassis to chassis consists of two laced cable systems. One system is coaxial, the other is a group of single conductor wires. The two systems are laced together and secured to the cabinet by means of cable clamps. When a unit is to be installed or removed, these cables must be connected or disconnected at appropriate plugs and terminals. External signal connections are brought out to coaxial connectors at the rear of the cabinet, just above the doors. Provision is made for running 2-1/2-inch Square D duct fittings into two openings at the top rear corners of the cabinet. One of these openings is for power circuits and the other is for control circuits. The duct opening covers shipped with the cabinet have knockouts for other types of conduit fittings. Four brackets at the top of the cabinet may be used to support whatever duct work is used.

b. RADIO FREQUENCY OSCILLATOR TYPE O–202/FPN–30.—The oscillator is an ultra-precision source of the 100-kc signal which is used as the timing standard of the timer. The unit is essentially self-contained (except for power supply) and performs only one function, that of furnishing as accurate and stable a 100-kc sine wave as possible. Refer to figure 1–5.

The oscillator chassis is supported on a slide mechanism which permits convenient withdrawal from the cabinet.

Basic components of the oscillator include a two-stage amplifier which supplies energy to sustain oscillations and a crystal-controlled frequency determining network. All essential frequency determining elements are housed in a double oven. An outer oven is thermo-

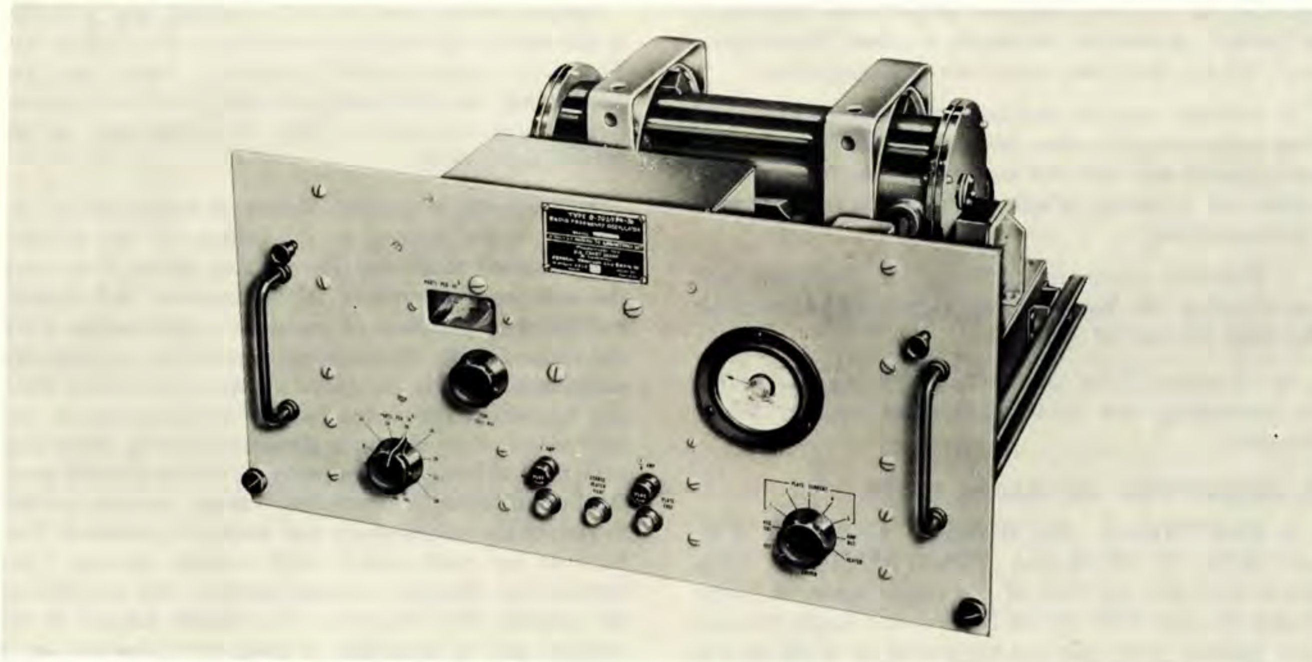


Figure 1–5. Radio Frequency Oscillator Type O–202/FPN–30, Front Oblique View

statically controlled to within 0.5°F., and an inner oven is controlled by an electronic bridge circuit which maintains temperature with an accuracy better than 0.005°F.

As compensation for the slight physical tolerances which affect frequency, the oscillator is provided with frequency adjustment controls. A COARSE FREQ. ADJ. control covers a total range of 3.6 cps (36 parts per million) in ten steps. A FINE FREQ. ADJ. control provides a continuous range over about 0.5 cps (5 parts per million). Additional control is provided, at a slave station, by a motor driven capacitor in the sync control unit which is connected to the oscillator to provide a continuous range of about 0.08 cps (approximately 0.8 part per million).

A meter selector switch and appropriate multipliers are incorporated in the oscillator to permit monitoring of the more important circuits of that unit. The multipliers are so chosen that the normal meter reading, for all switch functions, is about midscale.

c. SYNCHRONIZATION CONTROL TYPE C-1238/FPN-30.—The synchronization control unit, shown in figure 1–6, provides means for isolating, amplifying, and controlling the phase and frequency of the 100-kc signal generated by the oscillator. Outputs are provided for delivering a separately phase-adjusted 100-kc signal to the timer and to the loran transmitter. (In some loran transmitters the carrier frequency is obtained by multiplication and division of the 100-kc signal.)

The chassis of the sync control unit is supported on a slide-and-tilt mechanism which permits convenient access to all working surfaces.

Means are provided for bypassing the phase control when the timer is to be used at a master station. Control of the oscillator frequency is provided, over a very limited range, by a capacitor in the sync control unit. This capacitor and the phase control are geared to a sync control motor. An error correcting voltage, generated by Electrical Synchronizer Type SN-117/FPN-30, is supplied to the motor through an amplifier in the sync control unit. The electrical synchronizer, motor, and phase and frequency controls are so arranged at a slave station that the 100-kc signal is automatically and continuously adjusted to maintain synchronization. At a master station the synchronizing system is used to monitor the performance of a slave station.

d. FREQUENCY DIVIDER TYPE CV-274/FPN-30.—In dividing the 100-kc signal to produce a square wave of the required frequency to control the pulse recurrence rate of the station, the frequency divider, shown in figure 1–7, performs one of the most important functions of the timer. As an essential by-product of performing this function, the frequency divider develops timing markers which permit precise measurement and control of vital time relationships. All timing functions depend on signals generated in the frequency divider.

The frequency divider is slide and tilt mounted.

e. TIME DELAY TYPE TD-92/FPN-30.—One of the basic steps in timing the transmitter trigger pulse is accomplished in the time delay unit. This unit, shown in figure 1–8, controls the A delay and B delay, essential timing operations in establishing and monitoring the time difference between master and slave pulses.

Figure 1–6. Synchronization Control Type C–1238/FPN–30, Front Oblique View

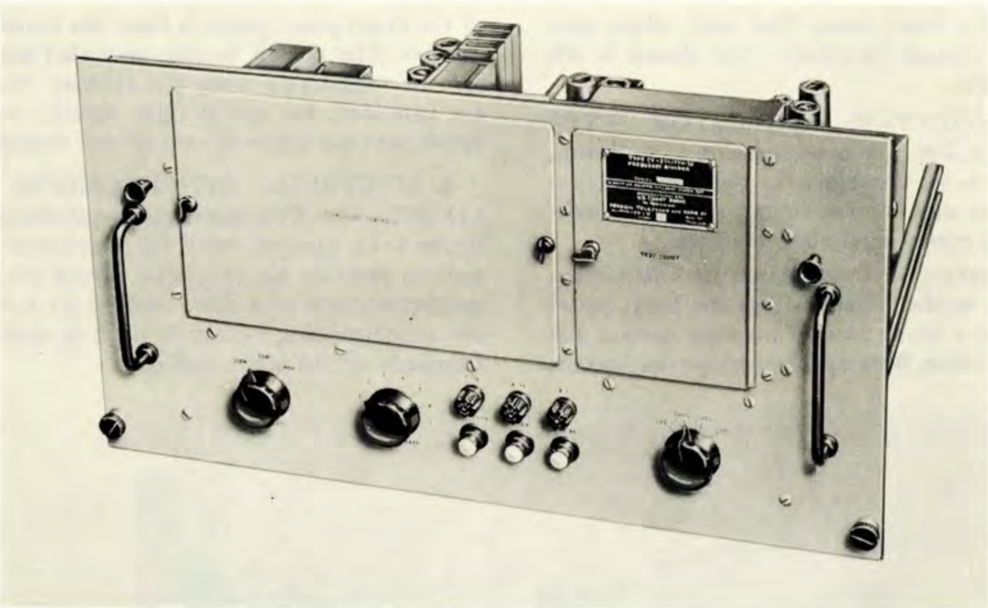


Figure 1–7. Frequency Divider Type CV–274/FPN–30, Front Oblique View

As a convenience, to permit rapid change of the loran coding delay, the time delay unit is provided with five separate sets of delay adjustments. Each set of adjustments may be preset, so that any five different coding delays may be selected at the turn of a switch.

The delay circuits control the timing of two pulses, one associated with master time functions and the other associated with slave. At a given station one of these pulses initiates the local transmitter trigger pulse and the other establishes time factors required to monitor the remote station.

This unit is slide and tilt mounted.

f. RADIO RECEIVER TYPE R–564/FPN–30.—The receiver provides an essential link between the local and remote stations. Refer to figure 1–9 for a photograph of the unit. Operating in conjunction with a discriminator circuit in the station switchgear (Navy Model UM or Loran Switching Group Type AN/FPN–2), the receiver picks up local and remote signals and delivers two detected signals and an undetected signal to other units in the timer. The receiver includes differentiator circuits which generate the first and second derivatives of the video signal for use in other timer circuits.

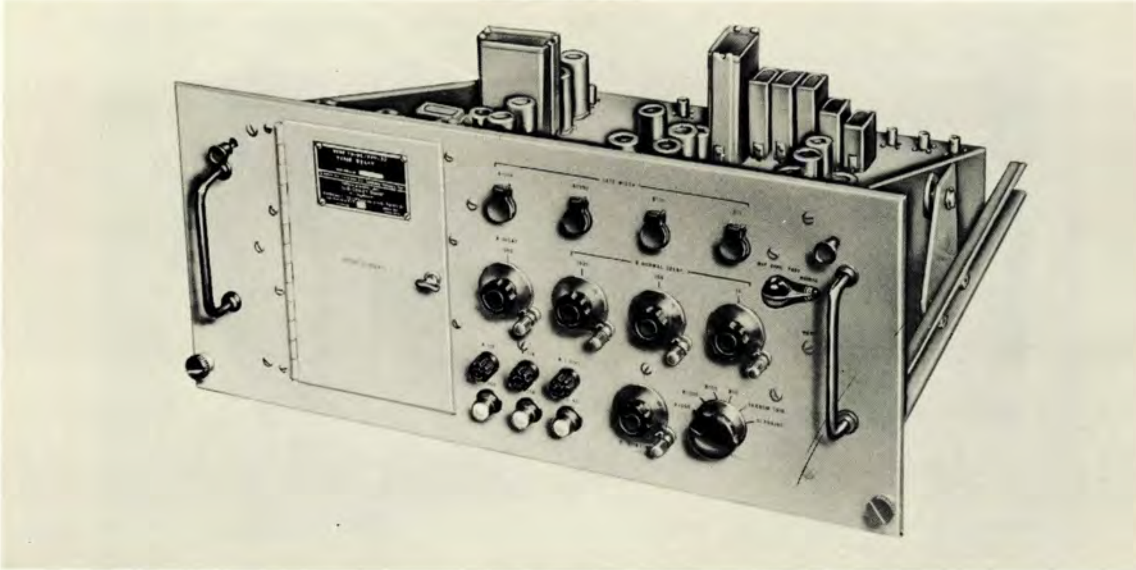


Figure 1–8. Time Delay Type TD–92/FPN–30, Front Oblique View

The receiver is a fixed tuned TRF unit which uses plug-in coils to change frequency. The chassis is tilt and slide mounted.

g. SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30.—The synchronization indicator, shown in figure 1–10, combines, in one unit, oscilloscopes required to monitor the signal, and alarm indicators to indicate operational abnormalities.

This unit is unique in construction by comparison with other units in the timer, in that the front panel slopes to provide a more natural viewing surface for the three scope screens. Because of this slope the bottom of the front panel projects from the front of the timer cabinet. The chassis is slide mounted and may therefore be withdrawn from the cabinet. Extension tubes are provided, for use as light shields, which may be fitted over the faces of two of the scopes.

h. ELECTRICAL SYNCHRONIZER TYPE SN–117/FPN–30.—The electrical synchronizer, shown in figure 1–11, operates with the synchronization control unit to provide an automatic means for maintaining synchronization at a slave station. At a master station the synchronizing system is used to monitor the performance of the slave station.

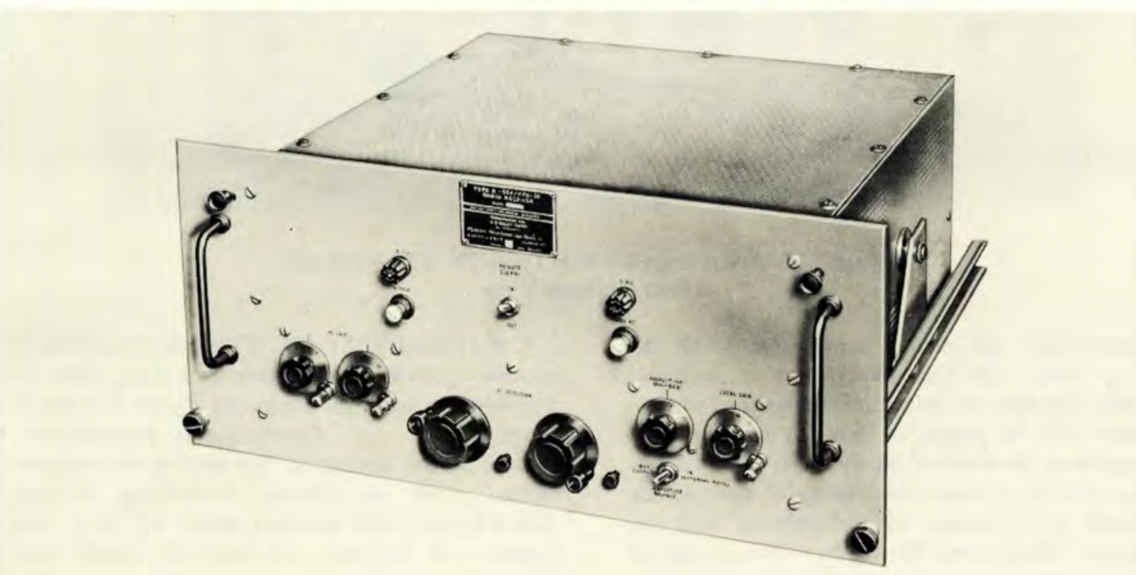


Figure 1–9. Radio Receiver Type R–564/FPN–30, Front Oblique View

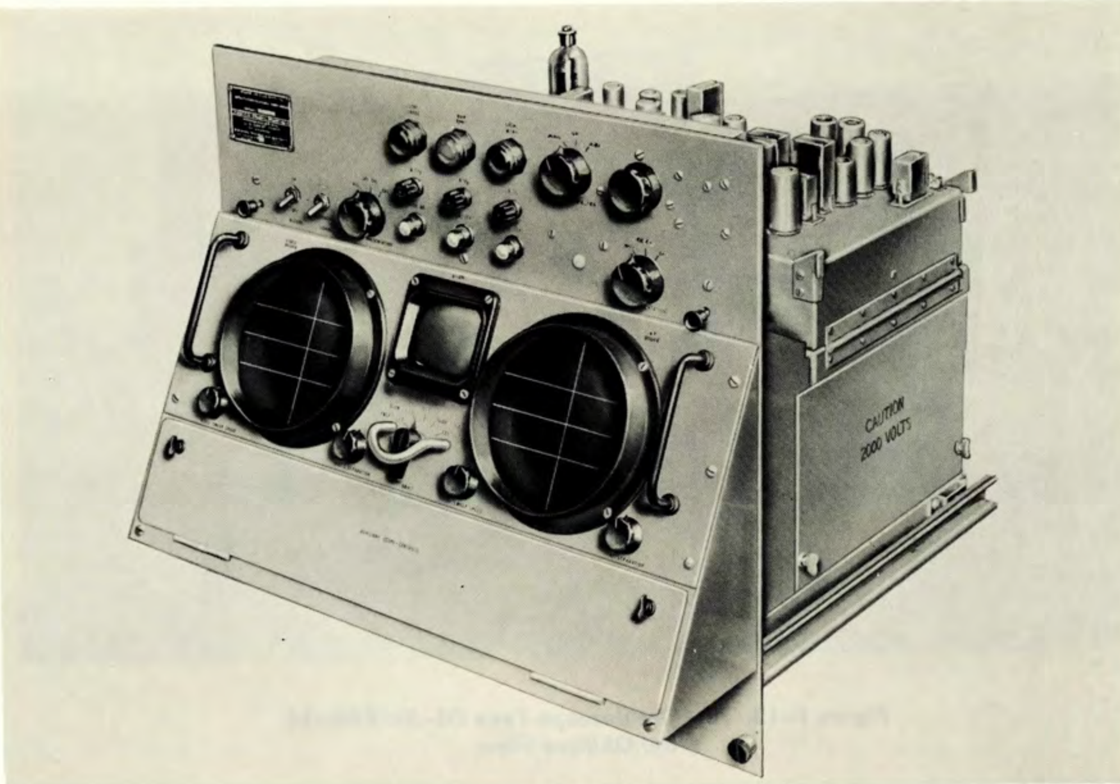


Figure 1-10. Synchronization Indicator Type IP-238/FPN-30, Front Oblique View

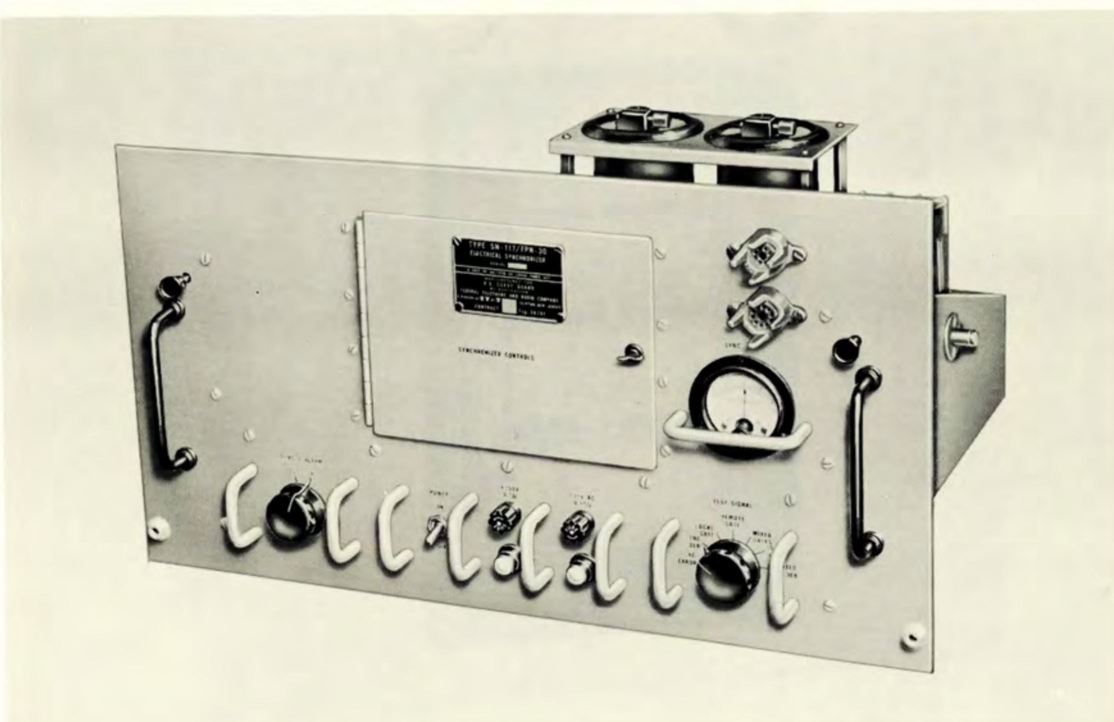


Figure 1-11. Electrical Synchronizer Type SN-117/FPN-30, Front Oblique View

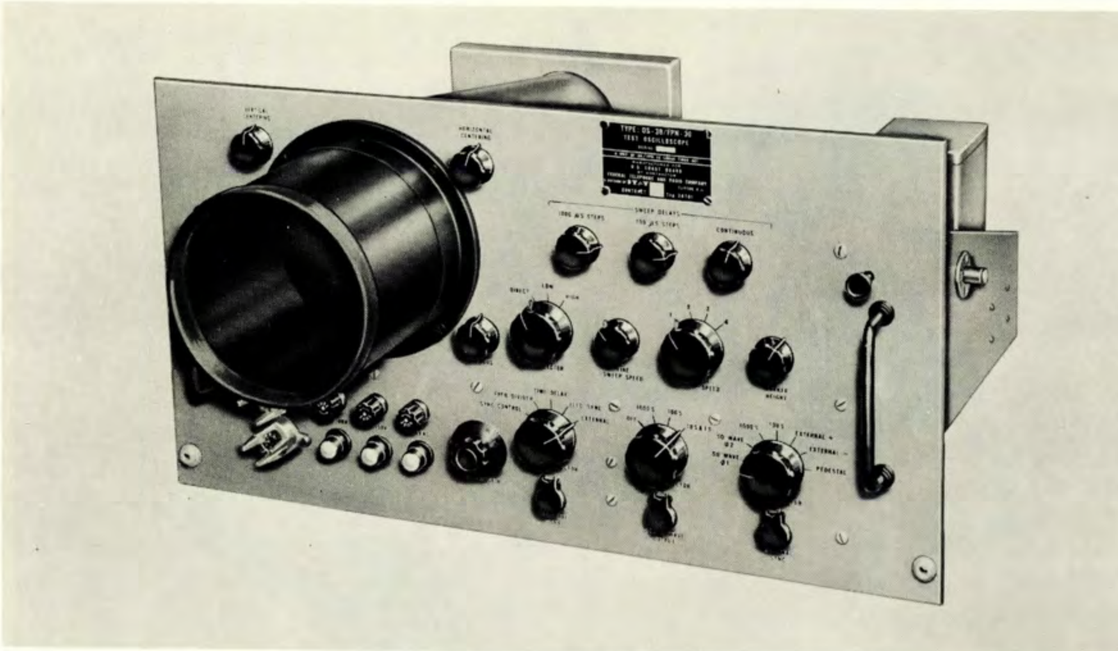


Figure 1–12. Test Oscilloscope Type OS–39/FPN–30, Front Oblique View

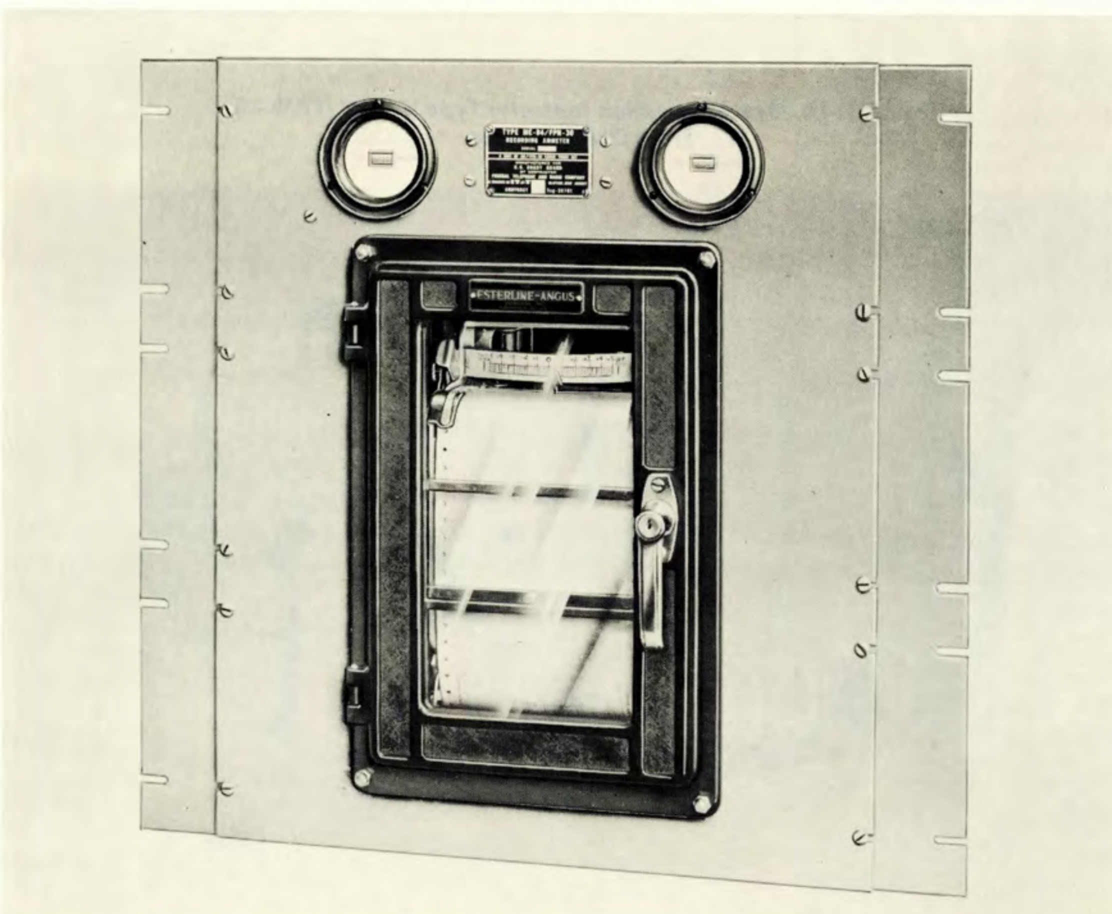


Figure 1–13. Recording Ammeter Type ME–84/FPN–30, Front Oblique View

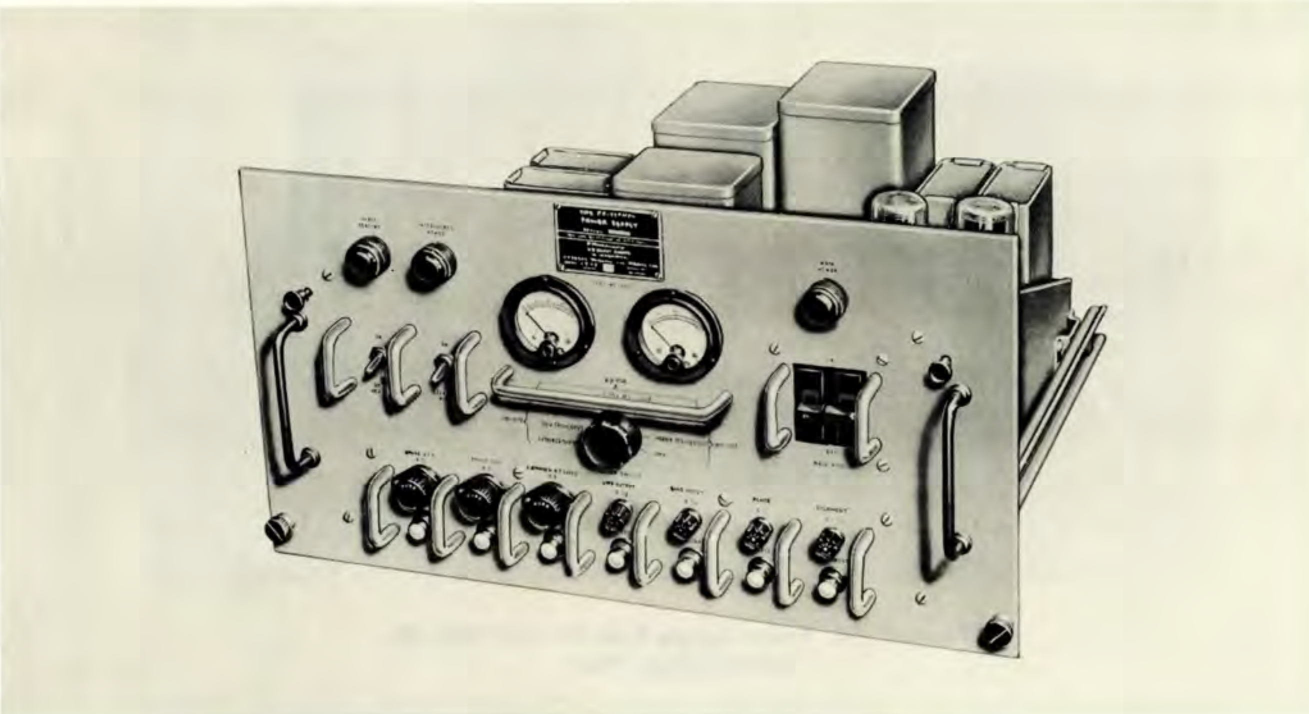


Figure 1–14. Power Supply Type PP–959/FPN–30, Front Oblique View

The synchronizer is provided with alarm circuits which operate lamps and a buzzer to signal synchronization difficulty. In addition to the lamps and buzzer located in the timer, a duplicate set of lamps and a buzzer, at a remote location, may be operated by the synchronizer. The synchronizer chassis is slide and tilt mounted.

i. TEST OSCILLOSCOPE TYPE OS–39/FPN–30.—The test oscilloscope is shown in figure 1–12. This unit is a requisite to proper adjustment and test of timer circuits; it is therefore provided as a vital accessory. The test scope features a versatile range of sweep speeds and sweep delays so that any desired portion of a waveform may be observed. Timing markers permit accurate measurement of waveform time relationships. The test scope is slide and tilt mounted.

j. RECORDING AMMETER TYPE ME–84/FPN–30.—The recording ammeter, shown in figure 1–13, is provided as a means for recording the monitoring action of the synchronizing system at a master station and for recording the correcting action of the synchronizing system at a slave station. This unit is a combination of a graphic recorder and two running time meters. The graphic recorder has three pens which trace their deflections on a moving chart strip. The center pen deflects to follow the excursions of the synchronizing system. The two side pens are each connected to the same circuits as the running time meters. Each pen and the associated running time meter indicate a particular operational abnormality.

Unlike most of the other timer major units, the recorder is not mounted in Electrical Equipment Cabinet CY–1437/FPN–30 but is to be mounted in a separate 19-inch or 24-inch rack or cabinet supplied by the Coast Guard. The option of mounting widths is made possible through the use of adapter plates which may be fitted to the 19-inch panel of the recording ammeter. The meter is furnished with a supply of chart paper, ink, an inkwell filler, a pen filler, spare pens, accessory timing gears, and a connecting cable.

k. POWER SUPPLY TYPE PP–959/FPN–30.—Power Supply PP–959 contains the basic switches, indicator lamps, and circuitry for the control of timer power. This unit also contains a metering circuit for measuring the d-c voltage outputs of all three power supply units of the timer. Power Supply PP–959 is shown in figure 1–14. This unit supplies a portion of the regulated +150 volts used in the timer as well as regulated —108 volts and —30 volts for use in timer units. The chassis is mounted on slides.

l. POWER SUPPLY TYPE PP–958/FPN–30.—Power Supply PP–958, shown in figure 1–15, provides regulated +135 volts and +300 volts as well as unregulated +1,000 volts for timer units. The chassis is mounted on slides.

m. POWER SUPPLY TYPE PP–957/FPN–30.—Power Supply PP–957, shown in figure 1–16, provides regulated +150 volts and unregulated —1,800 volts, +2,100 volts, +8,000 volts and 6.4 volts ac at a high voltage to ground. The +150 volts dc is in addition to

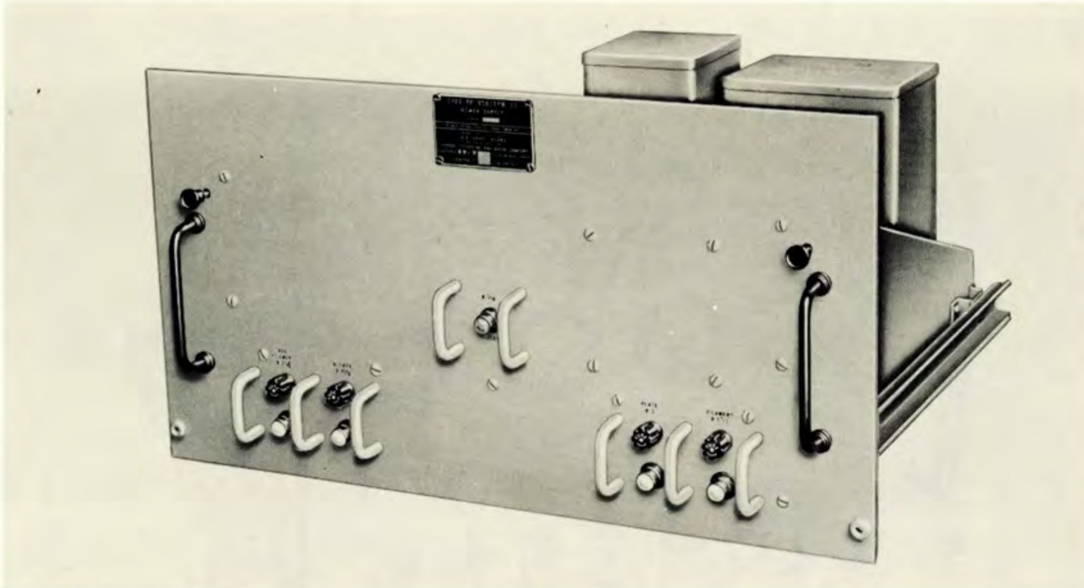


Figure 1–15. Power Supply Type PP–958/FPN–30, Front Oblique View

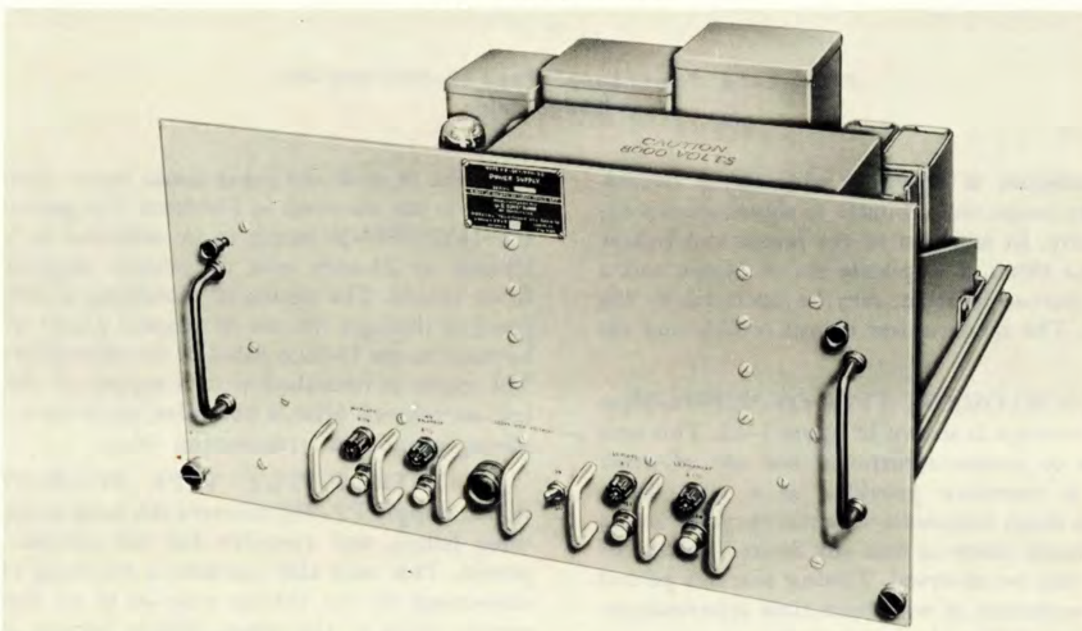


Figure 1–16. Power Supply Type PP–957/FPN–30, Front Oblique View

that provided in PP–959 and is required because of the large current demand of the many circuits operating from one or the other of the two +150-volt supply buses. This chassis is mounted on slides.

n. VOLTAGE REGULATOR TYPE CN–235/FPN–30.—A voltage regulator is provided to maintain the a-c line at a constant voltage. Refer to figure 1–17. This unit is essentially a fast-acting, motor-driven, variable transformer arrangement. It is intended for mounting in a separate cabinet, not an integral part of Electrical Equipment Cabinet CY–1437/FPN–30. Switches permit this unit to be disconnected, in the event of failure, so that the timer may be operated directly from the a-c line. The regulator maintains a constant 115-volt output over an input range of 98 to 132 volts.

The voltage regulator is of the rack-mounting type and may be mounted in either a 19-inch or a 24-inch rack or cabinet. Adapter plates are furnished for the 24-inch mounting arrangement.

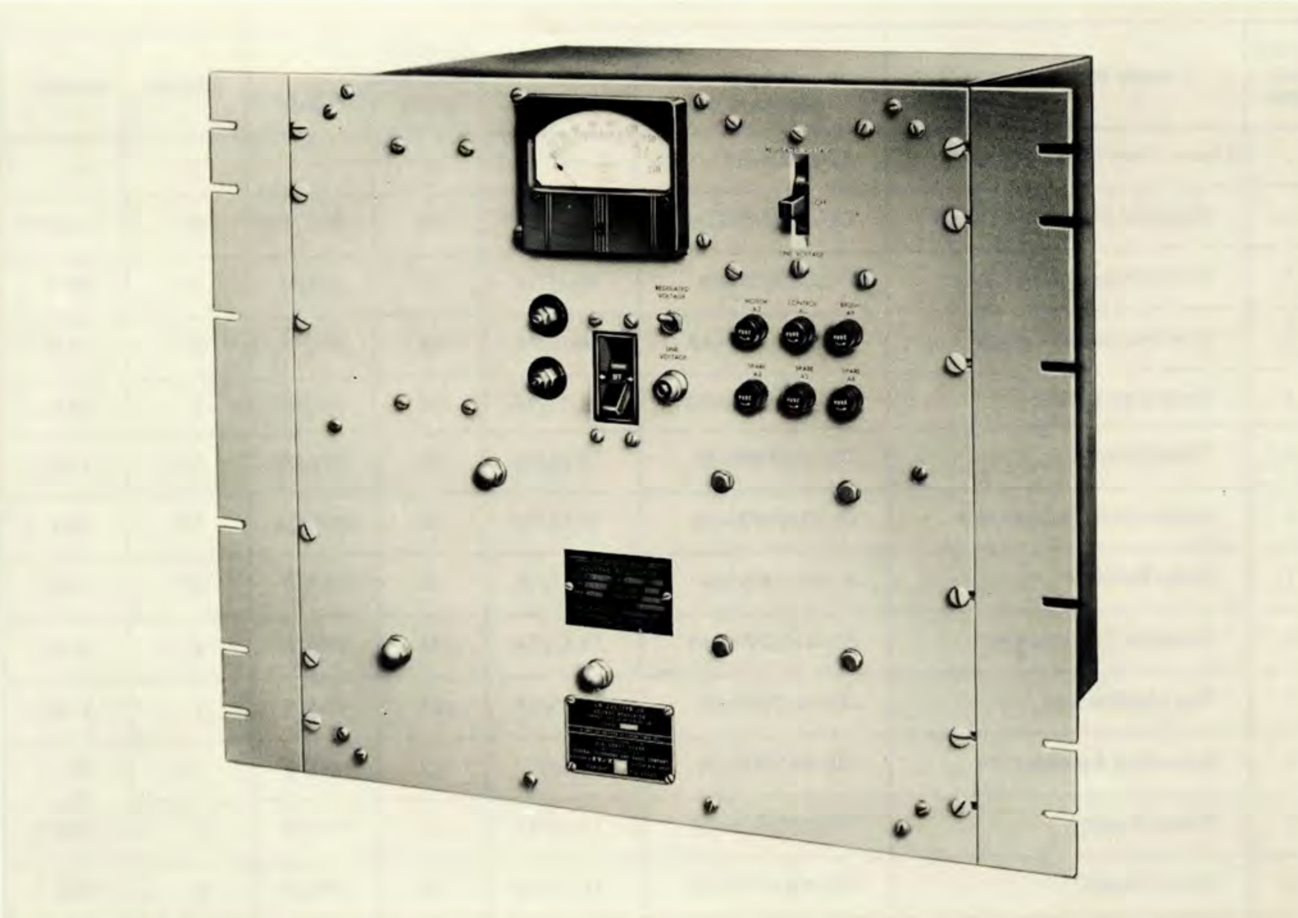


Figure 1–17. Voltage Regulator Type CV–235/FPN–30, Front Oblique View

5. REFERENCE DATA.

a. NOMENCLATURE.—Loran Timer Set AN/FPN–30.

b. CONTRACT NUMBERS AND DATES.—Tcg–38701 (CG–20,181–A), 14 November 1951; Tcg–39263 (CG–27,298–A), 20 March 1953 Tcg–40020 (CG–35,978–A), 14 September 1955; Tcg–41083 (CG–44,327A), 12 May 1959.

c. CONTRACTOR.—ITT Federal Division, Clifton, N. J.

d. COGNIZANT COAST GUARD INSPECTOR.—Inspector of Electronic Material, Coast Guard Supply Center, Jersey City, N. J.

e. NUMBER OF PACKAGES PER COMPLETE EQUIPMENT.—7 including equipment spares.

f. TOTAL CUBICAL CONTENT.—115 cubic feet, uncrated; 150 cubic feet crated; including equipment spares.

g. TOTAL WEIGHT—1,850 lbs. uncrated; 2,872 lbs. crated; including equipment spares.

h. FREQUENCY RANGE.

(1) RECEIVER.—Fixed tuned at one of five frequencies by means of hermetically sealed plug-in coils.

(2) TIMING CIRCUIT.—4 cps total adjustment of 100-kc signal.

i. TYPE OF FREQUENCY CONTROL.

(1) RECEIVER.—Fixed tuned coils to cover the frequencies 1,750, 1,800, 1,850, 1,900 and 1,950 kc.

(2) TIMING CIRCUIT.—Crystal with supplemental LC components to vary frequency over small range by manual or automatic adjustment.

j. TYPE OF OUTPUT.

(1) TRANSMITTER EXCITATION PULSE CHARACTERISTIC.

(*a*) Polarity: positive.

(*b*) Width at 50 percent amplitude: 4 microseconds ±2 microseconds.

(*c*) Rise time 10 to 90 percent amplitude; 0 to 2 microseconds.

(*d*) Output levels: 20 volts ±5 volts.

(*e*) Output impedance: 50 ohms.

(*f*) Pulse recurrence rates: Three basic rates of 20, 25, and 33-1/3 pps; modified by specific rates as listed under *k*, below.

TABLE 1-1. EQUIPMENT SUPPLIED

QUAN. PER EQIP.	NAME OF UNIT	TYPE DESIGNATION	OVER-ALL* DIMENSIONS			VOLUME*	WEIGHT*
			HEIGHT	WIDTH	DEPTH		
1	Loran Timer Set including:	AN/FPN-30	—	—	—	—	—
1	Electrical Equipment Cabinet	CY-1437/FPN-30	77-1/2 **	48	26-1/4 **	56	651.0 **
1	Radio Frequency Oscillator	O-202/FPN-30	10-15/16	22	19-5/8	2.7	86.5
1	Synchronization Control	C-1238/FPN-30	10-15/16	22	19-5/8	2.7	51.0
1	Frequency Divider	CV-274/FPN-30	11-15/16	22	19-5/8	3	42.5
1	Time Delay	TD-92/FPN-30	9-15/16	22	19-5/8	2.5	37.0
1	Synchronization Indicator	IP-238/FPN-30	19-15/16	22	23-5/16	5.8	80.5
1	Radio Receiver	R-564/FPN-30	9-15/16	22	19-5/8	2.5	50.5
1	Electrical Synchronizer	SN-117/FPN-30	11-15/16	22	19-5/8	3	46.5
1	Test Oscilloscope	OS-39/FPN-30	11-15/16	22	19-5/8	3	47.0
1	Recording Ammeter***	ME-84/FPN-30	22-3/4	19	10-5/8	2.5	36
1	Power Supply	PP-959/FPN-30	11-15/16	22	19-5/8	3	84.0
1	Power Supply	PP-958/FPN-30	11-15/16	22	19-5/8	3	93.0
1	Power Supply	PP-957/FPN-30	11-15/16	22	19-5/8	3	81.5
1	Voltage Regulator***	CN-235/FPN-30	19-7/32	19	16-1/16	3.2	100
1	Chest of maintenance spare parts	—	15-3/4	43-3/4	16-1/2	6.4	125 (est)
1	Chest of maintenance spare parts	—	15-3/4	43-3/4	16-1/2	6.4	136 (est)
1	Set of 300% tube spares for Loran Timer Set and accessory kit for Recording Ammeter	—	36 †	29 †	27 †	16 †	50
2	Instruction Books	CG-273-15	11-1/2	9	1-1/2	0.1	6 ††
2	Sets of plasticized schematic drawings	—	20	12	1-1/2	0.2	8††
2	Sets of installation drawings	—	10	13	1/2	—	3/4 ††
2	Sets of Tuned R-F Transformers	—	9	7	14	0.5	5

* Dimensions are given in inches, volume in cubic feet, and weight in pounds.

** Exclusive of top mounting brackets, operator's table and table supporting bracket, which increase cabinet height to 81-3/8 inches, depth to 41-1/4 inches, and weight to 688 lbs.

*** These units are independent rack-mounting assemblies, not mounted in main cabinet; the 19-inch width may be extended to 24 inches by means of adapter plates.

† Approximate.

†† Per set.

(2) BLANKING PULSE CHARACTERISTICS.

(*a*) Length: 500 to 1,500 microseconds (measured between 50-percent amplitude points).

(*b*) Rise time: Less than 10 microseconds.

(*c*) Polarity: positive.

(*d*) Amplitude: 100 volts to 150 volts.

(*e*) Impedance: 1,000 ohms.

k. PULSE RECURRENCE RATES AND INTERVALS.

RATE BASIC SPECIFIC	FREQUENCY (PULSES PER SECOND)	INTERVAL* (MICROSECONDS)
0	20	50,000
S 1	20-1/25	49,900
(Slow) 2	20-2/25	49,800
3	20-3/25	49,700
4	20-4/25	49,600
5	20-5/25	49,500
6	20-6/25	49,400
7	20-7/25	49,300
0	25	40,000
L 1	25-1/16	39,900
(Low) 2	25-2/16	39,800
3	25-3/16	39,700
4	25-4/16	39,600
5	25-5/16	39,500
6	25-6/16	39,400
7	25-7/16	39,300
0	33-1/3	30,000
H 1	33-4/9	29,900
(High) 2	33-5/9	29,800
3	33-6/9	29,700
4	33-7/9	29,600
5	33-8/9	29,500
6	34	29,400
7	34-1/9	29,300

* Between pulses of either station of the loran pair.

l. TYPE RECEIVER.—Fixed tuned; TRF.

m. TYPE OF RECEPTION.—P0 (Pulse).

n. BANDWIDTH.—35 kc (±5 kc) at 6 db down; less than 150 kc at 60 db down.

o. INPUT IMPEDANCE OF RECEIVER.

(1) LOCAL ANTENNA.—52 ohms (J1220).

(2) REMOTE ANTENNA.—52 ohms (J1201).

p. TIMING CIRCUIT CRYSTAL.

(1) FREQUENCY.—100 kc.

(2) TYPE.—GT cut, vacuum sealed.

q. POWER SOURCE.—115 volts ±15 percent, ac, single phase, 55 to 65 cps.

r. POWER CONSUMPTION.

(1) Interlocked Power Off; Space Heaters On.—5 amps at 99 percent power factor.

(2) Operating.—11 amps at 99 percent power factor.

s. HEAT DISSIPATION.

(1) Time Delay Type TD-92/FPN-30	74 watts
(2) Radio Receiver Type R-564/FPN-30	55 watts
(3) Synchronization Indicator Type IP-238/FPN-30	108 watts
(4) Electrical Synchronizer Type SN-117/FPN-30	60 watts
(5) Power Supply Type PP-957/FPN-30	145 watts
(6) Frequency Divider Type CV-274/FPN-30	125 watts
(7) Test Oscilloscope Type OS-39/FPN-30	70 watts
(8) Radio Frequency Oscillator Type O-202/FPN-30	65 watts
(9) Synchronization Control Type C-1238/FPN-30	60 watts
(10) Power Supply Type PP-958/FPN-30 (including drain of cabinet blowers)	180 watts
(11) Power Supply Type PP-959/FPN-30	270 watts
(12) Voltage Regulator Type CN-235/FPN-30	35 watts
(13) Recording Ammeter Type ME-84/FPN-30	Negligible
(14) Cabinet Space Heaters	375 watts
(15) Total, Items (1) through (13)	1,248 watts

6. EQUIVALENT TUBE TYPES.

Loran Timer Set AN/FPN-30 employs several of the new reliable type tubes. To help the technician become familiar with these tubes, table 1-5 lists the reliable types with their lower quality counterparts. The lower quality counterparts should not be used in the timer, except in cases of emergency.

A new system of tube designations is being put into effect to identify the lower quality counterpart of reliable type tubes which are employed in military equipment. In this system, the reliable type number is given first, followed by a separating virgule (/) and by the number of the lower quality counterpart. The 6005/6AQ5W shown in table 1–5 follows this system of nomenclature. It should be noted that, although the 6005/6AQ5W replaces the 6AQ5W and the 6AQ5, these lower quality tubes should not be used to replace the 6005/6AQ5W. It is expected that this system of nomenclature will be applied to all reliable type tubes to be supplied for military use.

TABLE 1–2. EQUIPMENT REQUIRED BUT NOT SUPPLIED

QUANTITY PER LORAN STATION	NAME OF UNIT	REQUIRED USE	REQUIRED CHARACTERISTICS
1 or more	Rack or cabinet	For mounting one Recording Ammeter Type ME–84/FPN–30 and two Voltage Regulators Type CN–235/FPN–30 per two timers of a loran rate.	Either 19-inch or 24-inch wide rack; 22-3/4 inches of rack height needed for each recording ammeter and 19-1/4 inches of rack space needed for each voltage regulator.
	Miscellaneous wire, coaxial cable, installation hardware, and fittings.	To connect station equipment together and to connect equipment to power source and to the station antenna system.	As called for in installation drawings, figures 3–8, 3–9, 3–10, 3–11, or Coast Guard instructions.

TABLE 1–3. SHIPPING DATA

SHIPPING BOX NO.	CONTENTS	OVER-ALL* DIMENSIONS			VOLUME*	WEIGHT*
		HEIGHT	WIDTH	DEPTH		
1	Electrical Equipment Cabinet with all drawer units, operator's table, installation hardware, instruction books	90	56	30	87.5	2,100
2	Recording Ammeter	29	28	18	8.5	66
3	Voltage Regulator	32	28	26	13.5	225
4	Set of 300% tube spares and accessory kit for Recording Ammeter	39-1/8	31-5/8	29-1/2	21	125
5	Two sets of tuned r-f transformers	10-1/8	8-1/4	18-5/8	.9	25
6	Chest of Maintenance Spare Parts	17-1/8	46	18-3/4	8.5	175 (est.)
7	Chest of Maintenance Spare Parts	17-1/8	46	18-3/4	8.5	186 (est.)

* Dimensions are given in inches, volume in cubic feet, and weight in pounds.

TABLE 1–4. VACUUM TUBE COMPLEMENT

UNIT	NUMBER OF TUBES OF TYPE INDICATED																											
	0A2	0B2	1N34A	1N69	2D21W	2X2A	3RP1	5CP1A	5RP2A	5R4WGY	5Y3WGTA	6AC7	6AC7W	6AG7	6AS7G	6AU6	6CL6	6V6GT/G	6Y6G	12AT7	5651	5654	5725	5726	5749	5814	5933	6005/6AQ5W	Total No. of Tubes
Radio Frequency Oscillator												4						1											5
Synchronization Control																										6		1	7
Frequency Divider				1	1									1		3				3				1		25			35
Time Delay Unit					1															2			5	6		14			28
Synchronization Indicator				1			1	1	1					1		4				1			2	4		10	1		27
Radio Receiver																	1					3		1	5	5		1	16
Electrical Synchronizer					2															2			3	6		12			25
Test Oscilloscope				1				1					2			3				2			1	3		10			23
Power Supply PP–957						2				2					2					1	1								8
Power Supply PP–958										2					3	1				1	2							1	10
Power Supply PP–959	1	1								2	1				2				1	1	1					1			11
Voltage Regulator			2		2																								4
Total Number of Each Type	1	1	2	3	6	2	1	2	1	6	1	4	2	2	7	11	1	1	1	13	4	3	11	21	5	83	1	3	199

TABLE 1–5. EQUIVALENT TUBE TYPES

RELIABLE TUBE TYPE	5Y3WGTA	5654	5725	5726	5749	5814	5933	6005/ 6AQ5W
Lower quality counterpart(s)	5Y3WGT 5Y3GT	6AK5W 6AK5	6AS6W 6AS6	6AL5W 6AL5	6BA6	12AU7	807W	6AQ5W 6AQ5

SECTION 2
THEORY OF OPERATION

1. INTRODUCTION.

The carefully timed transmitter trigger pulse generated and controlled by the timer is a simple signal, the nature of which was explained in Section 1. The generation, and particularly the control, of this signal, however, is a complicated process involving highly accurate, stable electronic timing circuits. To present the reader with a clear understanding of timer operation, this section is divided into three major parts. The first part (paragraph 2) briefly describes the basic functions of the timer to acquaint the reader with the broad principles of operation. Many minor functions are omitted, so that the initial description may highlight only major functions. Paragraph 3 describes, functionally, all of the timer major units. All signals developed within each unit are discussed and the relationship between the various voltages developed throughout the timer is described to show detailed timer functions. Paragraph 4 provides a detailed description of each timer circuit, giving the method of, and showing the reason for, developing each waveform. In addition, the complete timer operation is summarized in paragraph 5.

The arrangement of this section is such that three separate descriptions of timer operation are given; each description is increasingly complex, each unfolds the story gradually so that the reader may digest the information slowly and so that the average reader need not go into great detail to acquire the general understanding required by most personnel. Technicians requiring complete details of timer operation, on the other hand, will find these by reading through the entire section.

The experienced loran technician will note that this equipment is similar, in many respects, to the previous Loran Timer, Navy Model UE–1. By reviewing paragraphs 2 and 3 of this section, the experienced technician will recognize those elements of the timer circuit which differ from equipment he already knows. He may then concentrate his study of detailed circuits on elements not previously encountered.

2. BASIC FUNCTIONS.

As discussed in Section 1, a loran system consists of two co-operating stations which generate alternate repetitive pulses. The timer equipments, which determine the moment of pulse occurrence at each station, are identical at both the master and slave stations of a pair. The operational differences, between master and slave stations of a pair, are effected by making different adjustments at each timer.

Only the basic functions of developing the transmitter trigger and monitoring the relationship of the local and remote loran pulses are discussed in this paragraph. A block diagram of the functional arrangement used to perform these functions is shown in figure 2–1.

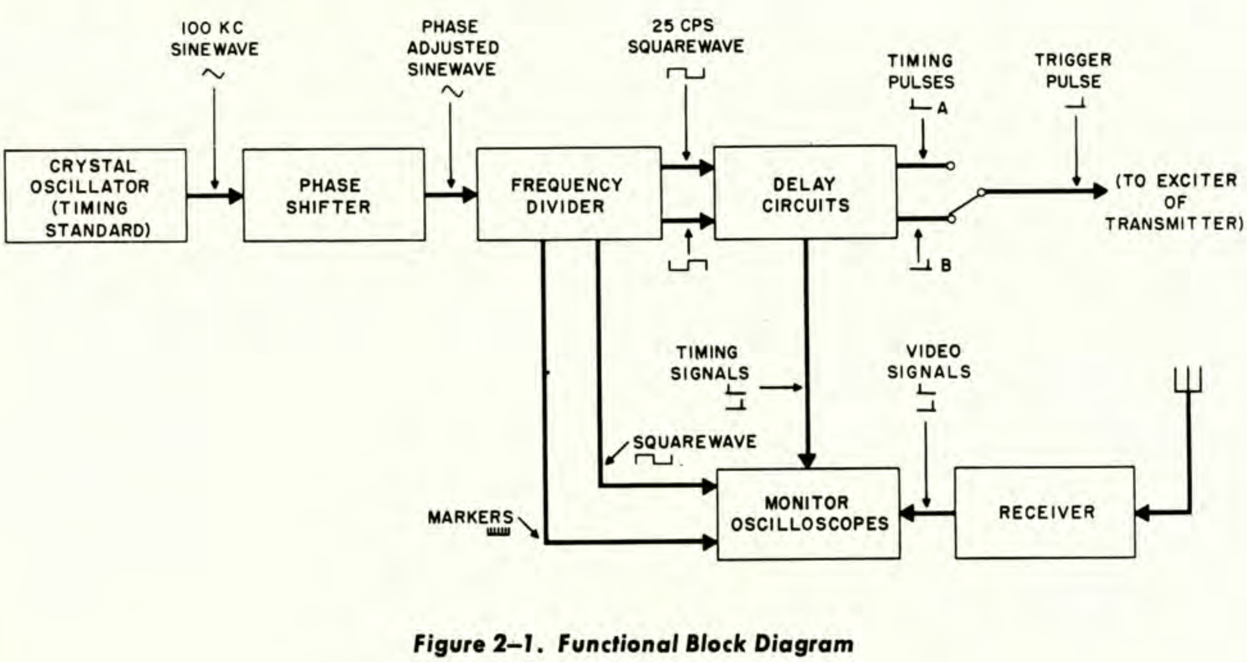


Figure 2–1. Functional Block Diagram

CG-273-15
(Volume 1)

INSTRUCTION BOOK

for

LORAN TIMER SET
AN/FPN-30

SECTION 2
THEORY OF OPERATION

ITT *Federal Division*

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

Clifton, New Jersey, U.S.A.

FORMERLY
FEDERAL TELEPHONE AND RADIO COMPANY

TREASURY DEPARTMENT
U.S. COAST GUARD

Contracts: Tcg-38701(CG-20,181-A)
Tcg-39263(CG-27,298-A)
Tcg-40020(CG-35,978-A)
Tcg-41083 (CG-44,327-A)

Approved by C. G. Headquarters:
16 October 1959

Theory of Operation
Section 2

TABLE OF SECTIONS

Theory of Operation
Section 2

a. PURPOSE OF TIMER.—The timer controls the moment of occurrence of the transmitted signal. In doing this it performs three basic functions; these are:

(1) ESTABLISH RATE.—The timer generates a pulse whose precise recurrence establishes the loran rate. This pulse triggers the associated transmitter. Thus a carefully timed radio-frequency signal is sent out by the loran station.

(2) ESTABLISH REFERENCE DELAY.—A timing interval is established within the timer which may be used to compare the time difference between the remote signal and the local signal. This interval is a reference delay and is used as a standard against which the time difference between the reception of local and the reception of remote signals may be measured.

(3) MONITOR TIME DIFFERENCE.—The time difference between local and remote signals may be controlled by the timer. This time difference is adjusted only at a slave station. The occurrence time of the slave signal is adjusted, either manually or automatically, so that the time difference equals the reference delay. The condition that the time difference equals the reference delay is called synchronization.

b. ESTABLISHING RATE.

(1) TIME STANDARD.—The basic timing standard for the timer is a 100-kc crystal oscillator. The timer is so arranged that the phase and/or the frequency of this oscillator may be adjusted to maintain synchronization. If the two oscillators in a normally operating loran pair are in step, the two stations will be synchronized. How the oscillator controls all the important time relationships in the timer will be explained below.

The correctly timed 100-kc signal, as delivered from the output of the phase shifter, is divided down in frequency by the frequency divider to produce a square wave at the desired loran repetition rate. Because the square wave is a submultiple of the 100-kc signals the phase and frequency of the square wave are controlled by the phase and frequency of the 100-kc signal.

(2) SQUARE WAVE.—The square wave, which controls the pulse repetition rate, is obtained by dividing the frequency of the 100-kc signal by a factor required to produce the desired rate. For a 25-cycle square wave, which is required for rate LOW 0, the 100-kc signal is divided by a factor of 4,000.

All loran rates are obtainable by dividing the frequency of the 100-kc signal by a suitable factor. The frequency of the square wave varies, depending on the particular rate used; for explanatory purposes, throughout this book, the square wave is assumed to have a nominal frequency of 25 cps.

Actually two square waves are produced in the timer: both are identical in all respects except that they are of opposite polarity (180° out of phase). To distinguish one from the other, they are designated square wave phase 1 (written: square wave ϕ 1) and square wave phase 2 (square wave ϕ 2). Important time reference points are established by the leading edge of the *positive* half of each square wave. As shown in figure 2–2, the leading edges of the positive halves of the square waves differ by exactly half the pulse recurrence interval. This is true because the negative and positive halves of each square wave are precisely symmetrical. These leading edges are identified, in this book, as the ϕ 1 time reference point and the ϕ 2 time reference point for the leading edges of the positive half of square wave ϕ 1 and square wave ϕ 2, respectively. The ϕ 1 time reference point is used for measuring time relationships associated with master functions and the ϕ 2 time reference point is used for measuring the time relationships associated with slave functions. The square wave is used to divide the loran repetition interval into the two halves associated with master and slave functions.

Time relationships of the complete loran cycle, from one ϕ 1 time reference point to the next, are displayed on one of the monitor oscilloscopes. This oscilloscope, identified as the SLOW SCOPE, uses two traces, one above the other, to compare master and slave time relationships. The duration of the upper trace is coincident with the positive half of the square wave ϕ 1 and is therefore associated with master time functions; this trace is called the master trace, or, in short, the A trace. Correspondingly, the lower trace, associated

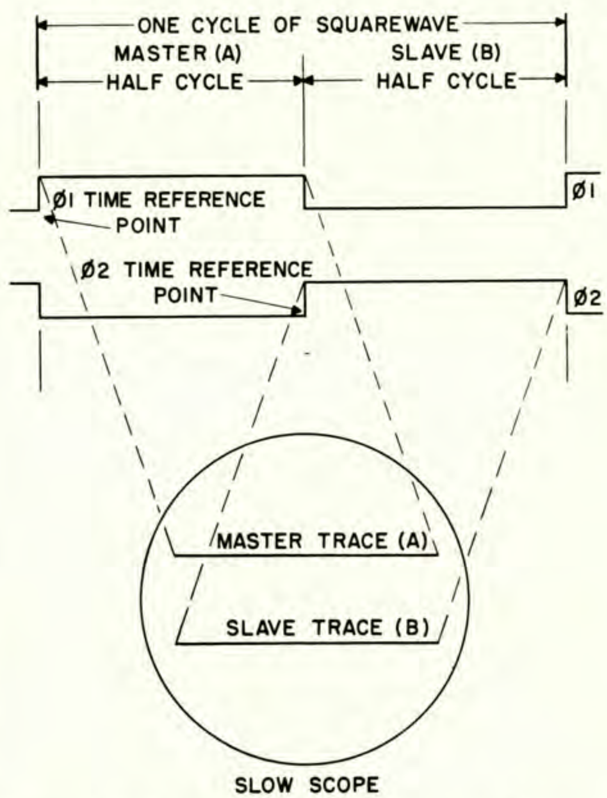


Figure 2–2. Square Wave Time Reference Points and Relationship to Slow Scope Presentation

with slave time functions, is called the slave trace or B trace. The A and B traces and their relationships to the square waves are shown in figure 2–2. The advantage of displaying master and slave time relationships by means of a double trace presentation will be apparent when it is seen how delay is measured.

The ϕ 1 and ϕ 2 time reference points are used as starting points for the two delay circuits which establish the reference delay within the timer. Two timing pulses are generated in the timer: an A-timing pulse is delayed with respect to the ϕ 1 time reference point, and a B-timing pulse is delayed with respect to the ϕ 2 time reference point. Depending on whether the timer is used at a master or a slave station, one or the other of these pulses is used to initiate the transmitter trigger pulse which times the transmitted signal.

c. ESTABLISHING REFERENCE DELAY.—The reference delay is a time interval which is used as a standard for comparison when determining that the time difference between local and remote transmitted signals is correct. The reference delay is measured as the difference between the two main delays set up in the timer. These are the A delay and the B delay. Refer to figure 2–3.

(1) A DELAY.—The A delay is measured with respect to the ϕ 1 time reference point. It is adjustable in increments of 1,000 microseconds. The A delay controls the occurrence time of the A-timing pulse, which is used to control the occurrence time of the transmitter trigger at a master station or to time other functions in the slave timer which are synchronized with the triggering of the master pulse. The A delay is normally adjusted so that the master pulse, as displayed on the SLOW SCOPE at both the master and the slave station timers, is positioned near the left edge of the upper trace.

(2) B DELAY.—The B delay is measured with respect to the ϕ 2 time reference point. It is continuously adjustable over a wide range. The B delay controls the occurrence of the B-timing pulse, which is used to control the occurrence time of the transmitter trigger at a slave station. At a master station it is used to time other functions which are synchronized with the triggering of the slave pulse. The B delay is adjusted so that the B delay, minus the A delay, produces the reference delay required to measure the time difference assigned to the loran pair. With this arrangement, the signal generated by the slave station is displayed on the lower trace of the SLOW SCOPE, and is always positioned to the right of the master signal.

(3) REFERENCE DELAY.—The reference delay has been previously defined as the B delay minus the A delay. The reference delay is established in the time delay unit as a known time interval which is highly accurate and stable. All three of the above delays are

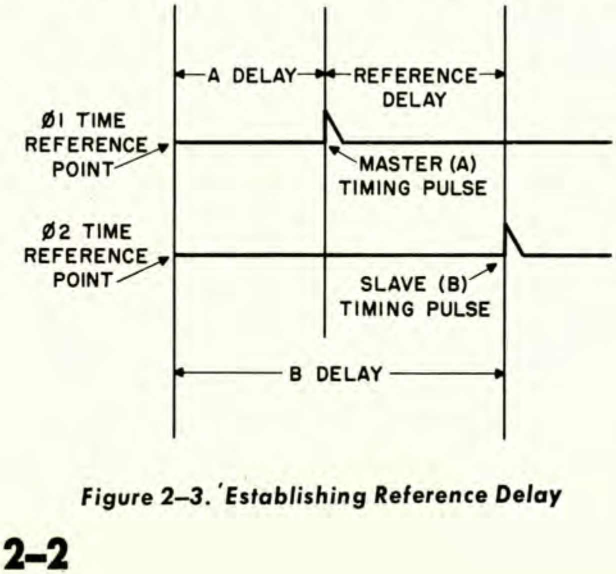


Figure 2–3. Establishing Reference Delay

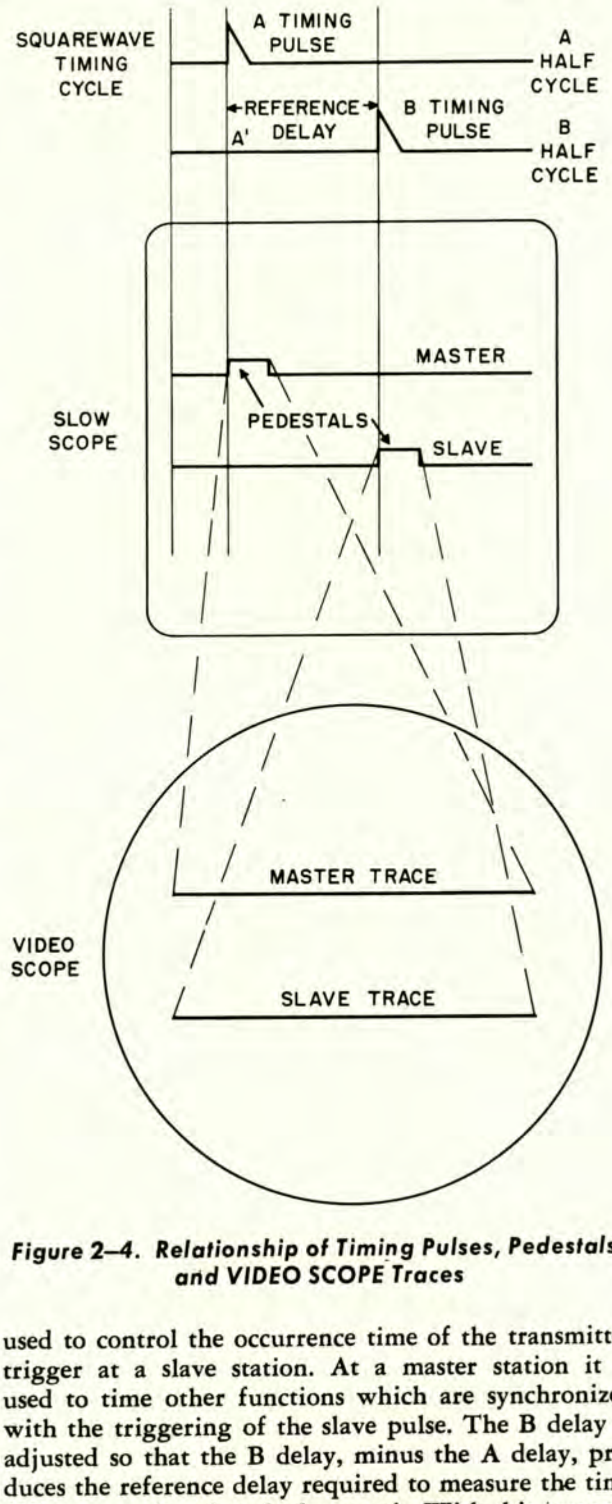


Figure 2–4. Relationship of Timing Pulses, Pedestals, and VIDEO SCOPE Traces

shown on the SLOW SCOPE presentation. However, as shown on this scope, the reference delay cannot be determined simply or accurately. An accurate and simple method for determining reference delay is furnished by a VIDEO SCOPE, which operates at a fast sweep speed.

The detailed relationship of the scope presentations to the time delays is discussed in the next paragraph.

(4) SLOW SCOPE PRESENTATION. (*Refer to figure 2–4.*)—As previously shown in figure 2–2, the upper and lower traces of the SLOW SCOPE are identified as the master and slave traces, respectively. These master and slave traces are initiated concurrently with the ϕ 1 and ϕ 2 time reference points, respectively. Each trace starts at approximately where the other stopped (in time); therefore, almost the complete loran cycle is covered by the SLOW SCOPE presentation. (A small portion of the cycle is lost in the retrace period which necessarily occurs between sweeps.) A rectangular pulse, or "pedestal", is shown on each trace. The start (leading edge) of each pedestal is determined by the A- or B-timing pulse; thus the difference between the start of the master pedestal and the start of the slave pedestal is the reference delay. For reasons which will become obvious, this arrangement for measuring reference delay provides only a coarse measurement; the detailed measurement is provided by the VIDEO SCOPE.

The VIDEO SCOPE provides means for measuring the reference delay accurately. Each VIDEO SCOPE sweep shows an expanded portion of the SLOW SCOPE sweep. The pedestals shown on the SLOW SCOPE indicate those portions of the loran cycle which are shown on the VIDEO SCOPE. As shown in figure 2–4, the start of each pedestal, the start of the corresponding VIDEO SCOPE trace, and the corresponding A- or B-timing pulse are all coincident.

The time intervals illustrated in figure 2–4 show how reference delay is indicated on the SLOW SCOPE. It will be noted that the absolute time interval between the A- and B-timing pulse is half the pulse repetition interval (the time between the A-timing pulse and the corresponding point, labeled A,′ on the B half-cycle) plus the reference delay (the time from point A′ to the B-timing pulse, equal to the B delay minus the A delay). However, the absolute time interval is not used in describing the time between the A and B pulses. It is more convenient to drop out half the pulse repetition interval and use the reference delay to designate this time interval between the A and B pulses.

Dropping out half the repetition interval eliminates the complications involved in measuring the absolute time interval between the A- and B-timing pulses, a measurement which would be of no more value than the figure obtained with the system shown in figure 2–4. Absolute delay would be much more difficult to obtain and would complicate the system unnecessarily. In all forms of loran timers, and of receiving equipment, the same type of double trace presentation is used. Therefore, when the received loran signals are stationary on the scope of the navigator's receiver indicator, for example, the repetition intervals of the two transmitting stations and the receiver indicator must be exactly equal. It follows, then, that exactly the same amount of time (1/2 the repetition interval) is dropped out when the reference delay is used to describe the time interval between the A and B pulses and no error is introduced.

An important advantage of the illustrated method of measuring reference delay, wherein half the pulse interval drops out, is that the actual pulse repetition rate (or interval) has no bearing on the measured time difference. The two characteristics of a loran pair, pulse repetition rate and time difference, become independent of each other. This is important because the pulse recurrence rate can be any one of 24 different rates. The variations caused by changing the pulse repetition rate merely add or subtract times equally at the right-hand end of both the A and B traces.

(5) VIDEO SCOPE PRESENTATION.—As previously discussed, the start of each of the two VIDEO SCOPE traces is determined by the A- or B-timing pulses for the upper or lower traces, respectively. The traces are separated, one above the other, when establishing or checking delays; however, for normal observation of synchronization, the trace separation is reduced to zero so that the two traces are made to coincide.

It has already been established that the time delay between the start of the upper VIDEO SCOPE trace and the start of the lower VIDEO SCOPE trace is the reference delay. It is also true that any point along one trace occurs at the same time with respect to the start of that trace as the corresponding (superposed) point of the other trace occurs with respect to the start of the other trace. This identical linearity of the two traces is produced by generating both traces, alternately, in the same sweep circuit. Because of this, a point 12 microseconds from the start of one trace must correspond to, and thus superpose with, a point 12 microseconds from the start of the other trace. For the example shown in figure 2–5, 12 microseconds are added to the A delay and 12 microseconds are added to the B delay when the observation point selected for this example is used. It will be seen that the time distance between the selected observation points still equals the reference delay. The above considerations are true regardless of the observation point selected; any two superposed points, therefore, must be separated by the reference delay. Thus if two signals were present on the VIDEO SCOPE, one on each trace, and the two signals were superposed, they would also be separated by the reference delay. This is the method by which a very accurate comparison can be made between the reference delay and the time difference between the two signals.

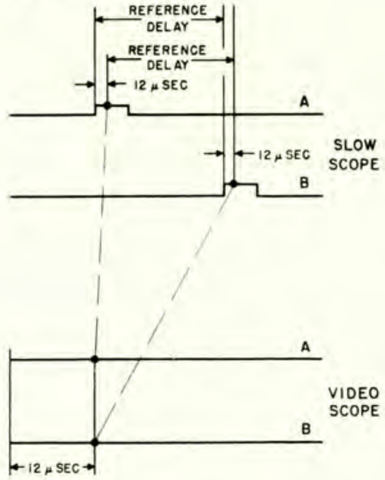


Figure 2–5. How Reference Delay Is Measured by Comparison of Two Points on VIDEO SCOPE Trace

(6) MEASUREMENT BY MARKERS.—To provide an accurate, readable system of measuring time units, a series of decimally scaled marker pulses is developed in the frequency divider for application to the monitor oscilloscopes. These markers are presented on the scope traces when measuring the reference delay; they are not required during the continuous process of monitoring synchronization.

d. MONITORING TIME DIFFERENCE.

(1) USE OF MONITOR OSCILLOSCOPES.—In the previous paragraph it was shown how a reference delay was developed and made available for oscilloscope comparison. The purpose of establishing the reference delay is to provide a timing standard which may be used to measure the time difference between the local and remote loran signals, as received at the timer. Normally the local and remote signals are visible on both oscilloscopes. They are shown on the SLOW SCOPE as spikes on top of the pedestals. On the VIDEO SCOPE presentation, the received signal occupies most of the trace length; because of the expanded time scale, the pulse waveform is shown in detail.

The time difference between the master and slave pulses is the most important characteristic of the loran signal. This time difference is measured as the interval between remote and local signals as measured at the output of the timer receiver. (Because of the effect of signal travel time, the time difference measured at a master station will be greater than that at the slave station by twice the travel time between stations.) The time difference is monitored by observing the superposition of local and remote signals on the VIDEO SCOPE. When the two pulses are superposed, the time difference is equal to the reference delay and synchronization is correct. If synchronization is in error, owing to such causes as phase or frequency error of the 100-kc timing signal, the two pulses will be displaced with respect to each other.

An observer will note that the local signal remains stationary on the VIDEO SCOPE, with respect to its location along the trace, while the remote signal moves in accordance with sync error. The local signal occurs at a fixed time after the local timing pulse. This fixed time is the sum of such miscellaneous delays as occur in the transmitter and the receiver. Since the occurrence of the local timing pulse and the beginning of the VIDEO SCOPE sweep are coincident, the local signal will appear at a fixed time after the beginning of the VIDEO SCOPE sweep. This will be true regardless of any sync error between master and slave stations since it is a condition controlled only by the local station. Because the remote signal is always shown in relation to the local signal, and because the local signal necessarily occupies a fixed position on the scope, only the remote signal will appear to move. This is true regardless of whether the timing error originates at the local or remote station.

At a master station the operator observes superposition of the two pulses as a check against the slave. The only action taken by the master station is to alert the attention of the slave operator after it becomes apparent that the slave operator is not attempting to correct an error.

The slave operator's principal duty is to monitor superposition and to vary the phase of the 100-kc signal to correct any change in the time difference of the two signals. An automatic synchronizer is incorporated in the timer which performs this function by electrically comparing the phase relationship of local and remote signals and developing a voltage which is approximately proportional to the magnitude and direction of any error in the synchronization of the two signals. The error voltage thus developed is used to operate a control motor which changes the phase to correct the error. Either manual or automatic synchronization may be used.

(2) HOW PULSES ARE MOVED BY CHANGING PHASE OF THE 100-KC TIMING SIGNALS.—As previously implied, the relative time position of the transmitted loran signals is directly controlled by the time relationship between the 100-kc timing signals at both stations. It remains to be shown how this is accomplished.

The transmitted radio-frequency signal is timed by the A- or B-timing pulse, which in turn is timed, after a precise delay, with reference to the leading edge of one-half of the square wave. As shown in figure 2–6 and as previously discussed, the square wave is timed by frequency division of the 100-kc timing signal. Every 4,000th cycle of the 100-kc signal controls the beginning of a new cycle of the square wave. (The 100-kc signal is divided by 4,000 to produce a 25-cps square wave.) Every 4,000th cycle therefore contains a reference point which coincides with the beginning of a new cycle of the square wave. By adjusting phase the 100-kc signal is shifted in time, and the reference point is shifted accordingly. By moving this reference point, the start of the square wave is moved a corresponding amount. Moving the square wave, in turn, moves the transmitter trigger pulse and changes the timing of the transmitted radio-frequency signal by a controlled amount. Thus the moment of transmission of the radio-frequency signal is directly related to the phase of the 100-kc signal.

(3) THE RELATIONSHIP BETWEEN PHASE AND FREQUENCY OF THE 100-KC SIGNAL. — Although not previously considered, there is a direct relationship between phase and frequency of the 100-kc timing signal. This relationship is important because even the slightest frequency error can cause the accumulation of several cycles of phase error in a relatively short time. By way of illustration, consider two signals, one at a frequency of 100,000.00 cps and the other at a frequency of 100,000.01 cps. (This represents a frequency error of 1 part in 10^7.) If the two signals are superposed on an oscilloscope, they will appear to coincide only once in every 100 seconds; one signal will continuously move with respect to the other. The two signals are constantly changing in phase. This phase shift is a shift in time, that is, a change in the interval between corresponding points on the two signals. It will be seen that if the above condition were allowed to exist in the oscillators of a loran pair, there would be a constant change in time difference at the rate of 10 microseconds (one cycle of the 100-kc signal) in every 100 seconds.

This constant change of phase, which is actually caused by a minute frequency error, may be corrected by changing the phase at the local station.

In normal operation the two oscillators of a loran pair will be stabilized and their average frequencies will be equal. However, owing to short time frequency errors encountered during normal operation, it will usually be necessary to change phase (at a slave timer) in one direction for a short time and then in the opposite direction to maintain a constant phase relationship between master and slave timers. If the average frequency is in error, it will be necessary to correct phase in one predominant direction. This phase correction will be required as long as the frequency error exists.

The need for continual phase correction may be eliminated by making a small change in frequency, at the slave station, at the same time as the phase is changed. With such an arrangement, any recurring phase correction, predominantly in one direction because of frequency error, will be accompanied by a small frequency correction such that the phase drift is reduced. Eventually this arrangement will reduce the frequency error to zero.

The timer is equipped with a control for changing phase without changing frequency. This is the PHASE control. A separate FREQUENCY CORRECTOR control permits frequency to be corrected without im-

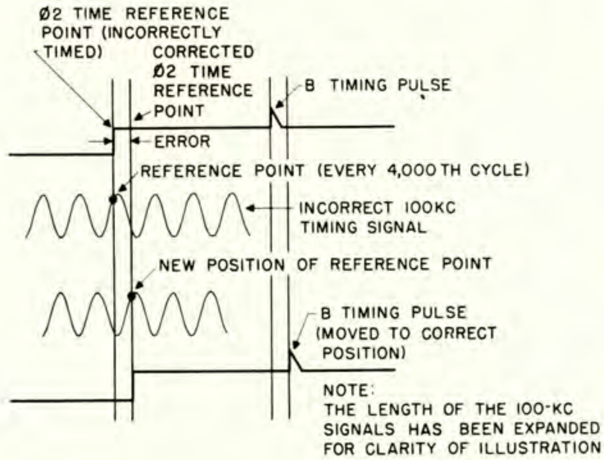


Figure 2–6. How Phase of 100-kc Signal Controls Transmitter Timing Pulse

mediately affecting phase. These controls are normally geared together so that as the PHASE dial is operated to maintain synchronization, the FREQUENCY CORRECTOR dial is also operated to provide the automatic frequency correction described in the previous paragraph. For the normal frequency errors obtained in actual timer operation, synchronization is maintained at a slave station, to a very satisfactory degree, by this arrangement.

(4) CONCLUSION.—It has been shown that the master and slave stations are kept in synchronization by adjustment of the 100-kc timing signal at the slave station. It has also been shown that an error in synchronization is evidenced by a difference between the reference delay and the time difference of arrival of master and slave signals. This time difference is observed on monitor oscilloscopes. These are the basic operating principles of the timer. The other principles of operation, used in the various units which perform these basic functions, are discussed in the next paragraph.

3. TIMER UNITS.

The units which make up Loran Timer Set AN/FPN-30 are described in this paragraph. Refer to the unit block diagram, figure 2–7. In addition to those units which provide the basic functions described in paragraph 2, all other units essential to the efficient operation of the timer are described below.

Radio Frequency Oscillator Type O–202/FPN–30 develops the 100-kc sine wave which is used as the basic timing signal for all timer operations. The phase and frequency of this sine wave are adjusted in Synchronization Control Type C–1238/FPN–30, at a slave station, to establish the required phase relationship between the signal transmitted by the master station and the signal transmitted by the slave station. A submultiple of the 100-kc timing signal is developed in Frequency Divider Type CV–274/FPN–30 and used to control

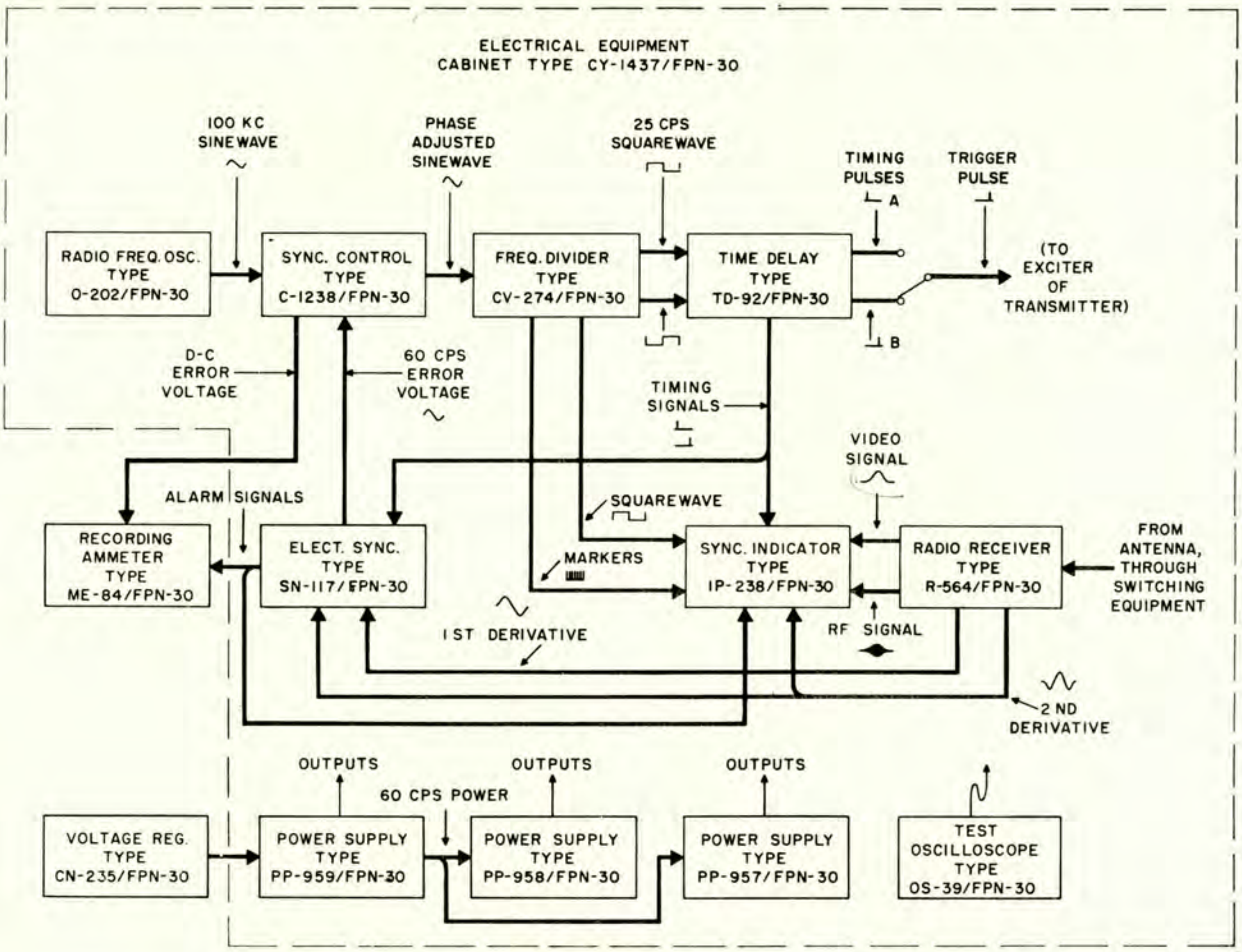


Figure 2–7. Loran Timer Set AN/FPN–30, Unit Block Diagram

the loran rate. This submultiple is the 25-cycle square wave and is generated in two opposite phases. The square wave is used to divide the loran repetition interval into two halves. An A half is associated with master functions and a B half is associated with slave functions. Time Delay Type TD–92/FPN–30 generates the A-timing pulse during the master half of the repetition interval and the B-timing pulse during the slave half of the repetition interval. The A-timing pulse is used to trigger the transmitter at a master station and the B-timing pulse is used to trigger the transmitter at a slave station. Thus the timing of the transmitted signal is controlled by the oscillator through the sync control unit, the frequency divider, and the time delay unit.

The time difference between the master and slave transmitted signals is monitored on Synchronization Indicator Type IP–238/FPN–30. These signals are picked up by Radio Receiver Type R–564/FPN–30 and presented on the oscilloscopes of the synchronization indicator. The two halves of the repetition interval are defined on these oscilloscopes by a square-wave signal fed from the frequency divider. The reference delay is the difference between the A delay and the B delay and is presented on the oscilloscopes for comparison with the time difference of the received signals. The duration of the reference delay is measured by means of marker pulses developed in the frequency divider and presented on the oscilloscope screens. Equality of the time difference of the received signals with the reference delay indicates a desired condition of synchronization. This equality is established by adjustment of slave signal timing in the sync control unit. The phase relationship between the slave and the master signal is thus maintained. At a master station equality of time difference with reference delay is monitored as a check on slave performance.

In addition to the visual comparison to determine the above-mentioned equality, an electronic comparison is made by Electrical Synchronizer SN–117/FPN–30. This comparison is used to automatically maintain synchronization at a slave station and to automatically monitor synchronization at a master station. Monitoring synchronization at a master station is performed as a precautionary check against failure at a slave station. Any inequality between time difference and reference delay is detected by the synchronizer, and an error signal is produced. This error signal is used to operate a sync control motor, in the sync control unit. At a slave station the motor corrects the synchronization error. At a master station the motor drives an indicating dial which reads directly in microseconds of error. The synchronizer also contains an alarm system to indicate synchronization abnormalities by actuating indicator lights and a buzzer.

The operation of the sync control motor, either to monitor or to correct error, provides a driving signal for the operation of Recording Ammeter ME–84/FPN–30. The recording ammeter is used to make a permanent record of the error observed at a master station or the correcting action of the sync control motor at a slave station. These indications are recorded by a moving pen on a chart strip. The recording ammeter also records the time that synchronizer alarms have operated.

Test Oscilloscope Type OS–39/FPN–30 is provided as an accessory unit to aid in adjusting and maintaining timer circuits.

Power for the timer is supplied through Voltage Regulator Type CN–235/FPN–30, which maintains a stable line voltage to the timer. The various a-c and d-c voltages required by the timer units are supplied from three power supply units. These units are Power Supply Type PP–959/FPN–30, Power Supply Type PP–958/FPN–30, and Power Supply Type PP–957/FPN–30. All the timer units, with the exception of the line voltage regulator and the recording ammeter, are housed in Electrical Equipment Cabinet CY–1437/FPN–30.

a. RADIO FREQUENCY OSCILLATOR TYPE O–202/FPN–30.—As the generator of the basic timing signal for the timer, Radio Frequency Oscillator Type O–202/FPN–30 is required to meet extremely close limits of frequency stability. To meet these requirements this 100-kc oscillator is constructed with very high precision, and the basic design of the oscillator is such that the effects of external variations of temperature, humidity, and voltage are practically eliminated. Temperature effects are materially reduced by using two electrically heated ovens, one within the other. The outer (coarse) oven is kept at a nearly constant temperature of 55°C. (131°F.) by means of a thermostatic control; the inner (fine) oven, which operates at a temperature a few degrees higher, 58°C. (136°F.), than the outer oven, is kept at a very constant temperature by a self-regulating vacuum tube oscillator heating circuit. Refer to figure 2–8.

The frequency governing element of the 100-kc oscillator is a precisely ground quartz crystal. This crystal and associated components are housed in the inner oven to provide maximum temperature stability. The oven is sealed to protect the enclosed components from the effects of humidity. The crystal is mounted in an evacuated glass bulb. A very small degree of control of the crystal frequency is provided so that master and slave oscillators may be synchronized and so that the master oscillator may be synchronized with a standard. The frequency may depart from exactly 100 kc as a result of production variables and as a result of crystal aging. Two controls are provided on the oscillator, a coarse, step-type control and a fine, continuously variable control.

The oscillator step-type control is the COARSE FREQ. ADJ. control which consists of a switch connected to inductors and capacitors in a "microfrequency network". Each step of this switch covers a range of about 4 parts per 10^6 with a total range of 36 parts per 10^6 (3.6 cycles per second). A FINE FREQ. ADJ. control has a continuous range of 5,000 parts per 10^9 (0.5 cycle per second). Since each step of the COARSE FREQ. ADJ. control represents 4,000 parts per 10^9, it can be seen that the FINE FREQ.

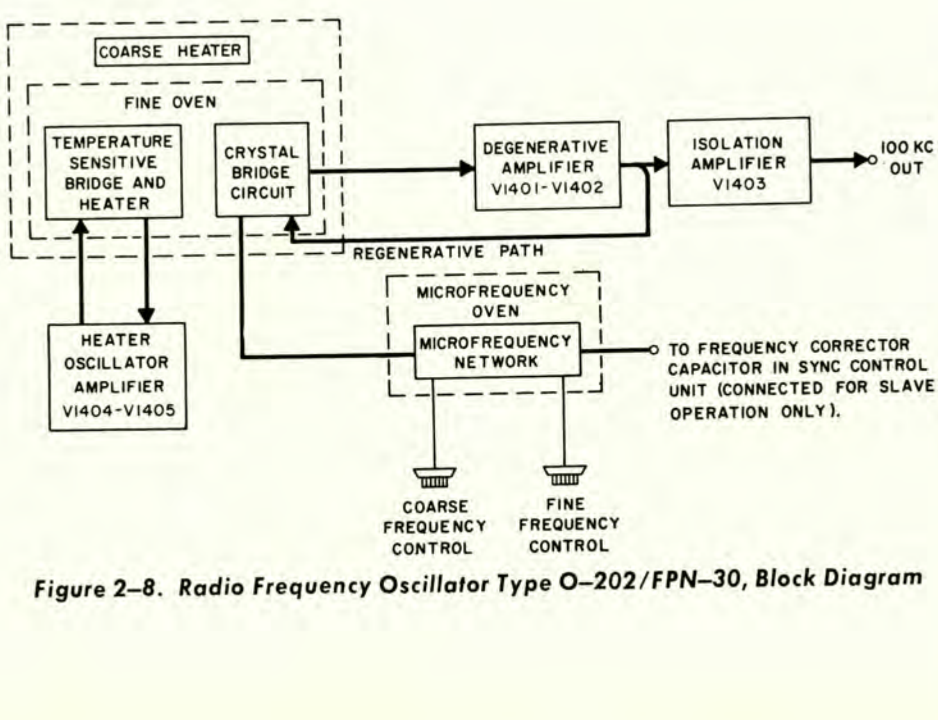


Figure 2–8. Radio Frequency Oscillator Type O–202/FPN–30, Block Diagram

ADJ. control has sufficient overlap to provide continuous variation of frequency over the entire range. The arrangement for reading the FINE FREQ. ADJ. control requires detailed explanation.

The calibrated scale of the FINE FREQ. ADJ. control is divided into two sections: a dial and a drum. The drum is marked in steps of 0 to 50 with 50 representing 5,000 parts per 10^9. The dial is calibrated from 0 to 100; each dial division is equal to 1 part per 10^9. Thus if the drum reads 21 and the dial reads 37 the total reading for the FINE FREQ. ADJ. control is 2,137 parts per 10^9.

In addition to the controls incorporated in the oscillator, provision is made for connecting the FREQUENCY CORRECTOR capacitor of the sync control unit in parallel with the FINE FREQ. ADJ. control for making the continuous adjustment of frequency described in paragraph 2 *d* (3) above. The range of control provided by this external capacitor is ± 400 parts per 10^9.

The crystal is employed in one arm of a bridge circuit as the frequency determining element of a regenerative oscillator. A driving amplifier is used to supply energy to sustain crystal oscillation. The driving amplifier incorporates negative feedback to make it practically insensitive to normal voltage variations and to eliminate the effects of usual variations in tube characteristics or tube aging. The output of the highly stable amplifier is connected via the crystal bridge circuit in such a manner as to cause oscillation at the series resonant frequency of the crystal.

Proper oscillator operation may be checked by means of a built-in metering circuit which may be switched to measure significant currents and voltages.

The output of the driving amplifier is fed, via a single stage isolation amplifier, to the sync control unit.

b. SYNCHRONIZATION CONTROL TYPE C–1238/FPN–30.—The synchronization control unit contains facilities for controlling the timing of the 100-kc signals and thus the transmitter timing pulse. These facilities include a means for correcting the phase of the oscillator output (the previously discussed PHASE control), a means for correcting the frequency of the oscillator (the previously discussed FREQUENCY CORRECTOR control), and a means for adjusting the phase relationship between the signal sent to the frequency divider and a second 100-kc signal, sent to the transmitter. This second signal may be used in the transmitter to generate the carrier frequency. Associated with the PHASE and FREQUENCY controls is a system of gears and electrically operated clutches which link the two controls together.

Additional facilities in the sync control unit serve the purpose of boosting the level of the 100-kc signal to provide adequate drive for the frequency divider and for the transmitter frequency generating circuits.

A subordinate facility which adds to the complexity of the sync control unit is the provision for automatic synchronization, at a slave station, or automatic monitoring, at a master station. This facility uses a motor drive system and an arrangement of cams, switches, and precision potentiometers; all these components operate in conjunction with the electrical synchronizer. To permit maintenance of the sync control unit circuits, the unit is equipped with a test signal circuit selector switch and cathode follower.

The arrangement and signal path of the sync control unit are shown in block form in figure 2–9.

(1) 100-KC PHASE CONTROL CIRCUIT.—Control of the phase of the 100-kc signal, which was discussed in paragraph 2 *(d)* (1) above, is accomplished by the 100-kc phase control circuit. The heart of this circuit is a rotary transformer (autosyn) which is operated by the PHASE dial. The arrangement is such that angular rotation of the PHASE dial through a given number of mechanical degrees produces a corresponding electrical phase shift of the same number of degrees. For each turn of the phase dial a full cycle (360°) of 100-kc phase shift is provided (this is equivalent to the 100-kc signal shifting 10 microseconds in time); continuous rotation of the PHASE dial produces continuous phase shift.

The autosyn is a special rotary transformer which has one primary stator winding, and two secondaries. The secondaries are physically located 90° apart from each other, about the axis of rotation. The voltages induced in the secondaries are combined in RC networks so that the output voltage shifts in phase as the rotor is turned. This electromechanical arrangement is fed from the low impedance output of a cathode follower.

The phase shift circuit is used only at a slave station, since phase correction is strictly a slave function. For use at a master station a switch is provided to obtain the 100-kc signal from a point preceding the phase shifter and the phase shifter is not used.

(2) 100-KC AMPLIFIER AND CATHODE FOLLOWER.—A three-stage amplifier is provided to boost the amplitude of the 100-kc signal. This amplifier is driven directly by the oscillator at a master station and by the output of the 100-kc phase shifter at a slave station. The final stage of the 100-kc amplifier uses a tuned circuit to provide a clean waveshape. This stage is overdriven and acts as a limiter so that minor variations in input level provide essentially constant output. A cathode follower provides a low output impedance for driving the frequency divider. Output is taken from the plate circuit of the tuned stage and fed to the transmitter phase shifter.

(3) TRANSMITTER PHASE SHIFTER AND CATHODE FOLLOWER.—The transmitter phase shifter and its associated output cathode follower provide a means for feeding phase controlled 100-kc signal to the transmitter. Some loran transmitters (those of the T–137 and T–325 type) generate their carrier

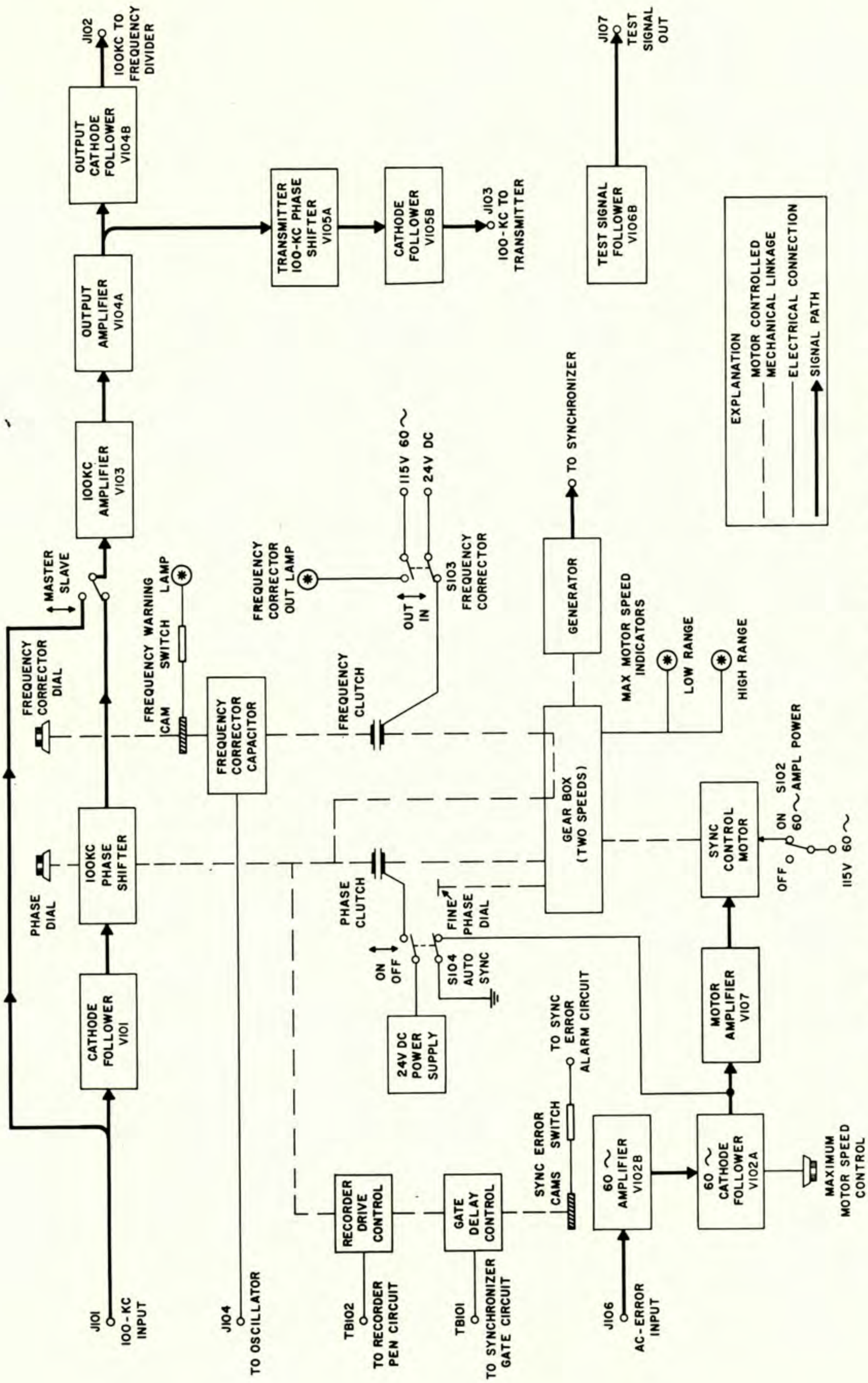


Figure 2–9. Synchronization Control Type C–1238/FPN–30, Block Diagram

frequency by a process of multiplication and division of the 100-kc timing signal; thus any change in phase or frequency of the 100-kc signal will appear in the carrier.

This second process of phase shifting, following any phase control which may be effected by the PHASE dial, is applied only to the signal fed from the timer to the transmitter. This phase shift is accomplished in the transmitter phase shift circuit, which has a range of control of about 40°. Because of the multiplication process required to raise the 100-kc signal to the carrier frequency, this 40° range is multiplied to a range of about 720°. This range of two carrier cycles is adequate to permit easy alignment of the r-f cycles within the signal envelope. Such alignment permits the eventuality of cycle matching. Cycle matching, i.e., the superposing of individual r-f cycles, provides a more accurate means for time comparison than does pulse matching. Note that carrier phase control is applied to the signal after it has been phase-controlled for delivery to the frequency divider; thus the phase relationship of the carrier and the signal envelope will remain fixed under the direct control of the PHASE dial. In other words, moving the signal envelope, by means of the PHASE dial, also moves the carrier; the two signals move together.

Adjustment of the transmitter phase control circuit is accomplished by means of two XMTR 100 KC ϕ SHIFT potentiometers; one is a FINE control, the other a COARSE control.

The output of the transmitter phase control is delivered to the transmitter via the low output impedance of a cathode follower stage.

(4) FREQUENCY CORRECTOR CAPACITOR.—As previously discussed in paragraph 2 *d* (3) the sync control unit is equipped with a FREQUENCY CORRECTOR control which permits the frequency of the 100-kc oscillator to be corrected in a manner directly related to the amount of phase correction required to maintain synchronization. The essential element of this control is the frequency adjust capacitor which is electrically connected to the crystal oscillator to provide a minute adjustment of the oscillator frequency. The FREQUENCY CORRECTOR control is mechanically geared to the shaft of the PHASE autosyn so that, with the phase clutch engaged, the FREQUENCY CORRECTOR and PHASE controls operate together.

Because frequency correction is carried out only at a slave station, the frequency adjust capacitor is not required at a master station. Therefore, to provide utmost stability at a master station, the frequency adjust capacitor is disconnected from Radio Frequency Oscillator Type O–202/FPN–30 for master operation.

The frequency adjust capacitor has a range of ±4 parts per 10^7; when this limit is approached, it is necessary to reset the FREQUENCY CORRECTOR control to its center position and make a compensating frequency adjustment in the crystal oscillator. To facilitate this adjustment, the FREQUENCY CORRECTOR control is marked RAISE OSC DIAL READING BEFORE RESETTING at one end of its range and LOWER OSC DIAL READING BEFORE RESETTING at the other end of its range. Thus if the FREQUENCY CORRECTOR dial reaches 3.9 on the "raise" side, for example, the FINE FREQ. ADJ. control on the oscillator should be adjusted to read 3.9 parts per 10^7 higher (390 parts per 10^9). The adjustment is carried out by making the FINE FREQ. ADJ. drum and dial read 390 parts per 10^9 higher. (Each drum division is equal to 100 parts per 10^9 or 1 part per 10^7.)

To warn the operator that the FREQUENCY CORRECTOR dial has reached its limit the sync control unit is equipped with a cam and switch arrangement which closes the circuit to a FREQUENCY WARNING indicator lamp. As the capacitor approaches either limit of its range, the switch is tripped by the cam, and the lamp lights to provide a very noticeable indication of the condition.

(5) TEST CIRCUITS.—The sync control unit is equipped with a selector switch and isolating cathode follower for picking up significant circuits and delivering their waveforms to the test scope for observation. The circuits picked up by this arrangement are the 100 KC INPUT, the SHIFTER OUTPUT, the 100 KC TO XMTR output, and the 100 KC TO FREQ DIV output.

(6) SYNC CONTROL DRIVE SYSTEM.—The sync control drive system is a motor driven chain of gears which drives the PHASE and FREQUENCY CORRECTOR controls of the synchronization control unit. The system includes two electrically operated clutches which permit the driven controls to be disconnected from the chain so that they may be manually operated. Disengaging only the phase clutch will leave the PHASE control connected to the FREQUENCY CORRECTOR control, through a portion of the gear chain, but will disconnect both controls from the drive system. Disengaging only the frequency clutch will disconnect the FREQUENCY CORRECTOR control from the PHASE control and the drive system. Disengaging both clutches will disconnect both controls from the drive system and from each other.

The motor operated system is a self-controlled automatic arrangement for correcting synchronization error. Any change in the relationship between the time difference and the reference delay will be observed in the electrical synchronizer and an error signal will result. At a slave station this error signal operates the motor to drive the PHASE control and thus reduce the error to zero. At a master station the error signal is used in another way. The error signal causes the motor to rotate the PHASE dial, which, in master service, indicates the amount of error. The PHASE dial shaft operates an error recording circuit; thus the master station only indicates and records error, it does not correct error.

With manual operation the error is monitored on the indicator scopes and the PHASE dial is manually adjusted whenever an error is observed.

(*a*) SYNC CONTROL MOTOR. — The sync control motor is a two phase a-c motor which is operated from an error voltage developed in the electrical synchronizer. This 60-cycle error voltage, which is the principal output signal of the electrical synchronizer, is applied to one of the two windings of the motor. The other winding is connected to the 60-cycle line. The phase of the error voltage will differ by 90° or 270° from the phase of the 60-cycle line, depending on the direction of the error; thus the motor will rotate in the direction required to reduce the error. With zero error the error voltage is zero and the motor is stationary.

The error voltage delivered by the synchronizer does not have sufficient power to drive the motor; therefore the sync control unit is provided with a three-stage amplifier which develops adequate power from the synchronizer output voltage. This amplifier is equipped with a MAX MOTOR SPEED control which regulates the amplitude of the error voltage and thus controls motor speed. The MAX MOTOR SPEED control regulates speed in a unique manner. For small error signals motor speed is proportional to the amount of error; however, with a large error the motor reaches a maximum speed which does not increase, despite an increase in error. This occurs because the circuit limits motor voltage to a maximum value determined by the setting of the MAX MOTOR SPEED control. Thus this control limits the maximum motor speed without appreciably affecting motor speed when the error is small and speed is limited without materially reducing sensitivity to small error signals.

To prevent oscillatory "hunting" about the zero error point, a d-c generator, operated by the motor, is used to develop a feedback voltage. This voltage is applied to the error circuits of the electrical synchronizer in such a way that the motor is effectively prevented from hunting.

(*b*) GEAR SYSTEM.—The gear system incorporates reduction gears and electrically operated clutches to connect the motor to the PHASE and FREQUENCY dials. The gear system also drives a FINE PHASE indicator dial. (A detailed drawing of the functional arrangement of this system is shown in figure 2–55, later in this section.)

A gear shift arrangement is incorporated so that a wide range of speed may be obtained. The gear shift provides a change in gear ratio of 8:1; however, because of motor characteristics, the actual speed change ratio is approximately 10:1. With the gear shift set for LOW speed, the MAX MOTOR SPEED control covers a range of 1 to 10 microseconds of error per minute. With the gear shift in high speed, this range is increased to 10 to 100 microseconds of error per minute. The speed range employed is indicated by MAX MOTOR SPEED panel lights appropriately labeled LOW RANGE and HIGH RANGE.

Gearing is such that the FREQUENCY CORRECTOR dial is operated at a rate 1/64th that of the PHASE dial. Thus significant correction is made only after the PHASE dial has rotated an appreciable amount. On the other hand, the FINE PHASE dial rotates 20 times faster than the PHASE dial so that one turn of the FINE PHASE dial indicates a phase change of one-half microsecond. The FINE PHASE dial is subdivided into fifths to provide tenth-microsecond indications.

With the gear system connected, it is not practical to operate the PHASE or FREQUENCY CORRECTOR dials by hand; therefore, clutches are provided for disengaging each dial from the gear train. The clutches are operated electrically by means of front panel switches. With the phase clutch disengaged, the PHASE dial is disconnected from the motor but remains connected to the FREQUENCY CORRECTOR dial; the FINE PHASE dial is always connected to the motor and operates with the motor. With the frequency clutch disengaged, the FREQUENCY CORRECTOR dial is completely disengaged from the gear train.

The phase clutch will be disengaged at such time as it is desirable to disable the automatic synchronizing system or to manually adjust phase. A switch, labeled AUTO SYNC ON-OFF, short-circuits the output of the motor amplifier and disengages the clutch at the same time. With this switch OFF, the PHASE dial may be easily turned by hand.

The frequency clutch will be disengaged whenever it is desirable to reset the FREQUENCY CORRECTOR dial, or to adjust phase, without changing frequency. A front panel FREQUENCY CORRECTOR IN-OUT toggle switch is provided to disengage the frequency clutch when required. To remind the operator whenever this switch is in the OUT position, a FREQUENCY CORRECTOR OUT indicator glows to provide a conspicuous indication of this abnormal condition. Thus the operator is alerted to the need to return the switch to the IN position when frequency correction has been completed.

(*c*) SLAVE OPERATION. — For slave operation, the sync control motor drives the PHASE and FREQUENCY CORRECTOR dials through the gear train. The PHASE dial is connected to the autosyn which shifts the phase of the 100-kc signal by a number of electrical degrees corresponding to the number of mechanical degrees of dial rotation. Simultaneously, the FREQUENCY CORRECTOR dial is rotated to vary the setting of the frequency capacitor. Thus, for slave operation, the sync control motor drives the autosyn and frequency capacitor in a manner which maintains synchronization. Synchronization is maintained because the time difference between master and slave transmitted signals, as observed by the electrical synchronizer, is continuously adjusted to be equal to the reference delay.

(*d*) MASTER OPERATION.—For master operation the sync control drive system drives the PHASE and FREQUENCY CORRECTOR dials through the gear system, as before; however, the autosyn and the frequency adjust capacitor are electrically disconnected so that they have no control on synchronization. Additional control elements are connected to the shaft of the PHASE dial through a mechanical linkage. The elements consist of a two-section precision potentiometer plus accessory cams and switches. These elements permit ± error to be shown on the PHASE dial, in microseconds, by the arrangement described below. For master operation, this error indication system is designed to operate over a range of ±5 microseconds of error. This arrangement coincides with the 10 microseconds per revolution of the PHASE dial correction required for slave operation; thus each dial division equals one microsecond for both master and slave operation.

Note

Although the PHASE dial is calibrated over a ±5-microsecond range, for 360° of rotation, the electrically active portion of the potentiometer winding is less than 360°. Because of this, the PHASE dial rotation is limited to ±4.6 microseconds.

One of the potentiometer sections controls a delay circuit in the synchronizer in such a manner that the delay circuit follows any error in timing of the slave signal. With this arrangement, the delay circuit is adjusted to an initial condition corresponding to correct synchronization. Any subsequent errors, which result because the slave station fails to maintain synchronization, are observed by the synchronizer at the master station and an error voltage is generated. This error voltage is applied to the sync control motor so that the precision pot is rotated. Rotation of the pot adjusts the delay circuit so that the synchronizer no longer generates the error voltage, and the motor stops. Under these conditions, the precision potentiometer has rotated away from center position; the amount of rotation is indicated, in ± microseconds error, on the PHASE dial. Thus the operator at the master station can always observe any synchronization error existing in the system because of inefficient slave operation. Note that the master only *observes* error; no attempt should be made to correct error at a master station.

The second section of the precision potentiometer drives the pen of a recording milliammeter to make a permanent record of synchronization conditions. The recording milliammeter and the chart paper supplied with it are calibrated in ± microseconds error so that a record is made of the error indications which appear on the PHASE dial.

Potentiometer rotation away from center unbalances a d-c bridge so that the milliammeter pen is linearly deflected in accordance with the amount and direction of rotation.

Two cams, on the potentiometer shaft, are arranged to trip a switch and thus indicate that the PHASE dial has rotated a preset amount away from center. This rotational displacement is indicative, at a master station only, of a synchronization error. At a slave station the condition of correct synchronization does not necessarily correspond to the zero setting of the PHASE dial. The cams are adjustable to monitor a ±1- to a ±3-microsecond error. The switch tripped by these cams is connected to a sync error alarm circuit in the electrical synchronizer. This alarm circuit is arranged to alert the operator to excessive error.

The same potentiometer shaft which carries the sync error cams is also equipped with a small stop mechanism arranged to limit shaft rotation to less than 360° for master operation, to prevent the potentiometer arm from exceeding the winding limitation and going abruptly from one end of the winding to the other. Were this to happen, the electrical synchronizer would "see" a sudden increase in error and would drive the motor continuously in one direction, past the ends of the winding, until the error was corrected. This action would cause the milliammeter pen to move slowly from one side of the paper to the other, jump back to the starting position, and then repeat the cycle. The stop mechanism prevents this by arresting potentiometer rotation before the ±5-microsecond limit is reached; thus with a large error the motor will keep turning, but because of stop action and clutch slippage the pot will be stopped. At such time as the error is corrected, the motor will reverse direction and cause the pot to return to center position.

The stop mechanism is required only with master operation. To permit the mechanism to be disabled, for slave operation, the arrangement incorporates an adjustable screw. The screw may be extended to contact the stop for master operation and retracted to clear the stop for slave operation.

c. FREQUENCY DIVIDER TYPE CV–274/FPN–30.—The frequency divider establishes the loran repetition rate by dividing the 100-kc signal by a suitable factor. A circuit arrangement is used which generates a square wave at an exact submultiple of the 100-kc timing signal so that the phase and frequency of the square wave may be adjusted by variation of the phase and frequency of the 100-kc signal to effect the control described previously in paragraph 2 *d* (2). The frequency divider "counts off" 4,000 cycles of the 100-kc timing signal to produce one 25-cycle square wave.

The loran system employs three groups of repetition rates which are called basic rates. These are designated slow, low, and high for rates of 20, 25, and 33-1/3 pulses per second, respectively. Each group is subdivided into eight specific rates designated 0 through 7.

The various rates which the frequency generator can establish, the total factor by which the 100-kc signal is divided, the pulse recurrence interval (duration of one square-wave cycle), and the duration of one-half the square-wave cycle are given in table 2–1. A BASIC RATE switch and a SPECIFIC RATE switch select the division factors of the frequency divider to provide all the tabulated rates.

The quantity of available basic and specific rates permits a maximum of 24 stations to operate on a given carrier frequency in any one service area. Separation of different pairs operating at the same carrier frequency is accomplished, at receiving stations, by synchronizing the rate of the receiver indicator to the rate of the station to be received. The desired signals will appear stationary on the screen while all other signals will appear to move across the screen. This apparent motion, of a pulse signal recurring at a different rate, results because the signal appears at a different place along the time base with each recurring sweep. For example, if the received signal occurs at the rate to which the receiver indicator is synchronized, the signal will occur at the same point along the time base, for each sweep, and appear stationary. If the received signal occurs at some faster rate, it will recur a little ahead of time, with each sweep, and appear a little to the left of its previous position. Thus it will appear to move continuously to the left, The speed of apparent motion will depend on how much the rate of the moving signal differs from that of a stationary signal; the greater the difference the faster the apparent motion. The effect may be likened to an image on a motion picture film. If the image appears in the same place on each successive frame of the film, it will appear to stand still; if it appears at a slightly different place, each time, the illusion of motion is created.

The ability to make a signal appear to move by making it occur at a nonsynchronous rate is used in the timer to aid in positioning the local signal with respect to the remote signal when initially placing the timer into operation. A DRIFT switch is provided to select one of four modified rates to make the remote signal appear to drift at a slow or a fast rate, to the left or right, in accordance with the position of the switch. The switch is normally spring returned to the center, but may be depressed, in two steps, to either side of center to make the signal drift in a corresponding direction at a slow or fast speed. The center position of the switch maintains the normal rate as selected by the BASIC RATE and SPECIFIC RATE switches. The rate selected by the DRIFT switch is deliberately made unequal to any specific rate to prevent any possibility of confusion.

Aside from the basic function of frequency division the divider also performs several secondary timing functions. These include generation of marker pulses for accurate measurement of time on the timer oscilloscopes, generation of the square wave, generation of the SLOW SCOPE sweep voltage, mixing of the SLOW SCOPE markers and pedestal, and control of the separation of SLOW SCOPE traces. To permit maintenance and adjustment of the frequency divider circuits the unit is equipped with a test count generator and a test signal circuit selector switch and cathode follower.

TABLE 2–1. LORAN RATES, TOTAL DIVISION FACTORS, AND PULSE RECURRENCE INTERVALS

RATE	TOTAL DIVISION FACTOR	PULSE RECURRENCE INTERVAL IN MICROSECONDS (Duration of one square-wave cycle)	INTERVAL OF ONE-HALF SQUARE WAVE IN MICRO-SECONDS
SLOW (20 cycles)			
0	5,000	50,000	25,000
1	4,990	49,900	24,950
2	4,980	49,800	24,900
3	4,970	49,700	24,850
4	4,960	49,600	24,800
5	4,950	49,500	24,750
6	4,940	49,400	24,700
7	4,930	49,300	24,650
LOW (25 cycles)			
0	4,000	40,000	20,000
1	3,990	39,900	19,950
2	3,980	39,800	19,900
3	3,970	39,700	19,850
4	3,960	39,600	19,800
5	3,950	39,500	19,750
6	3,940	39,400	19,700
7	3,930	39,300	19,650
HIGH (33-1/3 cycles)			
0	3,000	30,000	15,000
1	2,990	29,900	14,950
2	2,980	29,800	14,900
3	2,970	29,700	14,850
4	2,960	29,600	14,800
5	2,950	29,500	14,750
6	2,940	29,400	14,700
7	2,930	29,300	14,650

(1) FREQUENCY DIVISION.—Frequency division is accomplished by a number of essentially identical counter circuits. A counter circuit, in its simplest form, is one which divides the input signal by two. The circuit "counts off" two pulses and then produces an output, thus dividing by two. Such a counter is called a binary counter. Groups of binary counters are used to obtain the required division factors.

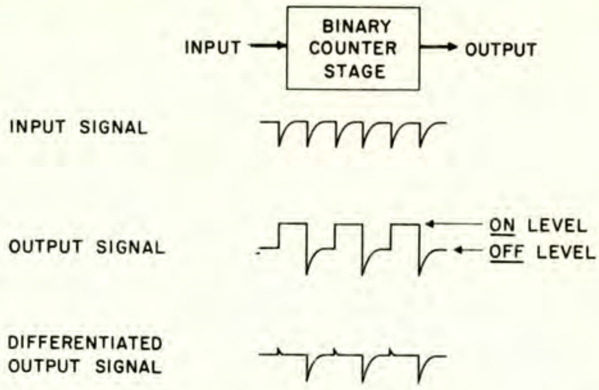


Figure 2–10. Binary Counter Stage, Block Diagram and Simplified Waveforms

(*a*) BINARY COUNTER.—A binary counter is a circuit which produces one output pulse for every two input pulses. The type of binary counter used here is a modified version of the Eccles-Jordan "flip-flop" multivibrator, a bistable device which requires no critical adjustments. The circuit consists of a single stage composed of two tube sections designated A and B. The sections are arranged so that A will always conduct when B is nonconducting, and vice versa. Each time a negative pulse is applied to the common input of sections A and B they reverse their state. A neon lamp, connected across the A section, goes on and off to indicate the condition of the stage. In accordance with the lamp indications, the stage is said to go *on* and *off* with alternate input pulses. The binary counter stage produces an output pulse every time the lamp goes *off*. No output pulse results when the lamp goes *on;* thus, because it takes two input pulses to make the stage go through a complete *on-off* cycle, producing only one output pulse, the binary counter divides by two. The basic binary counter, which is the building block which forms all other counter circuits, is shown in block form, with input and output signals, in figure 2–10. The useful output signal is obtained by differentiating the binary stage output waveform to provide negative pulses. The small positive pulses may be ignored since the succeeding counter stages respond only to negative pulses. Observe that, because the output pulses occur half as frequently as the input pulses, they are spaced twice as far apart as the input pulses. Thus a circuit which divides frequency also multiplies pulse recurrence interval.

(*b*) COMBINING BINARY STAGES.—Larger division factors than two are obtained by grouping binary counters so that the output of the first counter drives the second and so on as shown in block form, with waveforms, in figure 2–11. The sequential operation of this counter is shown by the waveforms of figure 2–11 and is also tabulated in figure 2–12. The condition of each of the four stages is shown in the tables by the symbols — and 0 for *off* and *on* respectively. At the beginning of the cycle (pulse number zero) all stages are *off*. The first input pulse turns the first stage (called the 1 stage because it turns *on* after application of one pulse) *on*. Remembering that when a binary stage goes *off* it transmits an output pulse, we can follow the progress through automatically. At the second pulse the 1 stage goes *off* to turn the 2 stage *on*. Pulse number 3 turns the 1 stage back *on* and pulse number 4 turns the 1 stage *off*, turning the 2 stage *off* and thus the 4 stage *on* (the third stage is called the 4 stage because it takes four pulses to turn it *on*). The progression continues until pulse number 16 turns the 8 stage *off* and an output pulse is thus transmitted. At this time all stages are *off* and the counter is ready to start a new cycle. It will be observed that if the cycle is stopped after any number of input pulses have been introduced, the total "count" of input pulses will be indicated by the sum of the numbers identifying those stages which are *on*. Thus, if the cycle is stopped after application of 11 pulses, the 1 stage, the 2 stage, and the 8 stage will be *on* to indicate a total count of 11. For the number 16 the indicated count is zero; this is because the count of 16 completes the cycle and the lights indicate that the counter is about to start a new cycle.

(*c*) DECIMAL COUNTER.—The 4 stage counter described in the preceding paragraph may be modified to count to ten instead of 16 by a simple feedback arrangement. In the simple 4 stage counter (figure 2–11) the 1 stage and the 8 stage are *on* at the count of nine. The count of ten turns the 1 stage *off* and the 2 stage *on*. To modify this counter for decimal counting, it is necessary to terminate the cycle at the count of ten by making all stages go *off*. This is accomplished by using feedback, in the form of output pulses selected from appropriate stages, to turn the 8 stage *off* and prevent the 2 stage from coming *on* at the

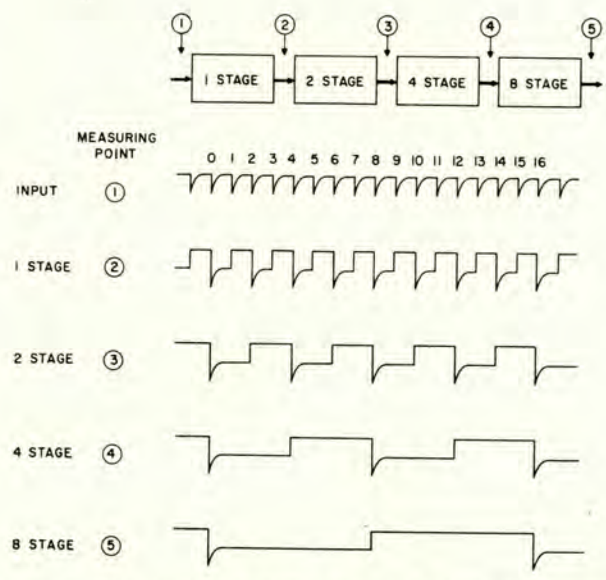


Figure 2–11. Simple 4 Stage Counter, Block Diagram and Waveforms

STAGE	INPUT PULSES TO COUNTER																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	–	O	–	O	–	O	–	O	–	O	–	O	–	O	–	O	–
2	–	–	O	O	–	–	O	O	–	–	O	O	–	–	O	O	–
4	–	–	–	–	O	O	O	O	–	–	–	–	O	O	O	O	–
8	–	–	–	–	–	–	–	–	O	O	O	O	O	O	O	O	–

SIMPLE FOUR STAGE COUNTER

LEGEND
– = OFF
O = ON

STAGE	INPUT PULSES TO COUNTER										
	0	1	2	3	4	5	6	7	8	9	10
1	–	O	–	O	–	O	–	O	–	O	–
2	–	–	O	O	–	–	O	O	–	–	–
4	–	–	–	–	O	O	O	O	–	–	–
8	–	–	–	–	–	–	–	–	O	O	–

DECIMAL COUNTER

Figure 2–12. Progressive Circuit Conditions for Simple 4 Stage Counter and for Decimal Counter

count of ten. The output of the 1 stage is fed, via a special path, to the 8 stage to turn it *off*. Another special path feeds the 8 stage output pulse to the 2 stage to hold it *off*. Thus, on the tenth pulse, all stages are *off* and the counter is ready to start a new cycle. The sequence of this modified counting cycle is shown in figure 2–12. The arrangement for decimal counting is shown in block form in figure 2–13. The waveforms in this figure show the complete counting cycle. For counts from zero to nine the cycle is the same for decimal counting as for counting with the simple 4

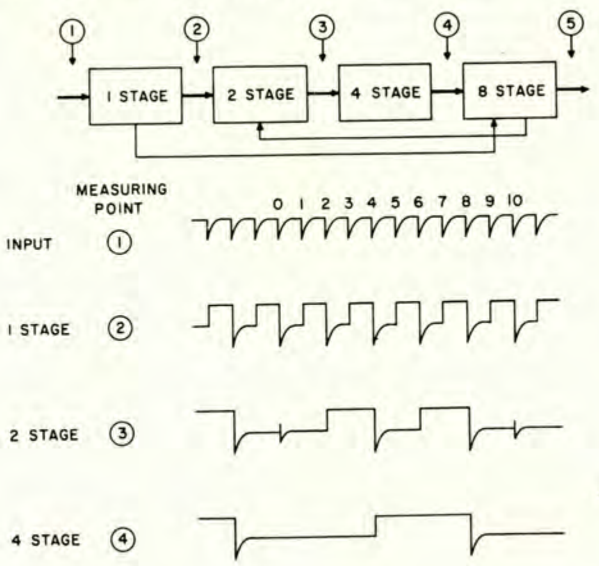


Figure 2–13. Decimal Counter, Block Diagram and Waveforms

stage counter shown in figure 2–11. At the count of ten the feedback pulses turn the 8 stage *off* and hold the 2 stage *off*. The short wavy line on the 2 stage waveform, at the count of ten, is caused by the feedback pulse applied to prevent the stage from coming *on*.

The pulses which turn *off* the 8 stage and hold the 2 stage *off* are termed "reset" pulses because they reset the counter to the start of the cycle. The reset pulse from the 1 stage is generated each time an even number pulse turns the 1 stage *off;* however, it is only effective at the count of ten because this is the only time during the counting cycle that the 8 stage is *on* when the 1 stage goes *off*. Because the reset pulse applied to the 2 stage is generated by the 8 stage, it occurs only at the count of ten. Thus, reset pulses are effective only at the count of ten in a decimal counter.

Decimal counters are used, instead of counters by 16, 32, or any other number, because decimal counting is consistent with everyday arithmetic. The decimal counters, as employed in the counter, yield pulses every 100 microseconds and every 1,000 microseconds.

(*d*) MODIFICATION OF COUNT BY USE OF PRESET PULSES.—The preceding paragraph explained how it is possible to modify a 4 stage counter to count by tens, by resetting the counter to the beginning of the cycle on the tenth count. It is also possible, by use of another feedback scheme, called presetting, to make the counter count by any number. A counter without preset will have all stages turned *off* at the end of the cycle; the stages will remain *off* until application of the first pulse at the start of a new counting cycle. If some of the counter stages are turned *on* at the beginning of the cycle, prior to application of the first count, then fewer counts will be required to complete the cycle and produce an out-

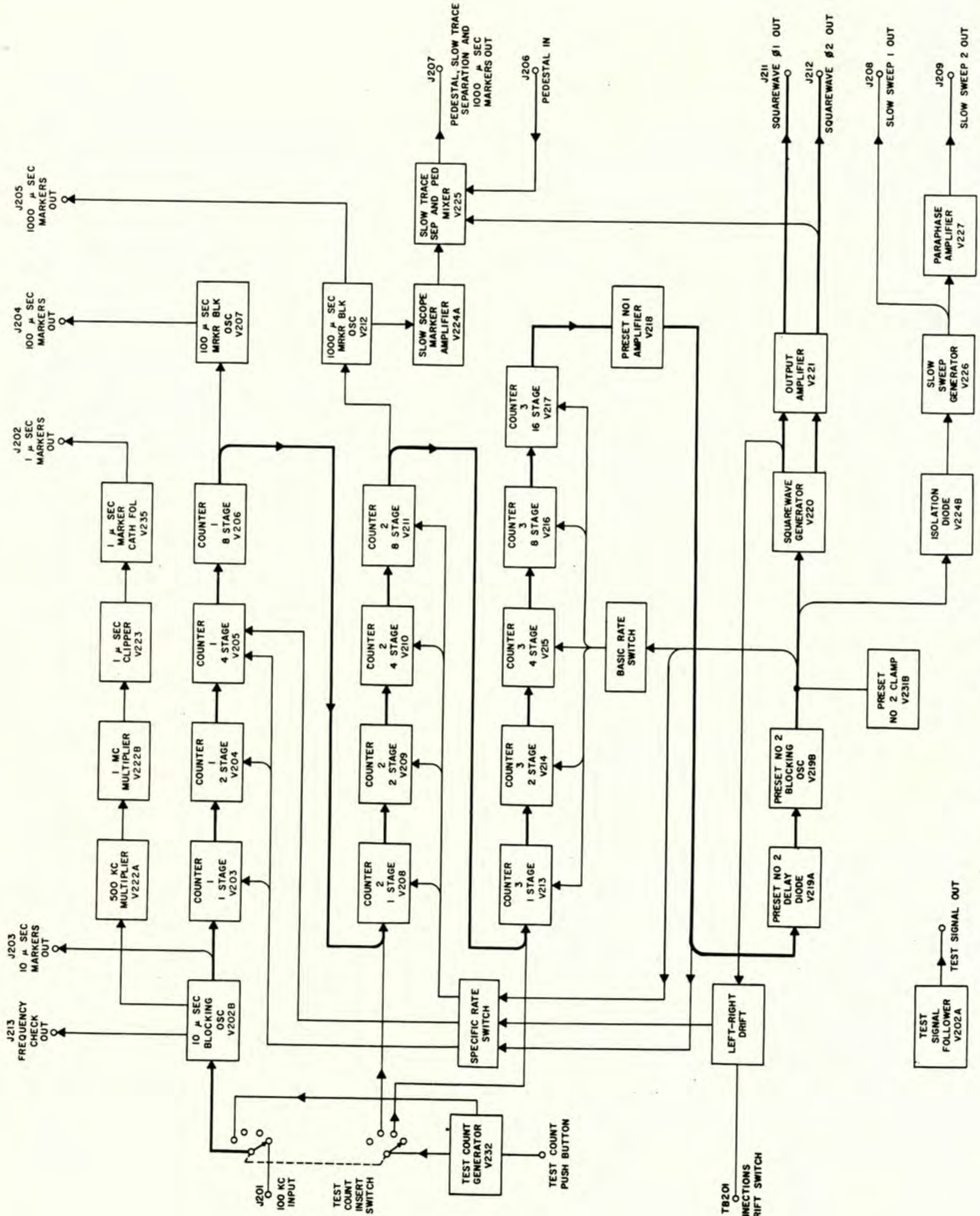


Figure 2–14. Frequency Divider Type CV–274/FPN–30, Simplified Block Diagram

put pulse. For example, if the 1 stage and the 2 stage were artificially turned *on* at the start of the cycle, only seven pulses would be required to produce an output pulse. From this example it can be seen that the stages which must be artificially turned *on,* or preset, must be the complement of the desired count.

Each binary stage has two grids; application of a pulse to one grid will turn the stage *on.* Application of a pulse to the other grid will turn the stage *off.* Since at the end of a count all stages are *off,* and it is desired to turn some of them *on,* preset pulses are applied to *on* grids. The counter circuit is arranged so that the preset pulse is derived from the counter output pulse. The preset pulse is applied to the *on* grids of those stages which must be preset for the required complementary count. Thus a counter can be preset for a count less than its normal total by inserting a complementary count artificially. A decimal counter can be preset, in this manner, to count any number from one to ten. The use of preset counts will be discussed in greater detail in later paragraphs.

The basic difference between presetting and resetting is that at reset the counter is forced to terminate a cycle before the maximum count has been reached. In presetting the counter completes a cycle normally but the count is modified, at the beginning of the next cycle, by insertion of an artificial count.

(2) ARRANGEMENT FOR FREQUENCY DIVISION.—The groups of binary counters in the frequency divider are designated counter 1, counter 2, and counter 3. Counter 1 and counter 2 are 4 stage decimal counters. Counter 3 is a 5 stage counter which can provide a maximum count of 32. As shown in the block diagram, figure 2–14, counter 1 feeds counter 2 and counter 2 feeds counter 3. The output of counter 3 drives the square-wave generator (through the preset stages). The square-wave generator is essentially a binary circuit and divides by two. Thus, the counter circuits need to provide only half the total division factor required of the frequency divider. To divide the 100-kc timing signal by 5,000, the largest factor required of the divider, the counter circuits need divide by only 2,500.

The output pulses of counter 2 recur at intervals of one-half the loran cycle. Since it is essential to keep master and slave halves of the square wave equal, timing modifications, to provide different rates, are performed ahead of the square-wave generator. The square-wave generator, which divides the counter 3 output by 2, thus necessarily has equal half-cycles.

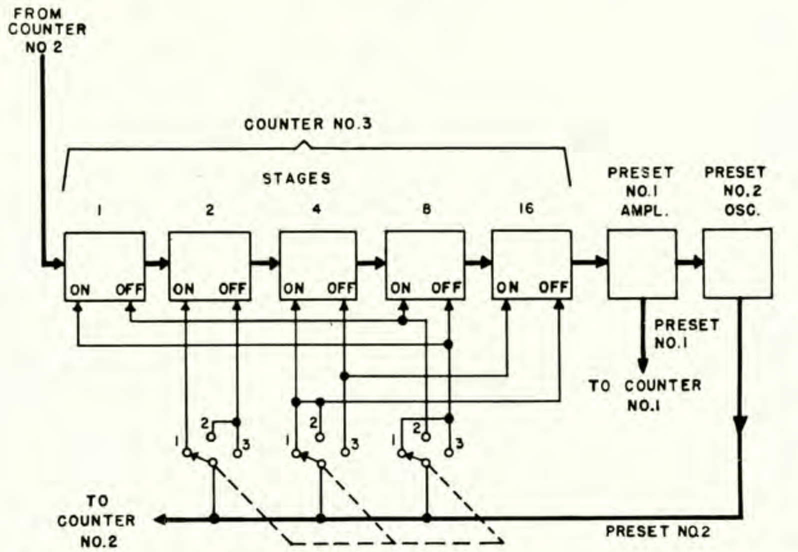
Because the square-wave generator is not a variable element in the determining of the loran rate, the following discussions on the arrangement for frequency division will be confined to the three counter circuits.

It is often convenient to speak of pulse interval multiplication rather than frequency division. As previously shown, pulse interval multiplication is coincident with, and proportional to, frequency division. Pulse interval and frequency for the three counters are shown here for the high basic rate.

SIGNAL	FREQUENCY	PULSE RECURRENCE INTERVAL
100 kc	100 kc	10 μsec
Counter 1 output	10 kc	100 μsec
Counter 2 output	1 kc	1000 μsec
Counter 3 output	66-2/3 cps	15,000 μsec

(*a*) DEVELOPMENT OF BASIC RATE.—The basic rate is established by the division factor of counter 3. At specific rate 0 counter 3 is driven by 1,000-microsecond pulses resulting from decimal division of the 100-kc signal by counter 1 and counter 2. For the three basic rates, S, L, and H, counter 3 divides by factors of 25, 20, and 15, respectively. To obtain these division factors, counter 3 is designed as a 5 stage binary counter with a maximum count capability of 32. This count of 32 is modified, by presetting, to one of the three required division factors. The insertion of preset pulses, to obtain the required division factors, is illustrated in figure 2–14. The block diagram shows counter 3 to consist of five binary stages and two preset amplifiers. The two preset amplifiers are used to develop preset pulses which can be fed to two isolated destinations. Pulses from preset amplifier number two are applied, via a switch, to all stages of counter 3. These pulses are applied to the *on* grids of the various stages to preset them for the required complementary count. They are also applied in the form of "holding" pulses to the *off* grids of other stages to prevent those stages, which are not to be preset, from coming *on.* The use of holding pulses prevents spurious triggering from pulses caused by triggering earlier stages.

To obtain a count of 25, preset pulses are applied to the 1, 2, and 4 stages to insert the required count of seven. Holding pulses are applied to the 8 and 16 stages. This arrangement and the arrangement for obtaining the other two basic counts are tabulated at the bottom of figure 2–15. Waveforms for the complete counting cycle, for each arrangement, and the waveforms for a simple 5 stage counter are shown in figures 2–16, 2–17, 2–18, and 2–19. The scheme of presentation in these figures is the same as used for explaining the behavior of the binary counter and the decimal counter. The waveforms show that at the count of zero all stages go *off;* almost immediately the preset pulses then turn appropriate stages *on* to insert the required complementary count. The cycle then progresses to termination without additional modification. Thus, because the 5 stage counter is modified by presetting, counter 3 produces the required division factors of 25, 20, or 15 and the basic rates are established by the division factor of counter 3.



SWITCH POSITION	"ON" PULSE TO	INSERTED COUNT	RESULTANT COUNT	"OFF" PULSE TO
1 (SLOW)	1, 2, AND 4	7	25	8 AND 16
2 (LOW)	4 AND 8	12	20	1,2 AND 16
3 (HIGH)	1 AND 16	17	15	2,4, AND 8

Figure 2–15. Modification of Counter 3 to Obtain Basic Rates

(*b*) DEVELOPMENT OF SPECIFIC RATES.—The specific rates are derived by modifying the basic rates in decrements of 100 microseconds, as shown in table 2–1 (page 2–13). The rate which defines each group of basic rates is specific rate 0. The other specific rates, within each basic group, differ by continuous progressive steps. The progression is the same for each of the basic rates. Thus for specific rate 3 the pulse recurrence interval is 300 microseconds shorter than for specific rate 0, for all basic rates.

As discussed above, all modifications to the loran rate are performed ahead of the square-wave generator and appear in the output of counter 3. Thus specific rate modifications are applied to one-half the loran cycle and are in decrements of 50 microseconds. This is illustrated in the right-hand column of table 2–1 and in table 2–2. These tables show the total time subtracted from the loran half-cycle for each rate.

Table 2–2 shows that the time subtraction requirements are met by combining decrements of zero or 50 microseconds in counter 1 and zero, 100, 200, or 300 microseconds in counter 2. Counter 1 decimally multiplies 10-microsecond intervals and is readily modified by presetting to provide 50-microsecond intervals. Counter 2 decimally multiplies 100-microsecond intervals and is readily modified, by presetting, so that a counter 2 counting cycle contains less than ten 100-microsecond periods.

For the high basic rate, counter 1 must go through 150 counting cycles to complete one loran half-cycle. To subtract 50 microseconds from the half-cycle, it is only necessary to subtract 50 microseconds from one of the counter 1 counter cycles. This is readily accomplished by using the preset pulse developed from the counter 3 output. Because this preset pulse occurs at the termination of each half-cycle, it is used to preset the first counter 1 counting cycle of each new loran half-cycle. The remaining 149 counter 1 counting cycles are normal decimal cycles. The same method is used in counter 2 to modify the first of its 15 counting cycles. This first counting cycle is modified so that 900, 800, or 700 microseconds are required for the cycle to complete. The remaining 15 cycles are normal 1,000-microsecond intervals.

TABLE 2–2. SPECIFIC RATE TIMING OPERATIONS FOR ONE LORAN HALF-CYCLE

SPECIFIC RATE	TOTAL TIME SUBTRACTED (MICROSECONDS)	TIME SUBTRACTED FROM COUNTER 1 (MICROSECONDS)	TIME SUBTRACTED FROM COUNTER 2 (MICROSECONDS)
0	0	0	0
1	50	50	0
2	100	0	100
3	150	50	100
4	200	0	200
5	250	50	200
6	300	0	300
7	350	50	300

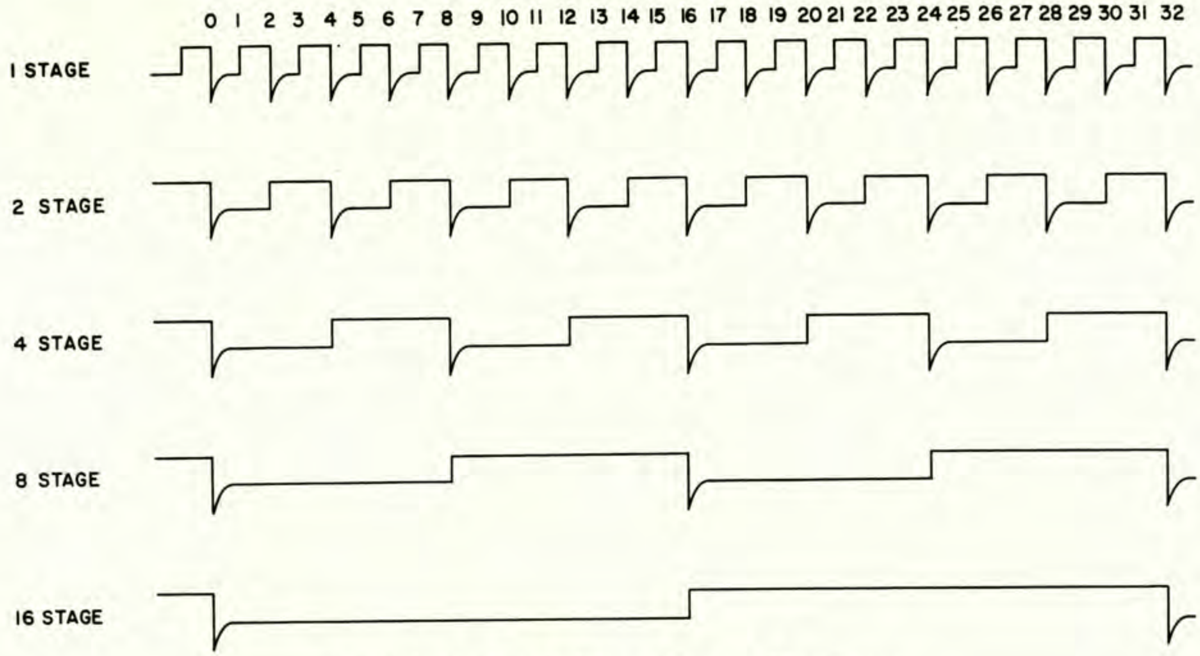


Figure 2–16. Simple 5 Stage Counter, Waveforms

The timing arrangement for one complete loran half-cycle is shown in figure 2–20 for all specific rates of the high basic rate. This illustration has been drawn with the first two "1,000-microsecond" periods shown in detail and the remaining 13 periods shown as a 13,000-microsecond interval. This figure graphically illustrates that the first period of each loran half-cycle is the period which is shortened to develop the specific rates and that the remaining 14 periods are each a full 1,000 microseconds long. The half-cycle duration for each modified rate is thus one shortened "1,000-microsecond" period plus the 14,000-microsecond interval of the remaining full periods of the half-cycle. The shortened period contains less than ten 100-microsecond periods and, for odd-numbered rates, one 50-microsecond period. This method of shortening the loran half-cycle is applied, in the same manner, to the first counting cycle of counters 1 and 2, for all three basic rates.

A review of the sequence of events, for one complete counter 3 cycle, may help the reader to a detailed understanding of the method for obtaining specific rates. Refer to figure 2–20 for specific rate 5. The preset pulse, at the completion of the preceding cycle, is applied to counters 1 and 2 to determine the specific rate. Counter 1 is preset so that its first output pulse occurs after the first five input pulses, or 50 microseconds after the start of the cycle. All succeeding counter 1 output pulses recur at 100-microsecond intervals. Counter 2 is preset so that it will require only eight input pulses to provide the first output. Because the first pulse driving counter 2 is the shortened, 50-microsecond count, the first eight driving pulses complete the first counting cycle of counter 2 in 750 microseconds. Thus 250 microseconds have been subtracted from the first "1,000-microsecond" period. The shortened period, plus 14 full periods, provides the 15 driving pulses to complete the cycle of counter 3. Thus the loran half-cycle requires only 14,750 microseconds for specific rate 5.

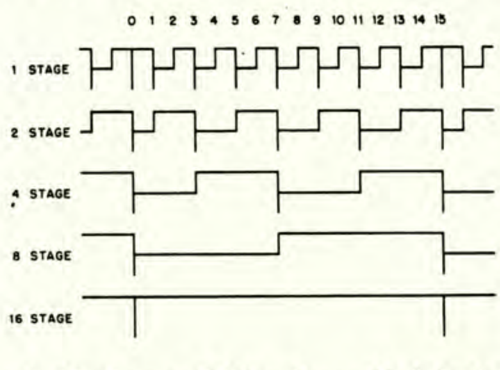


Figure 2–17. Counter 3 Waveforms, High Basic Rate

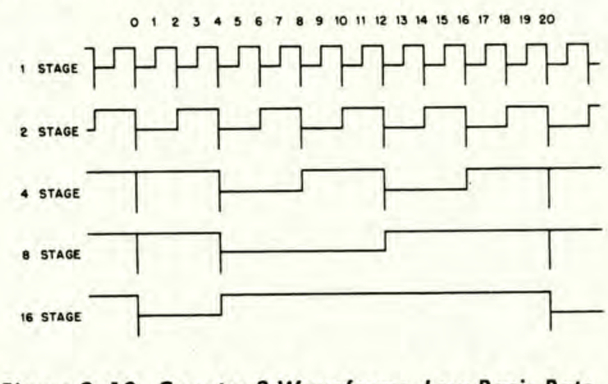


Figure 2–18. Counter 3 Waveforms, Low Basic Rate

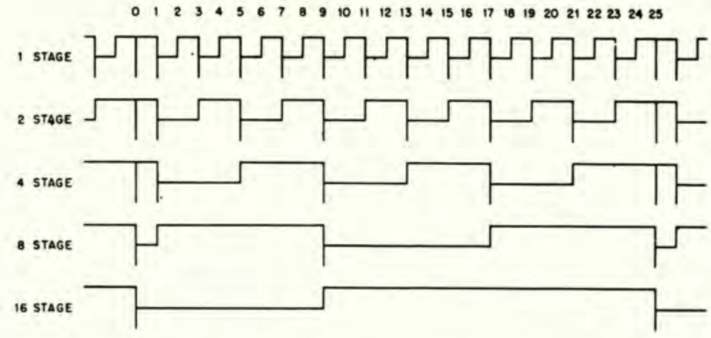


Figure 2–19. Counter 3 Waveform, Slow Basic Rate

The arrangement for applying the required preset pulses to appropriate counter stages is illustrated by the switching system shown in figure 2–21. It will be observed that an initial count of six is preset into counter 1, on odd rates, rather than five as might be expected. With this arrangement, counter 1 requires only four input pulses, after preset, to produce an output pulse; even so, a full 50-microsecond period is taken up by this first cycle. This apparent paradox results because of the delay accumulated through the three counters. The preset pulse generated by counter 3 does not occur soon enough to be applied efficiently

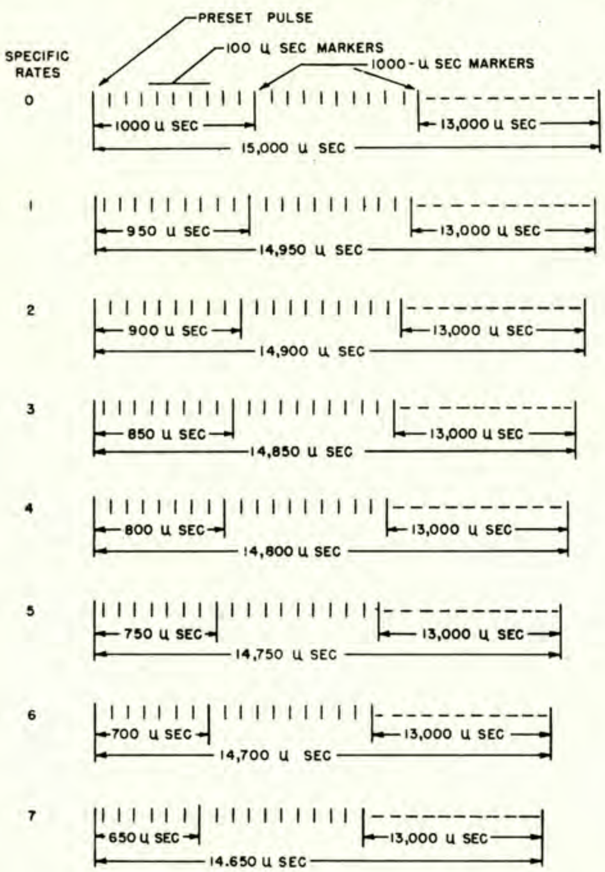


Figure 2–20. Pulse Interval Modification to Obtain Specific Rates

to counter 1. That is, the preset pulse arrives so late that the counter does not have time to recover from preset application before arrival of the first input pulse. To overcome this difficulty, this first input pulse is blocked out by applying the preset pulse to the *off* input of the 1 stage. The missing pulse is then effectively replaced by presetting six instead of five so that only four input pulses are needed to complete the cycle. Thus, because the counter is paralyzed for the first 10 microseconds of its cycle and because the counter has been preset to a count of six, it requires only four 10-microsecond binary operations to make up the required 50-microsecond period.

It should be noted that the shortening of counts in counter 1 and counter 2 will not affect the usefulness of their respective 100- and 1,000-microsecond marker outputs. The count modification is effective only for the first counting operation within each square-wave half-cycle and this modification affects A and B delays in an identical manner; hence the time change cancels out.

(3) LEFT-RIGHT DRIFT.—Left-right drift is an arrangement whereby the remote signal may be moved to the left or to the right, on the timer scopes, to position it on the remote pedestal. Two rates of drift are available for each direction. The panel control which operates the drift circuits, to move the signal, is the DRIFT switch. This switch, located on the control panel of the synchronization indicator unit, has five positions. Spring tension normally holds the switch in the central, OFF, position. Moderate pressure to the left moves the switch to a SLOW LEFT position. Heavier pressure in the same direction moves the switch to a FAST LEFT position. Correspondingly, pressure to the right moves the switch to SLOW RIGHT and FAST RIGHT positions. The illusion of motion in the indicated directions is created because the repetition rate of the local signal is made different from that of the remote signal.

The remote signal moves to the right because switch operation modifies the frequency divider circuits to shorten the pulse repetition interval. Thus the local signal, on a shorter time base than that controlling the remote signal, is moved to the left of the remote signal with each recurring modified cycle. Because the local square wave, and the local signal, are locked together in time, and since the local square wave times the local scope, the local signal must appear stationary on the local scope. The remote signal therefore appears to move to the right, even though, from the viewpoint of absolute time, it is the signal which should appear stationary. Similarly, the switch can be set to lengthen the pulse repetition interval and make the remote signal appear to move to the left.

Drift is accomplished by appropriate temporary change of the pulse recurrence interval of the square wave. This change is effected by a feedback arrangement which modifies the first counting cycle of counter 1 by insertion of an artificial count, or by blocking out a normal count. Insertion of one extra pulse to the 4 stage of counter 1 shortens the cycle by 40 microseconds to make the remote pulse move to the right. Blocking out one pulse normally applied to the 4 stage of counter 1 lengthens the cycle by 40 microseconds to make the remote pulse move to the left. Thus the remote pulse is moved 40 microseconds along the time base each time the cycle is modified by one count. The rate at which this pulse drift takes place is determined by the frequency of the feedback pulse.

Two drift rates are obtained by providing one pulse for every six loran half-cycles, for slow drift, and one pulse for every loran half-cycle for fast drift. As there is only one feedback pulse generated for every three loran cycles, at the slow rate, the average change of recurrence interval is 13.3 microseconds per cycle. At the fast rate two feedback pulses per cycle change the recurrence interval by 80 microseconds per cycle. Thus the fast rate moves the pulse six times faster than the slow rate. The drift rates were deliberately made not equal to adjacent specific rates so that a minimum of confusion would arise.

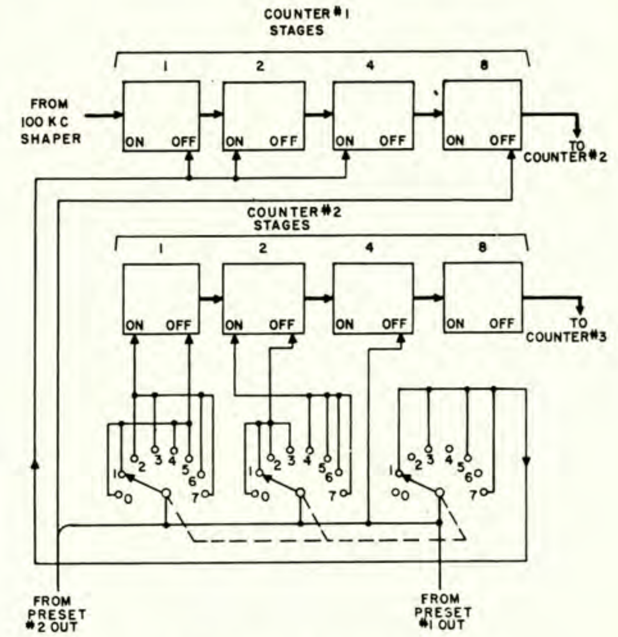


Figure 2–21. Preset of Decimal Counters, Explanatory Diagram

A block diagram, figure 2–22, shows the arrangement for obtaining one pulse every third cycle or two pulses every cycle and shaping the pulse so that it can be fed back to modify appropriate counting cycles. For the slow drift rates, square-wave output is fed through an isolation diode to a network which differentiates the square wave to obtain a single negative pulse for each square-wave cycle. This pulse is applied to the left-right divider, a 2 stage binary counter which is arranged to divide by three. Thus one output pulse is obtained for every third loran cycle.

For the fast rate preset #2, pulses are applied to the fast left-right cathode follower. The preset #2 pulses occur twice per loran cycle and are thus used

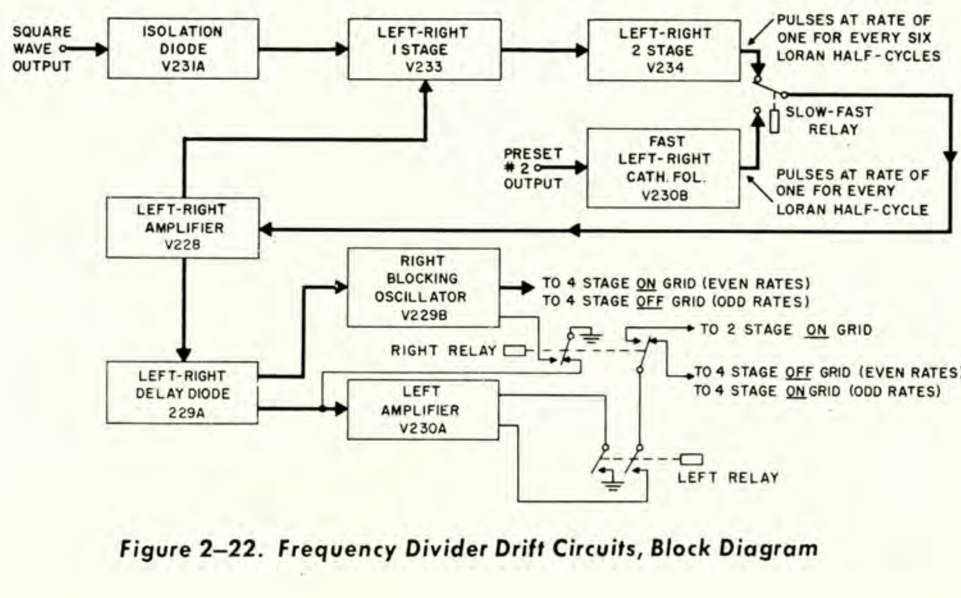


Figure 2–22. Frequency Divider Drift Circuits, Block Diagram

for fast drift. The output of either the left-right divider or the left-right cathode follower is selected by a slow-fast relay and fed to a left-right amplifier. The output of this amplifier is fed back to preset the left-right divider to a count of three, for a slow drift, and is also fed to a left-right delay diode. The delay diode feeds the right blocking oscillator and the left amplifier. Delay is such that the output pulses of these two shaping circuits occur approximately 23 microseconds after the start of the counter 1 counting cycle.

The right blocking oscillator produces sharp narrow pulses, suitable for inserting an artificial count between the second and third input pulses of counter 1, to shorten the cycle by 40 microseconds. Because the artificial count is applied to the 4 stage the change of count is four counter 1 input pulses, or 40 microseconds. Because the time base is shortened, the remote pulse is moved to the right. Insertion pulses are applied to the 4 stage by operation of the right relay. The left amplifier produces a broad pulse which blocks out the first input trigger to the 4 stage and thus lengthens the cycle by 40 microseconds to move the remote signal to the left. This broad pulse is also used, for right drift operation, as a holding pulse. The need for this holding pulse is explained later in paragraph 4 *c* (8). Blocking pulses are applied to the 4 stage by operation of the left relay when the right relay is not operated and they are applied to the 2 stage when the left relay and the right relay are operated together.

The feedback pulses occur at approximately 23 microseconds after the start of the first counter 1 counting cycle in each loran half-cycle. At this particular time the 4 stage is *off* for even rates and *on* for odd rates; therefore, it is necessary to insert a pulse to the *on* grid for even rates and the *off* grid for odd rates to shorten the cycle. Likewise, it is necessary to apply a blocking pulse to the *off* grid for even rates and to the *on* grid for odd rates to lengthen the cycle. This change of feedback pulse destination is accomplished by a section of the SPECIFIC RATE switch. Selection of an insertion pulse or a blocking pulse, at the desired drift rate, is accomplished by relay operation in response to the position of the DRIFT switch.

(4) SQUARE-WAVE GENERATION. — The square wave is generated in a binary stage which is identical to the stages used in counter 3. Square-wave output, of two opposite phases, called ϕ 1 and ϕ 2, is taken from each of the two plate circuits of the generator. This stage is triggered by counter 3 output so that each square-wave half-cycle is equal in duration to the counter 3 output pulse recurrence interval. The two generator outputs are amplified and isolated by a two-section output amplifier for delivery to other circuits.

(5) MARKER GENERATION.—As shown in the block diagram, figure 2–14, marker pulses are obtained from decimally separated signal points in the frequency dividing chain. These pulses are formed by blocking oscillator circuits and fed to other timer circuits. The 100-kc timing signal is used to generate 10-microsecond markers. The 10-microsecond markers, in turn, are multiplied, by factors of five and two respectively, in 500-kc and 1-mc harmonic amplifiers. The resulting 1-mc signal is shaped in a clipper stage and fed, as 1-microsecond markers, to other circuits via the low impedance output of a cathode follower. The counter 1 and counter 2 outputs drive blocking oscillators to generate the 100-microsecond and 1,000-microsecond markers.

Note

For convenience the markers are designated by the short form 1's, 10's, 100's, and 1,000's for the 1-microsecond, 10-microsecond, 100-microsecond, and 1,000-microsecond markers respectively. These designations are used on the timer and throughout this book. It is also customary to speak of a 1, a 10, a 100, or a 1,000 when referring to one particular marker in any chain of markers.

(6) SLOW SCOPE DEFLECTION CIRCUITS.— The frequency divider chassis incorporates circuits which develop some of the SLOW SCOPE deflection voltages. These circuits include the SLOW SCOPE sweep generating circuits and the slow trace separation, pedestal, and marker mixing circuits.

(*a*) SLOW SWEEP GENERATION.—The slow sweep voltage generated in the frequency divider is used to produce horizontal deflection in the SLOW SCOPE located on the synchronization indicator unit. The generator uses the "50-cycle" output pulses of counter 3 to trigger a circuit which produces a single sawtooth output for each input pulse. Successive sawtooths, having the same occurrence time as the successive halves of the square wave, are thus produced.

The circuit arrangement uses an isolation diode to produce the sweep trigger pulses, a pentode slow sweep generator stage to develop an extremely linear trace, and a paraphase amplifier to provide push-pull sweep.

(*b*) SLOW TRACE SEPARATION, PEDESTAL AND MARKER MIXING.—A combination of voltages is mixed in frequency divider circuits and fed to the SLOW SCOPE to vertically deflect the trace and thus separate alternate SLOW SCOPE sweeps, provide pedestals, and provide 1,000-microsecond markers. In addition to the mixer circuit which combines these voltages, a marker amplifier circuit is provided to broaden the 1,000-microsecond markers for presentation on the SLOW SCOPE. If the markers were not broadened, the compressed time base of the SLOW SCOPE would make them too sharp to be seen clearly.

Separation of the two SLOW SCOPE sweeps is accomplished by using the square wave to supply two different voltage levels to the lower deflection plate of the SLOW SCOPE. Depending on which half of the square wave is being generated, one or the other volt-

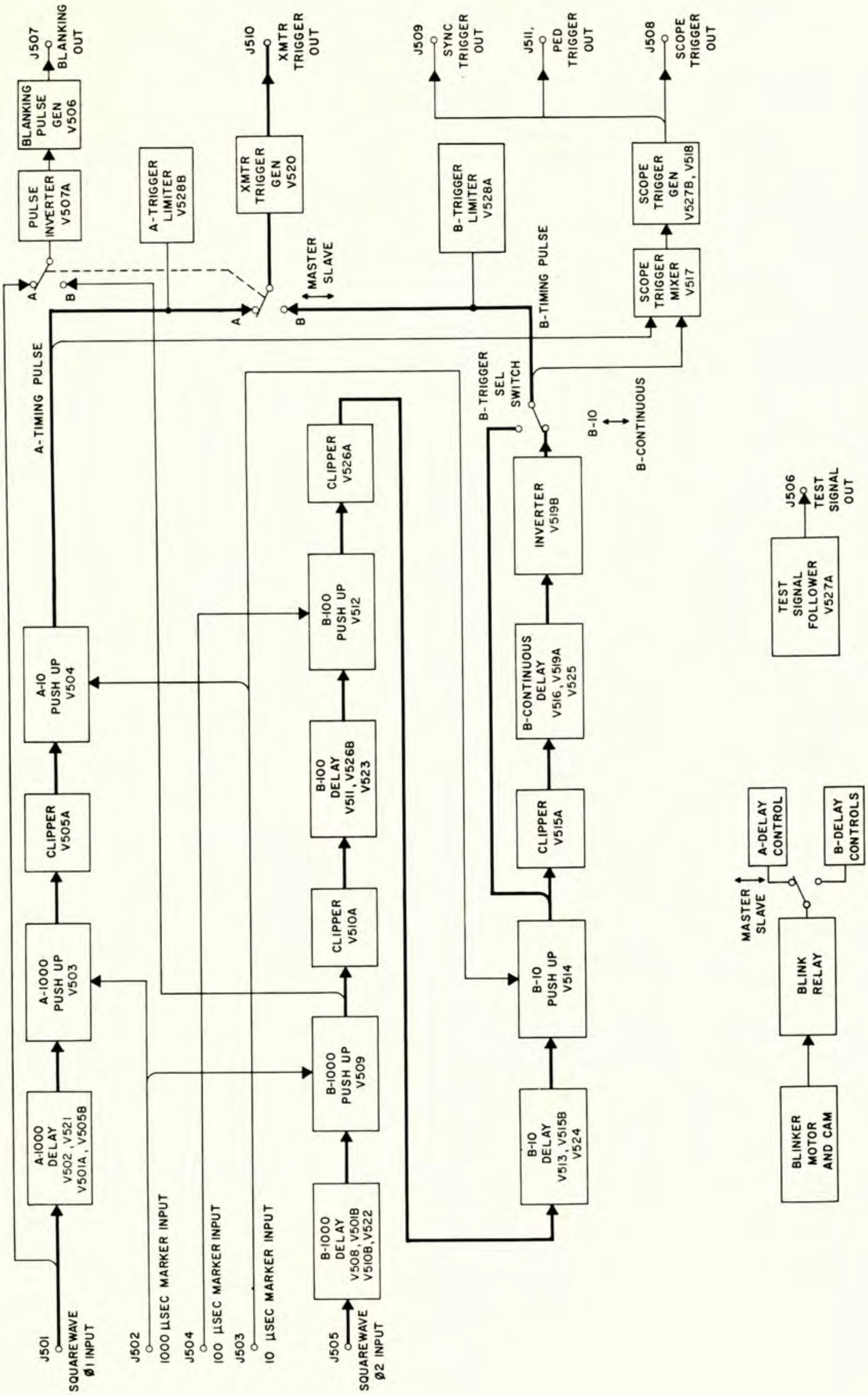


Figure 2–23. Time Delay Type TD–92/FPN–30, Block Diagram

age will deflect the SLOW SCOPE trace to one of two vertical positions. Thus the slow sweeps appear as two separate lines, one above the other, which display the two halves of the loran cycle.

The pedestal is a rectangular deflection which is presented on the SLOW SCOPE to relate the fast VIDEO SCOPE presentation to the loran cycle. Voltages for pedestal deflection are obtained from the fast video sweep generator so that the pedestal is of the same duration as the fast video sweep. Pedestal and slow trace separation voltages are combined in one mixer circuit.

A second circuit broadens the 1,000-microsecond markers and mixes them with the output of the trace separation and pedestal mixer. The resulting output thus contains markers which are wide enough to be clearly visible on the compressed time base of the SLOW SCOPE. The polarity of these markers is so arranged that they deflect downwards from the trace.

(7) TEST COUNT GENERATOR. — A manual test-count insert circuit is provided for a convenient check on counter operation. Refer to the block diagram, figure 2–14. The test count generator is a circuit which provides one artificial counting pulse each time a TEST COUNT push button is depressed. This count may be inserted into any of the three counter circuits to permit testing of each counter individually. By this means it is possible to check out the operation of each stage of each counter. Observation of the on-off state of the neon lamps associated with the various stages permits comparison with the normal counting sequence such as shown in figure 2–12. Counting sequence charts are provided for this purpose in Section 7, tables 7–27, 7–28, and 7–29.

The test count is inserted into the desired counter through operation of a TEST COUNT INSERT switch. This four-position rotary switch interrupts the normal 100-kc input signal and connects the output of the test count generator to the one of three counters selected. Positions of this switch are appropriately labeled COUNTER 1, COUNTER 2, COUNTER 3, and OFF (CIRCUIT NORMAL).

(8) TEST SIGNALS.—A test signal circuit is provided in the frequency divider to pick up significant waveforms and deliver them to the test oscilloscope for observation. These circuits are selected by a TEST SIGNAL switch and delivered to the oscilloscope via a cathode follower. Selected circuits are the 10's, the 100's, the 1,000's (markers) and the 50-cycle output of preset amplifier number 2.

d. TIME DELAY TYPE TD–92/FPN–30. — The time delay unit sets up the reference delay in the timer by means of circuits which establish the A and B delays. A high degree of accuracy and stability of delay is obtained by using the markers which are developed in the frequency divider from the 100-kc timing signal.

Included in the time delay unit are circuits for generating the transmitter trigger, for generating a pulse used to blank out the input to the receiver during transmission of the local signal, and for generating triggers for the fast scope sweeps from the A- and B-timing pulses. Also included is an arrangement for changing the A or B delay by exactly 1,000 microseconds in response to the cyclic operation of a motor-driven cam. This arrangement blinks the local signal to indicate that operational difficulties prevail. A switch and other appropriate controls are provided so that the B delay may be rapidly changed to provide any of five preset coding delays. Refer to figure 2–23.

(1) A-DELAY CIRCUIT. — The A-delay circuit provides a delayed pulse (the A-timing pulse) which may be positioned over a 1,000- to 24,000-microsecond range in steps of 1,000 microseconds. The circuit first establishes an approximate delay by means of an R-C time constant employed in a phantastron delay circuit. The output of this circuit is a wide (about 980 microseconds) gate. The position of this gate may be varied continuously over a range of 1,000 to 24,000 microseconds. The accuracy of this position is inadequate to permit direct use of the gate as the A-timing pulse; therefore, the gate is used to select one particular marker from the chain of 1,000-microsecond markers generated by the frequency divider. By this means the A delay is controlled by a 1,000-microsecond marker. The selected 1000 is broadened and used as a gate to select a particular 10-microsecond marker. The selected 10 is used as the A-timing pulse so that the final delay has a stability directly controlled by the 100-kc timing signal, with a minimum number of intervening circuits which might degrade the timing accuracy.

Figure 2–24 shows the time relationship of the various signals in the A-delay circuit. The square wave ϕ 1 is applied to a differentiating circuit so that a positive trigger pulse is obtained which corresponds to the ϕ 1 time reference point. This trigger is applied to a phantastron delay circuit to produce a variable width rectangular pulse. The width of this pulse may be varied by a front panel control so that the trailing edge is moved about in time. Differentiation of the variable width pulse produces a gate which is positioned in time by the trailing edge of the pulse. Thus a continuously variable delay, between the ϕ 1 time reference point and the gate, is fixed by a panel control.

The gate is employed in a mixer circuit to "push-up" one particular 1000. Only one 1000 can be selected at a time because gate width is adjusted (using the A1000 WIDTH control) to slightly less than 1,000 microseconds. Thus the phantastron delay must shift at least 500 microseconds to make the gate coincident with an adjacent 1000. The characteristics of the mixer circuit are such that the one marker coincident with the gate will be amplified more than any other marker. In addition, the gate voltage will produce a pedestal, on the

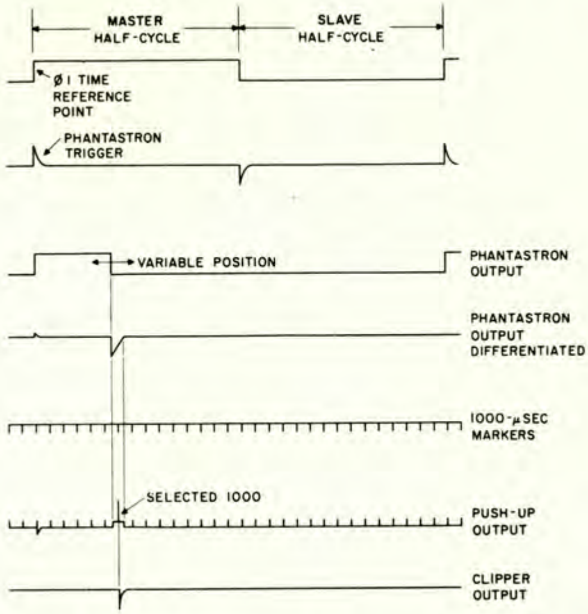


Figure 2–24. Selection of the Delayed A1000 Pulse

marker base line, and thus further push up the marker sitting on the pedestal. As a result the selected marker will have greater amplitude than any other marker. This pulse is isolated in a clipper stage because it is the only marker with sufficient amplitude to drive the normally cutoff clipper stage into the conducting region. The clipper output would normally be a narrow pulse; however, circuit modifications produce a broadened pulse which has sufficient width to make it coincident with the 10-microsecond marker immediately following the selected 1000. The broadened clipper output is used to push up this 10 in the same manner used to select the desired 1000. Likewise this 10 is isolated by clipper action in succeeding circuits.

The 10 following the 1000 is selected, instead of the 10 which is nominally coincident with the 1000, because of delays inherent in counters 1 and 2 of the frequency divider. These delays prevent the 1000 from being developed coincidently with the 10; therefore the next 10 must be used. This causes the A delay to be 10 microseconds greater than nominal. This added delay is of no consequence since it is readily compensated for, when establishing reference delay as the difference between the A delay and the B delay.

The pushed up 10-microsecond marker is the A-timing pulse, an extremely accurately delayed signal obtained from a relatively simple circuit. That is, the A-timing pulse is timed by the continuously variable phantastron delay which selects a particular 1000 and this in turn selects an accurately timed 10 to form the A-delay circuit output.

Note that, although the A-timing pulse is delayed with respect to the ϕ 1 time reference point, a considerable amount of instability can be tolerated in the timing of this reference point without affecting the timing of the 10-microsecond marker which becomes the A-timing pulse.

(2) B-DELAY CIRCUIT. — The B-delay circuit provides the B-timing pulse. The position of this pulse may be continuously varied over a 1,120- to 24,000-microsecond range. In this respect it is not like the A-delay circuit which provides delay in only 1,000-microsecond steps. The B-delay circuit is an expansion of the arrangement used in the A-delay circuit. Like the A1000 circuit the B1000 circuit provides an output in steps of 1,000 microseconds; however, additional circuits are incorporated to interpolate between the 1,000-microsecond steps. The selected 1000 drives a B100 delay circuit to select one of the ten 100-microsecond markers following the selected 1000, thus permitting 100-microsecond steps. Steps of 10 microseconds are

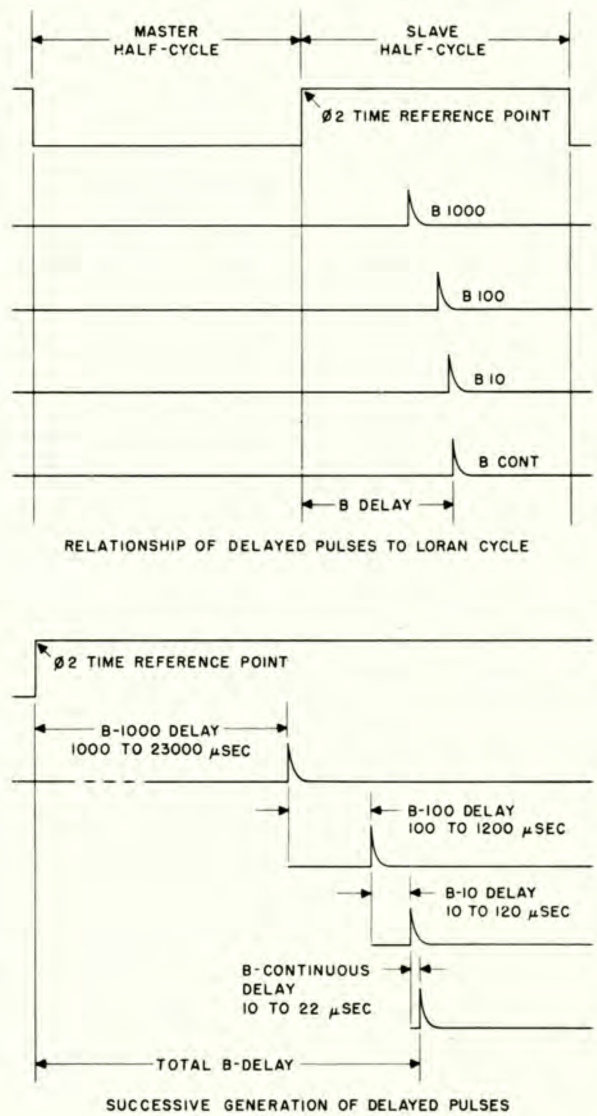


Figure 2–25. Timing of B-Delay Pulses

similarly provided by the B10 delay circuit to interpolate between the 100's. The selected 10 drives a B-continuous delay circuit, with a range of 10 to 22 microseconds, so that the final B delay is stepless and continuous. Time relationships of B delay pulses are shown in figure 2–25.

Arrangement of the B1000 delay circuit is identical to the A1000 delay circuit except that, as shown in figure 2–23, the B1000 delay is initiated by the ϕ 2 time reference point. Thus a different 1,000-microsecond marker, spaced more than half a loran cycle from the A-timing pulse, is selected in the B1000 circuit. The selected 1000 is used to time the start of the phantastron time delay of the B100 circuit. Action is essentially the same as in the B1000 circuit except that in this circuit a specific 100-microsecond marker is selected. This 100 is used, in the B10 circuit, to time the selection of a specific 10. Thus a 1000 is selected, one of the 100's following the 1000 is selected and one of the 10's following the 100 is selected; all by consecutive action of similar circuit groups. Therefore, any required delay, in 10-microsecond increments, is made available. Should a B delay which is not in full increments of ten be required, one additional circuit arrangement is used to provide a continuous delay over a 10-microsecond range. The selected 10 is used to initiate a B-continuous phantastron delay signal. This signal is a rectangular pulse, similar to that used in the preceding delay circuits, which is differentiated and inverted to provide proper polarity for direct use as the B-timing pulse. B-continuous delay is never greater than about 22 microseconds so that the stability of the circuit at this small delay is adequate to provide an over-all timing stability of better than 0.1 microsecond.

The B-timing pulse is the result of the several successive delays provided in the B-delay circuits. Should the desired B delay be an increment of 10, the B-continuous delay circuit is not used and the B10 output becomes the B-timing pulse. Thus the final B delay has a stability directly controlled by the 100-kc timing signal with a minimum number of intervening circuits which might degrade timing accuracy.

The phantastron delays of the B-delay circuit are controlled by d-c voltages applied through panel-mounted potentiometers. Four additional sets of potentiometers are also mounted on the front panel, behind a door labeled PRESET B DELAYS, and connected to a switch which selects one of the five sets of controls. These controls permit adjustment of the B1000, B100, and B10 delays to provide a number of different coding delays. Only one B-CONTINUOUS DELAY control is provided because the same continuous delay setting will always be used in combination with all of the preset delay changes. By means of the PRESET B DELAY SELECTOR switch any one set of potentiometers may be connected to control the delay. Thus five different sets of B-delay adjustments may be preset for rapid selection so that coding delay may be instantly switched to any of five values.

(3) TRANSMITTER TRIGGER GENERATOR. —The pulse which actually triggers the loran transmitter is generated by a thyratron circuit in the time delay unit. This thyratron is triggered by either the A- or B-timing pulse, depending on whether the timer is used at a master or a slave station. The thyratron produces a pulse shape which is suitable for triggering the transmitter; the instant of triggering is determined by the A- or B-timing pulse.

(4) BLANKING PULSE GENERATOR. — Concurrently with the generation of the transmitter trigger pulse, a blanking pulse is generated to paralyze the remote channel of the radio receiver. This pulse starts ahead of the local transmitter trigger pulse and continues for 500 microseconds beyond the transmitter trigger, during which time the local signal is transmitted.

The blanking pulse is applied to electronic switch circuits, both in the receiver and in the associated switchgear, so that the remote channel, which is adjusted to amplify the weak remote signal, is completely inoperative during transmission of the strong local signal. This allows the local and remote pulse amplitudes to be equalized.

(5) SCOPE TRIGGER GENERATOR.—The A- and B-timing pulses are mixed together and fed to a pulse forming circuit to generate the fast scope triggers. The resulting trigger pulses are used to initiate the fast scope sweeps and to time gate circuits in the electrical synchronizer. Thus a fast scope trace is started by each timing pulse and there are two fast scope traces for each full cycle of the square wave.

(6) BLINK CIRCUIT.—A blink circuit is provided to modify either the A or B delay so that the local delay may be periodically increased by 1,000 microseconds to transmit special information. It is used primarily to warn navigators not to use the signal because of timing errors. The circuit consists of a motor driven cam and microswitch arrangement, a relay, and a dual potentiometer arrangement which may be connected to the A1000 or B1000 delay phantastron to modify the delay.

In operation the motor drives the cam to turn the switch on and off periodically to control the blink cycle. The duration of the blink cycle is one second (at a power line frequency of 60 cycles). The ratio of blink to no-blink time is adjustable from 30 to 70 percent. Thus the relay is switched on and off to modify the delay circuit and shift the time position of the local signal. The increase of delay is accomplished by means of a BLINK ADJUST control. This dual potentiometer is connected to the A1000 or B1000 delay control potentiometer, through contacts of a STATION SELECTOR MASTER SLAVE switch, to modify the local delay. One or the other of the dual potentiometer sections is shorted out by the cyclic operation of the blink relay so that blink or no-blink delay results. Thus the local signal is made to jump back and forth from its normal time position to one 1,000 microseconds late. This cyclic displacement is used to signal that synchronization difficulties prevail. Provision is also made to interchange the blink shift of the A and B delay for check of the OFF-SYNC ALARM system. Also, facilities are provided to operate the blink relay from an external key.

(7) TEST SIGNAL CIRCUITS.—A test signal circuit is provided in the time delay unit to pick up significant waveforms and deliver them to the test oscilloscope for observation. These circuits are selected by a TEST SIGNAL switch and delivered to the oscilloscope via a cathode follower. Selected circuits are the A1000 push-up output, the B1000 push-up output, the B100 push-up output, the B10 push-up output, the TRANS TRIGGER, and the BLANKING pulse.

e. RADIO RECEIVER TYPE R–564/FPN–30.—The radio receiver provides means for delivering r-f and detected video pulses to the other units of the timer. Primarily this unit receives the local and remote loran signals and makes them available for presentation on the timer oscilloscopes. The receiver also differentiates the detected video signal to obtain the first and second derivatives. Derivative signals are used in the electrical synchronizer and in the synchronization indicator oscilloscopes for pulse matching.

The receiver is a high gain TRF unit. The use of a tuned radio-frequency receiver at these loran frequencies is a novel feature which permits the eventuality of cycle matching. Because the receiver does not employ a local oscillator the phase relationship between the pulse envelope and the r-f carrier is preserved and the individual r-f cycles may be used for phase comparison of local and remote signals. The r-f cycles provide a more sensitive indication of phase relationships. This indication is useful when the r-f cycles are harmonically generated from the same 100-kc signal which times the loran signal.

Another feature not usually employed in receiver design is the use of pretuned plug-in coils to control the receiver frequency. Separate sets of hermetically sealed coils are supplied for each of the five loran frequencies so that the receiver may be set up as a fixed tuned receiver for any operating frequency. This feature provides maximum operating stability and eliminates any need for adjustment of the receiver tuned circuits during the life of the receiver.

The receiver is equipped with two rejection traps. Each of these traps may be adjusted to tune out one particular interfering frequency over the range of loran frequencies. The traps may both be tuned to the same frequency, to provide maximum rejection, or to two separate frequencies.

The receiver has two input channels, one for the local signal, the other for the remote signal. The local channel is provided with a variable gain control so that the amplitudes of the received signals may be exactly equalized. Refer to figure 2–26.

(1) INPUT CIRCUIT.—The loran receiver amplifies the signals radiated by both the local and the remote transmitters. Since the local transmitting antenna is generally, at most, a few hundred feet from the receiving antenna and the remote transmitter is usually several hundred miles away, the difference in signal amplitudes at the receiving antenna terminal is tremendous. This difference is equalized, without introducing delay distortion, by the receiver input circuit and the electronic switch units of Loran Switching Group AN/FPA–2.

The receiver input channel for local signals consists of a resistive attenuator which includes two fixed 20-db pads and a potentiometer with an attenuation range of about 40 db. An additional attenuator pad, mounted on the back of the receiver and connected in series with the local channel input, provides attenuation of 0 to 60 db in 20-db steps. The remote channel is an approximately unity gain amplifier which is biased to cutoff by the blanking pulse generated in the time delay unit during the time of transmission of the local signal. This unity gain channel is called the electronic switch. Both channels employ identical tuned circuit inputs to attenuate off-frequency signals and thus prevent cross modulation in the electronic switch stage.

The remote signal is picked up by the antenna and passed through the remote channel of one of the electronic switch units of the switching equipment to the electronic switch in the receiver. Because no blanking signal exists at the time of transmission of the remote signal, it passes through the remote channel without attenuation. A portion of the remote signal passes through the resistive attenuators of the local channel; attenuation is so great that this portion is of negligible consequence.

The local signal passes through resistive attenuators, in one of the electronic switch units of the loran switching equipment and in the receiver, and is thus reduced in amplitude to a level equal to that of the remote signal. The levels of the two signals are made equal by adjustment of the attenuation. Any minor change in this adjustment, as may be required from time to time, is made by means of the continuously variable LOCAL GAIN control mounted on the receiver front panel. The local signal cannot pass through the remote channel because, at the time of transmission of the local signal, the remote channel is cut off by the blanking pulse. Thus the local signal can only pass through the attenuated local channel and the remote signal is passed through the remote channel.

The electronic switch and the resistive attenuators in the receiver are extensions of corresponding circuits in the switching equipment. They are provided to insure greater isolation of the two signals and so permit an additional range of adjustment for equalizing signal levels. The presence of the continuously variable

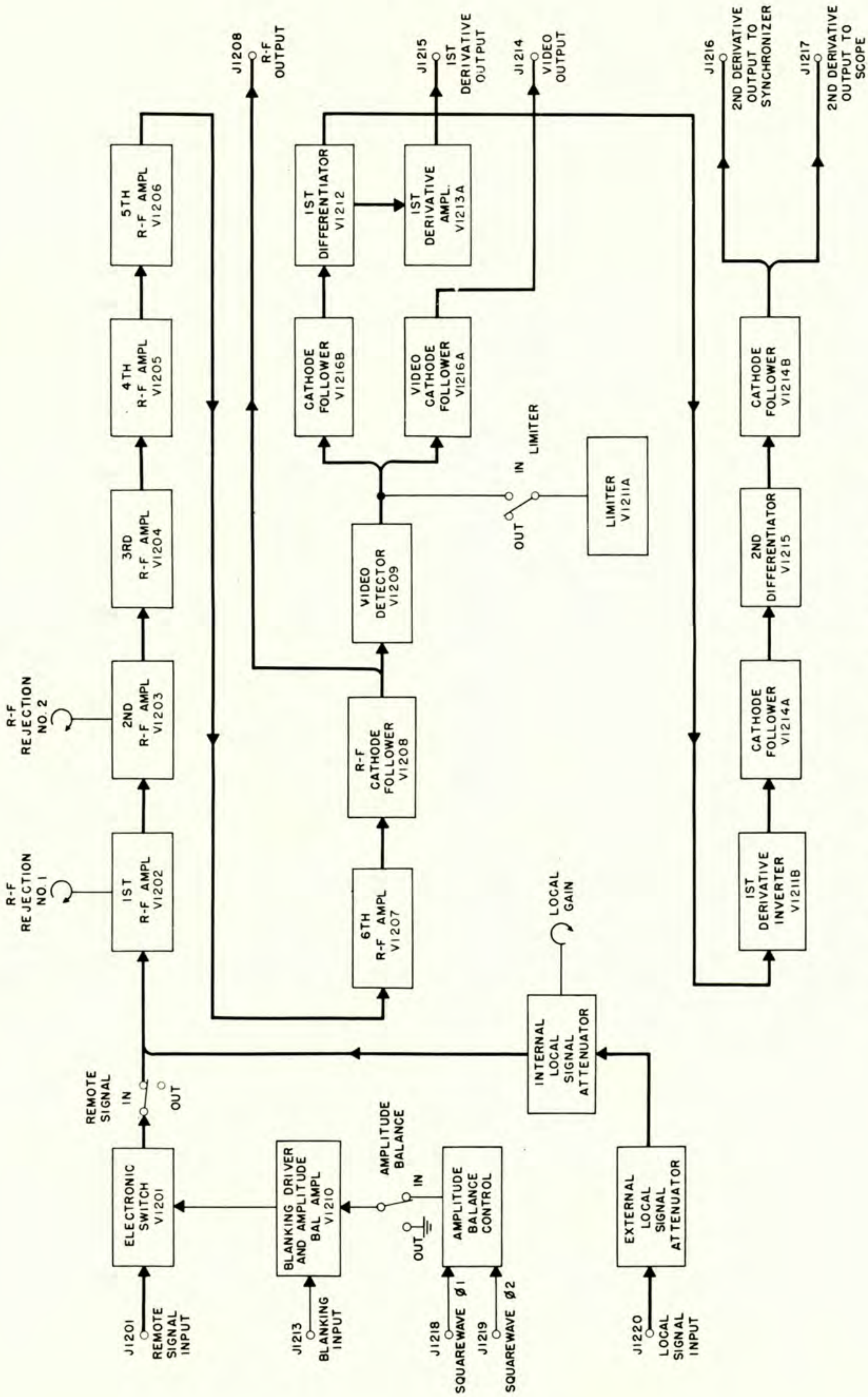


Figure 2–26. Radio Receiver Type R–564/FPN–30, Block Diagram

LOCAL GAIN control on the receiver unit allows the operator to conveniently make an exact adjustment of the local signal amplitude.

The equalized outputs of the local and remote channels are combined and delivered to the radio-frequency amplifiers of the receiver.

(2) AMPLITUDE BALANCE ADJUSTMENT.—An arrangement is provided in the receiver which permits special use of the timer to monitor a loran pair. For such use the timer is operated as a highly accurate receiver indicator and may or may not be used in conjunction with the loran switchgear required at a transmitting station. The amplitude balance adjustment permits the gain of the remote channel to be different for the two loran half-cycles so that two monitored signals of different amplitudes may be equalized. The arrangement uses square-wave voltage, applied through an AMPLITUDE BALANCE control, to bias the electronic switch for decreased gain during the half-cycle of the stronger signal. The gain during the half-cycle of the weaker signal is unchanged. In such service the amplitude balance voltage is only made large enough to reduce the gain of the electronic switch; the circuit is never disabled by the blanking pulse in the manner used for service at a transmitting station. An AMPLITUDE BALANCE IN-OUT switch permits removal of amplitude balance bias at a normal transmitting station.

(3) R-F AMPLIFIERS.—Six stages of r-f amplification provide the required gain and bandwidth. The first three stages are sharply tuned to the operating frequency by means of plug-in coils. The last three stages are broad-banded to cover the five-channel tuning range of the receiver. The sixth stage uses a tube with larger power capability than the first five stages to provide a large amplitude output signal. The r-f rejection traps are incorporated in the plate circuits of the first two r-f amplifiers. R-f gain control is provided by a variable grid bias applied to the first three stages through COARSE GAIN and FINE GAIN potentiometers.

(4) R-F CATHODE FOLLOWER. — The radio-frequency output of the sixth r-f amplifier is fed through a cathode follower to an output jack. The jack makes the undetected radio-frequency signal available for presentation on one of the timer oscilloscopes. This signal is known as the r-f signal.

(5) DETECTOR.—The r-f signal is taken from the output of the r-f cathode follower and rectified and filtered by a diode detector stage to remove r-f components. The resulting signal is the video signal. The video signal is applied to two separate circuits; one is via a cathode follower to an output jack connecting to the synchronization indicator, the other is via a cathode follower to a derivative generator circuit in the receiver. A PHONE jack in the output of this cathode follower permits listening to the detected signal to aid identification of interfering signals. A limiter circuit may be connected across the detector output to limit noise peaks.

(6) VIDEO LIMITER.—The video limiter stage restricts the peak amplitude of the detector output signal. This peak limiting reduces the amplitude of large noise bursts to a level comparable to the video signal peak amplitude to prevent overloading of other timer circuits. The amplitude at which limiting takes place is regulated by means of a LIMITER ADJ potentiometer. A LIMITER IN-OUT switch permits the limiter to be disconnected if desired.

(7) DERIVATIVE GENERATOR.—The derivative generator employs two consecutive differentiator stages to produce the first and second derivatives of the video pulse. The derivatives are new waveforms which contain voltage points bearing significant time relationships to portions of the video signal. These voltage points are employed in the electrical synchronizer to mark specific timing conditions for control of synchronization and for operation of automatic alarms. These uses will be discussed in detail under paragraph 3 *g* covering the electrical synchronizer. The second derivative of the video signal is also made available for visual observation on the synchronization indicator unit. Under some conditions this waveform may be more convenient for pulse matching than the video signal.

A discussion of the operation of a differentiator circuit to obtain a new waveform and the nature of the derivative waveforms generated in the receiver will help the reader to understand the significant relationships between the video signal and its derivatives.

The theory of differentiation may be better understood by considering first a simple differentiating network, figure 2–27, and a square-wave pulse. The differentiator, in its simplest form, consists of a small capacitor, C, in series with a relatively low resistance, R. Differentiation is the process of deriving a new waveform from an existing waveform; the instantaneous amplitude of the new waveform is proportional to the rate of change (slope) of the original waveform. In this circuit the differentiation occurs because the current through C is proportional to the rate of change of the applied voltage. If a square wave having a finite (4-microsecond) rise time (figure 2–28) is passed through this network, the following detailed analysis of the leading edge may be made. In the period from 0 to 2 microseconds the square-wave slope is zero and unchanging. No current can flow through C and there is no voltage drop (IR) across R; the amplitude of the

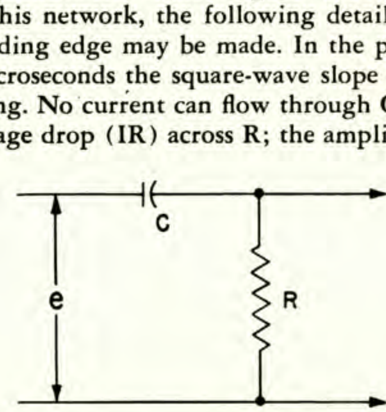


Figure 2–27. Simple Differentiating Network

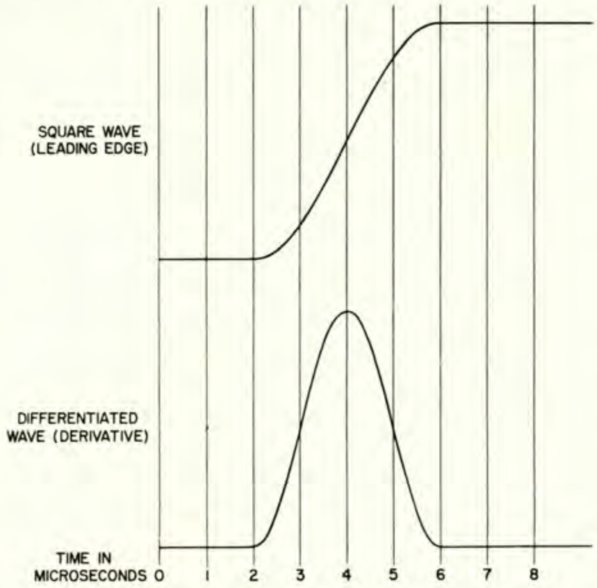


Figure 2–28. Differentiation of the Leading Edge of a Square Wave Having a Finite Rise Time

differentiated wave is therefore zero. In the period from 2 to 4 microseconds the amplitude of the square wave rises at a continuously increasing rate. As the slope increases, so also does the current through C increase.* The output voltage of the differentiating network, appearing across R, therefore increases accordingly. At 4 microseconds the rate of change shifts from an increasing to a decreasing rate; at this point the differentiated wave reaches maximum amplitude and starts to decline. The decline continues until the end of the period 4 to 6 microseconds, when the square wave reaches a second point of constant rate of change (zero slope) and the differentiated wave returns to zero amplitude. In the drawing the differentiated wave has been shown at approximately the same amplitude as the square wave for clarity. Actually, the amplitude of the differentiated wave would depend on the relative values of C and R. The steeper the slope of the applied waveform, the higher the current through C and the larger the voltage across R. Because R is very small, as compared with the impedance of C, the current through R and C is determined primarily by C; R is made large enough so that some voltage drop (IR) will appear across it as the useful output of the differentiating network. It is necessary that the current be determined by C to obtain the faithful differentiation shown in figure 2–28.

* This change of current through C occurs because the instantaneous impedance of the capacitor decreases as the slope of the waveform increases. The effect may be compared with the change of impedance of a capacitor with change in frequency of a sine wave. As the frequency of the sine wave is increased, the rate of change of the sine wave increases and the impedance of the capacitor decreases. A capacitor behaves the same way to a nonsinusoidal wave even though the impedance cannot be explained in the same manner.

In the first differentiator the applied voltage (e) (refer to figure 2–27) is the video signal. Refer to figure 2–29, Derivation of Derivatives. Note that the video signal sits on a flat base line (zero rate of change) and that the forward amplitude rises at a continually increasing rate (increasing rate of change) until the point marked A. Note that at the time this is happening the first derivative rises in accordance with the increasing rate of change of the video signal. At the instant the video signal reaches maximum rate of change, at point A, the first derivative attains maximum voltage. Beyond point A the rate of change of the video signal decreases (as shown by the more gradual slope) and the corresponding voltage of the first derivative decreases accordingly. The first derivative reaches the base line when the video signal reaches its maximum amplitude (zero slope). The second half of the video signal (trailing slope) is similar to the first half and therefore the two halves of the first derivative are similar except that as the trailing slope of the video signal is a declining slope the corresponding portion of the first derivative is negative. It may be seen from the foregoing that by virtue of the change of the current in the capacitor with change in the slope of the video signal a new waveform, having a positive and a negative peak, has been produced which precisely corresponds, in time, with the video signal. It may also be seen, from figure 2–29, that the second derivative contains a point, marked B, which exactly corresponds in time with the point marked A. This exact time relationship results because at the point of inflection of the video signal (A) the rate of change is maximum. This point marks the positive peak of the first derivative. The positive peak of the first derivative is a point of zero slope—that is, zero rate of change—and therefore the corresponding point on the second derivative is the zero voltage point marked B. Thus point B exacrly corresponds in time to point A, and point B is a zero voltage point regardless of the amplitude of the video signal.

The second differentiator is provided to change the first derivative to the second derivative. The theory of operation behind this change is the same as that for the first differentiator and the reader may use the same type of analysis to derive the second derivative from the first derivative.

The circuit arrangement for obtaining the derivatives is shown in the block diagram, figure 2–26. A cathode follower provides a low impedance driving source to the first differentiator to insure that the current through the differentiating network is primarily determined by the impedance of the differentiating capacitor. The differentiated output is applied to an output jack via a cathode follower and also to an inverter stage to invert the phase of the first derivative signal. The phase inversion is required to provide proper deflection polarity for visual observation of the second derivative on the synchronization indicator. The inverter output drives a cathode follower to provide a low impedance source for the second differentiator. The second derivative is taken from the second differentiator, via a cathode follower, and applied to an output jack for delivery to the electrical synchronizer and to the synchronization indicator.

f. SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30.—The synchronization indicator unit graphically displays the received loran signals to permit comparison of their time difference with the reference delay. The reference delay is preset into the presentations of the synchronization indicator oscilloscopes so that the comparison may be readily made. The unit incorporates three oscilloscopes. The SLOW SCOPE is used to display the complete loran cycle and thus show coarse time relationships. The VIDEO SCOPE is used to display expanded portions of the SLOW SCOPE presentation to show fine time relationships. The SLOW SCOPE and VIDEO SCOPE presentations were discussed in paragraphs 2 *c* (4) and 2 *c* (5) above. A third oscilloscope, not previously discussed, is the RF SCOPE. The RF SCOPE is used for the display of carrier frequency cycles of the loran signal; this presentation is primarily useful for pulse matching under noisy conditions.

The advantage of the r-f presentation over the video presentation under noisy conditions is freedom from "base line bounce". Detected noise components change the average d-c voltage in the detector output circuit to shift the video base line up and down with noise. This shift makes the video presentation bounce up and down, making pulse matching difficult. Because the r-f presentation is an a-c presentation, noise will not shift the base line. Thus the envelopes of the signals presented on the RF SCOPE are better suited to pulse matching under noisy reception conditions. Because the r-f presentation permits detailed observation of individual carrier cycles, it also permits the eventuality of cycle matching.

The fast sweep speeds of the RF SCOPE provide the additional advantage of higher resolution than that available on the VIDEO SCOPE because of the greater time expansion afforded. This permits attainment of a closer measurement of reference delay.

A summary of the presentations of the three different scopes is given in table 2–3. Note that the VIDEO SCOPE is used to present either the video pulse or the second derivative. The function of this scope, using either waveform, is essentially the same.

To permit setting up and maintaining the reference delay, markers are made available for display on all three oscilloscopes. Only 1000's are shown on the relatively long time base of the SLOW SCOPE since this scope is used only to provide a rough measurement. All markers (1000's, 100's, 10's, and 1's) are shown on the shorter time base of the VIDEO SCOPE and only 10's and 1's are shown on the very short time base of the RF SCOPE. Thus a means for precise measurement of

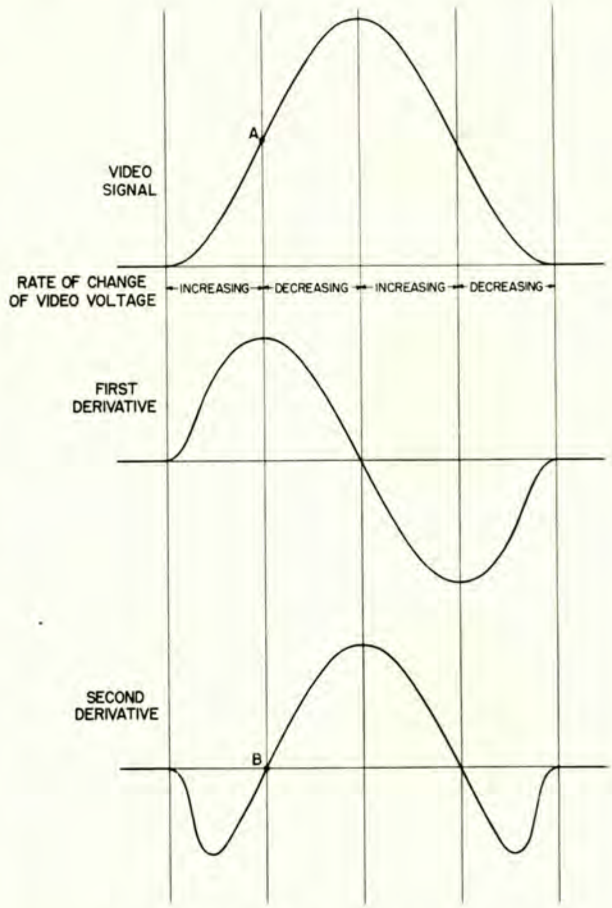


Figure 2–29. Derivation of Derivatives, Idealized Waveforms

reference delay is provided. Once reference delay has been established the markers in the VIDEO SCOPE and the RF SCOPE are switched off and time difference is compared with reference delay by superposition of the local and remote signals on the VIDEO SCOPE and the RF SCOPE.

In addition to the three scopes the synchronization indicator unit incorporates SYNC ERROR and OFF-SYNC alarm indicators which are connected to alarm circuits in the electrical synchronizer. These lamps will glow if synchronization abnormalities exist. A buzzer is mounted in the synchronization indicator chassis and connected to the alarm circuits so that, if a BUZZER switch is turned ON, the buzzer will sound whenever a lamp glows. The BUZZER switch is located on the synchronization indicator control panel.

A BLINK SELECTOR switch is provided on the control panel for operation of the blink circuit in the sync control unit. This switch may be set to MANUAL for continuous local blink, may be set to OFF, or may be set to AUTO to initiate local blink simultaneously with operation of either of the electrical synchronizer alarm circuits.

TABLE 2–3. SCOPE PRESENTATIONS

PRESENTATION	WAVEFORMS SHOWN	USE
 SLOW SCOPE	Master half-cycle, pedestal, 1000's, and master video signal. Slave half-cycle, pedestal, 1000's, and slave video signal.	Coarse measurement of reference delay and coarse location of remote signal.
 VIDEO SCOPE (video)	Time span contained in above master pedestal, master video signal. Time span contained in above slave pedestal, master video signal. Optional presentation of mixed 1000's, 100's, 10's and 1's.	Fine measurement of reference delay and fine matching of local and remote signals for comparison of reference delay with time difference.
 VIDEO SCOPE (derivative)	Same as video presentation above except 2nd derivatives of master and slave signals.	Same as video.
 RF SCOPE	Time span following A-pedestal trigger, master r-f signal. Time span following B-pedestal trigger, slave r-f signal. Optional presentation of mixed 10's and 1's.	Same as VIDEO SCOPE; permits ultra fine measurement of reference delay. Useful for pulse match under noisy conditions. Permits matching individual r-f cycles.

Note: The VIDEO SCOPE and RF SCOPE traces are shown separated for clarity of illustration. The normal presentation is with the traces superposed.

The physical arrangement of the timer permits the operator to conveniently monitor synchronization by observation of the three scopes and to make any adjustments which may be required to correct synchronization while watching the scopes. A DRIFT switch, located on the synchronization indicator unit control panel, permits the operator to move the remote signal to the left or right in coarse or medium steps as required. This switch operates the previously described left-right circuits of the frequency divider to change the pulse recurrence rate. Fine adjustment of the position of the remote signal as required at a slave station may be effected by operation of the PHASE control on the front panel of the synchronization control unit. This unit is located to the right of the synchronization indicator unit. By use of the DRIFT and PHASE controls the slave operator may make the time difference of the local and remote signals equal the reference delay, as indicated by superposition of the two signals on the synchronization indicator unit oscilloscopes.

Signal paths and functions of synchronization indicator circuits are described below and illustrated in the block diagram, figure 2–30.

(1) SLOW SCOPE.—The SLOW SCOPE employs a three-inch cathode-ray tube to display the complete loran cycle. A rectangular viewing mask distinguishes this scope from the other two. The sweep circuits for the SLOW SCOPE provide one horizontal trace for each loran half-cycle. Alternate traces are separated,

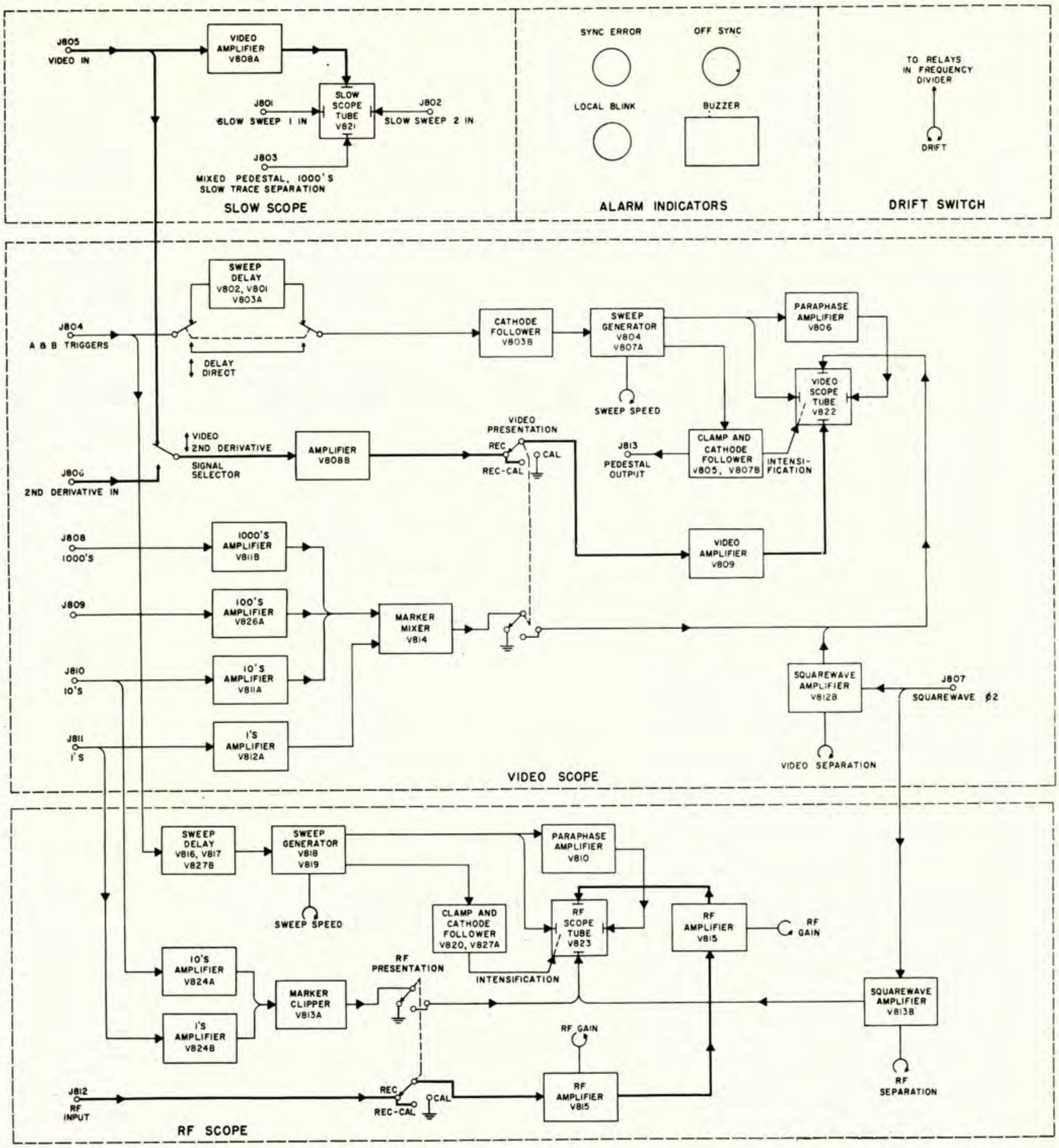


Figure 2–30. Synchronization Indicator Type IP–238/FPN–30, Block Diagram

one above the other, so that the master half-cycle is always presented on top and the slave half-cycle is shown below, by application of a trace separation voltage. Rectangular pulses are applied to the traces to form the A and B pedestals and relate the SLOW SCOPE presentation to the VIDEO SCOPE presentation. Markers are also applied to the traces to permit coarse time measurement in 1,000-microsecond increments. The markers may be removed by turning a SLOW MARKERS switch, in the frequency divider, OFF. The deflection voltages for all these functions are generated in the frequency divider and the circuit arrangement is covered under that unit.

The video output of the receiver is amplified by an amplifier stage in the synchronization indicator and applied to the upper deflection plate of the cathode-ray tube with the correct polarity to cause upward deflection of the cathode-ray beam in direct proportion to the amplitude of the video signal. Thus the SLOW SCOPE relates the occurrence time of the local and remote signals to the two loran half-cycles, to the 1,000-microsecond markers, and to the display periods of the VIDEO SCOPE.

(2) VIDEO SCOPE. — The VIDEO SCOPE displays two traces, either superposed or one above the other, to present an expanded picture of the information contained within the A and B pedestals shown on the SLOW SCOPE. This time expansion is accomplished by using the A- and B-timing pulses to initiate a fast, short duration sweep. The time expansion is further advanced by the provision of a delay circuit to permit starting the sweep some time after the A and B pulses.

The video sweep period is variable, by means of a VIDEO SWEEP SPEED control, over a range of 75 to 1,300 microseconds; thus only a portion of the signal may be made to occupy the trace length or, at the other extreme of the range, the pulse may occupy but a small fraction of the total trace. In addition to this control over the portion of the pulse viewed, the VIDEO SCOPE incorporates the sweep delay circuit which makes it possible to delay the start of the trace from 10 to 100 microseconds. Thus the sweep may be delayed until such time as a desired portion of the waveform occurs so that this desired section may be made to appear at the start of the visible trace. By using the sweep delay in conjunction with a fast sweep speed, only a portion of the pulse may be observed. The sweep delay feature is of little value with slower sweeps because the maximum available delay is only a small fraction of the maximum sweep period.

The same circuit which generates the sawtooth sweep voltage also generates a rectangular waveform which is the SLOW SCOPE pedestal. Thus the pedestal has the same duration as the sweep, and the pedestal therefore marks the VIDEO SCOPE sweep period on the SLOW SCOPE trace. Because one VIDEO SCOPE sweep is generated each half-cycle, there are two pedestals displayed on the SLOW SCOPE.

The VIDEO SCOPE circuits are shown in the block diagram, figure 2–30. The A and B triggers, as mixed together and supplied by the time delay unit, are used to trigger the sweep generator. These triggers may be applied to a sweep delay circuit and thus delayed to make the sweep start after the triggers. A switch ganged to the SWEEP DELAY control allows the delay to be switched out when the control is turned to the extreme clockwise position. Thus the minimum delay inherent in the sweep delay circuit may be eliminated. The sweep generator produces a sawtooth deflection voltage and, concurrently, a rectangular pulse. The deflection voltage is applied directly to one horizontal deflection plate and, via a paraphase amplifier, to the other horizontal deflection plate to produce push-pull sweep. The rectangular pulse is applied, via a cathode follower, to a PEDESTAL OUTPUT jack. This output is mixed with other SLOW SCOPE deflection voltages in the frequency divider and forms the pedestal. The cathode follower output voltage is also applied to the cathode-ray tube as an intensifying pulse. For most of the loran cycle the VIDEO SCOPE cathode-ray tube is negatively biased to blank out the beam. The intensifying pulse is a positive voltage of sufficient amplitude to make the beam visible so that the trace is brightened only during sweep periods and extinguished when the beam is stationary.

Markers and the loran signal are applied to opposite vertical deflection plates of the tube. Either the video pulse or its second derivative is applied to a wide-band video amplifier to develop the vertical signal deflection voltage applied to the lower vertical deflection plate. The 1000's, 100's, and 10's markers are mixed together in a push-up circuit which makes them all coincident. Two push-up stages feed broadened 1000's and broadened 100's to a 10-microsecond push-up stage to mix the three signals together and produce a chain of markers in which the 100's are taller than the 10's and the 1000's are taller than the 100's. This chain is fed to a mixer circuit which clips the broadened push-up voltages from the base line and mixes in pulses from a 1's amplifier to produce a comb of markers containing 1's, 10's, 100's, and 1000's in progressively increasing amplitude. The markers are coincident because the broadened 100's and 1000's are used to push-up the next 10-microsecond markers; thus the 100's push-up the next ten to increase the amplitude of the 10 by a fixed amount and the 1000's push-up a next 10, which is also coincident with a 100, by a larger amount. The 1's are made coincident with the 10's by adjustment of the phase of the 1's in the frequency divider. The markers may be applied to the upper deflection plate of the scope by means of a VIDEO PRESENTATION switch. The three positions of this switch permit scope presentation of either the received signal, the received signal and the markers, or the markers alone.

Trace separation voltage is also applied to the upper deflection plate. This voltage is developed by controlled amplification of ϕ 2 of the square wave so that different d-c voltages are applied to the deflection plate, for alternate halves of the loran cycle, to deflect the trace to alternate vertical positions, thus producing two parallel traces. The trace separation may be reduced to zero, for trace superposition, by reducing the amplification of the square wave to zero.

The VIDEO SCOPE thus displays the local and remote signals in an expanded presentation which enables convenient and detailed measurement of the time relationships of the two signals.

(3) RF SCOPE.—The RF SCOPE employs the same general arrangement as the VIDEO SCOPE. A completely duplicate sweep circuit is provided to enable separate sweep speed and sweep delay adjustment. The sweep delay circuit may not be switched out; therefore there is an inherent minimum delay of 10 micro-

seconds. The range of sweep delay is 10 to 100 microseconds and sweep speed may be varied over a 5- to 100-microsecond range. Thus any 5-microsecond or wider pulse segment, or the complete r-f presentation, may be observed. The presentation is therefore useful for matching individual r-f cycles or for matching pulse envelopes.

Only 1's and 10's are presented on the RF SCOPE. These markers are applied through push-up stages and a mixer circuit to produce a comb of 1's and 10's in the same way as for the VIDEO SCOPE. An RF PRESENTATION switch provides the same arrangement for marker and signal display as used in the VIDEO SCOPE.

The r-f amplifier employed in this scope differs from the video amplifier employed in the VIDEO SCOPE in that the r-f amplifier employs tuned circuits which must be adjusted for the carrier frequency of the received signal. One other circuit difference in the RF SCOPE exists. The sweep generator does not supply a pedestal voltage to any other scope to relate the RF SCOPE presentation to the loran cycle. It is not necessary to show this relationship because the start of the r-f presentation is controlled by the A- and B-timing pulses and the received signals occur immediately after these pulses. Thus, so long as a reasonable pulse match is established on the VIDEO SCOPE, the r-f signal must appear on the RF SCOPE. The amplitude of the r-f pulse is adjustable by means of an RF GAIN control located on the front panel.

g. ELECTRICAL SYNCHRONIZER TYPE SN–117/FPN–30. — The electrical synchronizer performs distinctly different primary functions at a master and slave station. When used at a slave station, the output signals of the synchronizer automatically control the time difference between a signal received from a master station and a signal generated locally by the slave station. This control maintains synchronization. When used at a master station the output signals of the synchronizer are used solely to provide indications of the degree of synchronization accuracy. Controlling synchronization at a slave station and indicating synchronization error at a master station are the primary functions of the synchronizer. The synchronizer also incorporates two alarm circuits which are used, in the same manner at both master and slave station, to alert the operator to synchronization difficulties.

The two alarm circuits are the sync error alarm and the off sync alarm. The sync error alarm circuit responds when synchronization error exceeds one microsecond. The off-sync alarm circuit responds to four different conditions, all equivalent to a large error. These conditions, to be defined later in this paragraph, are remote blink, lost signal, wrong zero, and large sync error. Alarm indications are given by the SYNC ERROR and OFF SYNC indicator lights and an alarm buzzer which are located on the synchronization indicator unit. The buzzer will be sounded simultaneously with either or both lights. If desired the buzzer may be silenced by means of a switch located on the front panel of the synchronization indicator unit. Facilities are provided for connecting an additional set of lights and a buzzer at a remote point which may be located up to two miles from the timer. The alarm circuits are arranged so that they initiate automatic blinking, when either circuit operates, provided the BLINK SELECTOR switch is set to AUTO.

Before any discussion of synchronizer theory can be attempted, it is necessary to define synchronizer delay. Refer to figure 2–31 and note that the leading edge of the video signal, which is used for visual synchronization throughout the loran system, contains a point marked A. Point A was previously related (paragraph 3 *e* (7)) to a point marked B on the second derivative. Point A and consequently point B occur at a fixed time after the A- or B-timing pulse. Because this time is the same for master and slave signals, when synchronization is correct, the two observation points (point B on master and slave signals), are separated by the reference delay. (Reference delay was defined in paragraphs 2 *a* (2) and 2 *c* at the beginning of Section 2.)

The synchronizer uses electrical gate circuits to measure synchronization of the master and slave signals. The gates developed by the synchronizer are timed by the A- and B-timing pulses and are arranged to occur at the time of the first zero cross-over point (point B) of the second derivative of each signal when synchronization is correct. The A-timing pulse initiates a delayed pulse which is the master gate and the B-

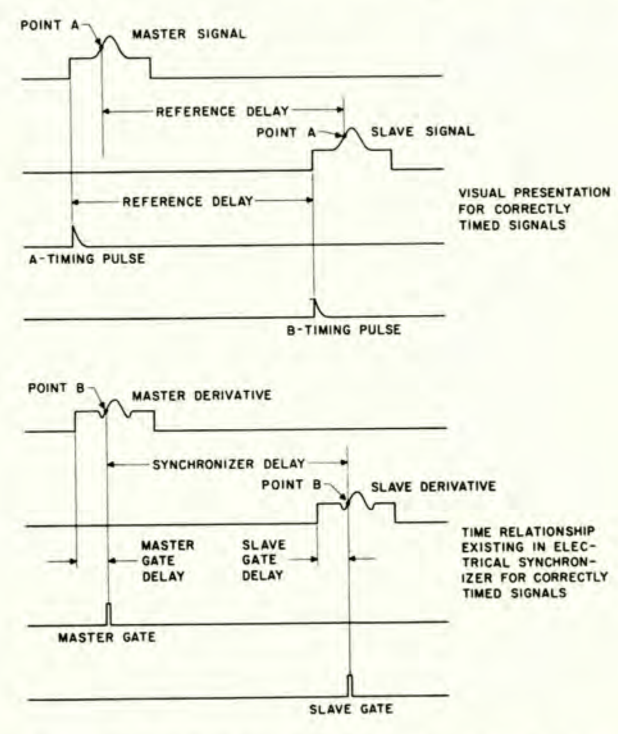


Figure 2–31. Relationship of Synchronizer Delay to Reference Delay

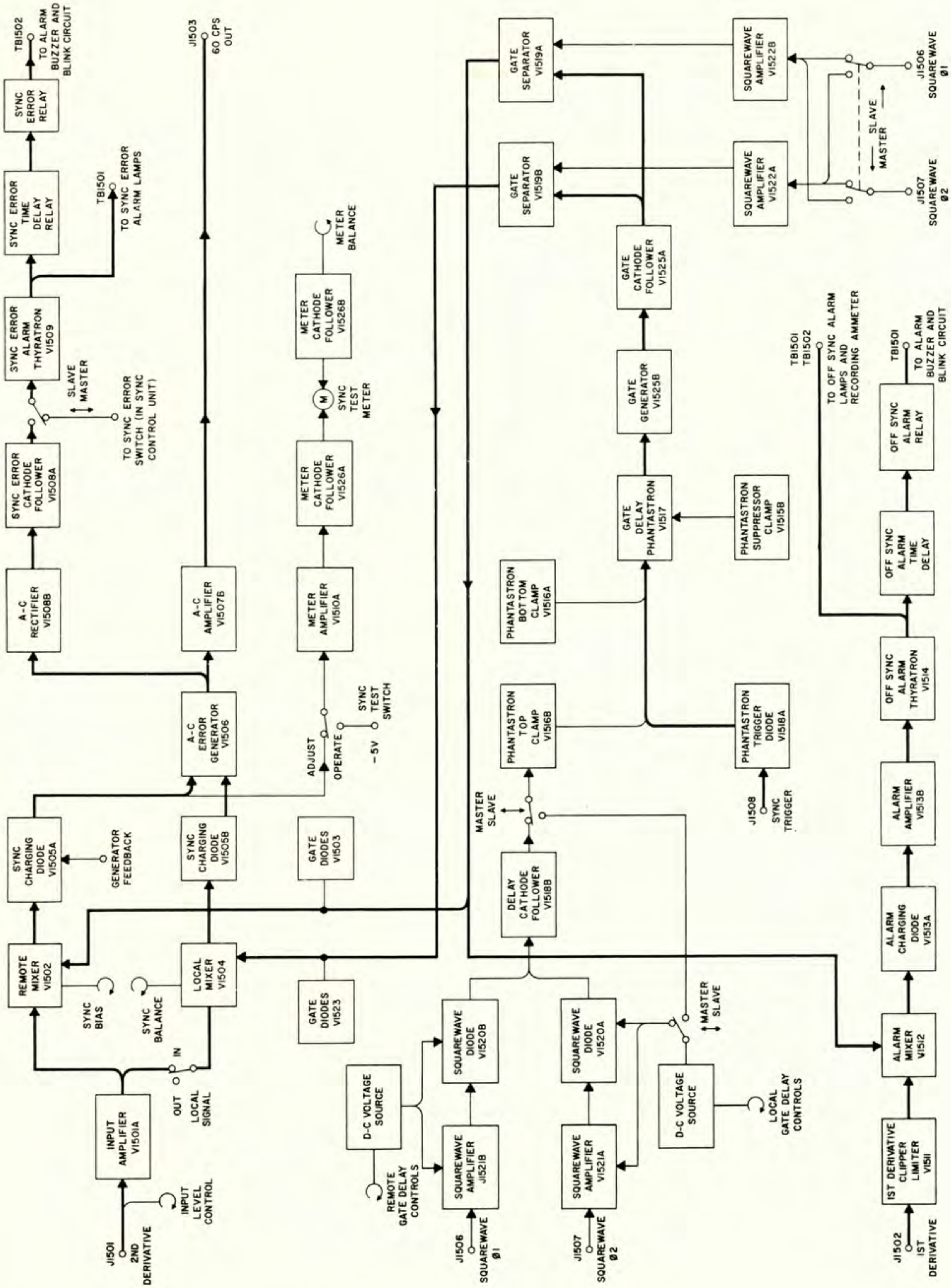


Figure 2–32. Electrical Synchronizer Type SN–117/FPN–30, Block Diagram

timing pulse initiates a delayed pulse which is the slave gate. The interval between the master gate and the slave gate is defined as the synchronizer delay. At a slave station the synchronizer delay will always equal the reference delay. At a master station the synchronizer delay will only equal the reference delay when there is no error. When there is a synchronization error, the two will not be equal. This is because the synchronizer delay is always adjusted to equal the time difference between master and slave signals.

The gates are used to electronically sample the amplitudes of the derivatives of the video pulse. The amplitude of each sampled waveform, for the duration of the gate, provides information which is used to generate a 60-cycle error voltage.

The synchronizer controls synchronization at a slave station by shifting the phase of the 100-kc signal to correct the error (i.e., to make the time difference equal to the synchronizer delay); the combination of the electrical synchronizer and the synchronization control unit form an automatic error correction system which continuously corrects any error. At a master station the sync control motor is connected to a gate delay control to make the synchronizer delay equal the time difference, even though the time difference may not be correct. Any change in synchronizer delay will appear on the PHASE dial as ± so many microseconds of error. Thus, if the slave fails to maintain synchronization, for any reason, the time difference will not be correct; however, the master station will change its synchronizer delay to match the error in time difference, thus creating an artificial condition of synchronization within the master timer. The difference between true synchronization and the artificial synchronization required to match the error will be shown on the PHASE dial at the master station. In addition to the rotational displacement which may be seen on the PHASE dial, an electrical signal is also produced to operate the pen of the recording milliammeter and make a permanent record of the error.

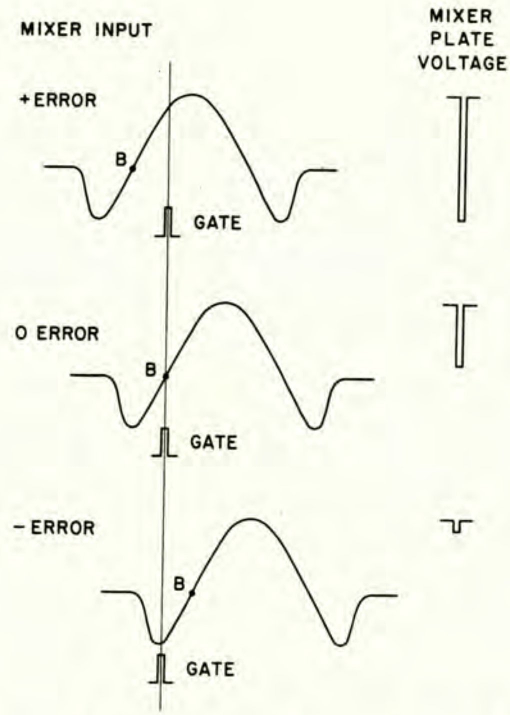


Figure 2–34. Changes in Output of Remote Sync Charging Diode with Change in Error

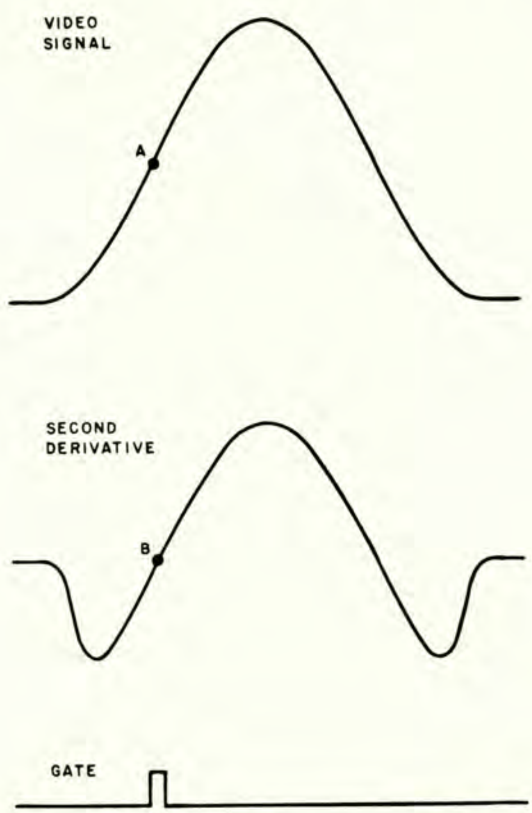


Figure 2–33. Video Pulse and Second Derivative

(1) SYNC MEASURING CIRCUITS.—The sync measuring circuits are shown in the upper row on the block diagram, figure 2–32. They generate the 60-cycle error voltage which operates the sync control motor and the sync error alarm. The arrangement of the motor operating circuits is identical for master and slave operation.

The sync measuring circuits operate by sampling the first zero cross-over point (point B) of the master and slave derivative signals. Refer to figure 2–33. These points correspond in time to the approximate middle of the leading edge of the video pulse and are always zero voltage points regardless of the video pulse amplitude. The second derivatives are taken from the receiver and applied to the input amplifier of the receiver via J1501 and DERIVATIVE INPUT LEVEL control R1501. The output of this amplifier branches into two paths and is fed to the remote mixer and the local mixer. The remote mixer is gated open for a brief

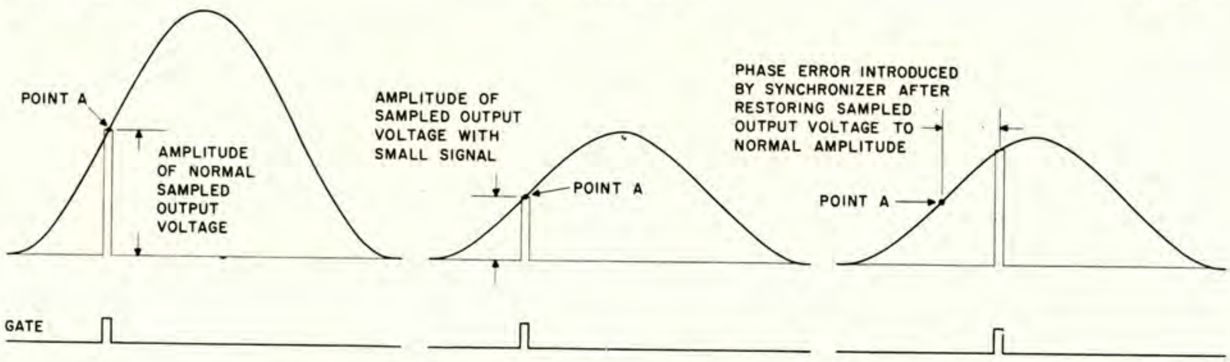


Figure 2–35. Video Synchronization, Explanatory Diagram

period, during which point B on the remote pulse should occur, and the local mixer is gated open for the corresponding period, during which point B on the local pulse occurs. Assuming normal operation, the mixers will generate alternate pulses of equal amplitude, as a result of the gating process. These pulses are applied to capacitors via the sync charging diodes. The voltages stored in these capacitors, under these conditions, will be equal. With equal d-c voltages applied to the input of the a-c error generator, the generator will be balanced, and no a-c voltage will be produced. Under zero error conditions, the output of the a-c error generator will be zero volts.

Should the remote pulse occur ahead of the time it should arrive (+ error), the output of the remote mixer will be greater than the output of the local mixer, and the d-c voltages applied to the a-c error generator will no longer be equal. Refer to figure 2–34. The resulting unbalance will produce a 60-cps error voltage. For small errors the magnitude of this voltage will be directly proportional to the amount of error.

Should the remote pulse occur later than normal (— error), the output of the remote mixer will be less than that of the local mixer, and the d-c voltages applied to the a-c error generator will unbalance the generator in the opposite direction. The resulting 60-cps voltage will be 180° out of phase with respect to the voltage produced with a + error. Thus the error voltage will be of one phase or the other and will drive the sync control motor in the direction required to correct the error.

The 60-cps output of the a-c error generator is applied, via the a-c amplifier stage, to the motor amplifier in the sync control unit.

The sync measuring circuit operates using the second derivative of the video pulse. Theoretically it is possible to obtain the same result using the video pulse, thus eliminating the need to generate the derivative. The derivative has a distinct practical advantage, however, because the operating point (point B) used for derivative synchronization is a zero voltage point.

Refer to figure 2–35 for an explanation of the difficulty encountered with video synchronization. A video synchronization system gates the video pulse, in the same manner as for derivative synchronization, to obtain an output voltage which varies in amplitude as sampling takes place to the right or to the left of the operation point (point A). Thus a specific output voltage will be obtained when the remote pulse is sampled at point A and a larger or smaller voltage will result if a sync error exists. The servo system is arranged to maintain the normal sampled voltage by appropriate phase shift of the gate with respect to the video pulse. If the video pulse changes in amplitude, as will happen under poor reception conditions, the gated output voltage resulting from the sampling of point A will be less than normal, and the video synchronizer will "see" an error. The synchronizer will falsely correct for this error by changing the gate-video pulse phase relationship to restore the gated voltage to normal amplitude. The result will be a synchronization error arising from the change of amplitude of the video signal. Thus, because signal amplitude under practical operating conditions is not always constant, video synchronization cannot be a dependable means for maintaining normal operation.

Derivative operation is free from susceptibility to signal amplitude variations because the zero voltage operating point cannot change in amplitude despite large changes of signal amplitude. Even if the signal fades to zero amplitude the derivative synchronizer will "see" normal sampled voltage and will not introduce an error by falsely attempting to correct synchronization. So long as the received signal approaches a reasonable amplitude for part of the time, the synchronizer will be able to detect an error and adjust for correct synchronization. In practice it may be expected that, even during very bad reception periods, the signal will "break through", and thus be useful for synchronizer operation, frequently enough to overcome all normal drift of the 100-kc timing signal. Because the synchronizer responds in the same manner to no signal as it does to a normal signal, the system has the additional advantage of greater freedom from noise. Large bursts saturate the limiter circuit in the receiver to produce rectangular output pulses to the derivative generator. Unless the leading edge of the rectangular output pulse happens to coincide with the normal operating point, the differentiated output voltage, at the time of gating, will be zero, and the synchronizer will thus not be influenced by noise. The practical advantage of this system, for noise immunity, is extremely great.

(2) GATE CIRCUITS. — The gate circuits are shown in the middle row in the block diagram, figure 2–32. They produce a very narrow gate, timed by the A- and B-timing pulses, and properly delayed to occur when point B on the master and slave derivatives should arrive. For slave operation the slave gate delay and the master gate delay are equal. For master operation the local gate will be delayed a constant amount; however, the remote gate delay will be varied as required to make the synchronizer delay equal the time difference of the received signals. Thus, with synchronization, the two gate delays will be equal and the synchronizer delay will equal the reference delay and the time difference. When synchronization fails—that is, when the slave station fails to correct an error in time difference—the master station synchronizer will vary gate delay. The remote gate delay, at the master station, will be changed to make the synchronizer delay equal the observed (incorrect) time difference. If an error is not corrected by the slave station the remote gate, in the master station synchronizer, will not coincide with point B of the slave derivative and the outputs of the remote and local mixers will unbalance, causing the sync control motor to rotate. Rotation of the sync control motor will operate the PHASE dial and the precision potentiometer connected to the PHASE dial shaft. One section of this potentiometer controls the remote gate delay, so that, for example, if the observed error is + 3 microseconds, the gate delay will be decreased 3 microseconds to make the synchronizer delay equal the observed time difference.

When the synchronizer delay equals the observed time difference, the outputs of the local and remote mixers will be restored to equality, and the motor will stop. The system is so arranged that PHASE dial calibration indicates the amount the gate has been shifted to restore equality. The current flowing through the second section of the potentiometer will be such that the pen of the recording milliammeter will indicate the + 3-microsecond error.

Two different circuit arrangements, selected by a STATION SELECTOR MASTER SLAVE switch, enable the gate circuits to provide identical delay for local and remote gates or independently controlled delay for both gates. For slave service, delay of both gates is controlled by the d-c voltage applied through the COARSE LOCAL DELAY and FINE LOCAL DELAY potentiometers. This voltage is applied to the gate delay phantastron via a clamping diode. The width of the rectangular output pulse generated by the phantastron, as controlled by the d-c voltage, determines the gate delay. This pulse is initiated by a trigger pulse timed by the A- or B-timing pulses. Thus gate delay is the time from either the A- or B-timing pulse to the trailing edge of the phantastron output pulse. The trailing edge of this pulse is differentiated and applied to the gate generator. This stage provides a positive rectangular pulse corresponding in time to the trailing edge of the phantastron output pulse. Both local and remote gate pulses are applied to a gate separator via a cathode follower. The gate separator is a two-channel electronic switching arrangement which feeds one gate to each mixer in the sync measuring circuit. Switching is controlled by the square waves, applied through a square-wave amplifier. The amplified square waves are applied to two diodes so that each diode conducts for only one half-cycle. Therefore, the local gate can pass through only one diode and the remote gate can pass through only the other diode.

One mixer, designated local, samples the master pulse at a master station and the slave pulse at a slave station. The functions of the other mixer, designated remote, are just the opposite. The pulse to be sampled by each mixer is controlled by application of the appropriate (master or slave) gate to each mixer. Channeling of the gates is changed by reversing phase of the square wave by means of the STATION SELECTOR MASTER-SLAVE switch.

To permit independent delays for each of the gates, for master operation, two separate d-c voltage sources are provided. One source is obtained by adjustment of the FINE LOCAL DELAY and COARSE LOCAL DELAY controls. The other source is obtained by adjustment of the gate delay section of the potentiometer connected to the PHASE dial and other associated remote delay controls.

The two voltages are combined in a circuit which enables one source to control the local gate delay during the master half-cycle and the other source to control the remote gate delay during the slave half-cycle. Combination of the two d-c voltages is achieved by applying these voltages to two diodes whose output connections are connected in parallel. The two square waves are fed to amplifiers and are then applied to the diodes so that each diode alternately conducts for one half-cycle. Therefore, the d-c voltage from each source is delivered, alternately, to the delay phantastron via a cathode follower. Thus at a master station the remote gate delay and the local gate delay are each adjusted by independent controls. Initially, local and remote gate delays are adjusted to be equal for correct synchronization. Thereafter, the remote gate delay is controlled, by variation of the PHASE dial, to adjust synchronizer delay.

(3) METER CIRCUIT.—A SYNC TEST meter is provided to facilitate adjustment of the sync measuring circuits. This circuit allows the output voltage of the remote mixer charging diode to be adjusted to a fixed reference level under no-signal conditions. The adjustment is necessary because at any fixed setting the output

voltage is a function of the repetition rate. The meter is initially set to read zero with a reference voltage of approximately −5 volts applied to a d-c amplifier and cathode follower arrangement connected to one of the meter terminals. A METER TEST switch is used to connect the amplifier input to the reference voltage to permit adjusting the d-c voltage applied to a second cathode follower, connected to the other meter terminal, by means of a METER BALANCE control. The charging diode output voltage is adjusted by switching the meter amplifier input to the charging diode output circuit and adjusting the SYNC BIAS control to make the meter read zero. With the meter amplifier connected to the charging diode output, zero reading of the meter indicates that the output of the charging diode is equal to the reference voltage.

(4) SYNC ERROR ALARM. — The sync error alarm responds to synchronization errors greater than 1 microsecond. With slave operation this circuit operates using the same 60-cycle error voltage that is applied to the sync control motor. This voltage is fed from the output of the a-c error generator to the a-c rectifier in the sync error alarm circuit. The rectified voltage is a d-c voltage proportional to sync error. This voltage is applied, via a cathode follower, to the sync error alarm thyratron. The thyratron is normally adjusted, by means of the SYNC ERROR SENSITIVITY control, to respond to a d-c voltage corresponding to a 1-microsecond error. The thyratron operates a group of relays arranged so that sync error alarm circuits are operated only after the sync error has persisted for a specific, adjustable, length of time (five seconds to one minute). The SYNC ERROR lamp lights immediately, however. Because this arrangement makes the circuit unresponsive to sync errors which do not persist for a long enough period to complete the time delay sequence, false alarms occurring because of noisy reception will be greatly minimized.

At a master station the motor, operated by the 60-cycle error voltage, drives the PHASE dial to a rest position indicative of the amount of slave station error. At this rest position the 60-cycle error voltage is zero and is thus not available to operate the sync error alarm circuit. For master operation, therefore, the thyratron is connected to a cam-operated switch in the sync control unit. This switch closes to apply operating voltage to the thyratron whenever the PHASE dial indicates an error greater than a preset value of ± 1 microsecond to ± 3 microseconds. Application of this voltage fires the thyratron to operate relays in the same way as for slave operation.

The detailed sequence of alarm indications is as follows. Almost immediately after the thyratron fires, the SYNC ERROR lamp lights, and an associated chronograph pen, on the recording ammeter, is deflected to record the error. After the preset time delay interval, power is applied to the buzzer in the sync control unit, through a BUZZER switch, and local blink is initiated through a BLINK switch.

(5) OFF-SYNC ALARM. — The off-sync alarm system provides a warning indication for practically every operational abnormality beyond the control capability of the slave station sync control motor. The system responds to remote blinking, a large sync error, a lost signal, and operation on a wrong zero of the second derivative.

Remote blinking occurs when the remote station shifts the time position of its signal back and forth in 1,000-microsecond steps to indicate operating difficulty.

A large sync error is an error which is so large that the gate will not coincide with any part of the second derivative.

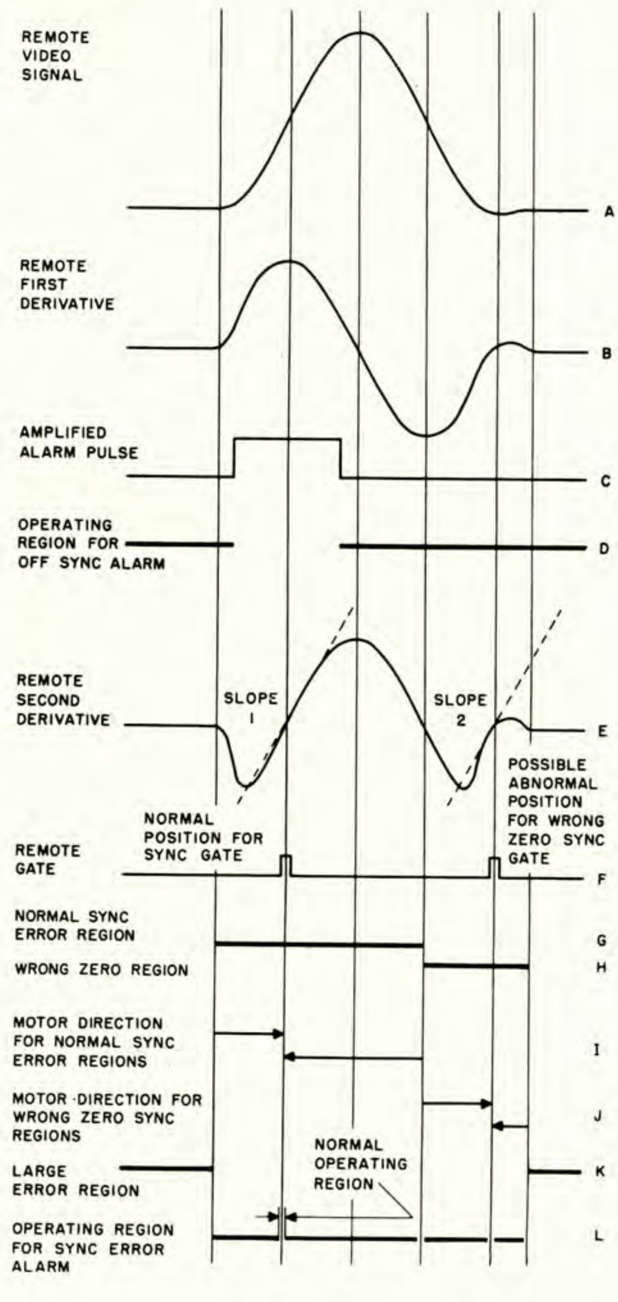


Figure 2–36. Time Relationships for Synchronizer Error and Alarm Circuits

A lost signal occurs when the remote signal is not received by the local synchronizer. This will happen, for example, if there is a transmitter failure at the remote station.

A wrong zero condition is illustrated in figure 2–36. Normally the synchronizer operates along the positive slope of the second derivative (slope 1). There is, under some conditions, a second positive slope, containing negative and positive voltages, over which the synchronizer can also operate (slope 2). This second slope occurs because, in some cases, the shape of the trailing edge of the detected video pulse is such that an additional zero cross-over point is present at the end of the derivative. It is possible for the synchronizer to operate falsely on this slope to maintain synchronization on the wrong zero. This will be understood after consideration of the motor direction for negative and positive amplitudes of the derivative pulse at the instant of sampling. The direction of motor operation, for the various conditions of improper synchronization, is shown in I and J of figure 2–36.

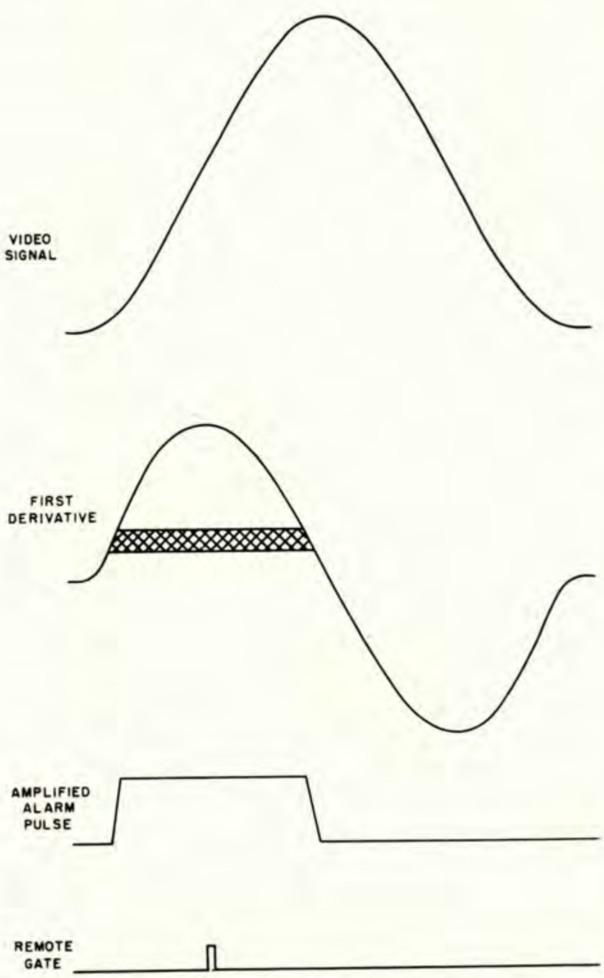


Figure 2–37. Portion of First Derivative Used in Alarm Circuit

The off-sync alarm circuit responds to all four of the above conditions to signal the operator that attention is needed. Refer to figure 2–37 and observe that the positive half of the first derivative corresponds in time to the leading edge of the video pulse. As described above, all the off-sync conditions to which this alarm circuit responds involve lack of coincidence of the remote gate with the leading edge of the video pulse for either a part of the time, as is the case for remote blink, or all of the time, as is the case for the other three conditions. By clipping, limiting, and amplifying the positive half of the first derivative, an amplified alarm pulse is obtained which corresponds in time to the operating region in which the off-sync alarm is not required to operate. Coincidence, or lack of coincidence, of the amplified alarm pulse and the remote gate, therefore, is information which operates the alarm circuit. The amplified alarm pulse is sampled, in an amplitude mixer by the remote gate, in a circuit arrangement which responds to coincidence or lack of coincidence of the remote gate with the leading edge of the video pulse.

The off-sync alarm circuit path is shown in the lower row on the block diagram, figure 2–32. The first derivative, from the receiver, is applied to the first derivative clipper-limiter via J1502. Because the clipper-limiter is responsive only to signal voltage levels within the shaded area of figure 2–27, the signal is clipped and limited to form the rectangular shaped amplified alarm pulse. This drawing shows an idealized alarm pulse. The actual pulse is somewhat delayed, as explained later in paragraph 4 *g* (5). This pulse is applied to one input of an alarm mixer. The remote gate is applied to the other input so that the gated output will be a negative pulse of large amplitude when the gate and the negative pulse coincide. The mixer output pulses are applied, via a charging diode, to a charging capacitor. A large negative voltage will be stored in the charging capacitor when the alarm pulse and gate coincide. Small mixer output pulses, and thus low charging capacitor voltage, will result if the alarm pulse and gate do not coincide. For remote blink the mixer output pulses will be large for one part of the blink cycle and small for the remainder of the cycle. The average voltage in the charging capacitor will be an intermediate value, less than the high value obtained with normal coincidence. For the three other conditions the value will be even lower. This difference, therefore, indicates either normal or off-sync operation. The charging capacitor voltage is amplified by a d-c amplifier and applied to an off-sync alarm

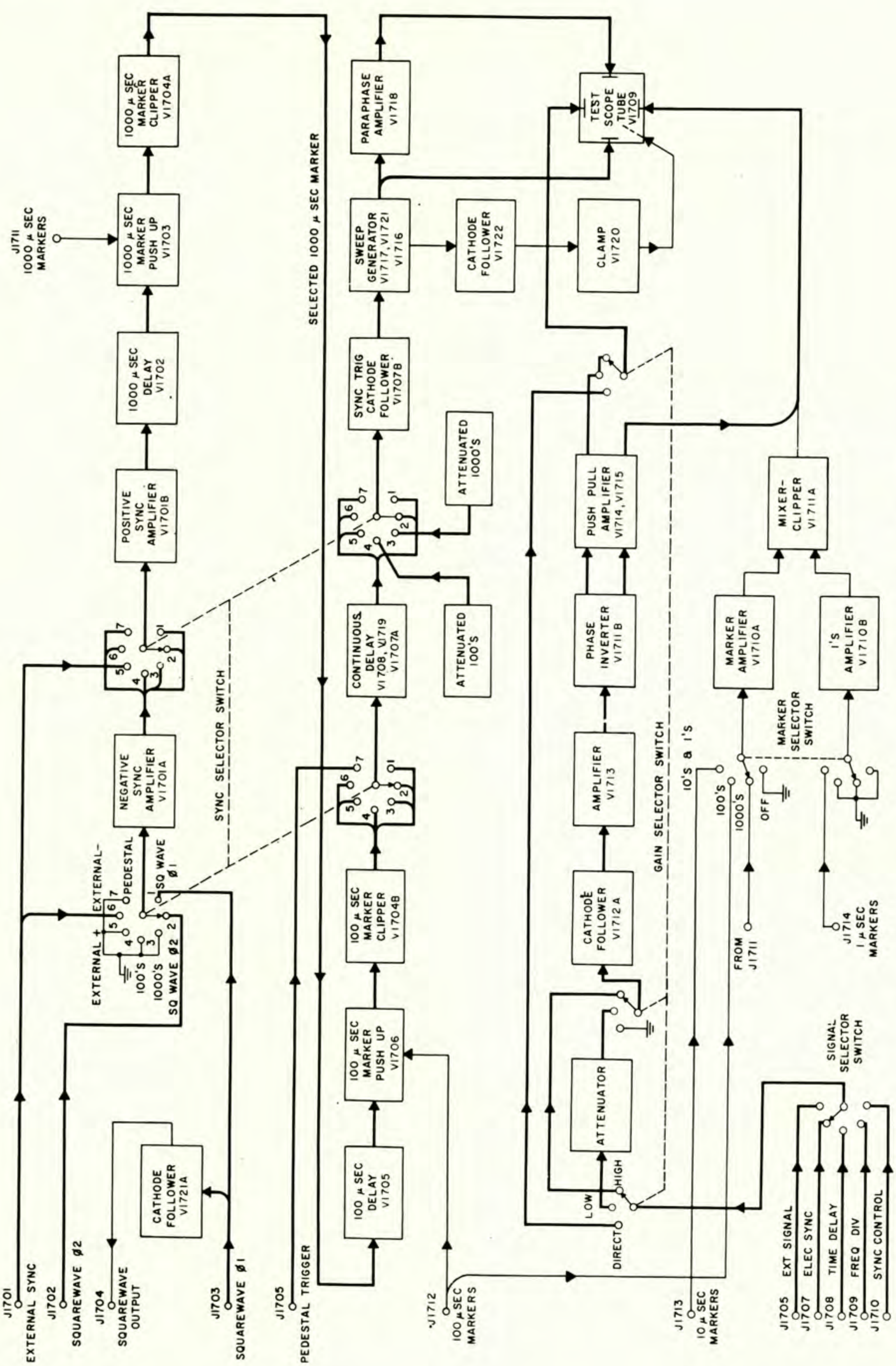


Figure 2–38. Test Oscilloscope Type OS–39/FPN–30, Block Diagram

thyratron. The thyratron is adjusted, by means of an OFF SYNC SENSITIVITY potentiometer, so that the thyratron will not conduct upon application of the normal d-c voltage obtained with correct synchronization but will conduct with the amplitude of the reduced voltages obtained for the different conditions. The thyratron conduction current operates a relay system to actuate the alarms. This relay system operates in the same way as the system in the sync error circuit which was previously discussed, except for the following: (*a*) The recording ammeter is operated by an indirect path (through the blink circuit) instead of directly by the alarm. The blink circuit is operated directly by the alarm when the BLINK SELECTOR is set to AUTO. (*b*) The time delay for the off sync alarm circuit is adjustable over a range of 15 seconds to 5 minutes.

(6) TEST SIGNALS.—A test signal circuit is provided in the synchronizer to pick up significant waveforms and deliver them to the test oscilloscope for observation. These circuits are selected by a TEST SIGNAL switch and delivered to the oscilloscope via a cathode follower. Selected circuits are the 60-cps AC ERROR output voltage, the 2ND DER, the LOCAL GATE, the REMOTE GATE, the MIXED GATES, the 1ST DER, and the LIMITED 1ST DER.

(7) NOVEL FEATURES. — Loran personnel familiar with operation of the Loran Timer, Navy Model UE–1, should familiarize themselves with certain novel features of the automatic synchronizing system in the FPN–30 timer which require different operating procedures from those used with the UE–1 timer. These features offer improved, more dependable, and more accurate operation. Operational and adjustment differences must be appreciated, however, so that the operator may discard those practices, formed by habit, which prevent derivation of maximum benefit from the new features.

It is not necessary to establish a precise manual match of the received signals, as seen on the VIDEO SCOPE, to set up the timer for automatic synchronization. In the UE–1 timer it was necessary to accurately establish synchronization manually before the gate delay could be properly adjusted. In the FPN–30 timer the gate delay circuit is accurately adjusted without reference to the remote signal. Only a coarse visual synchronization adjustment ($\pm$ 20 microseconds) need be established at a slave station before allowing the synchronizer to take over. Similarly, at a master station it is not necessary to determine that the slave has established accurate synchronization. The synchronizer may be adjusted without reference to the remote signal and will then indicate actual synchronization. This feature is particularly useful under noisy reception conditions.

The FPN–30 synchronizer operates using the time difference between the local and remote signals, whereas the UE–1 timer operates using the interval between the remote signal and a local trigger (the A- or B-timing pulse) occurring at the time of the remote signal. The advantage of the FPN–30 system is that it works directly from the received signals, whereas the UE–1 system assumed that the time from the local trigger to the gating point on the local pulse remains constant.

An incorrect gate delay setting in the UE–1 timer affects the UE–1 equivalent of synchronizer delay so that the synchronizer maintains a fixed error equal to the error in gate delay setting as established by the AUTO SYNC BAL control. With the double gate system employed in the FPN–30 timer, synchronization error caused by improper adjustment of the gate delay setting is tremendously reduced because both gates necessarily have the same error and therefore sample equal (even though not zero) amplitude points on the derivatives of local and remote signals (provided the signals are of equal amplitude and similar shape).

b. TEST OSCILLOSCOPE TYPE OS–39/FPN–30.—The test oscilloscope is provided to facilitate adjustment and test of all other timer circuits. It is an accessory unit with no direct operating function.

As a device for observation and study of the various waveforms generated by timer circuits, the test oscilloscope is provided with a wide-band signal amplifier, a versatile sweep circuit with a wide range of sweep speeds and sweep delay, and a marker mixer arrangement which permits the display of markers to permit accurate measurement of waveform time relationships.

The signal amplifier is a wide-band, low distortion channel, equipped with a frequency compensated attenuator network which permits observation of signals having a wide range of amplitudes.

The sweep circuit provides a one-shot triggered sweep which may be synchronized with a number of significant time points in the loran cycle. A delay circuit is provided which has the very wide range of 2,000 to 28,000 microseconds. This delay has less than 0.1-microsecond jitter. Sweep speed is variable over most of the range of 15 to 28,000 microseconds so that with the range of sweep speeds and delays available any desired portion of a waveform may be studied.

The marker circuit permits the display of 1000's, 100's or mixed 10's and 1's.

Refer to figure 2–38 for the block arrangement of the test scope.

(1) TEST SIGNAL PATH.—The test signal may be taken from any of several units by switch selection or it may be taken from an external source by means of a jack connection and flexible probe. The synchronization control unit, the frequency divider, the time delay unit, and the electrical synchronizer are each provided with a switch and cathode follower arrangement which picks up one of several significant signals and feeds it to the test scope SIGNAL SELECTOR switch. This switch, in turn, selects one of several units

or connects to the EXTERNAL SIGNAL jack on the front panel of the test scope. By means of a set of test cords any external signal, from points in the timer or from some other signal source, may be fed to the scope. Included in this set is a low capacity probe which permits waveform observation with a minimum of circuit loading. This probe has a 10:1 attenuation ratio.

The path of the test signal is through the SIGNAL SELECTOR switch to a three-position GAIN SELECTOR switch. The HIGH position feeds the signal to the input of the amplifier. The LOW position feeds the signal through a frequency compensated attenuator to provide a 20-decibel gain reduction. The DIRECT position feeds the signal directly to the upper vertical deflection plate of the cathode-ray tube. The first stage of the signal amplifier is a cathode follower which presents a high input impedance to the signal and also provides a low output impedance which permits the use of a relatively low resistance potentiometer as a SIGNAL GAIN control. This arrangement accommodates a wide range of input voltages and permits adjustment of the amplitude of the test scope presentation. The potentiometer output is fed to a voltage amplifier stage which drives a phase splitter. The resulting push-pull voltage is applied to a push-pull output stage to feed the upper and lower vertical deflection plates of the cathode-ray tube.

(2) SWEEP CIRCUIT. — The sweep circuit employs a phantastron sweep generator in the same arrangement used in the VIDEO SCOPE. A triggered sawtooth sweep voltage and a rectangular intensifying pulse are generated. Thus, in the absence of a sync trigger, the test scope beam is stationary and blanked out. For each trigger pulse applied one visible trace is generated. The output of the sweep generator is fed directly to one of the horizontal deflection plates and, via a paraphase amplifier, to the other horizontal deflection plate.

A SYNC SELECTOR control is provided to permit the sweep generator to be triggered by either phase of the square wave, by mixed A- and B-triggers (PEDESTAL), by 1,000- or 100-microsecond markers, or by an external signal. A delay circuit provides a wide range of delayed triggering from the square wave or from the external signal. A portion of the delay circuit is used to provide a limited range of delay for the mixed A- and B-pedestal triggers. No delay is available on the 1,000- or 100-microsecond positions of the switch.

Square wave ϕ 1 is applied through an input connector to a cathode follower. The output of this cathode follower is applied to a SQUAREWAVE OUTPUT jack on the test scope front panel to make the square wave available for test purposes. The input connector also feeds one contact of the SYNC SELECTOR switch to make the square wave available to trigger the delay circuit. Likewise square wave ϕ 2 is applied to this switch through an input connector. The external sync signal is fed to the SYNC SELECTOR switch via a front panel jack. One position (—) of this switch feeds negative sync signals to a negative sync amplifier, also employed for both phases of the square wave. The + switch position bypasses the negative sync amplifier to feed negative sync pulses directly to a positive sync amplifier. When used, the negative sync amplifier provides phase inversion to drive the positive sync amplifier. The negative sync stage also provides additional gain so that more sensitivity is provided for negative sync signals.

The output of the positive sync amplifier feeds a 1,000-microsecond and a 100-microsecond step-delay circuit which is very similar to the B-delay circuit; a 10-microsecond step-delay circuit is not used in the test scope, however, because the requirement for long time stability of this delay is not as stringent as it is in the B-delay circuit. The output of the 100-microsecond step-delay feeds a continuous delay circuit which has a range of approximately 150 microseconds, permitting the total delay to be set for any desired value. The output of the continuous delay circuit feeds a sync trigger cathode follower through contacts of the SYNC SELECTOR switch to trigger the sweep generator. The PEDESTAL position of the SYNC SELECTOR switch feeds the mixed A and B pedestal triggers into the continuous delay circuit to provide only a limited range of delay for this sync signal. The 1,000- and 100-microsecond markers are fed, through contacts of the SYNC SELECTOR switch without delay, to the sync trigger cathode follower.

As has been discussed above, the output of the test scope sweep generator is a push-pull horizontal deflection voltage which may be triggered from a number of sources. Delay circuits may be used with some of these sources to provide a wide range of sweep delay. This makes the test scope particularly suitable for observation of timer waveforms.

(3) MARKERS.—Either 1000's, 100's, or mixed 10's and 1's may be applied to the test scope presentation to permit time measurement of observed waveforms. A MARKER SELECTOR switch feeds the desired markers, or combination of markers, to marker push-ups and clipper stages. The 1000's and 100's are not mixed with any other markers and go through one of the push-ups and the clipper. The 10's and 1's go through the two push-up stages and are combined in the clipper in the same arrangement as used for the RF SCOPE. The clipper output feeds markers to the lower vertical deflection plate of the cathode-ray tube. The height of any markers selected by the MARKER SELECTOR switch may be controlled by a MARKER HEIGHT control. It may be noted that the SIGNAL GAIN control does not affect marker height and that the MARKER HEIGHT control does not affect signal gain. Thus markers may be introduced without degrading the waveform of the observed signal.

i. RECORDING AMMETER TYPE ME–84/FPN–30.—The recording ammeter is provided as a means for making a permanent record of the synchronization conditions of a loran pair. It will be recalled from the discussion of the operation of the synchronization control unit at a master station (paragraph 3 *b* (6) (*d*)) that the PHASE dial is used to indicate synchronization errors which result if the station fails to maintain synchronization. The range of this indication is limited by the ± 5-microsecond markings on the PHASE dial. Special circuits in the sync control unit make the recorder pen deflect in proportion to the motion of the PHASE dial and thus provide a permanent record of synchronization error.

The circuits which cause pen deflection are controlled by the potentiometer which is ganged to the PHASE dial. This arrangement provides a current whose amplitude is proportional to error and whose polarity depends on the direction of error. At a master station the zero error position of the PHASE dial produces zero output current and the pen rests at the center of the calibrated ammeter scale. A — error position of the PHASE dial produces current flow in one direction to deflect the pen to the left, and a + error position of the PHASE dial produces current in the opposite direction to deflect the pen to the right. The meter scale and the chart paper supplied with the meter are both calibrated in ± microseconds error; thus it is possible to read error directly on the meter scale and on the chart paper.

The permanent record is made by having the chart move at a slow and constant rate so that the excursions of the pen draw a graph of the minute-by-minute synchronization conditions. The graph is drawn on chart paper which is moved under the pen and stored on rollers. A choice of five chart speeds is available so that a proper compromise may be made between detailed presentation of information, at the faster speeds, and economy of paper, at the slower speeds. Chart speed may be changed by substituting sets of gears. Gears are supplied for speeds of 3/4, 1-1/2, 3, 6, and 12 inches per hour. The recommended chart speed is 3 inches per hour, and therefore the chart is calibrated with time markings, in accordance with the 24-hour clock, for that speed. When used at other speeds, this calibration does not apply. The chart is driven by a synchronous motor, and timing is based on a 60-cycle supply. Time markings are therefore incorrect for any other supply line frequency.

Chart speed may be multiplied by 60, to convert speed to inches per minute instead of inches per hour, by operation of a lever which is located on the right side of the chart drive frame. This fast speed may be found useful for special test applications.

Each roll of chart paper is 103 feet long so that at the recommended speed the chart will last for about 400 hours or just over 16 days. A writing door is provided on the front of the recorder to permit direct access to the chart so that manual notations may be made to supplement the automatically drawn graph.

In addition to the sync error recording arrangement, two chronograph pens, operating at the left and right edges of the chart, indicate that the local blink circuit is operated by either or both of the alarm circuits and that the off-sync alarm is operated. One of these pens operates along the left margin of the chart to indicate, by a 1/8-inch deflection to the left, the periods that the local blink circuit is actuated. The other pen operates along the right margin to indicate, by similar deflection to the right, the periods that the off-sync alarm is actuated. This indication is for all off-sync periods, as indicated by the lighting of the OFF SYNC lamp on the synchronization indicator panel, and is not subject to the time delay between the lighting of the lamp and the initiation of automatic blinking.

Two running time meters on the front panel of Recording Ammeter ME–84/FPN–30 are provided to indicate the total number of minutes each of the two chronograph pens have been actuated. It may be noted, in conjunction with this feature, that station switching operations are such that the recorder is always connected to the operating timer; thus the chart record is continuous even though different timers may be switched in and out of operation during the period of the record. Two recorders are supplied with the two timers comprising a loran rate; however, one of these meters is to be kept in continuous operation and the other is to be considered a spare. Should it be necessary to change meters the operating recorder must be removed and replaced by the spare. The spare meter may be connected, for test purposes, to J105 on the front panel of the synchronization control unit. This connection will permit operation of the chart drive motor and the center, error recording, pen; however, the two chronograph pens will not be connected.

In addition to the above described use of the meter at a master station, the meter will be found very useful at a slave station as an aid in detecting abrupt changes in the normal maintenance of synchronization. It has been found that, after the two oscillators at the master and slave station become stabilized, the PHASE dial at the slave station will generally oscillate back and forth at an extremely slow rate, with very little tendency to move in one predominant direction. The meter record made under these conditions will thus be a slowly moving line, oscillating back and forth in response to PHASE dial motion. The PHASE dial at the slave station does not stay at zero because the slave changes phase as required to maintain synchronization. Therefore, the line drawn on the meter chart will not necessarily stay on the zero error center line. The 1-microsecond chart calibrations will be accurate, however, so that the amount of oscillator drift, in any given period, may be measured. The PHASE dial may rotate to any position of its 360° range to maintain synchronization,

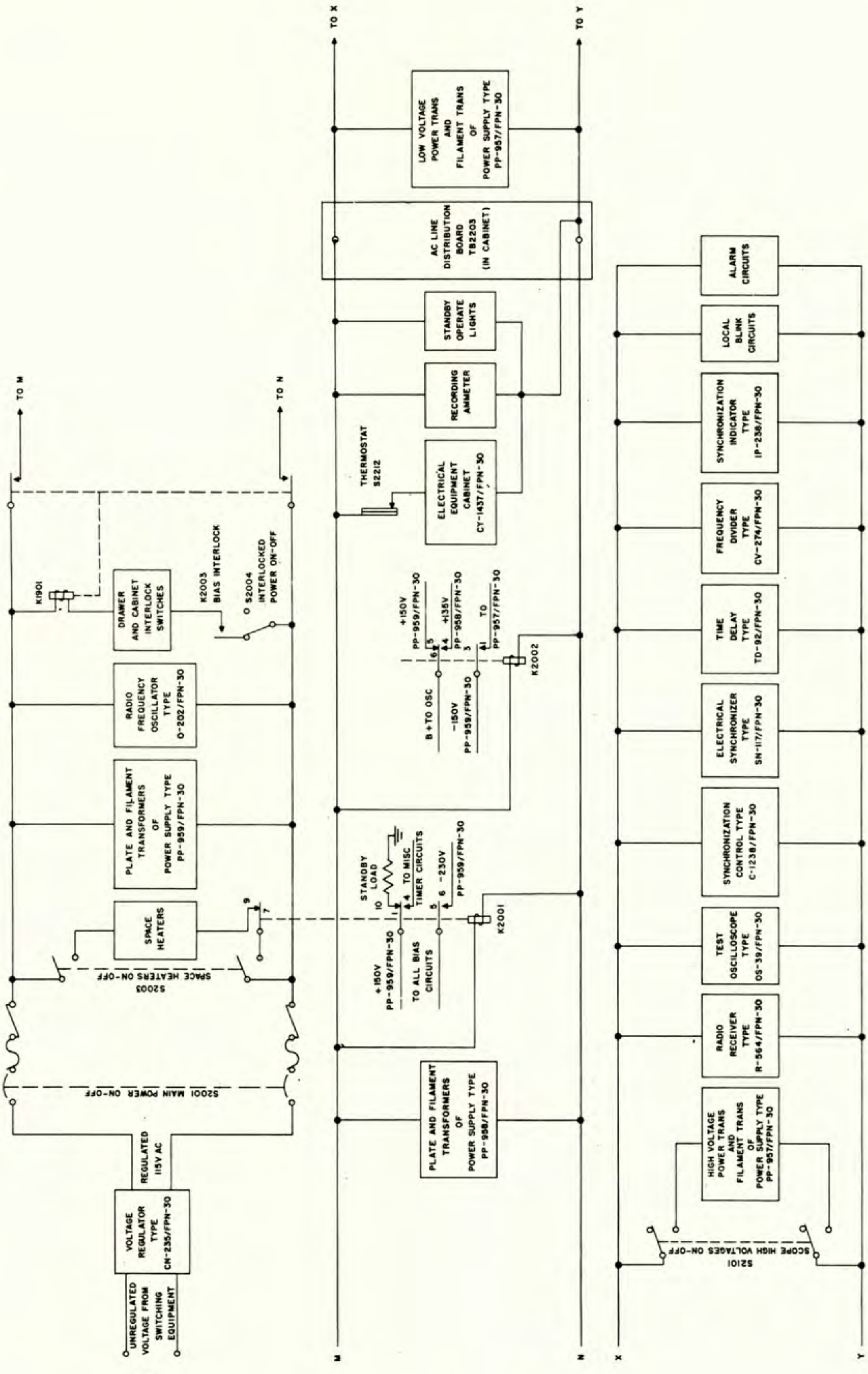


Figure 2–39. Block Diagram of A-c Power Distribution in Loran Timer Set

but, because the winding on the potentiometer is discontinuous, there will be a position where the arm of the potentiometer passes from one end of the winding through an open area to the other end of the winding. As the arm crosses the open area, current through the coil of the meter pen will be zero, and the pen will rest at the center of the chart. As the arm reaches the other end of the winding, the pen will be driven to the opposite side of the chart so that it may continue moving in the same direction as before, following the continuous rotation of the PHASE dial in the one direction.

Because the normal excursions of the PHASE dial are slow, the line normally drawn on the chart will be a smoothly wavering line except for random fluctuations caused by noise. Any abrupt changes of this line will indicate a synchronization disturbance which may require investigation.

j. POWER CONTROL CIRCUITS. — The power control circuits, treated here as a group, are physically distributed throughout the timer units and the timer cabinet. Sources of power are treated in the next paragraph under power supplies. Refer to figure 2–39 and 2–40.

Line voltage, regulated by Voltage Regulator Type CN–235/FPN–30, is applied to the timer input terminals. This voltage is controlled by a MAIN POWER circuit breaker located on Power Supply Type PP–959/FPN–30. The circuit breaker provides protection against current overloads exceeding 20 amperes. Power applied through this circuit breaker lights the MAIN POWER indicator lamp and provides power to Power Supply Type PP–959/FPN–30. This power supply, one of three, supplies d-c voltages of 150 volts and less. Power from this supply is used to keep Radio Frequency Oscillator Type O–202/FPN–30 in operation when power is removed from all other circuits; thus the oscillator need not be shut down and full operating stability may be maintained. All main power control switches and indicators are located on the front panel of Power Supply Type PP–959/FPN–30. A SCOPE HIGH VOLTAGES switch and indicator lamp are located on Power Supply Type PP–957/FPN–30.

An interlock system is provided to permit removal of power from all circuits except those required to maintain operation of the oscillator. This power may be removed, when working on any of the units, by operation of an INTERLOCKED POWER toggle switch. Interlocked power will also be removed if timer units are withdrawn from the cabinet, if the rear cabinet doors are opened, or if the lower control panel of Synchronization Indicator Type IP–238/FPN–30 is disassembled. Interlock switches are not provided for Power Supply Type PP–959/FPN–30 or Crystal Oscillator Type O–202/FPN–30 because power will still be applied to these units, even though the interlocked power is removed. In addition a-c power will still be present at a few isolated points in the timer when interlocked power is removed. The interlocked power circuit includes an arrangement whereby power is applied to the cabinet space heaters when the interlocked power is removed. This power to the space heaters is applied only if the SPACE HEATERS switch is turned ON and the interlocked power is off. Two indicator lamps are provided to show when power is applied to the INTERLOCKED POWER circuits and when power is applied to the SPACE HEATERS. A BATTLE SHORT switch by-passes the entire interlock circuit and facilitates unit adjustment without disabling any of the time power circuits.

The cabinet includes a thermostatically controlled blower arrangement and a pair of indicator lamps which are controlled by a stand-by operate circuit. The blower arrangement draws air through the cabinet, whenever the thermostat closes, to prevent excessive temperature rise. The thermostat is set to operate at 10°C. (50°F.) and remain closed until the temperature is reduced to —1°C. (30°F.). The indicator lamps show whether the timer is in OPERATE or STANDBY service. The OPERATE lamp glows if a relay, contained in the cabinet, is actuated by power applied from Loran Switching Group AN/FPA–2. The STANDBY lamp glows if the relay is not actuated. These lamps glow only if power is applied to the timer through all power control circuits including the INTERLOCKED POWER switch. Other relays in the stand-by-operate circuit connect the operating timer to the recording ammeter.

k. POWER SUPPLIES.—Three power supply units are provided in the timer. These units supply all required ac and dc. The d-c supplies are highly regulated by electronic stabilizing circuits. The three power supply units are identified as Power Supply Type PP–959/FPN–30, Power Supply Type PP–958/FPN–30, and Power Supply Type PP–957/FPN–30. Refer to figure 2–40.

(1) POWER SUPPLY TYPE PP–959/FPN–30.—Power Supply Type PP–959/FPN–30 includes all switches and indicator lamps, for the control of timer power, except the SCOPE HIGH VOLTAGES switch and indicator lamp. Power controls and indicators are discussed in paragraph 3 *j* above. In addition this unit incorporates a metering arrangement for measuring the d-c voltage output of all three power supply units.

Three electronically regulated voltages are developed by this power supply. A positive 150-volt supply, at 400 milliamperes maximum current, is developed through use of series voltage control tubes. The conduction of these tubes is automatically adjusted by a cascode (series connected) voltage feedback amplifier to maintain constant output voltage despite fluctuations of input voltage or load current. The 150 volts developed by this arrangement is used to power circuits of the sync control unit, the frequency divider, the time delay unit, and the synchronization indicator unit. A relay operates, upon removal of interlocked power, to transfer this voltage to the oscillator and thus replace the voltage normally supplied the oscillator by Power Supply PP–958/FPN–30. This transfer

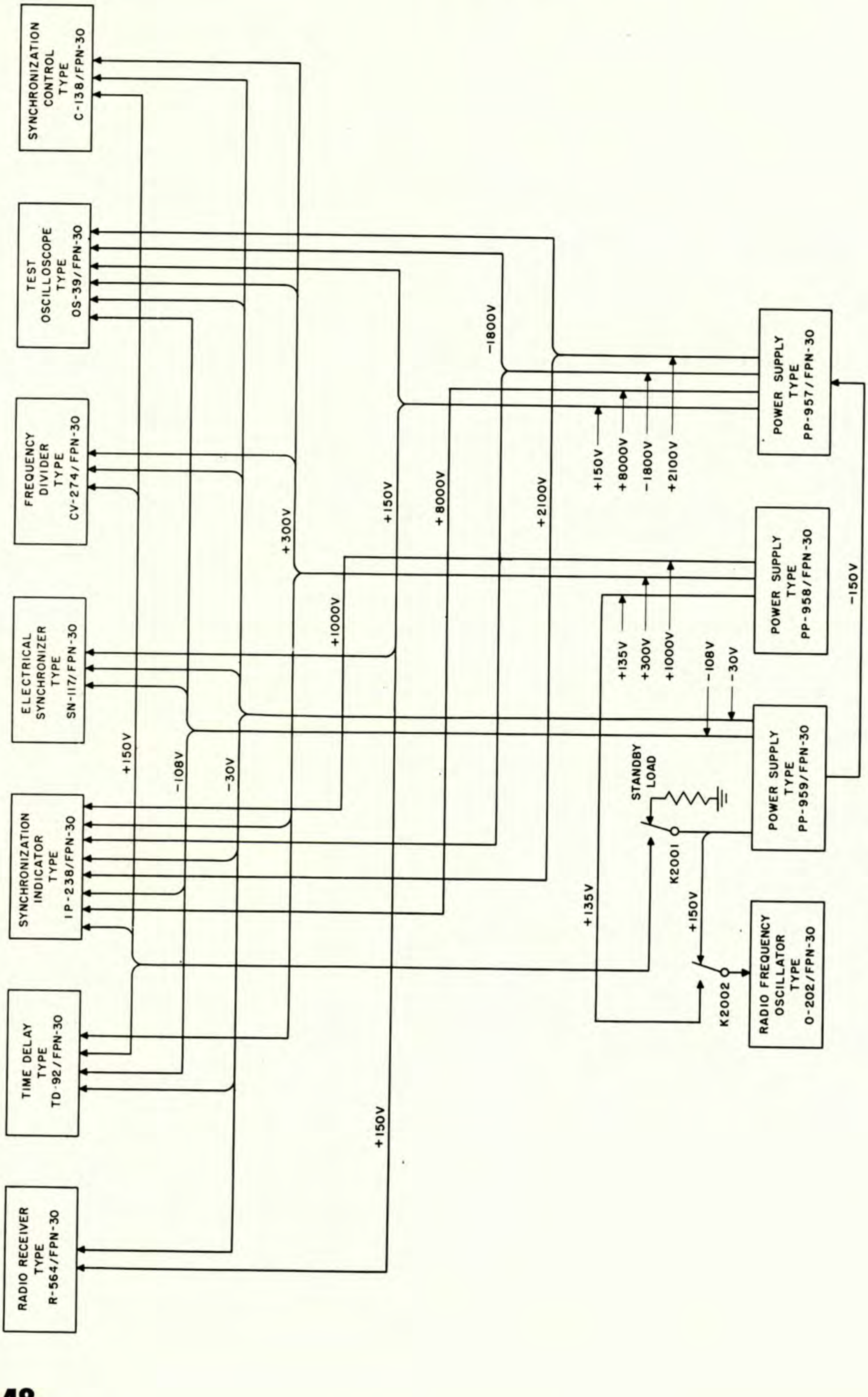


Figure 2–40. Block Diagram of D-c Power Distribution in Loran Timer Set AN/FPN–30

operation removes the 150-volt supply from all other units and places a resistive load across the supply to maintain regulation.

A similar arrangement using a shunt regulator tube is used to develop a bias voltage of —30 volts at a nominal current of 35 milliamperes. This bias is used throughout the timer. Another bias voltage of —108 volts at 12 milliamperes maximum current is controlled by a gas regulator tube. Both these bias voltages are developed from a common, unregulated, —230-volt supply. The —230-volt supply is also applied to a gas regulator tube to provide a —150-volt source which controls a reference voltage tube in the +150-volt regulator circuit of Power Supply PP–957/FPN–30. Protection to timer circuits, upon failure of the —230-volt supply, is provided by a relay circuit which removes interlocked power in the absence of —230 volts. All bias power is removed from other units of the timer when the interlocked power circuit is opened.

This power supply also provides filament power for Radio Frequency Oscillator O–202/FPN–30 and 115-volt a-c power for the oven heater of the oscillator and for the cabinet space heaters.

(2) POWER SUPPLY TYPE PP–958/FPN–30.— Power Supply Type PP–958/FPN–30 is the source for the +300 volts, +135 volts and +1,000 volts used in the timer. This unit also supplies 6.4 volts for spare purposes. The +300 volts, at 350 milliamperes maximum current, is used throughout the timer. This voltage is developed by an electronic regulator arrangement similar to that used for developing the +150 volts in Power Supply PP–959/FPN–30.

The +135 volts, at 50 milliamperes maximum current, is developed for use in Radio Frequency Oscillator O–202/FPN–30. This voltage is regulated by a series regulator tube whose conduction is adjusted for constant output voltage by a pentode control tube. This voltage is routed to the oscillator via Power Supply PP–959/FPN–30 so that a relay switching arrangement in that unit may provide +150 volts to the oscillator when the +135 volts is removed by the interlocked power circuit.

The +1,000 volts, at 25 milliamperes maximum current, is used for the video amplifier stage, V809, in Synchronization Indicator IP–238/FPN–30. This voltage is supplied via a full-wave selenium rectifier and has no special regulating arrangement. A voltage divider is used to reduce the +1,000 volts to a lower value so that it may be metered by the arrangement in Power Supply PP–959/FPN–30.

The 6.4-volt a-c supply is provided from two isolated sources at maximum currents of 14 amperes and 2.75 amperes for availability in contemplated auxiliary equipment.

This power supply houses the interlock circuit control relay and provides a 115-volt output controlled by that relay. This output provides the majority of a-c power to other units. Additional 115-volt outputs, controlled by the interlock relay, are provided to operate control relays in Power Supply PP–959/FPN–30 and to operate the cabinet blower and the relay controlling the OPERATE-STANDBY lights.

(3) POWER SUPPLY TYPE PP–957/FPN–30.— Power Supply Type PP–957/FPN–30 is the source of a second +150-volt supply and the high voltage supplies and filament voltages for the four oscilloscope cathode-ray tubes. Spare 6.4 volts ac at 2.75 amperes is also provided.

The +150 volts, at 400 milliamperes maximum current, is supplied by an arrangement identical to the +150-volt supply of Power Supply PP–959/FPN–30. This supply operates from the —87-volt reference voltage developed by the —150 volts fed from that unit. The +150 volts developed here is applied to the receiver, the electrical synchronizer, and the test oscilloscope.

The oscilloscope high voltage supplies include a —1,800-volt, a +2,100-volt, and a +8,000-volt source. All scope high voltages and filament voltages are controlled by a switch labeled SCOPE HIGH VOLTAGES ON-OFF. The —1,800 volts and the +2,100 volts are each developed from separate half-wave vacuum tube rectifier circuits; —1,800 volts is used in all four scopes, the +2,100 volts is used in the SLOW SCOPE, the VIDEO SCOPE, and the test oscilloscope.

The +8,000 volts is developed by a selenium-rectifier voltage-quadrupler circuit for use in the RF SCOPE. Filament supply of 6.4 volts at 2.4 amperes is developed for use in all four scopes.

l. VOLTAGE REGULATOR TYPE CV–235/FPN–30.—The voltage regulator is provided as an accessory unit to maintain the 60-cycle power to the timer at a constant 115 volts. The regulator consists of a motor driven autotransformer which is operated by a control circuit to adjust the line voltage as required to correct for voltage changes. Refer to figure 2–41 for the block diagram.

The autotransformer is connected through an isolating transformer in a buck-boost arrangement to add or subtract voltage, in series with the power line. The voltage which this arrangement adds or subtracts from the power line is varied by means of a motor geared

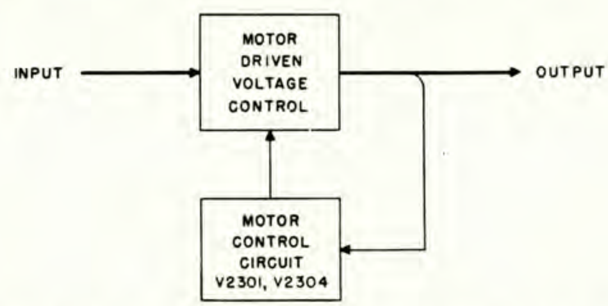


Figure 2–41. Line Voltage Regulator, Block Diagram

to the control shaft of the autotransformer. Power may be applied to the motor to drive it in either direction.

The control circuit uses a voltage sensitive resistor to monitor the regulator output voltage. If the circuit senses a decrease in voltage it produces an output of one phase and causes one of two thyratrons to fire. This thyratron fires to close a relay and apply power to the motor in such a manner that the motor raises voltage. When the voltage has been raised to the normal value, the circuit produces no output, the thyratron stops firing, and the motor is stopped. If the circuit senses a raise in voltage, it produces an output of opposite phase and fires the other of the two thyratrons. This causes a similar correction sequence, in the opposite direction, to lower voltage. If the circuit senses normal voltage, it produces no output.

The voltage at which the circuit produces no output and hence the output voltage which is maintained by the regulator may be adjusted by means of an OUTPUT VOLTAGE control. The sensitivity of the circuit, and hence the voltage change which the regulator will permit to take place before initiating a correcting sequence, may be adjusted by means of a SENSITIVITY control. This control should be set to produce the maximum sensitivity which does not result in more than occasional operation of the motor for normal small voltage surges. The sensitivity should not be made so great that the motor constantly hunts back and forth.

Power through the regulator is controlled by a three-position toggle switch which either interrupts power completely, feeds regulated output voltage to the timer, or feeds unregulated output voltage to the timer. The three positions of this switch are appropriately labeled OFF, REG VOLT, and LINE VOLT. Unregulated voltage should be used only in the event that the regulator fails and the stand-by timer and its associated regulator cannot be pressed into service.

A line voltage meter is provided to permit monitoring output voltage and to permit testing the input voltage. A switch connects this meter to either regulated or unregulated voltage. This switch is spring-returned to the regulated position and must be hand-held in the unregulated position. Positions of this switch are appropriately labeled OUTPUT VOLTAGE and INPUT VOLTAGE. The connection to the input voltage is made at the regulated voltage terminals of the three-position toggle switch so that the meter reads unregulated voltage only when the regulator circuit is in use. The meter cannot be used to read line voltage when the toggle switch is placed in the LINE VOLT position.

A MAIN POWER circuit breaker, in the input side of the regulator wiring, is used only when the regulator circuit is in use and is disconnected in the LINE VOLT position of the toggle switch. This circuit breaker provides protection against current overload in excess of 20 amperes. Supplementary protection, against current overload exceeding 30 amperes, is provided by the fuses in the loran switching equipment. This protection is required when the timer is operated on unregulated voltage by direct connection to the power line through the LINE VOLT position of the toggle switch.

The circuits of the regulator unit are protected by two instrument-type fuses located on the regulator front panel. One of these fuses protects the control circuit and the other protects the buck-boost autotransformer arrangement. A POWER ON indicator lamp is provided to show that power is reaching the control circuit.

4. DETAILED CIRCUIT DESCRIPTION.

This paragraph continues the description of timer theory with detailed descriptions of the operating theory of individual circuits. The information is of specific interest to the advanced technician who will be concerned with adjustment, maintenance, and repair of the timer. Emphasis is placed on the schematic arrangement of the timer units, rather than a functional description, as made in paragraph 3 above. Some of the more technical aspects of timer operation, beyond the scope of paragraph 3, are also described here. *It is essential, at this point, that the reader have a thorough understanding of timer operation, as described in preceding paragraphs, before proceeding with the detailed circuit analysis which follows.*

a. RADIO FREQUENCY OSCILLATOR TYPE O–202/FPN–30.—As discussed in paragraph 3 *a* preceding, the radio-frequency oscillator employs a crystal (temperature stabilized in a double oven), a driving amplifier, an isolation amplifier, and a fine heater oscillator to generate an extremely stable 100-kc signal. Adjustment of the frequency of this signal, over a limited range, is provided by a microfrequency network.

(1) CRYSTAL BRIDGE CIRCUIT.—The inherently high stability of the radio-frequency oscillator may be attributed to employment of the frequency determining crystal in a bridge circuit. The bridge arrangement, driven by the highly degenerative driving amplifier, permits oscillator frequency to be determined almost entirely by the resonant frequency of the crystal, with virtual freedom from changes of voltage or of component characteristics. Because the crystal is isolated from the effects of temperature, humidity, and variations of atmospheric pressure, an unusual degree of stability is achieved.

As shown in the simplified schematic diagram, figure 2–42, the bridge consists of four arms. One arm is R1401, another R1402, and a third is resistance lamp RV1401, which provides an amplitude stabilizing effect. The fourth arm consists of the crystal, Y1401, and an arrangement of inductors and capacitors which permits slight modification of the resonant frequency of the crystal circuit. This arrangement is called the mi-

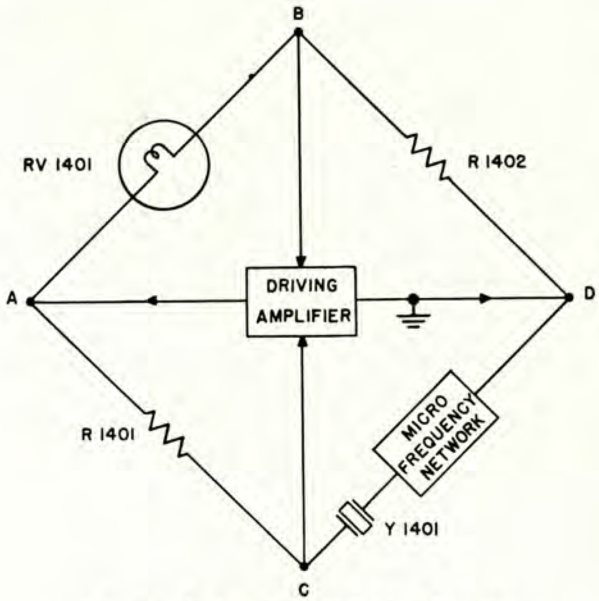


Figure 2–42. Crystal Bridge Circuit, Simplified Schematic

crofrequency network. The crystal is approximately equivalent, electrically, to a resistance of 15 ohms, a capacitance of 0.149 micromicrofarad, and an inductance of 17 henries, all connected in series. This is shown in the equivalent circuit diagram, figure 2–43. The resonant frequency of the crystal is thus subject to modification by the series connection of the components of the microfrequency network. At series resonance the impedance of this arm of the bridge is pure resistance; the phase shift is therefore zero.

If the bridge were adjusted for perfect balance, voltage impressed across the bridge input terminals, A and D, would not appear at the output terminals, B and C. Under such a condition oscillation is not possible because no feedback occurs from the amplifier output terminals, A-D, back to the input terminals, B-C.

In order to produce oscillation, the correct unbalance of the bridge is obtained by adjustment of R1402. This adjustment is a critical one and is made at the factory by careful removal of resistance wire to obtain the desired results. The unbalance of the bridge is in such a direction that the output voltage, between points B and C, is in the right phase to support oscillation.

Oscillation occurs at the fundamental frequency of the crystal because the slight bridge-unbalance situation described above occurs only at that frequency. At any other frequency the bridge is unbalanced to a greater degree, because of phase shift in the series resonant crystal circuit, and in such a direction that oscillation is suppressed rather than supported. Because the reactance of each of the individual parts (inductance and capacity) of the equivalent circuit of the crystal is so very high compared to the resistance, producing a high circuit Q, the impedance of the crystal rises very sharply and to a high value at a frequency which is only slightly removed from 100 kc. This unbalances the bridge greatly. At resonance, of course, the reactance of the crystal drops to zero, leaving only the resistive component of approximately 15 ohms on which the balance of the bridge is based.

The amplitude of oscillation is maintained at a stable level by means of the lamp, RV1401, in one of the legs of the bridge. As the amplitude of oscillation increases, more current flows through the bridge. The temperature coefficient of resistance of this lamp is quite high. The increased current through it raises the temperature of the filament and causes the resistance to increase. This in turn decreases the feedback ratio so that the amplitude of oscillation is reduced. The overall effect on the oscillator is that a stable amplitude is attained and maintained at a relatively constant level by the governing action of RV1401. Output level is kept small enough to assure class A operation of the driving amplifier so that excellent output waveform is attained.

It can be shown, for any oscillator circuit, that oscillation occurs at the frequency where the phase shift through the oscillatory loop is zero (or a multiple of 360°). Assuming zero phase shift through the driving amplifier and through the other components of the bridge, oscillation occurs at the resonant frequency of the crystal because the phase shift through the crystal is zero at resonance. Should component characteristics change so that the phase shift through all components except the crystal be other than zero, the crystal must introduce a compensating phase shift by effecting a slight change in frequency. This oscillator possesses exceptional frequency stability because it contains two features which permit a large phase shift to be effected by an extremely slight change in frequency. One of these is a crystal arm with an extremely high Q, as discussed previously. The other is the use of the bridge circuit which multiplies the phase shift of the crystal arm.

The magnification of phase shift, or phase angle multiplication, is best illustrated by a vector diagram. Refer to figure 2–44. The bridge is shown with an input voltage, E_{IN}, applied between terminals A and D. Output voltage, E_{OUT}, is obtained, if the bridge is unbalanced, between terminals B and C. Distribution of the voltage, at various points of the bridge, may be illustrated by the use of vectors. Vectors are directed line segments—that is, arrows—which show the magnitude of a voltage or current by their relative length and which show phase angles by their relative angular position. For the condition of resonance, the phase shift through all points of the bridge is zero and therefore

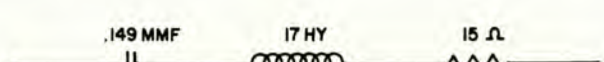


Figure 2–43. Crystal Y1401, Equivalent Circuit

all vectors lie along the same line, which is taken as horizontal. E_{IN} is shown for reference as vector A-D. The portion of E_{IN} developed across RV1401 is labeled E_{RV1401} and is vector A-B. Correspondingly, voltage E_{R1402} is vector B-D, E_{R1401} is vector A-C, and E_Z is vector C-D.

The ratio of A-B to B-D does not equal A-C to C-D, indicating bridge unbalance, and thus producing E_{OUT} between terminals B and C as shown by vector B-C.

Assume, for example, that a component in the driving amplifier changes characteristics, so that the phase shift through the driving amplifier is not zero, and therefore E_{IN} is not in phase with E_{OUT}. This is shown, for an off resonance condition, by the angle made by vector A-D with respect to B-C. The voltage through resistors RV1401 and R1402 is necessarily in phase with the applied voltage, E_{IN}, because there is no phase shift through a resistive circuit. Because oscillation can only exist when there is zero phase shift through the oscillatory loop, the crystal arm must produce phase shift if oscillation is to continue. Thus there is a small difference in phase angle between E_{IN} and E_Z as shown by angle BDC made by the intersection of vectors B-D and C-D. It can be seen from the vector diagram that this small phase shift in the crystal arm, angle BDC, causes a much larger shift in E_{OUT}, angle DBC. Thus the action of the bridge is to minimize the change of frequency required in the crystal arm to provide a large change in phase.

It will be seen that the ratio of angle DBC to angle BDC is large if E_{OUT} is small compared to E_{IN}. Thus, phase angle multiplication is enhanced by a large ratio of E_{IN} to E_{OUT}. Since E_{IN}/E_{OUT} expresses bridge loss, and since for oscillation to be sustained the bridge loss must equal the gain of the amplifier, the desired ratio will be large if the amplifier gain is large. The two stages of pentode amplification in the driving amplifier provide a very large amount of gain and thus establish an enormous amount of phase angle multiplication.

Note that, for clarity of illustration, the vector diagrams have been drawn to show a relatively small ratio of E_{IN} to E_{OUT} and that the phase shift in the crystal arm has been made much larger than would be expected in practice. The phase angle multiplication is actually much greater than is apparent from the diagrams. Because the phase angle multiplication is large, the crystal frequency need change only a negligible amount to produce the required phase shift, between E_{IN} and E_{OUT}, to compensate for normal component fluctuations. Thus the frequency of oscillation is determined almost entirely by the resonant frequency of the crystal circuit.

(2) MICROFREQUENCY NETWORK. — The microfrequency network, connected in series with Y1401 in the crystal arm of the bridge, permits slight variation of the oscillator frequency by changing the electrical reactance in the crystal arm. As shown in the simplified schematic diagram, figure 2–45, the microfrequency network consists of steps of inductance or capacitance selected by COARSE FREQ. ADJ. switch S1401, fixed capacitors C1409, C1424, and C1425, and FINE FREQ. ADJ. capacitor C1410. FREQUENCY CORRECTOR capacitor C120, located in the sync control unit, is also connected across C1410, via J1402, to permit frequency correction at a slave station. This connection is not made at a master station. The entire network is connected in series with the crystal and the switch-selected components are connected in parallel with the other fixed and variable capacitors. Because the permanently connected capacitors in series with the

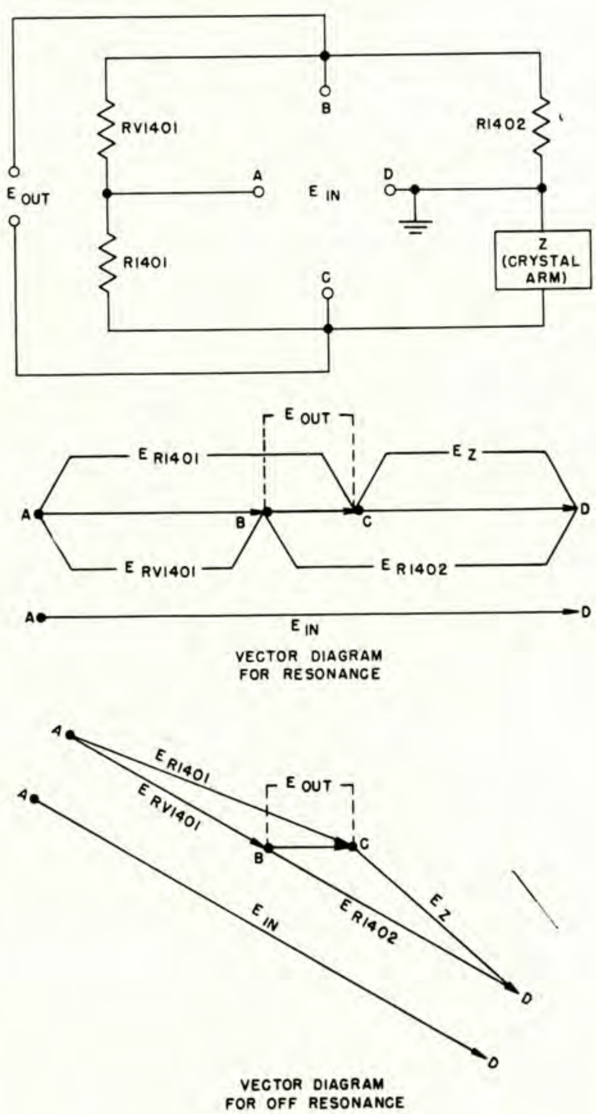


Figure 2–44. Crystal Bridge Circuit, Explanatory Diagram

crystal total about 2,000 micromicrofarads they have only a slight effect on the crystal frequency. To compensate for this effect, the crystal is ground about three cycles low. Thus, with only the fixed capacitances in the circuit, the nominal resonant frequency is exactly 100 kc. To permit correction for possible grinding errors and other circuit tolerance, and because the natural crystal frequency changes with age, the coarse and fine adjustments of the microfrequency network permit addition of either inductive or capacitive reactance in series with the crystal to lower or raise the crystal frequency as required.

The purpose of capacitors C1424 and C1425 is to provide a temperature-stabilizing effect. These negative temperature coefficient capacitors compensate for the positive temperature coefficient of the other components in the network.

The high value resistor, R1433, provides static drain which prevents accumulation of a charge which could develop across the network capacitors. Because the resistance is high compared to other impedances in the circuit, this resistor has no other effect.

The switch-selected components of the microfrequency network are enclosed in an insulated housing to minimize temperature effects on oscillator frequency. A heater (R1434) within this housing is controlled, by the same circuit which controls the temperature of the outer crystal oven, to provide rough temperature regulation. This rough temperature control reduces the change in reactance of the microfrequency components to a point where the resulting effect on frequency is negligible.

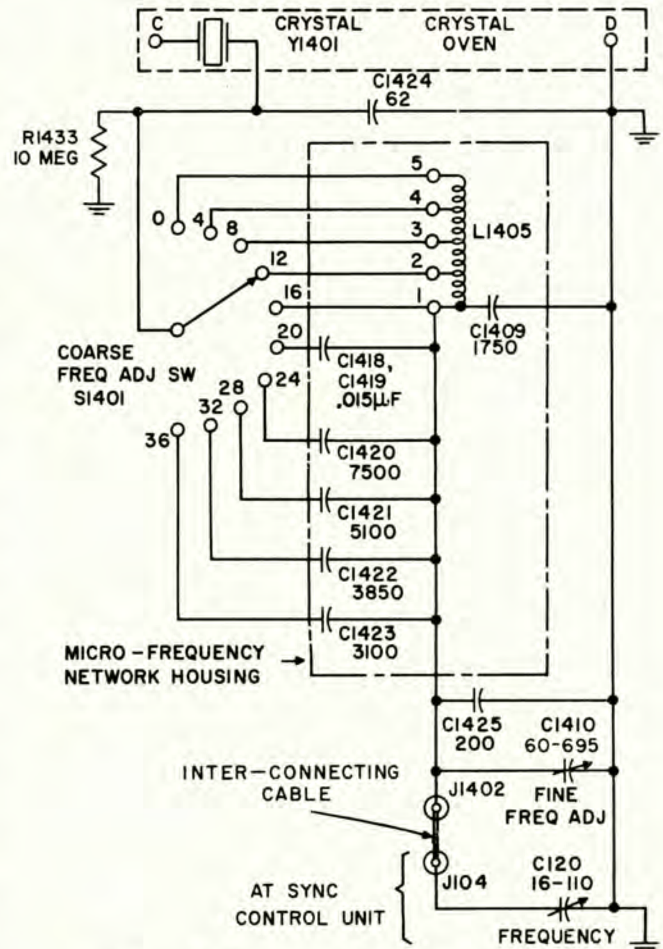


Figure 2–45. Microfrequency Network, Simplified Schematic

(3) DRIVING AMPLIFIER. — The driving amplifier provides electrical energy required to sustain oscillation. This amplifier employs two high gain stages, stabilized by a generous amount of negative feedback, to provide adequate drive. Frequency selective circuits provide maximum amplification at 100 kc, further enhancing the frequency stability of the oscillator and suppressing the generation of harmonics.

Tuned transformers at the input and output of the amplifier provide maximum transmission of the 100-kc signal with attenuation of all other frequencies. Resistance coupling is employed between the two class A operated 6AC7 stages which are entirely conventional except for the feedback circuit. Refer to figure 2–46. Feedback is taken from the secondary of the output transformer, T1402, and applied via frequency selective assembly Z1401 and the parasitic oscillation suppressing network R1403 and C1402 to the V1401 cathode. Because of the 180° phase shift inherent in this path, the feedback voltage subtracts from the signal voltage applied between the V1401 grid and cathode to reduce the amplifier output voltage, thus reducing the effective gain of the amplifier by negative feedback. Resistor R1405, connected to ground via d-c blocking capacitor C1403B, operates with the series impedance of the feedback network to reduce the feedback voltage to a desired value. The d-c return path for the cathode is via the feedback components, which have the correct resistance to provide proper cathode bias for the stage. Z1401 consists of a parallel tuned L-C circuit shunted by a resistor. This arrangement reduces the amount of feedback at 100 kc while permitting considerable feedback at other frequencies. The shunt resistor in this network limits the maximum impedance of the resonant circuit to provide adequate feedback, at 100 kc, to stabilize the amplifier against component variations. A major factor contributing to the peaked frequency response of the driving amplifier, at 100 kc, is the tuned output transformer, T1402. If the feedback circuit were not frequency selective, the peaked response of T1402 would be "flattened" by the feedback; however, because the feedback is reduced at 100 kc by the increased impedance of the resonant circuit, frequency selectivity is very high.

Plate decoupling, at 100 kc, is provided by L-C filters in the 135-volt supply bus to prevent coupling of 100 kc into other circuits through the power supply.

The 100-kc output of the driving amplifier is applied to a single stage isolation amplifier.

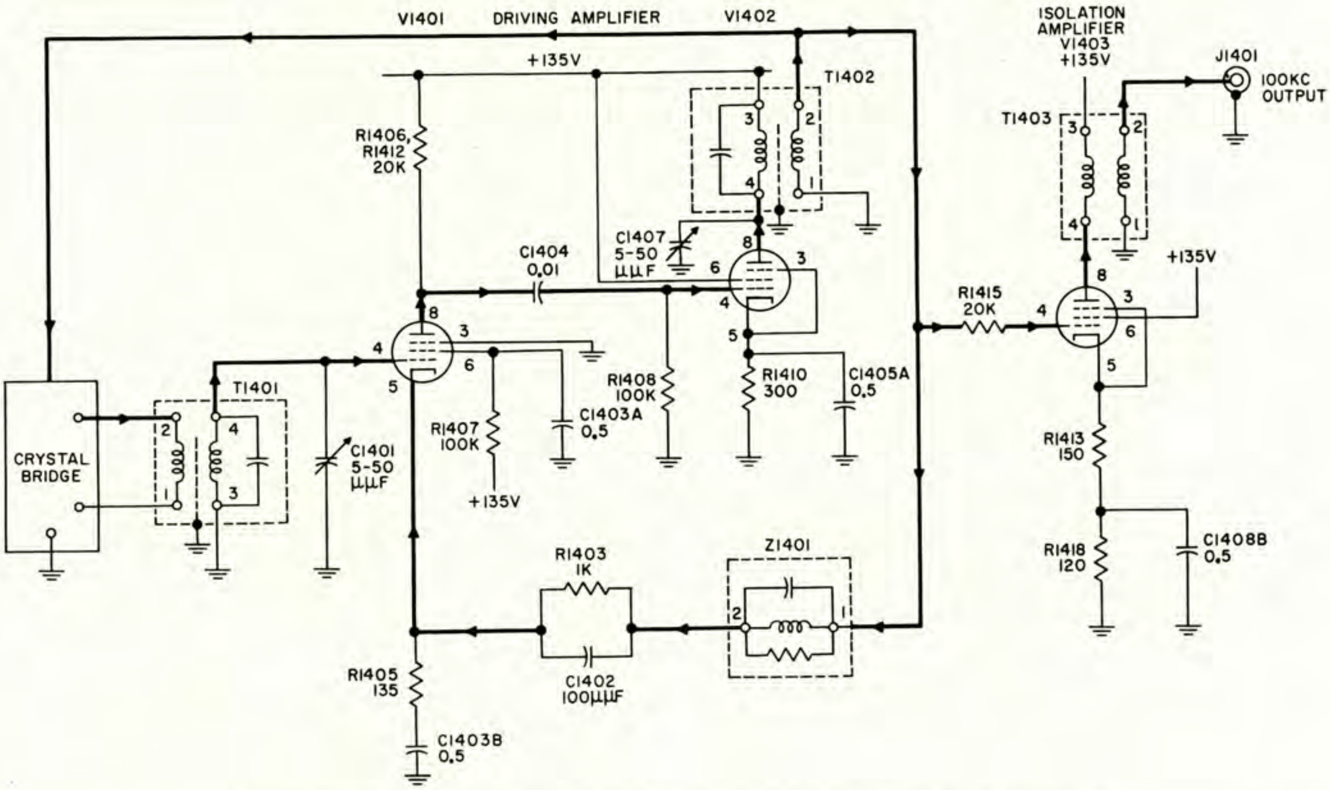


Figure 2–46. Driving Amplifier and Isolation Amplifier, Schematic Diagram

(4) ISOLATION AMPLIFIER. — The isolation amplifier, shown in figure 2–46, is a conventional class A amplifier which employs r-f transformer T1403 to supply a low impedance output to jack J1401. The 6AC7 single stage of the isolation amplifier is driven through series resistor R1415 which isolates the input capacity of this stage from the tuned circuit of the preceding output transformer. Plate and screen voltages are supplied through L-C decoupling filters to isolate the output signal from the power supply and from preceding stages.

The 100-kc output to J1401 is supplied to the synchronization control unit.

(5) CRYSTAL OVEN.—The crystal oven maintains the components of the crystal arm of the bridge at an extremely uniform temperature. This is accomplished by use of a dual oven, one within the other. The outer oven maintains coarse control of temperature by means of a thermostat; the inner oven maintains stepless control by means of a vacuum tube oscillator circuit which powers the fine heater of the inner oven. The fine heater is arranged in the form of a bridge so that the temperature coefficient of the fine heater wire controls oscillator output amplitude to establish an equilibrium at the desired temperature of the inner oven. The heat supplied by the fine heater will thus be equal to the heat lost by the inner oven to the outer oven. Since this heat is constant, within the few degrees of the thermostat differential, the fine heater arrangement need operate only over a narrow range of amplitude variation and thus is able to maintain an extremely constant temperature within the inner oven.

The inner oven consists of a closed-end, heavy-gauge, copper cylinder which has resistance wire wound around its outer surface. This wire, which heats the inner oven, is also used as the resistance elements of the fine heater bridge. The thick copper walls of the cylinder provide thermal storage which helps smooth out temperature fluctuations resulting from the on-off action of the coarse heater. The thermal conductivity of this cylinder insures even temperature distribution throughout the oven. Thermal insulation, provided between the inner oven and the outer oven, serves as an additional factor in the filtering out of temperature fluctuations. This insulation consists of a glass vacuum cylinder, closed at both ends by glass vacuum plugs, and a felt overwrap. The evacuated hollow glass walls provide heat insulation in the same manner as does an ordinary vacuum bottle. This assembly is enclosed in a second copper cylinder which is heated by the coarse heater winding wrapped around its outer surface. The temperature of this coarse heater cylinder is isolated from ambient changes in temperature by heat barriers and by an outer cylinder which serves as a protective housing for the entire assembly and as a reflector of radiant heat. The heat barriers consist of alternate wrappings of felt and metallation. The metallation, which is paper, coated on both sides with aluminum foil, provides thermal storage between the insulating layers of felt and also provides reflecting surfaces to reduce radiation losses.

The coarse heater is powered from the 60-cycle supply and controlled by a thermoswitch which projects into one end of the coarse heater cylinder. The thermoswitch, S1403, is a bimetallic element which operates at 56°C. (133°F.) to close a mercury relay (K1401) and power the heater. Relay arcing is minimized by spark suppression network C1428 and R1438. Thermoswitch arcing is minimized by network C1427, R1436. When heater operation raises the oven temperature to above 56°C. (133°F.), the thermoswitch opens. The coarse heater is connected in series with R1434, the heating element of the microfrequency network oven, so that R1434 makes up heat loss in the microfrequency network in response to the same factors governing heat loss in the coarse heater.

Thermoswitch S1403 is provided with a small heating coil which is wound on the glass envelope of the thermostat, shunted by variable resistor R1442, and connected in series with the coarse heater of the crystal oven. The temperature inside the coarse heater cylinder can be adjusted by varying the setting of R1442. For example, when the resistance of R1442 is increased, more heat is dissipated by the coil. This reduces the difference between the temperatures at the thermostat and at the coarse heater, resulting in a lowering of the temperature at the coarse heater. Conversely, a reduction in the resistance of R1442 increases the temperature at the coarse heater. Through initial adjustments of R1442 to an intermediate value, and of the operating temperature of the thermostat to a value which exactly compensates for the corresponding reduction in temperature at the coarse heater, a means is provided for correcting for either a positive or negative shift in the operating temperature of the thermostat. The total range of correction is somewhat less than 3°C. The initial setting of the thermostat is about 56.8°C. (134.3°F.). Depending on the setting of R1442 the cycling period of the coarse heater varies from about 2 minutes on and 4 minutes off for minimum resistance to a few seconds on and off for maximum resistance.

(6) FINE HEATER OSCILLATOR. — The fine heater oscillator is a bridge controlled circuit, similar in design to the crystal oscillator, which develops power for the fine heater. The bridge elements are arranged so that the bridge is unbalanced at room temperature and nearly balanced at the desired operating temperature of approximately 59°C. (138°F.). The circuit arrangement is shown in figure 2–47.

The bridge resistances, wrapped around the fine heater cylinder, consist of alternate arms of ADVANCE and HYTEMPCO wire. The ADVANCE wire has a negligible temperature coefficient so that its resistance remains fairly constant as the bridge heats up; however, the HYTEMPCO wire has a high temperature coefficient and its resistance therefore increases with heat. Thus, the bridge approaches a balanced condition as temperature rises.

Requirements for oscillation are the same as in the crystal oscillator. The phase shift from amplifier output to input is required to be 360° and bridge transmission must permit sufficient regenerative voltage to sustain oscillation. The phase shift is made equal to 360° at approximately 900 cps by tuning the secondary of input transformer T1404 to that frequency. (The "tuning" is not adjustable.) Since the bridge is resistive it produces no phase shift. The function of the bridge in this oscillator is purely the control of oscillator amplitude. Because oscillator output heats up the bridge to change its balance in a direction for reduced output,

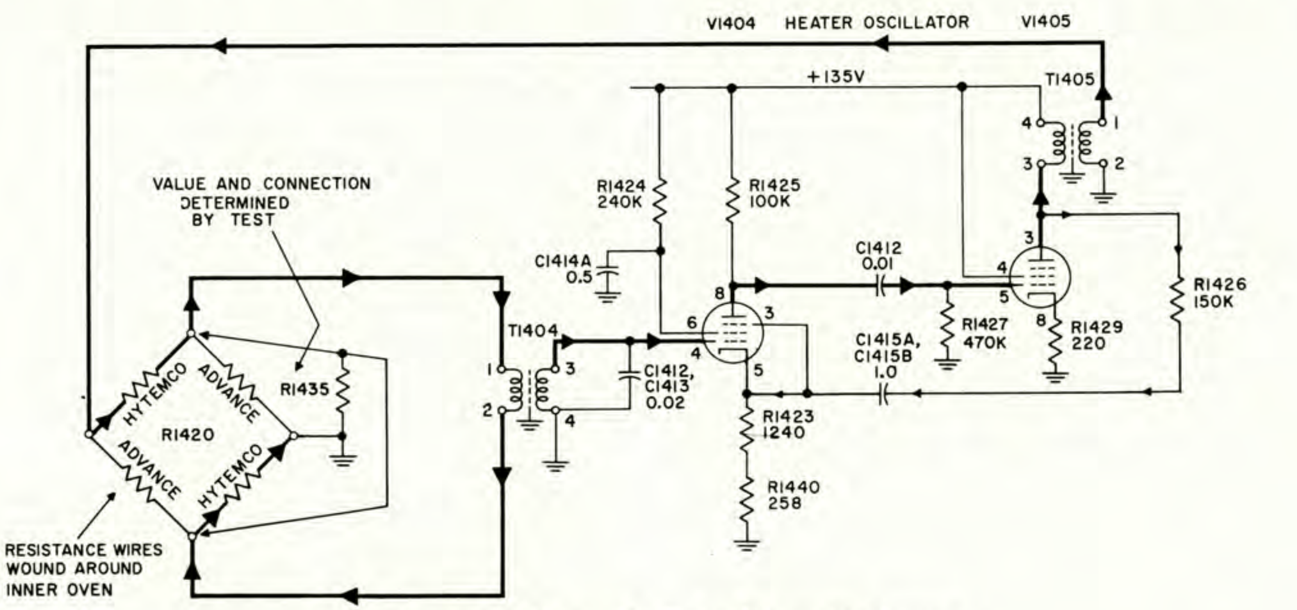


Figure 2–47. Fine Heater Oscillator, Schematic Diagram

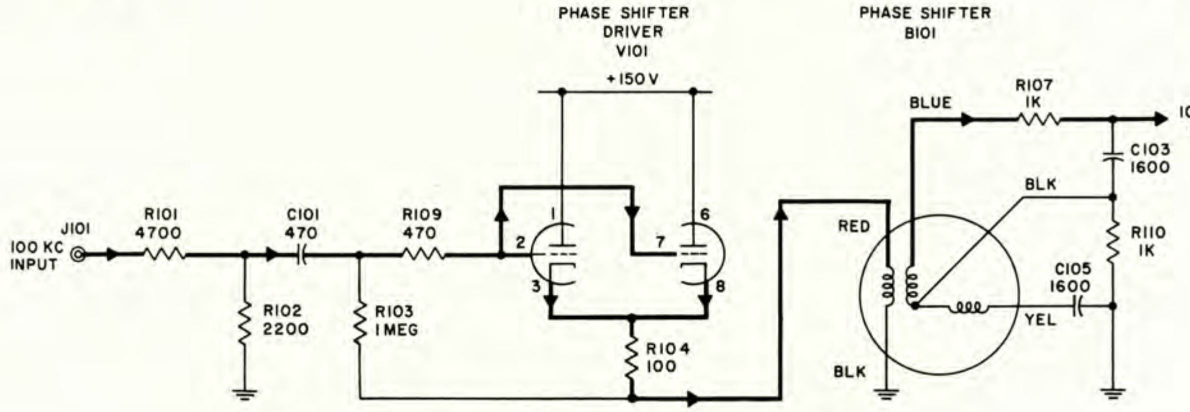


Figure 2–48. 100-kc Phase Shift Circuit, Schematic Diagram

the system is self-regulating, and oscillator output always supplies just enough energy to make up for the heat lost by the bridge. The system stabilizes at an equilibrium point where the oscillator produces an output which exactly compensates for the small heat loss of the inner oven. Thus this stepless control of fine heater output keeps the inner oven at an extremely constant temperature which is held to a differential of less than 0.01°C. The equilibrium point and hence the crystal temperature are established by adjustment of R1435 and by connection of this resistor to one of two arms of the bridge, as determined by factory tests.

The heater oscillator amplifier serves the same purpose as the driving amplifier in the crystal oscillator circuit; it provides energy to maintain oscillation. This amplifier is a two-stage high gain arrangement which is designed to supply higher power than the crystal driving amplifier. The two circuits are similar. R1426 supplies feedback to the input stage cathode via blocking capacitor C1415. The feedback stabilizes the gain of the amplifier so that it is virtually independent of normal tube or other component variations. Thus, because the amplifier supplies constant amplification of the bridge output voltage, the bridge equilibrium point is determined solely by bridge constants.

(7) METERING CIRCUIT. *(Refer to figure 7–273.)*—The metering circuit employs selector switch S1402 and d-c microammeter M1401 to pick up significant operating voltages within the oscillator and measure them as a percentage of normal reading. A-c voltages are rectified by small half-wave copper oxide rectifiers (CR1401, CR1402, CR1403) and applied as dc to the meter. Resistors employed at all the metering points adjust the measured voltage to produce an approximate midscale deflection of the meter for normal circuit indication. Plate currents are read as the voltage drop across a resistor in the tube cathode circuit. Bypass capacitor C1426 shunts the meter coil for ac and thus protects the coil from possible overload. The metering circuit is not a precision measuring device, as its only function is to provide an indication of relative performance of oscillator circuits. By maintaining a log of periodic meter readings, the operator is able to detect any performance abnormality before it becomes serious enough to degrade oscillator reliability. In this way tube failures and other component deteriorations may be predicted and sudden causes of failure may be located.

b. SYNCHRONIZATION CONTROL TYPE C-1238/FPN-30.—The sync control unit was functionally outlined in paragraph 3 *b* above. Discussions in this paragraph are confined to advanced technical theory of the more complex and novel circuits of this unit as well as a detailed description of the sync control drive system and gearing.

(1) 100-KC PHASE CONTROL CIRCUIT.—Control of the phase of the 100-kc timing signal is accomplished by a rotary transformer (autosyn) electrically driven by a cathode follower and mechanically rotated by means of the PHASE dial. Refer to figure 2–48. The 100-kc oscillator output signal is delivered to the sync control unit via input jack J101. Voltage divider resistors R101 and R102 attenuate this high amplitude signal to prevent it from overloading the cathode follower stage. Resistor R109, in series with the grid of the cathode follower, suppresses parasitic oscillations. Both triode sections of the tube, V101, are used in parallel to lower the output impedance to a value which permits driving the primary of the autosyn efficiently. Resistor R104, in series with the load presented by the autosyn primary, provides cathode bias. Because of the moderate signal voltage driving the stage, and because of the degeneration inherent in the cathode follower, the output waveform is essentially sine wave, as required to obtain linear phase shift from the autosyn circuit.

The autosyn incorporates two secondary rotor windings; these two coils are at an angle of 90 mechanical degrees with respect to each other. When one secondary is parallel to the primary, for maximum coupling, the other is perpendicular to the primary, for zero coupling. With this arrangement, the voltage in one coil increases as the voltage in the other coil decreases during rotation of the coils. The amplitudes of the voltages in the two coils vary as the sine and cosine of the mechanical angle of PHASE dial rotation. This is shown by figure 2-49 which graphs the peak amplitude of the induced voltage in each coil over 360 mechanical degrees of rotation. This figure shows that the voltage in one of the coils (secondary #1) is maximum when the mechanical angle of rotation, expressed as ϕ, is zero; that is, when secondary #1 is parallel to the primary. The autosyn is designed so that as ϕ increases to 90° the voltage in the coil decreases proportionally to the cosine of ϕ. As ϕ exceeds 90° the voltage makes a 180° phase reversal, because of the transposition of the extremities of secondary #1 with respect to the primary, and the voltage continues to increase in this phase in proportion to cosine ϕ. (The transposition of the extremities of secondary #1 is apparent from a comparison of the coil positions for $\phi = 45°$ and $\phi = 135°$.) The voltage reaches a maximum again when ϕ equals 180° and decreases to zero at ϕ equals 270°. A second 180° phase reversal occurs at this point and voltage increases until the original position of rotation, ϕ equals 360°, is reached. The change of voltage amplitude with change of ϕ is plotted as a function of cosine ϕ for secondary #1 in figure 2-49. The voltage in secondary #2 follows the same behavior except that its maxima and minima are displaced 90° from that of secondary #1; that is, the amplitude of voltage in secondary #2 behaves as sine ϕ. This is plotted for comparison with the voltage in secondary #1. The balloons in figure 2-49 show the relative positions of the autosyn coils for various positions of ϕ and show the mathematical values for the sine and cosine functions at each position. Vectors are drawn to show relative amplitude and phase of the voltages induced in the secondary windings for the various angles represented in the balloons. The relative amplitudes for other angles may be obtained by interpolation.

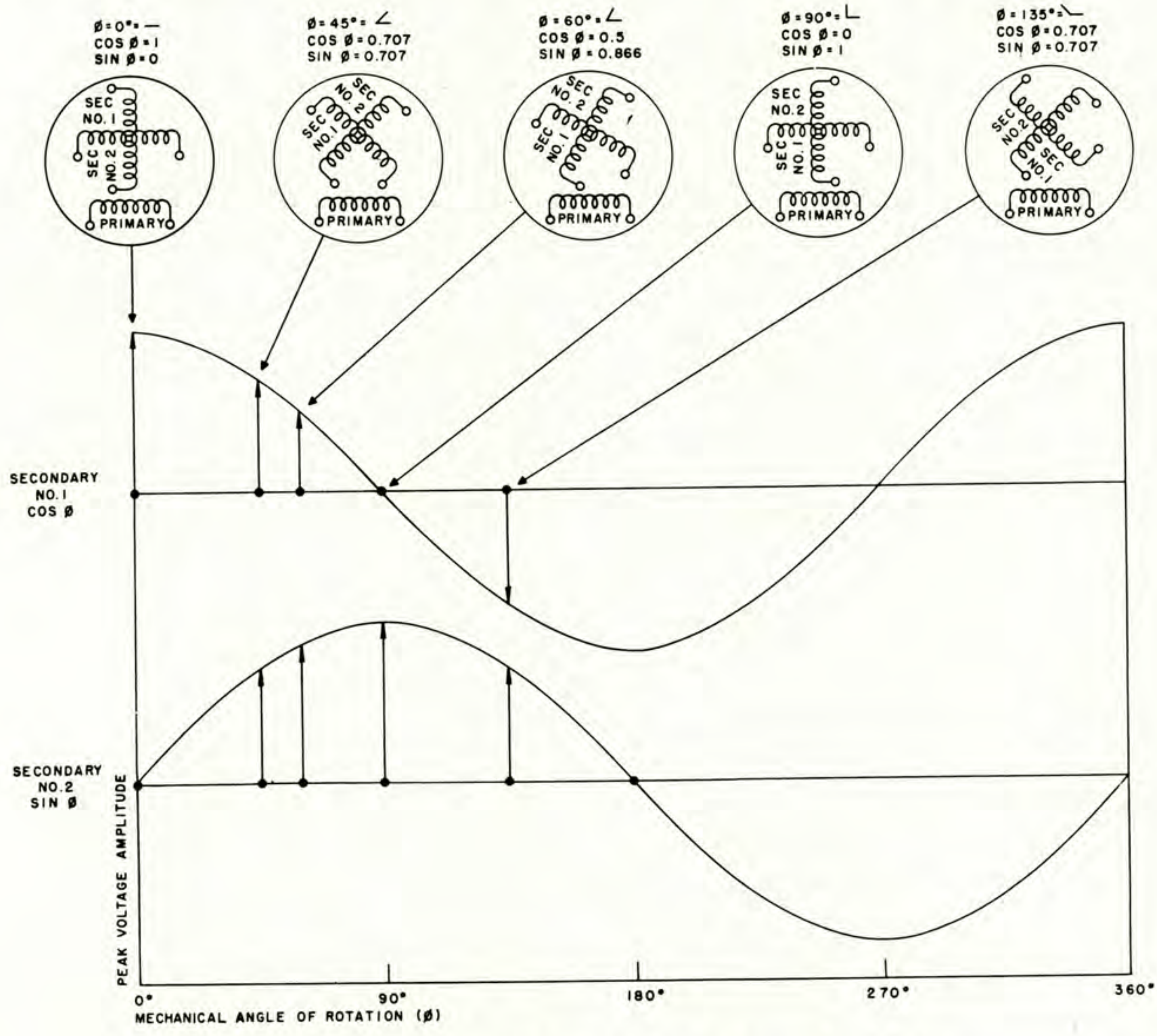


Figure 2-49. Amplitude of Voltage Induced in Autosyn Secondaries

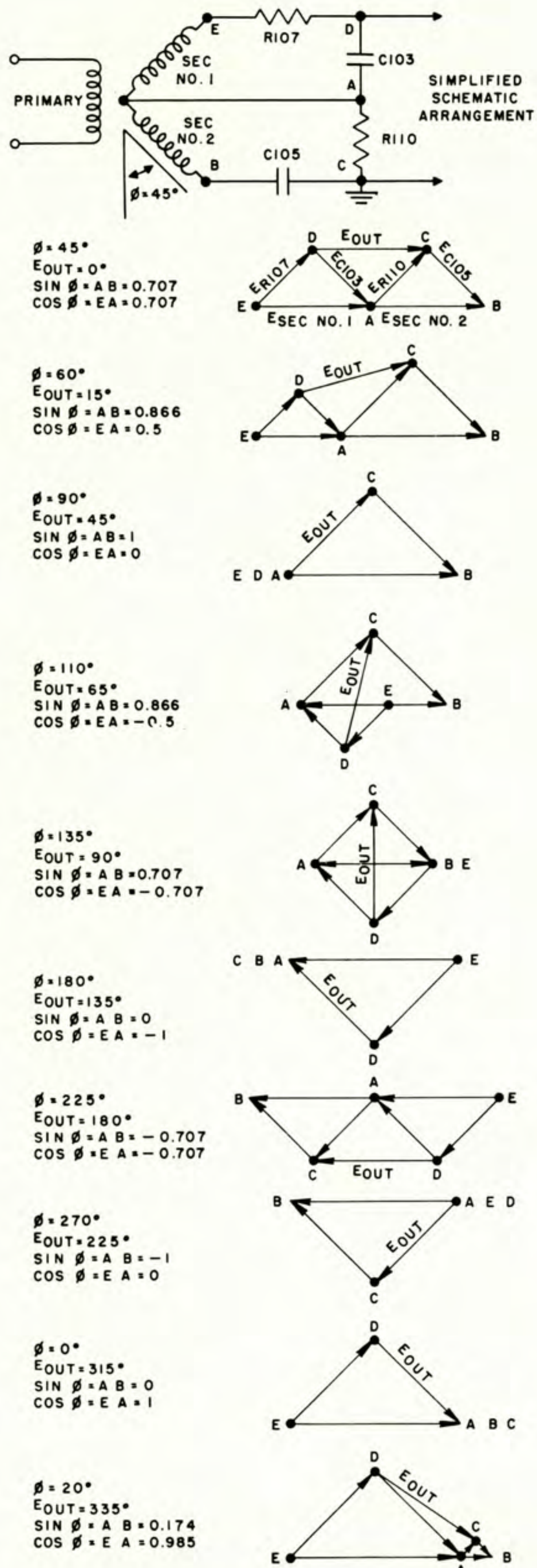


Figure 2–50. 100-kc Phase Shift Circuit, Explanatory Diagram

The amplitude variation in the two secondary coils is used to provide continuous phase shift through an arrangement of leading and lagging phase shift networks. As shown in the simplified schematic arrangement of figure 2–50, the two secondary windings are connected together at point A so that, for ϕ equal to 45°, the voltages in both coils are equal and the voltages are series aiding. This is shown in the first vector diagram of figure 2–50, for $\phi = 45°$, as two head-to-tail arrows, EA and AB, representing the vector voltages across coils EA and AB. These correspond to the vectors which represent voltages in figure 2–49.

The R-C phase shifting network across coil EA consists of resistor ED (R107) and capacitor DA (C103). At 100 kc the impedances of these two components are equal in magnitude so that the voltages developed across them are equal, as represented by vectors ED and DA, of equal length. Because the capacitor has a phase shift of 90° with respect to the resistor, angle EDA is shown as a right angle. Since the two vectors are equal they are drawn at an angle of 45°, with respect to voltage EA induced in the coil, with vector E_{C103} lagging vector EA. A similar network is connected across coil AB so that the triangle formed by vectors AC and CB across AB is identical to triangle EDA. Vector AC shows the 45° leading phase shift (with respect to vector AB) developed across output resistor R110. Output voltage is taken across points DC so that vector DC, representing the vector addition of the leading and lagging voltages across resistor R110 and capacitor C105, shows the magnitude and phase angle of the output voltage, E_{OUT}. For this value of ϕ, E_{OUT} parallels EAB and the indicated phase shift is zero. It will be noted, in this and all the following cases, that E_{OUT} lags ϕ, the physical angle between secondary #1 and the primary, by 45°.

For $\phi = 60°$ the magnitude of EA decreases and AB increases, as shown in figure 2–50, so that triangle EDA becomes smaller and triangle ACB becomes larger. As a result vector DC tilts, with respect to EAB, and the indicated phase shift is 15°. For $\phi = 90°$ voltage EA reduces to zero so that triangle EDA reduces to a point and E_{OUT} is the side of triangle ACB. The indicated phase shift is 45°. For $\phi = 110°$ vector EA reverses direction and a small triangle, ADE, is formed below triangle ACB. The indicated phase shift is 65°.

This change of phase angle may be followed through the succeeding vector diagrams. These show the effect of change of magnitude and direction of EA and AB on phase angle, for several other values of ϕ. To aid the reader, the magnitude and direction of EA and AB are expressed as numerical values of cosine ϕ and sine ϕ.

As has been shown, E_{OUT} lags ϕ by 45°, for all positions of the PHASE dial, so that phase shift may be continuously and accurately controlled. The proof that the phase of the output voltage varies linearly with the mechanical angle of rotation lies in the fact that a uniformly rotating vector is made up of two components; the amplitude of one of these components must be proportional to the sine of an angle and the amplitude of the other component must be proportional to the cosine of the angle. Additionally, the two components must have a phase separation of 90°. That the above is true in the circuit being described can be seen because the amplitude of component AC of the output voltage is proportional to vector AB which in turn is proportional to the sine of ϕ, the mechanical angle of the coil. Component DA of the output voltage is proportional to vector EA which in turn is proportional to the cosine of ϕ. Also, vectors AC and DA are always separated by a 90° phase difference. This is true because AC has been shifted 45° leading and DA 45° lagging by the phase shift networks connected to the coils.

The magnitude of E_{OUT} is a constant value which can be shown, mathematically, to be equal to 0.707 times the voltage induced in either secondary when that secondary is parallel to the primary. Thus a 100-kc signal, bearing any desired phase relationship to the 100-kc output of Radio Frequency Oscillator O–202/FPN–30, and having constant amplitude, may be obtained by adjustment of the PHASE dial.

(2) 100-KC AMPLIFIER AND CATHODE FOLLOWER.—The 100-kc amplifier, shown in figure 2–51, consists of two resistance-coupled stages and a plate tuned amplifier. The grid return for the input stage, V103A, is made through the d-c path of the autosyn phase shift network, when the circuit is employed at a slave station, or through R102, a part of the input attenuator, when used at a master station. The two different circuit paths are provided so that the 100-kc phase shifting arrangement may be disconnected for master operation. The 100-kc amplifier provides a large amount of gain so that the second and third stages are highly overdriven and thus act as limiters to smooth out any variations of input signal amplitude.

V103A, the first stage, is a conventional resistance-coupled amplifier. The second stage, V103B, is also conventionally resistance coupled; however, because it is overdriven, the grid draws current on positive signal peaks and grid leak bias is thus developed. The grid leak bias varies as a function of the driving signal and therefore acts to keep the output voltage constant. The third stage, V104A, is similarly overdriven to further limit the signal amplitude. This stage incorporates a tuned plate load, L103 and C111, to attenuate any harmonics generated by the nonlinear plate swing inherent in limiter operation. Output voltage is coupled from the plate of V104A to an output cathode follower, V104B, and through voltage divider R155 and R112 to the transmitter phase shifter.

The output cathode follower, V104B, employs inductance L101, tuned to resonance by the capacity of the interconnecting coaxial cable, as a cathode load. This arrangement is made necessary because of the large amount of cable capacitance involved. If a resistance loaded cathode follower were used, the phase

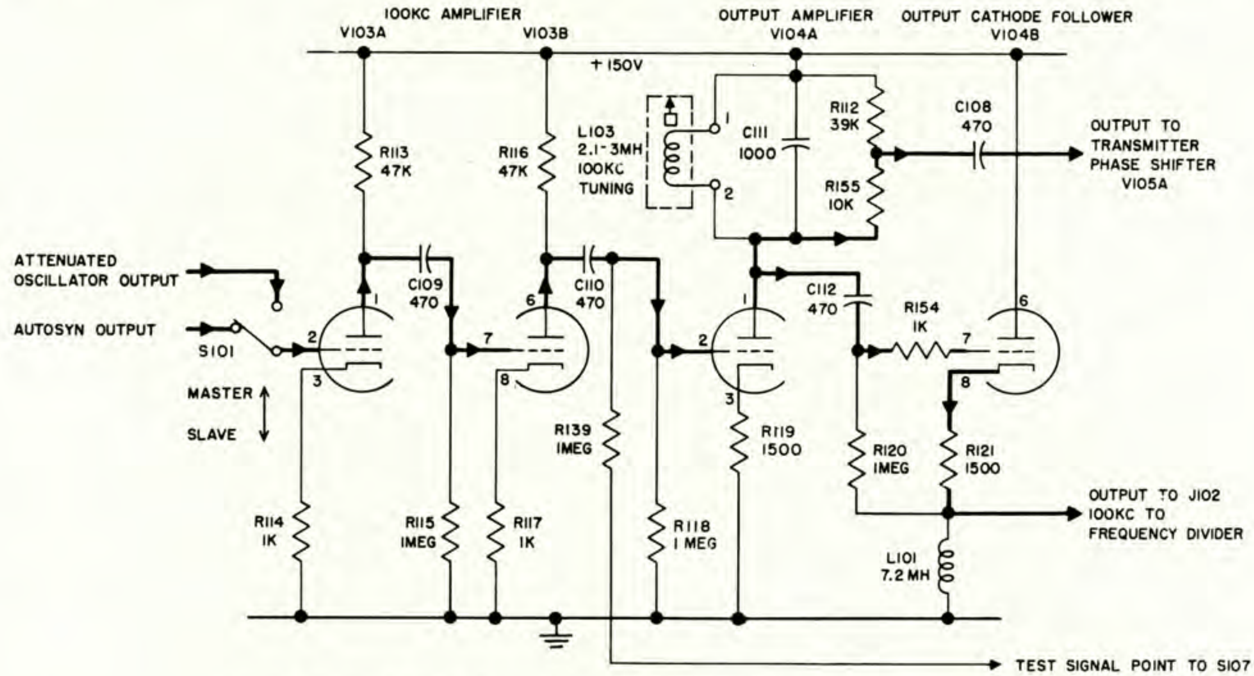


Figure 2–51. 100-kc Amplifier and Cathode Follower, Schematic Diagram

shift in the cathode circuit, caused by the shunt capacitance of the cable, would prevent the cathode from following the grid excursions so that true cathode follower action would not result and the output impedance would be excessively high and the output voltage would be reduced. A low output impedance source, providing large output voltage, is required to drive the blocking oscillator in the frequency divider. Resistor R154, in the grid circuit of the cathode follower, is used to suppress parasitics.

(3) TRANSMITTER PHASE SHIFTER AND CATHODE FOLLOWER. — The transmitter phase shifter permits separate control of the phase of the 100-kc signal fed to the carrier frequency generating circuits of the transmitter. This control permits the carrier phase to be changed with respect to the phase of the transmitter trigger pulse so that r-f cycles may be aligned with respect to the pulse envelope. The circuit arrangement, shown in figure 2–52, is a phase splitter with special output connections. An equivalent circuit of the phase shifter, with an explanatory vector diagram, is shown in figure 2–53.

As illustrated in the equivalent circuit, the plate and cathode resistors, R123 and R156, are connected in series and have a common junction at the signal ground point. (The 300-volt B+ bus is held at a-c ground by the power supply output filter capacitor.) The tube output signal may be represented by μ (the amplification factor of V105A) times E_{gk} (the output signal at the tube grid as referred to the cathode), in series with R_p (the a-c plate resistance of the tube) and cathode-bias resistor R126. The tube output signal, E, is connected across plate and cathode resistors R123 and R156. (E appears between plate and cathode.) A phase shifting network, C114 and $R_{adj.}$ (a series resistance consisting of R128, R127, and R125) is connected across the tube output terminals. An output connection is taken between the common junction (of C114 and $R_{adj.}$) and ground.

A vector diagram may be drawn for this circuit, using arrows to show relative phase and amplitude for the voltages in the various branches. All vectors are referred to a common point, labeled A on each of the three drawings. Load branch No. 1 is purely resistive and is represented by two head-to-tail arrows which show equal amplitudes and no phase shift for the voltages in the plate and cathode load circuits. In load branch No. 2 the current will lead the applied voltage because the impedance is partly capacitive. The current vector is represented by a single arrow of arbitrary amplitude and is shown extending beyond the voltage vector. The phase of this current is leading and therefore the arrow is shown rotated counterclockwise from the arrows representing the load branch No. 1 vectors. The voltage and current through $R_{adj.}$ are in phase and therefore the $E_{R_{adj.}}$ vector coincides with the current vector. The voltage across C114 lags 90° behind the current and therefore the E_{C114} vector is shown perpendicular to the current vector. The two load branches are connected to a common generator; therefore, the voltages across each branch are necessarily equal and the E_{C114} vector must join the top of the E_{R123} vector. Thus, regardless of the setting of $R_{adj.}$, a right triangle is formed by the vectors representing

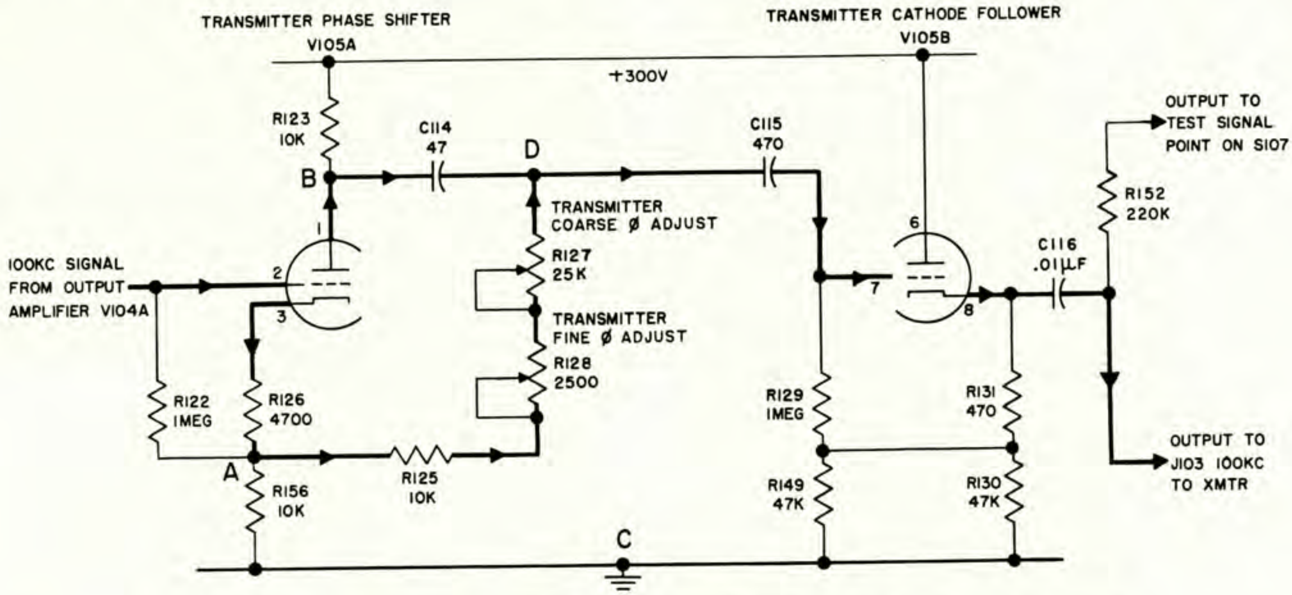


Figure 2–52. Transmitter Phase Shifter and Cathode Follower, Schematic Diagram

the voltages in the resistive and reactive loads of the circuit. By the geometrical relationship of a right triangle, the 90° junction of the $E_{Radj.}$ and E_{C114} vectors, labeled point D, will be located on a semicircle, regardless of the relative magnitudes of these two vectors.

Therefore, as $R_{adj.}$ is varied, point D moves on this semicircular path. The output voltage, E_{out}, is taken from the points labeled C and D on the drawings; E_{out} is the radius of a semicircle bounded by movable point D and is therefore constant for any setting of R_{adj}. The phase of E_{out}, as indicated by the angle of its vector, may be shifted anywhere along the 180° path of D, from A to B, by variation of $R_{adj.}$. This range is limited to about 40°, however, because of the limiting resistance imposed by R125. Because of the frequency multiplication process required to raise the 100-kc signal to the transmitter carrier frequency, this phase shift is multiplied to a useful range of about 720°; a larger range of phase shift would not be desirable. The two phase control potentiometers, R127 and R128, permit coarse and fine adjustment of the phase shift. The resistance of R128 is one-tenth that of R127 so that a given angular rotation of R128 produces only a tenth the phase shift of a corresponding rotation of R127. Thus, R128 provides fine control of phase.

The transmitter cathode follower is V105B, a conventional resistance loaded arrangement which provides a low impedance output to feed the transmitter signal via a coaxial cable. The low impedance, high voltage output provided by the circuit of the output cathode follower, V104B, is not required to drive the transmitter; hence the design of the V105B stage is less critical and resistance loading of the cathode circuit is used.

(4) TEST SIGNAL CATHODE FOLLOWER. *(Refer to figure 7–274.)*—The test signal cathode follower consists of a single stage, V106B, which provides a high impedance input, for minimum loading of the circuits under test, and a low impedance output, for minimum waveform distortion due to shunt capacitance of connecting cables. Isolation from the various circuits, which may be selected by means of TEST SIGNAL switch S107, is provided by the means of resistors inserted in series with each test point and the associated switch contact. Test points are the 100 KC INPUT, directly at the output of jack J101; the ϕ SHIFTER OUTPUT, at the grid of the output am-

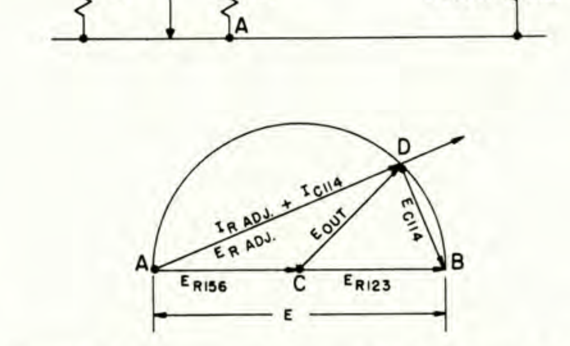


Figure 2–53. Transmitter Phase Shifter, Equivalent Circuit and Vector Diagram

plifier; the 100 KC TO XMTR output, at the output of the transmitter cathode follower; and the 100 KC TO FREQ DIV output, at the output of the output cathode follower.

(5) 60-CYCLE AMPLIFIER. — The 60-cycle amplifier provides sufficient amplification of the 60-cycle error voltage developed by the electrical synchronizer to power the sync control motor. This amplifier incorporates three stages. Refer to figure 2-54. The amplifier input circuit consists of the parallel tuned circuit, L102 and C107, which provides maximum transmission of the nominal 60-cycle input signal and attenuates the noise components generated by the gating process which supplies the error voltage. L102 is an adjustable reactor which may be varied to tune the circuit over the power frequency range of 50 to 65 cycles. The error voltage is reduced to a suitable amplitude by voltage dividers R108 and R140 and applied to the grid of V102B, a class A resistance-coupled amplifier. The amplified error voltage is applied to a cathode follower stage, V102A, which is used as a limiter for the control of maximum motor speed. Limiting is controlled by R157, the MAX MOTOR SPEED control, which varies the d-c voltage applied to the plate of cathode follower V102A. Lowering the plate supply voltage lowers the maximum output voltage capability of the cathode follower so that each position of this control corresponds to a specific maximum output. This output cannot be exceeded regardless of input signal amplitude.

Since the gain of a cathode follower does not change to anywhere near the degree that the plate voltage changes, the sensitivity of the cathode follower is relatively constant, even though the output capability is made variable. Examination of the output waveforms of this circuit for different settings of the maximum motor speed control reveals clipped sine waves rather than saturated sine waves, as might be expected. The reason for this is that as the plate voltage is reduced, thus reducing cathode bias, the input signal exceeds the bias voltage and grid current is drawn. Grid current develops grid leak bias to increase the grid-cathode negative potential and drive the tube to cutoff so that the output consists of only the positive peaks of the input signal. The advantage of this type of circuit is that it is possible to operate the synchronizer at low maximum motor speeds, which minimize errors caused by noise fluctuations, and still maintain extremely good sensitivity to actual errors.

It should be noted that the designation MAX MOTOR SPEED means the fastest speed that the motor can attain, for a given control setting, no matter how large the synchronization error may be.

The output of the maximum motor speed control cathode follower, V102A, is fed to the motor amplifier stage, V107, a pentode power amplifier which is transformer-coupled to one winding of the two-phase sync control motor (B103). Resistor R136, in the grid of this stage, suppresses any tendency to parasitic oscillation. Switch section S104B is part of the AUTO SYNC ON-OFF switch. This section shunts the grid of the motor amplifier stage, V107, to ground, to stop the motor whenever the phase clutch is disengaged. The phase clutch is disengaged by S104A to permit manual operation of the PHASE dial.

Power for all three of the motor amplifier stages is supplied from the regulated 300-volt B+ bus via switch section S102B and decoupling filter R158 and C117. Resistor R158 reduces the voltage applied to V107 to a value within the rating of the 6AQ5W tube. 60 CYCLE AMPL PWR switch S102 controls application of B+ and filament voltage to the amplifier and application of 60-cycle line voltage to the remaining winding of the two-phase sync control motor. This switch should be turned OFF only if a long period of manual synchronization is contemplated.

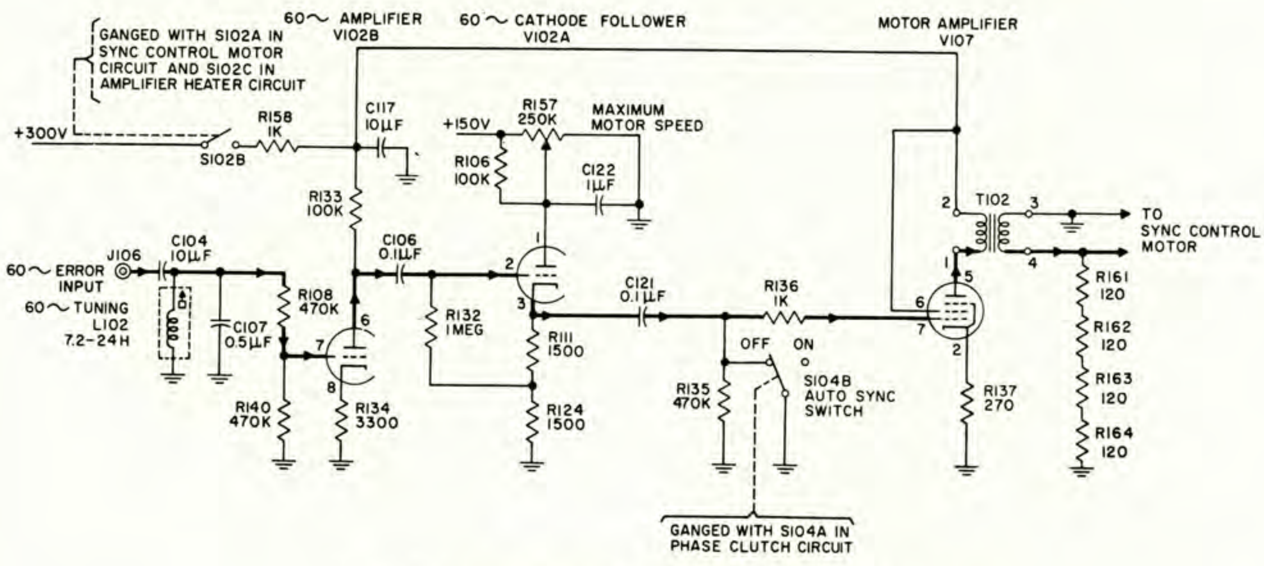


Figure 2-54. 60-Cycle Amplifier, Schematic Diagram

(6) GEAR DRIVE SYSTEM.—The arrangement of the gear drive system is detailed in figure 2–55. The drawing illustrates how the gear shift operates to provide an 8:1 speed change and shows how the phase and frequency correction controls are geared together.

The gear system is driven by the sync control motor. A gear on the motor shaft drives a feedback generator and also drives shaft #1 of the gear drive system. Shaft #1 is driven at one-fourth the motor speed. A speed change gear rotates with shaft #1 and slides laterally along a splined segment of this shaft. In the HIGH speed position, this gear engages the large gear shown at the end of shaft #2 and drives shaft #2 at one-fourth the speed of shaft #1. In the LOW speed position the speed change gear engages the larger of a pair of gears which rotate about shaft #2. The smaller of this pair engages the larger gear of a similar pair rotating about shaft #1. The smaller gear of this second pair engages a large gear on shaft #2 and drives shaft #2 at 1/32 the speed of shaft #1. Thus, the speed change gear effects an 8:1 speed change.

The speed change gear is moved laterally along shaft #1 by a sliding yoke which engages a collar located between the toothed ends of the gear. The yoke may be locked in either position by means of a knurled thumbscrew located on its top surface. A cam surface projects from the side of the yoke to engage two switch rollers to actuate microswitches S109 and S110. S109 selects a portion of the generator output voltage, in the LOW speed position, to reduce the feedback voltage. S110 operates one of two MAX MOTOR SPEED indicator lamps on the front panel to indicate the speed range in use.

This gear shift provides the wide ratio of maximum to minimum correction speeds required of the synchronizing system. The system is capable of correcting an error at a rate as fast as 60 microseconds per minute or as slow as 1 microsecond per minute. With a single gear ratio arrangement, the motor would be required to work very slowly at the slowest correction speed. At very low speeds motor torque is low, and the motor runs very erratically because it is sensitive to changes in load caused by minor imperfections in the gear train. Shifting gears permits faster motor speed, for a given PHASE dial speed, and also reduces the load on the motor.

A FINE PHASE dial is located at the panel end of shaft #2 and may be observed through a round plastic window in the panel. The FINE PHASE dial is useful only with automatic synchronization control; it is disconnected if synchronization is to be controlled manually. Because the PHASE dial rotates at 1/20 the speed of the FINE PHASE dial, each revolution of the FINE PHASE dial corresponds to 0.5-microsecond phase shift. The FINE PHASE dial is engraved with five radial lines; each line indicates a 0.1-microsecond phase shift.

A small gear on shaft #2 drives a large gear on shaft #3 to produce a 4:1 speed reduction. A small gear on shaft #3 drives a large gear which rotates about shaft #4. A magnetic clutch plate is riveted to this large gear and positioned next to a magnetic clutch which rotates with shaft #4. When the clutch is energized, by 24 volts dc applied to slip rings on the clutch, the clutch grips the clutch plate so that shaft #4 rotates at one-fifth the speed of shaft #3. Shaft #4 drives the PHASE dial, the autosyn, the two precision potentiometer sections, R138A and R138B, and a master sync error cam. At a master station this cam engages a roller on microswitch S108 to close the switch when PHASE dial rotation exceeds preset limits established by the cam position. The cam consists of two separate sections which may be adjusted to operate the switch on a ±1- to a ±3-microsecond error. The switch is used for master operation, to control the sync-error alarm circuit in the electrical synchronizer. A cogwheel is also provided on shaft #4 and is used in conjunction with an adjustable stop to limit PHASE dial rotation to less than 360°. The adjustable stop consists of a screw which may be adjusted to engage a single cog on the cogwheel and so prevent continuous rotation of the PHASE dial at a master station. This screw must be retracted to clear the cog at a slave station. With rotation of shaft #4 arrested by the stop, there is sufficient clutch slippage to permit the motor to continue driving shaft #3. A small gear on shaft #4 drives a large gear on shaft #5 to provide a 4:1 speed reduction. Similarly shaft #6 is driven at one-fourth the speed of shaft #5 and a large gear rotating around shaft #7 is driven at one-fourth the speed of shaft #6. A clutch plate, riveted to this large gear, is operated by a clutch mechanism identical with that on shaft #4. Thus, shaft #7 is driven at 1/64 the speed of shaft #4. Shaft #7 drives the FREQUENCY CORRECTOR dial, frequency corrector capacitor, C120, and a frequency warning cam. This cam is arranged to trip microswitch S105 whenever C120 is rotated beyond its normal 180° range. Switch operation lights indicator lamp I105. This arrangement warns the operator that the frequency of Radio Frequency Oscillator Type O–202/FPN–30 has drifted beyond the range of control of C120 and must therefore be reset by means of the FINE FREQ. ADJ. control on the oscillator.

Power to operate the phase and frequency clutches is provided by a transformer, T101, and a full wave bridge rectifier, CR101. T101 supplies 6.3 volts ac for all filaments of the sync control unit and provides 28 or 32 volts for CR101. The d-c output of CR101 is nominally 24 volts; the different input voltages permit compensation for the voltage drop accompanying rectifier aging.

The feedback generator provides a d-c voltage which is directly proportional to motor speed and which has a polarity that depends upon the direction of motor

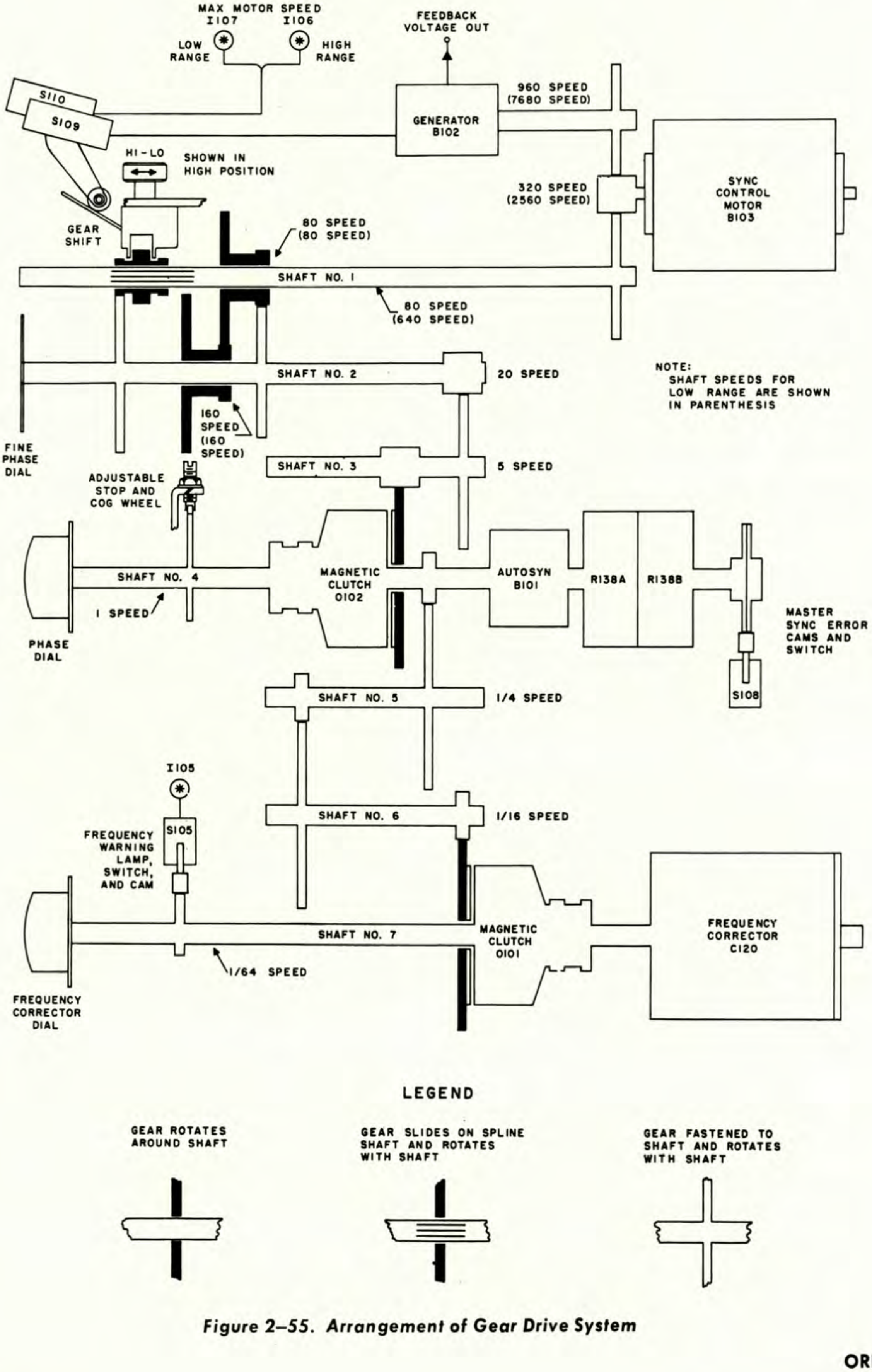


Figure 2–55. Arrangement of Gear Drive System

rotation. This voltage is used in a negative feedback system which provides electrical braking to check the speed of the motor. This braking overcomes the tendency of the motor to overshoot the zero error point because of motor inertia. Thus any possibility that the system might hunt is eliminated. The feedback voltage is fed to a circuit in the electrical synchronizer in such a way that the feedback acts upon the 60-cycle error voltage to check the speed of the motor and prevent hunting. Because of time lags inherent in the synchronizer circuit the system would overbrake if the full generator output were used in the LOW speed setting of the gear drive. Full generator voltage is required in the HIGH speed setting. Accordingly, the switching system described previously is used to reduce generator output in the LOW speed setting of the gear shift yoke. The behavior of the feedback to prevent hunting will be described in greater detail in the discussion of the electrical synchronizer, paragraph 4*g*.

The two precision potentiometer sections, R138A and R138B, control recorder drive and the master gate position, respectively. R138A is connected to the recorder drive bridge circuit which includes R144, R145, and R146. Refer to figure 2–56. R145 is a potentiometer which permits adjustment of the bridge balance point, to compensate for component tolerances, so that bridge balance (to zero the recorder pen) may be obtained with the PHASE dial set at the zero error position. R141 and R142, in series with one of the bridge output terminals, limit the bridge output current. Potentiometer R142 permits adjustment of the output current so that when the PHASE dial is set for a 4-microsecond error the pen deflection indicates a 4-microsecond error. Maximum pen deflection, away from center, occurs when the coil current is ±0.5 milliampere. D-c voltage, to power the bridge, is obtained from the —30-volt bias supply.

During operation, whenever the PHASE dial indicates a particular reading (away from 0), the bridge will be unbalanced and cause a current of the proper magnitude to flow in the recorder pen circuit to make the pen indicate the PHASE dial reading. By this action the recorder provides a permanent record of PHASE dial position.

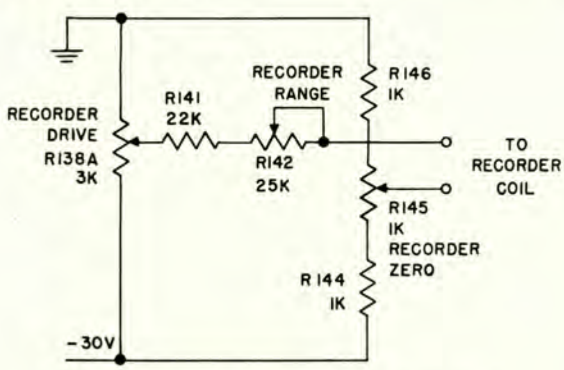


Figure 2–56. Recorder Drive Control, Schematic Diagram

The master delay control, R138B, is a 5,000-ohm potentiometer which is wired to the master delay circuit in the electrical synchronizer. The function of this potentiometer is to control gate delay at a master station only. This is explained fully in the description of the electrical synchronizer, paragraph 4*g*, later in this section.

c. FREQUENCY DIVIDER TYPE CV–274/FPN–30. —The functional description of the frequency divider in paragraph 3*c*, preceding, discussed the theory of frequency division without reference to the signal path through the frequency divider. In discussing the detailed theory of operation of frequency divider circuits this paragraph carries the description through the frequency divider from input to the various outputs.

(1) 10-MICROSECOND BLOCKING OSCILLATOR.—The 10-microsecond blocking oscillator shapes the 100-kc timing signal to obtain sharp negative output pulses to drive the 1 stage of counter 1 and for use as 10-microsecond markers.

The circuit, shown in figure 2–57, consists of triode stage V202B which employs a transformer, T201, with two closely coupled windings that provide a large amount of regenerative plate to grid feedback. If it were not for the action of capacitor C203, in series with the transformer grid circuit, the stage would operate as a conventional regenerative oscillator.

Because of the large negative bias applied through R203, the stage is inoperative in the absence of an input signal to terminal 1 of T201. A positive peak of the 100-kc timing signal overcomes the bias to start the oscillatory cycle. Positive voltage at the grid causes an increase in plate current which appears at terminal 2 of T201 as a positive voltage. Thus the regenerative cycle is started, and plate current increases to the point of tube saturation. The large induced grid voltage drives the grid considerably positive so that the resulting grid current charges capacitor C203. When the

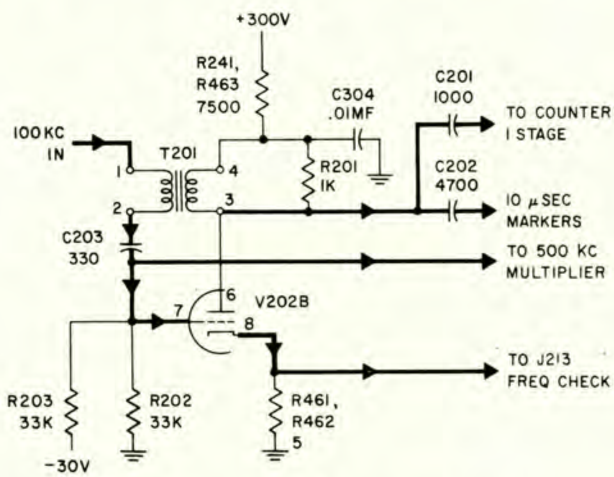


Figure 2–57. 10 μSec Blocking Oscillator, Schematic Diagram

inductive field of T201 collapses, capacitor C203 discharges, through R202 and R203, developing a voltage which swings the grid far below cutoff. The period of this portion of the cycle, which yields a steep, high amplitude, negative output pulse at the plate, is determined primarily by the natural frequency of T201. The period is influenced to a slight extent by the amount of regeneration employed and by the nature of coupling capacitor C203. Resistor R201 damps the tuned circuit to minimize the positive overshoot which would otherwise occur as a result of transformer ringing.

The latter portion of the cycle is a quiescent period during which the tube is held at cutoff by the charge accumulated across C203. This period lasts until C203 discharges sufficiently, via R202 and R203, to permit triggering the tube with the next positive excursion of the 100-kc timing signal. Thus the blocking oscillator produces a single pulse, of shorter duration than the period of one input cycle, for each cycle of the 100-kc timing signal. The phase and repetition period of this pulse are directly controlled by the timing signal.

Several useful outputs are taken from the blocking oscillator. Most important is the plate signal voltage coupled via C201 to drive the 1 stage of counter 1. Also taken from the plate is the chain of 10-microsecond markers which are used for display on the timer oscilloscopes. The use of separate coupling capacitors isolates the loading of the 1 stage of counter 1 from the marker circuits. Positive signal pulses are taken from the grid and used to drive the 500-kc multiplier which is part of the 1-microsecond marker generation circuit. The cathode circuit provides a small 100-kc signal with high harmonic content which is made available as a timer output for frequency checking purposes. The extremely small resistance of R461, in parallel with R462, provides a low impedance output which does not affect the performance of the blocking oscillator regardless of external connections.

(2) BINARY COUNTER STAGE.—The binary counter stage is the basic element of each of the three counters employed in the frequency divider. Consequently, the detailed description of these counter circuits is preceded by an explanation of how the binary stage divides by two.

A binary counter stage consists of a dual triode, with resistance-capacitance cross coupling between plates and grids, arranged so that the stage will seek one of two steady states. In one state triode section A will conduct and B will be cut off; in the other state triode A is cut off and B conducting. The sections are made to reverse state by application of a negative driving signal. Figure 2–58 illustrates a representative arrangement.

Plate load resistors R1 and R2 apply operating voltages to the two triode sections. Both cathodes are connected together and a large amount of cathode bias is provided by R8. Capacitor C3 bypasses the cathodes to signal voltage. Each grid is connected to the opposite plate by a resistor shunted by a capacitor so that d-c and a-c coupling is provided. The grids are isolated from each other by resistors R5 and R6 and connected to ground through the common impedance of R7. Input voltage is coupled to both grids through C4. Output voltage is taken from the section B grid via C5. A small neon lamp, I1, is connected, in series with current limiting resistor R9, from plate to cathode of section A. This lamp glows when the section is not conducting. In this state the stage is considered *on.*

Our study of the binary cycle starts with section A conducting and section B cut off. With the application of a negative input pulse through C4, the conduction of section A will be reduced; section B, already at cutoff, will not be affected by the negative pulse. The drop in conduction of section A results in an amplified positive plate swing which is coupled to the grid of section B. This positive swing overcancels the negative input pulse delivered to the section B grid and therefore increases the conduction of section B. This drops the section B plate voltage to couple a negative signal to the grid of section A. This negative signal reinforces the negative input pulse which started the cycle so that a regenerative condition is established which very rapidly drives section A to cutoff and section B to saturation. Thus the initial steady state condition has been reversed by application of the negative driving pulse.

The circuit remains in its steady state because of the d-c couplings through R3 and R4. With section A cut off, its plate voltage is approximately 200 volts.

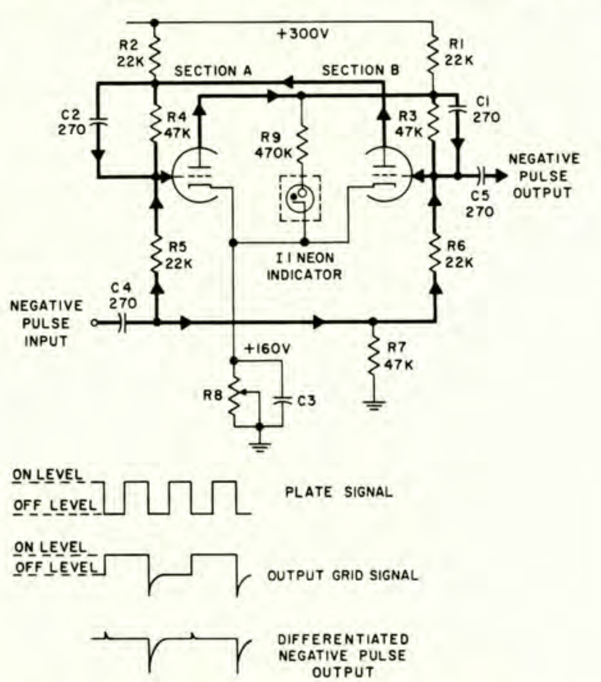


Figure 2–58. Typical Binary Counter Stage, Simplified Schematic and Waveforms

Voltage division through R3, R6, and R7 provides a voltage in excess of the 160-volt cathode bias at the grid of section B so that B conducts heavily. The resulting current through R2 lowers the plate voltage of section B so that the voltage at the grid of section A is sufficiently less than the 160-volt cathode bias, and section A is cut off. This state will be maintained until the application of another negative driving pulse. A positive pulse, of moderate amplitude, cannot cause a reversal of state because the saturated section B cannot be made to draw more current and because section A, at cutoff, is biased to an operating region where the gain is so reduced that the positive grid drive is ineffective.

Essentially negative output pulses are produced by the binary stage, as shown in the waveforms of figure 2–58. Because of the action of C1 with R6 and R7, the voltage applied to the grid of section B from the plate of section A has a sharp differentiated peak which overshoots the *off* level established by voltage division across R3 in series with R6 and R7. This action, caused by C1, is desirable because the full plate swing is coupled to the grid to increase regeneration and thus speed the time for switching from one state to the other. There is no overshoot beyond the *on* level because the saturated B section grid draws current to limit the driving signal and thus prevent positive excursion. Thus the negative swing of the output (B section) grid yields a larger pulse, for driving the next stage, than the positive swing. Advantage is taken of this grid waveform overshoot to obtain a larger negative peak than the positive peak by taking the output pulse from the grid. The difference between negative and positive peak amplitudes is further magnified by the output differentiating circuit because of a difference in rise time between negative and positive pulses. Because of this difference the sharper negative pulse is differentiated to a higher amplitude than the positive pulse. The rise time of the positive pulse is slowed because the A section is always going from conducting to cutoff coincidently with the generation of positive B section output pulses and, in this direction, the internal resistance of the A section increases to increase the time constant consisting of shunt circuit capacitances in series with the tube and other circuit resistances.

Each negative driving pulse causes a reversal of state, so that the stage goes *off* with every alternate negative driving pulse. Each time the stage goes *off*, it transmits a negative driving pulse to the next stage via differentiating capacitor C5. Because this output is produced only once for every other input pulse, the circuit divides by two.

The normal driving pulse is applied to the common grid connection at the junction of R5, R6, and R7 so that it affects each grid alternately. A negative pulse applied directly to the A section grid is only effective for turning the stage *on;* similarly, a pulse applied directly to the B section grid is only effective for turning the stage *off*. The pulses applied directly to the A or B grids require less amplitude, to be effective, than pulses applied to the common input for both grids.

The frequency divider employs a circuit arrangement which provides increased operating stability. The arrangement is a common cathode resistor, R282 (equivalent to R8 in figure 2–58), for all binary stages of all three counters. This resistor, the COUNTER BIAS potentiometer, provides a stable bias voltage which results from the total current flow of all binary stages. Adjustment of this control over the maximum and minimum range of bias at which all counter stages operate provides a test feature which rapidly detects any weak tubes before they deteriorate to the point of failure. The control is equipped with a calibrated dial so that the marginal limits may be periodically logged and any major change of performance noted. The most important contribution to stability made by this feature is that the control may be set midway between operating limits so that optimum bias is provided. With this optimum bias, maximum freedom from the effects of drift of component characteristics is assured.

(3) COUNTER 1.—Counter 1 employs four consecutive binary stages to provide a total count of ten. The inherent count of 16 is modified by resetting to provide a decimal count, as discussed in paragraph 3*c* (1) (*c*) preceding. Refer to figure 2–59. It will be noted that the 1 stage is provided with additional cathode bias by means of bias resistor R458, which is bypassed by C271. This added bias has been provided to make the stage responsive to test counts. The reset pulse obtained from the 1 stage is taken from the junction of R211 and R212, in the plate circuit of V203A, and fed to the *off* grid of the 8 stage, V206B. This grid is also the counter 1 output grid which feeds driving pulses to counter 2. Because the reset pulses are taken from the 1 stage at reduced amplitude, they do not operate counter 2. They do reset the 8 stage, however, because they are applied directly to the *off* grid instead of the common connection to both grids. A reset pulse is also taken from the junction of R239 and R240, in the plate circuit of V206A, to prevent the 2 stage from coming *on,* at the time the 8 stage is reset. Thus the reset pulses are generated to restore the counter to its initial state (all stages *off*) at the count of ten.

Counter 1 is preset to provide 50-microsecond decrements of the loran half-cycle for odd numbered specific rates by application of preset #1 pulses to the 1, 2, and 4 stages. Pulses are applied to the *on* grids of the 2 and 4 stages via R214 and R225 and to the *off* grid of the 1 stage via R213. This presets counter 1 to a count of six, and, at the same time, blocks out the first normal driving pulse, as explained in paragraph 3 *c* (2) (*b*), preceding, to shorten the count by 50 microseconds. Presetting is employed only for odd rates. Preset pulses are applied via contacts of SPECIFIC RATE switch S202.

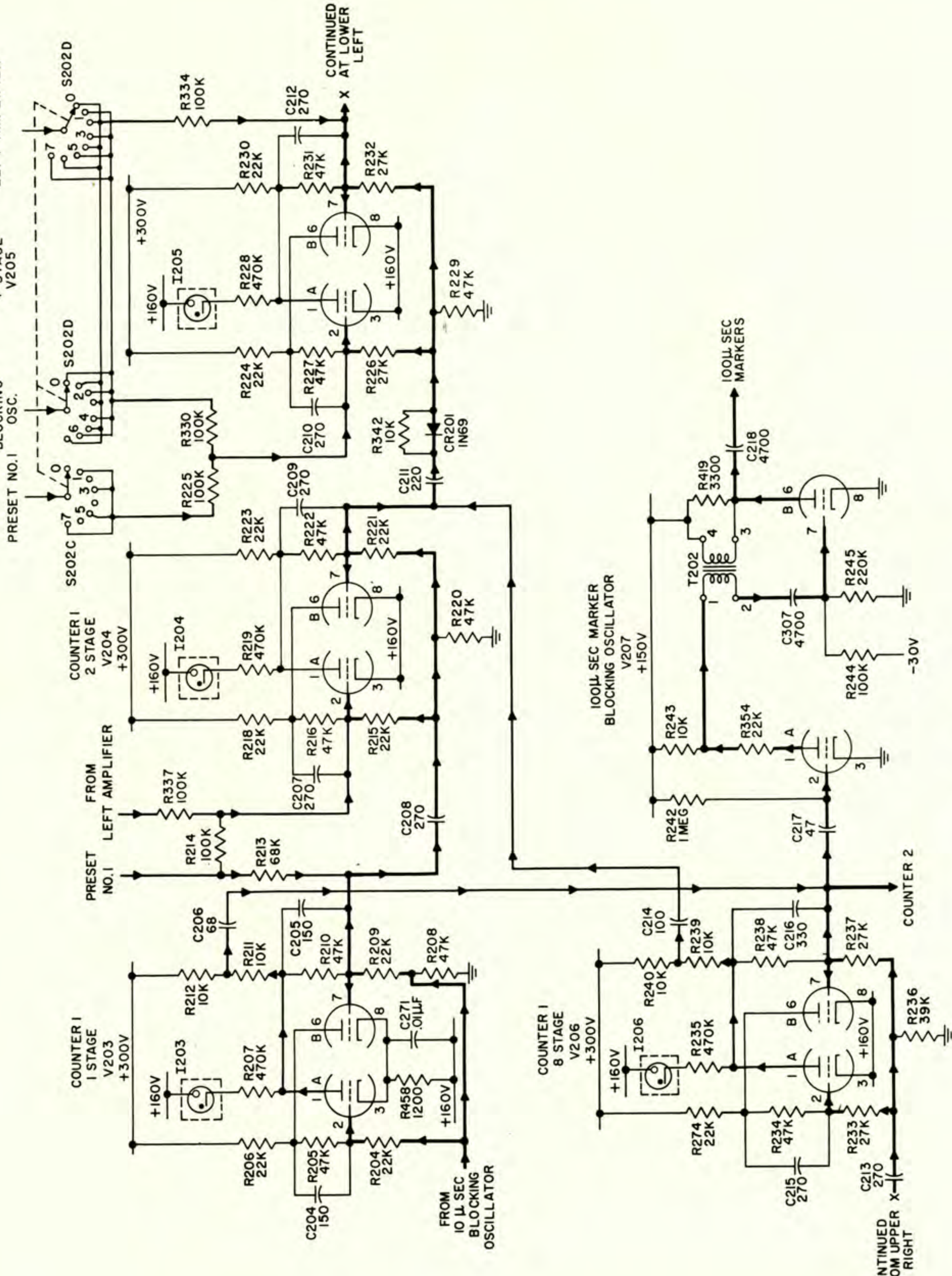


Figure 2–59. Counter 1, Schematic Diagram

The output of counter 1 drives counter 2 via C242 (shown in figure 2–60). Counter 1 output is also used to drive the 100-microsecond marker blocking oscillator, V207, via C217. V207A is an amplifier stage used to provide high amplitude positive driving pulses to the grid of oscillator stage V207B. The grid of V207A is returned to B+ via R242. This arrangement sharpens the input pulse to V107A because C217 charges more rapidly towards B+ than to ground. Decreased charging time results because of the greater voltage difference, which produces a faster exponential rise. The rise is arrested at the grid current point.

V207A output is taken from the junction of voltage divider resistors R243 and R354 which provides a low impedance source for driving V207B. The positive output signal times the recurrence interval of V207B, the blocking oscillator stage, which operates in the same way as the previously described 10-microsecond blocking oscillator, V202B. The resulting 100-microsecond marker pulses are delivered to other timer circuits.

(4) COUNTER 2.—Counter 2 is a 4 stage binary counter employing the same decimal feedback arrangement used in counter 1. Refer to figure 2–60. Preset pulses are applied to counter 2 to modify the count in decrements of 100 microseconds. Specific preset applications, for each rate, are provided by the different positions of SPECIFIC RATE switch S202 which applies preset and holding pulses to the 1 stage and 2 stage of counter 2. Holding pulses are applied permanently to the *off* grid of the 8 stage to prevent spurious triggering of that stage. The pulses used to preset and hold counter 2 stages are preset #2 output pulses.

The detailed arrangement for obtaining each specific rate, by presetting, is explained in paragraph 3 *c* (2) (*b*), preceding.

The output of counter 2 drives counter 3 via C285 and drives the 1,000-microsecond marker blocking oscillator, V212, via C256. Operation of V212 is identical to that of V207, the 100-microsecond marker blocking oscillator.

(5) COUNTER 3.—Counter 3 is a 5 stage binary counter which depends upon presetting to modify its count to 15, 20, or 25. This change of count permits change of basic rate. Preset application for the development of the basic rate was previously discussed in paragraph 3 *c* (2) (*a*). Except for the routing of preset #2 pulses through BASIC RATE switch S205, the stages of counter 3 are similar to those of the other two counters.

Counter 3 output drives the two preset stages which, in turn, drive the square-wave generator. Thus, each cycle of counter 3 controls the duration of a loran half-cycle.

(6) PRESET STAGES.—Preset pulses are derived from two stages which provide preset #1 and preset #2 outputs. Refer to figure 2–61. Preset #1 pulses are taken from the output of a dual triode amplifier, V218. The input triode, V218A, is zero biased through return of grid resistor R406 to the +300-volt bus. This arrangement sharpens the pulse in the same manner as the similar circuit of V207A, described in paragraph 4 *c* (3), above. The amplified output of V218A drives negatively biased V218B from cutoff to saturation so that the preset #1 amplitude is determined by the maximum plate swing of V218B. The negative output pulses at the plate of V218B are fed through C302 as preset #1 pulses and are also used to drive the preset #2 stages via C303.

The preset #1 pulses are sharp narrow pulses used to modify the count of counter 1. Narrow pulses are required in counter 1 because of the short repetition intervals of the pulses that enter that counter. The wider pulses of preset #2 are applied to counter 3 which requires wide pulses because its circuits employ longer time constants. Counter 2 is also fed by preset #2 pulses because the preset #2 output circuit is low impedance and can stand the extra loading better than the preset #1 output circuit. It is necessary to delay the preset #2 pulses slightly to prevent degeneration of the counter 3 output pulse on the high basic rate. On that rate the 16 stage of counter 3 is preset *on* immediately following the counter 3 output pulse which is generated when the 16 stage goes *off*. If the preset pulse occurred too soon, the 16 stage might not go fully *off* before it was preset *on*, and the resulting low amplitude output pulse would deteriorate the preset #1 pulse so that preset #1 pulses would not be effective.

Delay of the driving pulse to the preset #2 generator stage is explained in figure 2–62. The negative pulse charges C303 through the diode connected triode, V219A. The time constant for this charge is determined by the impedance of the driving pulse source and by C303. Because the diode has very low forward resistance, it does not influence this time constant, and negligible output appears across the diode. At the termination of the input waveform the charge across C303 is impressed across R411. The resulting positive pulse decays exponentially according to the discharge time constant of the R-C network. The leading edge of the output pulse starts at the time of the trailing edge of the input pulse; hence the delay is determined by input pulse width.

The delayed positive output of V219A is used to drive preset #2 blocking oscillator V219B. The operation of this circuit is similar to other blocking oscillators; however, positive excursions of the collapsing field are prevented by clamp V231B so that only negative output pulses are produced and the output pulses are broadened by using a large value of grid coupling capacitance.

The output of the blocking oscillator is applied as the preset #2 output pulse via C305. This output is also used to drive the square-wave generator via C308 and the slow sweep generator via C219 and isolation diode V224B.

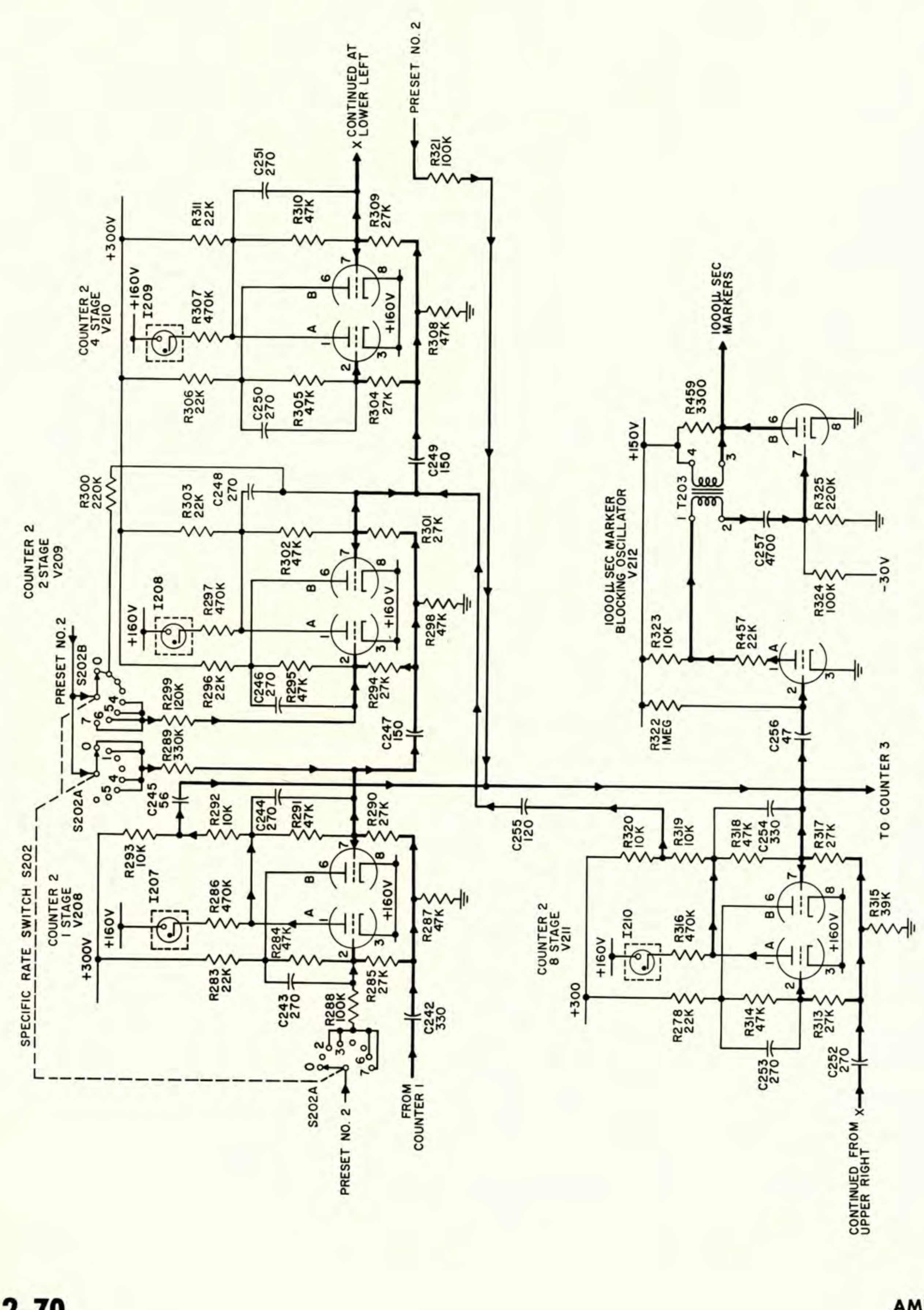


Figure 2-60. Counter 2, Schematic Diagram

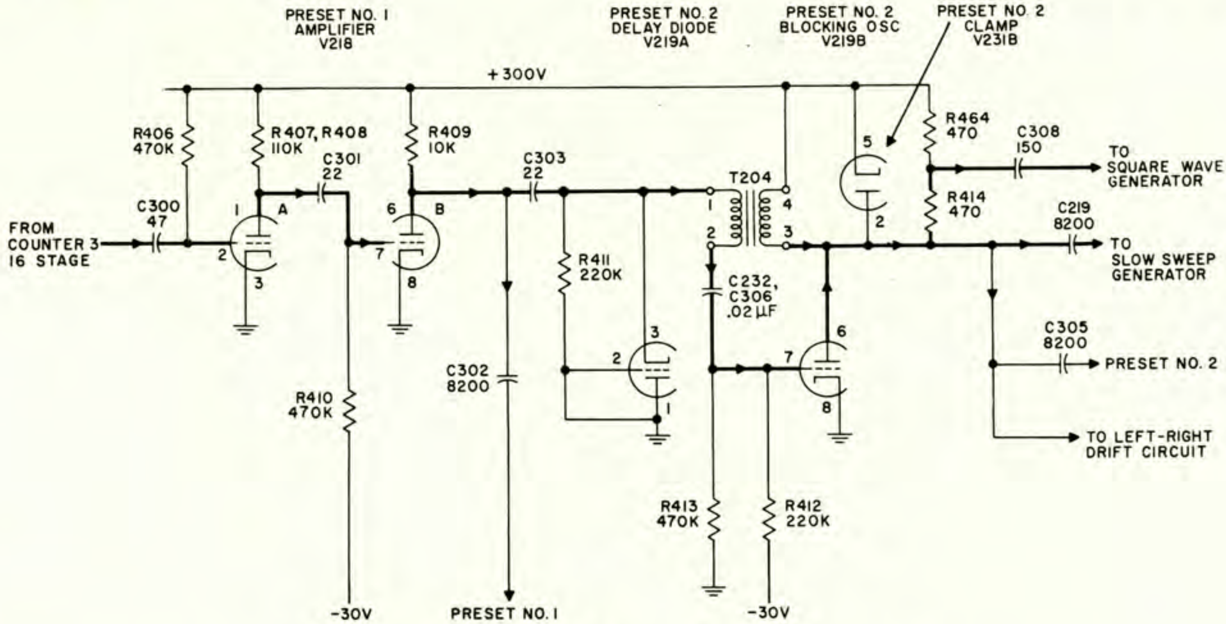


Figure 2–61. Preset Stages, Schematic Diagram

(7) SQUARE-WAVE GENERATOR AND OUTPUT AMPLIFIER.—The square-wave generator is a binary stage. Refer to figure 2–63. Because of the symmetrical configuration of a binary stage, the output waveforms are identical except that they are 180° out of phase. Square waves of both phases, i.e., ϕ 1 and ϕ 2, are taken from the plates of V220. The output of V220 is fed to a push-pull output amplifier, V221, via isolation resistors R424 and R433 and coupling capacitors C311 and C314. The output amplifier is driven from cutoff to saturation and therefore acts as a clipper-limiter to provide constant output. The stage provides low impedance output because of the low value plate resistors (R428, R429; R430, R431) used. To limit plate current, with these low value plate resistors, the stage is operated from the regulated +150-volt bus.

(8) LEFT-RIGHT DRIFT CIRCUITS.—The left-right drift arrangement was discussed in paragraph 3 *c* (3), preceding. It will be recalled that left or right drift is obtained by feeding pulses back to the 4 stage of counter 1. For left drift the feedback pulse serves to block out a normal input pulse, thereby increasing the repetition interval and causing apparent motion of the remote pulse to the left. For right operation the feedback pulse serves to introduce an extra input pulse, thereby shortening the repetition interval and causing apparent motion of the remote pulse to the right. Fast and slow rates of drift are obtained by providing feedback pulses at a rate of either two per loran cycle or one per three loran cycles respectively.

The circuits which provide drift include the left-right divider, the fast left-right cathode follower, the left-right amplifier, the left-right delay diode, the right blocking oscillator, and the left amplifier. Refer to figure 2–64.

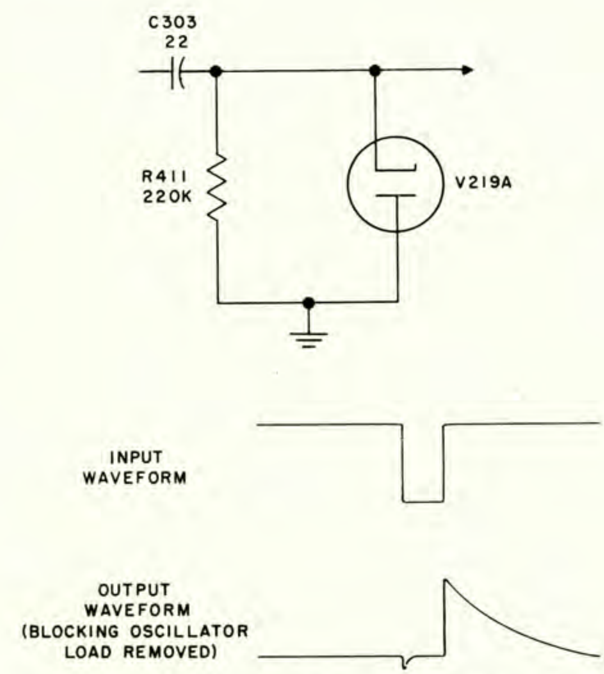


Figure 2–62. Preset #2 Delay Diode, Simplified Schematic and Waveforms

The left-right divider consists of two binary stages, V233 and V234, modified by feedback from the output of the left-right amplifier, V228, to divide by 3. Square wave is applied to the divider via isolation diode V231A. V231A passes only negative pulses through differentiating capacitor C315 to drive the 1 stage. Thus one output pulse is produced for every three square-wave cycles.

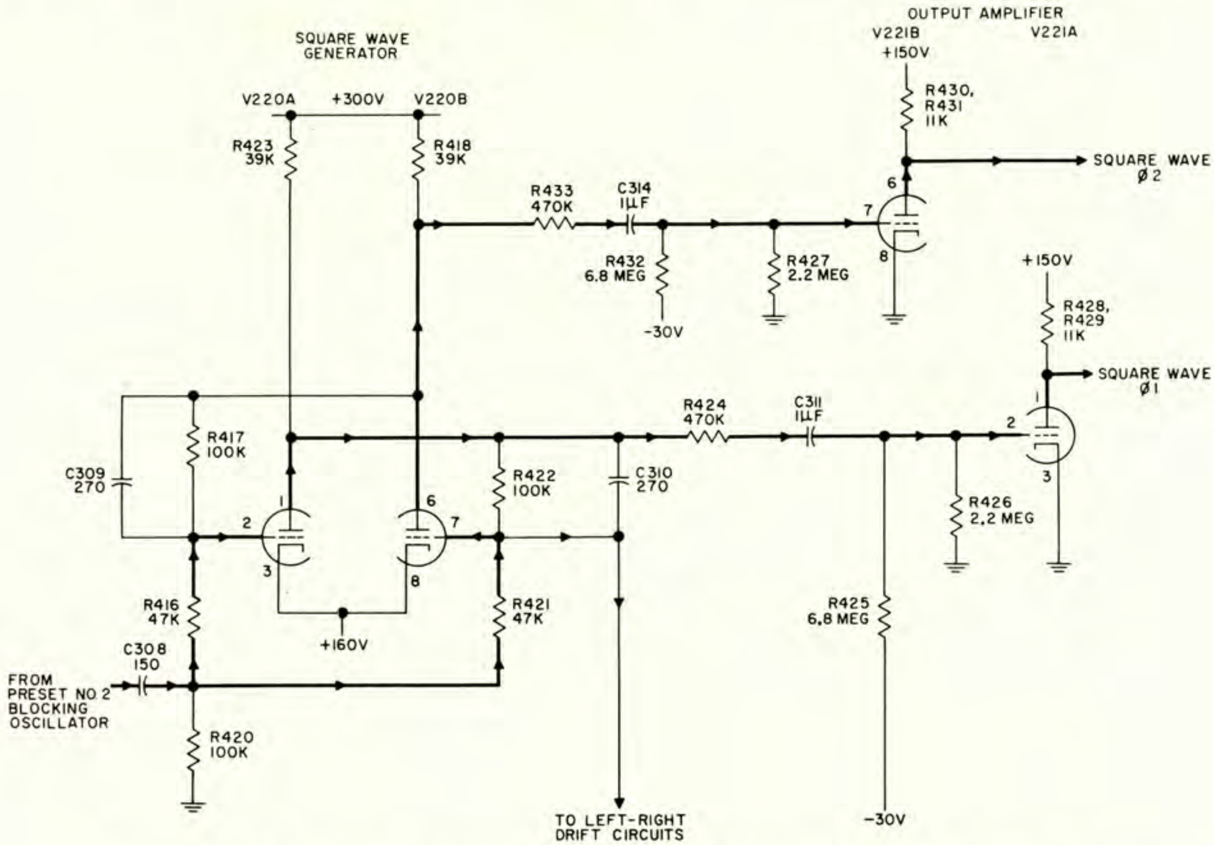


Figure 2–63. Square-wave Generator and Output Amplifier, Schematic Diagram

The fast left-right cathode follower, V230B, is driven by output pulses from the preset #2 blocking oscillator. A delay network, R338 and C269, provides the same order of pulse delay as does the left-right divider so that the output pulses of the two circuits are approximately coincident; however, because V230B is driven at twice the square-wave rate, the output of the fast left-right cathode follower occurs six times as frequently as the output of the left-right divider.

Output of either the left-right divider or the left-right cathode follower is selected by the slow-fast relay, K203, to provide a pulse at one of two rates. The selected output is amplified in the left-right amplifier, V228. The grid of the input section, V228B, is returned to the +300-volt bus to sharpen the pulse by increasing the charging rate of C321. The output stage is biased to cutoff and is driven from cutoff to saturation to provide an output pulse with a large fixed amplitude. Output is fed via coupling capacitor C274 and voltage dividing resistor R451 to the *off* grid of the left-right divider 1 stage, V233, to preset the divider for a count of three. Output is also fed to the left-right delay diode, V229A.

The delay diode, V229A, operates in the same way as the preset #2 delay diode, V219A, to produce a positive pulse whose trailing edge corresponds in time to the trailing edge of the input pulse. This positive pulse is delayed approximately 23 microseconds from the start of the counter 1 counting cycle by the delays accumulated in the three counters, in the preset stages and in the left-right delay diode. The delay may be varied slightly by means of DRIFT ADJUST control R329, which controls the shape of the positive pulse. There are other minor contributions to the 23-microsecond delay; however, the three above-mentioned circuit groups are the main elements. The output of delay diode V229A is used to drive the left amplifier, V230A, and to trigger the right blocking oscillator, V229B.

The left amplifier is fed by the broadened positive output pulse of the delay diode. The stage, V230A, is biased to cutoff, by the negative voltage applied through voltage dividing resistors R333 and R341, and driven to saturation by the input pulse to produce a broad, constant amplitude output pulse. Left relay K202 operates to ground the cathode of V230A, permitting the stage to operate, and thus provide an output pulse via C265 and normally closed contacts of K201, and the arm of S202D, a section of the SPECIFIC RATE selector switch. S202D routes the pulse to the *off* grid of the 4 stage of counter 1 for even rates and the *on* grid of the same stage for odd rates. The shortening of the first counter 1 counting cycle resulting from application of the left amplifier output pulse to

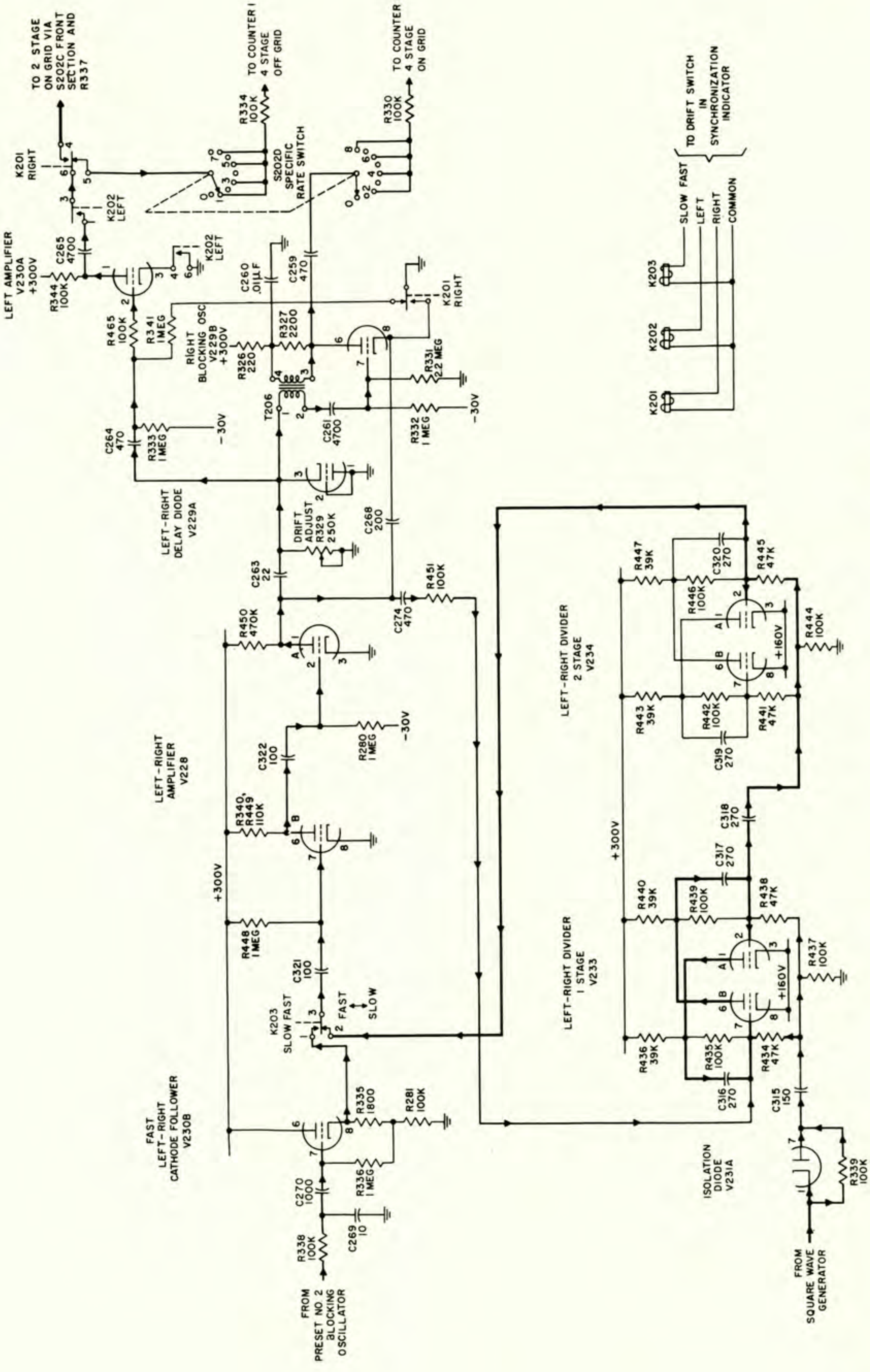


Figure 2–64. Left-Right Drift Circuits, Schematic Diagram

the 4 stage may be seen by study of the simplified waveforms of figure 2–65. The broadened pulse starts at approximately 23 microseconds; therefore, the counting cycle is unmodified until 40 microseconds after the start of the cycle. At this time, the normal 2 stage output pulse is blocked out by the broadened pulse. This prevents the 4 stage from coming *on*. Thus, at the end of the fourth count, counter 1 has been set to indicate a count of zero and requires 10 additional input pulses before it completes the cycle to transmit the first output pulse. By this means the cycle is lengthened 40 microseconds and the remote pulse is moved to the left.

For odd specific rates counter 1 is normally preset to indicate a count of six before the application of the first counting pulse. This is shown in the first group of waveforms of figure 2–66. Note that as a result of presetting to obtain the odd rate the first input pulse to the 1 stage, at 10 microseconds, is blocked out and that the 2 stage and the 4 stage are preset on at about 8 microseconds. For left drift the broadened output pulse of the left amplifier is applied to the on grid of the 4 stage. Because this pulse starts at 23 microseconds, it blocks the 2 stage output pulse which occurs at 30 microseconds. Thus, after the third counting pulse is applied, only the 4 stage is *on*. Thus, as shown in the waveforms, six more counts are required to terminate the cycle and transmit an output pulse at 90 microseconds. In the normal odd rate cycle, the output pulse is transmitted at 50 microseconds. It is thus apparent that the cycle has been lengthened by 40 microseconds and that the pulse will be moved to the left accordingly.

Note that, in the above case for left shifting at odd rates, and in the previous case for left shifting at even rates, the input pulse which is blocked out occurs at 30 microseconds and 40 microseconds, respectively. This input pulse is blocked, in both cases, because the blocking pulse starts at 23 microseconds and is sufficiently wide to be effective at 40 microseconds.

Right drift is accomplished by a narrow pulse generated by the right blocking oscillator, V229B. This stage operates in the same manner as other blocking oscillators used in the frequency divider and is triggered by the delayed positive output pulse of V229A. The cathode of the blocking oscillator is returned to ground through normally open contacts of K201, the right relay, so that an output pulse is only generated when the relay is operated. This pulse is switched to the *on* grid of the 4 stage of counter 1 for even rates and the *off* grid for odd rates.

For even specific rates the blocking oscillator output pulse, routed to the *on* grid, turns the 4 stage *on* about 25 microseconds after the start of the counter 1 counting cycle, as shown in figure 2–65. As a result the 4 stage develops a pulse which could feed back to the B section grid of the 2 stage and turn the 2 stage *off*. (Such a pulse is always generated whenever a binary stage reverses state but is normally of no consequence since the reversal of state is effected by a large driving

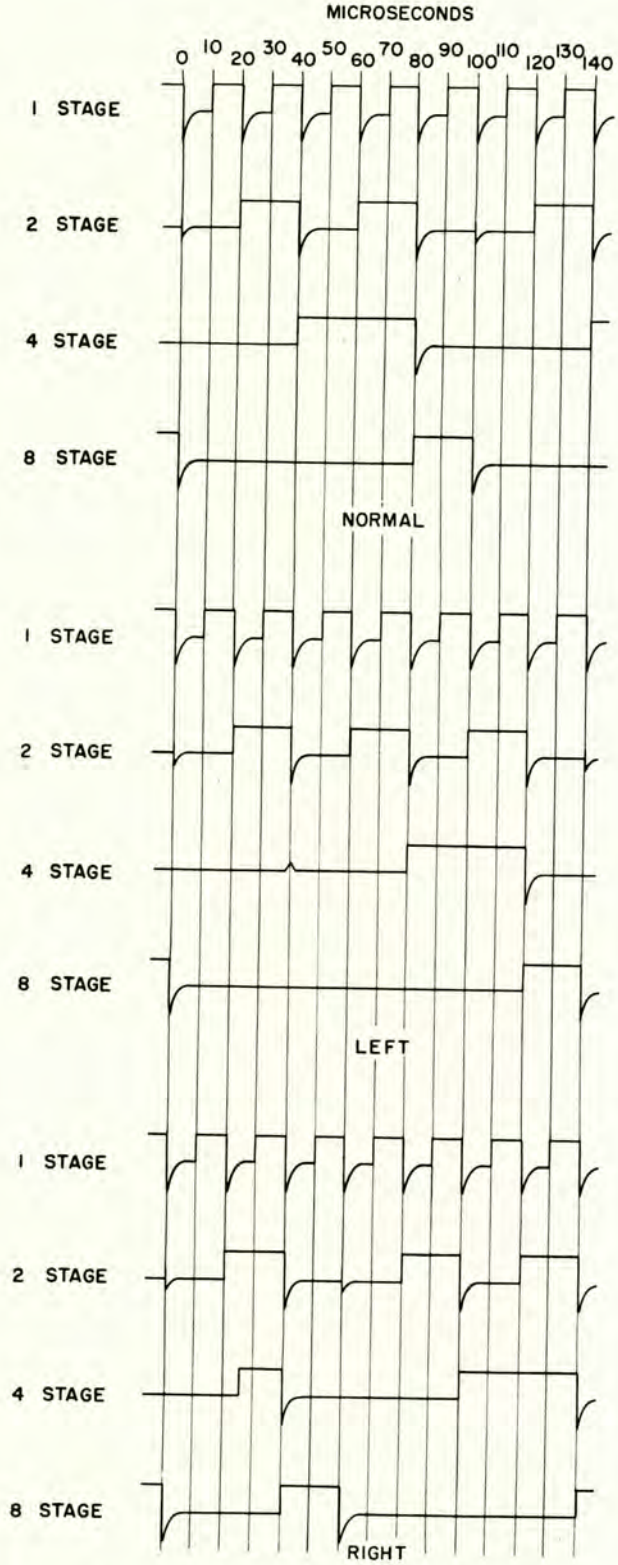


Figure 2–65. Counter 1 Waveforms for Even Specific Rates; Normal, Left, and Right Drift

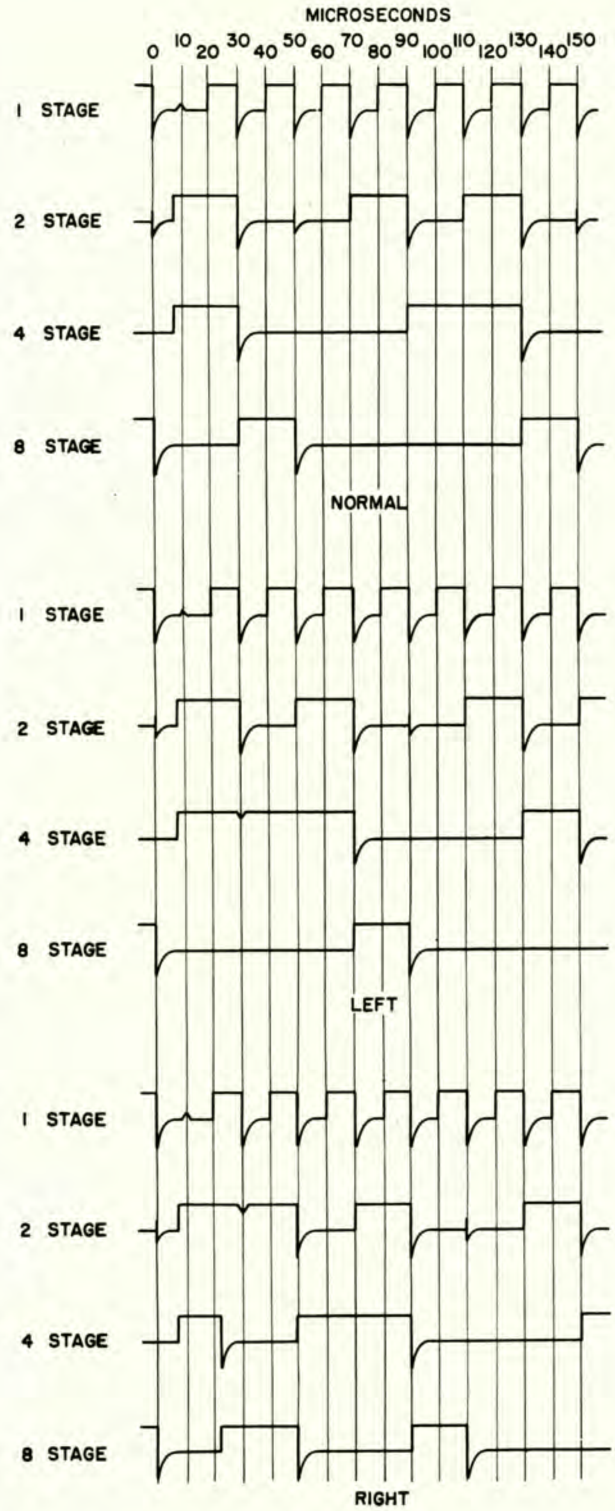


Figure 2–66. Counter 1 Waveforms for Odd Specific Rates; Normal, Left, and Right Drift

pulse from the preceding stage. This driving pulse is of such magnitude that it offsets the effect of the pulse generated in the following stage.) To prevent the 2 stage from going *off*, diode CR201 is connected in series with the coupling capacitor between the 2 stage and the 4 stage in such a manner that a negative pulse can be transmitted only in the desired direction. Resistor R342, connected across the diode, shunts the back resistance of the diode to provide a discharge path for the coupling capacitor. Thus the 4 stage is turned *on* and the 2 stage remains *on* so that the indicated count is six, instead of two, as would be normal after the second count. This shortens the counting cycle by 40 microseconds to move the remote pulse to the right.

For odd specific rates the insertion pulse generated by the blocking oscillator is connected to the 4 stage *off* grid so that the 4 stage is turned *off* about 25 microseconds after the start of the cycle. The 4 stage going *off* turns the 8 stage *on*. This is shown in figure 2–66. Just prior to the third count, between 23 and 30 microseconds, the 1 stage, the 2 stage, and the 8 stage are all *on*. At the third count the 1 stage is turned *off;* however, the resulting output pulse does not turn the 2 stage *on* because a blocking pulse is applied to the 2 stage *on* grid from the output of the left amplifier. The output pulse resulting from the 1 stage going *off* is also transmitted to the *off* grid of the 8 stage, because of the decimal feedback connection. This pulse does not turn the 8 stage off, however, because the 8 stage has just come *on*, at 23 microseconds, and has not yet had time to recover to a quiescent stable state from which it may be turned *off* again. Thus, because of these various effects, the 2 stage, and the 8 stage are *on* following the third count.

The fourth count turns *on* the 1 stage. At the fifth count the 1 stage is turned *off* and this turns the 2 stage *off*. The 1 stage going *off* also turns the 8 stage *off* because of the decimal feedback connection. This transmits an output pulse which occurs at the same time as the first output pulse of a normal odd rate counting cycle. The cycle is not terminated normally, however, because the 4 stage is turned *on* by the 2 stage going *off*. Thus, the counter requires only six more counts, or 60 microseconds instead of the normal 100, to complete the second counting cycle. It is the second counting cycle, therefore, which is shortened by 40 microseconds to move the remote pulse to the right.

Use of the left amplifier output as a holding pulse for right drift is effected by operating K202, the left relay, at the same time as K201, the right relay. For left drift K202 operates alone and the output of the left amplifier is routed to the 4 stage through normally closed contacts of K201. For right drift K201 and K202 both operate and the left amplifier output is transferred from the 4 stage to the 2 stage by contacts of K201.

At the same time the left amplifier output pulse is made narrower by changing the bias on V230A and thus changing the level at which clipping of the input

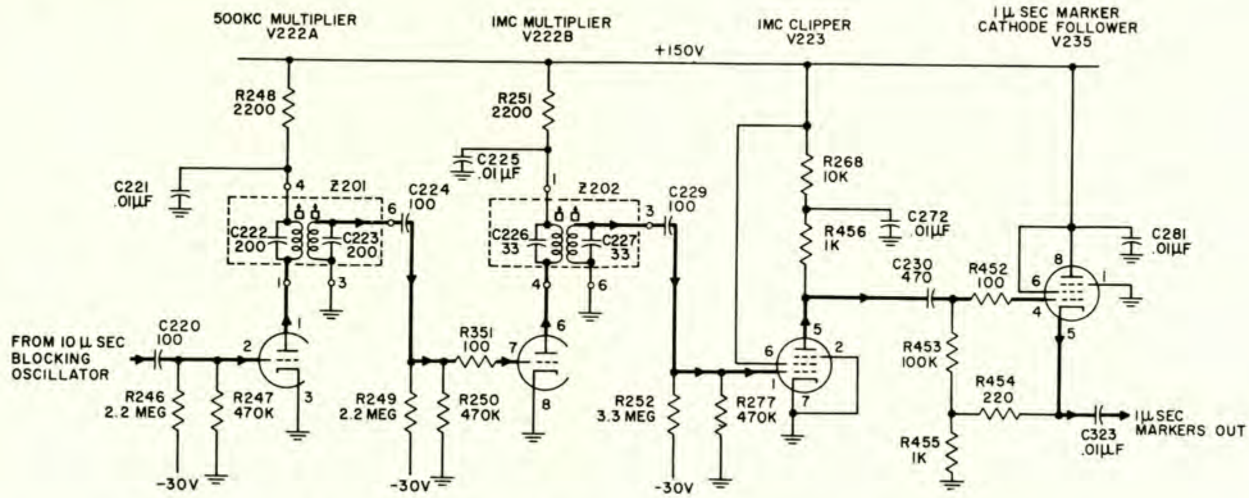


Figure 2–67. 1-Microsecond Marker Generator, Schematic Diagram

pulse begins. This change is made by opening the ground return for voltage dividing resistor R341 through normally closed contacts of K201. The holding pulse used for right drift does not have to be as wide as the insertion pulse generated for left drift. By making the pulse narrower, undesirable leakage effects have been eliminated. The left amplifier output is used as a holding pulse for right drift on odd rates only. For even rates the left amplifier output is removed from the 2 stage by contacts of the front section of S202C.

Operation of the specific combination of relays required for any drift condition is accomplished by appropriate grouping of the contacts of the DRIFT switch, S807, which is located on the synchronization indicator unit.

(9) 1-MICROSECOND MARKER GENERATION.—The 1-microsecond markers are generated by harmonic multiplication of positive 10-microsecond pulses taken from the grid of the 10-microsecond blocking oscillator, V202B. Refer to figure 2–67. These harmonically rich pulses are applied to the grid of the 500-kc multiplier, V222A, via C220 and multiplied by a factor of five. V222A is a harmonic amplifier with the primary of transformer Z201 as its plate load. Z201 is double tuned to enhance its frequency selectivity and thus provide maximum transmission for the fifth harmonic of the input pulse so that the principal output frequency is 500 kc. The harmonic amplifier is operated with grid leak bias because of the large driving signal applied to the grid circuit. The bias applied through voltage dividing resistors R246 and R247 is only a protective bias which prevents excessive tube current in the absence of driving signal. Because of the grid leak bias only the positive peaks of the driving signal are amplified. These peaks are extremely rich in harmonics and provide ample fifth harmonic signal to the plate circuit.

The 500-kc signal is multiplied by two in the 1-mc harmonic amplifier, V222B. Except for the different resonant frequency of the plate transformer and the addition of a parasitic suppressor resistor, R351, in the grid circuit, this stage is identical to V222A. The sine wave output of V222B is fed to clipper stage V223. V223 is a high gain pentode which is biased beyond cutoff by grid leak bias so that it amplifies only the positive peaks of the 1-mc signal. Because these peaks have a much shorter duration than the positive half-cycle of the input signal, the resulting 1-mc markers are extremely sharp. A low value of plate resistance, R456, provides low impedance output for the preservation of this sharpness. Series resistor R268, bypassed by C272, forms a decoupling filter to prevent the markers from getting on to the B+ bus. Markers are made available for delivery through high capacitance coaxial output circuits by cathode follower stage V235. A very low output impedance is attained by this stage through use of a triode connected power pentode which has an extremely high transconductance. The negative markers provided by this circuit are approximately 0.2 microsecond wide.

The 1-microsecond markers are not necessarily coincident with the 10-microsecond markers as delivered to the VIDEO SCOPE when all stages of the 1-microsecond marker generator are tuned to resonance. However, phase coincidence is achieved by detuning the secondary of Z201 slightly. The phase shift accompanying this detuning moves the 1-microsecond markers sufficiently to provide an adequate range of adjustment for marker alignment. This adjustment also provides proper coincidence of the 1's and 10's on the RF SCOPE and test scope presentations. The mixer circuits in these latter units are such that minor differences in input phase of the 1's and 10's does not affect coincidence in the mixer output. Thus the initial phase adjustment using the VIDEO SCOPE is adequate to insure proper presentation of all markers.

(10) SLOW SWEEP GENERATION. — The deflection voltage for horizontal sweep of the SLOW SCOPE electron beam is developed by a group of circuits in the frequency divider. The SLOW SCOPE beam is required to start the trace at the left side of the screen, move across the screen at a uniform rate to the right side, and rapidly jump back (retrace) to the left side to start a new trace. A uniform sweep rate is required so that each increment of trace length corresponds to the same amount of time as any other identical increment of trace length. Thus the distance between 1,000-microsecond markers on the SLOW SCOPE is uniform. A rapid retrace is required so that a minimum amount of time is lost between successive sweeps. Rapid retrace and uniform sweep are provided by the sawtooth waveform generated by the slow sweep circuits and applied to the horizontal deflection plates of the cathode-ray tube. This sawtooth is synchronized by the preset #2 blocking oscillator output pulses so that there are two sweeps per loran cycle. Since the preset #2 blocking oscillator also triggers the square-wave generator, the sweeps are synchronized with the square wave, and, except for time lost in retrace, the start of each trace corresponds to the ϕ 1 or the ϕ 2 time reference point. Thus the slow trace presentation is used to define basic time relationships of the loran cycle and provide a means for time comparison.

The sweep portion of the sawtooth voltage is extremely linear and is formed as the plate voltage of the sweep generator falls at a slow and uniform rate. This plate voltage fall is called a rundown. The rundown is made extremely linear because of plate-to-grid capacitive coupling. A circuit using this type of coupling to obtain a linear sweep is called a Miller time base circuit. Because of the extremely linear rundown of Miller time base circuits and because of their inherent extreme stability, they are used, in various forms for different functions, throughout the timer and will hence be encountered again in discussions of other units. The action of a Miller time base circuit, to produce a linear rundown, is as follows.

The circuit of the sweep generator stage, V226, is shown in figure 2–68. This circuit resembles a conventional pentode amplifier except for the plate-to-grid feedback connection via C235 and for the fact that the input signal is applied to the suppressor grid. The linear rundown produced by this circuit is typical of the rundown developed in all Miller time base circuits. At the beginning of this rundown the control grid is placed at a high negative voltage by conditions established in the preceding part of the cycle. This voltage permits only a small plate current to flow and thus puts the plate voltage at a value close to B+. The grid cannot remain at this negative voltage because of the connection to a positive voltage applied via R254, R275, and R267; this connection causes C235 to charge, making the grid rise and thus making the plate voltage fall. The rise of grid voltage is opposed by the fall of plate voltage, however, because of the coupling through C235. The rate at which the grid rises, and the plate falls, is therefore controlled by C235.

During the linear rundown a degenerative voltage is developed across grid resistor R267 because of feedback current flow through C235. Any change in the rate at which V226 plate voltage falls, resulting from a change of rate of grid voltage rise, changes the feedback current flowing through C235 and thus changes the amplitude of the feedback voltage. The direction of change of feedback voltage is such as to oppose the change of grid voltage rise and thus maintain the plate voltage fall at a linear rate. Except for the counteracting effect of feedback, the rate of grid voltage rise would occur at an increasingly slower rate because the cause of this rise is the exponential charging of capacitor C235 by voltage applied through resistors R267 and R269. Because the charging rate slows down as the rundown progresses, the feedback voltage diminishes and thus opposes the rise of grid voltage to a lesser and lesser degree. *This lessening of opposition to the rise of grid voltage very nearly offsets the effect of decreasing rise of grid voltage so that a very linear rundown results. This is the basic principle of operation for all Miller time base circuits.* These circuits differ principally in the methods by which the rundown is started and terminated and in the manner in which an output is utilized.

The output of the sweep generator consists of alternate sweep and retrace periods. The sweep periods are produced by the linear rundown just described; the retrace periods, which return the generator to a condition to start a new rundown, are initiated by a synchronizing trigger pulse. The manner in which this trigger causes retrace, to prepare the tube for the start of the rundown, is described next.

The negative trigger pulse is applied to the suppressor grid through isolating diode V224B. The pulse is of sufficient amplitude to drive the suppressor beyond cutoff and thus stop the flow of plate current. In this circuit arrangement the suppressor grid is used as the control element for distribution of cathode current to the plate and screen. With the suppressor highly negative, plate current does not flow and all the cathode current flows to the screen. With the suppressor at zero, the normal pentode distribution of plate and screen current is obtained. The total cathode current, flowing to only the screen or to both plate and screen, is determined by the control grid and is largely independent of the effects of suppressor grid distribution. Variations of screen current do not change screen voltage because of the bypassing action of C237.

The suppressor cuts off plate current so that B+ voltage is impressed across R269 and C235, driving the grid positive and thus causing grid current to flow. This happens almost instantly, as shown in the grid waveform of figure 2–68. The voltage at the plate then begins to rise exponentially as C235 charges through

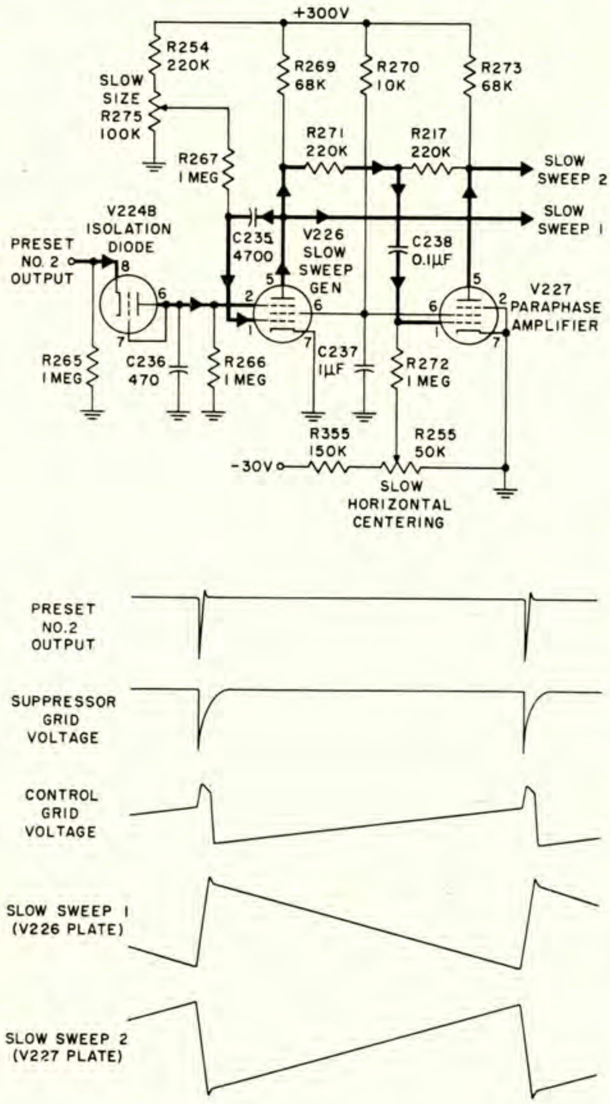


Figure 2–68. Isolation Diode, Slow Sweep Generator and Paraphase Amplifier, Schematic Diagram and Waveforms

R269 and the low impedance path of grid-cathode diode conduction. The grid is maintained positive for the duration of plate voltage rise. However, because this rise is exponential, capacitor current falls off so that the grid voltage decreases with time and produces a negative slope on the grid waveform. Note that the previously described degenerative coupling, which produced the slow Miller rundown, is absent during retrace because the increase of cathode current caused by control grid rise cannot lower the voltage of the cutoff plate. Thus, control of the rate of plate voltage rise is effected by the time constant of plate resistor R269 and coupling capacitor C235.

The fact that the plate voltage rises exponentially during retrace means that the amplitude of this rise is dependent upon the amount of time allowed for retrace. Because this time is controlled by the period during which the suppressor is held negative and because the trigger pulse is only about 8 microseconds wide, the suppressor pulse must be considerably broadened to permit adequate retrace time to develop the required sweep amplitude. This broadening is accomplished by connection of C236 from suppressor to ground. Upon the application of the negative pulse through the low impedance path of diode V224B, C236 charges very rapidly as the suppressor is driven negative. This charge holds the suppressor grid substantially negative for a long time, however, because the only discharge path for C236 is through the high resistance of R266. Thus the suppressor is held negative to make the retrace operation continue for over 400 microseconds.

The plate voltage rise which charges C235 continues only as long as the suppressor remains sufficiently negative to cut off the flow of plate current. After a time the suppressor voltage decreases to a point where plate current starts to flow. This flow arrests the rise of plate voltage, thus terminating the retrace, and starts plate voltage falling again. This fall of plate voltage occurs in a transition period during which the control grid is driven negative by the negative plate voltage applied through C235. The control grid goes negative until it causes that amount of plate current to flow which produces a plate voltage drop equal to the voltage coupled to the grid. Thus, because plate voltage drop is limited by its own action, an equilibrium point is established. If the rise of suppressor grid voltage were steep, the transition fall of plate voltage would also be steep and sharply defined. Because of the gradual rise of suppressor grid voltage, the transition slope is modified to a slight degree.

It should be noted that very little negative swing of the control grid is required to establish the above equilibrium state and that the plate voltage drop is therefore very small. As a result the plate is at a fairly high voltage at the beginning of the rundown and a large amount of voltage change is possible during the rundown. The rundown is started because of the positive drive on the control grid which does not permit the stage to rest at the equilibrium point. This positive drive is the d-c voltage applied to the grid through R267 to charge C235. The sequence of rundown, retrace, and transition is thus repeated continuously.

To permit control of the physical length of the SLOW SCOPE trace, the generator incorporates a circuit to change the peak amplitude of the output waveform. This change is accomplished by SLOW SIZE control R275 which determines the positive voltage applied to the grid return of V226 to charge C235. Because the charging rate of C235 depends on the applied voltage, R275 has a direct control of the slope of the rundown. By steepening the rundown, through increase of charging voltage, the drop in plate voltage, from the start of the rundown to the next trigger pulse, is made larger and thus the trace length is increased.

It may be noted, as an additional characteristic of Miller time base generators, that the control of plate current, by means of suppressor grid voltage, is essential to placing the circuit in condition to start a rundown. Although the means for varying suppressor voltage varies, in the different Miller time base circuits, use of the suppressor grid for switching plate current is a common feature found in all forms of the arrangement.

To summarize the operation of the slow sweep generator:

(*a*) RETRACE.—The retrace period starts the moment the rundown is interrupted by application of a steep negative pulse to the suppressor grid.

This pulse cuts off plate current. The plate voltage starts rising only as fast as B+ can charge C235 through R269 and the low impedance grid-cathode resistance.

This condition (retrace) is made to continue for as long as the suppressor cuts off plate current.

(*b*) TRANSITION. — The transition between retrace and rundown starts as soon as the suppressor voltage has decreased sufficiently to allow plate current to flow.

The drop of plate voltage, applied to the grid, causes the tube to seek an equilibrium point. This point is achieved when the plate and grid voltages both fall by the same small amount.

(*c*) RUNDOWN.—Following the above transitional state the rundown begins. The positive voltage applied to the grid raises grid voltage. The resulting fall of plate voltage opposes the rise of grid voltage to control the speed of the rundown until the application of the next trigger pulse.

Slow sweep deflection voltage is provided in push-pull. The output of V226 is identified, for convenience in signal tracing, as SLOW SWEEP 1. A paraphase amplifier, V227, provides SLOW SWEEP 2 which is of nearly the same amplitude and of opposite polarity with respect to the output of V226. The degenerative input arrangement of the paraphase amplifier provides the required unity gain with faithful phase inversion.

Grid drive for V227 is obtained from the junction of two equal resistors, R271 and R217, which are fed from the two plates. Assuming the desired condition that the two plate voltages, which are 180° out of phase, are equal, the voltage at the grid would be zero because of cancellation of the plate voltages. Naturally this condition cannot occur because an input signal must exist to produce an output at the plate of V227. The circuit therefore adjusts the output amplitude of V227 so that the amplitude difference between V226 and V227 outputs provides a signal at the grid of V227 which, when amplified, produces just the required output amplitude. This adjustment is continuous and automatic. The adjustment results because of the self-regulating characteristic of the feedback circuit. Because of the large amplification provided by the pentode employed as V227, only a small grid signal is required, and therefore the difference in output amplitudes of the two stages is negligible.

SLOW SWEEP 1 and SLOW SWEEP 2 are coupled directly to the deflection plates of the cathode-ray tube without use of d-c blocking capacitors. Theoretically, therefore, if the average plate voltage of the two tubes were equal, the trace would be centered. Control of trace centering is therefore possible through control of the d-c voltage of one plate with respect to the other. The current through each tube is controlled by the average d-c voltage of the grid circuit. The grid of V226 is always operated slightly negative; therefore the grid bias of V227 is varied from a negative voltage to zero voltage by adjustment of SLOW HOR CENT potentiometer R255 to provide control of trace centering. This variation of bias does not alter the output of V227 because of the large amount of degeneration employed.

(11) SLOW TRACE SEPARATION, PEDESTAL, AND MARKER MIXING.—The functional arrangement of the slow trace separation, pedestal, and marker mixing circuits was previously described in paragraph 3 *c* (6) (*b*). The detailed description to follow explains how these functions are accomplished. Refer to figure 2–69.

The three waveforms generated by this group of circuits are combined in the plate circuit of V225B. Pedestal voltage (the small rectangular pulse originating in the video sweep generator) is applied to the grid of this stage via high-pass filter R253, C266, and R260. This filter sharpens the leading and trailing edges of the pedestal waveform to compensate for pulse degradation effected by shunt wiring capacity. The amplified pedestal voltage is mixed with the other waveforms in the plate circuit.

Slow scope markers are provided by amplification of 1,000-microsecond markers applied to the grid of V224A. The positive excursion of the markers draws grid current in V224A to charge C231. As each marker is terminated, C231 discharges through R256. This is a relatively long time constant circuit producing broad negative markers at the V224A grid. This broadening provides sufficient pulse width so that the markers may be easily seen on the compressed time base of the SLOW SCOPE. The markers are amplified in the plate circuit and delivered as positive pulses to the plate of V225B through attenuating resistor R258. The markers may be cut off by means of SLOW MARKERS switch S206, in series with the cathode of V224A.

Slow trace separation is controlled by application of square-wave voltage to the grid of V225A via SLOW SEP control R264. R264 controls the amplitude of the square-wave voltage which appears across the common cathode resistor, R262. This voltage drives V225B and is amplified in the plate circuit. A large voltage swing, in the cathode circuit, is made possible because of the

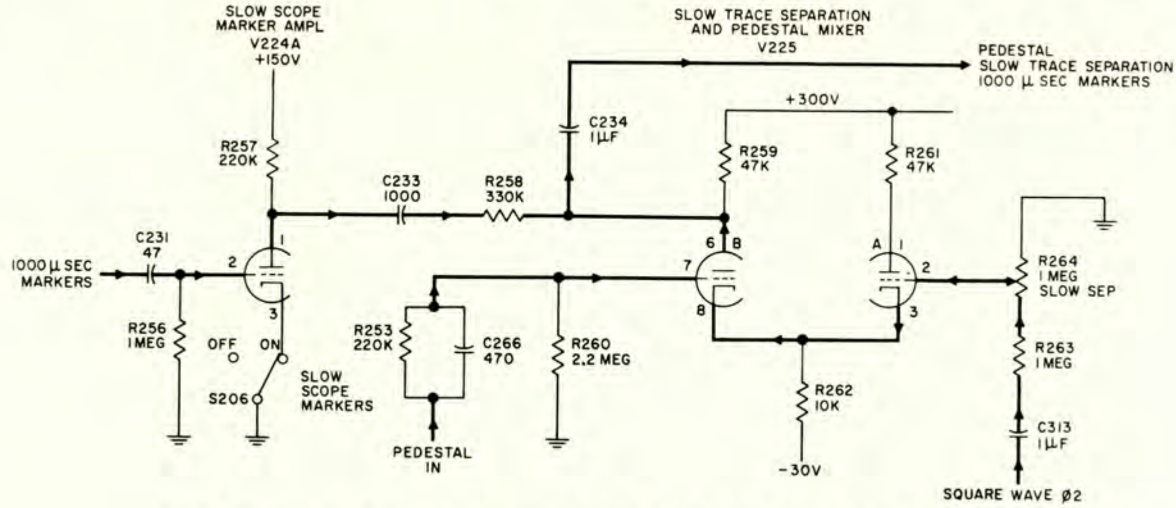


Figure 2–69. Slow Trace Separation, Pedestal, and Marker Mixing Circuits, Schematic Diagrams

return of R262 to the −30-volt bus. Because of this connection the cathode swing is from −30 volts, at V225A cutoff, to a positive voltage determined by the current through R262 at the grid conduction point. It will be seen that this voltage swing is 30 volts greater than could be developed across R262 alone if the resistor were returned to ground and that the voltage swing is therefore increased by this arrangement. The amplitude of this voltage swing may be reduced, if it is desired to decrease slow trace separation by adjustment of SLOW SEP control R264. Extreme counterclockwise rotation of this control will reduce trace separation to zero.

Resistor R261, in the plate circuit of V225A, permits current to be equalized in both sections of V225. The three waveforms which are mixed in the plate circuit of V225B are delivered to the lower vertical deflection plate of the SLOW SCOPE cathode-ray tube via blocking capacitor C234.

(12) TEST COUNT GENERATOR. — As discussed previously in paragraph 3 *c* (7), the frequency divider unit incorporates a test count generator to produce an artificial count each time a TEST COUNT push button is depressed. The pulses used for test count are derived from a single stage thyratron circuit which provides pulses of the proper shape. Refer to figure 2–70. A miniature type 2D21W thyratron is used (V232). Normally TEST COUNT switch S204 is open and a negative bias is applied to the thyratron grid through voltage divider R352 and R353. This bias prevents the stage from ionizing so that the plate does not draw current. Parallel capacitors C277 and C278 therefore charge to +300 volts through R347 and ground. Manipulation of S204 connects the grid to +300 volts through R350 to charge capacitor C262 and thus overcome the negative bias to make the tube ionize. (C262 is included in the circuit to eliminate any possibility of multiple triggering because of contact bounce in S204.) When the tube ionizes, C277 and C278 discharge through V232 and R347, in accordance with the time constant of the resistor and capacitors. Tube conduction stops when plate current falls below a value sufficient to maintain ionization; this terminates the output pulse. C277 and C278 will start recharging as soon as ionization stops. If the grid is maintained positive, by continuous pressure on S204, the circuit will behave as a relaxation oscillator and generate low amplitude pulses which will not drive the counters. Upon release of S204 the grid will go to cutoff and C262 will recharge completely through R353.

The generator develops a negative output pulse across resistor R347 and a positive output pulse across cathode resistor R349. The negative pulse is used to drive either counter 2 or counter 3 via C279 and TEST COUNT INSERT switch S201. The positive pulse is used to drive the 10-microsecond blocking oscillator which feeds counter 1. This pulse is applied to the oscillator grid via S201, T201, and C203. The positive pulse is used in this manner, instead of a negative pulse at the 1 stage input, because the low output impedance of the blocking oscillator, across the 1 stage output, prohibits driving the 1 stage directly from a high impedance source.

One additional circuit feature is incorporated to permit efficient test count application. The d-c level of the signal at the input of the 1 stage of counter 1 is different, when the stage is being driven at a high repetition rate, from when the stage is quiescent or being driven by a single test count. To make this stage respond equally well with either single test counts or rapidly repeated input signals, the stage requires more bias than other counter stages. This additional bias is provided by connection of R458 in series with the 1 stage cathodes and the positive bias voltage developed for all counter stages. R458 is bypassed to signal fluctuation by C271.

(13) TEST SIGNAL CATHODE FOLLOWER.— The test signal cathode follower consists of a single stage, V202A, which provides a high impedance input, for minimum loading of the circuit under test, and a low impedance output, for minimum waveform distortion caused by shunt capacitance of connecting cables. The circuits selected by means of TEST SIGNAL switch S203 are relatively low impedance circuits and are not disturbed by the very moderate loading presented by the capacitive voltage divider in the cathode follower grid circuit. Selected circuits are the 10's, 100's, 1000's, and the 50 ~ output.

d. TIME DELAY UNIT TYPE TD–92/FPN–30.— The time delay unit sets up the A and B delays to provide reference delay and generates a blanking pulse and transmitter and oscilloscope triggers as previously described in paragraph 3 *d.*

(1) A-DELAY CIRCUIT. — The A-delay circuit establishes the A delay by using a continuously variable phantastron delay to select one particular 1000 from the chain of 1000's generated by the frequency divider and, in turn, using the 1000 to select a particular 10. This 10, which is accurately controlled by the 100-kc timing signal, becomes the A-timing pulse.

(*a*) PHANTASTRON DELAY CIRCUIT. — The phantastron delay circuit provides a continuously variable delay which is controlled by a d-c voltage. Variation of the d-c voltage, by means of a single wire-wound potentiometer, controls the width of a rectangular output pulse, so that a nominal delay of 1,000 to 24,000 microseconds is provided. The time from the leading edge to the trailing edge of this output pulse is the delay. The trailing edge is used, in succeeding circuits, to select a particular 1000.

The A-delay phantastron is V502, shown in figure 2–71. The circuit may be identified as a Miller time base generator by virtue of the plate-to-grid feedback provided by the parallel combination of capacitors C503 and C504. The linear operation of a Miller time base generator was previously discussed in the description of the slow sweep generator, paragraph 4 *c* (10). The primary characteristic of all Miller time base circuits is this linear rundown. Associated with the rundown are the end points where the plate voltage is high, as at the beginning of the rundown, and where the plate voltage is low, as at the end of the rundown. Plate voltage is made high by cutting off the suppressor grid. It is made low by setting the suppressor grid at zero. The circuit may be made to rest in a stable state at either or both of these end points, depending on the circuit arrangement used. The circuit is made to depart from these end points by changing the suppressor grid voltage.

In the slow sweep generator the circuit arrangement is such that the plate voltage would remain low in the absence of a trigger. Triggering is such that this stable state is never reached because the trigger forces the stage to attain a high plate voltage and thus begin the rundown. In this arrangement the rundown occupies almost all the loran cycle and little time is taken up by retrace. (Retrace is the operation which raises plate voltage to the level required for the start of a new rundown.)

In the phantastron the circuit arrangement is such that plate voltage remains high in the absence of a trigger. The duration of the rundown is only a small part of the loran cycle so that the stage remains in this high plate voltage state most of the time. To start the rundown, it is necessary to trigger the suppressor grid to drive the tube away from its steady state. This trigger is applied to the suppressor grid indirectly. At the end of the rundown, it is necessary to make the plate voltage recover so that it will be ready for the next rundown.

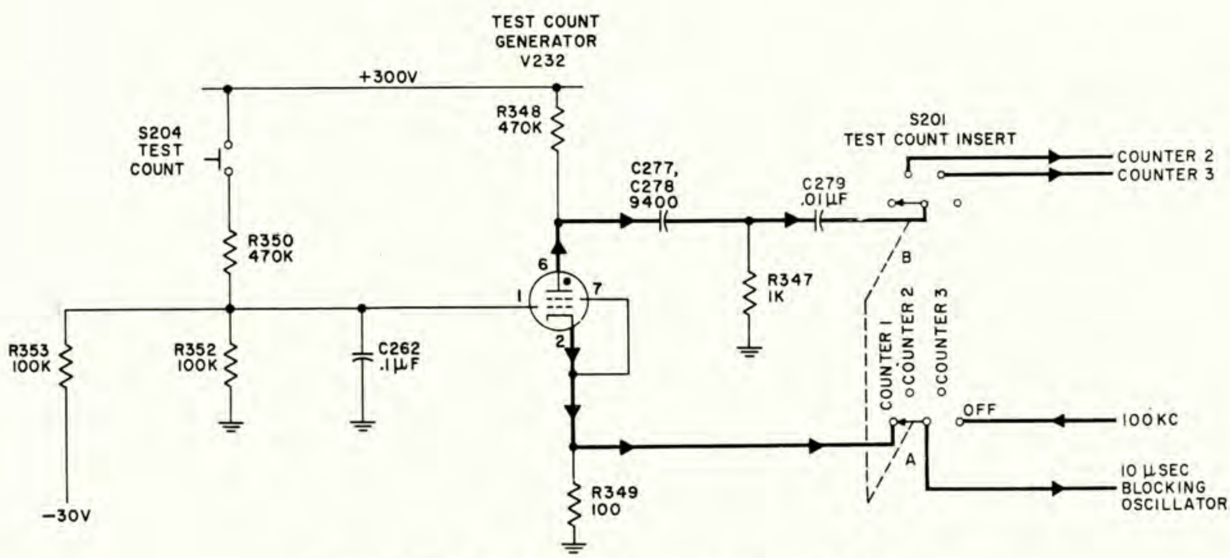


Figure 2–70. Test Count Generator, Schematic Diagram

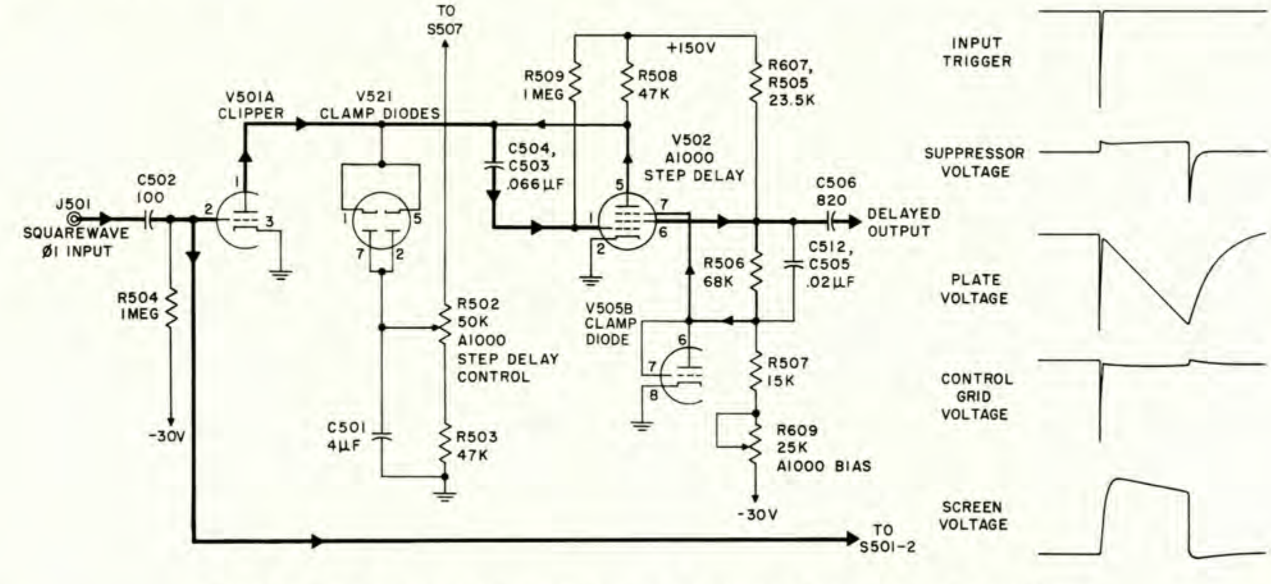


Figure 2-71. Phantastron Delay Circuit, Schematic Diagram and Waveforms

Recovery is initiated by a signal developed at the end of the rundown and furnished the suppressor grid from the screen grid. This signal drives the suppressor grid negative and makes plate voltage rise so that the stage is ready for the next trigger.

Because of the functional differences of the phantastron, the circuit configuration is somewhat different from that of the slow sweep generator. Note that the same arrangement of plate-to-grid capacitive coupling (C503, C504), for the control of the rundown, and application of positive voltage to the control grid through a series resistor (R509), to start the rundown, is retained in the phantastron. To permit self triggering, the phantastron screen is left unbypassed. This permits screen voltage to change with screen current changes, and the screen is coupled to the suppressor grid so that changes in screen voltage control suppressor grid action. This arrangement provides the required means for developing a trigger at the suppressor grid from the external trigger applied to the plate, and for developing a signal to initiate recovery at the end of the rundown. Quiescent voltage control of the suppressor grid is obtained by the negative bias applied via R609 to hold the plate at cutoff. The phantastron also employs an isolating trigger clipper, V501A, and plate and suppressor-grid clamps, V521 and V505B, which enhance the stability of the circuit.

In the quiescent state, before triggering, the control grid of V502 is essentially at zero bias because of the positive voltage applied from B+ via R509. As a result cathode current is heavy and screen voltage is low. Plate voltage is equal to B+ because the suppressor is biased to cutoff and plate current does not flow. The diode clamps, V521 and V505B, do not conduct because their cathodes are maintained positive with respect to their plates. Clipper stage V501A has no effect because of the cutoff bias applied through R504.

Square wave ϕ 1 is differentiated by capacitor C502 and grid resistor R504 to produce a positive pulse corresponding to the leading edge of the positive half of the square wave and a negative pulse corresponding to the trailing edge of the same half. Only the positive pulse can overcome the high negative bias on clipper stage V501A and produce an amplified negative trigger pulse in the common plate circuit of V501A and V502. This negative trigger is coupled to the grid of V502 through C503 and C504 to cut off cathode current. With cathode current cut off, screen voltage rises. The rise of screen voltage is coupled to the suppressor via a-c and d-c paths. D-c coupling is through R506 and is of reduced magnitude because of the voltage dividing action of R506 and R507. The a-c coupling of C505 and C512 provides full application of transient voltages to the suppressor. Thus the full amplitude of screen grid rise drives the suppressor positive until it is clamped at zero by conduction of V505B. The rise of suppressor voltage makes plate voltage fall to reinforce the original trigger voltage and regeneratively speed the rise of screen grid voltage. These conditions are achieved very rapidly and are maintained throughout the brief triggering period. When the trigger is terminated, plate and control grid voltages cannot return to the previous levels of the quiescent state because the suppressor has been driven positive. The tube therefor seeks an equilibrium state corresponding to this new condition. Because the suppressor voltage is clamped at zero, normal pentode distribution of plate and screen grid currents obtains. Because of plate current flow, plate voltage will not return to B+ and since plate voltage changes are coupled to the control grid the grid will not return to zero. The control grid will attain a negative voltage which permits that plate current to flow which develops a negative plate voltage equal to the voltage coupled to the grid. The equilibrium point thus reached is the same as that reached at the end of the transition period of the slow sweep generator, just at the start of rundown. Thus, the phantastron is ready to start a rundown.

Rundown takes place because of the positive voltage applied to the control grid via R509. The rate of rundown is controlled because the pentode amplifier provides a large amount of plate-to-grid feedback. This feedback makes the plate voltage fall oppose the grid voltage rise so that the rundown is maintained at a constant rate.

When the phantastron plate voltage falls to the point where the cathodes of diode clamp V521 are at the same voltage as the diode plates, conduction starts. This conduction effectively connects the phantastron plate to the voltage at the tap of R502. This tap is maintained at a constant voltage, despite current flow through the diode, because of the bypassing action of C501. Thus, because plate voltage cannot become more negative than the voltage at the tap of R502, the rundown is terminated. Adjustment of R502 permits the rundown to be terminated at any voltage point so that the length of the rundown may be varied. Because the voltage point at which the rundown is terminated is rigidly fixed by the setting of R502, the A DELAY 1000 control, the duration of the rundown is precisely controlled.

The termination of rundown sets in motion a series of events which cause recovery to the stable, pretriggered state. When the rundown is terminated, feedback voltage is no longer applied to the control grid. Because the rate of grid voltage rise is no longer opposed by feedback, the rate of grid voltage rise increases to the much greater, natural, exponential rate of R509 and C503, C504. This increase causes a rapid drop in screen voltage which is coupled through capacitors C505 and C512 to develop a large negative voltage across R506 in the suppressor grid circuit. The negative voltage starts cutting off the plate. This allows B+ to impress a positive voltage on the grid through C503 and C504, reinforcing the grid rise. The rate of control grid rise is thus regeneratively increased so that the control grid is rapidly driven to the grid current point. With control grid voltage arrested, screen grid voltage levels off and C505 and C512 discharge exponentially as suppressor voltage settles at the bias level established by R609. The negative suppressor voltage cuts off plate current so that C503 and C504 charge exponentially through plate resistor R508 and the grid-cathode path of diode conduction. Plate voltage thus rises slowly as the stage recovers to the condition where it is ready for the next trigger. This recovery corresponds to the retrace of the slow sweep generator.

The bias level established by R609 must be sufficiently negative to cut off the plate during the quiescent part of the cycle, so that the stage cannot operate as a free running oscillator. This bias level must not be too large or it will limit the length of the rundown. In normal operation the rise of screen voltage holds the suppressor in a clamped state despite the exponential decay through coupling capacitors C505, C512. If the bias voltage is too large the voltage applied to the suppressor by the screen will fall below the clamping level before the end of the rundown. When this happens, the negative suppressor swing starts a regenerative cycle which terminates the rundown at a voltage level above that determined by R502. To prevent this, adjustment of R609 is made, with R502 set for maximum delay, to reduce the bias to somewhat before the point where the rundown is shortened.

Clamping is used to hold the suppressor grid at a constant voltage during rundown so that plate current is not affected by suppressor grid variations. This arrangement stabilizes the circuit to make the rundown largely independent of tube operating characteristics.

The rectangular output pulse taken from the screen grid controls the delay. The leading and trailing edges of this pulse are steep sided and thus sharply defined because of the regenerative action which accompanies triggering and follows clamping of the rundown. The trailing edge is rigidly fixed in time because it corresponds to the end of the rundown. This trailing edge is differentiated, by coupling capacitor C506 and the next stage input resistor, and is used to select a particular 1,000-microsecond marker in a push-up circuit. The particular marker selected is thus controlled by the setting of A DELAY 1000 control R502. This delay is extremely stable because of the large amount of negative feedback inherent in the phantastron.

It should be noted that the maximum delay range of approximately 30,000 microseconds provided by the A-delay phantastron is far greater than will usually be required. Where an A delay of less than 15,000 microseconds is needed, greater circuit stability and ease of adjustment will be obtained if the circuit time constant is shortened. This may be effected by removing one of the two equal plate-grid coupling capacitors, C503 and C504, from the circuit. This same consideration applies to the B1000 phantastron in the B-delay circuit. If none of the five possible B1000 delays (NORMAL, 2, 3, 4, 5) exceed 15,000 microseconds, one of the B1000 coupling capacitors (C517 or C518) may be removed.

(*b*) 1,000-MICROSECOND PUSH-UP CIRCUIT.—The rectangular output pulse of the phantastron screen circuit is differentiated by output capacitor C506 and by resistor R510 in the input circuit of the push-up stage. Refer to figure 2–72. The leading edge of the phantastron output pulse is differentiated to a positive pulse which has no significant effect on the operation of the push-up stage, V503A. The trailing edge, however, is differentiated to a negative pulse which drives V503A to cutoff. The duration which V503A is cut off, and hence the width of the positive pulse appearing in the V503A plate circuit, is determined by the setting of A1000 WIDTH control R511. As is evident from the drawing, R511 controls the positive voltage applied to the grid via R510. Variation of R511 does not significantly change the time constant of C506, R511; what it does is vary the voltage level to which C506 charges immediately after the application of a negative input pulse. The rate at which C506 charges depends upon the instantaneous voltage at the junction of C506 and R510 and the applied voltage at the junction of R511 and R510. Variation of this rate controls the exponential charging slope and hence the pulse width. The charging slope does not continue smoothly, until it reaches the voltage at the junction of R511 and R510, but breaks abruptly when grid voltage rises to the grid current point. Thus pulse width is determined in part by the time constant of C506 and R510 and is controlled by the voltage applied through R511. The pulse is used as a gate to select a particular 1,000-microsecond marker.

The gate pulse applied to the grid of V503A cuts the triode section off for most of the pulse duration. During the cutoff time the section draws no plate current and the load shunting V503B is effectively removed. V503B is fed negative 1,000-microsecond marker pulses via C508. These pulses are amplified by V503B and appear as positive pulses in the plate circuit. Normally, because of the shunting effect of V503A, the gain of V503B is low and pulse amplitude is low. When V503A is cut off by the gate, the gain of V503B increases, and the marker output amplitude increases. The amplified gate pulse will normally be coincident with one of the amplified markers in the plate circuit of V503B. The voltage addition of the marker and the gate "pushes up" the marker to a higher voltage level than any of the other 1000's. The amplitude of the marker selected by this means is much greater than any of the other markers because of the increased amplification of V503B at the moment of push-up.

The gate width is adjusted, by means of A1000 WIDTH control R511, so that the gate is a trifle narrower than the space between two adjacent 1000's. This arrangement provides maximum stability because the phantastron must drift about 500 microseconds before coincidence between the gate and the desired marker is lost. If the gate were narrower, a phantastron drift of less than 500 microseconds would cause lost coincidence. If the gate were wider, a phantastron drift of less than 500 microseconds might cause the circuit to select an adjacent marker in addition to the desired marker. Since the stability of the phantastron is much better than 500 microseconds, the gate will not normally drift away from coincidence with the desired marker.

The output of V503 is a high amplitude marker which "sits" on the push-up gate. In addition to this desired marker the signal includes the chain of markers and the gate. The gate and all markers in the chain except the pushed-up 1000 are removed in the next stage by clipping. The amplitude of the V503 output signal must be reduced to a value which places the gate and chain of markers below the clipping level to prevent these signals from passing through the clipper. The required amplitude reduction is achieved by attenuator network R513 and R530 in the plate circuit of V503.

(*c*) 1,000-MICROSECOND CLIPPER AND 10-MICROSECOND PUSH-UP CIRCUIT. — The 1,000-microsecond marker selected by the push-up circuit is isolated from the chain of 1000's by being fed to a clipper stage. The clipper stage, V505A, is biased to cutoff by the —30 volts applied to the grid via R515. This bias is overcome only by the positive peak of the selected 1000 so that the clipper output is the amplified peak of the 1000. This peak is broadened by plate shunting capacitor C531 and used as a gate in the plate circuit of the 10-microsecond push-up stage, V504.

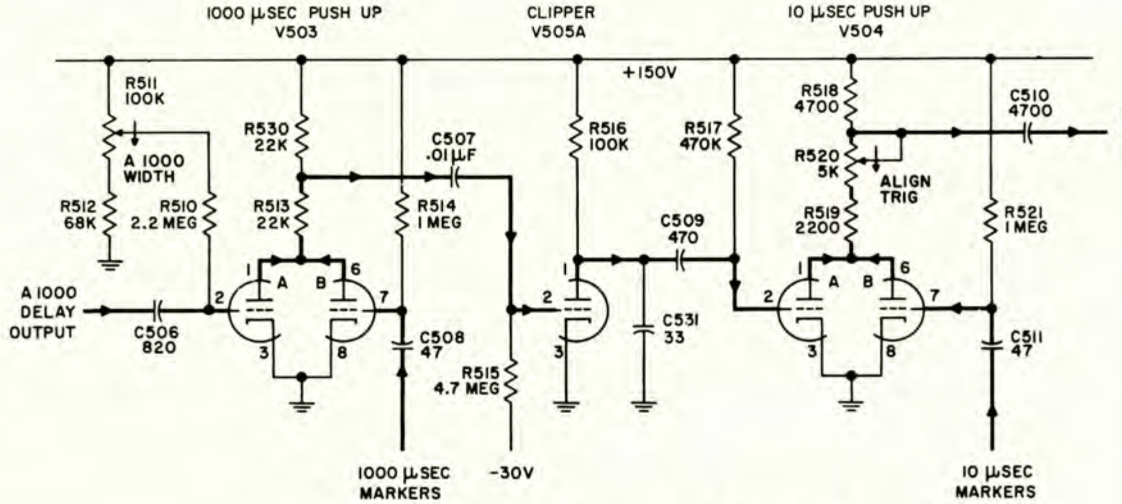


Figure 2–72. A1000 Push-Up Circuits, Schematic Diagram

This stage functions in the same manner as the 1,000-microsecond push-up stage, V503, to select a particular 10 from the chain of 10's applied to its grid via C511. The selected 10 is always the 10 which immediately follows the selected 1000, hence the A delay is always some increment of 1000 *plus 10 microseconds.* Because of the fixed time relationship between 10's and 1000's no gate width control has been provided in this circuit. The selected 10 is used as the A-timing pulse, instead of using the selected 1000 directly, because the 10 has a stability directly controlled by the 100-kc timing signal.

(2) B-DELAY CIRCUIT.—The B-delay circuit uses a group of circuits, each similar to the A1000 circuit, to provide any desired delay. Refer to figure 2–73. As previously described in paragraph 3 *d* (2), the range of delay available from the combined action of the several B delays is continuous from 1,120 to 24,000 microseconds. The first B-delay circuit provides a delay in 1,000-microsecond steps in the same way as the A1000 delay circuit. The output of this B1000 delay circuit drives a similar B100 delay circuit which, in turn, drives a B10 circuit. Where the B delay must be interpolated to a value which cannot be obtained in 10-microsecond steps, the B10 output is used to drive a continuous delay phantastron. The output signal of the B-delay circuit is taken from either the B10 delay or the B-continuous delay circuit. This output signal is the B-timing pulse. Because any desired value of B delay may be obtained, the reference delay (B delay minus A delay) may be any desired value.

(*a*) 1,000-MICROSECOND DELAY.—The circuit arrangement for obtaining the B1000 delay employs a phantastron, push-up stage, and clipper stage identical to those of the A1000 delay. The B1000 circuit is triggered from the leading edge of the positive half of square wave ϕ 2 and the delay setting is always made larger than that of the A1000 delay so that the marker selected by the B1000 circuit always follows the A-timing pulse by more than one-half of a loran cycle. This selected 1,000 is used to trigger the B100 delay phantastron. A nominal delay range of 1,000 to 23,000 microseconds is available in this circuit.

(*b*) 100-MICROSECOND DELAY. — The arrangement of the B100 delay circuit is identical to the B1000 delay circuit except that a particular 100-microsecond marker is selected and the nominal range of delay is 100 to 1,200 microseconds. The selected 100 is always one of the ten 100-microsecond markers following the selected 1000. The 100 selected by this circuit is used to trigger the B10 delay phantastron.

(*c*) 10-MICROSECOND DELAY. — A particular 10-microsecond marker is selected by the B10 circuit, using an arrangement identical to the B100 circuit. Because of the 10-microsecond delay, following the selected 1000 in the A10 circuit, a 10-microsecond delay in the B10 circuit is cancelled out. For this reason, the first 10-microsecond marker, following the selected 100, corresponds to a B10 delay of zero.

Where the desired B delay is in steps of 10, the B10 output is used as the B-timing pulse. Where it is necessary to interpolate between steps of 10, the B10 output is used to trigger the continuous delay phantastron. At a slave station, the assigned delay will always be in increments of 10 to take advantage of the extreme stability of the 10-microsecond markers. At a master station, the required delay will be affected by radio signal transit time so that the reference delay will be the reference delay at the slave station plus twice the transit time of the signal. It follows that the delay added by signal transit time will rarely be exactly 10 microseconds, so that the continuous delay circuit must be employed at a master station. Any slight timing instability (which will not normally exceed 0.1 microsecond) contributed by the continuous delay circuit will be of no great consequence, however, because the master station only monitors synchronization. Thus the effect of such timing instability will be that the master station detects a small apparent error.

(*d*) CONTINUOUS DELAY.—The B-continuous delay circuit uses a phantastron to produce a rectangular pulse 10 to 22 microseconds wide. The trailing edge of this pulse is differentiated to form an output pulse. Except for the delay range, the addition of a top clamp, and a minor change in the delay control circuit, this phantastron, V516, is identical to the other time delay phantastrons. A fixed resistor, R589, is placed in series with the continuous delay potentiometer to limit the minimum circuit delay. Increased circuit stability is achieved by clamping the tube at the top of the rundown, using V525B, as well as at the bottom. The stability of this arrangement is adequate to insure that the timing accuracy of the B-timing pulse is better than 0.1 microsecond.

Pulse inversion is accomplished by V519B, a low gain triode amplifier which is zero biased so that a large negative output pulse is produced by differentiation of the trailing edge of the phantastron output pulse. This pulse inversion makes the polarity of the output pulse the same as that of the A10 and B10 output pulse. The resulting positive output is the B-timing pulse.

(*e*) RELATIONSHIP OF B DELAYS TO REFERENCE DELAY.—As previously discussed in paragraph 3 *d* (2), the total B delay is the sum of the delays of each individual B-delay circuit. Reference delay is the total B delay minus the A delay. Because the A delay is subtracted from the B delay in the loran presentation, the B-delay circuit is adjusted to produce a reference delay directly, with no regard to the total B delay.

The B-delay adjustment procedure used for the majority of values of reference delay is straightforward. The B1000 delay circuit is adjusted to provide the delay called for by the 1000 digit (first number) of the reference delay. The B100 delay circuit is then adjusted to produce the delay called for by the 100 digit, the

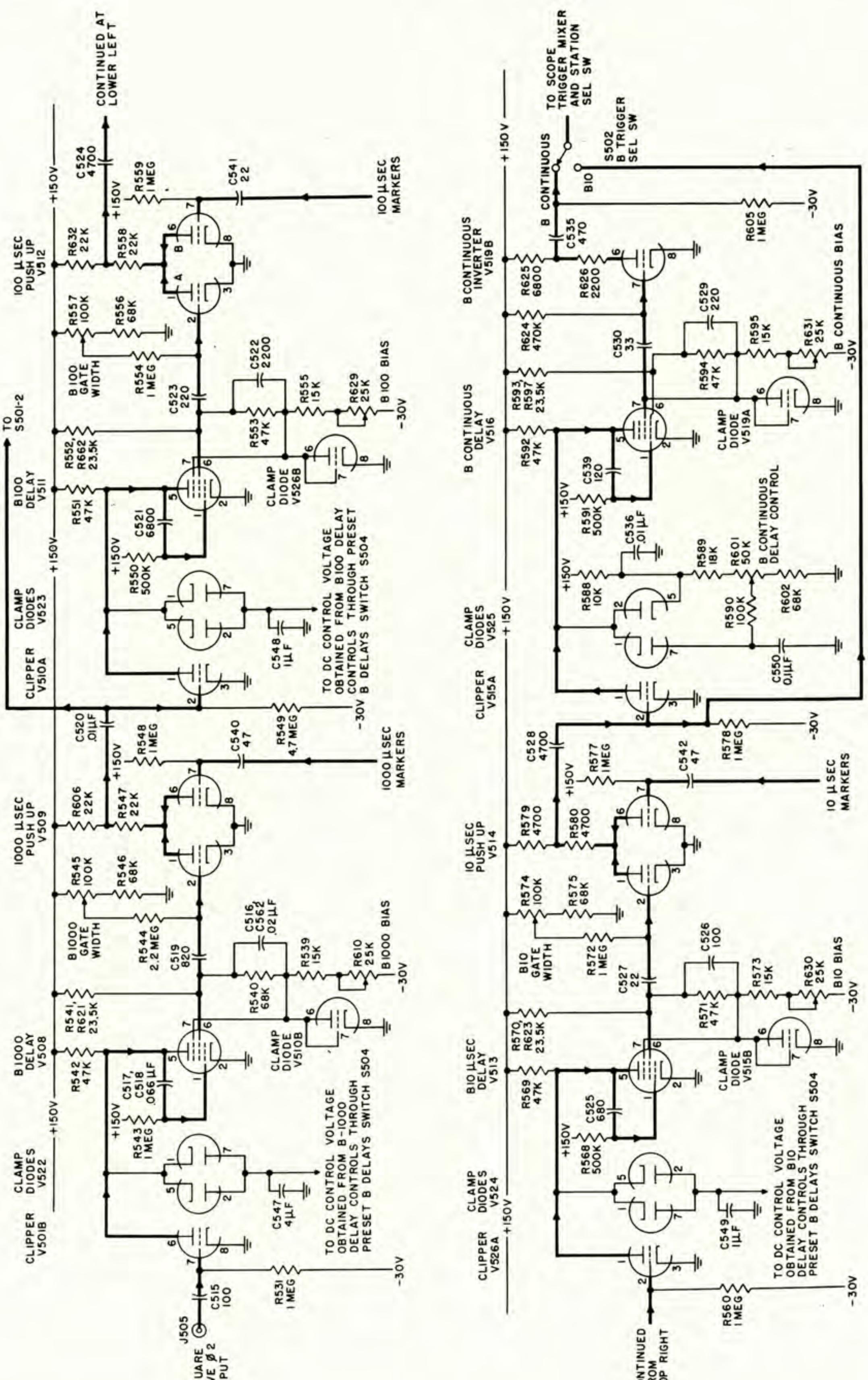


Figure 2-73. B-Delay Circuit, Schematic Diagram

B10 delay circuit is adjusted to produce the delay called for by the 10 digit and, if required, the B-continuous delay circuit is adjusted to produce the delay called for by the unit digit. For most values of reference delay, the above procedure may be used; however, because of the minimum delays present in the B-delay circuits, this procedure cannot be used for values of reference delay ending in 000 to 110.

Figure 2–74 shows the minimum delays present in the A-delay circuit and also in the B-delay circuit for the two cases where the B-continuous delay circuit is and is not used. The B1000 minimum delay is of no importance and may be neglected because it is cancelled by the A1000 delay. The B100 has a minimum delay of 100 microseconds, which is not cancelled by a corresponding A delay, and must therefore be considered. The B10 and B-continuous delay circuits each contribute a minimum delay of 10 microseconds. When the B-continuous delay circuit is used to provide the output it is desirable to consider that the fixed 10-microsecond A10 delay cancels the B-continuous minimum delay. When, instead, the B10 delay circuit is used to provide the output, the A10 delay cancels the B10 minimum delay. Thus, when the B-continuous delay is not used, the total minimum delay is 100 microseconds and, when the B-continuous delay is used, the total minimum delay is 110 microseconds.

Assume a reference delay of 6,000. Because the unit digit is zero, the B-continuous delay circuit is not needed and is therefore switched out. A B1000 delay of 6,000 would mean a B delay of 6,100 because the B100 delay cannot be reduced below its minimum value of 100. Obviously 6,100 is too large and, therefore, a B1000 delay of 5,000 is used and the B100 delay circuit is made to produce a delay of 1,000. The B10 delay is set for the minimum 10-microsecond delay, which is cancelled by the fixed A10 delay, so that the total delay is the desired 6,000.

Assume a reference delay of 6,109. Because the unit digit is nine the B-continous delay circuit is used and an additional 10-microsecond minimum delay is encountered. The B1000 delay circuit is set to produce a delay of 5,000, because the minimum delay of 6,110 would be too high; the B100 delay circuit is set to produce a delay of 1,000, to make the total 6,000; the B10 delay circuit is set to produce a delay of 100; and the B-continuous delay circuit is set to produce a delay of 9. This adds up to the required total of 6,109 even though the delays have not been set up in accordance with the numbers called for by the digits of the reference delay.

(*f*) PRESET CONTROLS.—The B-delay circuit is provided with facilities for rapidly changing the B-delay by means of a multideck switch, S504, and five sets of B-delay controls. One set is located on the front panel of the time delay unit and the remaining four sets are located behind a PRESET B DELAY door. Each set consists of three potentiometers for controlling the

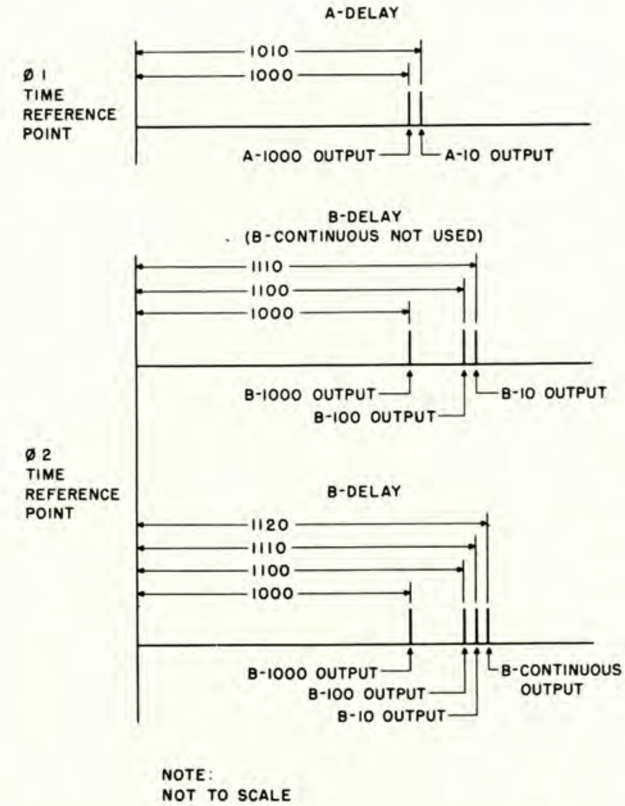


Figure 2–74. Minimum Circuit Delays, Explanatory Diagram

d-c voltage that can be applied to the B1000, B100, and B10 delay phantastrons. No provision is made for changing the continuous delay since the B-continuous delay is not used at a slave station and since the same considerations of signal transit time affect the B delay at a master station regardless of the particular value of B delay used. By connecting each of the sets of controls to the delay circuits, one set at a time, five different values of B delay may be preset. Once these values are set up it will be possible to switch rapidly from one delay to any other delay. The positions of PRESET B DELAY SELECTOR S504 are labeled NORMAL, 2, 3, 4, and 5. The NORMAL position connects the front panel set of controls to the delay circuits and the other four positions select one of the control sets mounted behind the PRESET B DELAY door. For these positions a section of S504 applies power to a load in an external keyer unit and connects the blink relay to one of four keys in that unit. The circuit connecting to the external keys may be broken by means of EXT KEY push button S506.

(3) TRIGGER ALIGNMENT CIRCUIT.—When using the output of the B10 delay circuit directly as the B-timing pulse, the circuits for generating the A- and B-timing pulses furnish theoretically identical circuit paths for the chain of 10-microsecond markers. It would be expected, then, that the two timing pulses would be

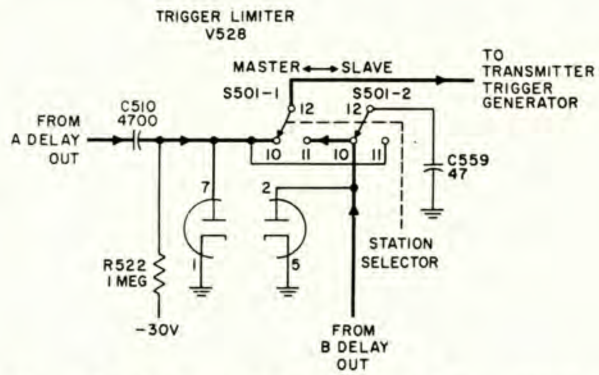


Figure 2–75. Trigger Switching and Trigger Limiter Circuits, Schematic Diagram

separated by some precise increment of 10 microseconds. With such a separation, the 10's shown on one trace of the RF SCOPE should be superposed on the 10's of the other trace on that scope.

The above effect is prevented because the two circuit paths are not identical. Variations of plate load resistors and tube characteristics cause different output pulse amplitudes from the A10 and B10 delay circuits. The two circuits also feed different loads so that capacitive loading on the output circuits vary and pulse rise times differ. The primary cause of this loading difference is that the transmitter trigger generator is driven by the local timing pulse only and does not load the circuit generating the remote timing pulse. Thus there is a smaller capacitive load across the remote timing pulse generator. It will be recalled that the local timing pulse is the A-timing pulse at a master station and the B-timing pulse at a slave station. The variations of amplitude and rise time discussed above act together to change the triggering time of the output circuit by a slight amount.

The difference in capacitive loading is compensated by use of fixed capacitor C559 (refer to figure 2–75) which approximates the input capacity of the trigger generator. The switching arrangement which transfers the transmitter generator from the output of one timing pulse generator to the other also cross transfers C559 to the opposite output so that approximately the same loading is maintained.

The amplitude difference is offset by the use of a variable rheostat, R520, shown in figure 2–72, as one of the elements of the plate circuit attenuator, in the A10 push-up stage, V504. This ALIGN TRIGGERS control is used to compensate for inequalities in pulse amplitude and also any inequalities in pulse rise time to provide an exact time relationship, in 10-microsecond increments, between the A10 and B10 outputs. The control of pulse amplitude provided by R520 can change the effective instant of triggering over a range of a few tenths of a microsecond.

Even where the continuous delay circuit is used it is desirable to first align the triggers, using the direct output of the B10 delay, so that the A10 output pulse will be approximately the same amplitude as the B10 output pulse. As previously implied, R520 is adjusted by observing that the 10's on one RF SCOPE trace are coincident with the 10's of the other RF SCOPE trace.

(4) TRIGGER LIMITER CIRCUIT. *(Refer to figure 2–75.)*—Two trigger limiter stages, V528A and V528B, are used to prevent the triggers from driving the succeeding stages (V517 and V518A) into the grid current region. Because of this limiting, the loading presented by the grid circuits driven by the A- and B-timing pulses remains uniform, and the pulse shapes of the two timing pulses remain similar.

(5) TRANSMITTER TRIGGER GENERATOR CIRCUIT.—The transmitter trigger generator provides an output pulse which is used to time the generation of the transmitted loran signal. Depending on whether the timer is used at a master or a slave station, this pulse is timed by either the A- or B-timing pulse. Refer to figure 2–76. The circuit is driven from the A-delay or B-delay output via STATION SELECTOR MASTER SLAVE switch S501. The input pulse is fed to clipper-limiter stage V518 which isolates the input circuit from the thyratron pulse generator. Two stages are used so that the positive polarity of the input pulse is retained. Input triode V518A is biased beyond cutoff by return of the output resistor of either the A- or B-delay output circuit to —30 volts. Tube V518B is held at essentially zero bias by return of grid resistor R634 to B+. Thus, the positive input pulse drives the two sections of V518 beyond their linear grid swings to clip and limit the signal to a fixed amplitude. This output signal is used to drive the thyratron trigger generator, V520.

The thyratron is held cutoff by the —30-volt grid bias applied via R636. This bias prevents the thyratron from firing so that C537 and C538 are permitted to charge to full B+ via plate resistor R611 and series resistor R613. The positive driving signal, applied through grid current limiting resistor R608, causes the thyratron to fire so that capacitors C537 and C538 discharge their current through current limiting resistor R613 and cathode resistor R612. This produces an output pulse across the cathode resistor. Resistors R613

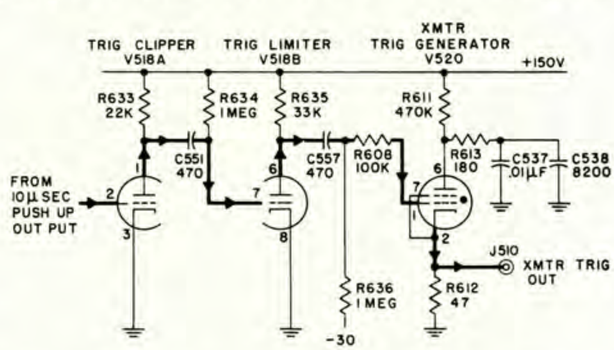


Figure 2–76. Transmitter Trigger Generator Circuit, Schematic Diagram

and R612 limit the peak current and proportion the output voltage so that an output of about 20 volts is developed from a low impedance source.

The thyratron extinguishes when the capacitors discharge to the point where plate current is insufficient to support ionization. The capacitors then recharge to B+ to make the stage ready for the next trigger.

The output pulse has an extremely sharp rise time of less than 0.2 microsecond. The pulse decays exponentially so that the pulse width at 50 percent amplitude is approximately 4 microseconds. This positive 20-volt pulse is applied to output jack J510 as the transmitter trigger.

(6) BLANKING PULSE GENERATOR. — The blanking pulse generator provides a wide rectangular blanking pulse which is synchronized with the transmitter trigger. This pulse is used in electronic switch circuits of the switching equipment and the receiver to disable the sensitive remote channel during transmission of the local signal. The blanking pulse generator is driven ahead of the source which drives the transmitter trigger generator. For master service it is driven by differentiated square wave ϕ 1 (ϕ 1 timing point) and for slave service by the output of the B1000 push-up (V509). Refer to figure 2–77. The generator consists of a pulse inverter, a multivibrator, and an output cathode follower. The pulse inverter, V507A, is biased beyond cutoff by —30-volt bias applied through a resistor of the A- or B-delay circuit. The positive A- or B-timing pulse is amplified and inverted in this stage to provide a negative trigger for the multivibrator. The multivibrator is of the one-shot type and produces a single rectangular output pulse for each input pulse.

The multivibrator stage is V506, a dual triode with cathode coupling between sections through R526. Capacitive coupling is provided from V506A to V506B. The grid of V506B is returned to B+ so that in the quiescent state the stage draws grid current and the grid is maintained at essentially zero bias. The grid of V506A is connected to a positive voltage applied through voltage divider R528, R529. R529 is variable to permit adjustment of this voltage.

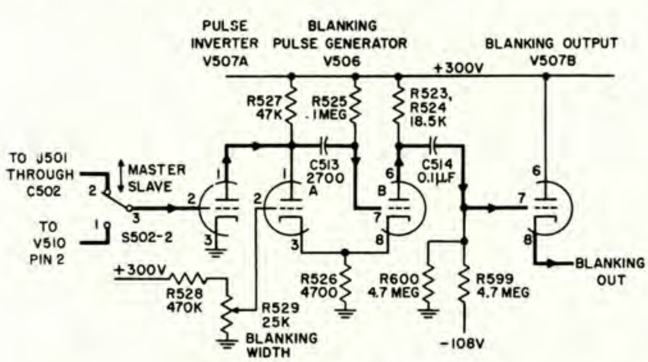


Figure 2–77. Blanking Pulse Generator, Schematic Diagram

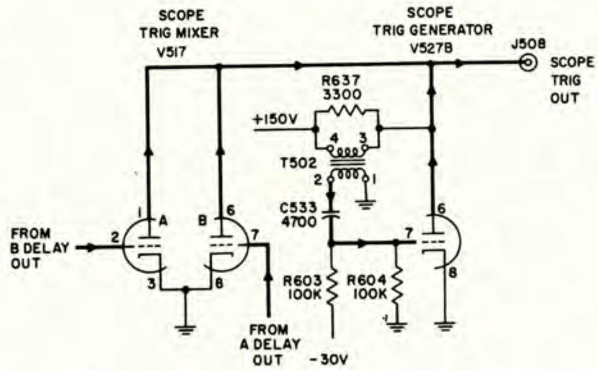
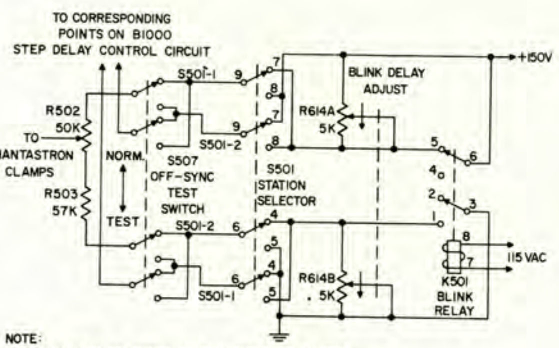


Figure 2–78. Scope Trigger Generator, Schematic Diagram

In the quiescent state V506B is zero-biased and conducts heavily, thus developing a large voltage across cathode resistor R526. This voltage is larger than the positive voltage applied to the grid of V506A so that V506A is cut off. Under these conditions the plate of V506A is positive with respect to the grid of V506B and a charge is accumulated across C513. The negative input trigger applied to the plate of V506A is coupled to the grid of V506B to reduce current in V506B. Cathode voltage is thus lowered, reducing the cathode bias, so that V506A conducts. The resulting voltage drop at the plate of V506A reinforces the negative trigger so that the change of tube voltages is regeneratively speeded, and V506B is rapidly driven beyond cutoff. This condition is maintained until C513 has discharged sufficiently through R525 to raise grid voltage to the point where V506B is no longer cut off. At this point V506B draws plate current so that the voltage across cathode resistor R526 increases, and V506A therefore draws less current. The V506A plate goes positive to drive the grid of V506B positive, regeneratively speeding the initial increase of current through V506B. The multivibrator is thus rapidly driven back to the quiescent state.

The two regenerative changes of state produce a steep-sided rectangular positive output pulse at the plate of V506B. The width of this pulse is controlled by R529 which determines the grid bias on V506A and hence controls the plate swing of V506A during the initial regenerative change. Making this bias more negative decreases the V506A conduction during the period that V506B is cut off so that the V506A plate swing, and therefore the V506B grid swing, is decreased. Because the amount that the V506B grid is driven beyond cutoff is lessened, a smaller rise of grid voltage is required to drive V506B to the point of conduction. This smaller rise requires less time. This shortens pulse width.

The multivibrator output is applied to cathode follower output stage V507B. This stage is biased beyond cutoff by application of —108 volts to grid circuit voltage divider R599, R600. The load resistor for this



NOTE:
S501, STATION SELECTOR SWITCH, SHOWN IN MASTER POSITION CONNECTING BLINK CIRCUIT TO A1000 DELAY.

Figure 2–79. Blink Relay and Blink Control Elements, Schematic Diagram

cathode follower is located in the switching equipment. The blanking pulse is simultaneously applied to all the electronic switch units in the switching equipment and is also fed to the receiver through switchgear wiring. The output pulse has a nominal amplitude of 125 volts and is normally 500 microseconds wide. This width is adjustable over a nominal range of 300 to 1,500 microseconds.

(7) SCOPE TRIGGER GENERATOR CIRCUIT. —The scope trigger generator circuit mixes A- and B-timing pulses and uses them to alternately drive a blocking oscillator which generates sharp trigger pulses. Refer to figure 2–78. The mixer consists of V517, a dual triode, with a common plate load (the secondary of T502) for both sections. The negative triggers developed in the secondary of T502 are used to trigger blocking oscillator stage V527B. This stage operates in the same way as the blocking oscillators of the frequency divider to produce a sharp positive output pulse for each input trigger. This output pulse is fed to J508 to trigger the VIDEO SCOPE, to J509 to trigger the synchronizer gate delay circuits, and to J511 to feed the pedestal trigger circuits of the test scope.

(8) BLINK CIRCUIT. — The blink circuit consists of a control system, located in the synchronization indicator and electrical synchronizer units, a blink relay and control circuit, and a motor-driven cam and switch. Operation of the blink relay increases the delay of the transmitter trigger by 1,000 microseconds. This change of timing is used for signaling purposes. At a master station the change is achieved by increasing the A delay and at a slave station it is achieved by increasing the B delay. This increase is made to occur cyclically by the switching action of the motor-driven cam and microswitch. The control system permits blinking to be initiated manually, by operation of a switch, or automatically, by the alarm circuits of the electrical synchronizer. The blink relay may also be operated through the control of an external keyer unit. Refer to figure 2–79.

(*a*) BLINK RELAY AND BLINK CONTROL ELEMENTS.—The blink relay, K501, operates to increase delay by changing the electrical position of an auxiliary delay potentiometer which is connected to either the A- or B-delay circuit, depending upon whether the station is a master or slave, respectively. This potentiometer, R614, is connected to either the A-DELAY 1000 potentiometer R502, or the B-DELAY 1000 potentiometer R532, for B NORMAL, through contacts of STATION SELECTOR MASTER SLAVE switch S501. The auxiliary potentiometer, R614, consists of two 5,000-ohm sections; section A is connected in series with B+ and the top of the 1,000-step delay potentiometer, and section B is connected in series with the bottom of the 1,000-step delay potentiometer and ground. Normally closed contacts of blink relay K501 are connected across R614A, and normally open contacts of K501 are connected across R614B. With this arrangement the resistance of one of the two equal potentiometers is connected in series with the top or bottom of the local 1,000 delay potentiometer as the relay is energized and de-energized. Thus, as the relay operates, the voltage drop across a section of R614 is either added or subtracted from the voltage at the arm of the delay potentiometer. Because the current through R614 remains constant, as different B1000 delay controls are switched into the circuit by means of PRESET B DELAY SELECTOR S504, the voltage added or subtracted from the delay control voltage will be constant. Thus, once R614 is adjusted to produce a voltage change equivalent to a phantastron delay change of 1,000 microseconds, the circuit will produce a 1,000-microsecond shift for any setting of the 1,000-step delay control. Blink relay K501 is made to operate, to produce the 1,000-microsecond blink shift, by an elaborate control system.

(*b*) BLINK MOTOR, CAM, AND SWITCH.— The blink motor drives a cam to actuate a switch and thus operate the blink relay in a cyclic pattern. This pattern is repeated once per second.

The blink motor, B501, is a synchronous motor which is geared to drive the cam at one revolution per second. The cam is mounted eccentrically on the shaft so that it pushes the switch arm back and forth as it rotates. A slotted hole, in the switch mounting arrangement, permits adjustment of the switch arm relative to the cam for control of the ratio of blink to no-blink time. This adjustment provides for from 30- to 70-percent blink time. Moving the switch closer to the cam increases the percentage of blink time. Capacitor C536, across the switch contacts, suppresses any a-c line transients generated by switching.

(*c*) BLINK CONTROL SYSTEM.—Operation of the blink relay is controlled by a system consisting of a BLINK SELECTOR switch, the alarm circuits of

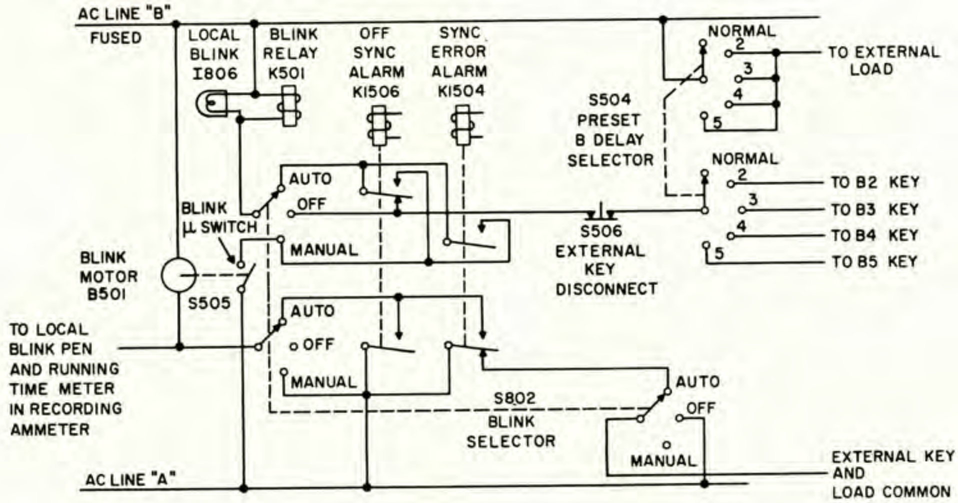


Figure 2–80. Blink Control System, Simplified Schematic

the electrical synchronizer, and an optional external keyer unit. Refer to figure 2–80. The BLINK SELECTOR, S802, on the synchronization indicator unit, has three positions labeled MANUAL, OFF, and AUTO. Placing this switch in the MANUAL position connects the blink motor and one terminal of blink switch S505 to a-c line "A" and the other terminal of S505 to blink relay K501 and a LOCAL BLINK indicator lamp, I806, located on the synchronization indicator unit. This starts the motor operating so that the blink switch alternately turns the blink relay on and off. The LOCAL BLINK lamp lights simultaneously with the energizing of the relay. The LOCAL BLINK pen and the LOCAL BLINK running time meter of the recording ammeter are connected in parallel with the motor circuit so that the pen records a local blink condition whenever the blink motor is running.

Placing the BLINK SELECTOR switch in the OFF position permits operation of the blink relay from the external keyer circuit. The line common to an external load and the external key circuit is connected to a-c line "A" and the blink relay is connected to one of four key lines through contacts of S504, the PRESET B DELAY SELECTOR, when that switch is not at the NORMAL position. This latter connection may be broken by operation of EXT KEY push button S506. Completion of this circuit closes the blink relay but does not operate the blink motor and switch.

Placing the BLINK SELECTOR switch in the AUTO position connects a-c line "A" to the common line for the external load and common key line through normally closed contacts of sync error alarm relay K1504. The return circuit from one of the four key lines is also completed, through S504, S506, and normally closed contacts of off sync alarm relay K1506, to operate the blink relay from the external key circuit in the same way as for the OFF position of S802. However, should either K1504 or K1506 operate in response to an alarm condition, the external key circuit will be broken; a-c line "A" will be connected to the blink motor and one terminal of S505 and the blink relay will be connected to the other terminal of S505. This will start cyclic blinking in the same manner as for the MANUAL position of S802.

(*d*) OFF-SYNC ALARM TEST.—Provision is made to check the OFF-SYNC alarm by simulation of remote station blink by means of the OFF-SYNC TEST switch. The action of this switch interchanges the blink shift of the A and the B pedestals without disturbing the trigger or blanking voltages of the operating timer. Operation of the OFF-SYNC TEST switch and initiation of manual blink (via BLINK SELECTOR switch S802), actuates the blink motor B501 to periodically shift the pedestal (1000 μs) from under the remote signal. Under these conditions, the adjustment of OFF-SYNC circuit may be checked without disturbing rate synchronization.

(9) TEST CATHODE FOLLOWER. — The test cathode follower permits delivery of significant waveforms, originating in the time delay unit, to the test scope. This device isolates the monitored circuit from the test circuit load and provides a low impedance output for the signals. The six monitored circuits are the A1000 gate, at the output of the 1,000-microsecond push-up stage, V503; the B1000 gate, at the corresponding point of the B-delay circuit, V509; the B100 gate at the B100 push-up output, V512; the B10 gate, at the output of the B10 push-up, V514; the transmitter trigger, at the cathode of the transmitter trigger thyratron, V520; and the blanking pulse, at the cathode of the blanking output cathode follower, V507B. An isolating resistor is included in the test cathode follower input circuit for monitoring the blanking pulse, and an isolating capacity compensated voltage divider is included in the test cathode follower input circuit for monitoring all other signals. D-c coupling is used to provide good low frequency response to prevent distortion of the relatively wide A1000 and B1000 push-up gates. A large amount of cathode bias, provided by R598, offsets the positive grid voltage which results because of the d-c coupling.

e. RADIO RECEIVER TYPE R–564/FPN–30.—The general arrangement of the receiver has been described in paragraph 3 *e* preceding. The receiver picks up the

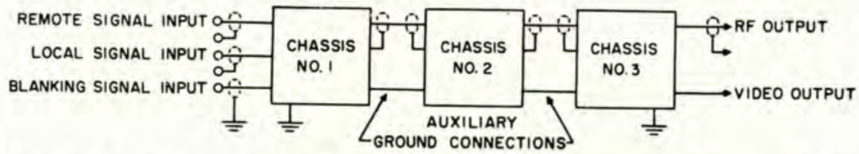


Figure 2–81. Receiver Subsections, Simplified Schematic of Ground Path

local and remote signals and delivers them, at equal amplitudes, to other timer circuits. The undetected r-f pulse is delivered to the RF SCOPE for display. The detected pulse is delivered to the SLOW SCOPE and VIDEO SCOPE for display. The first and second derivatives of the detected video pulse are delivered to the electrical synchronizer to operate automatic synchronization control and alarm circuits, and the second derivative is also delivered to the VIDEO SCOPE for display.

The receiver incorporates high gain TRF circuits which provide an r-f signal whose carrier cycles bear a fixed phase relationship to the pulse envelope so that r-f cycles may be used for accurate phase comparison.

Special care has been taken, in the physical design of the receiver, to prevent circuit regeneration. The r-f amplifier stages, which provide a voltage gain of more than 120 db (1,000,000 times) at the signal frequency, are divided into three isolated subsections to prevent feedback from output stages to input stages. Each subsection is an enclosed metal box containing all the radio-frequency components required by its circuit group. The box is insulated from the main chassis and all ground connections are made through a deliberately planned path which avoids the common impedance coupling of ground loops. The arrangement is shown in figure 2–81 which shows that chassis #1, the input chassis, and chassis #3, the output chassis, are each grounded to the main receiver chassis at only one point and that interchassis grounds are made through the shielding of coaxial connectors. For safety, supplemental ground straps from chassis #1 to chassis #2 and from chassis #2 to chassis #3 are connected very close to the coaxial ground return points to maintain power supply ground connections when the coaxial interconnections are removed.

Unlike most other timer units the radio receiver does not contain a test signal circuit. The significant waveforms of the receiver are fed to other units and may be observed through circuits external to the receiver. The r-f output of the receiver is presented on the RF SCOPE. Correspondingly, the video pulse and the second derivative are presented on the VIDEO SCOPE. The first and second derivatives are delivered to the electrical synchronizer and may be observed through the test signal circuit of that unit.

(1) INPUT CIRCUIT.—The input circuit consists of the local channel attenuators and the remote channel electronic switch. Two attenuators, one external and one internal, are provided. The internal attenuator and the electronic switch are housed in the first of three subsections. This section is identified as chassis #1. The external attenuator is a separate shielded assembly which is mounted on the back of the main chassis. The shielded housing is insulated from the main chassis so that the ground return is through the shield of the coaxial connector to chassis #1.

The two channels provide means for equalizing the amplitudes of the two signals and combining these signals in a common output circuit. Refer to figure 2–82.

The external attenuator provides attenuation of the local signal of from zero to 60 db in 20-db steps. Attenuation is changed by rearrangement of internal links and moving the output plug from one of several jacks to another. This pad has been included to facilitate use of the timer without a shielded enclosure. By providing a higher signal from the switching equipment, and then attenuating that signal in the external pad, any leakage signal picked up by the coaxial line from the switching equipment to the timer will be attenuated, along with the desired signal, and proper control of the local signal amplitude may be effected.

The output of the external attenuator is applied to Z1207, a plug-in tuned transformer circuit identical to Z1201, which provides frequency selectivity required in the remote signal channel. Z1207 is used so that the delay characteristics of the local channel duplicate those of the remote channel. The output of Z1207 is terminated by the internal attenuator. The internal attenuator has two input connections so that, by changing a link connection, either of two attenuation steps may be obtained. The minimum attenuation, nominally 20 db relative to the remote signal path, is provided primarily by voltage dividing action of series resistor R1206 which feeds the low impedance tap of input transformer Z1202, in the first r-f amplifier stage. The remainder of this attenuation results because the output of the local channel is taken from the junction of C1274 and the load presented by the attenuator instead of at the junction of the transformer secondary and C1274, as is the case for the corresponding circuit of the remote channel. Additional attenuation, to provide a nominal total of 40 db, results when the link is transferred to connect a second attenuator section into the circuit. The output of the attenuator is taken from the arm of LOCAL GAIN potentiometer R1209, which provides continuous adjustment for a fine setting of the total attenuation. The attenuation provided by R1209 is limited by series resistor R1318 so that R1209 provides a maximum attenuation of about 20 db. This permits adjusting the amplitude of the local signal to exactly equal that of the remote signal.

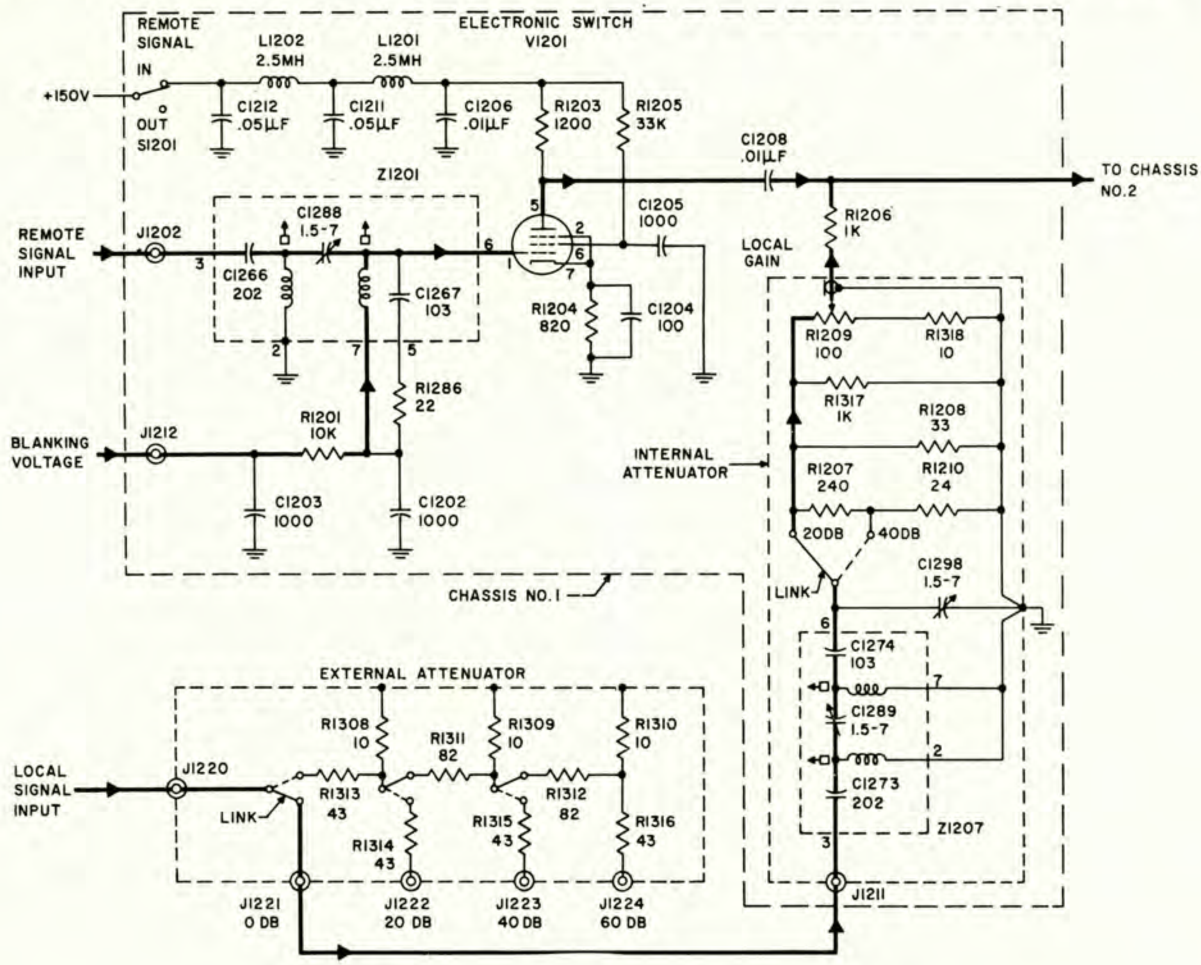


Figure 2–82. Receiver Input Circuit, Schematic Diagram

Transformer assembly Z1207 is an exact duplicate of Z1201. Z1201 has been designed for optimum performance working into the input circuit of V1201. To obtain optimum performance of Z1207 adjustable capacitor C1298 is used to duplicate the input capacitance of V1201. Capacitor C1298 is adjusted at the factory for maximum signal output. Although this adjustment is made with the coil for one particular loran frequency, the adjustment provides the correct capacity for the coils of all loran frequencies.

The remote channel incorporates an electronic switch stage, V1201, which is biased past cutoff by a blanking pulse to disable the channel during the time of transmission of the local signal. The input circuit of this unity gain amplifier is Z1201, a tuned plug-in assembly which is made selective so that signals at other than the desired frequency will be attenuated and any overloading of the input stage will be minimized. This frequency selective arrangement thus materially reduces the possibility of cross modulation. The stage is made to have unity gain through use of an extremely small value of plate load impedance, provided principally by the loading of the first r-f amplifier stage input transformer, Z1202. The output of V1201 is capacitively coupled to the input terminal of Z1202 where it is mixed with the output of the local channel internal attenuator.

The blanking pulse, which disables the remote channel, is applied to the grid circuit through J1212 and pulse filter network C1203, R1201, and C1202. This network reduces the slope of the leading and trailing edges of the blanking pulse and therefore removes transient r-f components which would otherwise be applied to the plate circuit. Blanking voltage is applied in series with the secondary of Z1201 to drive the grid well beyond cutoff. Screen and cathode bypass circuit time constants for V1201 have been kept small to make the tube recover from the effects of blanking as quickly as possible.

In addition to the circuit isolation provided through use of the insulated shielded subassembly, chassis #1, filament and plate power lines into V1201 are rigorously filtered to prevent r-f coupling from other circuits. The plate supply filter consists of feedthrough capacitor C1212, series choke L1202, mounted in a shielded compartment at one end of chassis #1, feedthrough capacitor C1211, series choke L1201, and bypass capacitor C1206. This filter supplies B+ to the plate and screen circuits of V1201. A similar filter, consisting of feedthrough capacitor C1213, series choke L1203, and feedthrough capacitor C1214 is used for the filament supply. To permit attainment of adequate inductance, despite the large-size wire required to pass filament current, L1203 is wound over a powdered iron slug. This slug is factory-set to provide maximum inductance.

The single direct connection between chassis #1 and the main receiver chassis is made through one of the chassis mounting screws. This screw is not provided with the insulated washers used for the other chassis mounting screws.

(2) BLANKING DRIVER AND AMPLITUDE BALANCE CIRCUIT. — The blanking pulse which drives V1201 to cutoff is provided through a blanking driver stage, V1210B, shown in figure 2–83. The blanking pulse is delivered from the switching equipment via J1213 and filtered through C1244, R1250, and C1236 to reduce the slope of the leading and trailing edges of the blanking pulse and therefore remove transient r-f components which would otherwise be passed through the signal channel. This positive pulse is inverted in the plate circuit of the tube and passed to the electronic switch stage, V1201, through coupling capacitor C1218. Positive excursions of the negative output pulse are prevented by clamp tube V1213B. This clamp maintains the grid return at ground potential during normal reception periods.

Another circuit feature, associated with the blanking driver stage, is the amplitude balance arrangement. This arrangement is used only in the case where the timer is used as a monitor of a remote loran pair operating at a different rate. In this case both signals are received through the remote channel and the amplitude balance arrangement is required to equalize the two signal amplitudes. This circuit uses square-wave voltage to change the gain of electronic switch stage V1201 during alternate halves of the loran cycle. Square wave ϕ 1 is applied to one end of potentiometer R1303, through jack J1218 and isolating resistor R1301, and square wave ϕ 2 is applied to the opposite end of R1303 through J1219 and R1302. By moving the arm of the AMPLITUDE BALANCE potentiometer from one end of the resistance to the other, the potentiometer output is varied from square wave ϕ 1 of high amplitude, through diminished square wave ϕ 1 amplitude, to a balance point of zero output, and then through increasing amplitude of square wave ϕ 2. Thus square wave of either phase, at any desired output, is delivered, through AMPLITUDE BALANCE IN OUT switch S1203 and coupling capacitor C1290, to amplitude balance amplifier V1210A.

The square wave applied to V1210A is amplified and used to vary the voltage at the grid return of V1201 and thus change the gain of this stage during alternate halves of the loran cycle. The output of V1210A is prevented from going above ground by clamp V1213B so that the gain of V1201 can be reduced by square-wave voltage during negative halves of the square-wave cycle but the grid is not driven positive during positive halves of the cycle. With this arrangement, the gain of V1201 is reduced during the time that the stronger signal is received, thus reducing the amplitude of the stronger signal, and the gain of V1201 is maintained at maximum for reception of the weaker signal.

(3) R-F AMPLIFIERS. — The receiver incorporates six stages of r-f amplification, housed in two subassemblies. These assemblies, identified as chassis #2 and chassis #3, are part of the precautionary arrangement to prevent circuit regeneration. Chassis #2 contains three stages pretuned to the signal frequency by means of plug-in coils. Chassis #3 contains three

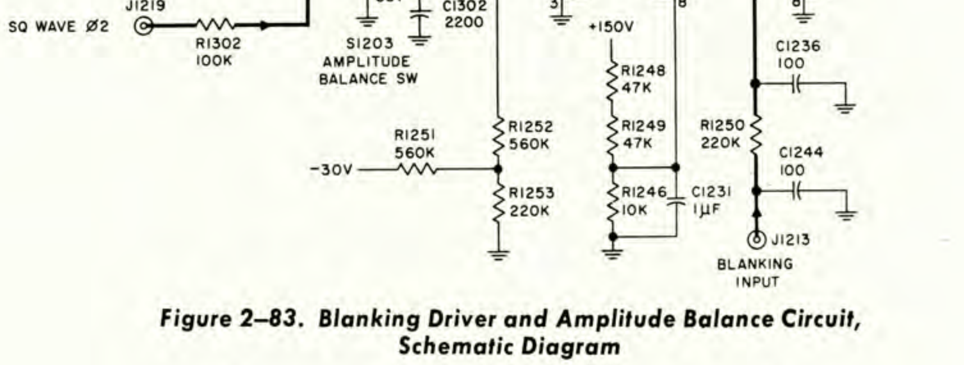


Figure 2–83. Blanking Driver and Amplitude Balance Circuit, Schematic Diagram

stages, broadly tuned for optimum sensitivity over the range of loran signal frequencies, and an output cathode follower and video detector.

(*a*) TUNED R-F STAGES.—The first three r-f stages are sharply tuned to the operating frequency by means of factory-sealed plug-in coils. In addition to this control of frequency selectivity, two tunable traps are provided, one in each of the plate circuits of the first two r-f amplifiers, to permit rejection of interference signals. These traps operate, independently, over a range of 1,500 to 2,500 kc and may both be tuned to the same frequency, to provide maximum rejection of one signal, or they may be tuned to different frequencies to tune out two signals. Each trap is most effective when tuned to the center frequency of its operating range; however, when tuned to any frequency in this range, that frequency will be attenuated at least 30 db.

The over-all selectivity characteristic of the receiver, with the traps tuned away from the received channel so that they have no effect, is between 30 and 40 kc, 6 db down, and less than 150 kc, 60 db down, from the gain at the resonant frequency. This characteristic assures negligible distortion of the received waveshape while still providing ample rejection of adjacent channel signals. When this characteristic is altered, through use of the interference traps, some pulse distortion may be encountered; therefore, it is desirable to tune the traps to frequencies outside the receiver pass band when they are not required for interference rejection.

The first r-f stage, V1202, is fed the mixed output of the electronic switch and the internal attenuator. Refer to figure 2–84. This output is applied to the low impedance tap of the primary of Z1202, the plug-in input transformer. Z1202 is a double-tuned transformer which is made to have wide bandwidth by using shunt resistors R1297 and R1298, across the primary and secondary, to lower the circuit Q. Grid bias, applied through the secondary winding, is a negative voltage which is varied by the use of coarse and fine r-f gain controls, to vary tube amplification. A remote cutoff pentode is used so that the plate characteristic slope varies with change in bias to provide the required gain control. R1291, in the cathode circuit, provides negative current proportional feedback to stabilize the circuit against change of input capacity with change of grid bias. This minimizes detuning with change in gain control setting. The resistor also provides cathode bias to limit the minimum bias of the stage. The tube is operated as a class A amplifier. Screen voltage is taken from voltage divider R1212 and R1295 which provides nearly constant voltage, despite change in screen current effected by bias change, so that good gain control characteristics are obtained.

The first r-f trap is in series with the plate circuit of V1202. This trap is a parallel resonant circuit which provides maximum impedance (effectively an open circuit), and therefore maximum attenuation, at resonance. Impedance is maximum because the capacitive and inductive currents through the trap are 180° out of phase and therefore the voltages cancel. This 180° phase relationship occurs only for the theoretical case of the ideal inductor and capacitor. In the practical case the resistance of the inductor becomes significant and infinite rejection is not possible. The resistance component of the inductance is balanced out by an external resistance in the circuit arrangement of the actual trap. Figure 2–85 shows the fundamental parallel resonant circuit and the arrangement used to compensate for the resistance of the inductor. The capacitance is divided into two series sections and a variable resistance is connected from their common junction to ground. The circuit is called a bridged T network. The variable resistor can be adjusted so that the phase shift through the capacitor branch of the circuit will be exactly 180° with respect to the phase shift through the inductor branch. Thus the resistor compensates for the less than 90° phase shift through the inductor.

The resistance of the inductor can be balanced out at any frequency by adjustment of the variable resistor. For this resistor adjustment, the balance at other frequencies in the tuning range will not be perfect; however, the rejection at these other frequencies will still be very high. The adjustable resistor is factory-set for balance at 1,850 kc. This adjustment may be changed in the field if it is desired to change the attenuation characteristic of the trap. By varying the resistance and noting the effect on filter characteristics, it is possible to increase the bandwidth of the trap so that a broader range of frequencies may be suppressed. This broader bandwidth will be obtained at some sacrifice in the maximum attenuation of the filter.

The rejection frequency of the trap is varied by changing the position of a powdered iron tuning slug. This slug is mounted on a threaded shaft so that shaft rotation moves the slug in or out of the coil form. The slug is rotated by means of a front panel control (RF REJECTION NO. 1) which is linked to the threaded rod through an insulated coupling. This insulation preserves the ground isolation of chassis #2. A stop mechanism, on the front panel shaft, limits rotation to prevent moving the slug beyond its useful range. This stop consists of a gear, on the shaft, which drives an idler gear having a different number of teeth. Cogs on the idler gear and the driving gear mesh at one extreme of rotation, do not mesh during rotation because they are thrown out of mechanical phase by the difference in gear teeth, and mesh again at the other extreme of rotation, as determined by the ratio of gear teeth. Thus, at the two positions where the cogs mesh, rotation is limited.

Output of V1202 is coupled to the second stage, V1203, through a double tuned plug-in transformer, Z1203, which is identical to Z1202 except that the primary of this interstage transformer is not tapped.

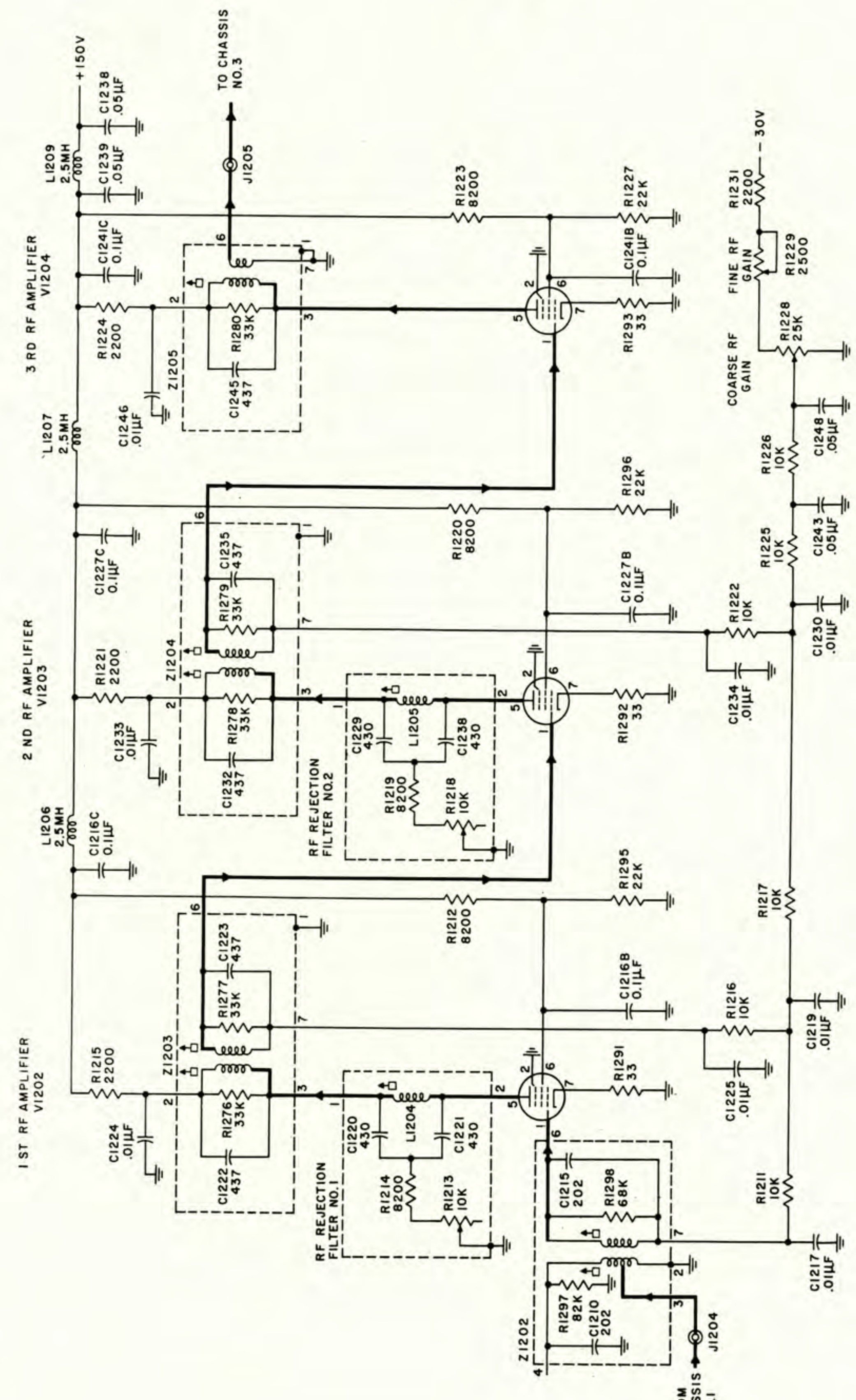


Figure 2–84. Tuned R-F Stages, Schematic Diagram

The circuit of V1203 is identical with that of V1202, even to the inclusion of an r-f trap. This second trap is operated by a panel control labeled RF REJECTION NO. 2. Output of V1203 is coupled to the third r-f stage through plug-in transformer Z1204.

The third r-f amplifier, V1204, is identical to the second r-f amplifier except for the omission of the rejection trap and a difference in the output circuit. The plug-in output transformer for V1204 has a tuned primary which is broadbanded by resistor R1280. The secondary of this transformer, Z1205, is used to link-couple the output of V1204 to the fourth r-f amplifier, V1205, through the coaxial connection between chassis #2 and chassis #3.

The plate, filament, and gain control voltages applied to chassis #2 are filtered by the same arrangement used for chassis #1. An LC filter arrangement is provided for plate and filament voltages and an RC arrangement for the gain control voltage. The gain control voltage is developed by application of —30 volts bias voltage through FINE RF GAIN rheostat R1229 in series with COARSE RF GAIN potentiometer R1228. This voltage is fed to circuits in chassis #3 and also to chassis #2. R-f decoupling, from one grid circuit to another, is provided by RC filters in the bias voltage line. A similar arrangement, using LC filters, provides r-f decoupling for the plate voltage. Filament voltage is decoupled by bypass capacitors at the ungrounded filament terminal of each tube.

(*b*) UNTUNED R-F STAGES.—The last three r-f stages are broadly tuned impedance-coupled amplifiers. These three stages, plus an r-f cathode follower and a video detector, are housed in chassis #3. Refer to figure 2–86.

The link-coupled output of Z1205 is applied to Z1206, the input transformer for V1205. The tuned secondary of this plug-in transformer completes the tuning arrangement for the V1204 plate circuit and is similar in construction to the primary of Z1205. Grid bias, cathode degeneration, and screen supply connections for this stage are the same as for the second and third r-f stages and permit manual control of tube gain. The output circuit for V1205 is an impedance-coupling arrangement consisting of a tuned choke, L1212, which is broadbanded by the resistance loading of R1236, the grid resistor for the next stage. This circuit is peaked at 1,850 kc, but has almost uniform transmission over the band of loran frequencies. Output is capacitively coupled to R1236 through C1201.

The signal output of the fourth stage has been amplified to a level where further amplification in a remote cutoff tube is not satisfactory. Therefore, the fifth r-f amplifier, V1206,. is designed to handle this higher signal level without distortion. The first four stages employ a remote cutoff tube which has a nonlinear plate transfer characteristic to permit change of gain by means of a variable bias .This nonlinear characteristic does not introduce any significant distortion

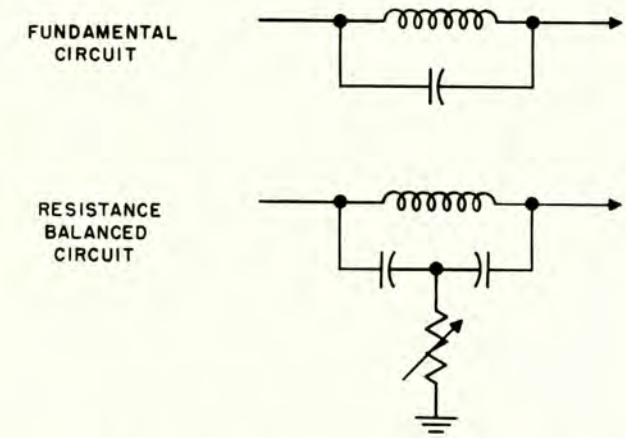


Figure 2–85. Rejection Trap, Explanatory Diagram

because the extremely small signals involved swing the plate over only a small portion of the curve. V1206 is a sharp cutoff pentode which has a linear plate characteristic, permitting relatively large signal swings without distortion, and does not lend itself to gain control. For this reason grid resistor R1236 is returned to ground and cathode bias is developed in R1237. Because bias is not varied the cathode is bypassed by C1250 for maximum gain, and a single series screen resistor, R1238, suffices.

The sixth r-f amplifier, V1207, is similar to V1206 except that a power pentode is used to permit development of the desired amplitude output signal with a minimum of distortion. The output of this stage is impedance-coupled to an output cathode follower, V1208.

The output cathode follower, V1208, is used to feed the r-f signal into the large amount of capacity present in the coaxial connection to other units. Even the low source impedance provided by this cathode follower is insufficient to prevent phase shift across the capacitive load with the loran frequencies involved. Such phase shift is undesirable because it makes the feedback from the cathode other than 180° out of phase with the input voltage. This shift, therefore, reduces the amount of degeneration so that a large output voltage, at low distortion, cannot be developed. The desired condition is obtained by tuning the cable capacity with inductor L1219 so that no phase shift is obtained and maximum undistorted output voltage is developed.

The receiver has been designed to provide a standard output of 15 volts. In terms of pulse signals this standard output is defined as the RMS value of a continuous wave signal having the same amplitude as the maximum sized r-f cycles of the pulse signal. This relationship is illustrated in figure 2–87. The standard output is made to produce a two-inch zero-to-peak deflection on the VIDEO SCOPE by adjustment of scope gain.

For adjustment purposes the standard receiver output must be set up with a continuous wave signal and read on any suitable vacuum tube voltmeter calibrated in RMS volts.

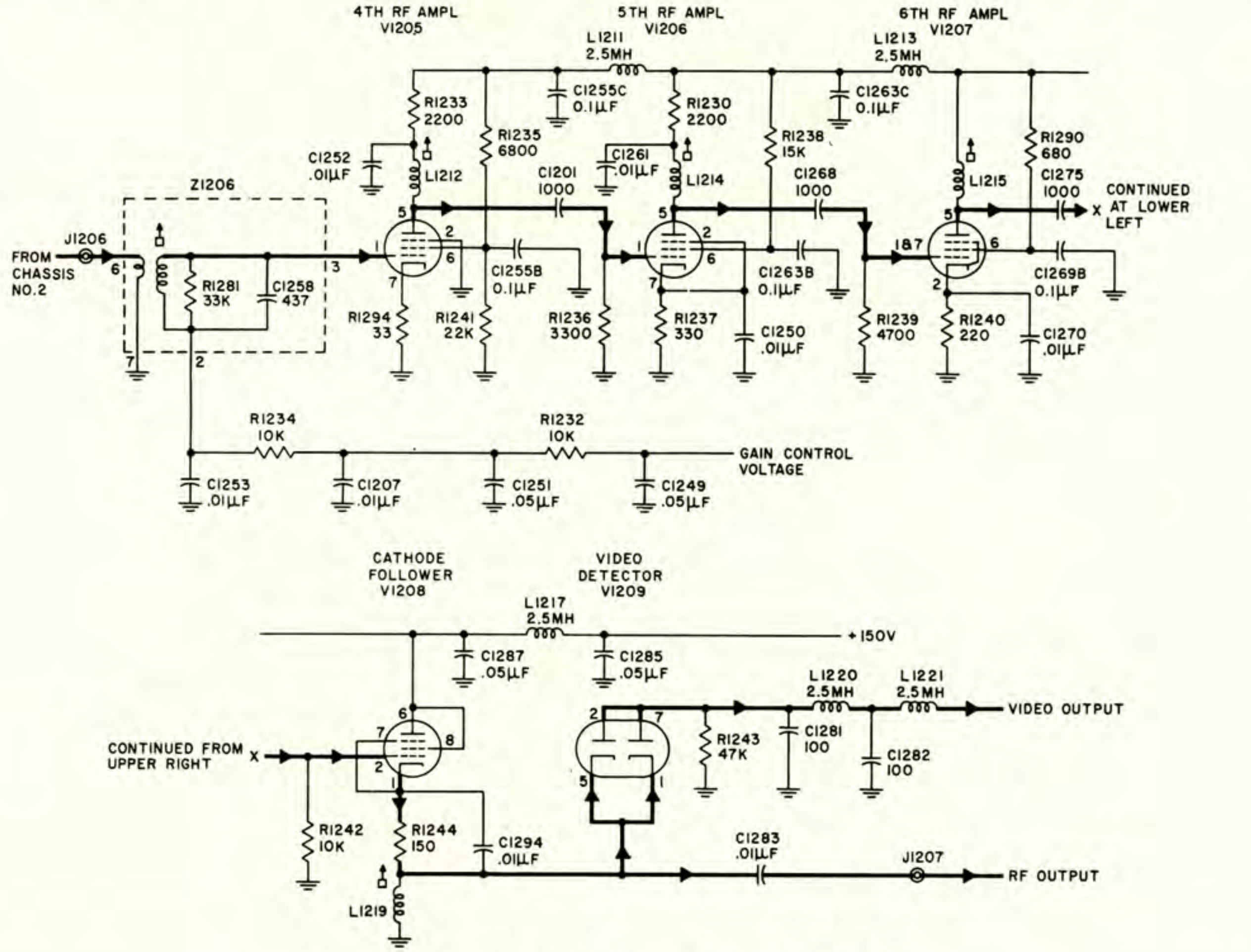


Figure 2–86. Untuned R-F Stages, Schematic Diagram

When operated with output amplitudes of 50 to 150 percent of the standard 15 volts the receiver produces negligible distortion. In terms of VIDEO SCOPE presentation this amounts to a deflection of from one to three inches. Thus, if the receiver gain is adjusted for a two-inch deflection, normal amplitude fluctuations due to fading will not cause the pulse to be distorted within the receiver. If the receiver is not set to this midpoint of its distortion-free operating range, however, signal amplitude variations may cause the pulse to be distorted by the receiver. This distortion will not be apparent on the scopes, but will cause errors in the operation of the electrical synchronizer. The r-f output is fed to the RF SCOPE, via an output jack, and to the video detector.

The r-f output is applied though the video detector, V1209. The two parallel sections of this dual diode are connected in series with the signal path to rectify the negative half of the r-f signal. A low value of diode load resistance is used to prevent distortion of the trailing edge of the video pulse. The rectified signal is filtered by C1281, L1220, C1282, and L1221 to remove r-f components. This signal is passed through a feed-through terminal in chassis #3 and fed to LIMITER IN OUT switch S1202 and cathode followers V1216A and V1216B.

Plate, filament, and gain control voltages are applied to r-f chassis #3 through decoupling arrangements similar to those used for the first two subchassis.

(4) VIDEO LIMITER. — A limiter diode is arranged so that it may shunt noise peaks in the detector output signal and thus prevent overloading of other timer circuits by noise. Refer to figure 2–88. Detector output is fed to the diode, V1211A, via series resistor R1285. Any detector signal exceeding the negative voltage applied to the diode plate, through LIMITER ADJ potentiometer R1289, will cause diode conduction. Because of the resulting voltage drop across R1285, the signal will be prevented from exceeding the level established by the voltage at the arm of R1289. Capacitor C1297 is used to maintain this voltage constant despite current flow during diode conduction. The LIMITER ADJ control should be adjusted so that the level at which limiting occurs is substantially higher than the peak signal amplitude. LIMITER IN OUT switch S1202 is connected in series with the diode

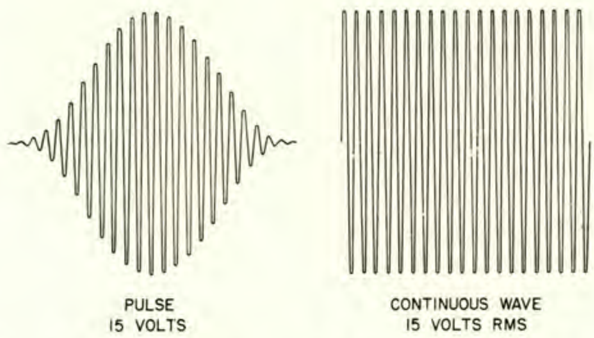


Figure 2–87. Measurement of Pulse Amplitude in Terms of the Amplitude of a CW Signal

cathode and the detector output so that the limiter may be disconnected when it is not required.

(5) VIDEO OUTPUT CATHODE FOLLOWER.—A video output cathode follower is used to provide isolation and a low impedance output so that the video pulse may be fed through coaxial cable to the SLOW SCOPE and the VIDEO SCOPE for presentation. An output is also provided to a PHONE jack so that the operator may listen to the detector output through earphones as an aid to the identification of interfering signals.

The cathode follower circuit, shown in figure 2–88, is conventional except that the two outputs are taken from separate points in the cathode circuit. A correct operating bias is obtained by return of grid resistor R1305 to the junction of R1306, the bias resistor, and R1307, the cathode load resistor. Greatest signal output is obtained by direct connection to the cathode. This point is used for the output to the scopes. A lesser signal output, isolated from the direct cathode output, is obtained at the tap in the cathode load. This output is used to feed the PHONE jack through isolating resistor R1237.

(6) DERIVATIVE GENERATOR.—The derivative generator is used to provide the first and second derivatives of the video pulse by two consecutive processes of differentiation. The nature of the first and second derivative waveforms, and the explanation of how they are obtained by differentiation, was described in paragraph 3 *e* (7) preceding.

Detector output is attenuated by voltage divider R1299 and R1300 to prevent overload of the first differentiator stage. This attenuated output is fed to a cathode follower which isolates the derivative generator from other circuits and provides a low impedance output for driving the first differentiator. A low impedance source is required in a differentiator circuit to obtain good differentiation since the source impedance is in series with the differentiator network and contributes to the determination of the current through the differentiator capacitor.

The simple differentiator shown in figure 2–27 has the disadvantage that it provides an extremely low output signal because of the very low resistance required. The differentiated signal must therefore receive considerable amplification to raise it to a useful output level. Eeedback differentiators are used in the radio receiver to provide the same differentiation as in the simple differentiator and provide the same output voltage, plus greater stability and freedom from distortion, as would be obtained from that differentiator and an amplifier without feedback. Feedback is employed, in a differentiator, to lower the input impedance of the differentiator stage. The lower input impedance thus obtained replaces the low impedance provided by a low value of resistance in conventional circuits.

To understand how feedback functions to lower the input impedance, refer to figure 2–89, Feedback Differentiator, Explanatory Diagram. Two conditions are represented in this diagram, one a resistive dividing network in the input network of an amplifier, and the second the identical circuit with one extra connection to feed part of the amplifier output back to the input circuit. In both cases $R_1 = R_2$ and the input signal is assumed to be 100 volts. In the first case there is an equal voltage drop across each equal resistor. In the second case the feedback voltage, which is out of phase with the voltage across R_2, subtracts from that voltage and lowers it to a value of one volt. This particular new voltage is based on the assumption that the amplification of the tube is of such a value as to develop the specified feedback voltage with an applied grid voltage of one volt. Thus, as represented in the drawing, the input voltage is reduced to the one-volt value by being bucked out by a portion of the output voltage. As the input signal is still 100 volts, and as the total drop across R_1 and R_2 must also be 100 volts, the drop across R_1 is necessarily 99 volts; thus a new voltage ratio of 99:1 has been established. Since the voltage ratio has been changed to present a lower voltage across R_2, and since R_1 has not changed, it follows that, for the new voltage division to take place, the equivalent impedance of R_2 must be lower. Thus the input impedance of the stage has been reduced through the application of inverse feedback.

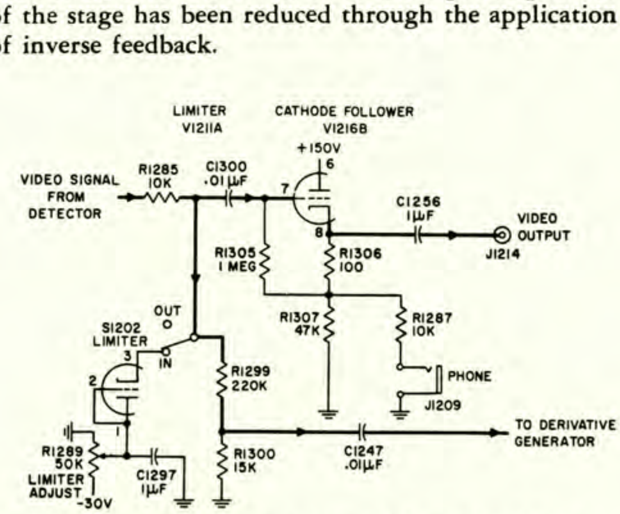


Figure 2–88. Video Limiter and Output Cathode Follower, Schematic Diagram

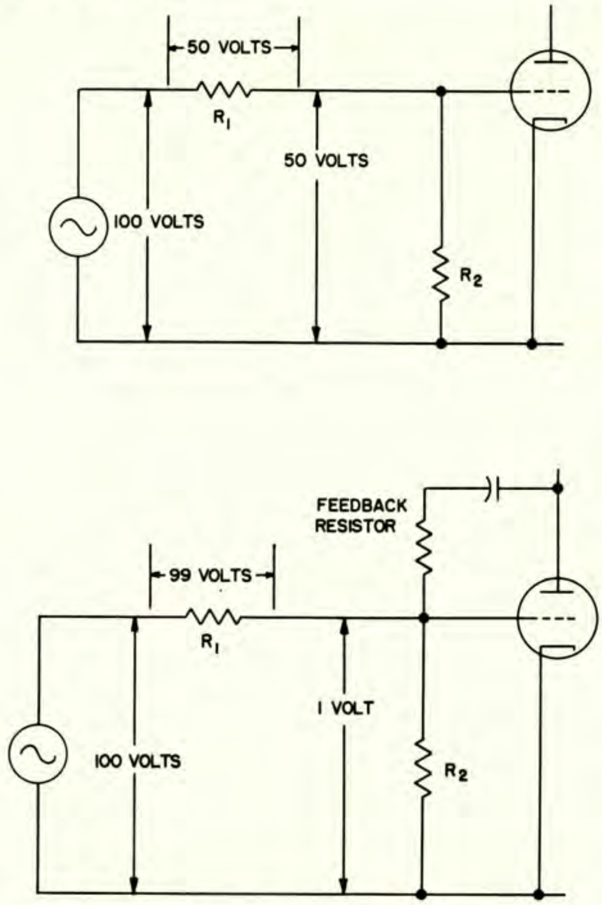


Figure 2–89. Feedback Differentiator, Explanatory Diagram

In the preceding discussion the input network was chosen to be a resistive divider to avoid a discussion of the vector relationships of an RC voltage divider. The behavior of the input network of the feedback differentiator is essentially that of the resistive network described. R_1 is analogous to the impedance of the differentiating capacitor C1257 (refer to figure 2–90), and R_2 is the input resistor, R1259, of the feedback differentiator. The video pulse is thus differentiated. The resulting derivative is amplified in V1213A. A low value of plate resistor, R1265, permits feeding this signal to the electrical synchronizer, through J1215 and a coaxial cable, without significant distortion.

Because of signal polarity requirements of later stages, the first derivative is inverted by V1211B. It is required that the first derivative be subjected to a minimum of distortion. This requirement is met by the cathode degeneration provided by R1288.

Cathode follower stage V1214A provides a low source impedance for driving the second differentiator, V1215. The circuit arrangement is the same as in the first differentiator. The output of the second differentiator is the second derivative. This signal is applied to cathode follower V1214B and then fed through output jacks J1216 and J1217 to the electrical synchronizer and the VIDEO SCOPE.

(7) POWER CIRCUITS.—All input power to the receiver is fed through r-f filters located in a shielded compartment at the rear of the receiver, below the chassis deck. LC filters are provided for the −30-volt, +150-volt and 115-volt a-c power connections. Filament power is supplied through T1201, which steps down the 115 volts ac to 6.5 volts at 3.5 amperes, for the stages in subchassis #1, #2, and #3, and 6.3 volts at 2.5 amperes for all other stages. The higher heater voltage is required to offset the voltage drop in the filament r-f decoupling filters used in each subchassis.

f. SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30.—As previously described in paragraph 3 *f*, the synchronization indicator unit contains three oscilloscopes and the essential controls for monitoring and maintaining synchronization. The three oscilloscopes are the SLOW SCOPE, the VIDEO SCOPE, and the RF SCOPE. They permit measurement of reference delay, and comparison of time difference, in steps of increasing detail. A DRIFT switch permits change of repetition rate, to permit a rough adjustment when first setting up synchronization. A BLINK SELECTOR switch provides control of the blink circuits and a set of alarm indicators warn of synchronization errors or other operational abnormalities.

A unique physical arrangement is used in the synchronization indicator unit to provide maximum accessibility to component parts and to permit ease of viewing the oscilloscope screens. Two subchassis assemblies, mounted on the top rear of the main chassis, fold out to afford access to the subchassis bottoms and to components in the main chassis. Because of its size and shape the main chassis has not been mounted on a tilt assembly. Access to the interior is through removable side, rear, or bottom cover plates and through the top opening provided when the subchassis are folded out of the way and a top shield is removed. The cathode-ray oscilloscope tubes are housed in magnetic shields attached to the main chassis so that the tubes project through a tilted front panel which provides an optimum viewing angle. Auxiliary operating controls are located behind a hinged door, directly under the oscilloscope screens, for ready access when adjusting any of the scopes. Figures 4–6 and 7–256 through 7–261 show these mechanical features.

(1) SLOW SCOPE.—Most of the deflector circuits for the SLOW SCOPE are located in the frequency divider unit; the only SLOW SCOPE circuits included in the synchronization unit are a video amplifier stage, FOCUS, INTENSITY, and SLOW VERT CTR controls, and the cathode-ray tube. Refer to figure 2–91.

The video amplifier, V808A, is a straightforward triode amplifier. It is zero-biased so that maximum grid swing is provided for the negative input pulse. Input voltage divider R850, R860 is used to attenuate the receiver output pulse to a level which provides a convenient SLOW SCOPE presentation. The positive output pulse is applied to the upper vertical deflection

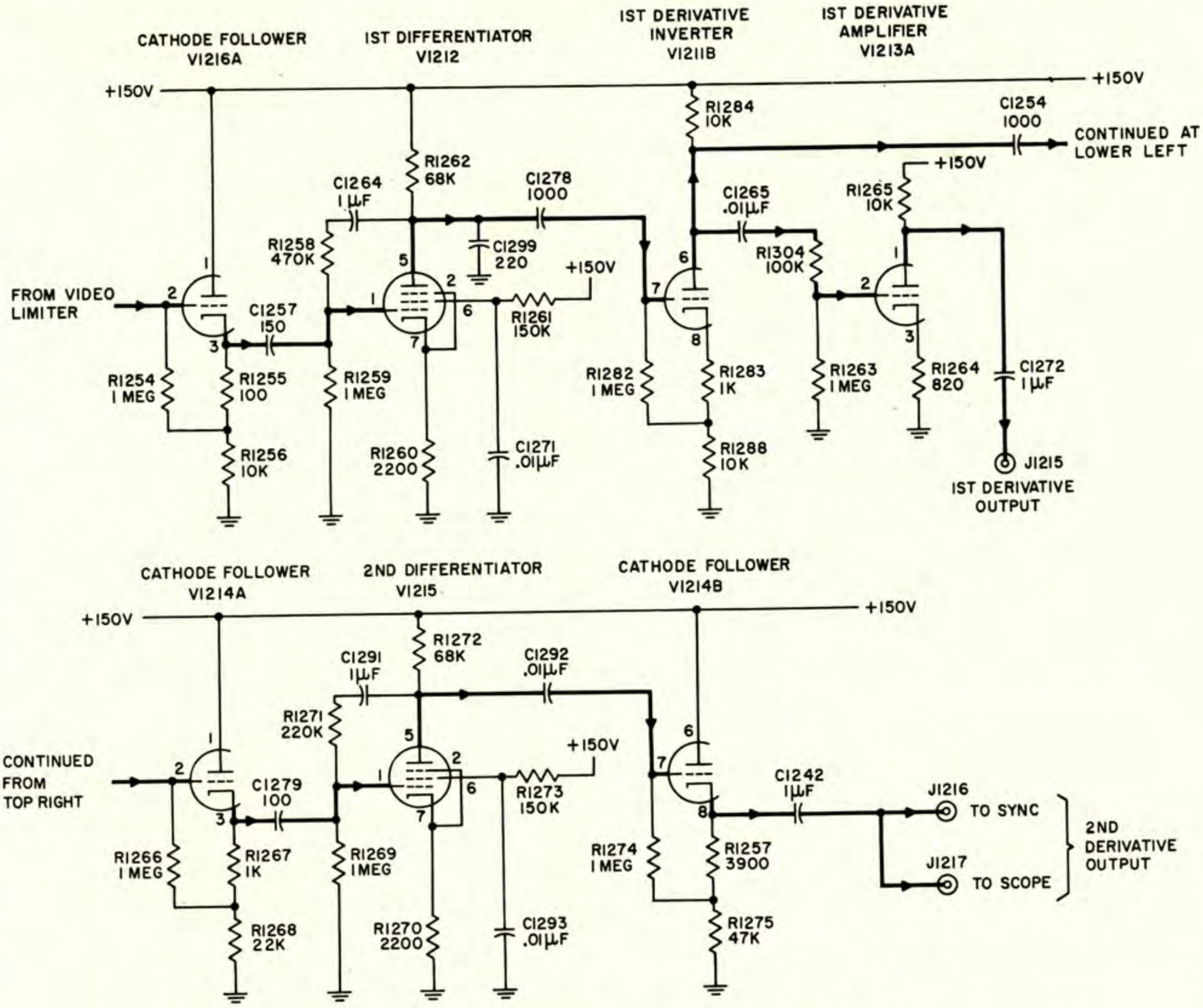


Figure 2–90. Derivative Generator, Schematic Diagram

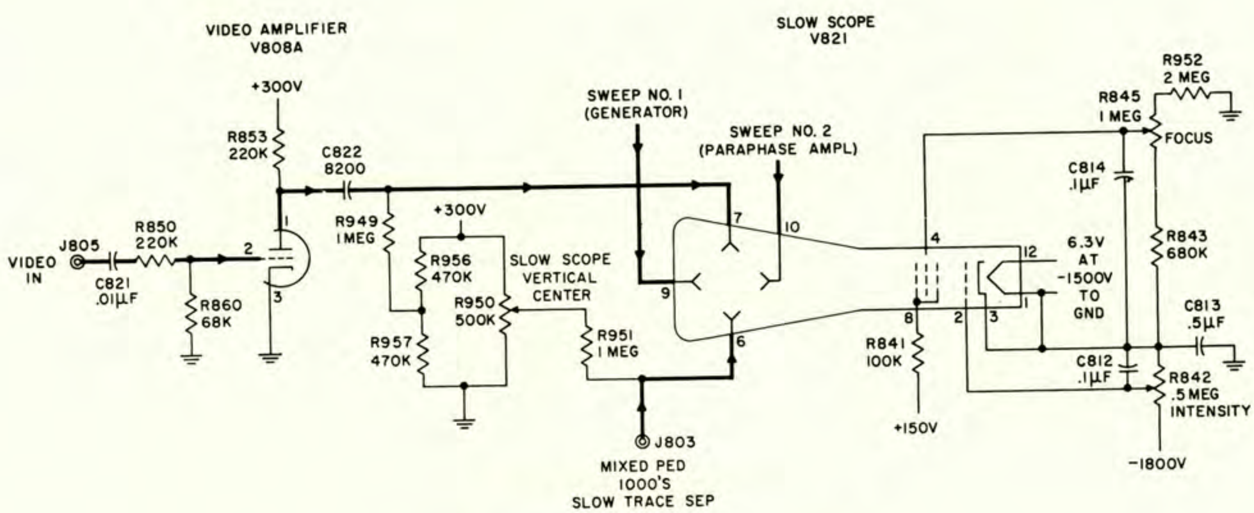


Figure 2–91. SLOW SCOPE, Schematic Diagram

plate of the cathode-ray tube so that it provides a positive pulse on the scope. Markers, trace separation voltage, and pedestals are inserted into the SLOW SCOPE presentation by application to the lower vertical deflection plate. These signals are fed from circuits in the frequency divider unit.

The three-inch 3RP1 cathode-ray tube is operated from the −1,800 volt, +150-volt, and +300-volt supplies. A voltage divider string supplies correct operating potentials to all of the electrodes in the tube. The heater and cathode are connected together and are connected to a point on the voltage divider strings of all three oscilloscopes through the common 6.3-volt a-c heater supply. The voltage divider string includes FOCUS potentiometer R845 and INTENSITY potentiometer R842.

Electrostatic deflection of the oscilloscope trace is provided by horizontal and vertical deflection plates. The circuits for horizontal sweep, and control of horizontal centering, are located in the frequency divider. Vertical centering is provided by variation of the d-c potential on the lower deflection plate with respect to a fixed d-c potential applied to the upper deflection plate. The fixed potential is established by voltage division of +300 volts across R956, R957. A variable d-c potential, above or below the fixed potential, is established by voltage division of +300 volts at the arm of SLOW VERT CTR potentiometer R950. R949 and R951 are d-c return resistors for the upper and lower plates, respectively.

(2) VIDEO SCOPE.—The VIDEO SCOPE has a trigger delay circuit, horizontal sweep circuit, video amplifier, marker mixer circuits, a trace separation circuit, and a five-inch cathode-ray tube.

The delay circuit uses a phantastron to provide a rectangular delay pulse which is differentiated for use as a sweep trigger. Refer to figure 2–92. This phantastron, V802, is identical in operation and circuit arrangement to the phantastrons in the time delay unit, previously described in paragraph 4 *d* (1) (*a*), except that a top clamp is also used. This top clamp, V801A, operates as a trigger diode, to apply mixed A and B triggers to the phantastron and also clamps the tube at the top of the rundown. The clamping voltage is derived from a high impedance voltage divider, R801, R802, which acts as a load resistance for the trigger. The duration of the rundown is controlled by bottom clamp V801B, which is used to establish a voltage difference between the clamping voltage at the top of the rundown and that at the bottom of the rundown. The voltage level at the bottom of the rundown is controlled by VIDEO SWEEP DELAY potentiometer R804 which provides a delay range of 10 to 100 microseconds.

As with any phantastron circuit the delay phantastron has a fixed minimum delay. This delay may be switched out by applying the phantastron trigger pulses directly to the next stage. This switching is accomplished by relay K801, which is operated when VIDEO SWEEP DELAY control R804 is rotated beyond its minimum delay setting to trip S801. S801 is ganged to R804 and is bypassed by C866B to suppress a-c line transients. Relay K801 is powered from the 115-volt a-c line and routes the input trigger through the phantastron via normally closed contacts. The input trigger bypasses the phantastron via normally open contacts so that closing the relay switches out the delay.

Direct or delayed triggers are differentiated by C804 and R817, at the input of cathode follower stage V803B, which drives the phantastron. The cathode follower is required because a relatively low amplitude trigger is used to drive the sweep generator phantastron grid. Because one of the operating controls of this sweep circuit varies the grid supply voltage, the quiescent grid current also varies by a large amount. This causes

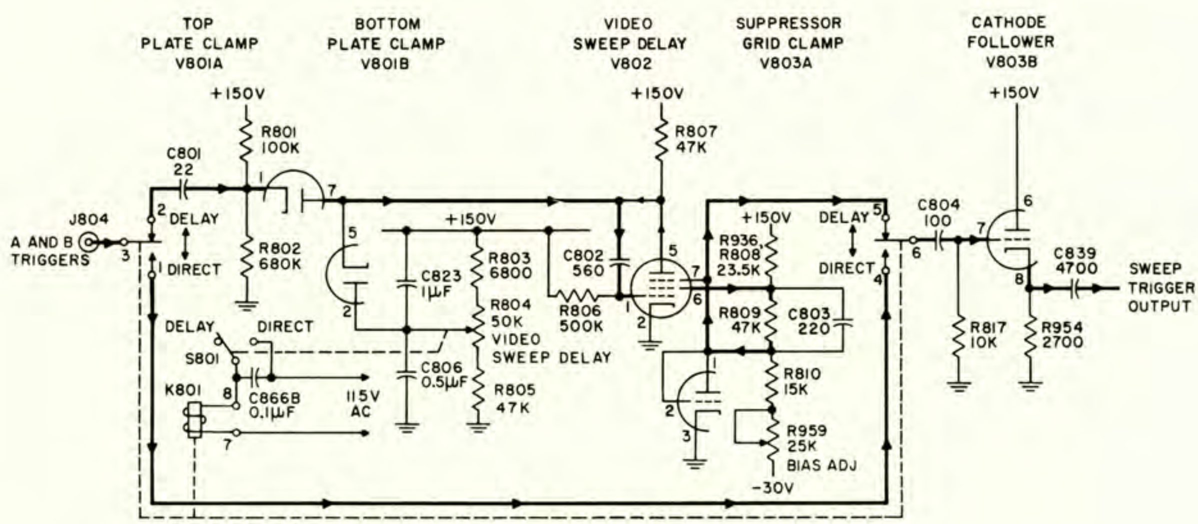


Figure 2–92. VIDEO SCOPE, Sweep Delay Circuit, Schematic Diagram

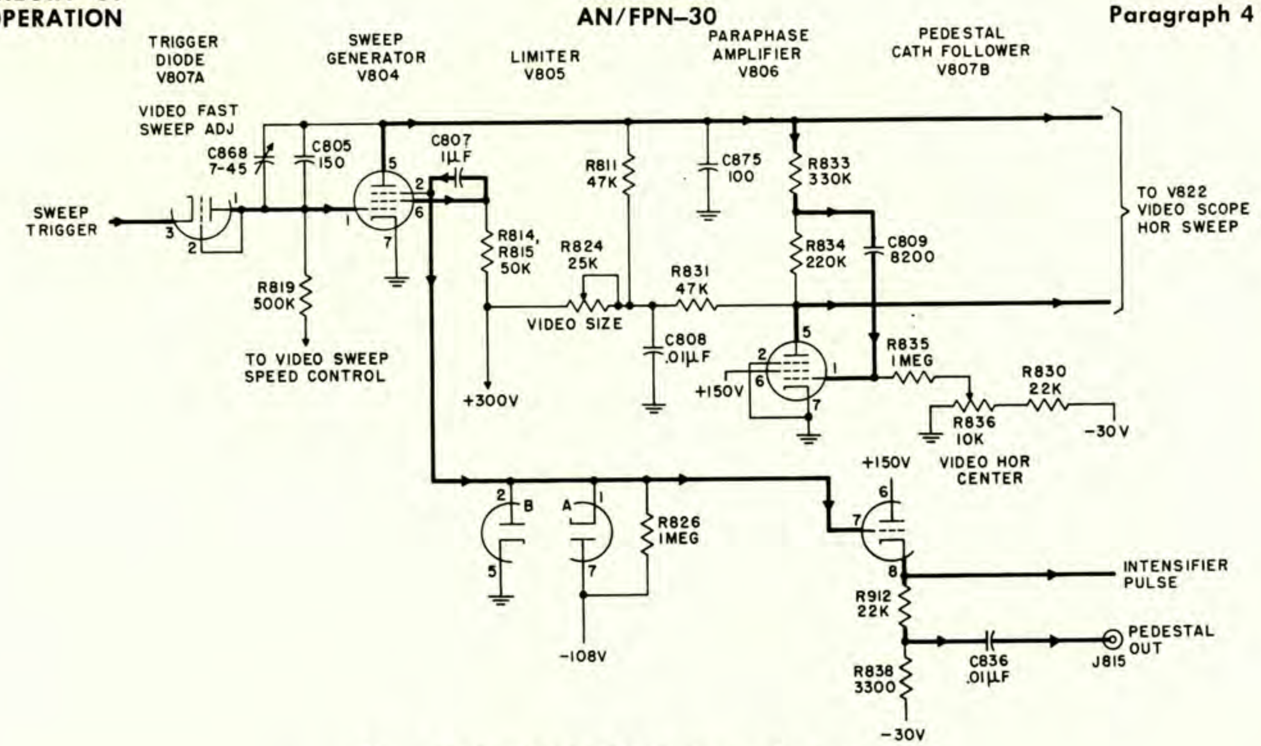


Figure 2–93. VIDEO SCOPE, Sweep Deflection and Intensifier Circuits, Schematic Diagram

a considerable variation of the loading presented by the grid circuit. The low impedance output of the cathode follower maintains relatively constant trigger amplitude despite this change in loading so that the small trigger provides dependable drive. The large trigger used in other phantastron circuits cannot be used in the sweep generator because the trigger is coupled to the plate, through C805, C868, and would cause a false trace and retrace to occur ahead of the linear rundown. The negative pulse which would cause this effect has been shown in the plate waveform of the phantastron delay circuit, figure 2–71.

Although the triggers applied to the cathode follower grid, for direct and delayed triggering, have different amplitudes, they are limited to the same value by the cathode follower. Limiting takes place because the triggers drive the grid from a quiescent zero voltage to beyond cutoff, causing the maximum possible swing of cathode voltage, regardless of relative trigger amplitude. In the quiescent state a small positive voltage is developed across cathode resistor R954. When the tube is cut off by the trigger, this cathode voltage falls to zero; since it cannot go beyond zero, the amplitude of the cathode follower output pulse is limited to a maximum value established by the quiescent cathode voltage. This maximum value is reduced somewhat by the loading of the next stage. Thus a small output of relatively stable amplitude is provided.

The trigger provided by the cathode follower is applied through isolation diode V807A to the control grid of the phantastron, V804. Refer to figure 2–93. This trigger initiates rundown in the same manner as previously described for other phantastron circuits. Because the rundown is extremely linear, it is ideally suitable as a horizontal sweep voltage. The phantastron has the additional advantage that the rectangular screen pulse it generates is coincident with the rundown and may therefore be used as an intensifier pulse to make the trace visible during the sweep. Because the deflection spot is stationary during most of the operating cycle, it is necessary to extinguish the beam at all times, except the sweep period, to avoid burning a spot on the cathode-ray tube phospher. The blanking bias used to extinguish the beam is overcome by the intensifier pulse so that the beam is made visible.

Because this phantastron is used as a sweep generator, it has a slightly different circuit arrangement from that used for the delay phantastrons. The sweep speed is varied by changing the charging voltage applied to the grid coupling capacitor which determines the sweep time constant. This method of control is used, so that the trace size will remain constant for all sweep speeds, instead of controlling the voltage drop during rundown by means of a variable bottom clamping voltage, as done in the delay phantastrons. Control of trace size is effected by variation of the applied plate voltage to change the output voltage of the circuit as required. No fixed voltage bottom clamp is used as adequate circuit stability for sweep purposes is realized by letting the rundown terminate at the bottom of the linear plate characteristic. The d-c coupling resistor from the screen grid to the suppressor grid has been omitted to permit developing a large screen output pulse. The loss of coupling caused by this omission is compensated by use of a large value of coupling capacitance.

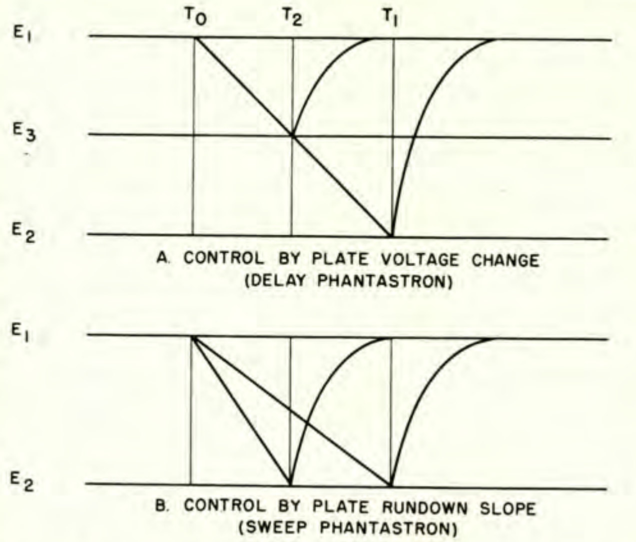


Figure 2–94. Two Methods for Control of the Duration of a Phantastron Rundown

The difference between control of the duration of the rundown by changing the voltage at which the rundown is terminated and by changing the rate of the rundown by variation of the voltage applied to the grid circuit time constant is shown in figure 2–94. In A of this drawing plate voltage is made to drop from quiescent voltage E_1 to a lower value E_2. The time at which the rundown terminates is shown as T_1. The rundown is made to terminate at earlier time T_2 by changing the voltage at which the rundown will terminate, to a higher value, E_3. This change of time is made with the slope, or rate of fall, held constant. In B of figure 2–94 the time of termination is shortened from T_1 to T_2 by increasing the slope of the rundown so that voltage E_2 is reached in a shorter time. This change of time is made with the value of E_2 held constant. In this second case the phantastron plate output voltage is kept constant, even though the rundown duration is shortened. This is not true in the first case, shown in A, which is the arrangement used for delay phantastrons. The arrangement shown in B, for the second case, is used for sweep circuits because the resulting constancy of output amplitude maintains a constant trace size with any sweep duration.

The change in the slope of the rundown is accomplished by varying the charging time of the grid circuit time constant C805, C868, R819 by changing the charging voltage. The charging voltage is applied through VIDEO SWEEP potentiometer R813. The minimum sweep speed is limited by resistor R885, in series with R813. Capacitor C806B and series resistor R837 filter this voltage. The higher the charging voltage applied to C805, C868 the faster they charge and hence the greater the slope of the rundown and the faster the sweep speed. Capacitor C868 is variable so that the circuit time constant may be adjusted, when R813 is set for fastest sweep, to provide a sweep speed of 75 microseconds. With proper adjustment of C868, the slowest sweep speed will be at least 1,300 microseconds.

The trace size depends upon the amplitude of the phantastron plate output voltage. This amplitude is controlled by variation of the plate voltage. Output amplitude is proportional to this voltage. Control is effected through VIDEO SIZE rheostat R824, and the voltage at the output of R824 is bypassed by C808. The voltage drop across this resistor is used to reduce plate voltage of the phantastron, V804, and an associated paraphase inverter, V806. The reduced voltage is also applied to VIDEO SWEEP SPEED potentiometer R813 so that changes in sweep speed, with changes in size, are minimized.

The sweep rundown is not terminated by a bottom clamp, as done in the delay phantastrons, so that the rundown is allowed to terminate at the "knee" of the tube characteristic where change in plate voltage with change in control grid voltage falls off abruptly. At this point degenerative control of the rate of rundown ceases and a sharp regenerative transition takes place, just as in the previously described circuit where clamping terminates the rundown. This method of termination is called plate bottoming. The fact that the rundown terminates through the tube characteristic, rather than a bottom clamp, is of no importance because the point of rundown termination has no time significance.

The intensifier pulse is taken from the suppressor grid, where it is coupled over from the screen grid at full amplitude by C807. Because of the omission of a d-c coupling resistor, the current variation in the screen grid circuit provides a high amplitude rectangular pulse. The width of this pulse varies as the sweep speed is varied, since the pulse width corresponds to the duration of the rundown. This pulse is therefore useful as an intensifier pulse for making the video trace visible during sweeps and for forming a pedestal on the SLOW SCOPE trace to relate the VIDEO SCOPE sweep periods to the SLOW SCOPE presentation.

In the quiescent portion of the sweep cycle, the period from one rectangular screen pulse to the next, coupling capacitor C807 is charged by current flow from the +300-volt bus through screen resistors R814, R815, capacitor C807, and the suppressor return resistor, R826, to the −108-volt bus. The positive, leading edge of the screen pulse drives the junction of C807 and R826 positive from the quiescent −108-volt level until diode action of V805B clamps this point at zero. During the rundown the charge on C807 increases because of current flow through R814, R815, and diode V805B. At the termination of the rundown, the negative excursion of the screen grid drives the junction of C807 and R826 negative. Because of the charge built up across C807 during rundown, this junction is driven beyond the original −108-volt point. This causes conduction of V805A, which prevents negative excursion of the suppressor pulse waveform. Conduction of V805A also enables C807 to discharge quickly, thus permitting the circuit to rapidly recover to the quiescent operating condition before the next sweep trigger. In addition, an undesirable negative overshoot is prevented from occurring at the trailing edge of the SLOW SCOPE pedestal.

The suppressor voltage is applied to the grid of cathode follower V807B. The cathode resistor is returned to —30 volts. When the grid is at —108 volts, the stage is cut off and the cathode is at —30 volts. When the grid is at zero, current flows through cathode resistors R912 and R838, and the tube adjusts itself to normal cathode bias conditions. This results in the cathode being approximately 10 volts positive with respect to ground. Thus a cathode swing of about 40 volts is obtained because of the return to the —30-volt bus; a much smaller swing would result if the cathode were returned to ground. The full positive cathode pulse is used as an intensifier pulse and applied to the intensity control grid via coupling capacitor C815. The quiescent voltage applied to this grid blanks the tube off so that the trace is not visible except during the sweep period when the intensity grid voltage is raised by the intensifier pulse. A portion of the positive cathode pulse is taken from the junction of R912, R838 and fed to the frequency divider for use in developing the SLOW SCOPE pedestal. Thus the pedestal corresponds in time to the sweep period.

The sweep voltage generated at the phantastron plate is applied directly to one horizontal deflection plate and, through a paraphase inverter stage, to the other horizontal deflection plate to provide push-pull sweep. The paraphase inverter is a feedback circuit which provides unity gain for the phantastron plate signal with faithful phase inversion. The circuit arrangement and operation are identical to that of V227, the paraphase inverter of the SLOW SCOPE deflection circuit located in the frequency divider and previously described in paragraph 4 *c* (10). VIDEO HOR CENT potentiometer R836 controls the bias on the inverter to change the d-c plate voltage. Because direct coupling is used between the phantastron and inverter plates to the deflection plates, the variation of inverter plate voltage controls centering.

The 5CP1A cathode-ray tube is operated from the —1,800-volt, +150-volt, +300-volt, and +2,100-volt supplies. A voltage divider string, similar to that in the SLOW SCOPE, supplies proper operating voltages to the tube electrodes. This string includes INTENSITY potentiometer R879 and FOCUS potentiometer R882. The d-c voltage applied to the intensity grid is through isolating resistor R878 which permits the intensity grid voltage to be varied by the intensifier pulse.

An AUX FOCUS potentiometer, R839, is connected as a voltage divider between the +300-volt and —108-volt buses so that it supplies a negative or a positive voltage to the #2 and #4 grids of the cathode-ray tube. This voltage is used to adjust the scanning beam for minimum astigmatism. Capacitor C810A bypasses this voltage.

Either the video signal or the second derivative is displayed on the VIDEO SCOPE. Refer to figure 2–95. The desired signal is switched into the two-stage video amplifier by relay K802, which is controlled by SIGNAL SELECTOR switch S803. Capacitor C819 bypasses S803 to suppress a-c line transients. Normally closed contacts of K802 connect VIDEO IN jack J805 to the amplifier via VIDEO GAIN potentiometer R854. R854 is adjusted to produce a two-inch zero-to-peak deflection when the receiver output is the standard 15 volts described previously in paragraph 4 *e* (3) (*b*). Normally open contacts of K802 connect 2ND DERIV IN jack J806 to the amplifier via DERIV GAIN potentiometer R846. R846 is adjusted to produce a two-inch peak-to-peak deflection for the standard receiver output.

The signal selected by K802 is amplified in V808B, a resistance coupled triode amplifier. The output of V808B is applied to a second video amplifier, V809, via contacts of VIDEO PRESENTATION switch S804.

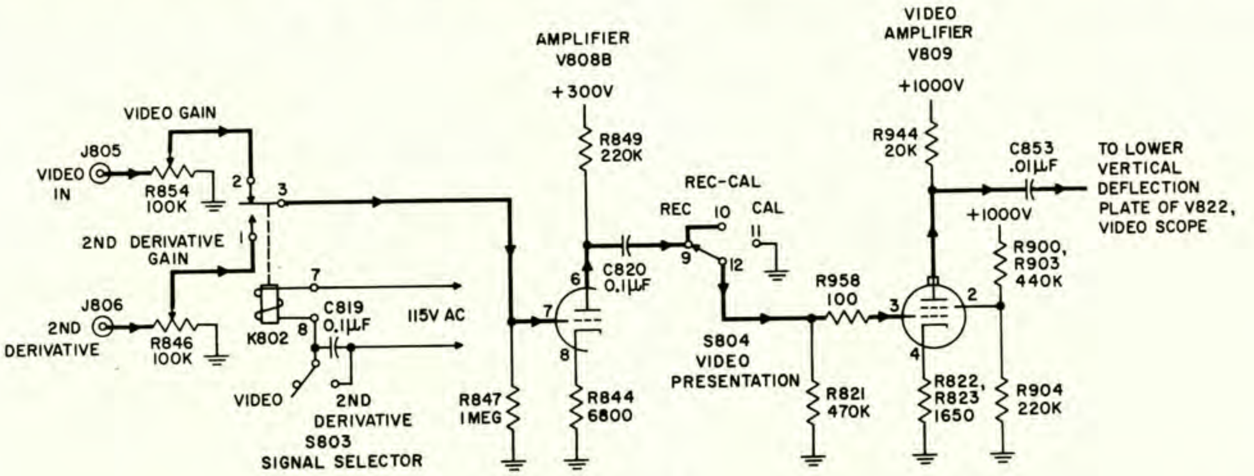


Figure 2–95. VIDEO SCOPE, Video Amplifier, Schematic Diagram

This switch permits display of either the video signal alone, the video signal with markers, or markers alone. S804 opens the circuit from V808B and grounds the grid of V809, when in the calibrate (CAL) position, so that only markers are displayed on the scope. V809 is a resistance coupled beam tetrode amplifier which is designed to provide a high output voltage. Resistor R958, in the grid circuit, is a parasitic suppressor. A low value of plate resistance, R944, is used to insure good pulse transmission with minimum distortion of the leading and trailing edges. The cathode bias provided by R822 and R823 is offset from the center of a linear operating point so that a four-inch zero-to-peak video presentation may be obtained without saturation. This requires a negative plate signal of over 300 volts. The desired output is obtained, with negligible distortion, through use of a large beam tetrode and a 1,000-volt plate supply. The output signal is fed to the lower vertical deflection plate through coupling capacitor C853. A dual potentiometer arrangement, R863A and R863B, is used to vary the d-c voltages applied to the vertical deflection plates to control centering. This dual voltage control keeps the average voltage of the deflection plates at a constant level to maintain good focusing.

A series of markers is introduced into the VIDEO SCOPE presentation by application to the upper vertical deflection plate. A marker mixer arrangement is used to produce a comb of 1000's, 100's, 10's and 1's. The amplitudes of the markers produced by this arrangement are controlled so that each marker may be identified by its relative height. The comb of markers is produced by these two mixers. The 1000's, 100's, and 10's are combined in one mixer; this group is then mixed with the 1's in another mixer to form the complete comb of markers.

The circuit for combining the first group of markers operates by using 1000's and 100's to increase the amplitude of specific 10's. Thus the output signal is not a mixture of the original 1000's, 100's, and 10's, but a group of 10-microsecond markers in which all input 10's coincident with the 1000's and 100's are increased by a large fixed amount and all input 10's coincident with the 100's only are increased by a lesser fixed amount. Because of this arrangement the exact position of the 100's and 1000's is not important, so long as some part of these markers is coincident with a 10.

It will be recalled that the 10's are produced by the 100-kc timing signal, at the input to the frequency divider, and that the 100's and 1000's are the outputs of counter 1 and counter 2, respectively. Because of the delays in the counter circuits, the 1000's, 100's, and 10's are not coincident. To produce a group of markers with everything coincident with the 10's, it is necessary to delay the 1000's and 100's so that they are coincident with the 10 which immediately follows the 1000's and 100's. This delay is accomplished by broadening the 1000's and 100's so that they have sufficient width to make them coincident with the desired 10.

The width of the 1000's and 100's is increased by pulse broadening networks at the input to the 1000's amplifier, V811B, and the 100's amplifier, V826A. Refer to figure 2–96. The network for V826A consists of series resistor R869 and shunt capacitor C825; a similar network is used for V811B. The 10's are sharpened, to provide narrow markers, by an input differentiator network, C867 and R872, in the grid circuit of 10's amplifier V811A.

The group of markers is produced at the output of the 10's amplifier, V811A. This amplifier is shunted by V811B and V826A, the 1000's and 100's amplifiers. These amplifiers are zero-biased so that, except when cut off by the negative input markers, they load the plate circuit of V811A. The loading reduces the plate voltage rise of the 10's amplifier when it is cut off by an input 10. Reduction or removal of the loading increases the amplitude of the output 10. Thus when the 1000's and 100's amplifiers are both cut off by input markers the loading is completely removed and the 10's have maximum amplitude. When only the 100's amplifier is cut off, by an input 100, the loading is reduced, and the output 10's have an intermediate amplitude. The three different amplitudes of the output 10's identify 10's, 100's, and 1000's.

The amplitude of the 10's in the marker group is dependent upon the amount of loading presented across V811A when the other two amplifiers are conducting. This loading is limited by the plate resistors for the two amplifiers and controlled by variation of one of the plate resistors for 100's amplifier V826A, 10 MARKER HEIGHT rheostat R868. This control has no effect on the amplitude of the 100's because V826A is cut off by negative 100's and no current flows through R868; the only time the current through R868 is significant is the time of transmission of the string of nine 10's between each 100. In a like manner the amplitude of the 100's is dependent upon the value of plate resistor R866, which is fixed. The value of resistance used has been chosen to make the 100's noticeably smaller than the 1000's. The amplitude of the 100's is the full output of the 10's amplifier when it is not loaded by the other two stages. When properly adjusted, there is a small, discrete amplitude difference between the three markers. This small difference is made much larger, so that the marker amplitudes are in the ratio 1:2:3, by clipping and amplifying the output of the 10's amplifier in a following stage, V814B. V814A and V814B comprise a dual triode clipper-mixer which combines the group of markers with 1's and provides for control of the amplitude of the group and the 1's.

The 1's are fed through input jack J811 to amplifier stage V812A and from there to V814A. The amplitude of the 1's is controlled by 1-μs MARKER HEIGHT control R967, located on the chassis. This potentiometer adjusts the bias, and hence the clipping level, of V814A. In a similar manner MARKER HEIGHT con-

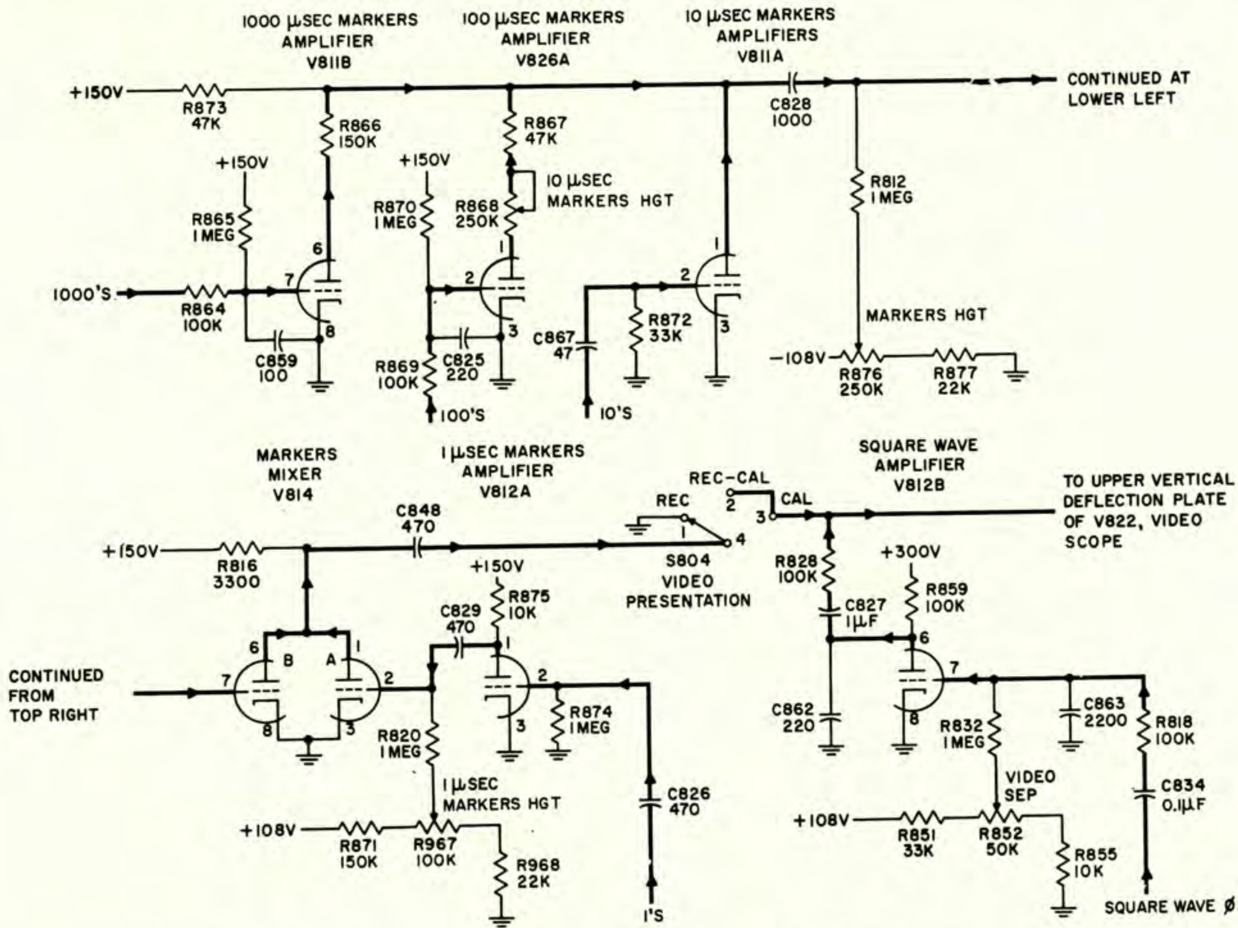


Figure 2–96. VIDEO SCOPE, Marker Mixer and Trace Separation Circuits, Schematic Diagram

trol R876, on the front panel, controls the over-all height of the group of markers fed to V814B. The clipping action not only controls marker amplitude but also sharpens the markers.

The signal at the common output of V814A and V814B is a comb of amplified 1000's, 100's, 10's, and 1's. The mixing action which produces this comb of markers differs from that used to produce the group of 1000's, 100's, and 10's. The time positions of the two signals fed to V814 are completely independent of each other and therefore small differences in the occurrence time of the 1's, with respect to that of the group, are immediately obvious. For this reason the VIDEO SCOPE presentation is used to adjust the phase of the 1's with respect to the 10's. It will be recalled, from the frequency divider discussion, that the phase of the 1's is controlled by tuning an r-f transformer.

The mixed comb of markers is fed to VIDEO PRESENTATION switch S804 via coupling capacitor C848. This section is part of the switching arrangement which controls presentation of markers and received signal, as previously discussed in the description of the video amplifier, earlier in this paragraph. Markers are grounded in the receive (REC) position of this switch and fed to the upper vertical deflection plate in the two remaining switch positions.

Square wave is also applied to the upper vertical deflection plate, via mixing resistor R828, to provide trace separation. Since one half-cycle of the square wave is negative, and the other half is positive, and since the master and slave traces occur in alternate halves of the square wave, one trace will be deflected upwards and the other will be displaced downwards regardless of the time these traces occur within each half-cycle of the square wave. The square-wave amplitude, and hence the amount of trace separation, is controlled by varying the bias on square-wave amplifier tube V812B. This bias may be adjusted to completely cut off the tube, so that the input square wave has no effect on plate voltage (zero trace separation), or bias can be reduced so that the square wave varies plate voltage by any desired amount (any desired trace separation). Bias control is effected by VIDEO SEPARATION potentiometer R852, which is connected in a voltage divider string from −108 volts to ground. An RC filter consisting of R818 and C863, in the grid cir-

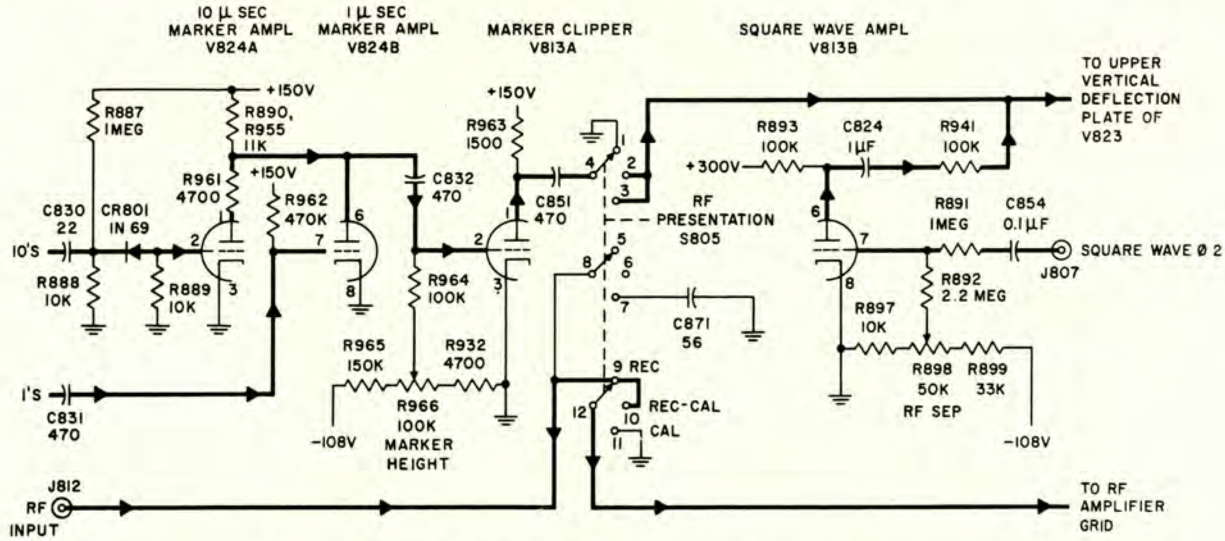


Figure 2–97. RF SCOPE, Marker Mixer, Schematic Diagram

cuit, and shunt capacitor C862, in the plate circuit of V812B, are used to remove undesirable marker voltages picked up by stray coupling in the input wiring.

(3) RF SCOPE.—The RF SCOPE has a circuit arrangement which is nearly identical to that of the VIDEO SCOPE. The principal circuit difference stems from the faster sweep range of the RF SCOPE. A sweep speed range of 5 to 100 microseconds is used. The circuit has no provision for switching out the minimum sweep delay. Because of the range of sweep speeds employed, the marker circuit provides only 1's and 10's.

The only circuits which differ significantly from those of the VIDEO SCOPE are the marker mixer circuit, the r-f amplifier, and the cathode-ray tube circuit; hence only these circuits will be described.

The marker mixer arrangement for the RF SCOPE consists of dual triode mixer V824A and V824B and clipper stage V813A. Refer to figure 2–97. Negative 1's are applied to the zero-biased grid of V824B. The amplitude of the output 1's is reduced by the loading presented by V824A when this stage is in the quiescent, zero-biased state. This loading, on the V824B plate circuit, is limited by R961 in the V824A plate circuit. The loading is removed when V824A is cut off by an input 10. Thus the amplitude of every tenth 1 is increased, in the same arrangement used to increase the amplitude of every tenth and hundredth 10 in the VIDEO SCOPE mixer described in the preceding paragraph.

The 10's contain a slight positive overshoot which is removed by a diode clipper in the input circuit of V824A. The negative 10's are applied to the series diode clipper, CR801, through differentiating capacitor C830. Because of the slight positive voltage present at the junction of voltage divider resistors R887, R888, the diode is biased positively with respect to the ground return made through R889. The input 10 must exceed this small positive bias before it can pass through the diode, thus also eliminating a small negative overshoot which follows the positive overshoot. Overshoot must be removed before the signal is applied to V824A to prevent changing the amplitude of any of the 1's except that 1 which is coincident with a 10. If the overshoot were not removed, it would affect the amplitude of several 1's following the 10.

The comb of 1's and 10's at the output of V824 is applied to clipper stage V813A which employs MARKER HEIGHT control R966 to vary marker am-

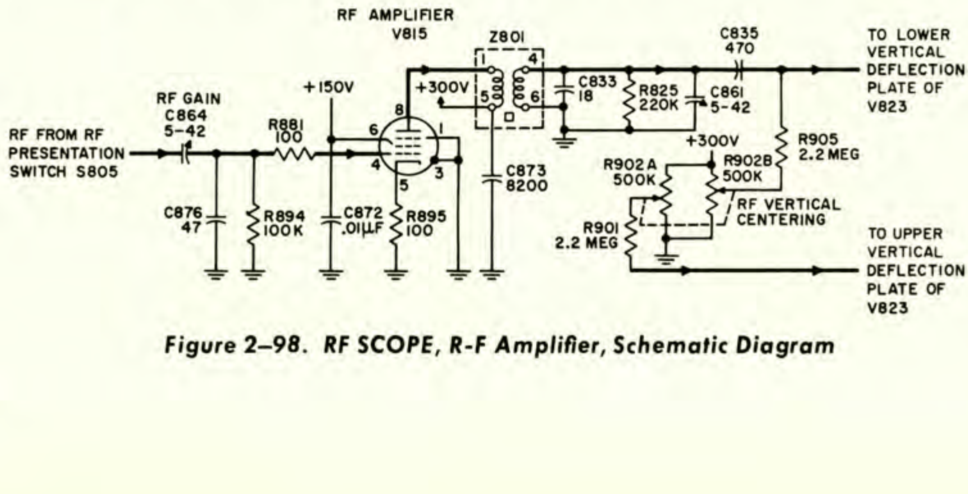


Figure 2–98. RF SCOPE, R-F Amplifier, Schematic Diagram

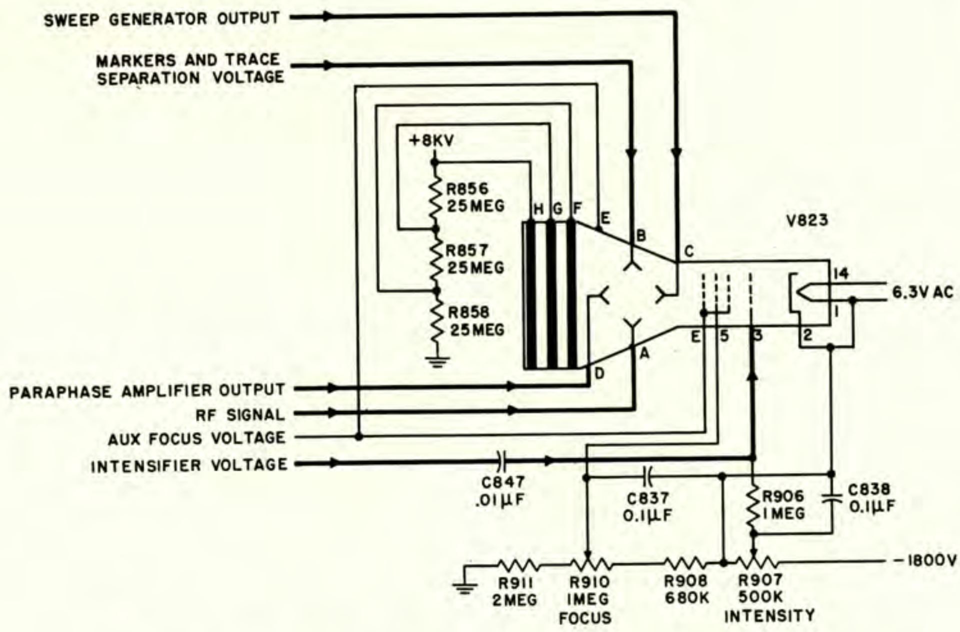


Figure 2–99. RF SCOPE, Cathode Ray Tube, Schematic Diagram

plitude by change of bias in the same manner as the clipper for the markers in the VIDEO SCOPE. Markers are applied through RF PRESENTATION switch S805 and mixed with trace separation voltage in the same way as for the VIDEO SCOPE.

The r-f amplifier uses a receiving type power pentode, V815, with a resonant plate circuit to develop a high output voltage. Refer to figure 2–98. The deflection sensitivity of the 5RP2A cathode-ray tube used in the RF SCOPE is lower than that of the cathode-ray tube used in the VIDEO SCOPE; however, because the r-f amplifier uses a tuned transformer to provide voltage step up, this large deflection requirement is met with only a small tube. A capacitive voltage divider is used in the input of the r-f amplifier to control signal amplitude. C864, in this divider, is the variable RF GAIN capacitor and is operated from the front panel through a flexible drive cable. The grid is returned to ground through parasitic suppressor R881 and resistor R894. Cathode bias is provided by R895 which is left unbypassed to provide degeneration and thus reduce distortion. Plate supply voltage is from the +300-volt bus and screen supply is from the +150-volt bus. The plate supply is bypassed by C873, the screen is bypassed by C872, and the filament is bypassed by C860 to provide r-f decoupling. The output circuit is tuned by C861; this adjustment must be made for the operating frequency of the station. The stage is broadbanded slightly by resistor R825 which shunts the secondary of output transformer Z801. Output is coupled to the lower vertical deflection plate of the cathode-ray tube through capacitor C835.

Because of the high writing rate required, the 5RP2A cathode-ray tube used in this scope is powered from the 8,000-volt supply. Refer to figure 2–99. This voltage assures adequate trace brightness with the extremely short duration trace used at the faster writing rates. Trace brightness becomes a problem at faster writing rates because the duration of the trace becomes a smaller proportion of the recurrence period, and the average illumination, for a given intensity of the scanning beam, is reduced accordingly. High beam intensity is achieved by use of three accelerator electrodes near the face of the tube. These electrodes receive voltages from the 8,000-volt supply through voltage divider R856, R857, R858. An auxiliary focusing voltage, provided by AUX FOCUS potentiometer R948, is applied to the second anode of the tube. The tube also incorporates a voltage divider string similar to that used in the SLOW SCOPE and the VIDEO SCOPE for application of intensity and focus voltages. This string is connected to the −1,800-volt supply.

(4) ALARM AND CONTROL CIRCUITS.—The alarm and control circuits include the buzzer and indicator lights for the synchronization alarms, the BLINK SELECTOR switch, and the DRIFT switch. An interlock circuit is also provided to cut off timer power when the front subpanel, which provides access to high-voltage control elements, is removed. Refer to figure 2–100.

The alarm indicators are SYNC ERROR lamp I804, OFF SYNC lamp I805, and buzzer I807. The lamps and buzzer are operated by 115 volts ac, supplied through circuits of the electrical synchronizer. These indicators are protected by fuse F801 in the a-c supply line to the synchronization indicator. BUZZER switch S806, in series with the buzzer, permits silencing the buzzer when desired.

The BLINK SELECTOR switch, S802, is a three-position wafer switch which is wired to the blink circuits in the time delay unit. Contacts of this switch are bypassed by C870 to suppress a-c line transients. Associated with the BLINK SELECTOR is LOCAL BLINK indicator lamp I806 which is lighted by blink relay K501 in the time delay unit whenever local blinking takes place. The lamp goes on and off, with operation of K501, to follow the blink cycle.

The DRIFT switch, S807, is a five-position wafer switch which is spring loaded to return to its center position. This switch applies 115 volts ac to relays in the frequency divider to operate the drift circuits. Capacitors C865A, C865B, and C866A bypass this switch to suppress a-c line transients.

Interlock switch S808 is connected in series with the cabinet interlocks and is provided to remove power whenever the front subpanel, covering high-voltage terminals of the control circuits, is removed.

g. ELECTRICAL SYNCHRONIZER TYPE SN–117/FPN–30.—As previously described in paragraph 3 *g*, the electrical synchronizer develops signals which control or indicate the accuracy of synchronization. The synchronizer compares the time difference of the received signals with an internal synchronizer delay. This comparison is used to develop an a-c error voltage which is of one phase or the other, in accordance with the direction of a synchronization error, and which has a magnitude proportional to that error. The error signal is fed to the sync control unit and used to drive a motor. At a slave station the motor drives the PHASE dial to correct the error; at a master station the motor also drives the PHASE dial, but only to indicate the error.

At a slave station the error voltage is also used to operate the sync error alarm circuit. This alarm is operated by the PHASE dial, through a cam and switch arrangement, at a master station. The synchronizer also includes an off sync alarm circuit which compares coincidence of the positive half of the first derivative, with a gate which occurs at the time the first zero cross-over point of the second derivative should occur. In this manner the circuit is sensitive to large sync errors of all types.

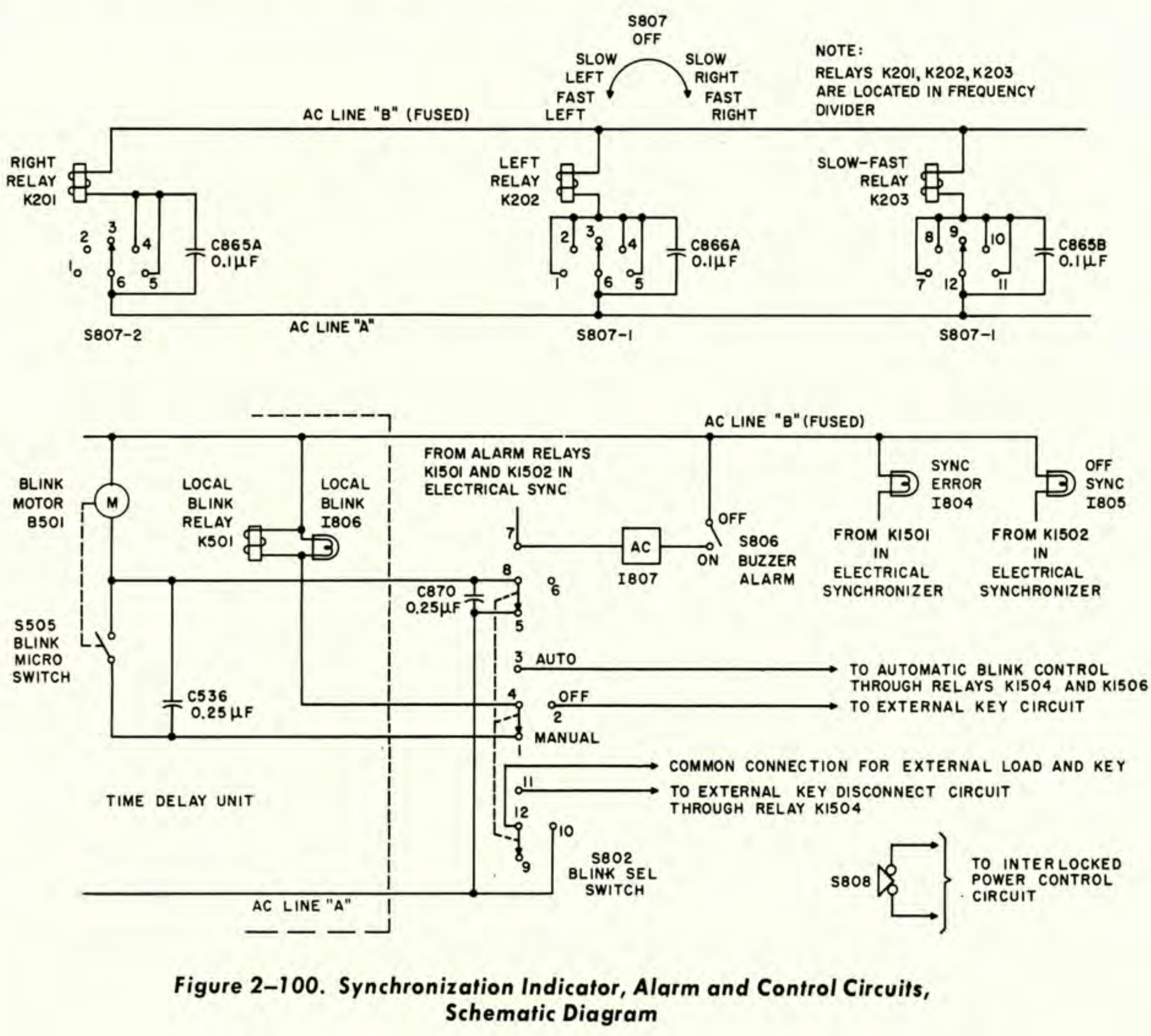


Figure 2–100. Synchronization Indicator, Alarm and Control Circuits, Schematic Diagram

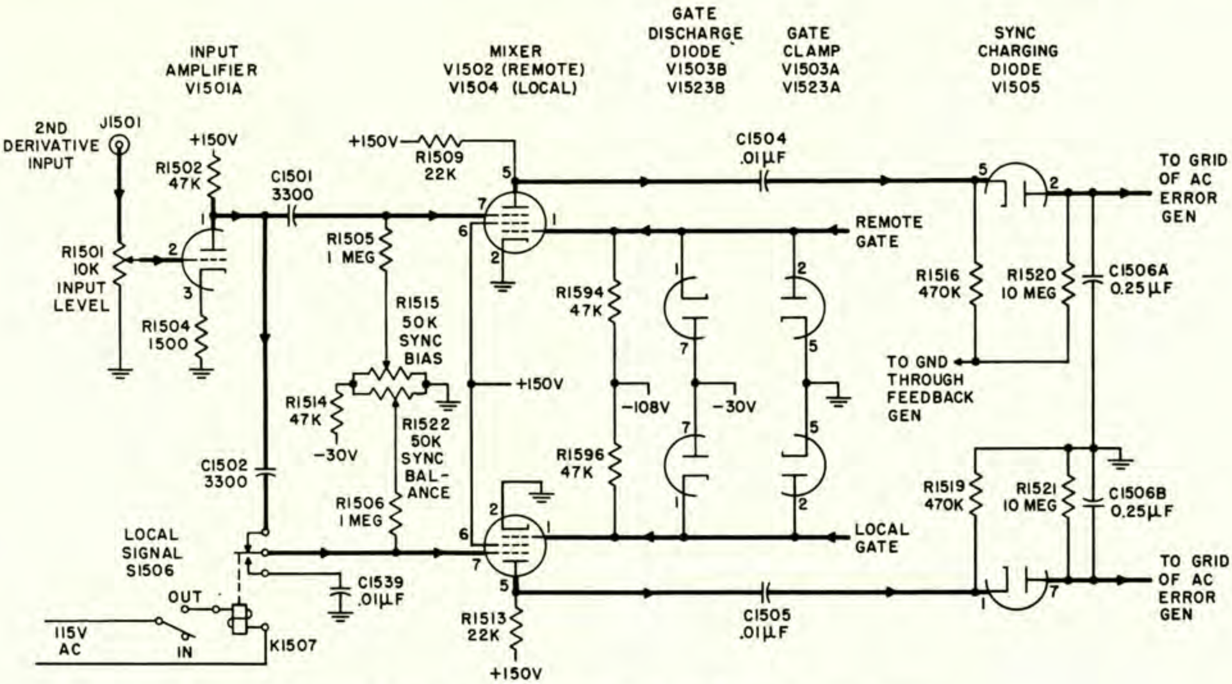


Figure 2–101. Sync Measuring Circuit, Local and Remote Channels, Simplified Schematic

Sync error is detected in a sync measuring circuit. The synchronizer delay is developed in a gate circuit. An auxiliary meter circuit is provided to aid in the adjustment of the sync measuring circuit. The sync error alarm circuit detects small synchronization errors and the off sync alarm circuit detects all other forms of operational abnormality.

(1) SYNC MEASURING CIRCUITS.—The second derivatives of both the local and remote signals are applied to the sync measuring circuits from input jack J1501. Refer to figure 2–101. The amplitude of these signals is controlled by INPUT LEVEL potentiometer R1501. This control permits the circuit to be adjusted for constant sensitivity. Adjustment is necessary because sensitivity varies with different repetition rates and with the pulse shapes produced by different loran transmitter types. Changes in pulse shape cause different slopes on the derivative and hence different derivative voltage levels for a given amount of error. Because of the adjustment feature provided by R1501, the synchronizer can provide uniform results despite variations in operating conditions.

R1501 is adjusted to provide a specific sensitivity by means of the built-in metering circuit. This circuit indicates the sensitivity of the synchronizer for a given error. A meter sensitivity reading has been chosen which permits adequate circuit sensitivity but not so great a sensitivity that the motor has excessive overshoot when correcting past the zero error point. This meter reading is specified in the initial adjustment procedure for the synchronizer, described in Section 3, paragraph 28 *i* or 29 *k*.

The output of R1501 is amplified in V1501A, a resistance coupled triode amplifier. The resulting high amplitude signal is fed to remote and local channels and sampled by remote and local gates to produce a d-c voltage at the output of each channel. The magnitude of this d-c voltage is dependent upon the time position of the first zero cross-over point of each derivative with respect to its associated gate. Equality of the d-c output voltage produced in each channel indicates synchronization.

The two channels operate in the same manner. Initially the remote channel will be discussed. An output signal is taken from V1501A via coupling capacitor C1501 and fed to remote mixer V1502. The mixer tube is a pentode amplifier which has been especially designed so that the suppressor grid (grid 3) may be used as a control grid for mixer service. The derivative signal is fed to grid 3 and the gate is fed to grid 1 so that the output signal amplitude is controlled by both grids.

Although both local and remote signals are fed to the number 3 grid, the local signal has no effect because the tube is gated to conduction only during the transmission of the remote signal. The gate is a narrow, rectangular pulse, generated in the gate circuit of the synchronizer, which is suitably delayed with respect to the remote (A- or B-) timing pulse so that it occurs at the time of the first zero of the second derivative (point B, as explained previously in paragraph 3 *g*). The mixer is normally cut off by a bias of approximately —30 volts applied to grid 1. This bias is overcome by the gate which drives the grid positive until it is clamped at zero by diode V1503A. This clamp provides a fixed amplitude at grid 1, despite variations in gate drive, thus assuring that the output voltage varies only in accordance with changes on grid 3.

The gate is made to have a steep trailing edge, despite high source impedance and shunt wiring capacity, through return of grid resistor R1594 to the —108-volt bus. The shunt wiring capacitance charges at a rapid rate towards —108 volts but is clamped at —30 volts by gate discharge diode V1503B. Because of this arrangement, the trailing edge is much steeper than it would be if the grid capacity were made to charge toward —30 volts. The sharpness of the leading edge is preserved because the gate output circuit provides low source impedance to the positive going pulse. Thus the mixer is made to conduct for a brief period (about two microseconds) by the gate.

Because grid 1 is used only to gate the tube on and off, the amplitude of the output pulse is controlled by grid 3. In the quiescent operating state the grid 3 voltage is determined by the bias applied through SYNC BIAS potentiometer R1515. This adjustment controls the amplitude of the mixer output pulse and is used to adjust this amplitude so that the d-c voltage at the output of the remote channel provides a correct operating bias for the a-c error generator stage which follows. Because this bias varies with repetition rate the mixer output amplitude must be decreased as the repetition rate increases. The meter circuit permits adjustment of R1515 for the required bias.

With correct sync the gate coincides with the derivative zero and the output amplitude is the same as for the quiescent condition. In the event of a sync error, where the gate samples the derivative before or after the occurrence of the zero, the grid 3 voltage will be lower or higher than the quiescent level. Thus the amplitude of the gated output pulse will be reduced or increased with respect to the zero error amplitude and will therefore provide a measure of the departure from pulse coincidence.

The pulsed output of the mixer is made to charge an averaging capacitor so that a d-c voltage is obtained. The pulse is applied to charging diode V1505A through coupling capacitor C1504 and load resistor R1516. The diode conducts for the negative pulses so that a short time constant is obtained for charging C1506A during the short time the pulse is applied. The d-c voltage stored in C1506A biases the diode so that a small portion of the input pulse, which does not exceed the bias voltage, is prevented from passing through the diode. Because the input pulse is large compared to the bias voltage the effective pulse amplitude is not appreciably changed.

C1506A discharges through R1520 which provides an extremely long time constant so that the d-c voltage does not fall off appreciably during the relatively long period between pulses. This time constant has been made large so that noise bursts are integrated and have reduced amplitude. For this reason the synchronizer does not respond to rapid noise bursts. The large time constant also minimizes the sawtooth ripple of the d-c voltage which results from the exponential decay of d-c voltage between charging pulses. This attenuation is desirable to suppress harmonics of the repetition frequency. If these harmonics are near the power line frequency, and if they were not attenuated, they would cause undesirable effects. The size of the time constant is limited to a value which permits the synchronizer to follow the change of timing accompanying pulse drift, or correction, in a reasonable amount of time. A large time constant would make the d-c voltage lag far behind the change of timing. With excessive lag the d-c voltage would not return to the zero error level until long after the motor corrected the error, and the motor would therefore overshoot the zero error point. A feedback system, discussed below, is used to reduce the small amount of overshoot which does occur to a negligible amount.

The d-c output voltage produced by gating is not a convenient output for operating the sync control motor. It is much more convenient to use this voltage to produce an a-c error signal which can be readily amplified and used to drive the sync control motor. The a-c voltage is obtained in a balanced error generator circuit which depends upon the relative amplitudes of the d-c outputs of the local and remote channels to control the error signal. When the two d-c voltages are equal the generator is balanced and no output is obtained. When the output of the remote channel exceeds that of the local channel, the generator is unbalanced in one direction and an a-c voltage of a given phase is produced. When the local channel output is the larger, the direction of unbalance is reversed, and the phase of the a-c error signal is reversed 180°. The amplitude of the resulting error voltage is proportional to the amount of timing error.

The local channel operates in the same manner as the remote channel to produce a d-c voltage which is a measure of the departure from pulse coincidence with respect to the local gate. In the theoretically ideal case where the local and remote channels have identical characteristics, the d-c output of the two channels would be the same, for the quiescent, zero error condition, and the a-c error generator would be balanced for minimum a-c output. In the practical case minor differences exist in the two channels. To compensate for these differences, the d-c output of the local channel is controlled separately by means of SYNC BALANCE potentiometer R1522. This potentiometer controls the d-c output in the same way as the SYNC BIAS control in the remote channel. Thus the d-c output of the local channel is approximately equal to that of the remote channel and is that exact voltage which produces minimum output from the a-c error generator.

A feature of the local channel only is the inclusion of K1507 in the input signal circuit of local mixer V1504. Contacts of this relay permit the local channel to be disabled so that the synchronizer may be synchronized while it is in stand-by service. This feature is discussed later.

The a-c voltage is developed in V1506. Refer to figure 2–102. This dual triode has a common cathode connection which is used as the a-c input. A small 60-cycle voltage is applied to cathode resistor R1524 through voltage dropping resistor R1523. The grid of V1506A is connected to the d-c output of the remote channel, and the grid of V1506B is connected to the d-c output of the local channel. The gain of each triode is controlled by the d-c input voltage. Since no tube is absolutely linear, the tube amplification may be varied by control of d-c grid voltage. As the grid is made more positive, the gain increases. In the quiescent, zero error state the gain of V1506B is adjusted, by means of SYNC BALANCE control R1522, so that the 60-cycle output of V1506B exactly equals the output of V1506A. These two outputs are fed to push-pull transformer T1501 so that they cancel each other and zero 60-cycle output voltage results. In the presence of a sync error the d-c voltage on the grid of V1506A changes, and the 60-cycle output changes accordingly. Because the a-c output voltages of the two triode sections are not exactly equal in this case, an output voltage is produced at the secondary of T1501. This output voltage is in phase with the input when the V1506B output is predominant and out of phase with the input when the V1506A output is predominant. Thus a 60-cycle error voltage is produced which is of one phase or the other, in accordance with the direction of error, and which has a magnitude proportional to the error.

The 60-cycle error voltage is taken from the secondary of T1501 and fed to a-c amplifier V1507B. This voltage is also fed to the sync error alarm circuit, discussed later. V1507B is a resistance-coupled stage which employs isolation resistor R1560 in its grid circuit to prevent interaction with the sync error alarm circuit. The amplified output is fed to the motor driving amplifier in the sync control unit via coaxial connections. A low impedance source is not required for this circuit since the shunt cable capacity has negligible effect at the low frequency of the error signal. The input circuit for the motor amplifier is a parallel tuned circuit that attenuates harmonics of the repetition rate which result from the gating process. Harmonics which are very close to the power line frequency must be attenuated or they will cause motor oscillation at a rate equal to the small frequency difference between the power line and the harmonics. This oscillation will occur because the harmonics are present even when the a-c error generator is balanced for zero 60-cycle error. The tuned circuit is actually a shunt plate load for V1507B.

The use of the 60-cycle error voltage differs at a slave and master station. At a slave station the error voltage causes the motor to drive the phase autosyn in a direction which corrects the error. When the error has been corrected, no error voltage exists, and the motor stops. At a master station the error voltage causes the motor to drive the master gate delay potentiometer in a direction which moves the remote gate to restore balance in V1506. The motor stops when balance has been restored; however, the error has not been corrected. Instead, the gate has been moved by whatever amount was required to make the gate coincide with the derivative zero. This motion is accomplished by changing a d-c voltage controlling the remote gate delay. The required change of d-c voltage is effected by rotating the precision master gate delay potentiometer a specific amount. The amount of rotation required for any given change of gate position is calibrated on the PHASE dial in terms of ±microseconds error. Thus the error seen by the master station is indicated directly on the PHASE dial. As explained previously in the discussion of the sync control unit, paragraph 4 *b* (6), the rotation of the PHASE dial causes a corresponding motion of the center pen of the recording ammeter. This motion indicates error in accordance with the readings shown on the PHASE dial.

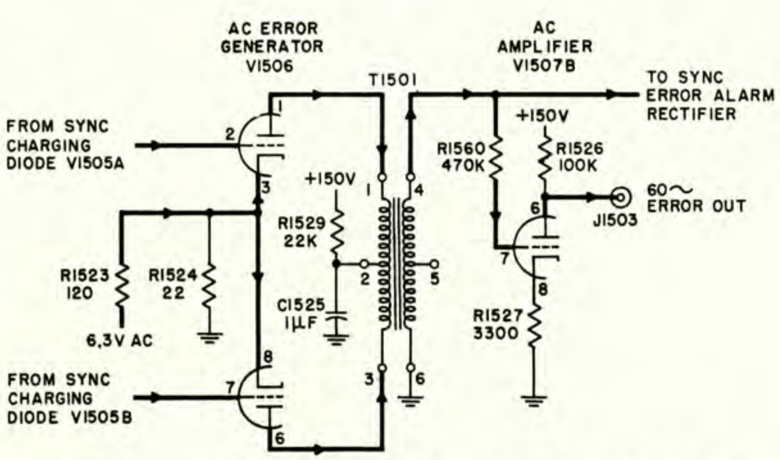


Figure 2–102. Sync Measuring Circuit, A-c Error Generator Schematic Diagram

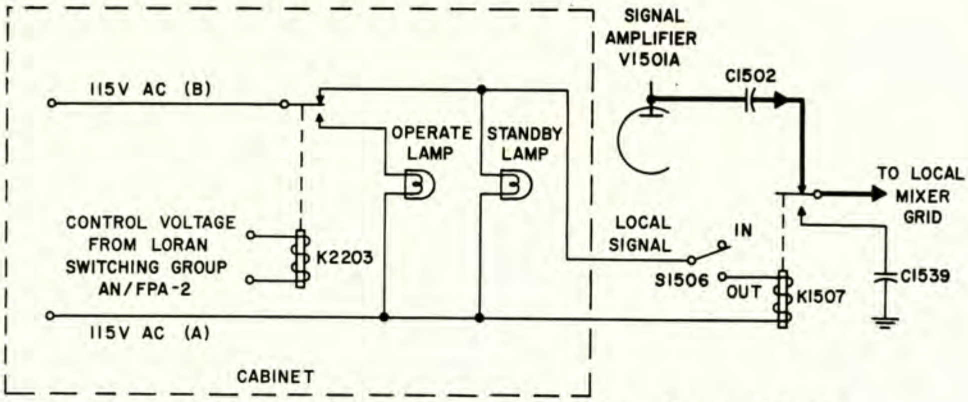


Figure 2–103. Electrical Synchronizer, Local Signal Control Circuit, Simplified Schematic Diagram

The circuit for disabling the local channel is provided so that the timer may be synchronized while operating in stand-by service. Because of the double gate synchronization system, the d-c output of each channel in the sync measuring circuit will be equal so long as the gates sample corresponding portions of the local and remote derivatives. For example, if the local gate samples a point which is one volt above the zero on the local derivative, and if synchronization is correct, the remote gate necessarily samples a point one volt above the zero on the remote derivative. This holds true only if the amplitudes of the two signals are identical and is a design feature of the circuit which permits an operating timer to maintain synchronization even when the gate delay is incorrectly set. In a stand-by timer this circuit feature causes the outputs of the two channels to be equal no matter where the signals are positioned with respect to the gates. Equal output from each channel results because the two signals move together when the phase of the stand-by timer is changed with respect to that of the operating timer. The local signal does not occur at some fixed time, with respect to the local timing pulse, as is the case in an operating timer. This is because the local signal is timed by the operating timer.

To permit the stand-by timer to synchronize, the local signal input to the synchronizer is disabled. This makes the local channel "see" a zero voltage which simulates the zero of a normally timed local derivative. Thus the local channel is made to produce a fixed reference voltage and therefore the phase of the stand-by timer may be automatically adjusted by the synchronizing system so that the output of the remote channel equals this fixed reference voltage. The stand-by synchronizer is able to operate in normal fashion because the local signal has been removed.

The local signal is removed by contacts of relay K1507. Refer to figure 2–103. These contacts lift the signal grid of local mixer V1504 from the output of signal amplifier V1501A and transfer the signal grid to signal bypass capacitor C1539. The coil of K1507 is operated by 115 volts ac supplied from stand-by operate relay K2203 in the timer cabinet. This relay is operated from a circuit in Loran Switching Group FPA–2/FPN and supplies power to K1507 when the timer is in stand-by service. LOCAL SIGNAL switch S1506, in series with the coil of K1507, permits the relay circuit to be broken when it is desired to apply local signal with the timer in stand-by service. This switch is used when the timer is operated with the Model UM Switching Equipment since this equipment has no provision for switching the stand-by-operate relay in the timer cabinet. Switch S1506 is also used when making certain adjustments with the timer in stand-by service. Capacitor C1540 bypasses S1506 to suppress a-c line transients.

The local signal control circuit is such that when the timer is set for normal operation, as an operating timer, the local signal is automatically fed through the synchronizer, regardless of the position of S1506. In stand-by service the local signal will be fed through if S1506 is set to IN so that the timer can be adjusted to synchronization. The local signal will not be fed through if S1506 is set to OUT so that the system can automatically maintain synchronization. This arrangement has been used because it is always desired to have the local signal fed through the synchronizer when the timer is in operating service.

It was stated above that the sync control motor stops when the error voltage no longer exists. The error voltage continues beyond the instant the motor drives the system to zero, however, because of the large time constant associated with the averaging capacitor. Because the error voltage lags the correcting action of the motor, and also because the motor and gear system have mechanical inertia, the motor overshoots beyond the zero error point. This overshoot, when excessive, causes hunting. Overshoot is effectively prevented by the use of the feedback arrangement described below.

The motor drives a generator to develop a d-c voltage proportional to the speed of the motor. The polarity of this voltage depends on motor direction.

The generator voltage is used as negative feedback to oppose the d-c error voltage developed in averaging capacitor C1506A. For purposes of this discussion the d-c error voltage is defined as the difference between the voltage in C1506A and the voltage in C1506B. Depending on the direction of the error (+ or −) this error voltage can be negative or positive with respect to the reference established by the voltage in C1506B.

Because the d-c generator voltage is opposite in polarity to the d-c error voltage, the addition of the two voltages produces a degenerative action. This degenerative action effectively opposes the effect of motor inertia by producing electrical breaking. With a large error, the feedback is small compared to the d-c error voltage. As zero error is appoached, and the d-c error voltage falls off, the feedback voltage is relatively constant because motor inertia maintains the generator at high speed. Under this condition the feedback voltage is larger than the d-c error voltage, and thus the error voltage is overcancelled. This results in a net d-c voltage opposite in polarity to the d-c error voltage. The phase of the a-c error voltage will therefore be such as to drive the motor in the reverse direction. Although the motor will not actually reverse, this action will electrically break the motor and make it slow down to follow the error condition more closely. This effect will continue until the zero error point has been reached. At this point the motor will be so slowed by feedback that any overshoot which might result from the remaining inertia is negligible.

Another cause of overshoot is the time constant of the d-c averaging circuit, C1506A and R1520. Because appreciable time is required for the d-c error voltage to change, after a change in the error condition has been made, the error voltage persists after the motor has driven the system to zero error. This lag causes motor overshoot and is the electrical equivalent of mechanical inertia. Because the feedback is of opposite polarity to the d-c error voltage, the addition of the feedback voltage to the d-c error voltage speeds the change so that the d-c error voltage follows the error. Thus the feedback compensates for the time lag of the RC circuit.

In the above discussion of the use of feedback to offset the effects of mechanical and electrical inertia, it was assumed that the feedback action is instantaneous. Actually the feedback is applied to averaging capacitor C1506A through series resistor R1520. (Feedback does not follow the seemingly lower resistance path through R1516 and diode V1505 because the negative voltage stored in C1506A biases the diode to prevent conduction. The feedback is a small voltage and cannot overcome the bias to pass through the diode.) Because of the large time constant in the feedback path, the feedback requires time to change the voltage across C1506A. This means that the feedback voltage cannot oppose the d-c error voltage until the feedback generator has operated for a period of time. Although this time lag complicates the operation of the circuit somewhat, it does not detract from the effectiveness of the feedback in preventing overshoot. Because of the time lag, the exact behavior of the feedback differs for the two ranges of gear speed employed.

In the high range of gear speed a given error will be corrected in a relatively short period of time. Because of the lag in the application of the feedback, the full generator output will not be developed across C1506A before the error is corrected and the feedback is stopped. The maximum generator output voltage is used, in this high speed position, so that sufficient feedback does develop to prevent overshoot. In the event that the error is very small, the feedback will not be permitted adequate time to develop significant voltage across C1506A; however, in this event motor speed will be so slow that inertia will be negligible and overshoot will not occur.

In the low range of gear speed, a given error will require approximately ten times as long for correction as in the high speed. With this increased time, the full generator voltage will develop across C1506A. If the generator output were as large as for the high speed range, the feedback would greatly overcancel the d-c error voltage before the error was corrected. This would cause the motor to come to a complete stop, thus stopping the generator. The motor would remain stopped until the feedback voltage thus built up across the capacitor decayed sufficiently to permit the motor to start again. With a large error, the motor will go through several such sequences before the zero error point is reached. To prevent this action, a switch and resistive voltage divider are provided in the gear change system to reduce the generator output in the low speed position.

The function of the feedback is to prevent overshoot; however, the feedback also acts as a check upon motor speed whenever the motor is correcting an error. With large errors the motor is operated at maximum speed, either as governed by the characteristics of the a-c motor or as limited by the action of the maximum motor speed circuit. Because of these limitations at high motor speeds the only effect of the feedback is to reduce speed slightly. Thus the primary effect of the feedback is to prevent overshoot and therefore eliminate hunting.

(2) GATE CIRCUITS.—The gate circuits employ a delay phantastron to produce gate pulses which are delayed a controlled amount with respect to the A- and B-timing pulses. A master gate is delayed with respect to the A-timing pulse and a slave gate is delayed with respect to the B-timing pulse. The two gates are separated, for delivery to the local and remote sync measuring channels, by a diode switching circuit operated by the square wave. At a slave station both gates are always delayed precisely the same

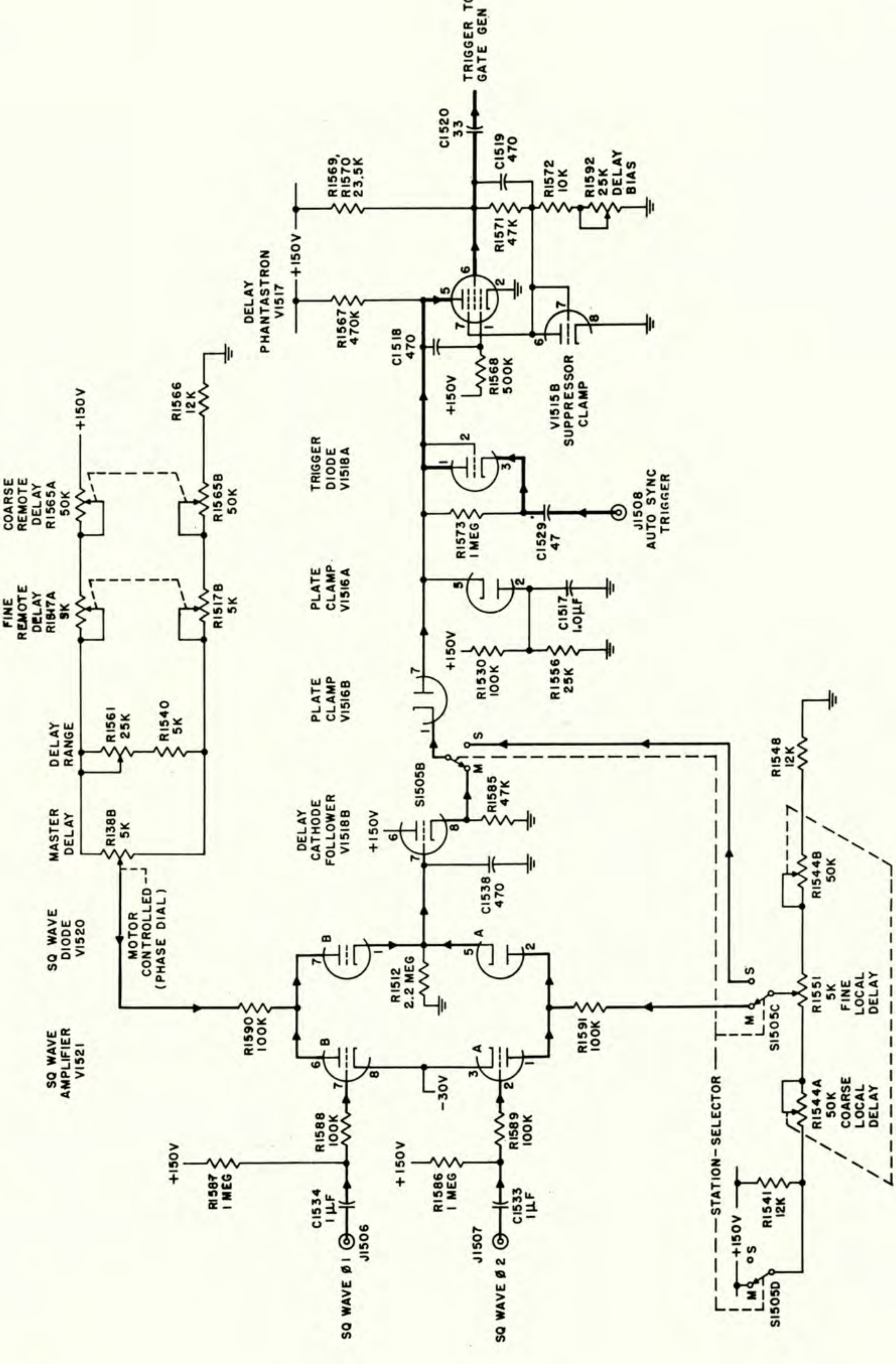


Figure 2–104. Gate Circuits, D-c Delay Control and Delay Phantastron, Schematic Diagram

amount of time. At a master station the remote gate delay is controlled by the automatic synchronizing system to provide the error indication used for master service. The local gate delay is controlled separately.

Because of the functional arrangement of circuit groups within the synchronizer the designations *local* and *remote* are more convenient than *master* and *slave*. All controls are therefore labeled LOCAL and REMOTE. At a master station *local* refers to *master* and *remote* refers to *slave*. The converse is true at a slave station.

Control of gate delay is effected by d-c voltages applied to the phantastron. Two voltage divider strings are the sources of these voltages. These strings are the local gate delay source and the remote gate delay source. At a master station the local source controls the local (master) gate and the remote source controls the remote (slave) gate. The two separate sources of gate delay control voltage are alternately connected to the phantastron by means of a diode switching system controlled by the square wave. Thus the gate which is developed in each loran half-cycle can be used to measure the time position of a signal transmitted in that half-cycle.

At a slave station, since both gates are always delayed the same amount, the remote delay source is switched out and the local source is used to control both the local and remote gates. The local delay source is a voltage divider string which includes R1541, R1544A, R1551, R1544B, and R1548. Refer to figure 2–104. R1544A and R1544B are sections of a dual potentiometer. This potentiometer is the COARSE LOCAL DELAY control and provides a means for setting the local delay to approximately the desired point over a wide range. A more exact control, to permit precise adjustment of local delay over a limited range, is provided by FINE LOCAL DELAY potentiometer R1551. Because the range of R1551 is only about 15 microseconds, a relatively large amount of rotation causes only a slight change of delay, and delay may be readily adjusted to within 0.1 microsecond. This 15-microsecond range is constant, for any setting of the COARSE LOCAL DELAY control, because the dual potentiometer arrangement of R1544A and R1544B maintains constant current through the voltage divider. As the resistance of one potentiometer section decreases, the other increases to keep the current constant and subtract voltage from one end of the string while adding the same amount of voltage to the other end of the string.

The output of the voltage divider string is taken from the arm of FINE LOCAL DELAY potentiometer R1551. For slave service this output is applied directly to the phantastron through contacts of STATION SELECTOR MASTER SLAVE switch S1505. For master service the output is connected through switching diode V1520A.

The remote delay source is a voltage divider string similar to that of the local delay source. This string includes R138B, the master delay potentiometer located in the sync control unit, and is provided with a greater number of auxiliary adjustments than the local delay string. The additional adjustments permit the range of R138B to be set up to match the PHASE dial calibrations. The adjustments for the remote source consist of COARSE REMOTE DELAY potentiometer R1565A and R1565B, FINE REMOTE DELAY potentiometer R1517A and R1517B, and DELAY RANGE rheostat R1561. The coarse and fine delay controls are used to make the remote gate delay exactly equal the local gate delay when the PHASE dial is set to zero (with R138B at the center of its range). The DELAY RANGE control shunts R138B and is used to make R138B change gate delay in accordance with the calibrations of the PHASE dial. The range of this shunt control is limited by series resistor R1540 to permit easier adjustment.

A dual potentiometer has been used for the coarse delay control to maintain constant current through the divider string and therefore provide the same range of adjustment for the fine delay control regardless of the setting of the coarse control. The fine delay control is also made a dual potentiometer to minimize interaction between the DELAY RANGE and FINE REMOTE DELAY settings caused by change of current with different settings of the two controls. If a single potentiometer were used, the current through R138B would change as the FINE REMOTE DELAY setting changed. This would necessitate resetting the DELAY RANGE control, which in turn would change the current through the FINE REMOTE DELAY control and require additional resetting. Because of the interaction of each control on the other, the adjustment would be extremely difficult to make. In the arrangement used, only the DELAY RANGE control causes appreciable current change so that once delay range is set the fine delay may be easily adjusted.

At a master station the two separate d-c sources each provide a voltage for control of gate delay phantastron V1517. A diode switch tube and a square-wave amplifier are each used to apply the d-c voltage from each source to the phantastron during alternate square-wave half-cycles so that only one source has control at a time. The local source controls the delay of only the local gate and the remote source controls the delay of only the remote gate.

The square-wave amplifier which controls application of the local d-c source voltage to the phantastron is V1521A. The cathode of this triode amplifier is connected to the −30-volt bus and the grid is returned to the +150-volt bus through R1586. The positive grid return causes the tube to draw grid current so that the grid rests at the −30-volt potential of the cathode. Resistor R1589 is provided to isolate this grid load from the square-wave output amplifier. Plate voltage is supplied through plate load resistor R1591 from the local d-c source. In the quiescent condition, the tube conducts heavily so that the voltage at the plate is negative. Under this condition the plate of diode V1520A is negative with respect to the diode cathode and the diode does not conduct. The local d-c source voltage is therefore not applied to the phantastron.

Square wave ϕ 2 is taken from input jack J1507 and coupled to the grid of square-wave amplifier V1521A. Positive excursions of the square wave cause the tube to draw additional grid current and the diode is cut off in the same way as for the quiescent condition described above. Negative excursions of the square wave cut the tube off so that the voltage at the plate of diode V1520A is almost that provided by the local d-c source. Because the diode plate is positive with respect to the cathode, the diode conducts and most of the source voltage is developed across diode load resistor R1512. The ratio of R1512 to series resistor R1591 is made high so that a minimum amount of voltage division takes place.

The circuit which controls application of the remote d-c source voltage to the phantastron is identical in operation to that used for the local source. The output diodes of the two circuits have a common cathode connection so that the output of each circuit is developed across diode load resistor R1512. The remote source is applied through square-wave amplifier V1521B and diode V1520B and controlled by square wave ϕ 1. Because the square wave halves controlling the two sources are 180° out of phase, the two sources are applied alternately. V1520B is always conducting when V1520A is cut off and vice versa. Thus the local source is applied during negative halves of square wave ϕ 2 and the remote source is applied during the corresponding portions of square wave ϕ 1.

The rise times of the two halves of the square waves are not equal and square-wave voltage does not exactly cancel during the brief switching period when the square waves reverse phase. For this reason a negative pulse may be developed which could trigger the phantastron falsely. This pulse is removed by bypass capacitor C1538, across the diode load resistor, which integrates the sharp pulses. Although this capacitor slows the switching of d-c source voltages, the effect is of no importance since the phantastron is not triggered until at least 1,000 microseconds after the moment of switching.

The output from the common cathode connection of the two sections of diode V1520 is applied to the phantastron through cathode follower V1518B and contacts of S1505. The low impedance cathode follower output is used to drive the phantastron so that the delay control voltage is not varied by the quiescent current drawn by the top clamp of the phantastron.

The phantastron circuit is like the time delay phantastron previously described in paragraph 4 *d* (1) (*a*) except that it is clamped at both the top and bottom of the rundown and that the clamping point is varied at the top, instead of at the bottom, to control delay. Because a large bypass capacitor must be used on the bottom clamping voltage, to prevent voltage change caused by the conduction of the bottom clamp at the end of the rundown, it is not practical to vary the bottom clamping voltage at the rapid rate used to switch d-c source voltages. For this reason a top clamp is used and the top clamping point is varied. This variation controls the voltage drop of the rundown just as effectively as variation of the bottom clamping point of previously discussed delay phantastrons. The cathode follower used to supply the two d-c source voltages provides a low impedance output with adequate stability to maintain constant voltage during the quiescent period of top clamping. Clamping current is varied only after the start of the rundown; since the purpose of clamping is to provide a stable voltage for the start of the rundown, it is obvious that any voltage changes occurring after the start of rundown are not important.

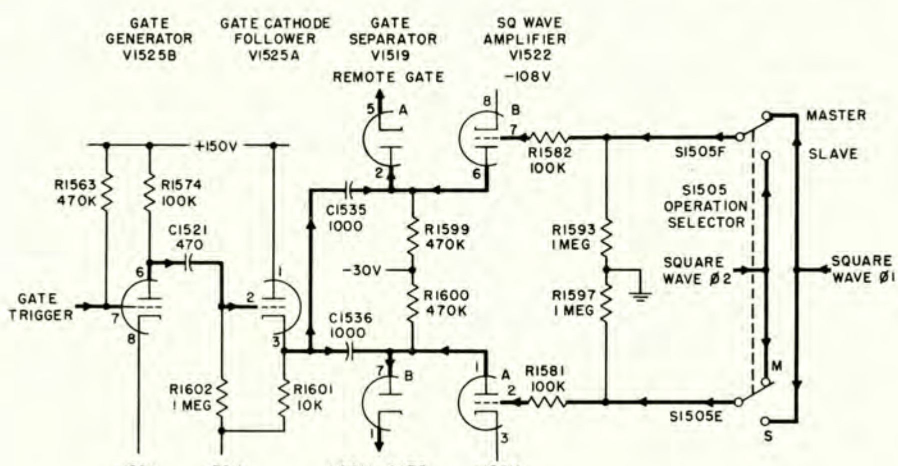


Figure 2–105. Gate Circuits, Gate Generator, and Gate Separator, Schematic Diagram

One additional minor circuit difference exists between the gate delay phantastron, V1517, and previously discussed phantastrons. The plate resistor, R1567, is 470,000 ohms instead of 47,000 ohms as used in the other delay phantastrons. The higher plate resistance must be used in this circuit to reduce the quiescent plate current during top clamping. A large amount of plate current, flowing through clamp diode V1516B to R1585, the cathode resistor of cathode follower V1518B, would develop a large voltage across R1585. This large voltage would become the minimum clamping voltage and would therefore limit the range of top clamping.

The delay phantastron produces a rectangular output pulse whose width depends upon the d-c voltage applied through top clamp V1516B. At a master station which detects a synchronization error, this output pulse will have different widths during alternate half-cycles of the square wave and therefore produce two different gate delays. The phantastron output pulse is differentiated by C1520 and R1563 in the input circuit to gate generator V1525B. Refer to figure 2–105.

The leading edge of the output pulse is differentiated to a positive pulse which is eliminated in the zero-biased gate generator. The trailing edge is a negative pulse which drives the grid of V1525B negative to produce an amplified output. This output is clipped in cathode follower V1525A to produce a positive rectangular output pulse about 2 microseconds wide. The cathode follower is heavily biased by the large value of cathode resistor R1601 to provide some clipping. This helps narrow the gate and also eliminates the slight negative excursion resulting from the leading edge of the phantastron output pulse.

The top of the gate is flattened by gate clamps V1503A and V1523A in the sync measuring circuit.

The output of the gate cathode follower consists of alternate local and remote gates which are delayed with respect to the A- and B-timing pulses. Before these gates can be applied to the local and remote mixers they must be separated. Separation is accomplished by a diode switching circuit, operated by the square wave, in an arrangement similar to that used to feed the two isolated d-c sources to a common point. Two separate and identical circuits are used to supply the proper gate to the local and remote channels of the sync mixer circuit.

Gate is fed through coupling capacitor C1536 and diode V1519B to the grid of local mixer V1504. The diode is made nonconducting through the action of square-wave amplifier V1522A so that the gate is allowed to pass only during alternate half-cycles and the proper gate is applied to the local mixer during the half-cycle identified with local functions. Amplifier V1522 is operated from a negative supply voltage. The cathode is returned to −108 volts and plate is returned to −30 volts so that the total plate supply voltage is 78 volts. The grid is returned to ground so that grid current is drawn and the tube conducts heavily in the quiescent stage. Tube conduction drops the plate voltage towards −108 volts so that the plate of diode V1519B is negative with respect to the −30 volts at the cathode. Diode conduction is prevented, and the gate does not have sufficient positive amplitude to pass through the diode.

Conduction of amplifier V1522A is controlled by square-wave voltage applied to the grid. Positive half-cycles of the square wave cause the tube to draw additional grid current so that the diode is cut off exactly as for the quiescent condition described above. Negative half-cycles of the square wave cut V1522A off so that the plate of diode V1519B is at the same −30-volt potential as the cathode, and the diode conducts. Thus a gate is passed on to the local channel during negative half-cycles of a square wave.

The remote channel receives a gate in exactly the same manner as the local channel, from diode V1519A and amplifier V1522B. The square wave fed to V1522B is 180° out of phase with respect to the square wave fed to V1522A. Whether square wave ϕ 1 or square wave ϕ 2 is fed to a particular mixer depends on whether the timer is used for master or slave service. The negative half of square wave ϕ 1 is associated with slave functions and hence must be used to bias V1522A to cutoff, feeding gate to the local mixer at a slave station, and bias V1522B to cutoff, feeding gate to the remote mixer at a master station. Conversely the negative half of square wave ϕ 2 is associated with master functions and is used to control the remaining gate. Application of the two square-wave signals to the grids of V1522 is controlled by contacts of STATION SELECTOR MASTER SLAVE switch S1505. Thus the appropriate gate is applied to each mixer of the sync measuring circuit.

(3) METER CIRCUIT.—The meter circuit provides means for comparison of the voltage stored in averaging capacitor C1506A with a reference voltage, so that SYNC BIAS control R1515 may be adjusted, and also permits measurement of the relative sensitivity of the sync measuring circuit so that INPUT LEVEL control R1501 may be adjusted. Refer to figure 2–106. The reference voltage is established by voltage division of the −30-volt bias across R1580 and R1579. These resistors provide approximately 5 volts at their common junction which is used to adjust the meter circuit so that zero reading of the meter indicates that the voltage applied to the meter circuit is equal to the reference voltage. The meter zero is at the center of the scale so that the meter reading can show input voltages of more or less negative amplitude with respect to the reference voltage.

The grid of meter amplifier V1510A is connected to either the junction of R1580 and R1579 or to averaging capacitor C1506A by METER SWITCH S1504. For normal operation the switch is placed in the OPERATE position, and the grid is connected

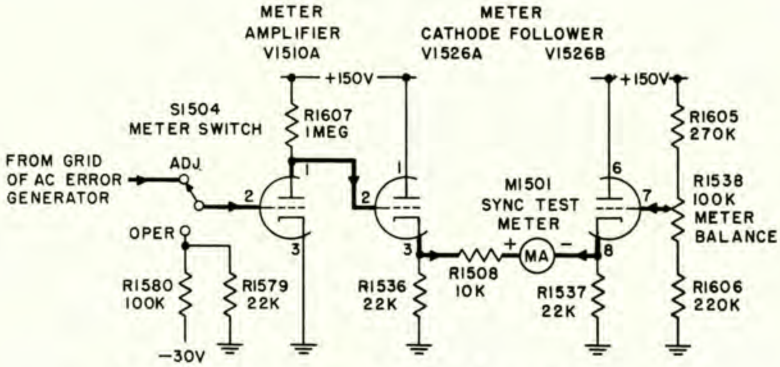


Figure 2–106. Meter Circuit, Schematic Diagram

to the negative reference voltage provided at the junction of the resistors. This voltage biases the tube so that approximately a 75-volt drop takes place across plate resistor R1607. The voltage at the plate of V1510A is directly coupled to the grid of cathode follower V1526A so that cathode voltage is controlled by the voltage applied to the meter circuit input. A similar cathode follower, V1526B, is used to provide a voltage reference point for operation of the indicating milliammeter. V1526B provides the same low source impedances as V1526A. Voltage divider string R1605, R1538, R1606 is used to supply grid voltage to V1526B to make the d-c output voltages of the two cathode followers equal when setting up the circuit. The output voltage of V1526B is controlled by adjustment of METER BALANCE potentiometer R1538. The meter is connected between the cathodes of V1526A and V1526B so that zero current flows through the meter, and the meter reads zero when the voltages at the two cathodes have been made equal.

Because the meter circuit is balanced for zero meter reading with the negative reference voltage, the meter indicates that the voltage across C1506A is equal to the reference voltage when the meter reads zero. When adjusting SYNC BIAS control R1515, the meter is first balanced against the reference voltage, and the meter input is then switched to the ADJUST position. R1515 is then adjusted so that the meter reads zero when no signal is applied to the signal grid of the remote mixer. With this adjustment the mixer output is made to provide a correct operating bias for the grid of a-c error generator stage V1506A. This operating bias is equal to the reference voltage provided in the meter circuit.

Adjustment of INPUT LEVEL control R1501 is made with an operating signal applied to the sync measuring circuit and a deliberate 1-microsecond error set up by means of the PHASE dial. The meter is switched to the ADJUST position and signal amplitude is adjusted until the meter reads full scale. This meter reading standardizes the sensitivity of the sync measuring circuit, regardless of rate and pulse shape.

(4) SYNC ERROR ALARM CIRCUIT.—At a slave station the sync error circuit operates an alarm relay when 60-cycle error voltage exceeds a preset amplitude. This amplitude corresponds to a ±1-microsecond error. At a master station the relay is operated by a signal applied through a microswitch in the sync control unit. The microswitch is tripped by a pair of cams, connected to the PHASE dial, when PHASE dial rotation exceeds preset limits. The cams can be set to trip the switch over a range of ±1- to ±3-microsecond error. Refer to figure 2–107.

The 60-cycle error voltage developed in the output of the sync measuring circuit is taken from T1501 and rectified by diode connected triode V1508B. The positive output of this series rectifier is filtered by C1512

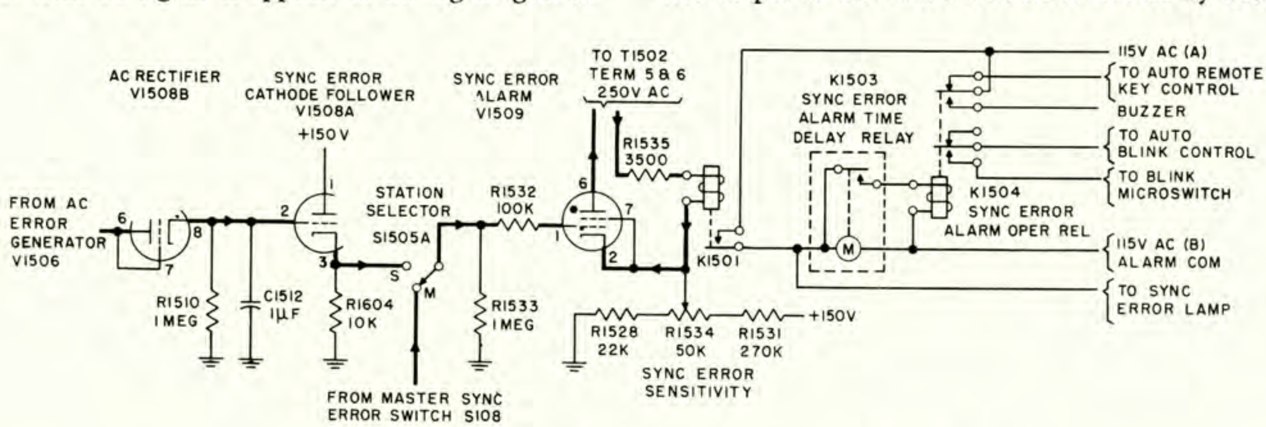


Figure 2–107. Sync Error Alarm Circuit, Simplified Schematic

so that a d-c voltage is obtained which is proportional to synchronization error. This voltage is applied to the grid of cathode follower V1508A to provide a low impedance source. For slave service cathode follower output is applied, through contacts of STATION SELECTOR MASTER SLAVE switch S1505, to the grid of sync error alarm thyratron V1509. A positive voltage which exceeds a preset value fires the thyratron to operate the alarm relay. For master service the positive voltage required to operate the thyratron is taken from the cam and switch arrangement of the sync control unit and applied to the thyratron through contacts of S1505.

The d-c voltage to operate the thyratron is applied to the grid through grid-current limiting resistor R1532. The thyratron is operated from an a-c supply voltage and is controlled by the d-c voltage applied between grid and cathode. To offset the d-c voltage applied to the grid by way of the direct coupling to the cathode follower, a d-c bias voltage is applied to the thyratron cathode. This bias cuts the thyratron off under zero error conditions. The bias is applied through voltage dividing resistors R1531, R1534, and R1528. R1534 is the SYNC ERROR SENSITIVITY control and permits the bias to be adjusted so that the value of input voltage which will cause the thyratron to fire may be varied.

When the control grid has been driven sufficiently positive, so that grid voltage is almost as positive as the cathode, the thyratron fires and draws current through current limiting resistor R1535 and relay K1501, thus closing the relay. Because current can flow through the thyratron in only one direction, no current flows in the circuit during negative halves of the a-c supply cycle and, therefore, provided the proper grid cathode voltage is maintained, the thyratron will fire anew on each positive half-cycle. (It is characteristic that a thyratron will continue to draw plate current as long as full plate voltage is applied, even though the grid voltage is reduced below the point at which the tube originally fired. To make the thyratron cease firing, the plate voltage is periodically interrupted by using an a-c supply voltage.) K1501 is a slow-operate slow-release relay and remains closed during negative half-cycles. When the thyratron grid voltage lowers sufficiently to prevent firing on the next positive cycle, the relay current stops and, after a short interval, the relay opens.

The contacts of K1501 control the application of 115 volts ac to time-delay relay K1503 and to SYNC ERROR indicator lamp I804 in the synchronization control unit. Thus operation of K1501 lights the indicator lamp and initiates the time-delay cycle of K1503. After the adjustable time-delay period of five seconds to one minute, K1503 operates to actuate K1504. Note that although the relay is calibrated for a delay of three seconds to one minute, the actual delay period is increased by about two seconds because of the time constant of the sync measuring circuit. The contacts of K1504 apply power to alarm buzzer I807 and control the blink circuit of the time delay unit. The blink circuit was previously described in paragraph 4 *d* (8).

(5) OFF SYNC ALARM CIRCUIT.—The off sync alarm circuit uses the coincidence or lack of coincidence of the remote gate with an amplified alarm pulse to detect large orders of synchronization abnormality. The functional operation of this circuit was previously discussed in detail in paragraph 3 *g* (5). The amplified alarm pulse is developed from the first derivative of the remote signal. Refer to figure 2–108.

The first derivative signal is applied to clipper-limiter stage V1511A and V1511B through input jack J1502 and filter network R1539, C1522. This network removes an undesirable secondary overshoot from the first derivative and therefore prevents the development of an unwanted second alarm pulse following the desired pulse. The filter has the unimportant effect of delaying the pulse slightly so that the amplified alarm pulse does not conform to the theoretically ideal time pattern described previously in paragraph 3 *g* (5) and illustrated in figures 2–36 and 2–37. V1511A is biased beyond cutoff by voltage division of the —30-volt bias across R1542 and R1543 so that only the positive half of the first derivative passes through this tube. The resulting negative pulse is applied to the zero-biased grid of V1511B to drive that stage beyond cutoff and produce an amplified alarm pulse which corresponds in time to the lower portion of the positive half of the first derivative.

The amplified alarm pulse is sampled by the remote gate in a coincidence mixer. This mixer consists of two series-connected triodes. V1512B, the lower triode, acts as a cathode resistor to control bias on the upper triode, V1512A. The grid of V1512B is connected in parallel with the grid of remote sync mixer V1502 and is biased negative in the same manner as the sync mixer. The positive remote gate drives the grid to zero and makes the tube conduct. Thus the upper tube is cut off by a large value of cathode resistance except at the time of gating. With normal synchronization, V1512A will be gated to conduction during the time the positive amplified alarm pulse is applied to the grid. This will result in a large amplitude negative output pulse. With abnormal synchronization (off sync), when the positive half of the first derivative is not coincident with the gate, V1512A will be gated to conduction when the grid voltage is zero. Zero grid voltage results because the grid is returned to ground through R1549 and R1518 and because the amplified alarm pulse is not present at the time of gating. The resistance provided by V1512B at the time of gating biases V1512A so that, with zero grid voltage on V1512A, a relative small negative output signal results. Thus the coincidence mixer provides a large negative output pulse when synchronization is normal and a small negative output pulse with an off sync condition.

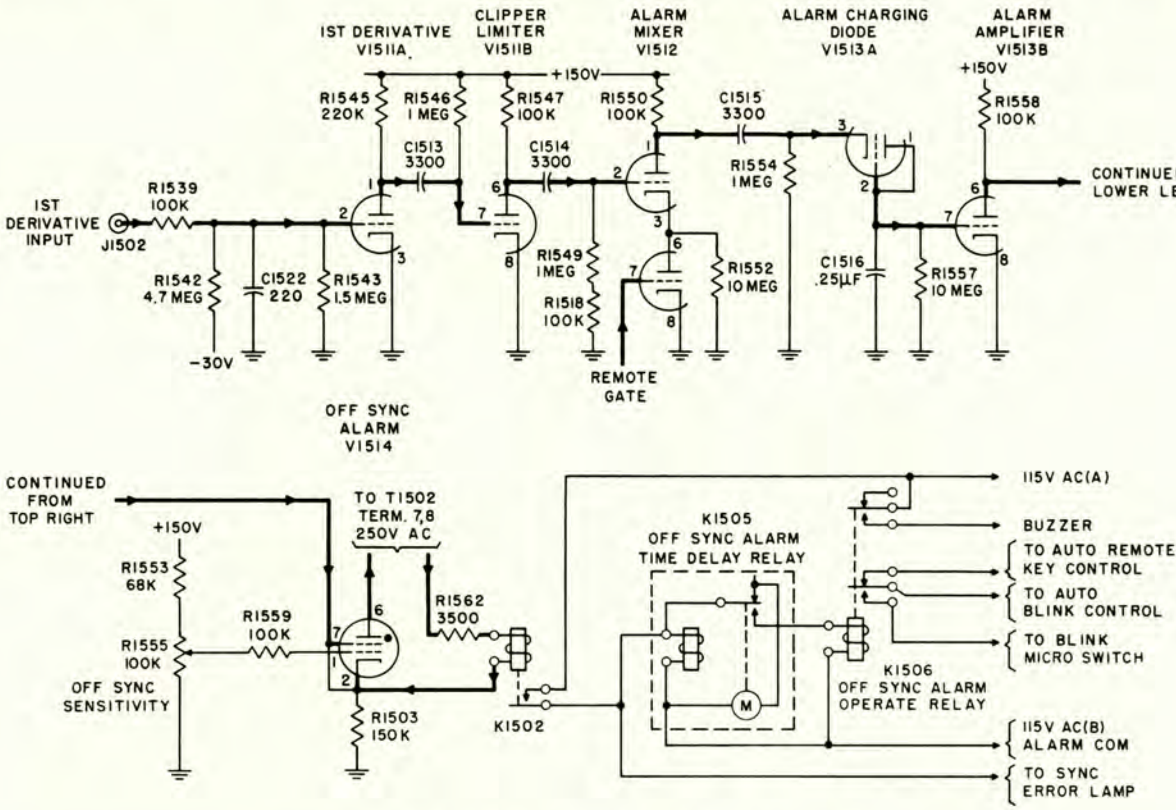


Figure 2–108. Off Sync Alarm Circuit, Schematic Diagram

Because V1512B is nonconducting in the absence of a gate, the cathode voltage of V1512A attempts to rise to B+ level, exceeding the heater cathode voltage rating for a type 5814 tube. This excessive voltage is prevented by the addition of R1552, which has an interesting voltage limiting effect. The action of this 10-megohm bias resistor is to hold V1512A almost at cutoff when V1512B is nonconducting. With this cathode bias arrangement, it is impossible for V1512A to become biased beyond cutoff, and since the bias voltage required to produce cutoff is less than the maximum heater-cathode voltage rating for the tube, this rating cannot be exceeded. The tube current is kept so low, by this 10-megohm bias resistor, that negligible output voltage is present in the absence of a gate pulse.

The negative output pulses of the coincidence mixer are applied to averaging capacitor C1516 through charging diode V1513A. This circuit operates in the same manner as the averaging capacitor circuits of the sync measuring circuit. A large negative voltage is stored in the capacitor when synchronization is normal and a lesser voltage for an off sync condition. This voltage, applied to the grid of amplifier V1513B, is amplified and inverted so that a relatively high voltage is normally obtained at the plate of V1513B and a lower plate voltage results for an off sync condition.

The plate of off sync alarm amplifier V1513B is directly coupled to the cathode of thyratron V1514. The control grid of this thyratron is connected to the arm of potentiometer R1555, the OFF SYNC SENSITIVITY control, through current limiting resistor R1559. R1555 and R1553 form a voltage divider to provide a positive bias voltage to the thyratron grid. This bias is adjusted, by means of R1555, so that the thyratron does not fire with the cathode voltage established under normal synchronization but does fire with the cathode voltage established for any off sync condition. The thyratron operates relay K1502 in the same manner as the sync error thyratron operates the relay in its plate circuit. The relay arrangement is the same as for the sync error arrangement previously discussed except that a different group of relays is used and the time delay relay, K1505, provides a delay range of fifteen seconds to five minutes. Operation of plate relay K1502 lights OFF SYNC indicator lamp I805, in the synchronization indicator unit, and starts the time-delay cycle. The OFF SYNC pen in the recording ammeter is connected in parallel with I805 so that the pen records an off sync condition whenever the lamp is lit.

(6) REMOTE ALARM PROVISIONS. — Provision has been made to connect a set of duplicate indicator lamps and alarm buzzer across the indicators of the alarm circuits. Connections for these duplicate indicators are wired through REMOTE ALARM switch S1501, which permits the remote alarms to be disconnected as desired. The remote alarm connections are terminated at TB1501 and may be extended by

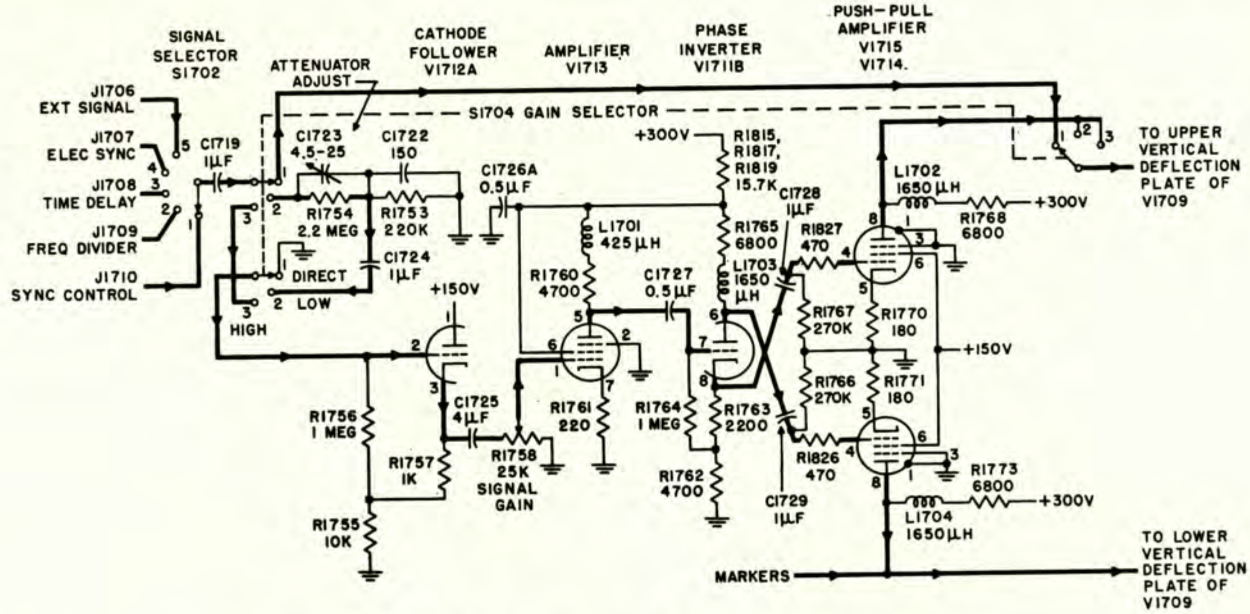


Figure 2–109. Test Scope Signal Circuit, Schematic Diagram

means of a four-conductor wire circuit. It is intended that the remote alarm indicators may be located up to two miles from the timer. The resistance of each conductor in the connecting circuit should not exceed 200 ohms.

(7) TEST SIGNAL CATHODE FOLLOWER.—The test signal cathode follower consists of a single stage, V1510B, which provides a high impedance input, for minimum loading of the circuit under test, and a low impedance output, for minimum waveform distortion due to shunt capacitance of connecting cables. The circuits are selected by means of TEST SIGNAL switch S1503 and are isolated from the cathode follower input circuit by resistive, capacitive, or resistive-capacitive coupling arrangements. The impedances of these coupling circuits are such that relatively uniform waveform amplitude is obtained in all positions of S1503. Selected signals are AC ERROR voltage, at the plate of V1507B; the 2ND DER, at input jack J1501; the LOCAL GATE and the REMOTE GATE, at the output of each gate separator diode, V1519B and V1519A; the MIXED GATES, at the output of gate cathode follower V1525A; the 1ST DER, at input jack J1502; and the LIMITED 1ST DER, which is the amplified alarm pulse at the output of V1511B.

b. TEST OSCILLOSCOPE TYPE OS-39/FPN-30.—As described in paragraph 3 *b*, the test oscilloscope is an accessory unit provided to facilitate test and adjustment of other timer circuits. This unit includes a wide band signal amplifier, a versatile sweep circuit, and a marker mixer arrangement.

(1) TEST SIGNAL PATH.—The test signal may be taken from any one of the test signal cathode followers in the various timer units or may be fed through EXTERNAL SIGNAL jack J1706. Refer to figure 2-109. SIGNAL SELECTOR switch S1702 connects the signal fed from one of the timer units, or from J1706, to the input switch of the signal amplifier. Signal may be applied to J1706 through one of a set of test cords furnished with the timer. A low capacity shielded probe, W2201, is included with this set to permit minimum loading of high impedance circuit points when checking waveforms. This probe, shown in figure 2–110, consists of resistive voltage divider R2204, R2205, and variable capacitor C2203. This capacitor is adjusted so that, when working into the combined capacity of the connecting coaxial cable and scope input circuit, it acts as a capacitive voltage divider with the same attenuation ratio as the resistive divider. Under this condition the probe has uniform frequency/attenuation characteristics over an extreme range.

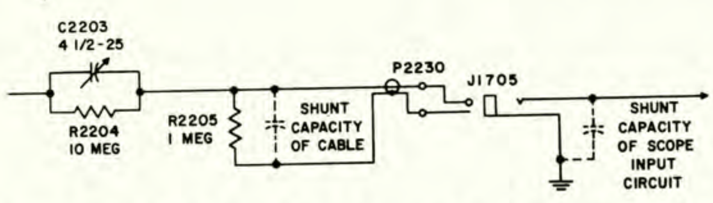


Figure 2–110. Test Scope, Low Capacity Probe, Simplified Schematic

The input switch for the signal amplifier, GAIN SELECTOR S1704, connects the test signal either directly to the amplifier input, through a 20-db attenuator to the amplifier input, or disconnects the amplifier and applies the signal directly to the upper vertical deflection plate of the cathode-ray tube. The attenuator is a resistance-capacitance voltage divider, C1723, R1754, C1722, R1753, which behaves in the same way as the divider in probe W2201. ATTENUATOR ADJUST capacitor C1723 is provided to balance out other circuit capacities and thus produce uniform frequency response over a wide range.

The input stage for the signal amplifier is a cathode follower, V1712A. In addition to providing a high impedance low capacitance input circuit, the low impedance output of this cathode follower permits the use of a low resistance potentiometer as a SIGNAL GAIN control. This control, R1758, is not affected by the capacitive loading of the next stage, for any attenuation setting, because of the relatively low value of resistance used. The second stage of the signal amplifier is a high gain pentode, V1713, which uses peaking coil L1701 in its resistance-coupled plate circuit to extend high frequency response. V1713 drives triode phase splitter V1711B. Plate circuit decoupling for V1713 and V1711B is provided by parallel resistors R1815, R1817, R1819 and filter capacitor C1726A.

V1711B employs peaking coil L1703 in its plate circuit to extend high frequency response. This phase splitter provides push-pull drive to output tubes V1714 and V1715. Pentode voltage amplifiers, with plate peaking coils, provide wide-band push-pull output. This output is applied to the upper and lower vertical deflection plates of the cathode-ray tube. A dual VERTICAL CENTERING potentiometer, R1776, and the push-pull output maintain the average voltage of the vertical deflection plates constant, for any condition of centering adjustment and signal deflection, so that good focusing is obtained throughout the vertical field.

(2) SWEEP CIRCUIT. — The horizontal sweep circuit produces a delayed, triggered sweep. Sweep delay is accomplished by two consecutive step delay circuits and a continuous delay circuit. Step delays of 1,000 and 100 microseconds are provided by delay multivibrators. These multivibrators produce the same rectangular delay pulses as generated by the delay phantastrons of the time delay unit. Multivibrators are used in the test scope, instead of phantastrons, because the higher stability provided by phantastrons is not required. The continuous delay circuit employs a delay phantastron because the greatest possible freedom from jitter is desired.

The sweep may be triggered from either phase of the square wave, mixed A- and B-triggers, 1,000- or 100-microsecond markers, or from an external signal applied through J1706 on the front panel. The full range of delayed triggering is provided for the square-wave sync triggers and external triggers; the continuous delay only is provided for the mixed A and B triggers. No delay is provided for the 1,000- and 100-microsecond marker triggers. The trigger is used to initiate the sweep generated by a phantastron generator stage. Generator output is inverted in a paraphase amplifier to provide push-pull sweep.

The sync signal, taken from the various jacks in the test scope, is selected by SYNC SELECTOR switch S1701. Refer to figure 2–111. Square wave ϕ 1, taken from J1703, is not only used to provide a sync trigger but is also applied to cathode follower V1721A which provides a low impedance output to SQUARE WAVE OUTPUT jack J1704. This output is used for test purposes wherever it is necessary to synchronize with the timer square wave. Both phases of the square wave are fed through negative sync amplifier V1701A, and the external signal is fed through this amplifier in the EXTERNAL— position of S1701. V1701A is a zero-biased amplifier which uses isolation resistor R1821, in series with the grid, to prevent loading the sync trigger source. The output of this amplifier is fed through a section of S1701 so that either the output of the negative-sync amplifier or the direct output of EXTERNAL SYNC jack J1701 drives positive-sync amplifier V1701B. This amplifier is biased beyond cutoff and responds only to strong positive sync pulses. V1701B triggers 1,000-microsecond step delay multivibrator V1702. This multivibrator and the arrangement for triggering are identical in operating principle to the multivibrator which generates the blanking pulse. Refer to paragraph 4 *d* (6) for a circuit description.

The output of the delay multivibrator is a positive pulse which may be any width from 1,000 to 27,000 microseconds. The trailing edge of this pulse is differentiated and used to form a push-up gate which selects one particular marker from the chain of 1,000-microsecond markers. Operation of this circuit is identical to the 1,000-microsecond push-up used in the time-delay unit. For a circuit description refer to paragraph 4 *d* (1) (*b*). The selected 1 000 is clipped in V1704A, to remove it from the chain of markers, and used to trigger the 100-microsecond delay multivibrator. This delay circuit is essentially a duplicate of the 1,000-microsecond delay circuit and is used to select a particular 100 from the chain of 100's. The circuit is shown in figure 2–112.

Either the selected 100 which is the output of clipper V1704B is used or the mixed A and B triggers are used, to trigger continuous delay phantastron V1708. A delay range of about 150 microseconds is provided by adjustment of CONTINUOUS DELAY potentiometer R1736. The circuit produces a rectangular output pulse which is differentiated to form a negative trigger. Operation is the same as for the continuous delay circuit previously described in paragraph 4 *d* (2) (*d*).

The sweep trigger selected by SYNC SELECTOR S1701 is either the differentiated output of continuous

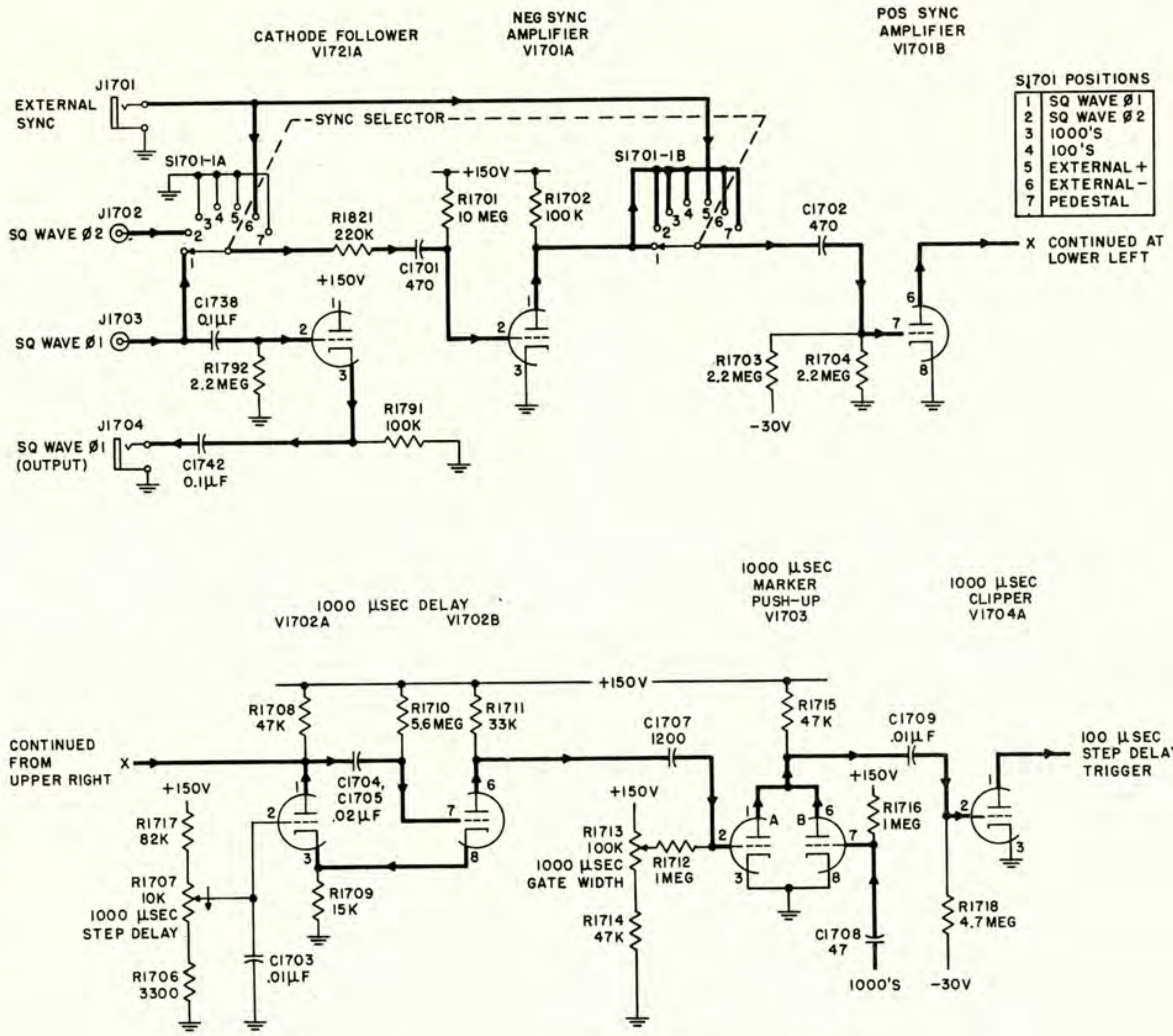


Figure 2–111. Test Scope, Sync Trigger Amplifiers and 1,000-Microsecond Step Delay Circuit, Simplified Schematic

delay phantastron V1708 or attenuated 1,000- or 100-microsecond markers. Refer to figure 2–113. The 1,000-microsecond markers are attenuated to a level suitable for triggering by voltage divider R1809, R1811, and the 100-microsecond markers are attenuated by R1810, R1812. The triggers are applied to sweep generator V1717 through cathode follower V1707B and trigger diode V1721B. Except for the switching arrangement, which provides different ranges of sweep speed, and for the method of controlling trace size, the sweep generator stage is identical in operating principle to the sweep generator of the VIDEO SCOPE. Refer to paragraph 4 *f* (2) for a circuit description. The range of sweep speed is changed by means of COARSE SWEEP SPEED switch S1706, which provides different values of plate-to-grid coupling capacitance to vary the circuit time constant. Sweep speeds of intermediate values, between those provided by S1706, are available by adjustment of FINE SWEEP SPEED potentiometer R1790. One other circuit difference, in this generator, is the inclusion of parasitic suppressor resistor R1823. The generator, with associated paraphase amplifier stage V1718, supplies a push-pull sawtooth voltage to the horizontal deflection plates of the cathode-ray tube and also supplies a rectangular intensifier pulse.

The paraphase amplifier associated with the test scope sweep generator differs from that associated with the VIDEO SCOPE sweep generator. The test scope paraphase amplifier, V1718, does not use a degenerative circuit to attain unity gain, but instead employs voltage divider R1801, R1795 to attenuate the output of the sweep generator by an amount which approximately complements the gain of the pentode amplifier employed in the circuit. Direct coupling is employed to assure that the scope trace always starts at the same place, regardless of sweep speed. If capacitive coupling were used, a change in the d-c level would occur for different sweep speeds and cause the trace centering to change. Proper grid bias is obtained by return of the voltage divider, R1795, to a negative voltage developed across R1806. R1806 is connected between the —108-volt bus and ground and is a variable potentiometer which permits the bias of V1718 to be adjusted to control horizontal centering. The bias voltage developed across HORIZONTAL CENTERING potentiometer R1806 is bypassed by C1744. This voltage controls tube current to vary plate voltage, with respect to the voltage on the plate of the sweep generator, so that the voltage on the direct coupled cathode-ray tube horizontal deflection plates may be varied. Sweep size is controlled by varying the output of V1718 by means of SWEEP SIZE potentiometer R1795.

The intensifier pulse supplied by the phantastron sweep generator is fed through cathode follower V1722 to the intensity grid of the cathode-ray tube. Refer to figure 2–114. The cathode follower provides a low source impedance which preserves the steep-sided shape of the rectangular intensifier pulse. The intensifier pulse is applied through coupling capacitor C1749, and because of the large variation in sweep duty cycle, it is necessary to use d-c restorer V1720 to maintain a constant d-c level on the intensifier grid for any setting of INTENSITY potentiometer R1781. The application of control voltages for the other electrodes of the 5CP1A cathode-ray tube is made in the same way as for the VIDEO SCOPE. Refer to paragraph 4 *f* (2) for a circuit description.

(3) MARKER MIXER CIRCUIT.—The marker mixer circuit provides either 1000's, 100's, or mixed 10's and 1's to the lower vertical deflection plate of the cathode-ray tube. Refer to figure 2–115. Either 1000's, 100's, or 10's are applied to the grid of marker amplifier V1710A through MARKER SELECTOR

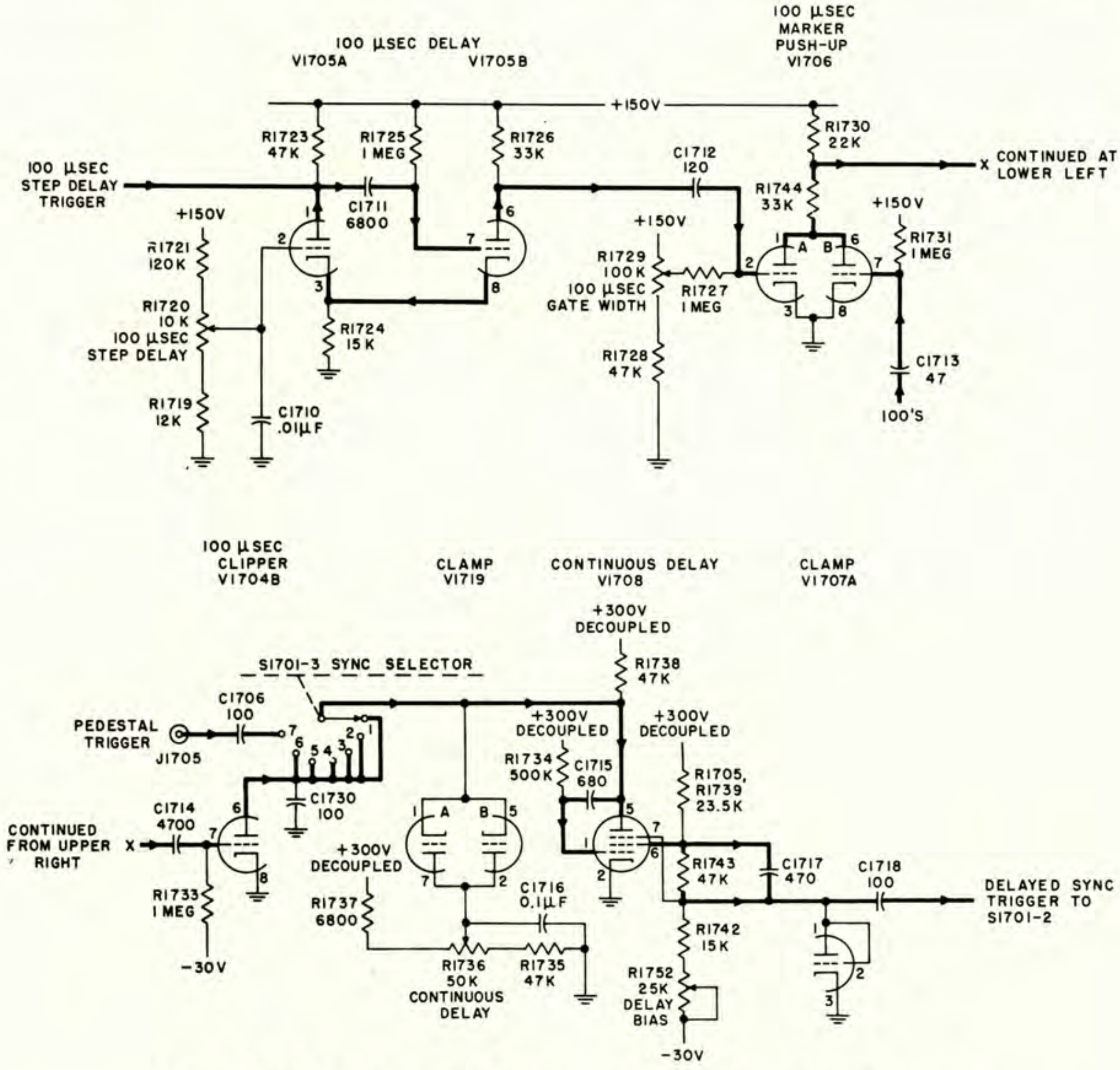


Figure 2–112. Test Scope 100-Microsecond Step Delay and Continuous Delay Circuit, Schematic Diagram

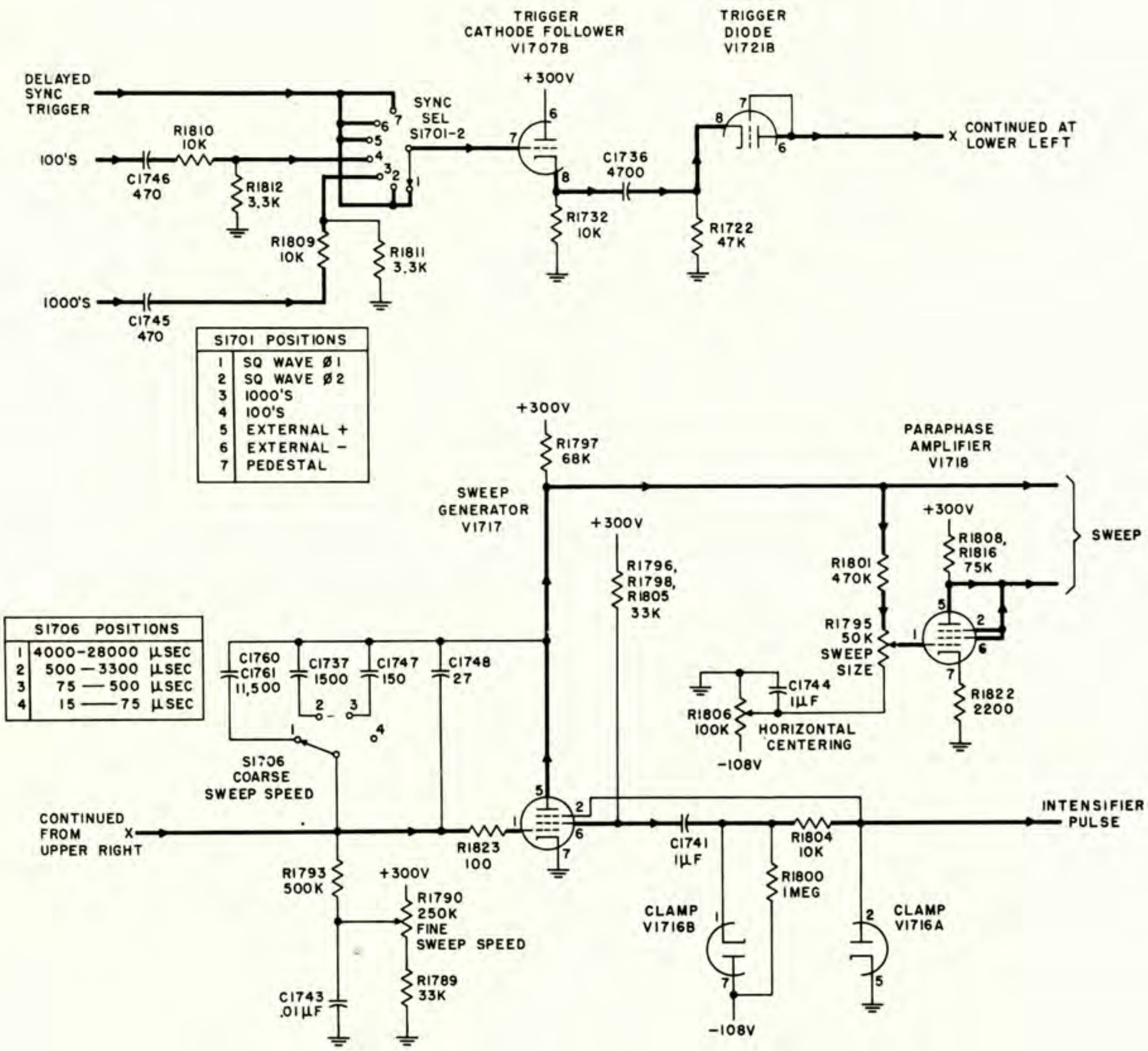


Figure 2–113. Test Scope Sweep Generator, Schematic Diagram

switch S1703. This switch also has an OFF position which grounds the grid of V1710A. A diode, and a diode bias voltage, supplied by voltage divider resistors R1782 and R1783, is used as a base-line clipper to remove positive and negative overshoot from the 10's. The negative markers drive the zero-biased grid negative and produce an output at the junction of plate resistors R1748, R1749, R1750. For the 1000's and 100's, this output is applied to the grid of clipper stage V1711A without any effect from 1's amplifier V1710B. The signal input of V1710B is grounded and the grid is zero-biased by return of grid resistor R1751 to +300 volts so that V1710B presents a fixed loading for these two inputs. With S1703 positioned to feed 10's to V1710A, 1's are fed to V1710B. The negative 1's are amplified by V1710B and appear in the output circuit. The output amplitude of the 1's is limited by the loading presented by V1710A, between 10's, when the grid voltage is zero. This amplitude increases when V1710A is cut off by a 10 so that the combined output of the two stages is a chain of 1's and 10's with the 10's coincident with the 1's to make the amplitude of every tenth 1 greater than the other nine 1's.

The output markers of V1710 are fed to the grid of clipper stage V1711A. The negative bias, and hence the clipping level, of this stage is controlled by MARKER HEIGHT potentiometer R1741. The plate of V1711A is connected in parallel with the plate of V1714, one of the push-pull output tubes of the signal amplifier, so that markers are applied directly to the lower vertical deflection plate of the cathode-ray tube. This permits adjustment of marker height which is independent of the signal amplitude.

i. RECORDING AMMETER TYPE ME-84/FPN-30.—As described functionally in paragraph 3 *i*, the recording ammeter is provided as a means for making

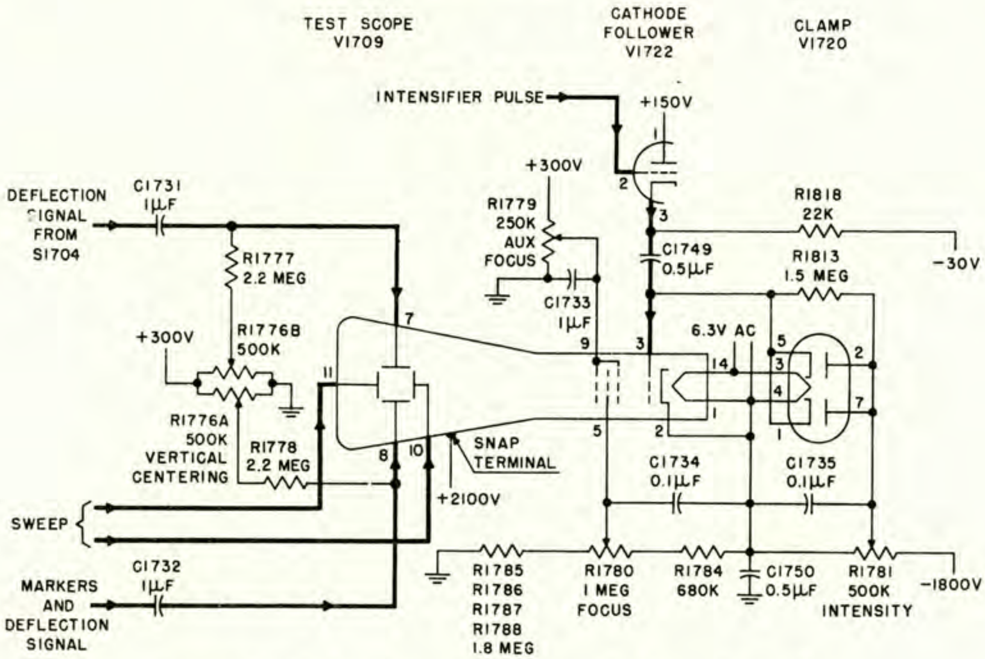


Figure 2–114. Test Scope Cathode-ray Tube and Intensifier Pulse Circuits, Schematic Diagram

a permanent record of the synchronization conditions of a loran pair. The meter consists of an electromagnetically deflected meter pen, which indicates the motion of the PHASE dial over a calibrated range of ±5 microseconds, and two side chronograph pens. Each of the side pens moves from a normal, spring-loaded position to an operating position under control of an electromagnet. The chronograph pens deflect to indicate off sync and local blink conditions. The pens draw ink from pen reservoirs by capillary action. The recording ammeter also includes two running time meters.

Pen deflections are recorded on a paper chart which is carried by a chart drive arrangement. This arrangement moves the chart at a fixed rate, as controlled by a synchronous motor. The motor drives the chart through a gear chain and a sprocket roller. The sprocket roller engages perforations on the chart to insure firm, slip-free drive. The chart is fed from a supply roller, past the pens, over the sprocket roller, to a take-up roller (reroll). The reroll is driven by an induction motor through a spring tension device. The spring tension device acts like a window shade roller to maintain take-up tension. The induction motor acts only periodically, as required to build-up spring tension. The synchronous drive motor and the induction take-up motor are both connected. to the 115-volt 60-cycle power line through a common toggle switch. This switch is located on the left-hand side of the drive. A lamp, located at the top of the case, is provided for illuminating the chart.

Chart speed is controlled by two different types of gear change. A gear ratio change of 60:1 is effected by means of a gear shift lever on the right-hand side of the drive. The lever may be placed in either the HOUR FEEDS or the MIN. FEEDS position to convert basic chart speeds from inches per hour to inches per minute. The basic chart speeds are established by using one of three pairs of gears in different combinations. The gears which accomplish this couple the synchronous motor output to the sprocket roller. The drive shaft is the lower of two shafts which project at the upper left side of the chart drive. Gears are held in place on the two shafts by knurled clamping nuts. Speed change gears are stored in a clip which mounts just above the sprocket roller shaft projection. Each pair of gears is coded a different color to facilitate identification. A gold pair of gears provides the largest gear ratio. With the smaller of the two gold gears on the lower (drive) shaft and the larger on the upper (sprocket roller) shaft, the chart speed is 3/4 inch per hour or 3/4 inch per minute. With the gear positions reversed, that is, with the larger gold gear on the drive shaft, the chart speed is 12 inches per hour or 12 inches per minute. A red pair of gears provide a unity gear ratio; both red gears have the same number of teeth. The red gears provide a speed of 3 inches per hour or 3 inches per mintue. A green pair of gears provide a speed of 1.5 inches per hour or 1.5 inches per minute with the smaller gear of the pair mounted on the drive shaft and a speed of 6 inches per hour or 6 inches per minute with the larger gear of the pair mounted on the drive shaft. The standard speed is 3 inches per hour and is based on a 60-cycle power line. The chart is calibrated with time markings, in accordance with the 24-hour clock, for that speed. When used at other gear speeds or power line frequencies, this calibration does not apply and an appropriate correction must be made.

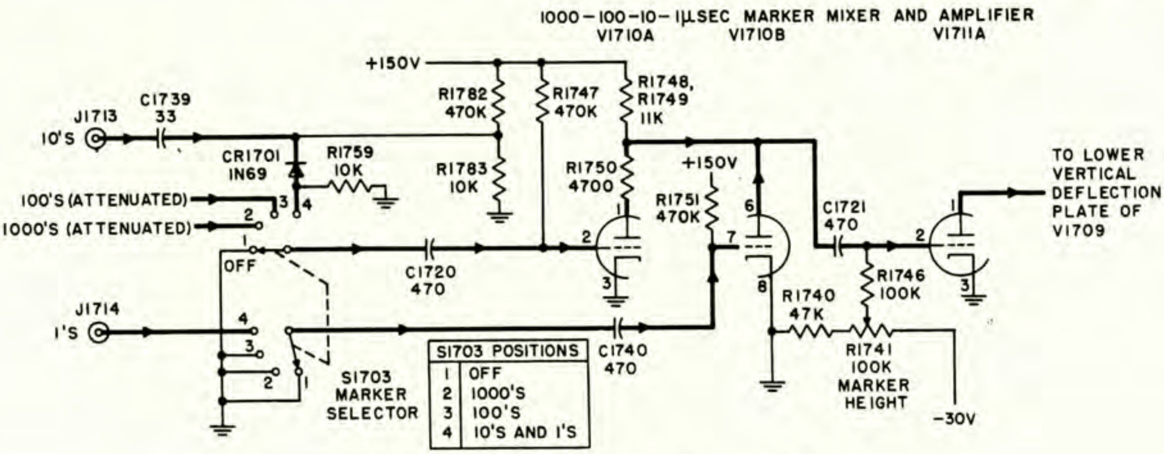


Figure 2–115. Marker Mixer Circuit, Schematic Diagram

The construction of the meter pen is essentially like a large ammeter in which the pointer is fitted with a pen tip. The meter is a 0- to 1.0-milliampere movement which is adjusted to provide deflections of —0.5—0— +0.5 by offsetting the mechanical centering adjustments for the pen. This centering adjustment, which behaves in the same way as the meter zero setscrew located on the front of most conventional meters, is a lever located at the bottom of the chart frame.

Two running time meters, which are independent assemblies, are mounted on the panel of Recording Ammeter ME–84/FPN–30. These meters are wired in parallel with the chronograph pens and indicate the total accumulated time of operation of the off sync alarm and of the local blink motor. Off sync time is that time that OFF SYNC alarm indicator I805 has been lit. This time is not affected by the delay period imposed by the off sync time delay relay. Local blink time is the time that the local blink motor has been operating, to cause cyclic blinking, and is the total time for both automatic and manual blinking.

Each running time meter is a Veeder-Root counting mechanism which is driven by a synchronous motor. The motor speed is based on a 60-cycle line frequency and elapsed time indications will therefore not be correct for any other line frequency. If the timer set is used with any line frequency other than 60 cycles, an appropriate correction factor must be applied to the meter readings. For example, with a 50-cycle line, multiply the meter reading by 6/5.

j. POWER DISTRIBUTION. — The main power controls of the timer are divided into two sections: (1) The MAIN POWER ON-OFF circuit breaker which connects the timer to the main power source and turns on Radio Frequency Oscillator Type O–202/FPN–30; and (2) the INTERLOCKED POWER ON-OFF switch which is used to extend power turned on by (1) to the other units in the timer. The purpose of this arrangement is to permit turning off the units controlled by the interlocked power switch for test, maintenance, and other purposes without impairing the operation of the oscillator. This is necessary to maintain a high degree of stability in the frequency produced by the oscillator. Whenever interlocked power is removed, the space heaters may be automatically operated to prevent condensation from forming in the cabinet. A thermostat controlled blower system reduces the heat rise in the cabinet when all the units are in operation. Power to the oscilloscopes in the timer is controlled by the interlocked circuit; however, a separate on-off switch is provided for the oscilloscope high voltages so they may be turned off without interrupting the interlocked power circuit. The complete a-c ladder diagram is shown in figure 7–288.

(1) MAIN POWER CONTROL.—Figure 2–39 is a block diagram of a-c power distribution. Unregulated a-c voltage (115 volts ±15 percent) 50-65 cycles, single phase, is applied to Voltage Regulator Type CN–235/FPN–30 through the switching equipment. The regulated 115-volt a-c output of the voltage regulator is applied to the timer through MAIN POWER ON-OFF circuit breaker S2001. This circuit breaker shuts off the timer completely if the timer draws more than 20 amperes of current.

(2) SPACE HEATER CONTROL.—The power to the space heaters is controlled with SPACE HEATERS ON-OFF switch S2003 and relay K2001. A set of contacts of relay K2001, in series with switch S2003, close the space heater circuit when the interlocked system is opened. This prevents moisture condensation. The space heaters consist of three 125-watt resistors located at the bottom of the timer cabinet. Relay K2001 is further described below.

(3) INTERLOCKED POWER CONTROL.—INTERLOCKED POWER ON-OFF switch S2004 is used to control the a-c power distribution to all of the timer units except the oscillator and Power Supply Type PP–959/FPN–30. These units are energized by power applied through circuit breaker S2001 and remain in operation when the interlocked power circuit is interrupted. This circuit consists of relay K1901, the cabinet and unit drawer interlock switches in series

with each other, contacts of K2003 and switch S2004. The contacts of relay K2003 open the interlock circuit if the output of the bias rectifier of Power Supply Type PP–959/FPN–30, through which the relay is energized, fails. An interlock switch is associated with each drawer in the timer cabinet, except the oscillator and Power Supply Type PP–959/FPN–30. When a drawer is withdrawn or a cabinet door is opened, the associated interlock switch will open the interlock power circuit. When this circuit is open, relay K1901 is no longer energized and its contacts open the a-c power circuit to all timer units except those directly controlled by circuit breaker S2001.

A BATTLE SHORT switch is provided which, when closed, by-passes the entire interlock circuit and enables any of the time units to be withdrawn from the cabinet without disabling any of the power supply circuits in the timer. The purpose of this switch is to allow adjustment of timer circuits, particularly those in the synchronizer drawer, while the equipment is operating. A red indicator light is installed next to the BATTLE SHORT switch to indicate when the switch is in the ON position. The INTERLOCKED POWER switch must also be in the ON position in order for power to be supplied to the units. When adjustment requiring shorting of interlocks is completed, the BATTLE SHORT switch shall be returned to the OFF position.

Note

Extreme caution must be exercised when adjusting any of the circuits while the battle short switch is in the on position because of dangerously high voltage present.

(4) RELAY K2001.—Relay K2001 is energized through the interlock power circuit. It accomplishes the following functions.

When relay K2001 is energized, +150 volts is applied to the timer units through contacts 1 and 4. When this relay is de-energized, contact 1 springs back to contact 10 and places a resistive load across the +150-volt output of Power Supply Type PP–959/FPN–30. The purpose of the resistive load is to maintain regulation since the only other load on this power supply under this condition is the oscillator.

When relay K2001 is energized, contacts 5 and 6 apply −230 volts to the −30-volt and the −108-volt regulator circuits in Power Supply Type PP–959/FPN–30.

Contacts 7 and 9 close the space heater circuit when this relay is not energized.

(5) RELAY K2002.—Relay K2002, is energized through the interlock power circuit. It accomplishes the following functions:

When this relay is energized, +135 volts is applied to the oscillator through contacts 4 and 6. When the relay is not energized, contact 6 springs back to contact 5 and applies +150 volts to the oscillator, to maintain operation of the oscillator.

When energized, the contacts of this relay apply the −150-volt output of Power Supply Type PP–959/FPN–30 to the voltage regulator circuit in Power Supply Type PP–957/FPN–30.

(6) BLOWER CIRCUIT.—When the timer units are all operating, the heat rise in the cabinet is reduced by the thermostat controlled blowers, which operate only when the interlocked circuit is energized. The nonadjustable thermostat is set to operate at 10°C. (50°F.) and remain closed until the temperature in the cabinet is reduced to −1°C. (30°F.).

(7) A-C DISTRIBUTION BOARD.—The interlocked relay contacts apply 115 volts ac to a-c distribution board TB2203. From this board a-c power is applied to each unit in the timer not mentioned above.

(8) SCOPE HIGH VOLTAGES.—The high voltages are applied to the oscilloscopes in the timer under control of the SCOPE HIGH VOLTAGES ON-OFF switch S2101. The purpose of this switch is to permit maintenance work to be done on the oscilloscope low voltage circuits without the hazard of having high voltages on.

(9) FILAMENT SUPPLY. — Each unit in the timer, except the oscillator, has a filament transformer included in it to provide filament power for the tubes. The a-c ladder diagram, figure 7–288, shows the input power connections to the primaries of all the filament transformers in the timer. The transformer is shown in the schematic diagram of each unit. Filament power for the tubes in the oscillator unit is obtained from Power Supply Type PP–959/FPN–30. Included in the timer are three filament transformers which provide voltages for use in contemplated auxiliary equipment. The transformers are (1) filament transformer T1902 in Power Supply Type PP–958/FPN–30 which provides 6.4 volts ac at 2.75 amperes, (2) transformer T1903 in the same power supply which provides 6.4 volts ac at 14 amperes, and (3) filament transformer T2104 in Power Supply Type PP–957/FPN–30 which provides 6.4 volts ac at 2.75 amperes. All the timer filament circuits, except the following, are conventional circuits.

The filaments of the control and regulator tubes in Power Supply Type PP–958/FPN–30 are placed above ground for dc by the voltage drop across resistor R1929, which forms a voltage divider with resistor R1928 across the regulated +300-volt output, to maintain heater-cathode voltage within ratings.

Transformer T2102 provides the filament voltage for the cathode-ray tubes in the timer indicator and test oscilloscopes. The filaments of the cathode-ray tubes are placed about −1,500 volts below ground potential by being tied to the cathodes of cathode-ray tubes. The purpose of this is to maintain the heater-cathode voltage within ratings.

The radio-frequency amplifiers and video detector filament circuits in Radio Receiver Type R–564/FPN–30 are filtered with capacitors and r-f isolation choke coils to prevent feedback through cathode-heater capacitance. The voltage drop across the coils is compensated for by having filament transformer T1201 provide 6.5 volts ac instead of 6.3 volts. For those tubes which are not filtered, a tap on the transformer provides 6.3 volts directly.

The filament current of delay phantastron tube V1517 in Electrical Synchronizer Type SN-117/FPN-30 is regulated by a ballast resistor, R1511, which is sealed in a gas-filled bulb.

The filaments of the tubes in Frequency Divider Type CV–274/FPN–30 are placed above ground for d-c potential by the voltage drop across resistor R415, which forms a voltage divider with resistor R276 across the +150-volt input to the unit. This is to maintain heater-cathode voltage within ratings.

(10) STAND-BY-OPERATE RELAYS. — Three relays, mounted in Electrical Equipment Cabinet CY–1437/FPN–30, are actuated by 115 volts ac supplied from the switchgear. These relays control the STANDBY and OPERATE indicator lamps on top of the timer cabinet, transfer the recording ammeter so that it is always connected to the operating timer, and control the passage of the local signal through the electrical synchronizer. Refer to the a-c ladder diagram, figure 7–288.

The coils of the three relays, K2201, K2202, K2203, are all connected in parallel so that the relays operate together. Power is applied to the relays, through the switchgear, when the timer is selected as an operating timer by the switchgear. This power application is accomplished automatically when the timer is used with a Loran Switching Group Type AN/FPA–2. Separate switching facilities must be added if the timer is used with a Navy Model UM switching equipment. These facilities are shown in figure 3–10. A lockout arrangement, through contacts 1 and 2 of relay K2201, prevents the power from the switchgear from reaching the stand-by-operate relays of the other timer (of the two timers used for each loran rate at a station) so that only one group of relays can operate at a time. Contacts 1 and 2 are normally closed; they open when K2201 is energized and thus interrupt the flow of power to the relays in the other timer. Thus only one set of relays can close at a time, and the recording ammeter can be connected to only one timer, the operating timer.

Power to STANDBY indicator I2201, and OPERATE indicator I2202, is applied through contacts 1, 2, and 3 of K2203 so that I2201 glows when the relay is unenergized, and I2202 glows when the relay is energized. Relay K1507, in the electrical synchronizer, is connected in parallel with I2201 (through LOCAL SIGNAL switch S1506) so that K1507 may be energized when the timer is in stand-by condition (K2203 de-energized). This arrangement disables the local signal channel of the electrical synchronizer. At a slave station the local signal must be removed, when the timer is in stand-by service, if the automatic synchronizing system is to lock in on the operating timer.

Power to the local blink and off sync pens and to the chart drive motor and chart lamp of the recording ammeter is applied through contacts of K2201. The power to the pens is 115 volts ac derived from a separate alarm circuit for each pen and the power for the chart drive and lamp is 115 volts ac taken through fuse F1904.

Signal is fed to the center pen through contacts 1 and 3 and 4 and 6 of K2202.

k. POWER SUPPLIES.

(1) POWER SUPPLY TYPE PP–959/FPN–30.— As discussed in paragraph 3*k* (1), three regulated voltages of +150 volts, −108 volts, and −30 volts are developed by Power Supply Type PP–959/FPN–30;

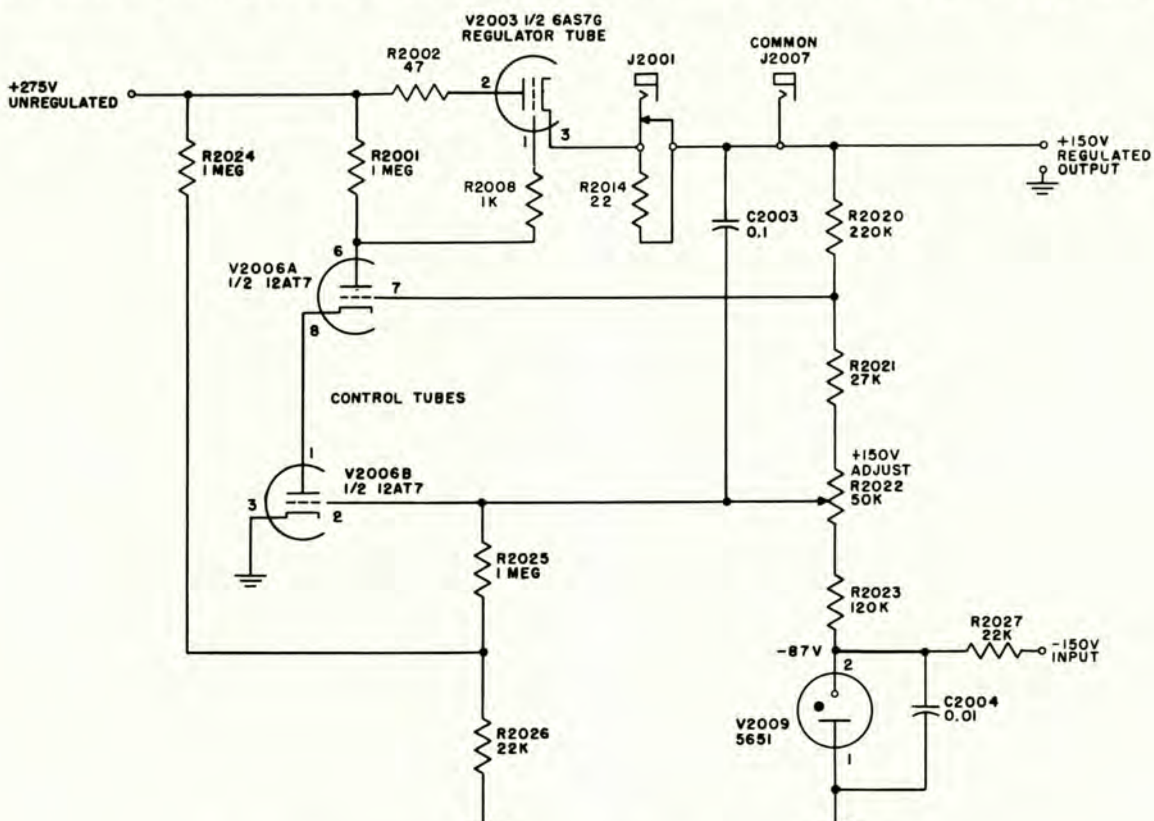


Figure 2–116. +150-Volt Regulator, Simplified Schematic Diagram

6.4 volts ac also is supplied for the filaments of the tubes in Radio Frequency Oscillator Type O–202/FPN–30. In addition, the 115 volts ac for the interlocked power circuit, through which the various a-c timer circuits are supplied, is taken from this power supply as discussed in paragraph 4 *j* (3). Two meters are provided, one to measure the a-c line voltages, and one to measure the d-c outputs of the three power supplies in the timer. Refer to figure 7–282 for the schematic diagram of the complete power supply.

(*a*) +150-VOLT SUPPLY CIRCUIT.

1. RECTIFIER CIRCUIT. — The +150-volt supply is derived from a conventional rectifier circuit consisting of power transformer T2001, rectifier tubes V2001 and V2002, and the associated filter circuit. The +275-volt output of the rectifier-filter circuit is applied to an electronically controlled regulator circuit to provide the regulated +150-volt output.

2. REGULATION OF THE +150-VOLT SUPPLY.—Refer to figure 2–116 for the simplified schematic diagram of the +150-volt regulator circuit. The unregulated output of the filter network is applied to the plate of regulator tube V2003. The regulated +150-volt output is taken from the cathode circuit of that tube. The output voltage is held constant by varying the internal resistance of the regulator tube in response to input voltage or output load changes. The internal resistance of the tube is determined by the potential on its grid. This potential is established by the control amplifiers V2006A and V2006B. The control tubes are connected in cascode (plate circuits in series) to provide a high stable gain for the feedback voltage to the regulator tube. The grids of the control tubes are returned to the voltage divider connected between the +150-volt output and the —87-volt reference voltage. This connection establishes the quiescent potentials of the control and regulator tubes and permits any error voltages at the +150-volt output to be applied to the control tube. The +150 V ADJ potentiometer, R2022, permits adjustment of the regulated output voltage by changing the point of return of control tube V2006B to the voltage divider, thus changing the quiescent condition of the regulator circuit.

3. REFERENCE VOLTAGE.—The fixed reference voltage of —87 volts used in this control circuit is developed from a negative source, regulated by gas tube V2009. The reasons for using a negative reference voltage are: (1) it permits a higher plate voltage for the operation of the control tubes, and (2) a larger portion of the error voltage is applied to control tube V2006B because the grid of V2006B is at a relatively higher point on the voltage divider, and this point is the error voltage source.

4. OPERATION OF THE VOLTAGE REGULATOR CIRCUIT.—If the output voltage tends to fall below +150 volts, part of this negative voltage change is applied to the grid of tube V2006B. The grid voltage change is amplified and applied to the cathode of tube V2006A. The amplified voltage drives the cathode of tube V2006A positive which is the same as making the grid of the tube more negative. The voltage is further amplified by tube V2006A, and a positive voltage develops across plate load resistor R2001. Since the amplified voltage is applied to the cathode of tube V2006A, there is no phase shift between the input and output voltage of that tube. The voltage developed across the plate load resistor is applied to the grid of tube V2003. The grid of the regulator tube is driven positive, and the internal resistance of the tube decreases. The voltage drop across the tube decreases, and the voltage across the cathode load increases accordingly, thus correcting for the original output voltage change. If the output voltage tends to increase, the correcting sequence would be the same, but with the opposite effect on the control and regulator tubes. Normally, a voltage regulator cannot compensate completely for changes in input voltage but, instead, reduces the changes to a very small value. This is so because a small error voltage must be furnished from the output of the regulator tube as a controlling agent. In this regulator, by connecting resistors R2024, R2025, and R2026 as shown in figure 2–116, advantage is taken of the fact that a small change in the unregulated voltage rather than a change in the load circuit (which is fixed) applies a correction. The corrective action, therefore, takes place as a direct result of changes in unregulated input voltage.

5. COUPLING. — The output error voltage applied to the grid of the control tube is developed across the voltage divider consisting of resistors R2020 through R2023. Only a portion of the total error voltage is applied to the control tube because it is connected across only a portion of the voltage divider. A-c voltages, fed back from the other circuits in the timer, and power supply hum voltage may also be present in the regulated output voltage. These a-c voltages are coupled at full amplitude to the control tube through the low impedance path provided by capacitor C2003. The low impedance a-c coupling makes the regulator tube more effective in suppressing these a-c voltages that are present in the output.

6. TEST JACKS.—Test jacks J2001 through J2004 and COMMON JACK J2007 are used in conjunction with a voltmeter to check the current flow through each regulator tube. When the meter leads are inserted into jack J2007 (COMMON) and one of the test jacks, the short across the resistor, in parallel with the test jack, is removed and the voltage drop across the resistor is measured by the meter. This permits the individual cathode currents to be checked so that defective tubes may be found and replaced.

7. ADDITIONAL COMPONENTS. — The simplified schematic diagram shows one triode as the series regulator tube; the actual unit consists of two twin triode 6AS7G tubes connected in parallel. Re-

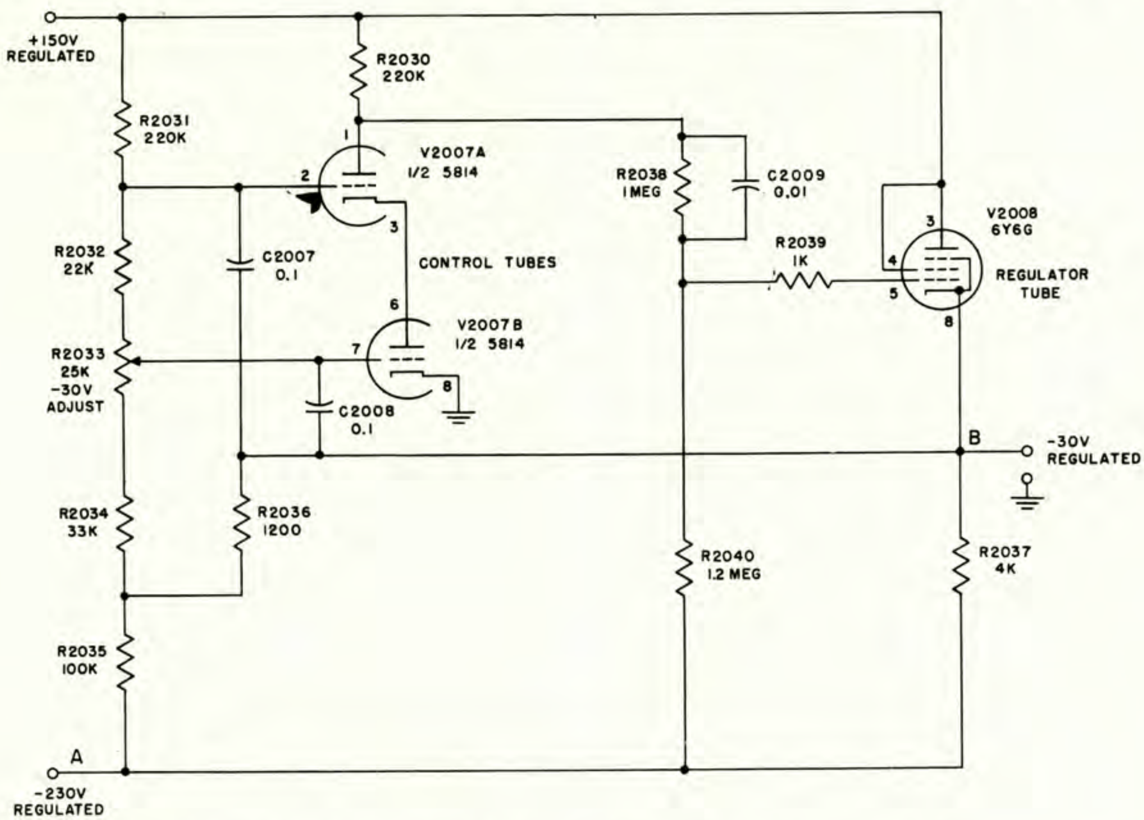


Figure 2–117. —30-Volt Regulator, Simplified Schematic Diagram

sistors R2002 through R2005 in the plate circuits and resistors R2008 through R2011 in the grid circuits of the regulator tubes prevent parasitic oscillations. Capacitor C2004 bypasses V2009 to ground for a-c signals.

(*b*) BIAS SUPPLY CIRCUIT.

1. GENERAL. — The negative bias voltages produced by this supply are derived from a conventional rectifier circuit consisting of power transformer T2003, full-wave rectifier tube V2011, and the associated filter network. The output of the filter network is an unregulated —230 volts from which the regulated —150 volts, —108 volts and —30 volts are derived. The —108-volt and the —30-volt outputs are used throughout the timer. The —150-volt output is used only to drive the gas regulator tubes for establishing the reference voltages for the +150-volt control circuits in power supplies PP–959/FPN–30 and PP–957/FPN–30.

2. REGULATION OF THE —150-VOLT AND —108-VOLT SUPPLIES.—The —150 volts and —108 volts are regulated in a conventional manner, by gas regulator tubes V2012 and V2010, respectively. These circuits are both driven by the —230-volt output of the filter network.

3. REGULATION OF THE —30-VOLT SUPPLY.—The circuit of the —30-volt regulator is shown in figure 2–117. The unregulated —230 volts is applied to the regulator circuit at point A. The regulated —30 volts is obtained from point B. Regulator tube V2008 acts as a variable shunt resistor between the —30-volt output and the regulated +150-volt output. It produces a correction in output voltage by changing the current flowing through resistor R2037. Control tubes V2007A and V2007B apply bias voltage to the regulator tube in accordance with variations in input voltage or output load current so as to maintain constant output at point B.

4. CONTROL AND REGULATOR TUBES BIAS VOLTAGES.—A voltage divider, consisting of resistors R2031, R2032, R2033, R2034, and R2036, is connected between the regulated +150-volt output and the —30-volt output. (Resistor R2035, connected between the —230-volt input and the junction of R2034 and R2036, will be considered as not in the circuit; its function is secondary and has little bearing on the basic theory of operation.) Bias voltages for both control tubes are obtained from the divider. The bias voltage for control tube V2007B is variable by means of the —30 V ADJ potentiometer R2033. The plate circuits of the control tubes are in series. This connection is the same as that of the control tubes for the +150-volt supply discussed above. A second voltage divider, consisting of resistors R2030, R2038, and R2040, is connected between the +150 volts and the unregulated —230 volts to provide plate voltage for tube V2007A and the grid voltage for V2008. Plate current of V2007A flows through R2030. Variations in

V2007A plate voltage are coupled by R2038 and R2039 to the grid of V2008, the regulator tube, thus changing its bias. The plate current of V2008 at this bias, together with the —30-volt load current, produces a voltage drop across R2037 of such proportions that the output voltage is maintained at —30 volts.

5. OPERATION OF THE —30-VOLT REGULATOR CIRCUIT.—If the output voltage tends to fall below —30 volts (become more positive), part of this voltage change is applied to the grid of tube V2007B. The grid voltage is amplified and applied to the cathode of V2007A. The amplified voltage drives the cathode of V2007A negative, which is the same as making the grid of the tube positive with respect to its cathode. The voltage is further amplified by V2007A, and a negative voltage develops across plate load resistor R2030. The new potential in the voltage divider R2030, R2038, and R2040 causes the voltage at the grid of V2008 to become more negative. This causes V2008 to draw less current, reducing the voltage drop across R2037. This permits the voltage to rise, providing almost complete cancellation of the error voltage. More complete cancellation of changes in the output voltage due to changes in the unregulated input voltage is provided by applying a portion of the unregulated input voltage to the grid of the control tube through resistor R2035. The function of this resistor is similar to that of resistors R2024, R2025, and R2026 in the +150-volt regulator circuit discussed above and is fully explained there. Resistor R2039 is used to prevent parasitic oscillations.

6. A-C COUPLING.—Capacitors C2007 and C2008 are connected between the —30-volt output and the grids of the control tubes to couple a-c variations in the output to these tubes at full amplitude. Similarly, capacitor C2009 couples the full control voltage to V2008. Together, the three capacitors provide more effective regulating action to suppress a-c voltages appearing in the output voltage.

7. METERS.—AC LINE meter M2002 is permanently connected across the a-c line for monitoring the a-c voltage input to the timer. All the d-c outputs of the three timer power supplies, except the +8,000-volt and the +2,100-volt outputs of Power Supply Type PP–957/FPN–30 and the —150-volt output of Power Supply Type PP–959/FPN–30, may be measured with DC VOLTS meter M2001. Meter M2001 is placed across the various outputs through DC METER SWITCH S2002. The meter is basically a 40-volt full-scale meter and multiplier resistors are provided to convert it to a 200-volt or 400-volt scale. Voltages up to 400 volts are applied directly to the meter through the necessary multiplier resistors. In the case of the +1,000- or —1,800-volt measurements, the full voltage is not applied to the meter. For example, when +1,000 volts is measured, the meter, in series with the 160,000-ohm multiplier, is shunted across the bottom resistor in the +1,000-volt voltage divider in Power Supply Type PP–958/FPN–30. The value of this resistor is such that when +1,000 volts is present at the voltage divider, only 100 volts is applied to the meter. When this voltage is measured, the 200-volt scale is used and it must be multiplied by 10 so that full-scale deflection is equal to 2,000 volts. Similarly, when —1,800 volts is measured, the meter is placed across the bottom resistor of the —1,800-volt voltage divider in Test Oscilloscope Type OS–39/FPN–30. This voltage is measured on the 40-volt scale and only —18 volts is applied to the meter. The 40-volt scale is multiplied by 100 so that full-scale deflection is equal to 4,000 volts. No provision is made to measure the +8,000-volt and the +2,100-volt outputs of Power Supply Type PP–957/FPN–30, since the current provided by these circuits is insufficient to drive the meter. The failure of these voltages will be apparent on the oscilloscopes in the timer. Since the —150-volt output of Power Supply Type PP–959/FPN–30 is used only to drive the gas regulator tubes that provide the reference voltage for the +150-volt control circuits in power supplies PP–959/FPN–30 and PP–957/FPN–30, it is not measured with DC VOLTS meter M2001. Table 2–4 shows the voltage measured by meter M2001 when switch S2002 is in the position indicated.

TABLE 2–4. METER SWITCH POSITIONS

SWITCH POSITION	VOLTAGE	POWER SUPPLY	FULL SCALE
1	+150 v	PP–959/FPN–30	200 v
2	— 30 v	PP–959/FPN–30	40 v
3	—108 v	PP–959/FPN–30	200 v
4	+300 v	PP–958/FPN–30	400 v
5	+135 v	PP–958/FPN–30	200 v
6	+1,000v	PP–958/FPN–30	2,000 v
7	+150 v	PP–957/FPN–30	200 v
8	—1,800v	PP–957/FPN–30	4,000 v
9	OFF		

(2) POWER SUPPLY TYPE PP–958/FPN–30.—Power Supply Type PP–958/FPN–30 develops two regulated voltages of +300 volts and +135 volts, and an unregulated voltage of +1,000 volts. The +300-volt control and regulator circuits are similar to the +150-volt control and regulator circuits in Power Supply Type PP–959/FPN–30 described in paragraph 4 *k* (1). The +135-volt control and regulator circuits differ from the one mentioned above only in that the control circuit consists of a one-tube amplifier instead of a cascode amplifier. Figure 7–283 is a schematic diagram of the complete power supply.

(*a*) REGULATED VOLTAGES.—The regulated voltages are derived from a full-wave rectifier-filter circuit consisting of power transformer T1901, rectifier tubes V1901 and V1902, and the associated filter circuit. The unregulated +425-volt output of the rectifier-filter circuit is applied to the plates of regulator tubes V1903 through V1905 to reduce the unregulated voltage to the regulated +300 volts obtained from the cathode circuits of these tubes. The regulated +300-volt output is applied to the plate of regulator tube V1908 to derive the regulated +135-volt output obtained from the cathode circuit of this tube. The one-tube amplier, V1909, is used in the control circuit of the +135-volt regulator circuit to provide an amplified feedback voltage for the regulator tubes.

(*b*) UNREGULATED VOLTAGE.—The secondary winding of power transformer T1901 is tapped to provide, in conjunction with selenium rectifiers CR1901 and CR1902 and the associated filter network, the +1,000-volt output of this power supply. An extra pair of taps on transformer T1901 is provided to compensate for the aging of the selenium rectifiers, which develop a higher internal resistance as they are used. Since the +1,000 volts is used in an oscilloscope amplifier, a two-section filter, consisting of capacitors C1903, C1912, C1904, choke L1902 and resistors R1941 and R1942, is used to reduce hum voltage. This is necessary to prevent jitter of the trace on the oscilloscope. A portion of the +1,000-volt output is developed across meter resistor R1937 to enable DC VOLTS meter M2002 to measure this output.

(3) POWER SUPPLY TYPE PP–957/FPN–30.—Power Supply Type PP–957/FPN–30 provides three unregulated voltages of +8,000 volts, +2,100 volts, and −1,800 volts. In addition this power supply provides a regulated +150 volts. The high voltages provided here are used for the operation of the oscilloscopes in the timer. The high voltage section of this power supply may be turned off independently of the interlock circuit with SCOPE HIGH VOLTAGES ON-OFF switch S2101. The +150-volt output is regulated by a regulator circuit similar to the +150-volt regulator circuit in Power Supply Type PP–959/FPN–30.

(*a*) UNREGULATED VOLTAGES.—The unregulated voltages are developed by the same power transformer, T2101, although separate half-wave rectifier-filter circuits are used. The −1,800-volt and the +2,100-volt circuits employ conventional half-wave vacuum tube rectifier circuits. The +8,000 volts is developed by a voltage quadrupler circuit consisting of selenium rectifiers CR2101 through CR2104 and capacitors C2110 through C2113.

(*b*) REGULATED VOLTAGE.—The unregulated +275 volts, used to produce the regulated +150-volt output of this power supply, is developed by power transformer T2103, rectifier tubes V2103 and V2104, and the associated filter circuit. The unregulated output of the filter circuit is applied to the plates of regulator tubes V2106 and V2107, which are in series with the output and load of the circuit. The voltage drop across the regulator tubes reduces the unregulated +275 volts to the regulated +150-volt output obtained from the cathode circuits of the regulator tubes. The −87 volts used as a reference voltage for this control circuit is derived from the −150-volt output of Power Supply Type PP–959/FPN–30.

l. VOLTAGE REGULATOR TYPE CN–235/FPN–30.—As described in paragraph 3 *l*, the line voltage regulator consists of a motor-operated autotransformer arrangement which is controlled by a voltage-sensitive element to maintain constant output voltage.

A voltage is developed by the autotransformer circuit which is added or subtracted, in series with the input voltage, to provide a desired output voltage. Refer to figure 2–118. Autotransformer T2301 is connected across the input line. Output voltage is taken from between a fixed tap, near the center of the winding, and a variable tap, which may be positioned anywhere along the winding. If the variable tap coincides with the fixed tap, zero output voltage will be obtained. If the variable tap is above the fixed tap, an output voltage will be developed proportional to the relative distance of the variable tap along the upper half of the winding. In the same way an output voltage of opposite phase will be developed if the variable tap is below the fixed tap.

The output voltage of the autotransformer is applied to the primary of isolation transformer T2302. The secondary of this transformer is connected in series with the power line and the load so that the output voltage will vary as the secondary voltage adds or subtracts voltage. Voltage will be added if the autotransformer output is of one phase and will be subtracted if it is of the other phase. In addition to isolating the autotransformer terminations so that voltage may be added or subtracted in series with the power line, T2302 also provides a voltage step-down which limits the range of voltage correction. As a result T2302 provides current step-up so that the autotransformer need supply only about one-fourth the load current and hence a physically smaller autotransformer may be used. Fuse F2301, in series with the autotransformer output and the isolation transformer, protects these two components from current overload.

It should be noted that the fixed tap is not at the electrical center of the winding, but has been deliberately displaced to permit the same output voltage to be developed on the low voltage side of the design center voltage as on the high side. The need for this displacement will be seen by consideration of the behavior of a center-tapped transformer. With an input of 97 volts the voltage impressed across one-half of the center-tapped transformer is 48.5 volts. This is the maximum correction voltage which can be applied to T2302 under this low input voltage condition. With an input of 132 volts, the voltage impressed across one-half of the center-tapped transformer is 66 volts. This is the maximum correction voltage which can be applied to T2302 under this high

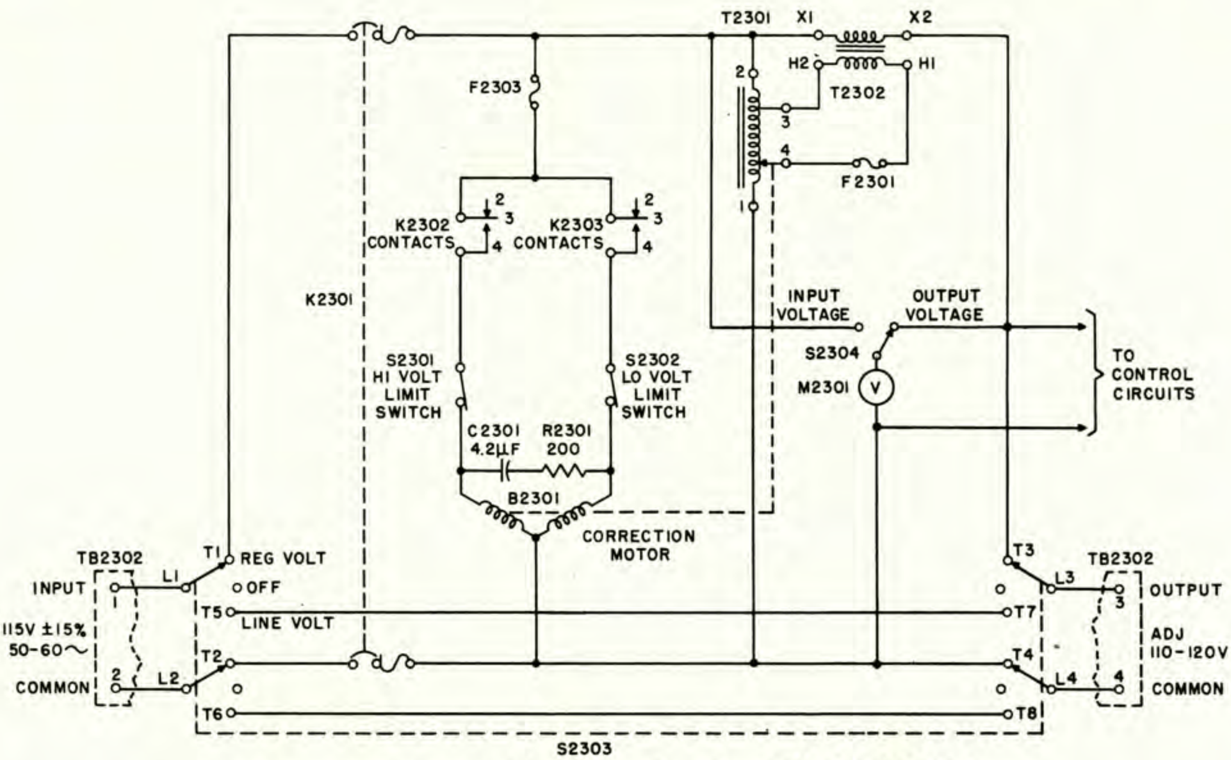


Figure 2–118. Line Voltage Regulator Type CN–235/FPN–30, Voltage Adjusting Circuit, Schematic Diagram

output voltage condition. Thus, it can be seen, a center-tapped transformer would provide 66 volts for correction of the worst *overvoltage* condition and only 48.5 volts for the correction of the worst *undervoltage* condition. This unequal range of correction is avoided by displacing the fixed tap away from center.

The variable tap on the autotransformer is a brush which is moved by the action of correction motor B2301. This motor will run in one direction or the other, depending on which of its two coils is connected to the power line through phase-shifting network C2301 and R2301. Relays K2302 and K2303 are arranged so that the motor will run in one direction if the contacts of K2302 close and will run in the opposite direction if contacts of K2303 close. Limit switches S2302 and S2301 interrupt motor power before the variable autotransformer tap is driven to either limit of its travel. The relays which cause the motor to run in one direction or the other are actuated by the control circuit. The control circuit closes one relay or the other, depending on whether output voltage falls above or below a preset value.

The control circuit is fed output voltage through step-down transformer T2303. Refer to figure 2–119. The center-tapped secondary of T2303, resistors R2305, Z2301, R2302, and R2304 all form a voltage-sensitive arrangement. The heart of this arrangement is a special incandescent lamp contained in Z2301. As in any incandescent lamp, the resistance changes as lamp temperature varies with different applied voltages. Because the lamp has a specific resistance for any specific applied voltage the resistance between points D and B will equal the resistance between points B and C for only one value of input voltage. The particular value of input voltage at which this equality is reached can be varied by means of OUTPUT VOLTAGE potentiometer R2302.

The equality of resistance in the two halves of the voltage divider is used to control the output of the voltage-sensitive arrangement. When equality is attained, the two equal voltages provided by the two halves of the T2303 secondary will cause equal voltages to be developed across the two halves of the voltage divider. Because the transformer secondary voltages are also equal, zero output will result between points A and B. Normally R2302 is adjusted to produce this equality when the regulator output is 115 volts. Should the regulator output then fall below 115 volts, the resistance lamp will cool off, and the resistance between B and C will be less than the resistance between D and B. This will make the voltage across B and C smaller than that across D and B, so that a voltage will be developed across A and B which is in phase with the voltage across terminals 3 and 4 of T2303. If the regulator output rises above 115 volts, the lamp will become hotter, and therefore the voltage across A and B will be in phase with the voltage across terminals 4 and 5 of T2303. Thus the output voltage of the voltage-sensitive arrangement will be zero if the regulator output is 115 volts, of one phase if the output falls below 115 volts, and of opposite phase if the voltage rises above 115 volts. This output voltage is taken from the voltage-sensitive arrangement through T2304 and used to control one or the other of motor control relays K2302 and K2303.

The output of T2304 is applied to thyratron control tubes V2301 and V2302. Bias voltage for these thyratrons is developed by crystal rectifiers CR2301 and CR2302, which provide full-wave rectification of the output of T2303. This voltage is filtered by R2308, C2302, C2303, and C2304. The bias developed by this circuit may be varied by SENSITIVITY rheostat R2303, which controls the voltage drop across filter resistor R2308. Bias is applied to the thyratrons through grid return resistors R2306 and R2307. The thyratrons are a-c operated from regulated output voltage applied, through the coils of K2302 and K2303, from plate to cathode of each thyratron. V2301 draws current through the coil of K2302, and V2302 draws current through the coil of K2303.

The plate voltages of the two thyratrons are in phase. The grids are driven out of phase through the center-tapped secondary of T2304. If the grid voltage is in phase with the plate voltage, the thyratron will fire. It will not fire if the grid voltage is out of phase with the plate voltage. Because the grids are driven out of phase with respect to each other, only one grid will fire upon application of the T2304 output voltage. Exactly which grid will fire depends on the phase of the T2304 output, which in turn depends on whether the regulated output voltage is above or below 115 volts. Thus one or the other tubes will fire, operating the associated plate relay, to make the motor run in the direction required to return output voltage to 115 volts.

The magnitude of T2304 output voltage which will cause a thyratron to fire depends on the bias voltage in the thyratron grid circuit. The sensitivity of the thyratrons to T2304 output voltage is controlled, by means of SENSITIVITY control R2303, so that there is a very small range of regulated output voltage change over which the thyratrons will not fire. This range is obtained by backing R2303 down to just below the point where hunting occurs.

The relays are shunted by capacitors C2305, for K2302, and C2306, for K2303, to bypass the a-c ripple which results because of the half-wave rectification of the thyratrons. This bypassing holds the relay closed through the nonconducting half of the supply cycle and thus reduces relay chatter.

The line meter, M2301, is connected to either the regulator input line or output line by means of switch S2304. Input power is applied either through the regulator to the output terminals, directly to the output terminals, or turned off by means of three-position switch S2303. A thermal circuit breaker, K2301, protects the regulator and the timer against current overloads in excess of 20 amperes. The control circuits of the regulator are protected by fuse F2302. The POWER ON indicator lamp, at the input to the control unit, indicates the application of power from the regulator output line, through F2302, to the control unit. The filaments for the two thyratrons are connected in series so that if either filament opens up both thyratrons will be disabled. This prevents the regulator from controlling in one direction only.

This heater connection has the additional advantage of providing a midvoltage point for the return of the full-wave diode rectifier circuit which develops bias voltage. This point is the effective ground point of the control circuit. Terminal 4 of T2303 cannot be used for this return point because it is at the electrical center between terminals 3 and 5, and the bias voltage is developed from the higher voltage output across terminals 3 and 6.

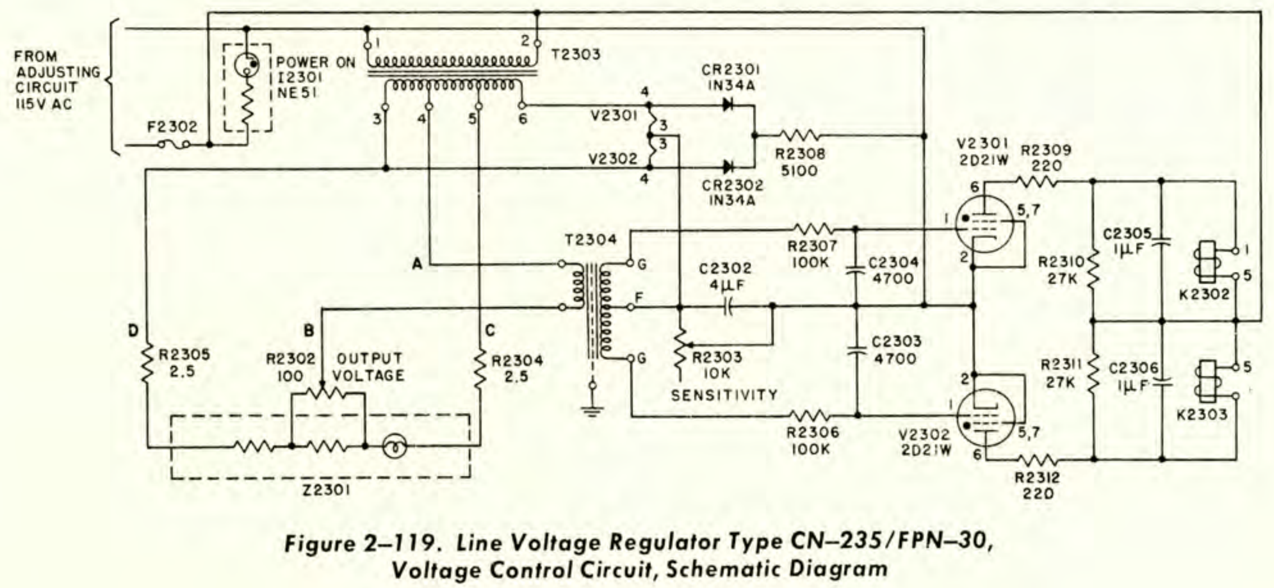


Figure 2–119. Line Voltage Regulator Type CN–235/FPN–30, Voltage Control Circuit, Schematic Diagram

5. CONCLUSION.

(*Refer to figure 2–120.*)

To review the functional arrangement of Loran Timer Set AN/FPN–30, and to show, in retrospect, how the circuits fit together, this concluding paragraph describes the Circuit Block Diagram. Italicized references are to circuits within the timer units. Only active timer circuits are shown in this diagram; power connections and the circuits of Test Oscilloscope OS–39/FPN–30 and Recording Ammeter ME–84/FPN–30 are not shown.

a. BASIC TIMING SIGNAL.—The basic timing signal, which is used in all active timer circuits, is the 100-kc signal developed in the r-f oscillator. Oscillator output is fed to the sync control unit, and the oscillator frequency may be varied over a narrow range (for correction purposes at a slave station only) by means of the FREQUENCY CORRECTOR capacitor in the sync control unit.

b. SYNC CONTROL.—The phase and frequency of the 100-kc timing signal is controlled (for correction purposes at a slave station only) by circuits of the sync control unit and the electrical synchronizer. At a master station the sync control unit is used, with the electrical synchronizer, as an automatic monitor of system timing.

The basic path of the 100-kc signal is through the *phase shift driver, phase shifter, 100-kc amplifier, tuned amplifier,* and *cathode follower.* This circuit permits the phase of the 100-kc signal to be changed continuously over a 360° range. Continuous phase shifting, over as many cycles as necessary, permits the slave station to adjust the phase of its transmitted signal, with respect to the occurrence time of the master signal, to maintain synchronization. (A coarse method of adjusting synchronization is also provided by the drift circuit in the frequency divider.)

The *tuned amplifier,* in this basic path, provides a limiting action which helps maintain the 100-kc timing signal at constant amplitude. The *phase shifter* is eliminated from the basic path at a master station so that the phase of the oscillator output signal is held constant.

The 100-kc signal is also fed, from the *tuned amplifier,* through a *transmitter phase shifter* and *cathode follower.* The *transmitter phase shifter* permits phase adjustment of the 100-kc signal fed to the transmitter so that the phase of the r-f cycles may be adjusted with respect to the pulse envelope.

In addition to the 100-kc signal path circuits, the sync control unit contains a sync control *motor and gear train,* which is powered through a *60-cycle amplifier and cathode follower* and a *motor amplifier.* The 60-cycle voltage fed to the motor is developed in the electrical synchronizer and is used to maintain synchronization at a slave station or to monitor synchronization at a master station. The synchronizer arrangement is a servo system. The motor drives the *frequency corrector* capacitor, the *phase shifter,* a *delay control,* a potentiometer which develops *error voltage for recorder drive,* a *sync error* cam, and a *feedback generator.*

At a slave station the *phase shifter* and *frequency corrector* capacitor are used to control the timing of the 100-kc signal. At a master station the 100-kc signal timing is controlled solely by the r-f oscillator, and the above controls are disconnected. Instead the *sync error* cam and the *delay control* are brought into service for monitoring synchronization. The potentiometer which develops *error voltage for recorder drive* is used at both a master and slave station to operate the center pen of the recording ammeter. The *feedback generator* is used as an anti-hunt device to stabilize the synchronization servo-system.

c. FREQUENCY DIVISION.—The 100-kc timing signal is divided (and multiplied) in frequency to provide timing markers and to provide the basic loran repetition interval. Circuits of the frequency divider multiply the 100-kc signal to 1 mc to form 1-microsecond markers, shape the signal to form 10-microsecond markers, and divide the signal decimally to form 100- and 1,000-microsecond markers. Additional frequency division provides a repetition interval of either 30,000, 40,000, or 50,000 microseconds to provide the three basic loran rates. Specific rates are derived from the basic rates by changing the rate of the division by relatively small amounts.

The 100-kc signal is fed to the *10 μsec blocking oscillator* where it is shaped into 10's. The 10's are used to drive the *1 μsec generator ckt* to form 1's and are also used to drive *counter 1. Counter 1* provides one output pulse for every ten input pulses and thus divides by 10 to provide pulses at 100-microsecond intervals. These pulses are shaped in the *100 μsec marker generator and ampl ckt* to form 100's. The output of *counter 1* is used to drive *counter 2,* also a decimal counter, which in turn drives the *1000 μsec marker generator and ampl ckt. Counter 2* also drives *counter 3. Counter 3* divides by factors of 15, 20, or 25, to provide the high, low, and slow basic rates, respectively. The output of counter 3 passes through the *preset 1 ckt* and *preset 2 ckt* to the *square wave generator.*

The *square wave generator* provides additional frequency division, by a factor of two, and drives a *square wave amplifier.* The output of this amplifier is the square wave (the fundamental repetition interval) and is used as a trigger in the time delay unit and to separate the master and slave traces in the timer oscilloscopes. The square wave is also fed to the SLOW SCOPE *pedestal, trace separation and marker ckt.* This latter circuit mixes the pedestal (fed from the VIDEO SCOPE sweep circuits in the synchronization indicator) with 1000's and the square-wave separation voltage to provide the basic presentation (minus the signal) of the SLOW SCOPE. The output of preset 2 is also used to trigger the *slow scope sweep ckt,* which provides the sweep voltage for the SLOW SCOPE.

The total division factor of the three counters may be modified by a feedback arrangement to provide different loran rates. Feedback from the *preset 2 ckt,* via the *basic rate switch,* is applied to various stages of *counter 3* to modify the division factor of counter 3 for different basic rates and is also applied, via the *specific rate sw ckt,* to *counter 2.* Feedback from the preset 1 circuit, via the *specific rate sw ckt,* is fed to various stages of *counter 1* to change its division factor (only once per counter 3 output pulse) for different specific rates.

Another arrangement is provided for modifying the division factors (temporarily) to permit a coarse change in phase (drift) of the local signal. This arrangement uses the left-right drift circuits to raise or lower the timer repetition rate by a small or large amount. This change in rate permits either left or right drift at a slow or fast rate. The circuits which control the rate of drift are the *left-right divider ckt* and the *left-right ampl and delay diode.* Left drift is accomplished through the *left ampl and control ckt* and right drift through the *right blocking osc and control ckt.*

d. TIME DELAY.—Delay circuits, in the time delay unit, develop the reference delay to establish the basic control of phase relationship between master and slave signals. Outputs are developed which control the timing of the local transmitted signal and which correspond to the time when the remote signal should be received. In addition a blanking voltage is developed for use during the time that the local signal is being transmitted.

The reference delay is the difference between the A delay and the B delay. The A delay is established by triggering the *A1000 delay* phantastron with the differentiated leading edge of the positive half of square wave ϕ 1, using the continuously variable phantastron delay to select a particular 1,000-microsecond marker, and using that 1,000 to select the next occurring 10-microsecond marker in the *A10 push up* circuit. Similarly the B delay is established by triggering the *B1000* delay phantastron with the differentiated leading edge of the positive half of square wave ϕ 2 (spaced exactly one-half the loran repetition interval from the positive half of square wave ϕ 1). The B-delay circuit includes the *B100 delay* and the *B10 delay* as well as the optional *B continuous delay* so that any desired delay may be obtained, not just a delay in steps of 1,000 microseconds, as is the case with the A-delay circuit.

The outputs of the A- and B-delay circuits are the A and B triggers. At a slave station the B trigger is used to fire the *transmitter trigger generator* and at a master station the A trigger is used for that purpose. Triggers are also developed in the A- and B-delay circuits by application to the *blanking pulse generator.* The desired triggers are selected by the *master or slave selector sw ckt.* A and B triggers are fed to the *mixer and trigger generator* and the mixed trigger output is used to trigger the VIDEO SCOPE and RF SCOPE sweep circuits and synchronizer circuits.

The delay provided by the B-delay circuit is controlled by a set of potentiometers (one potentiometer for each delay, that is, B1000, B100, B10, and B continuous) and five separate sets of potentiometers are provided (the B-continuous potentiometer is common for all five sets) so that a choice of any five preset B delays may be used. This arrangement is the *B preset delay control ckt* and permits the coding delay to be changed rapidly.

The *blink ckt* permits the time position of the local signal to be changed, cyclically, for signaling that the station is having operational difficulty.

e. RECEIVER.—The radio receiver amplifies the outputs of the local and remote signal channels fed from the switching equipment. In addition to the detected video signals, the receiver also supplies an undetected r-f signal and the first and second derivatives of the video signal. The local and remote output signals of the receiver are equalized to have identical amplitudes.

The strong local signal is attenuated in the *local attenuator* and mixed with the weaker remote signal at the output of the electronic switch. The sensitive remote channel is disabled, during transmission of the local signal, by a blanking voltage fed to the *attenuator bias driver and diff gain amplifier* and the *attenuator clamp.* The signal is passed through an *r-f amplifier* and fed to the *r-f cathode follower and video detector.* The undetected r-f signal is fed to the synchronization indicator for presentation on the RF SCOPE.

The detected signal is fed to a *video limiter and cath follower* and to a second *cath follower.* The video limiter is an optional circuit which may be used to remove noise peaks; it affects the detected signal fed to both cathode followers. One cathode follower feeds video signal to the SLOW SCOPE and VIDEO SCOPE of the synchronization indicator. The output of the other cathode follower goes to the *first differentiator and cath follower.* The output of the first differentiator is the first derivative. It is fed to an alarm circuit in the electrical synchronizer and is also fed to the *first derivative inverter and cath follower.* The second derivative is developed in the *second differentiator and cath follower* and fed to the VIDEO SCOPE in the synchronization indicator and also to the electrical synchronizer.

f. SIGNAL PRESENTATION.—The loran signals are presented on oscilloscopes of the synchronization indicator. Three oscilloscopes, using sweep speeds of different durations, are used to provide the over-all as well as the detailed picture of signal time relationships.

The SLOW SCOPE provides the over-all picture; the presentation bears a direct relationship to the square wave. The upper (master) trace of the SLOW SCOPE corresponds in time to the positive half of square wave ϕ 1. The lower (slave) trace corresponds in time to the positive half of square wave ϕ 2. The sweep and time marker circuits of the SLOW SCOPE are in the frequency divider and were discussed in paragraph 5 *c* preceding. The video signal is fed to the *slow scope* cathode-ray tube through the *slow scope video ampl.*

The VIDEO SCOPE provides a detailed picture used to establish accurate time relationships. Either the video signal or second derivative may be presented on this scope by selection through *signal selector sw and ampl.* Markers may be introduced through the *marker ampl and mixer ckt* and the *rec-cal switch.* Signal also passes through this switch so that signal may be removed and only markers presented. Signal is amplified in the *video ampl* and fed to the *video scope* cathode-ray tube. The sweep deflection circuits consist of an optional *sweep delay,* the *sweep generator,* the sweep *paraphase amplifier,* and the *intensifier and pedestal ckt.* This latter circuit provides trace intensification, during sweep, to make the trace visible and supplies the pedestal to the SLOW SCOPE. Trace separation is accomplished through the *square-wave amplifier and video sweep separation circuit.*

The RF SCOPE provides an even more detailed picture than the VIDEO SCOPE. The r-f signal is displayed on this scope and the sweep speeds have therefore been proportioned to permit r-f cycles to be seen. The r-f presentation may be found advantageous under noisy conditions, and it also permits the eventuality of cycle matching. The circuit arrangement of the RF SCOPE is very similar to that of the VIDEO SCOPE described above.

g. AUTOMATIC SYNCHRONIZATION. — The timer incorporates a servo system which is used to maintain synchronization at a slave station and to monitor synchronization at a master station. This system consists of the sync control motor circuits, discussed in paragraph 5 *b,* above, and the electrical synchronizer. The electrical synchronizer uses a balanced circuit which relies upon the coincidence of the local and remote signals with a pair of gate pulses to develop an error voltage. The error voltage is of such a nature that it will cause the sync control motor to turn in the proper direction to correct any detected error. At a slave station this action corrects the error; at a master station this action serves to indicate the error instead of correcting it.

The synchronizer uses the second derivative of the video signal because this derivative contains a zero voltage point, convenient for time reference, which is not affected by changes in signal amplitude. The second derivatives of both local and remote stations are fed to the *2nd derivative amplifier* and mixed with the pair of gates in a *mixer.* The gates are developed from the mixed triggers (A- and B-timing pulses) by obtaining a delayed pulse which is made to occur at the correct time of the first zero cross-over point of the second derivative. This pulse is the gate and is obtained from the *delay ckt* and the *gate generator and cath follower.* Gate delay (with respect to the A and B triggers) is the same for both gates at a slave station but is independently variable for each gate at a master station. Separate gate delay at a master station is obtained by applying square-wave voltage, to separate the operation into loran half-cycles, through the *square-wave amplifier and diode* to the *delay control and master-slave sw.* The gates are separated, so that one gate is effective only for the local derivative and the other only for the remote derivative, by the *square-wave amplifier, gate separator,* and *gate clamp* and applied to the *mixer.* Gate destination is changed, for master and slave operation, through the *master slave switch.*

The outputs from local and remote sections of the mixer are fed to a *sync charging diode,* which stores the output pulses to provide two d-c voltages which vary with changes in signal coincidence. These d-c voltages are applied to the *a-c error generator* so that no a-c voltage results if the pulses are coincident, an a-c error voltage of one phase exists if the local signal is lagging the remote signal, and an a-c error voltage of opposite phase exists if the local signal is leading the remote signal. This error voltage is fed to the sync control unit via an *a-c error amplifier.* The error voltage is also used in a sync error alarm circuit.

The sync error alarm circuit operates alarm indicators if sync error exceeds a preset amount. Error voltage is converted to dc in the *a-c rectifier* and fed to the *sync error cath follower and alarm.* The alarm is a thyratron which fires when the rectified voltage exceeds a preset amount. The thyratron controls indicators of the *alarm ckt.*

The synchronizer also has an off sync alarm circuit. This circuit depends upon lack of coincidence of the positive half of the remote first derivative with the remote gate to indicate large order synchronization abnormalities. The first derivative is fed to a *clipper and limiter* which selects a portion of the positive half of the first derivative and feeds it to the *alarm mixer.* The remote gate is also fed to this mixer so that the resulting output is a pulse which varies in amplitude in accordance with coincidence or lack of coincidence of the remote gate with the positive half of the first derivative. This pulse is converted to a d-c voltage in the *alarm charging diode and ampl* and applied to the *off sync alarm.* This alarm is a thyratron which responds to changes in applied d-c voltage in the same way as the *sync error cathode follower and alarm* discussed above.

The synchronizer also has a *meter ampl and meter ckt* which is used for adjusting the sync error detection circuits for correct operation.

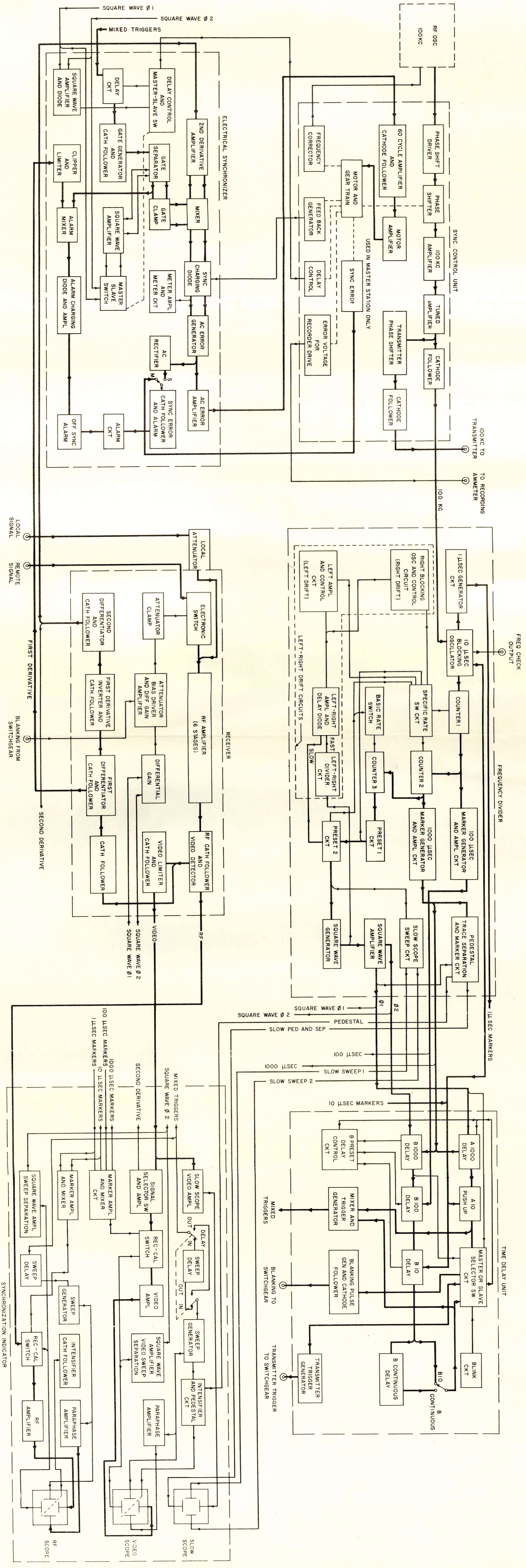


Figure 2-120. Loran Timer Set AN/FPN-30, Circuit Block Diagram

CG-273-15
(Volume 1)

INSTRUCTION BOOK

for

LORAN TIMER SET
AN/FPN-30

SECTION 3
INSTALLATION

ITT *Federal Division*

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

Clifton, New Jersey, U.S.A.

FORMERLY
FEDERAL TELEPHONE AND RADIO COMPANY

TREASURY DEPARTMENT
U.S. COAST GUARD

Contracts: Tcg-38701(CG-20,181-A)
Tcg-39263(CG-27,298-A)
Tcg-40020(CG-35,978-A)
Tcg-41083 (CG-44,327-A)

Approved by C. G. Headquarters:
16 October 1959

Installation
Section 3

Installation
Section 3

TABLE OF SECTIONS

SECTION 3
INSTALLATION AND INITIAL ADJUSTMENTS

1. SCOPE OF INSTRUCTIONS.

Figure 3–1 shows the relationship between the components of Loran Timer Set AN/FPN–30 and Loran Switching Equipment AN/FPA–2 in a typical loran station. Figure 3–2 shows a similar relationship between the components of Loran Timer Set AN/FPN–30 and Loran Switching Equipment Navy Model UM. In addition to the operating and stand-by timers, a typical loran station normally employs radio transmitters (not shown), a switching equipment (AN/FPA–2 or Navy Model UM), and other companion and accessory units. This section of the instruction book gives all the details necessary for the installation of the timer set, for interconnecting its components with each other and with the other units of the station, and for placing it into operation as an equipment unit. Problems of specific station layout, physical location of the timer set within the station, and installation and adjustment of units other than the timer set, are outside the scope of this book. For this information, refer to the instruction books supplied with the specific equipments involved.

2. PACKING INFORMATION.

a. GENERAL.—The major units of Loran Timer Set AN/FPN–30, namely, Electrical Equipment Cabinet CY–1437/FPN–30, Voltage Regulator CN–235/FPN–30, and Recording Ammeter ME–84/FPN–30, are packed in separate boxes or crates as listed in table 1–3. Accessory items, such as operator's table assembly components, including two support brackets, the table top with drawer, and mounting hardware, the duct support extension brackets with mounting hardware, plasticized drawings, instruction books, special tools supplied, cables and cable connectors are packaged within the crate containing the Electrical Equipment Cabinet CY–1437/FPN–30. Tools, materials, and equipments required for the installation but not supplied are listed in table 1–2. Note that the keying units and the WWV mixer units shown in figures 3–1 and 3–2 are not supplied as part of the timer set.

b. ELECTRICAL EQUIPMENT CABINET CY–1437/FPN–30.—Details of the packaging arrangement of the Electrical Equipment Cabinet CY–1437/FPN–30 are shown in figure 3–3. The cabinet with the drawer units installed and completely wired, with the strip heaters and ventilating blowers installed and interconnected, and with all tubes and other plug-in parts installed in their proper operating positions, is enclosed in a heat-sealed moistureproof plastic bag, and is packed in a wooden box. The operator's table assembly components, the ceiling brackets, the instruction books, and the plasticized drawings are included as separate packages within the wooden box. The special tools, cable connectors, mounting hardware, and other small parts supplied are contained within the operator's table drawer. Before sealing the moistureproof plastic bag, a part of the air is exhausted, and bags of silica gel are placed inside to absorb any moisture which may have remained in the bag. The plastic bags containing the other items listed above are similarly treated. The components are then placed in containers, within which they float on resilient packing material. The containers are then placed within a wooden shipping case, where they are held in position by means of cleats, blocks, braces, and straps. The shipping case is sealed at the joints with an asphalt compound against entry of water.

Note

> The packing precautions outlined above are taken to insure that little or no moisture accumulates within the inner box, described above.

c. EQUIPMENT SPARES.—The equipment spares are packed in metal cases. The covers of these cases are hinged so that they may be used as a permanent storage container. The equipment spares are protected from moisture by packing them in heat-sealed vaporproof packages containing suitable quantities of silica gel. The spare parts metal containers are not hermetically sealed, but are packed in wooden shipping containers.

3. PREPARATION FOR INSTALLATION.

Follow the instructions specified by local authority for the preparation of the station layout before attempting to unpack the equipment. In general, the following preparatory steps should be taken.

a. Determine the exact location of the timer set components with respect to the other units of the station.

b. In planning the positioning of the cabinet, clearance for opening the rear doors should be taken into account. Installation drawings, figures 3–4 through 3–6, show the clearances required for opening drawers and removing units.

c. In some cases it may be desirable to suspend extension rails from the ceiling for attachment to the duct support brackets supplied with the cabinet. Pertinent dimensions are given in figure 3–4. The extension rails may have to be predrilled or cut to accommodate the vertically adjustable ceiling brackets provided. The ceiling brackets are arranged to permit routing cable ducts between loran station units, if desired.

4. INSTALLATION OF CABINET.

Be certain that all boxes are kept upright, as indicated by the notation on the outside of the shipping containers. Observe the weight on each container, and make sure that appropriate lifting and transporting gear is used in handling the equipment without subjecting it to excessive shock or damage.

CAUTION

A nail puller should be used to remove nails. Do not use a pinch bar or claw hammer, unless instructions specifically state that such a tool may be used.

a. UNPACKING.—The cabinet should be unpacked first. The box containing the cabinet should be brought as close to its final location as is practical before it is uncrated. To uncrate the cabinet, the procedure outlined below should be followed. Reference should also be made to figure 3–3 for details of the packing boxes. Italicized items in the following description may be located in figure 3–3.

(1) Remove all nails, on the perimeter of the packing case, which secure the top shroud of the type *E3* waterproof *barrier.* A claw hammer may be used for this operation.

(2) Remove shroud.

(3) Remove all *corner straps.*

(4) Remove *nails* securing top of crate to ends and sides.

(5) Remove *top* of crate as one assembly.

(6) Remove nails securing each *end piece* to each *side piece.*

(7) Remove nails securing ends to *base assembly.*

(8) Remove each *end piece.*

(9) Remove nails securing sides to *skid.*

(10) Remove sides.

(11) Remove the *barrier blanket* and *corrugated wrapper.*

(12) Remove the top *corrugated wrapper;* locate and remove the *instruction books* before discarding this wrapper.

(13) Cut the *linen tape* holding the *operator's table* and the box containing *connectors* and *cabinet hardware* and set these items aside.

(14) Cut and remove the *steel strapping* which holds the cabinet to the base assembly.

(15) Withdraw the two slide mounted units at the bottom of the cabinet by releasing the panel thumbscrews, unlatching the push-button catches, and pulling at the handles until the units slide as far forward as possible.

(16) Open the two doors at the back of the cabinet and remove the *eight nuts* used to hold the bottom of the cabinet to the base assembly.

(17) Close the two doors and restore the drawer units to their normal positions. Remove any remaining packing material at the top, sides, and ends of the cabinet.

(18) Lift the cabinet off the *base assembly* and pull the *base assembly* out from under the cabinet. Either of two methods may be used to do this, depending on facilities available at the installation site. One method is to jack up the base of the cabinet, as described in steps 19 through 22, and the other method is to hoist the top of the cabinet, as described in steps 23 through 25.

(19) To jack up the base of the cabinet, push at the front of the cabinet to make it tilt sufficiently so that a length of 2 x 4 (approximately 6 feet long) may be slipped under the front half of the cabinet. (This will require at least three men.) Similarly tilt the back of the cabinet and insert a second 2 x 4.

(20) Using lift jacks, at the four ends of the 2 x 4s, raise the cabinet off the skid. Pull the skid out from under the cabinet and make sure that no packing material, or other obstruction, remains under the cabinet.

(21) Set as many 2 x 4 strips as required under each 2 x 4 so that when the jacks are lowered as far as possible the jacks may be easily removed. Lower the jacks and set them aside.

(22) Using the same process of tilting the front and back as in step (19), above, remove the 2 x 4s, one at a time, until the unit is resting on the floor.

(23) To hoist the top of the cabinet off the *base assembly,* install the four eyebolts (packed in the box containing *connectors and cabinet hardware* removed in step (13) above) to permit attachment of a hoist cable.

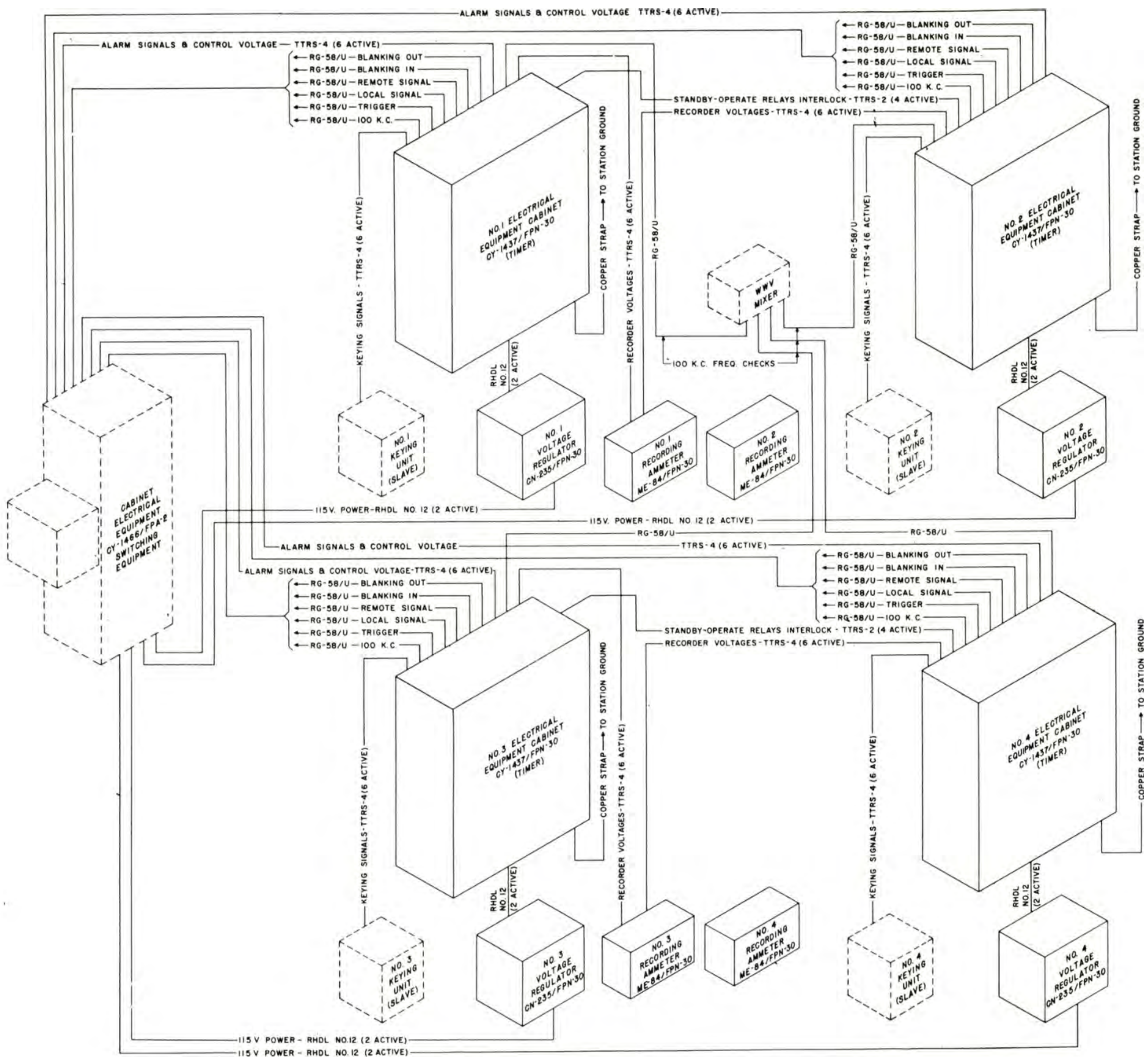
(24) Using a block and tackle, or other suitable hoist equipment, attach a hoist cable to the four eyebolts, being careful to distribute the pulling force evenly and in a vertical direction.

WARNING

Unless the pulling force is strictly vertical the frame may be badly distorted when the cabinet is hoisted. USE A SPREADER to prevent the pulling force from acting horizontally and forcing the eyebolts towards the center of the cabinet top.

(25) Lift the cabinet off the base assembly, remove the base assembly and all other possible obstructions from under the cabinet, and lower the cabinet to the floor.

b. MOUNTING.—Secure the cabinet to the floor, and in addition, optionally, to the ceiling by means of ceiling support extension rails. To mount the cabinet proceed as follows:



NOTES

1 NOTE THAT BOTH ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 (TIMERS) NOS. 1 & 2 ARE CONNECTED TO RECORDER NO. 1 IN PARALLEL AND THEREFORE THESE TWO SHOULD NOT BOTH BE SELECTED SIMULTANEOUSLY AS OPERATING TIMERS. WHEN ONE IS OPERATING, THE OTHER SHOULD BE STANDBY. SIMILARLY BOTH ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 (TIMERS) NOS. 3 & 4 ARE CONNECTED TO RECORDER NO. 3 AND SHOULD NOT BOTH BE SELECTED SIMULTANEOUSLY AS OPERATING. RECORDERS NOS. 2 & 4 ARE UNCONNECTED SPARES.
2 AT A SINGLE PULSED STATION ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 NOS. 3 & 4, RECORDERS NOS. 3 & 4, AND KEYING UNITS NOS. 3 & 4 WILL NOT BE USED.
3 COMPLETE SYSTEM IS NOT SHOWN, ONLY CONNECTIONS TO AN/FPN-30 EQUIPMENT SHOWN.
4 THE RECORDERS AND REGULATORS ARE DESIGNED TO MOUNT IN STANDARD 19 INCH WIDE RACKS, OR USING ADAPTERS WHICH ARE SUPPLIED, IN 24 INCH WIDE RACKS. RACKS ARE NOT SUPPLIED AS PART OF LORAN TIMER SET AN/FPN-30.
5 THE UNITS DRAWN IN DASHED LINES ARE NOT A PART OF LORAN TIMER SET AN/FPN-30.
6 TTRS-2 & TTRS-4 TYPE CABLES ARE PER MIL-C-915A (SHIPS) 30 JULY 1952
· RHDL NO. 12 TYPE CABLE IS PER FEDERAL GOVERNMENT SPECIFICATION J-C-103
7 INSTRUCTIONS REGARDING USE OF KEYING UNIT WILL BE ISSUED FOR SPECIFIC STATIONS.

FOR EACH LORAN TIMER SET AN/FPN-30
POWER-INPUT 115V 60~
ALLOWABLE VARIATION
VOLTAGE ±15%
FREQUENCY +5, -10 CPS
1260 VA 99% P.F. OPERATE
1260 VA 99% P.F. STANDBY
600 VA 99% P.F. INTERLOCKED POWER OFF, SPACE HEATER ON
HEAT DISSIPATION 1250 WATTS

TUBE COMPLEMENT FOR EACH LORAN TIMER SET AN/FPN-30

NO.	TYPE	NO.	TYPE	NO.	TYPE	NO.	TYPE	NO.	TYPE
1	OA2	1	3RP1	2	6AC7W	1	6Y6G	21	5726
1	OB2	2	5CP1A	2	6AG7	1	6V6GT/G	5	5749
2	1N34A	1	5RP2A	3	6005/6AQ5W	13	12AT7	83	5814
3	1N69	6	5R4WGY	7	6AS7G	4	5651	1	5933
6	2D21W	1	5Y3WGTA	11	6AU6	3	5654		
2	2X2A	4	6AC7	1	6CL6	11	5725		

REFERENCES

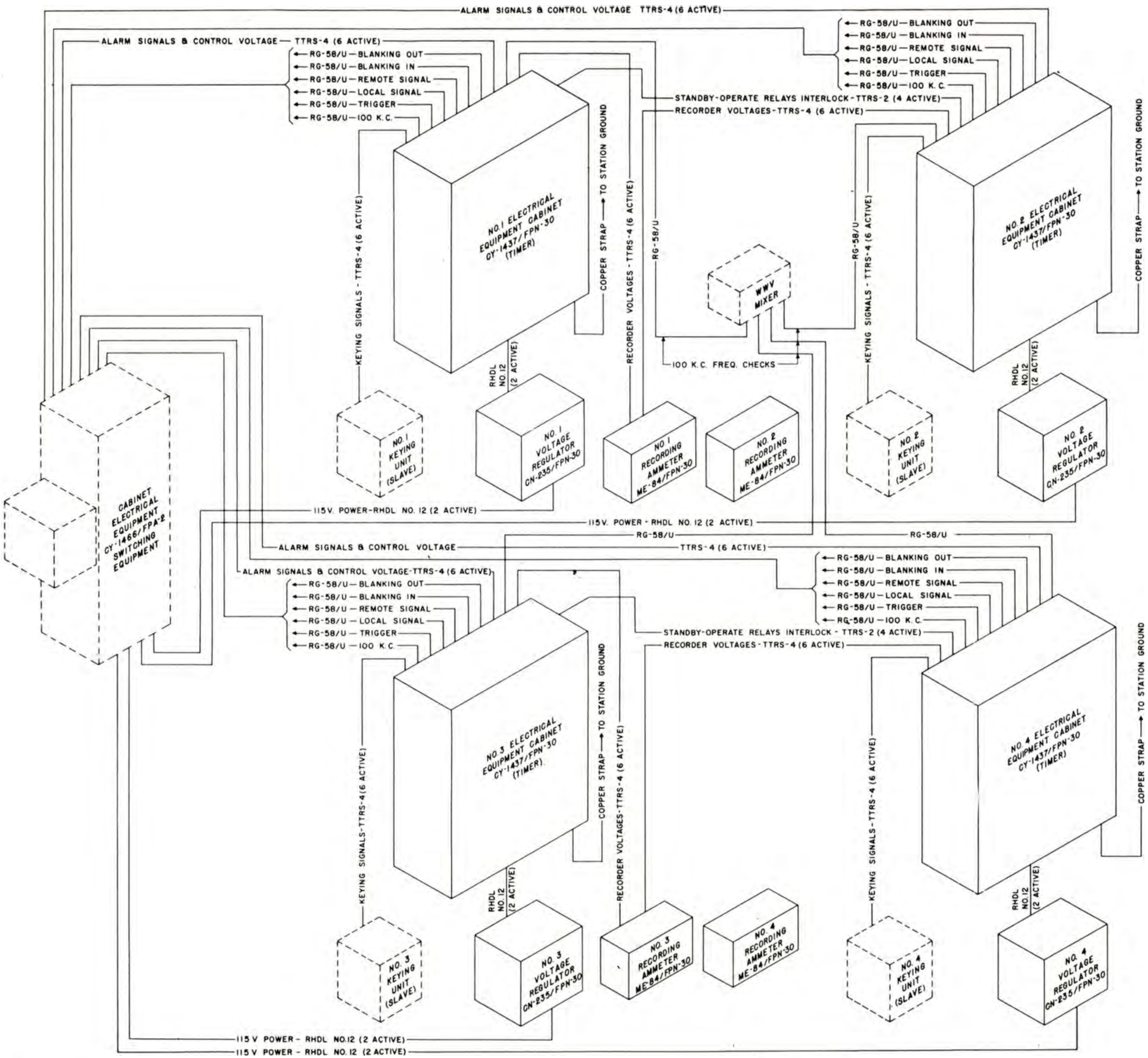
NO.	TITLE	FIGURE NO.
1	CABINET CY-1437/FPN-30 (TIMER) OUTLINE	3-4
2	RECORDING AMMETER ME-84/FPN-30 OUTLINE	3-7
3	VOLTAGE REGULATOR CN-235/FPN-30 OUTLINE	3-6
4	INTERCONNECTING AND CABLING DIAGRAM	3-8
5	INTERCONNECTION RUNNING SHEET	3-9
6	METHOD OF ASSEMBLING BNC+N CONNECTORS	3-12
7	METHOD OF ASSEMBLING UHF CONNECTORS	3-12

EQUIPMENT	UNCRATED WT.	CRATED WT.	OVERALL CRATED DIMENSIONS	CRATED CUBIC CONTENTS
TIMER	1400 LBS.	2100 LBS.	90"X 56"X 30"	87 1/2 CU. FT.
RECORDING AMMETER ME-84/FPN-30	36 LBS.	66 LBS.	29"X 28"X 18"	8 1/2 CU. FT.
VOLTAGE REGULATOR CN-235/FPN-30	100 LBS.	225 LBS.	32"X 28"X 26"	13 1/2 CU. FT.

MAINTENANCE PARTS BOXES

NO. BOXES	CRATED WEIGHT	DIMENSIONS UNCRATED	DIMENSIONS CRATED
2	150 LBS. EACH	42"X15"X 15"	46"X18 3/4"X17 3/4"

Figure 3–1. Pictorial System Diagram for Loran Timer Set AN/FPN–30 Used with Loran Switching Group AN/FPA–2



NOTES

1 NOTE THAT BOTH ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30(TIMERS) NOS. 1 & 2 ARE CONNECTED TO RECORDER NO. 1 IN PARALLEL AND THEREFORE THESE TWO SHOULD NOT BOTH BE SELECTED SIMULTANEOUSLY AS OPERATING TIMERS. WHEN ONE IS OPERATING, THE OTHER SHOULD BE STANDBY. SIMILARLY BOTH ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 (TIMERS) NOS. 3 & 4 ARE CONNECTED TO RECORDER NO. 3 AND SHOULD NOT BOTH BE SELECTED SIMULTANEOUSLY AS OPERATING. RECORDERS NOS. 2 & 4 ARE UNCONNECTED SPARES.
2 AT A SINGLE PULSED STATION ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 NOS. 3 & 4, RECORDERS NOS. 3 & 4, AND KEYING UNITS NOS. 3 & 4 WILL NOT BE USED.
3 COMPLETE SYSTEM IS NOT SHOWN, ONLY CONNECTIONS TO AN/FPN-30 EQUIPMENT SHOWN.
4 THE RECORDERS AND REGULATORS ARE DESIGNED TO MOUNT IN STANDARD 19 INCH WIDE RACKS, OR USING ADAPTERS WHICH ARE SUPPLIED, IN 24 INCH WIDE RACKS. RACKS ARE NOT SUPPLIED AS PART OF LORAN TIMER SET AN/FPN-30.
5 THE UNITS DRAWN IN DASHED LINES ARE NOT A PART OF LORAN TIMER SET AN/FPN-30.
6 TTRS-2 & TTRS-4 TYPE CABLES ARE PER MIL-C-915A (SHIPS) 30 JULY 1952 RHDL NO. 12 TYPE CABLE IS PER FEDERAL GOVERNMENT SPECIFICATION J-C-103
7 INSTRUCTIONS REGARDING USE OF KEYING UNIT WILL BE ISSUED FOR SPECIFIC STATIONS.

FOR EACH LORAN TIMER SET AN/FPN-30
POWER INPUT 115V 60~
ALLOWABLE VARIATION:
VOLTAGE ±15%
FREQUENCY +5, -10 CPS
1260 VA 99% P.F. OPERATE
1260 VA 99% P.F. STANDBY
600 VA 99% P.F. INTERLOCKED POWER OFF, SPACE HEATER ON
HEAT DISSIPATION 1250 WATTS

TUBE COMPLEMENT FOR EACH LORAN TIMER SET AN/FPN-30

NO.	TYPE	NO.	TYPE	NO.	TYPE	NO.	TYPE	NO.	TYPE
1	OA2	1	3RP1	2	6AC7W	1	6Y6G	21	5726
1	OB2	2	5CP1A	2	6AG7	1	6V6GT/G	5	5749
2	1N34A	1	5RP2A	3	6005/6AQ5W	13	12AT7	83	5814
3	1N69	6	5R4WGY	7	6AS7G	4	5651	1	5933
6	2D21W	1	5Y3WGTA	11	6AU6	3	5654		
2	2X2A	4	6AC7	1	6CL6	11	5725		

REFERENCES

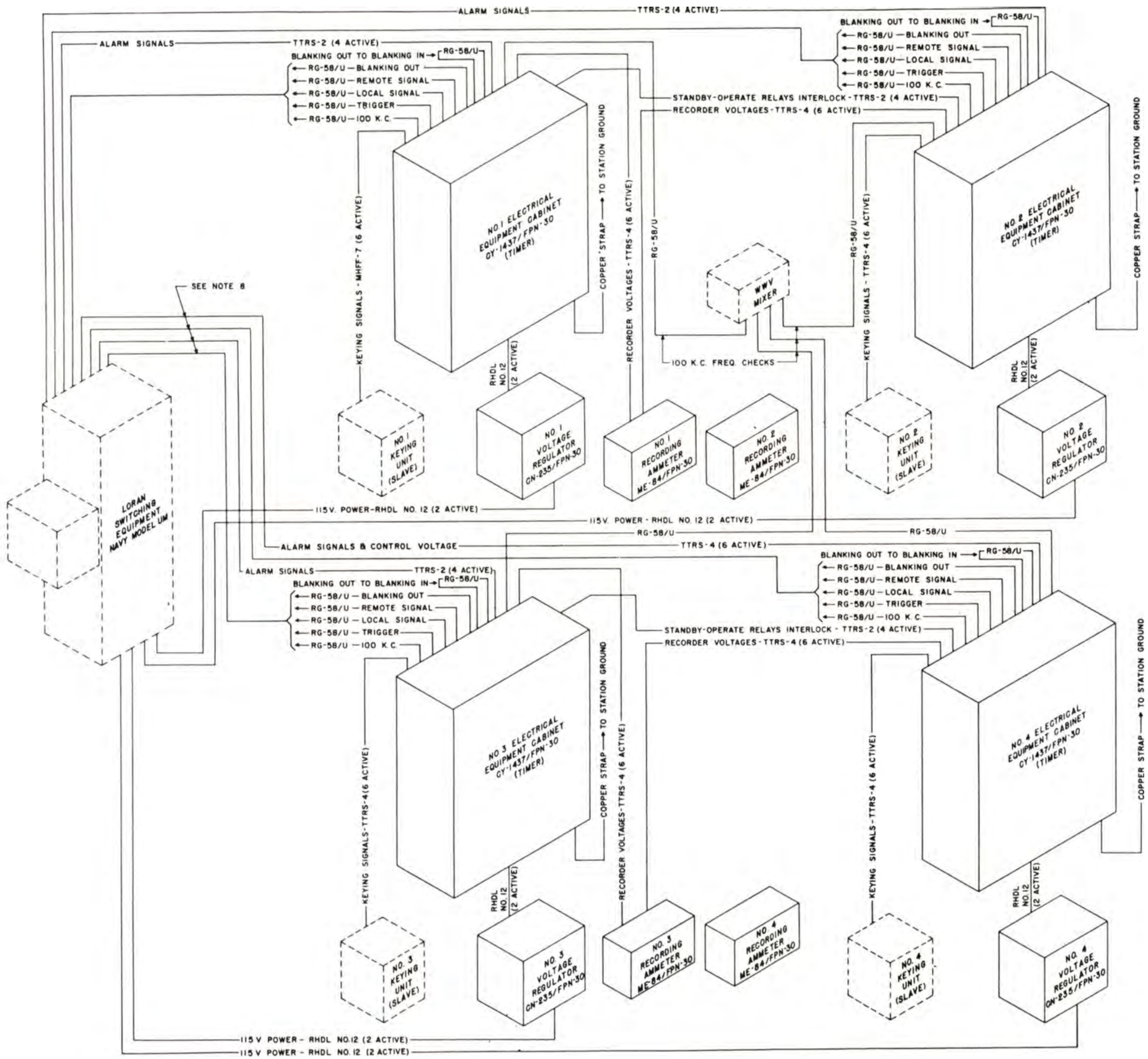
NO.	TITLE	FIGURE NO.
1	CABINET CY-1437/FPN-30 (TIMER) OUTLINE	3-4
2	RECORDING AMMETER ME-84/FPN-30 OUTLINE	3-7
3	VOLTAGE REGULATOR CN-235/FPN-30 OUTLINE	3-6
4	INTERCONNECTING AND CABLING DIAGRAM	3-8
5	INTERCONNECTION RUNNING SHEET	3-9
6	METHOD OF ASSEMBLING BNC+N CONNECTORS	3-12
7	METHOD OF ASSEMBLING UHF CONNECTORS	3-12

EQUIPMENT	UNCRATED WT.	CRATED WT.	OVERALL CRATED DIMENSIONS	CRATED CUBIC CONTENTS
TIMER	1400 LBS.	2100 LBS.	90"X 56"X 30"	87 1/2 CU. FT.
RECORDING AMMETER ME-84/FPN-30	36 LBS.	66 LBS.	29"X 28"X 18"	8 1/2 CU. FT.
VOLTAGE REGULATOR CN-235/FPN-30	100 LBS.	225 LBS.	32"X 28"X 26"	13 1/2 CU. FT.

MAINTENANCE PARTS BOXES

NO. BOXES	CRATED WEIGHT	DIMENSIONS UNCRATED	DIMENSIONS CRATED
2	150 LBS. EACH	42"X15"X 15"	46"X18 3/4"X17 3/4"

Figure 3–1. Pictorial System Diagram for Loran Timer Set AN/FPN–30 Used with Loran Switching Group AN/FPA–2



NOTES

1 NOTE THAT BOTH ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 (TIMERS) NOS. 1 & 2 ARE CONNECTED TO RECORDER NO. 1 IN PARALLEL AND THEREFORE THESE TWO SHOULD NOT BOTH BE SELECTED SIMULTANEOUSLY AS OPERATING TIMERS. WHEN ONE IS OPERATING, THE OTHER SHOULD BE STANDBY. SIMILARLY BOTH ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 (TIMERS) NOS. 3 & 4 ARE CONNECTED TO RECORDER NO. 3 AND SHOULD NOT BOTH BE SELECTED SIMULTANEOUSLY AS OPERATING. RECORDERS NOS. 2 & 4 ARE UNCONNECTED SPARES.
2 AT A SINGLE PULSED STATION ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 NOS. 3 & 4, RECORDERS NOS. 3 & 4, REGULATORS NOS. 3 & 4, AND KEYING UNITS NOS. 3 & 4 WILL NOT BE USED.
3 COMPLETE SYSTEM IS NOT SHOWN, ONLY CONNECTIONS TO AN/FPN-30 EQUIPMENT SHOWN.
4 THE RECORDERS AND REGULATORS ARE DESIGNED TO MOUNT IN STANDARD 19 INCH WIDE RACKS, OR USING ADAPTERS WHICH ARE SUPPLIED, IN 24 INCH WIDE RACKS. RACKS ARE NOT SUPPLIED AS PART OF LORAN TIMER SET AN/FPN-30.
5 THE UNITS DRAWN IN DASHED LINES ARE NOT A PART OF LORAN TIMER SET AN/FPN-30.
6 TTRS-2 & TTRS-4 TYPE CABLES ARE PER MIL-C-915A (SHIPS) 30 JULY 1952. RHDL NO. 12 TYPE CABLE IS PER FEDERAL GOVERNMENT SPECIFICATION J-C-103.
7 INSTRUCTIONS REGARDING USE OF KEYING UNIT WILL BE ISSUED FOR SPECIFIC STATIONS.
8 INSTALLING ACTIVITY SHALL PROVIDE LEAD THROUGH FACILITIES FOR REMOTE ALARM CABLES WHEN INSTALLED.

FOR EACH LORAN TIMER SET AN/FPN-30
POWER INPUT 115V 60~
ALLOWABLE VARIATION:
VOLTAGE ±15%
FREQUENCY +5, −10 CPS
1260 VA 99% P.F. OPERATE
1260 VA 99% P.F. STANDBY
600 VA 99% P.F. INTERLOCKED POWER OFF, SPACE HEATER ON
HEAT DISSIPATION 1250 WATTS

TUBE COMPLEMENT FOR EACH LORAN TIMER SET AN/FPN-30

NO.	TYPE	NO.	TYPE	NO.	TYPE	NO.	TYPE	NO.	TYPE
1	OA2	1	3RP1	2	6AC7W	1	6Y6G	21	5726
1	OB2	2	5CP1A	2	6AG7	1	6V6GT/G	5	5749
2	1N34A	1	5RP2A	3	6005/6AQ5W	13	12AT7	83	5814
3	1N69	6	5R4WGY	7	6AS7G	4	5651	1	5933
6	2D21W	1	5Y3WGTA	11	6AU6	3	5654		
2	2X2A	4	6AC7	1	6CL6	11	5725		

REFERENCES

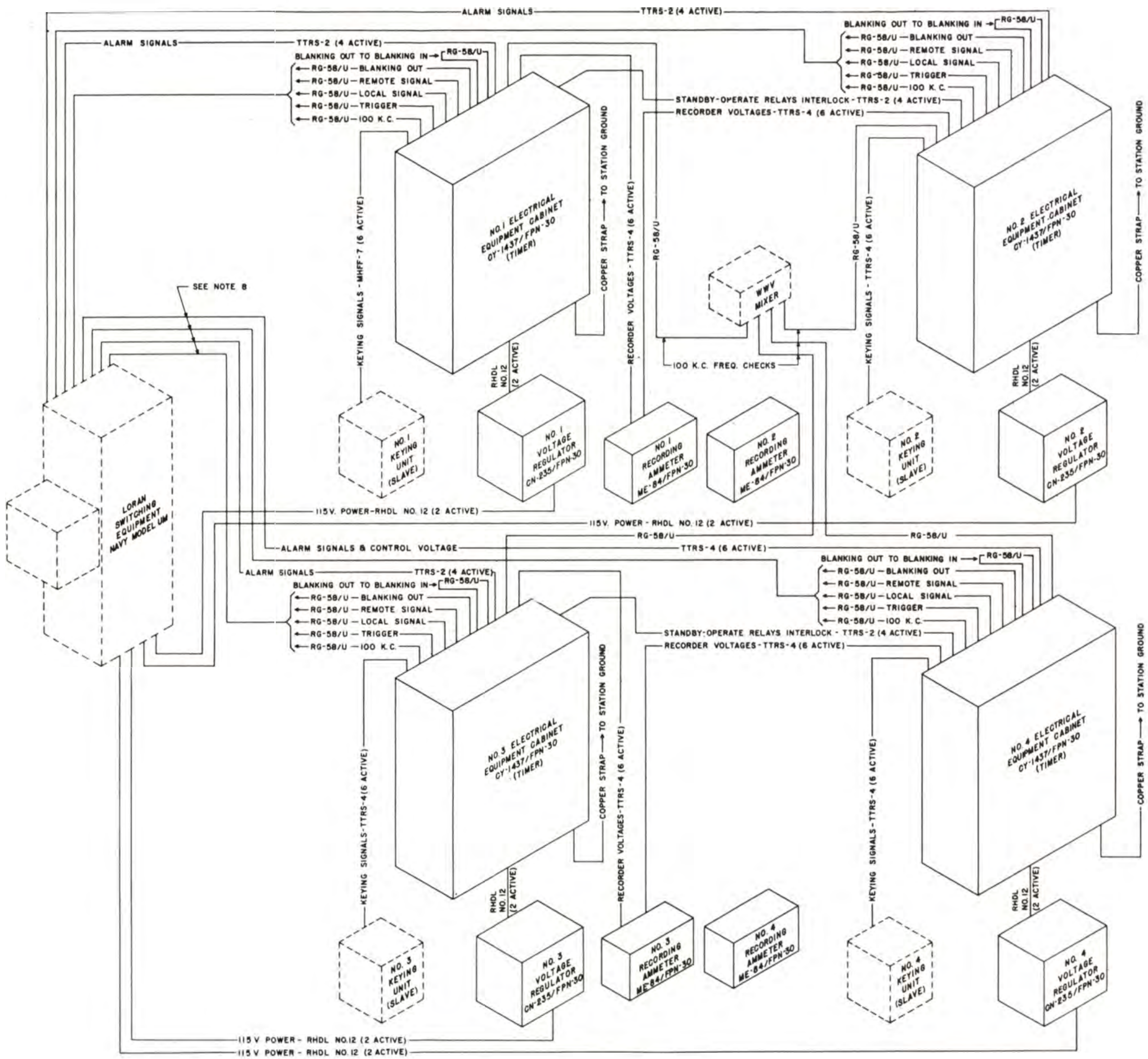
NO.	TITLE	FIGURE NO.
1	CABINET CY-1437/FPN-30 (TIMER) OUTLINE	3-4
2	RECORDING AMMETER ME-84/FPN-30 OUTLINE	3-7
3	VOLTAGE REGULATOR CN-235/FPN-30 OUTLINE	3-6
4	INTERCONNECTING AND CABLING DIAGRAM	3-10
5	INTERCONNECTION RUNNING SHEET	3-11
6	METHOD OF ASSEMBLING BNC+N CONNECTORS	3-12
7	METHOD OF ASSEMBLING UHF CONNECTORS	

EQUIPMENT	UNCRATED WT.	CRATED WT.	OVERALL CRATED DIMENSIONS	CRATED CUBIC CONTENTS
TIMER	1400 LBS.	2100 LBS.	90"X56"X30"	87 1/2 CU. FT.
RECORDING AMMETER ME-84/FPN-30	36 LBS.	66 LBS.	29"X28"X18"	8 1/2 CU. FT.
VOLTAGE REGULATOR CN-235/FPN-30	100 LBS.	225 LBS.	32"X28"X26"	13 1/2 CU. FT.

MAINTENANCE PARTS BOXES

NO. BOXES	CRATED WEIGHT	DIMENSIONS UNCRATED	DIMENSIONS CRATED
2	150 LBS. EACH	42"X15"X15"	46"X18 3/4"X17 3/4"

Figure 3–2. Pictorial System Diagram for Loran Timer Set AN/FPN–30 Used with Loran Switching Equipment Navy Model UM



NOTES

1 NOTE THAT BOTH ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 (TIMERS) NOS. 1 & 2 ARE CONNECTED TO RECORDER NO. 1 IN PARALLEL AND THEREFORE THESE TWO SHOULD NOT BOTH BE SELECTED SIMULTANEOUSLY AS OPERATING TIMERS. WHEN ONE IS OPERATING, THE OTHER SHOULD BE STANDBY. SIMILARLY BOTH ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 (TIMERS) NOS. 3 & 4 ARE CONNECTED TO RECORDER NO. 3 AND SHOULD NOT BOTH BE SELECTED SIMULTANEOUSLY AS OPERATING. RECORDERS NOS. 2 & 4 ARE UNCONNECTED SPARES.
2 AT A SINGLE PULSED STATION ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 NOS. 3 & 4, RECORDERS NOS. 3 & 4, REGULATORS NOS. 3 & 4, AND KEYING UNITS NOS. 3 & 4 WILL NOT BE USED.
3 COMPLETE SYSTEM IS NOT SHOWN, ONLY CONNECTIONS TO AN/FPN-30 EQUIPMENT SHOWN.
4 THE RECORDERS AND REGULATORS ARE DESIGNED TO MOUNT IN STANDARD 19 INCH WIDE RACKS, OR USING ADAPTERS WHICH ARE SUPPLIED, IN 24 INCH WIDE RACKS. RACKS ARE NOT SUPPLIED AS PART OF LORAN TIMER SET AN/FPN-30.
5 THE UNITS DRAWN IN DASHED LINES ARE NOT A PART OF LORAN TIMER SET AN/FPN-30.
6 TTRS-2 & TTRS-4 TYPE CABLES ARE PER MIL-C-915A (SHIPS) 30 JULY 1952 RHDL NO. 12 TYPE CABLE IS PER FEDERAL GOVERNMENT SPECIFICATION J-C-103
7 INSTRUCTIONS REGARDING USE OF KEYING UNIT WILL BE ISSUED FOR SPECIFIC STATIONS.
8 INSTALLING ACTIVITY SHALL PROVIDE LEAD THROUGH FACILITIES FOR REMOTE ALARM CABLES WHEN INSTALLED.

FOR EACH LORAN TIMER SET AN/FPN-30
POWER INPUT 115V 60~
ALLOWABLE VARIATION:
VOLTAGE ±15%
FREQUENCY +5, −10 CPS
1260 VA 99% P.F. OPERATE
1260 VA 99% P.F. STANDBY
600 VA 99% P.F. INTERLOCKED POWER OFF, SPACE HEATER ON
HEAT DISSIPATION 1250 WATTS

TUBE COMPLEMENT FOR EACH LORAN TIMER SET AN/FPN-30

NO.	TYPE	NO.	TYPE	NO.	TYPE	NO.	TYPE	NO.	TYPE
1	OA2	1	3RP1	2	6AC7W	1	6Y6G	21	5726
1	OB2	2	5CP1A	2	6AG7	1	6V6GT/G	5	5749
2	IN34A	1	5RP2A	3	6005/6AQ5W	13	12AT7	83	5814
3	IN69	6	5R4WGY	7	6AS7G	4	5651	1	5933
6	2D21W	1	5Y3WGTA	11	6AU6	3	5654		
2	2X2A	4	6AC7	1	6CL6	11	5725		

REFERENCES

NO.	TITLE	FIGURE NO.
1	CABINET CY-1437/FPN-30 (TIMER) OUTLINE	3-4
2	RECORDING AMMETER ME-84/FPN-30 OUTLINE	3-7
3	VOLTAGE REGULATOR CN-235/FPN-30 OUTLINE	3-6
4	INTERCONNECTING AND CABLING DIAGRAM	3-10
5	INTERCONNECTION RUNNING SHEET	3-11
6	METHOD OF ASSEMBLING BNC+N CONNECTORS	3-12
7	METHOD OF ASSEMBLING UHF CONNECTORS	3-12

EQUIPMENT	UNCRATED WT.	CRATED WT.	OVERALL CRATED DIMENSIONS	CRATED CUBIC CONTENTS
TIMER	1400 LBS.	2100 LBS.	90" X 56" X 30"	87 1/2 CU. FT.
RECORDING AMMETER ME-84/FPN-30	36 LBS.	66 LBS.	29" X 28" X 18"	8 1/2 CU. FT.
VOLTAGE REGULATOR CN-235/FPN-30	100 LBS.	225 LBS.	32" X 28" X 26"	13 1/2 CU. FT.

MAINTENANCE PARTS BOXES

NO. BOXES	CRATED WEIGHT	DIMENSIONS UNCRATED	DIMENSIONS CRATED
2	150 LBS. EACH	42" X 15" X 15"	46" X 18 3/4" X 17 3/4"

Figure 3–2. Pictorial System Diagram for Loran Timer Set AN/FPN–30 Used with Loran Switching Equipment Navy Model UM

(1) Open the doors of the cabinet to gain access to the eight mounting holes located on the bottom inside of the cabinet. Use heavy lag screws (or equivalent means) to secure the cabinet to the floor. Exercise caution not to damage parts and wiring inside the cabinet when driving the screws into the floor.

(2) Attach the angle brackets to the top sides of the cabinet, as shown in figure 3–4. If the extension brackets are to be used for ceiling support, extend the brackets, as necessary to line up with the mounting holes on the extension rails suspended from the ceiling, as indicated above.

(3) Use bolts, washers, and nuts to secure the angle brackets to the ceiling support extension rails, if the unit is to be supported.

c. FINAL UNPACKING AND INSPECTION.—After the cabinet has been positioned and mounted as outlined above, proceed to complete the unpacking and to inspect the unit for possible damage in shipment.

(1) Remove shoring, blocking, and bracing, from the interior of the cabinet, using a saw where applicable. Special care must be taken to prevent damage to the parts inside the cabinet during this operation.

(2) Remove any cord, tape, wire, etc., used to protect the equipment from damage during shipment.

(3) Make a careful detailed inspection of all mechanical and electrical connections, cables, terminal boards, for any damage possibly incurred during shipment.

(4) Remove the plasticized drawings and store them in the pocket mounted on the side of the cabinet.

(5) Inspect the cabinet carefully and locate all wire and tape lashing.

5. INSPECTION OF DRAWER UNITS: MOUNTING ARRANGEMENTS.

Each drawer unit in the timer cabinet is supported within the cabinet by channel rails, and is equipped with slide and latch mechanisms, one on each side, to permit the drawer to be opened and held in the opened position. Manual operation of the latch mechanisms permits the drawer to be removed from the cabinet. In addition, all drawers, except the synchronization indicator, the oscillator, and the three power supplies, are equipped with tilt mechanisms permitting the opened drawer to be tilted to an angle of about 90° and locked in that position for easy access to the bottom of the chassis. Figure 3–5 shows one of the drawers pulled out and tilted. Spring-operated panel catches and thumbscrews are used to keep the drawer in place when closed. Two thumb-operated push buttons near the front panel handles permit the catches to be released before the drawer is opened. The thumbscrews thread into metal plates attached to the framework of the cabinet itself. The arrangement of the slide-and-tilt mechanisms, and their adjustment to insure proper operation and proper fit of the drawer within the cabinet, is described in Section 7, paragraph 5 *a* (1).

CAUTION

The timer cabinet may tip over if several units are withdrawn when the cabinet is not fastened (or improperly fastened). Severe injury to personnel and damage to the equipment can result.

Inspect the contents of each drawer very carefully, to insure that no damage has occurred in shipment. Inspect electrical connections, cables, terminal boards, etc. In particular check that each tube is firmly seated in its socket, and that the tube shield, where applicable, is properly installed. Tube location charts are provided in Section 5, Operator's Maintenance. Use these charts to facilitate replacement of any tubes found to have been damaged in shipment.

6. INSTALLATION OF CATHODE-RAY TUBES.

The four cathode-ray tubes used in the timer have been packed with the box of tube spares and must be installed in the timer at this time. The mounting arrangement, for the three different tube types employed, is shown in figure 5–4.

WARNING

If power has already been applied to the timer, within the last 24 hours, discharge high voltage circuits in accordance with the instructions following the warning of Section 5, paragraph 2 *d*, before installing cathode-ray tubes.

a. INSTALLING THE 5RP2A.—The 5RP2A cathode-ray tube is used in the RF SCOPE of the synchronization indicator. Install as follows:

Step 1. Remove the four screws that attach the bezel to the front of the panel. When the four screws have been removed, the bezel, the clear plexiglass, and the filter plexiglass will fall away and expose the compartment in which the cathode-ray tube is to be mounted.

Step 2. Remove the 5RP2A from the packing case and insert the tube within the compartment formed by the magnetic metal shield. Pull the synchronization unit forward on its slides and swing the two subchassis aside (a procedure for this is given in the note in Section 7, paragraph 5 *g*). Remove the shield exposed when the subchassis were swung aside. Rotate the tube so that the tube terminal A lines up with the marking for terminal D on the magnetic shield. (If the markings cannot be read refer to figure 7–238.) Connect the appropriate lead to terminal A. Rotate the tube to bring tube terminal B in alignment with shield terminal D and connect the lead for terminal B. Continue in the same way, connecting leads to terminals E, C, and D. After terminal D has been connected, the tube will be in proper position for connecting the leads to terminals E, F, G, and H. Make the connections.

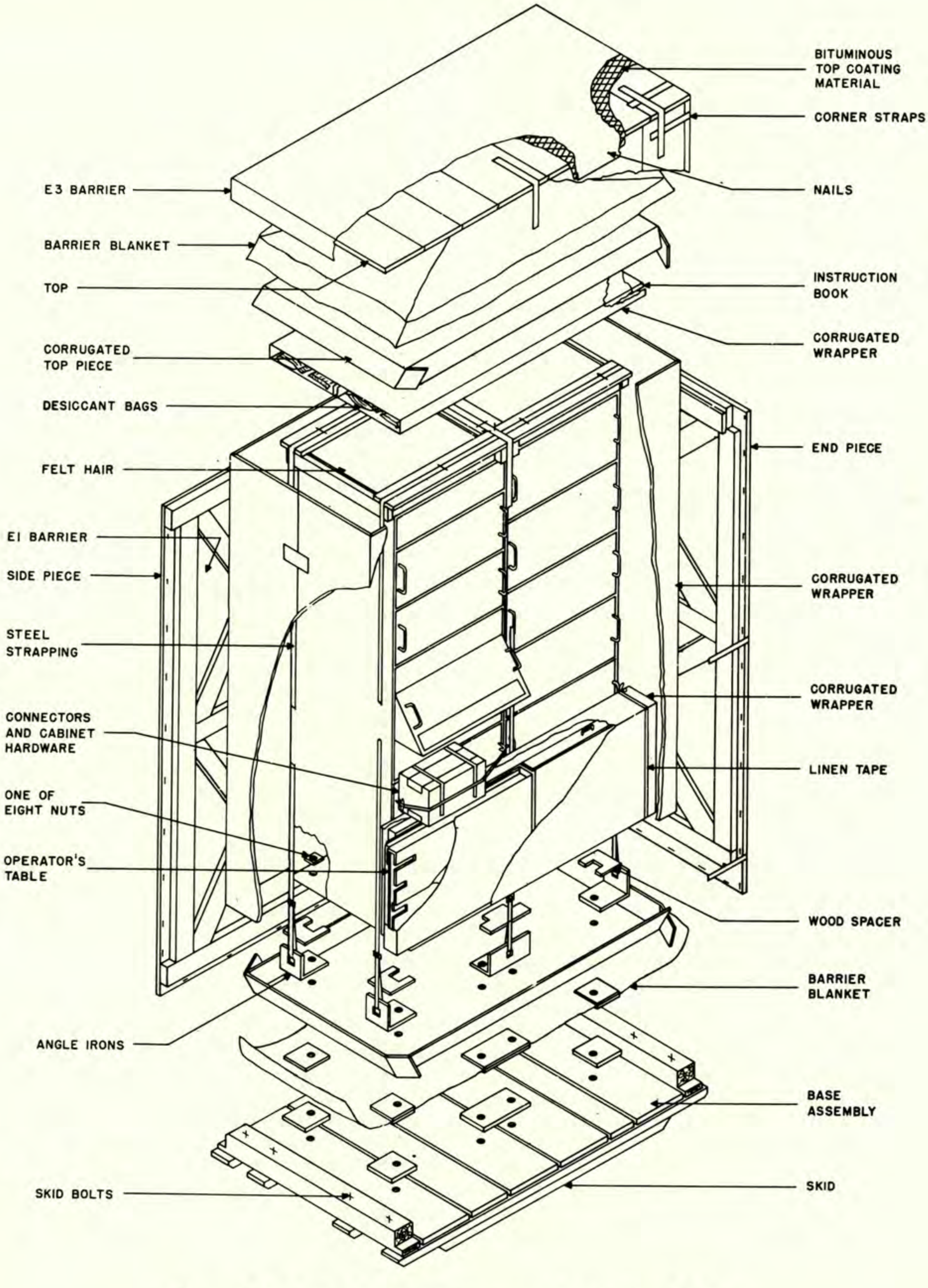


Figure 3–3. Typical Packing Arrangement for Electrical Cabinet CY–1437/FPN–30, Part of Loran Timer Set AN/FPN–30

Step 3. Note that a piece of sticky tape has been placed on the face of the cathode-ray tube to reference the position of the horizontal trace. Temporarily replace the bezel and two pieces of plexiglass removed in step 1. Position the tube with the face flush against the plexiglass and with the horizontal reference provided by the sticky tape parallel with the horizontal lines scribed on the plexiglass. Tighten the tube clamp which is located near the back of the tube. Push the tube socket onto the tube base. Remove the bezel and plexiglass, remove the sticky tape and clean the face of the tube, replace both pieces of plexiglass, the bezel, and all mounting screws. Install the light shield.

Note

Any slight error in aligning the horizontal reference line may be corrected, after the initial scope adjustments are made, by loosening the bezel screws and rotating the filter over the small range which is made possible through the use of slotted mounting holes.

b. INSTALLING THE 5CP1A.—The type 5CP1A cathode-ray tubes are used in both the synchronization indicator (VIDEO SCOPE)) and the test scope. Install a 5CP1A in each unit as follows:

Step 1. Remove the four screws that attach the bezel to the front of the panel. When the four screws have been removed, the bezel, the clear plexiglass, and the filter plexiglass will fall away and expose the compartment in which the cathode-ray tube is to be mounted.

Step 2. Remove the 5CP1A from the packing case and insert the tube in the compartment formed by the magnetic metal shield. Pull the drawer unit forward on its slides if it is not already out. Connect the high voltage lead for the second anode to the button on the side of the cathode-ray tube.

Step 3. Note that a piece of sticky tape has been placed on the face of the cathode-ray tube to reference the position of the horizontal trace. Temporarily replace the bezel and two pieces of plexiglass removed in step 1. Position the tube with the face flush against the plexiglass and with the horizontal reference provided by the sticky tape parallel with the horizontal lines scribed on the plexiglass. Tighten the tube clamp which is located near the back of the tube. Push the tube socket onto the tube base. Remove the bezel and plexiglass, remove the sticky tape and clean the face of the tube, replace both pieces of plexiglass, the bezel, and all mounting screws. Install the light shield.

Note

Any slight error in aligning the horizontal reference line may be corrected, after the initial scope adjustments are made, by loosening the bezel screws and rotating the filter over the small range, which is made possible through the use of slotted mounting holes.

c. INSTALLING THE 3RP1.—The 3RP1 cathode-ray tube is used in the SLOW SCOPE of the synchronization indicator. Install as follows:

Step 1. Remove the four screws at the corners of the rectangular bezel and pull the bezel away from the panel.

Step 2. Remove the 3RP1 from the packing case and insert the tube in the compartment formed by the magnetic shield.

Step 3. Temporarily replace the bezel and position the tube with the face flush against the plastic window in the bezel and with the horizontal reference line marked by a piece of sticky tape parallel with the horizontal borders of the bezel. Tighten the clamp which is located near the back of the tube and push the tube socket onto the tube base. Remove the bezel, remove the sticky tape and clean the face of the tube, replace the bezel, and replace all mounting screws.

Note

When all cathode-ray tubes have been installed, replace the shield on the synchronization indicator, swing the subchassis back into place, connect the control coupling and lock the thumbscrews, and restore the synchronization indicator and test scope drawers to their normal positions.

7. INSTALLATION OF OPERATOR'S TABLE.

The operator's table assembly consists of a table top with single drawer and two supporting brackets. The drawer, supported on the underside of the table top, is provided for storage of test leads, special small tools supplied with the equipment, and other small articles, as required. The supporting brackets are mounted at the sides of the cabinet by means of large hand knobs, three on each side. The table top rests on the supporting brackets and is retained in position by stop brackets at the rear and retaining pins on the top of the support brackets. Uncrate the box containing the operator's table assembly components and install as follows:

a. Loosen the three large hand knobs on each side of the cabinet.

b. Attach each one of the two supporting brackets. Note that the flat side of the bracket fits against the side of the cabinet. Fit the bracket over the hand knob shafts so that the large cutout in the supporting bracket fits over the two top knob shafts, and the lower small cutout fits over the lower single knob. When properly fitted, the notches in the bracket cutouts will rest on the knob shafts. Tighten the knobs.

c. Slide the table top over the two support brackets until the rear edge of the top fits snugly against the small stop brackets, one on each supporting bracket. Shift the top sideways slightly to insure that the retaining pins on each supporting bracket fit into the retaining holes under the corners of the table top. Lock the table top with the snap catches.

d. The stop brackets and the retaining pins on the support brackets are adjustable in position. If necessary, loosen the screws holding these items in place and shift slightly, as necessary to obtain proper fit of the table top.

Note

If the table top interferes with accessibility of adjustment controls or with opening the drawers on the lower portion of the timer cabinet, the table top only need be removed, and the support brackets may be left in place. To remove the table top, open the snap catches, and slide the top forward.

8. INSTALLATION OF VOLTAGE REGULATOR TYPE CN-235/FPN-30.

The voltage regulator is shipped as a complete assembly in its own shipping container. It is to be installed in some convenient location in the timer room. General factors to be considered, in positioning the unit, are accessibility for maintenance and service and the convenience to interconnecting ducts or trenchwork. After the shipping container is placed near the desired location, carefully uncrate the unit and inspect it for possible damage incurred in shipment. The procedure for uncrating is similar to that described in paragraph 3 *a.* One voltage regulator is required for each timer of the station. The unit is arranged for mounting on a 19-inch rack. Adapters are provided which make it possible to mount the unit on a 24-inch rack, if desired. Dimensional data and mounting details are given in figure 3-6. The rack is not supplied as part of the timer set.

9. INSTALLATION OF RECORDING AMMETER TYPE ME-84/FPN-30.

One Recording Ammeter Type ME-84/FPN-30 is supplied with each Timer Set AN/FPN-30. For each pair of timers (operating and stand-by) employed at the station, there are thus two recording ammeters. Only one of these instruments is to be installed and interconnected with each pair of timers. This unit will, hereafter, be referred to as the operating recording ammeter. The other recording ammeter supplied with the pair of timers is considered to be a spare unit, and will, hereafter, be referred to as such. Each recording ammeter is shipped as a complete assembly in its own shipping container. The container also includes boxes containing chart paper and an accessory kit for the recorder instrument. Uncrate the unit and inspect it for any damage possibly incurred in shipment. Make sure to locate and store the chart paper and the accessory kit. The procedure for uncrating is similar to that described in paragraph 3 *a.* The unit is arranged for mounting on a 19-inch rack. Adapters are provided to permit mounting the unit on a 24-inch rack, if desired. The rack itself is not supplied as part of the timer set. Dimensional data and mounting details are given in figure 3-7.

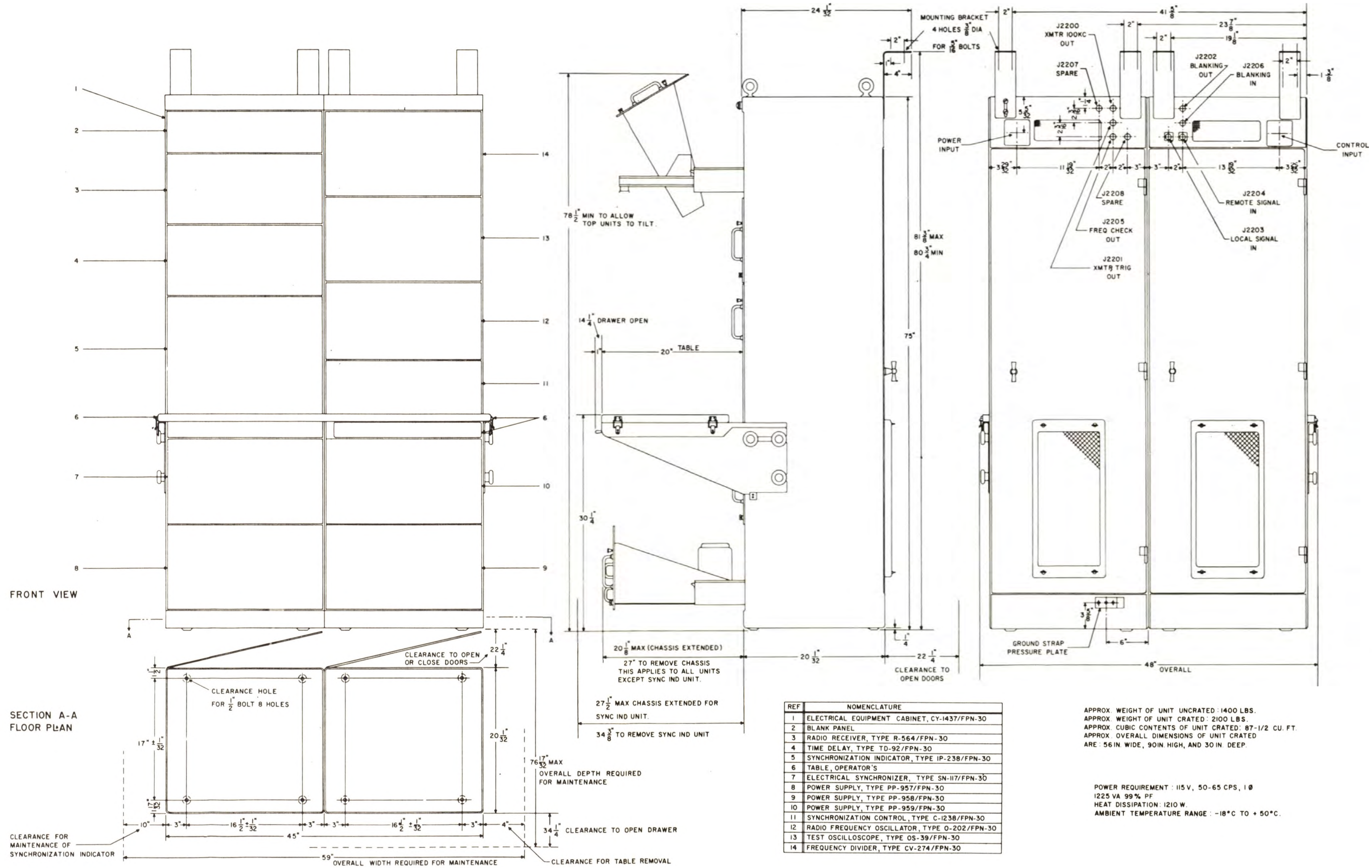
10. INTERUNIT CONNECTIONS.

The information for interconnecting the component units of the timer set with each other and with the other components of the loran station is given in figures 3-8 through 3-15, as indicated in the following subparagraphs. The drawings provide interconnection data for a double-pulsed station. For such a station all components shown are used and all connections indicated are to be made. For a single-pulsed station, the connections and the information pertaining to components marked No. 3 and No. 4 should be omitted. Interunit cables and connectors are not supplied as part of the timer set but must be obtained separately. Cables must be cut from bulk to the required lengths and assembled to the proper connectors. Lengths of leads and methods of running or channeling cables must similarly be determined for the specific station, and are not given.

a. INTERUNIT CONNECTIONS—STATION EMPLOYING LORAN SWITCHING EQUIPMENT TYPE AN/FPA-2 (ELECTRICAL EQUIPMENT CABINET CY-1466/FPA-2).—All interconnecting information for the timer set components at a station employing Loran Switching Equipment AN/FPA-2, of which Electrical Equipment Cabinet CY-1466/FPA-2 is the major component, is given in figures 3-8 and 3-9. Figure 3-8 is an interconnection diagram, showing actual cable runs between units and the points of connection of the cables. Each cable is identified by a "W" number (e.g.,W1. . . . .W40, etc.). The table on figure 3-8 summarizes the information given in the interconnecting diagram, identifies the nature of each cable, and lists the receptacles or terminal boards of the components to which the connections are to be made. This information serves, therefore, as the basis for determining cable lengths, actual channeling of cables, and the requirements for fabrication of the cables. Observe that the Notes provided on figure 3-8 are an integral part of the information given and should be studied carefully before the actual work is undertaken. The information given in the table of figure 3-8 is expanded in figure 3-9 to provide actual connection details and other pertinent data, such as cable functions and current carrying requirements.

b. INTERUNIT CONNECTIONS—STATION EMPLOYING LORAN SWITCHING EQUIPMENT NAVY MODEL UM.—Information for preparing interunit cables and for interconnecting Loran Timer Set AN/FPN-30 with components of a loran station employing the Navy Model UM Loran Switching Equipment is given in figures 3-10 and 3-11. Figure 3-10 is an interconnection diagram, and figure 3-11 summarizes the connection details, in a manner similar to that discussed in paragraph 10 *a* above.

c. INTERUNIT CONNECTIONS—SPECIAL APPLICATIONS WHERE SWITCHING EQUIPMENT IS NOT USED.—In some special cases, such as use of Loran Timer Set AN/FPN-30 as a monitor, it may be

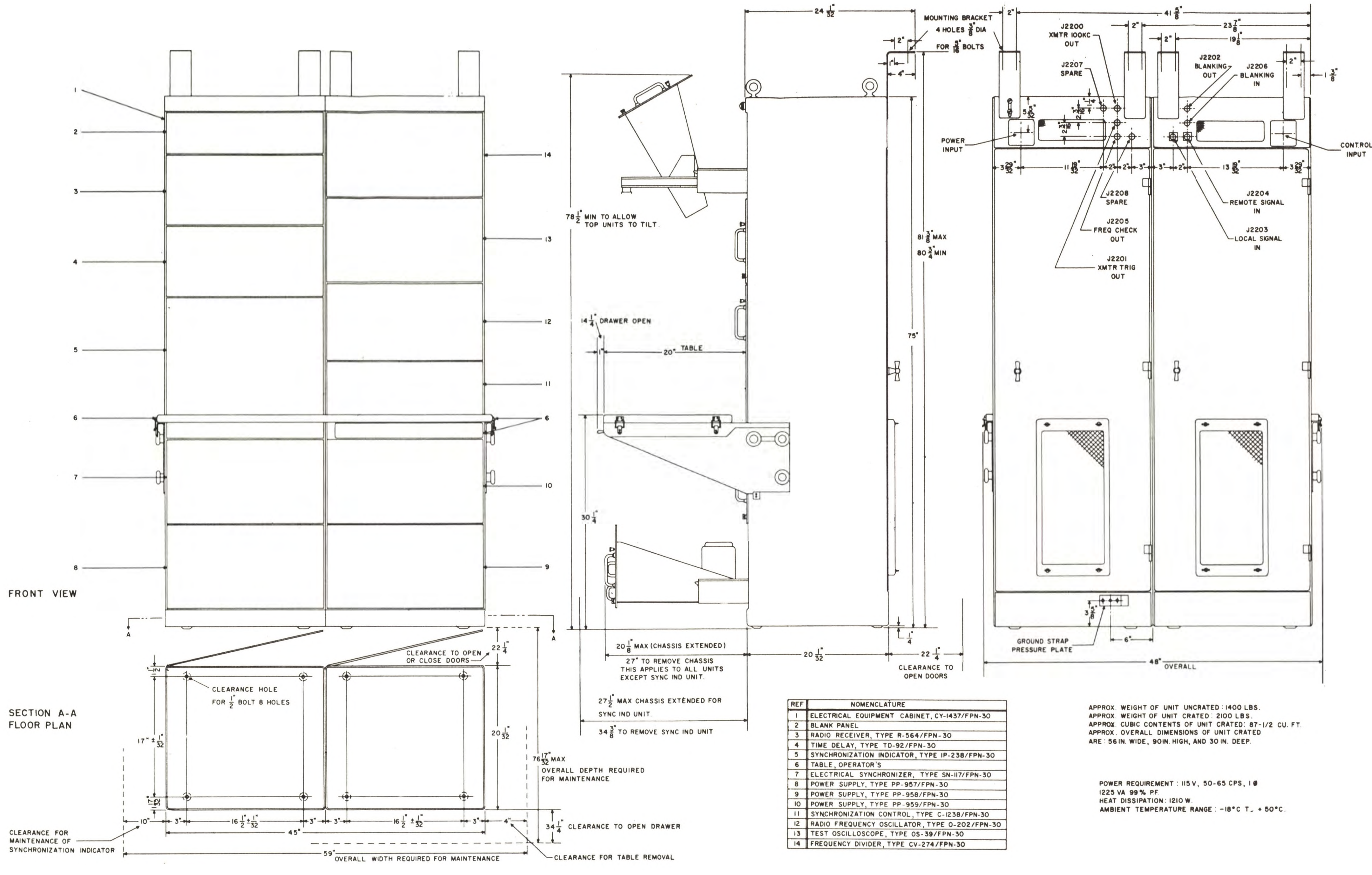


REF	NOMENCLATURE
1	ELECTRICAL EQUIPMENT CABINET, CY-1437/FPN-30
2	BLANK PANEL
3	RADIO RECEIVER, TYPE R-564/FPN-30
4	TIME DELAY, TYPE TD-92/FPN-30
5	SYNCHRONIZATION INDICATOR, TYPE IP-238/FPN-30
6	TABLE, OPERATOR'S
7	ELECTRICAL SYNCHRONIZER, TYPE SN-117/FPN-30
8	POWER SUPPLY, TYPE PP-957/FPN-30
9	POWER SUPPLY, TYPE PP-958/FPN-30
10	POWER SUPPLY, TYPE PP-959/FPN-30
11	SYNCHRONIZATION CONTROL, TYPE C-1238/FPN-30
12	RADIO FREQUENCY OSCILLATOR, TYPE O-202/FPN-30
13	TEST OSCILLOSCOPE, TYPE OS-39/FPN-30
14	FREQUENCY DIVIDER, TYPE CV-274/FPN-30

APPROX. WEIGHT OF UNIT UNCRATED: 1400 LBS.
APPROX. WEIGHT OF UNIT CRATED: 2100 LBS.
APPROX. CUBIC CONTENTS OF UNIT CRATED: 87-1/2 CU. FT.
APPROX. OVERALL DIMENSIONS OF UNIT CRATED ARE: 56 IN. WIDE, 90 IN. HIGH, AND 30 IN. DEEP.

POWER REQUIREMENT: 115 V, 50-65 CPS, 1Ø
1225 VA 99% PF
HEAT DISSIPATION: 1210 W.
AMBIENT TEMPERATURE RANGE: −18°C TO +50°C.

Figure 3–4. Electrical Cabinet CY–1437/FPN–30, Dimensional Data and Mounting Details



REF	NOMENCLATURE
1	ELECTRICAL EQUIPMENT CABINET, CY-1437/FPN-30
2	BLANK PANEL
3	RADIO RECEIVER, TYPE R-564/FPN-30
4	TIME DELAY, TYPE TD-92/FPN-30
5	SYNCHRONIZATION INDICATOR, TYPE IP-238/FPN-30
6	TABLE, OPERATOR'S
7	ELECTRICAL SYNCHRONIZER, TYPE SN-117/FPN-30
8	POWER SUPPLY, TYPE PP-957/FPN-30
9	POWER SUPPLY, TYPE PP-958/FPN-30
10	POWER SUPPLY, TYPE PP-959/FPN-30
11	SYNCHRONIZATION CONTROL, TYPE C-1238/FPN-30
12	RADIO FREQUENCY OSCILLATOR, TYPE O-202/FPN-30
13	TEST OSCILLOSCOPE, TYPE OS-39/FPN-30
14	FREQUENCY DIVIDER, TYPE CV-274/FPN-30

APPROX. WEIGHT OF UNIT UNCRATED: 1400 LBS.
APPROX. WEIGHT OF UNIT CRATED: 2100 LBS.
APPROX. CUBIC CONTENTS OF UNIT CRATED: 87-1/2 CU. FT.
APPROX. OVERALL DIMENSIONS OF UNIT CRATED
ARE: 56 IN. WIDE, 90 IN. HIGH, AND 30 IN. DEEP.

POWER REQUIREMENT: 115 V, 50-65 CPS, 1 Ø
1225 VA 99% PF
HEAT DISSIPATION: 1210 W.
AMBIENT TEMPERATURE RANGE: -18°C T. + 50°C.

Figure 3-4. Electrical Cabinet CY-1437/FPN-30, Dimensional Data and Mounting Details desired to permanently connect a recording ammeter to the timer. Note 1 of figure 3–10 provides specific information for obtaining a relay control voltage from the timer to achieve the permanent connection.

d. PROCEDURES FOR FABRICATION OF COAXIAL CABLES.—Some of the cables required for interconnection of the components of Loran Timer Set AN/FPN–30 with the other components of the loran station are of the coaxial type. As explained in the Notes on figures 3–8 through 3–11, either type RG–58/U or type RG–8/U cable may be used. Detailed instructions for attaching suitable connectors to these cables are given in figure 3–12. Figure 3–12 gives detailed instructions for assembly of type BNC and type N connectors to the RG–58/U and RG–8/U coaxial cable respectively and for assembling RG–8/U cable to the 83–1 SPN plug, Navy type 49195, used at stations equipped with Navy Model UM Loran Switching Equipment.

e. REMOTE ALARM EQUIPMENT CONNECTIONS.—As shown in the interconnection diagrams, figures 3–8 and 3–10, provisions are made for connecting the timer set equipment to remote alarm indicating devices. Cables W7 and W30 are used for making these connections, as shown. A schematic diagram for a suitable remote synchronization alarm unit is shown in figure 3–13. This unit is electrically identical to Synchronization Alarm BZ–30/FR, furnished to the Coast Guard on contract Tcg–38316 (CG–18,373–C). The previously furnished unit is suitable for use with Loran Timer Set AN/FPN–30 except that the alarm indicators are incorrectly marked for such service. The differences between the correct designations and those marked on Synchronization Alarm BZ–30 are tabulated below. For a description of the parts required to construct the unit shown in figure 3–13, refer to the parts list in the Instruction Book Supplement for Modification of Loran Timer Model UE–1 (Electrical Synchronizer SN–108/FR; Synchronization Alarm BZ–30/FR). The remote alarm equipment may be located a distance up to two miles away from the timer set. The resistance of each lead in the cables must not exceed 200 ohms.

11. INITIAL ADJUSTMENTS OF TIMER SET—GENERAL.

a. When the components of the timer set have been installed and interconnected as outlined in the preceding paragraphs of this section, they are ready for application of power and for initial adjustment. All parts and circuits of the timer set have been checked and adjusted at the factory, and it is assumed that they are in proper operating condition. It is further assumed that components of the timer set, as well as the auxiliary components which are not part of the timer set proper but are required for station operation, have been completely checked for any mechanical defects which may have occurred in shipment, and that all such defects found have been properly corrected. During initial operation, therefore, only those adjustments must be made which fit the timer set to the particular operating conditions and requirements of the station at which it is being used. Some adjustments are factory preset and need not be touched at this time, or at any time during normal operation, unless trouble in operation is experienced. Procedures for adjusting such factory preset controls are given in the corrective maintenance section, Section 7. Procedures for making initial adjustments are outlined in the following paragraphs of this section.

b. Since the various equipments of a loran station are functionally interdependent, a definite sequence of adjustments of the timer, with relation to adjustments of the loran switching equipment and the radio transmitters, must be followed. The recommended sequence, serving also as the basis of the procedures given in this section, is outlined in the following steps:

Step 1. First the loran switching equipment must be adjusted completely as described in paragraph 12 *g* except for two attenuation adjustments. These adjustments must be made in conjunction with corresponding adjustments of the timer, after it has been made ready.

COMPONENT	REQUIRED MARKING	MARKING ON BZ–30/FR	FUNCTION WHEN USED WITH AN/FPN–30
TB2901–1	BUZZER	BUZZER	Buzzer connection terminal.
TB2901–2	SYNC ERROR	SYNC ERROR OR WRONG ZERO	Sync error alarm connection terminal.
TB2901–3	OFF SYNC	REMOTE BLINK	Off sync alarm connection terminal.
TB2901–4	COMMON	COMMON	Common connection terminal.
I2901	SYNC ERROR ALARM	SYNC ERROR OR WRONG ZERO ALARM	Indicates sync error.
I2902	OFF SYNC ALARM	REMOTE BLINK ALARM	Indicates off sync, wrong zero, and remote blink.

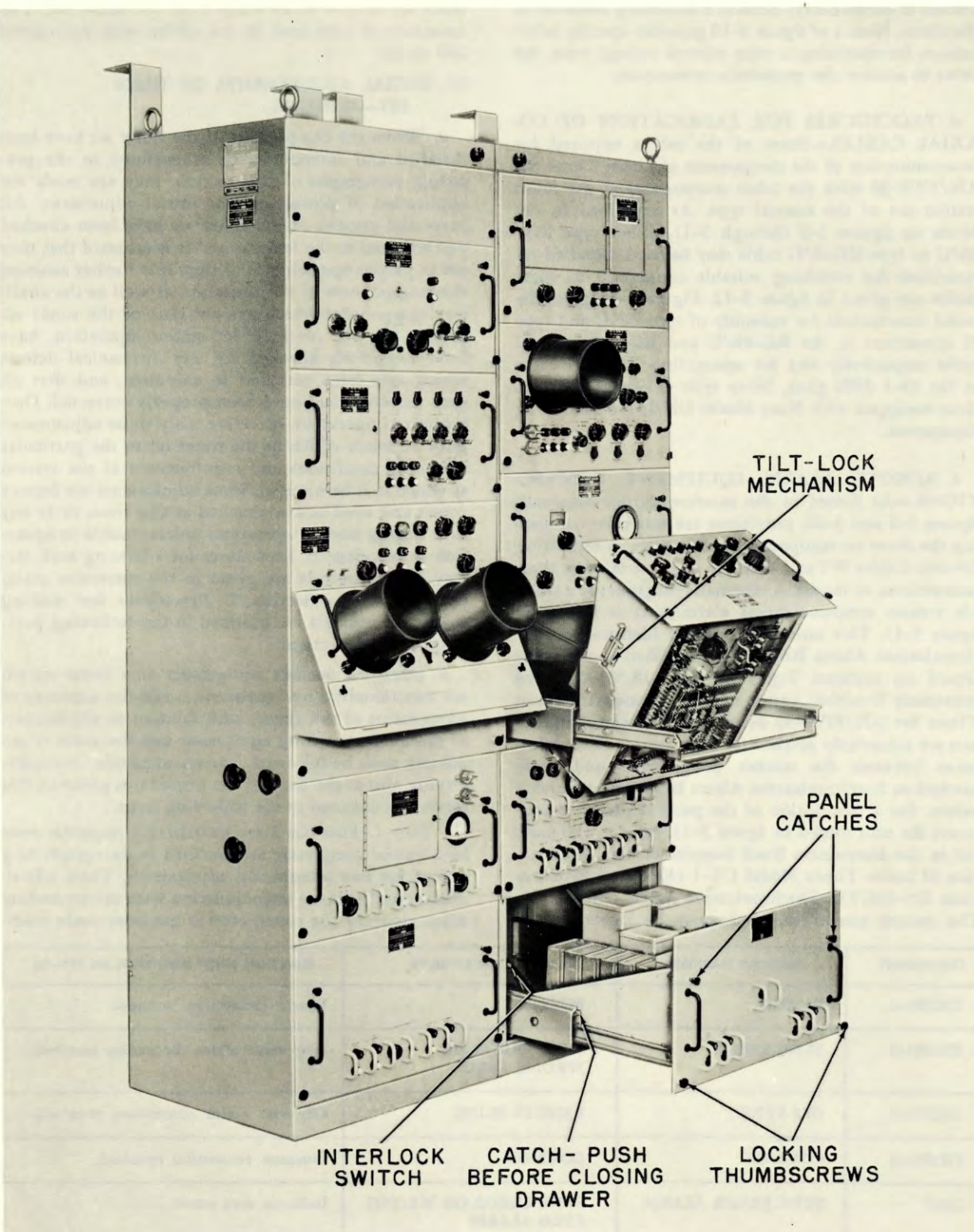


Figure 3–5. Drawer Unit Opened and Locked in Tilted Position

Step 2. Next the timer set adjustments, described in paragraphs 12 through 24, must be made. These adjustments do not involve the use of either remote signals or signals fed back from the local transmitter, and prepare the timer for signal adjustments.

Step 3. When the timer adjustments will have been completed as indicated in step 2, above, the radio transmitters should then be adjusted, utilizing the trigger pulses made available from the timer, as described in the instruction book for the particular transmitter equipment used.

Step 4. Finally, the signal adjustments of the timer should be completed, as described in paragraphs 25 through 28, completing at the appropriate points in these procedures the attenuation adjustments of the loran switching equipments. These points are indicated where pertinent in the following procedures.

c. At a station employing double-pulsed transmission, four timers, two operating and two stand-by, are involved. At a station employing single-pulsed transmission, two timers, one operating and one stand-by, are involved. The procedures outlined in the following paragraphs cover the initial adjustments of one timer, specifically, the first timer (for each repetition rate at a double-pulsed station) of the station to be placed into operation, where no fully adjusted operating timer for that repetition rate is yet available. With the minor differences indicated where pertinent, these procedures apply equally to the initial adjustments of the other timers of either a master or a slave station, at which a fully adjusted timer has already been placed into operation.

d. It is recommended that personnel become thoroughly familiar with the principles of operation of the timer set, given in Section 2, and with the principles of loran system and station operation, before proceeding with the adjustments.

12. PRELIMINARY CONTROL SETTINGS.

Before power is applied to the equipment, certain operating controls should be set as outlined in the following paragraphs. Unless otherwise indicated, these controls are located on the front panels of the timer set component units. Note that not all controls are listed below, but only those which are pertinent before initial application of power. Settings of controls not listed below are immaterial at this time. Refer to figures 4–1 through 4–13 to determine the locations of the controls. Refer also to tables 4–1 through 4–13 to determine the functions of these controls.

a. SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30.

Note

Initially turn the oscilloscope INTENSITY controls to the extreme counterclockwise positions, to avoid damage to cathode-ray tube screens. Adjust to the desired intensities, when called for in the following procedures. Particularly, observe the caution in paragraph 20 *d*, below.

(1) Check that the BLINK SELECTOR switch (S802) is in the OFF position.

(2) Check that the BUZZER ON-OFF switch (S806) is in the OFF position.

b. ELECTRICAL SYNCHRONIZER TYPE SN–117/FPN–30.

(1) Check that the REMOTE ALARM OUT-IN switch (S1501) is in the OUT position.

(2) Check that the POWER ON-OFF switch (S1502) is in the ON position.

Note

To prevent the alarm lights from being lit during the adjustment procedures, it is desirable to disable the alarm circuits temporarily, as follows:

(*a*) At a slave station, turn the SYNC ERROR SENSITIVITY control (R1534) to the extreme counterclockwise position.

At a master station, since the alarm is cam-operated, it will be necessary to temporarily remove sync error alarm tube V1509 from its socket.

(*b*) At both master and slave stations, turn the chassis-mounted OFF SYNC SENSITIVITY potentiometer R1555 to the extreme counterclockwise position.

Note

The individual power on-off switches of the timer set component units are set to their ON positions at this time, so that when the equipment is finally ready, power to the over-all equipment may be applied by means of a single switch, namely, the MAIN POWER circuit breaker on Power Supply Type PP–959/FPN–30.

c. POWER SUPPLY TYPE PP–957/FPN–30.—Operate the SCOPE HIGH VOLTAGES ON-OFF switch (S2101) to the ON position.

d. RADIO FREQUENCY OSCILLATOR TYPE O–202/FPN–30.—Operate the METER SWITCH (S1402) to the OSC. OUT position.

e. SYNCHRONIZATION CONTROL UNIT TYPE C–1238/FPN–30.

(1) Operate the 60∼ AMPL PWR ON-OFF switch (S102) to the ON position.

(2) Operate the AUTO SYNC ON-OFF switch (S104) to the OFF position.

(3) Operate the FREQUENCY CORRECTOR switch (S103) to the IN position.

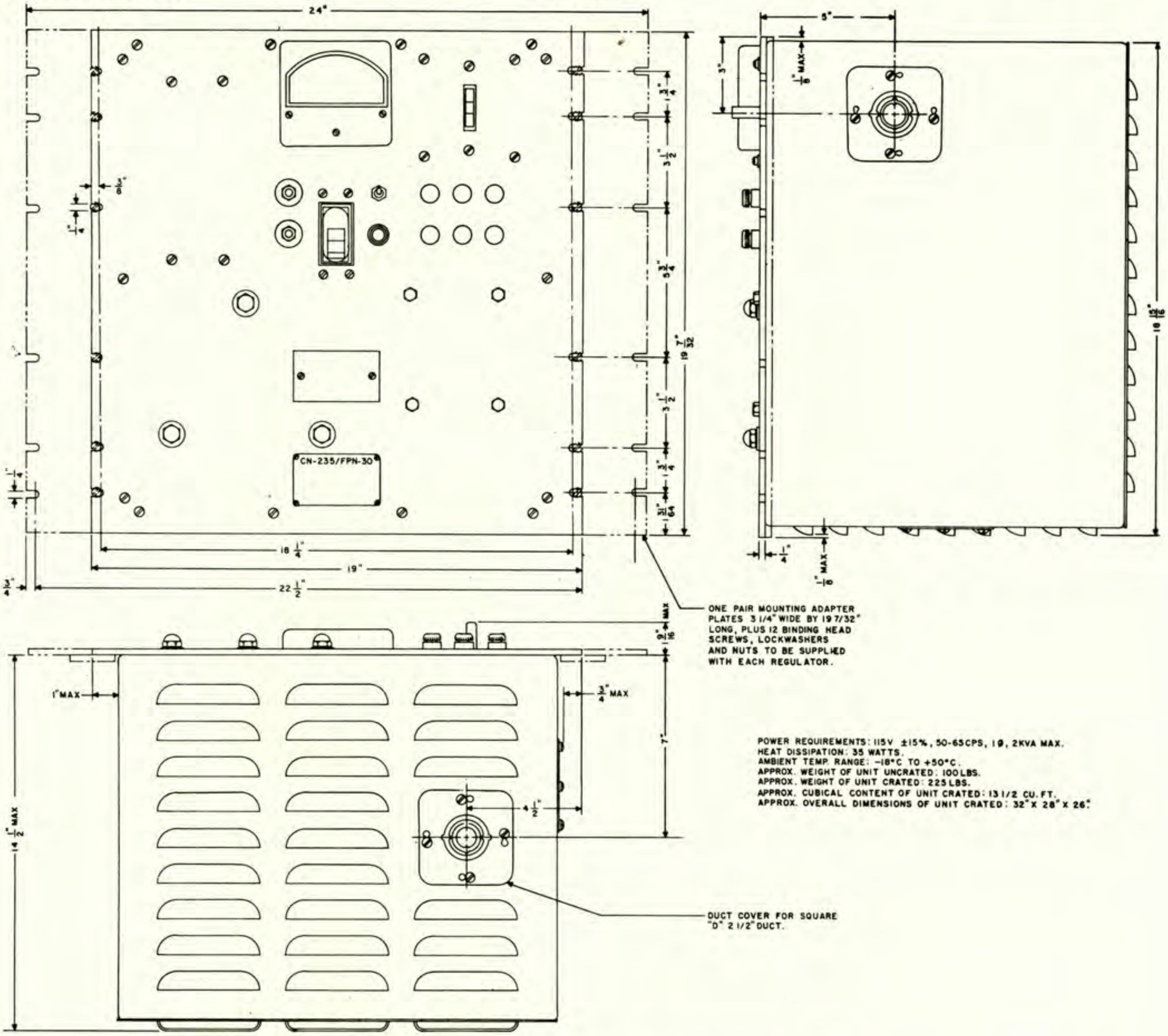


Figure 3–6. Voltage Regulator Type CN–235/FPN–30, Dimensional Data and Mounting Details

f. POWER SUPPLY TYPE PP–959/FPN–30.

(1) Operate the DC METER SWITCH (S2002) to the OFF position.

(2) Operate the SPACE HEATERS ON-OFF switch (S2003) to the ON position.

(3) Operate the INTERLOCKED POWER switch (S2004) to the ON position.

(4) Operate the MAIN POWER circuit breaker to the OFF position. This switch will be used to apply power to the units contained in the equipment cabinet.

g. LORAN SWITCHING EQUIPMENT.—The association of Loran Switching Equipment AN/FPA–2 with the timer set and the other equipments of the loran station is indicated in figure 3–1. Detailed operating instructions for that switching equipment are given in the Instruction Book for Loran Switching Equipment AN/FPA–2. If Model UM Loran Switching Equipment is used instead, refer to the instruction book supplied with that equipment. Proceed as follows:

(1) Turn the MAIN POWER LINE 1 and MAIN POWER LINE 2 circuit breakers of the switching equipment to their OFF positions.

(2) Assuming that timers 1 and 3 are operating timers, and timers 2 and 4 are stand-by timers, respectively (figure 3–1 or figure 3–2), it is recommended that the LINE 1—OFF—LINE 2 power line selector switches on the switching equipment be set as follows:

Timer 1 switch—set to LINE 1 position (operating timer)

Timer 2 switch—set to LINE 2 position (stand-by timer)

Timer 3 switch—set to LINE 1 position (operating timer)

Timer 4 switch—set to LINE 2 position (stand-by timer)

Note

The selection of a-c power lines given above connects the two operating timers of a (double-pulsed) station to one line and the two stand-by timers to the other line. This arrangement insures that in the event of failure of one of the power lines, a timer for each repetition rate is still powered and is thus available for use.

(3) Using the switching equipment controls as described in the instruction book for the particular switching equipment used (AN/FPA–2 or UM), select the timer set being adjusted as the operating timer.

Note

The switches on the Loran Switching Equipment AN/FPA–2 must be set to select the operating and stand-by timers so that one Recording Ammeter Type ME–84/FPN–30 can be used to monitor the operation of two timers, one operating and the associated stand-by timer, i.e,, the two timers employing the same repetition rate.

(4) Perform the other operations discussed in the instruction book for the particular loran switching equipment (AN/FPA–2 or Model UM) required to place that equipment into service, with the following exceptions:

(*a*) Insertion or removal of 20-db remote signal attenuator in Radio Receiver Type R–564/FPN–30 or selection of the antenna input attenuation of the Model UM equipment.

(*b*) Adjustment of local signal attenuation in the electronic switching units (ESU) of the AN/FPA–2 equipment, or corresponding adjustment in the discriminator units of the Model UM equipment. These adjustments must be made in conjunction with the timer adjustments, as referenced at the appropriate points in the following procedures.

b. VOLTAGE REGULATOR TYPE CN–235/FPN–30.—Set the switches of each timer set voltage regulator of the station as follows:

(1) Operate the main power circuit breaker to the OFF position. This circuit breaker, together with the MAIN POWER circuit breaker of Power Supply Type PP–959/FPN–30, will be used to apply power to the units in the associated timer.

(2) Operate S2203 on each voltage regulator to the REGULATED VOLTAGE position.

13. RESTORING POWER BY MEANS OF INTERLOCKING SWITCHES.

a. INTERLOCK CIRCUIT ARRANGEMENT. — A group of interlock switches controls application of power to all unit drawers in Electrical Equipment Cabinet CY–1437/FPN–30, except Radio Frequency Oscillator O–202/FPN–30, Power Supply Type PP–959/FPN–30, the space heaters, and a few other 115-volt a-c points in the cabinet. Refer to the a-c power ladder diagram, figure 2–39, for complete detail of circuits controlled by the interlock system. One interlock switch is associated with each drawer in the timer cabinet, except the two listed above, one with each door of the cabinet, and one is located under the hinged panel (figure 4–9) of Synchronization Indicator Type IP–238/FPN–30. All interlock switches are in series with each other and with the INTERLOCKED POWER switch (S2004) on Power Supply Type PP–959/FPN–30. Thus, whenever the switch is in the OFF position, or any one of the unit drawers associated with an interlock switch is opened for adjustments or servicing, or the cabinet door is opened, the corresponding interlock switch is spring-driven to its off position, and power is disconnected from all circuits, except those of the oscillator, one power supply (PP–959/FPN–30), and the other directly controlled circuits (figure 2–39). Paragraph 2 of Section 7 lists the points at which power remains when an interlock switch is opened. The oscillator supply is fed directly through the MAIN POWER circuit breaker on Power Supply Type PP–959/FPN–30, so that the oscillator may remain energized and thus maintain temperature and frequency stability, when power to all other units in the cabinet is shut off.

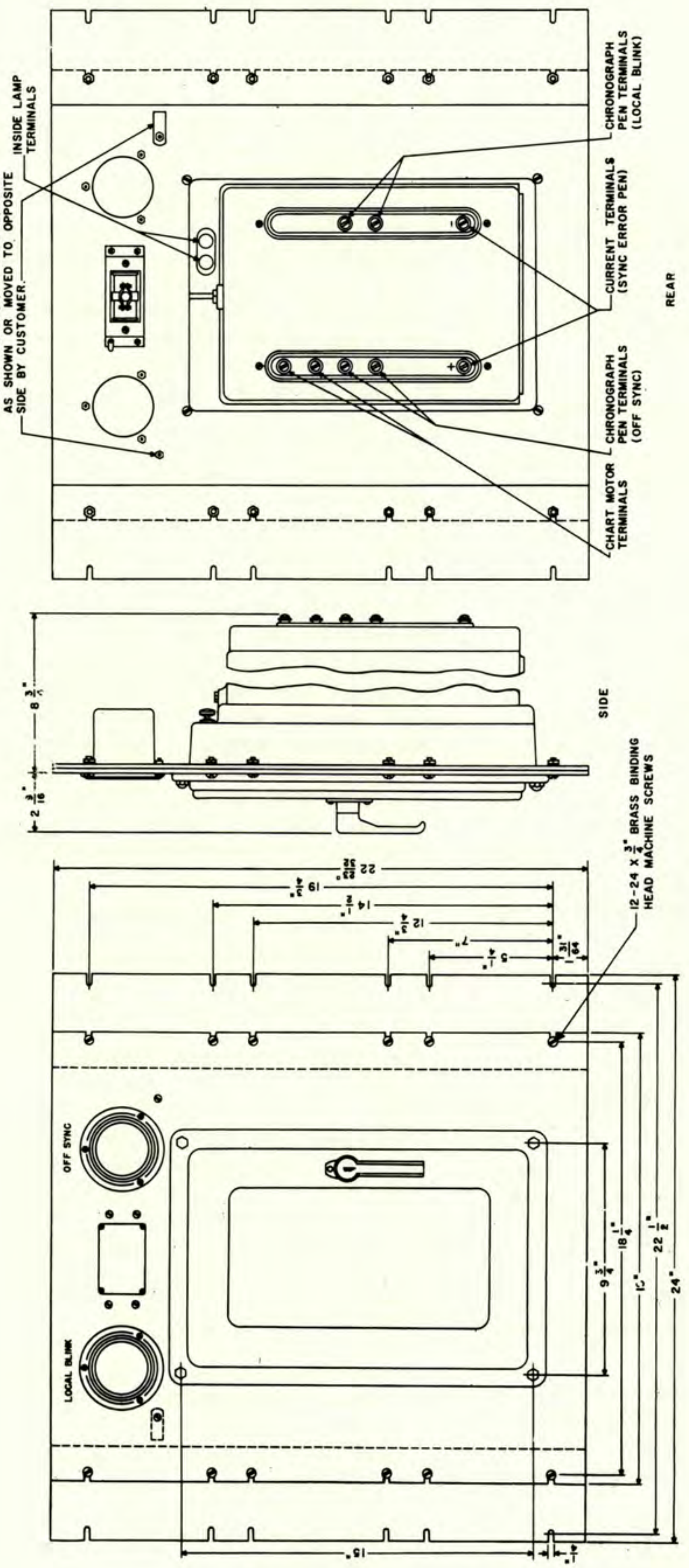
CAUTION

Even though an interlock switch is open, power still exists at some points. See Section 7, paragraph 2. Caution must, therefore, be exercised to avoid shock when testing or adjusting within the equipment under this condition.

b. RESTORING INTERLOCKED POWER.—To restore power disconnected by the opening of a drawer or the door of the cabinet, pull the shaft of the associated interlock switch outward. When a drawer or cabinet door is now closed, power will be momentarily shut off and then restored when the closing process is completed

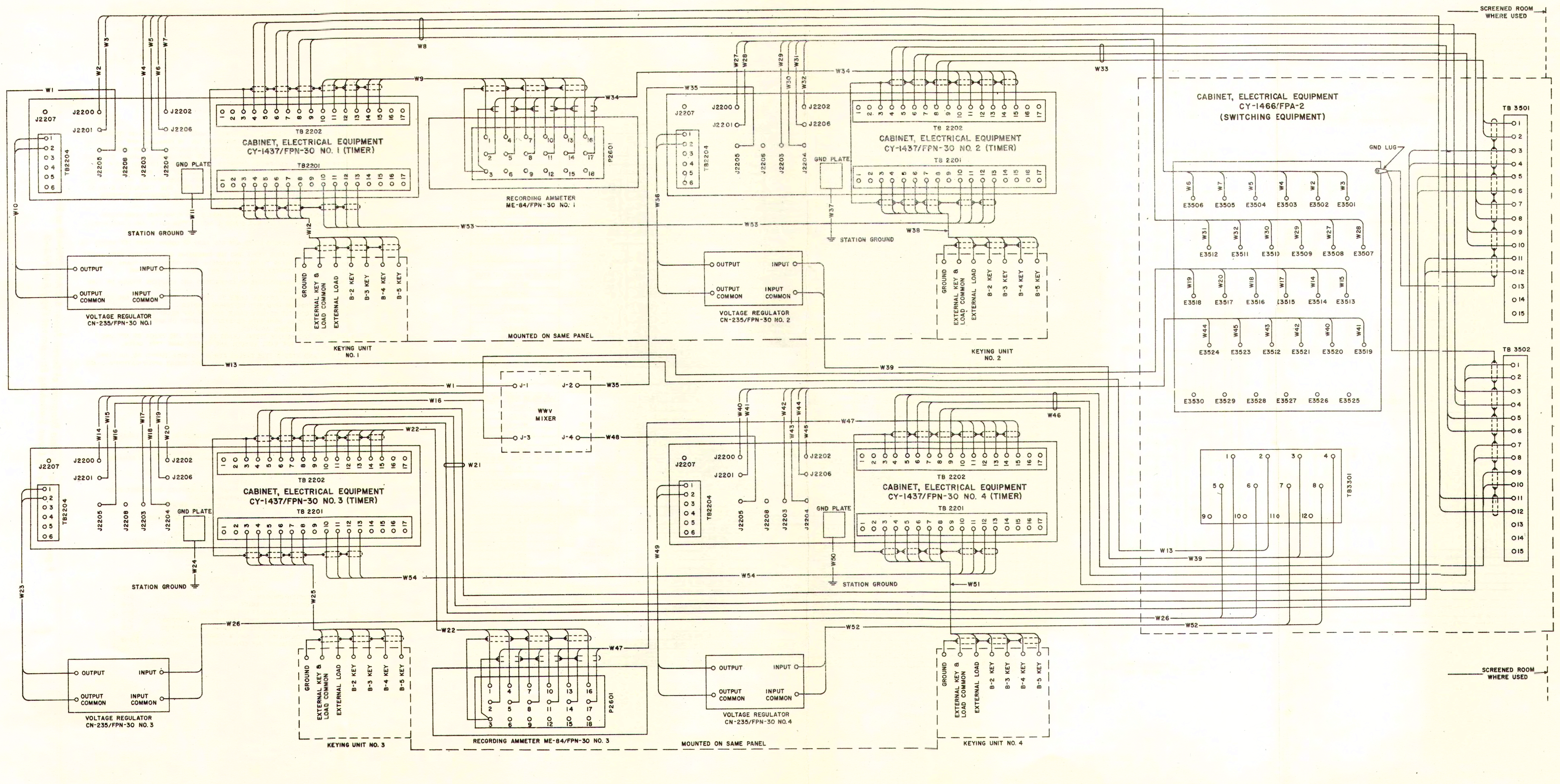
Note

Each interlock switch has three positions, namely ON-OFF-ON. The drawer, when closed, holds the switch in the ON position, against spring tension. Opening the drawer causes the spring to return the switch to the OFF position. Pulling the switch as indicated in *b*, above, operates the switch to the other ON position.



NOTES:
1- APPROXIMATE WEIGHT CRATED = 66 POUNDS
2- APPROXIMATE WEIGHT UNCRATED = 36 POUNDS
3- APPROXIMATE OVERALL DIMENSIONS CRATED = 29"L. X 28"W. X 18"D
4 OPERATING TEMPERATURE −18° TO +50°C.
5 APPROXIMATE CUBIC CONTENTS CRATED = 8 1/2 CU. FT.

Figure 3–7. Recording Ammeter Type ME–84/FPN–30, Dimensional Data and Mounting Details



SYMBOL	NAVY STOCK NO.	NUMBER COND	ACTIVE COND	NAVY TYPE NO. (SEE NOTE-5)	FROM LOCATION	FROM EQUIPMENT	FROM CABLE CONN TYPE (SEE NOTE-6)	TO LOCATION	TO EQUIPMENT	TO CABLE CONN TYPE (SEE NOTE-6)
W1		COAX	1	RG-58/U	J2205	CABINET ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER) NO. 1	UG-88/U		WWV MIXER	
W2		COAX	1	RG-58/U	J2200		UG-88/U	E3502	CABINET ELECTRICAL EQUIPMENT CY-1466/FPA-2	UG-88/U
W3		COAX	1	RG-58/U	J2201		UG-88/U	E3501		UG-88/U
W4		COAX	1	RG-58/U	J2203		UG-88/U	E3503		UG-88/U
W5		COAX	1	RG-58/U	J2204		UG-88/U	E3504		UG-88/U
W6		COAX	1	RG-58/U	J2206		UG-88/U	E3506		UG-88/U
W7		COAX	1	RG-58/U	J2202		UG-88/U	E3505		UG-88/U
W8	G15-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO. 18 WIRE, NO. 6 STUD	TB3501 & 2		LUG, NO. 18 WIRE, NO. 6 STUD
W9	G15-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO. 18 WIRE, NO. 6 STUD	P2601	REC AMMETER-1	* PLUG
W10	G15-C-16850	2	2	RHDL NO. 12	TB2204		LUG, NO. 12 WIRE, 1/4" STUD		VOLT REG-1	LUG, NO. 12 WIRE, 1/4" STUD
W11		1	1	COPPER STRAP 3" MAX. WIDTH	GROUND PLATE				STATION GROUND	
W12	G15-C-10955-5	8	6	TTRS-4	TB2201				KEYING UNIT-1	
W13	G15-C-16850	2	2	RHDL NO. 12		VOLT REG-1	LUG, NO. 12 WIRE, 1/4" STUD	TB3301	CABINET ELECTRICAL EQUIPMENT CY-1466/FPA-2	LUG, NO. 12 WIRE, 1/4" STUD
W14		COAX	1	RG-58/U	J2200	CABINET ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER) NO.3	UG-88/U	E3514		UG-88/U
W15		COAX	1	RG-58/U	J2201		UG-88/U	E3513		UG-88/U
W16		COAX	1	RG-58/U	J2205		UG-88/U		WWV MIXER	
W17		COAX	1	RG-58/U	J2203		UG-88/U	E3515	CABINET ELECTRICAL EQUIPMENT CY-1466/FPA-2	UG-88/U
W18		COAX	1	RG-58/U	J2204		UG-88/U	E3516		UG-88/U
W19		COAX	1	RG-58/U	J2206		UG-88/U	E3518		UG-88/U
W20		COAX	1	RG-58/U	J2202		UG-88/U	E3517		UG-88/U
W21	G15-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO. 18 WIRE, NO. 6 STUD	TB3501 & 2		LUG, NO. 18 WIRE, NO. 6 STUD
W22	G15-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO. 18 WIRE, NO. 6 STUD	P2601	REC AMMETER-3	* PLUG
W23	G15-C-16850	2	2	RHDL NO. 12	TB2204		LUG, NO. 12 WIRE, 1/4" STUD		VOLT REG-3	LUG, NO. 12 WIRE, 1/4" STUD
W24		1	1	COPPER STRAP 3" MAX. WIDTH	GROUND PLATE				STATION GROUND	
W25	G15-C-10955-5	8	6	TTRS-4	TB2201		LUG, NO. 18 WIRE, NO. 6 STUD		KEYING UNIT-3	
W26	G15-C-16850	2	2	RHDL NO. 12		VOLT REG-2	LUG, NO. 12 WIRE, 1/4" STUD	TB3301	CABINET ELECTRICAL EQUIPMENT CY-1466/FPA-2	LUG, NO. 12 WIRE, 1/4" STUD
W27		COAX	1	RG-58/U	J2200	CABINET ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER) NO.2	UG-88/U	E3508		UG-88/U
W28		COAX	1	RG-58/U	J2201		UG-88/U	E3507		UG-88/U
W29		COAX	1	RG-58/U	J2203		UG-88/U	E3509		UG-88/U
W30		COAX	1	RG-58/U	J2204		UG-88/U	E3510		UG-88/U
W31		COAX	1	RG-58/U	J2206		UG-88/U	E3512		UG-88/U
W32		COAX	1	RG-58/U	J2202		UG-88/U	E3511		UG-88/U
W33	G15-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO. 18 WIRE, NO. 6 STUD	TB3501 & 2		LUG, NO. 18 WIRE, NO. 6 STUD
W34	G15-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO. 18 WIRE, NO. 6 STUD	P2601	REC AMMETER-1	* PLUG
W35		COAX	1	RG-58/U	J2205		UG-88/U		WWV MIXER	
W36	G15-C-16850	2	2	RHDL NO. 12	TB2204		LUG, NO. 12 WIRE, 1/4" STUD		VOLT REG-2	LUG, NO. 12 WIRE, 1/4" STUD
W37		1	1	COPPER STRAP 3" MAX. WIDTH	GROUND PLATE				STATION GROUND	
W38	G15-C-10955-5	8	6	TTRS-4	TB2201		LUG, NO. 18 WIRE, NO. 6 STUD		KEYING UNIT-2	
W39	G15-C-16850	2	2	RHDL NO. 12		VOLT REG-2	LUG, NO. 12 WIRE, 1/4" STUD	TB3301	CABINET ELECTRICAL EQUIPMENT CY-1466/FPA-2	LUG, NO. 12 WIRE, 1/4" STUD
W40		COAX	1	RG-58/U	J2200	CABINET ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER) NO.4	UG-88/U	E3520		UG-88/U
W41		COAX	1	RG-58/U	J2201		UG-88/U	E3519		UG-88/U
W42		COAX	1	RG-58/U	J2203		UG-88/U	E3521		UG-88/U
W43		COAX	1	RG-58/U	J2204		UG-88/U	E3522		UG-88/U
W44		COAX	1	RG-58/U	J2206		UG-88/U	E3524		UG-88/U
W45		COAX	1	RG-58/U	J2202		UG-88/U	E3523		UG-88/U
W46	G15-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO. 18 WIRE, NO. 6 STUD	TB3501 & 2		LUG, NO. 18 WIRE, NO. 6 STUD
W47	G15-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO. 18 WIRE, NO. 6 STUD	P2601	REC AMMETER-3	* PLUG
W48		COAX	1	RG-58/U	J2205		UG-88/U		WWV MIXER	
W49	G15-C-16850	2	2	RHDL NO. 12	TB2204		LUG, NO. 12 WIRE, 1/4" STUD		VOLT REG-4	LUG, NO. 12 WIRE, 1/4" STUD
W50		1	1	COPPER STRAP 3" MAX. WIDTH	GROUND PLATE				STATION GROUND	
W51	G15-C-10955-5	8	6	TTRS-4	TB2201		LUG, NO. 18 WIRE, NO. 6 STUD		KEYING UNIT-4	
W52	G15-C-16850	2	2	RHDL NO. 12		VOLT. REG-4	LUG, NO. 12 WIRE, 1/4" STUD	TB3301	SAME AS W2	LUG, NO. 12 WIRE, 1/4" STUD
W53	G15-C-10955	4	4	TTRS-2	TB2201	TIMER NO. 1	LUG, NO. 18 WIRE, NO. 6 STUD	TB2201	TIMER NO. 2	LUG, NO. 18 WIRE, NO. 6 STUD
W54	G15-C-10955	4	4	TTRS-2	TB2201	TIMER NO. 3	LUG, NO. 18 WIRE, NO. 6 STUD	TB2201	TIMER NO. 4	LUG, NO. 18 WIRE, NO. 6 STUD

NOTES:

1 NOTE THAT BOTH ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 (TIMERS) NOS. 1 AND 2 ARE CONNECTED TO RECORDER NO. 1 IN PARALLEL AND THEREFORE THESE TWO SHOULD NOT BOTH BE SELECTED SIMULTANEOUSLY AS OPERATING TIMERS. WHEN ONE IS OPERATING, THE OTHER SHOULD BE STANDBY. SIMILARLY BOTH ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 (TIMERS) NOS. 3 AND 4 ARE CONNECTED TO RECORDER NO. 3 AND SHOULD NOT BOTH BE SELECTED SIMULTANEOUSLY AS OPERATING. RECORDERS NOS. 2 AND 4 ARE SPARES. IN THE SPECIAL CASE WHERE A RECORDER MUST BE USED WITH ONLY ONE TIMER, CABLE NO. 53 OR NO. 54 IS NOT REQUIRED AND A JUMPER MUST BE CONNECTED BETWEEN TB2201-10 AND TB2201-11 OF THE TIMER.

2 AT A SINGLE PULSED STATION TIMERS NOS. 3 AND 4, VOLTAGE REGULATORS NOS. 3 AND 4, RECORDERS NOS. 3 AND 4, AND KEYING UNITS NOS. 3 AND 4 WILL NOT BE USED.

3 UNITS DRAWN IN DASHED LINES ARE NOT PART OF LORAN TIMER SET AN/FPN-30.

4 INTERCONNECTING CABLE TYPES AND THE CONDUCTOR GROUPING MAY VARY AMONG INSTALLATIONS. REFER TO THE APPLICABLE SHIP OR STATION PLANS TO DETERMINE THE CORRECT CABLING FOR ANY SPECIFIC INSTALLATION.

5 THE FOLLOWING COMBINATIONS OF CONNECTORS AND ADAPTERS SHOULD BE USED WITH RG-58/U CABLE.
   (1) TO CONNECT RG-58/U CABLE TO TYPE N RECEPTACLE USE BNC CONNECTOR UG-88/U WITH UG-201A/U ADAPTER.
   (2) TO CONNECT RG-58/U CABLE TO TYPE UHF RECEPTACLE USE BNC CONNECTOR UG-88/U WITH UG-273/U ADAPTER OR UHF CONNECTOR 49190 WITH UG-175/U ADAPTER.

6 THE LOCAL AND REMOTE SIGNAL LEADS TO J2203 AND J2204 ON ANY ONE TIMER MUST BE THE SAME LENGTH AND OF THE SAME TYPE CABLE.

7 TTRS-4, AND TTRS-2 TYPE CABLES PER MIL-C-915A (SHIPS) 30, JULY 1952. RHDL NO. 12 TYPE CABLE IS PER FEDERAL GOVERNMENT SPECIFICATION J-C-103

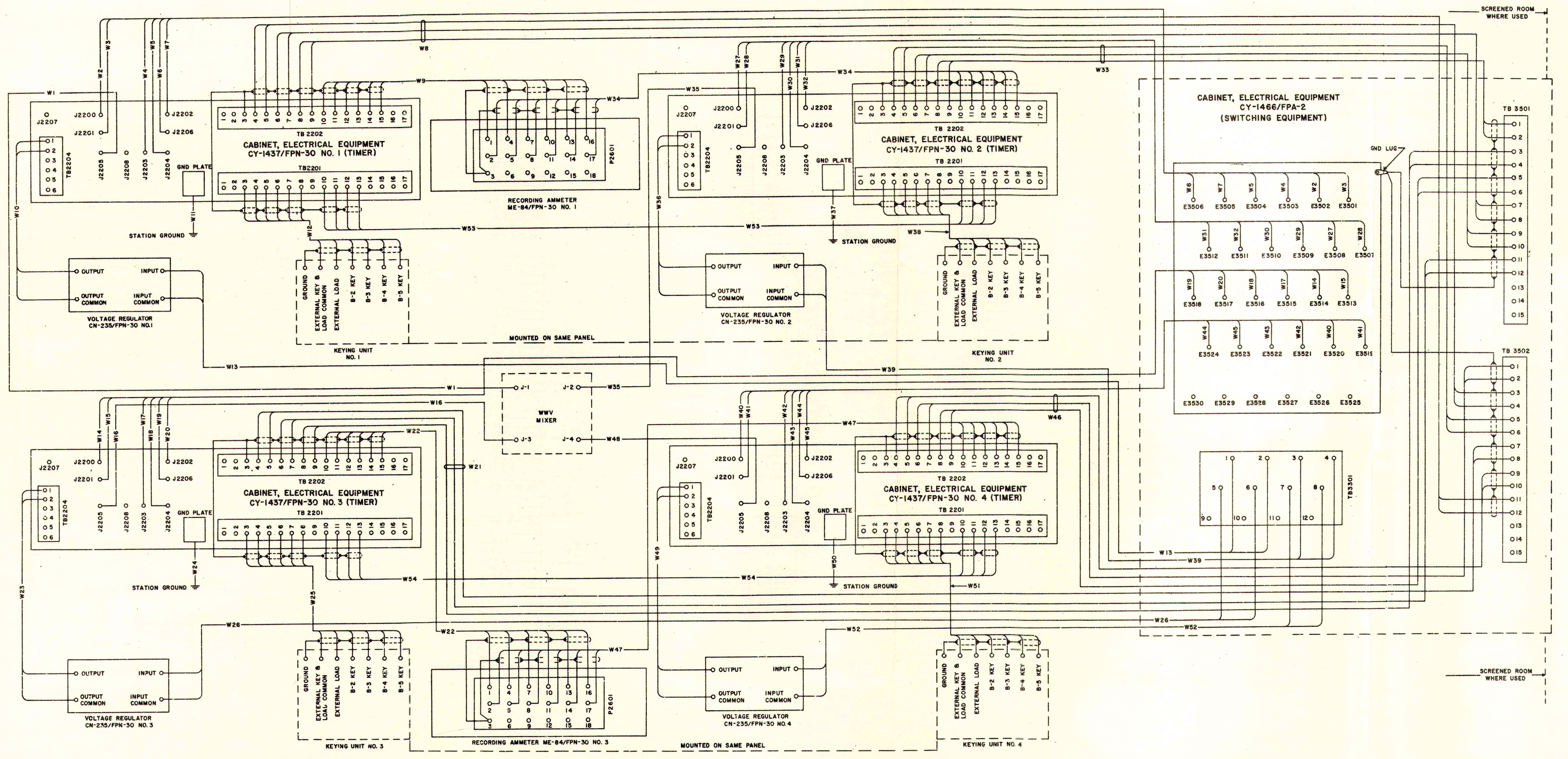
LIST OF CONNECTORS SUPPLIED BY MANUFACTURER AS PART OF LORAN TIMER SET AN/FPN-30.
- 9 ADAPTERS, N RIGHT ANGLE TYPE UG-27C/U
- 10 ADAPTERS, TYPE UG-201A/U (TO MATE BNC MALE AND N FEMALE)
- 10 PLUGS, BNC TYPE UG-88/U
- 10 PLUGS, N TYPE UG-21D/U
- 1 ADAPTER, TEE TYPE UG-107B/U
- 2 TERMINAL LUGS NO. 8, WIRE, 1/4" STUD SUPPLIED ON CABINET, ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER)
- * 1 CONNECTOR, PLUG SUPPLIED ON RECORDING AMMETER

LIST OF CONNECTORS TO BE SUPPLIED BY INSTALLING ACTIVITY
- ALL TERMINAL LUGS FOR TTRS-4 TYPE CABLES
- ALL TERMINAL LUGS FOR RHDL NO. 12 TYPE CABLES
- ALL COAX FITTINGS EXCEPT THOSE SUPPLIED BY MANUFACTURER
- ALL CABLES ARE TO BE SUPPLIED BY INSTALLING ACTIVITY

REFERENCES

TITLE	FIGURE NO.
PICTORIAL SYSTEM DIAGRAM	3-1
INTERCONNECTION RUNNING SHEET	3-9
OUTLINE DRAWING OF CABINET CY-1437/FPN-30	3-4
OUTLINE DRAWING OF RECORDING AMMETER ME-84/FPN-30	3-7
OUTLINE DRAWING OF VOLTAGE REGULATOR CN-235/FPN-30	3-6
METHOD OF ASSEMBLING BNC AND N CONNECTORS	3-12
METHOD OF ASSEMBLING UHF CONNECTORS	3-12

Figure 3–8. Interconnection Diagram of Loran Timer Set AN/FPN–30 at Station Employing Loran Switching Equipment Type AN/FPA–2



SYMBOL	NAVY STOCK NO.	NUMBER COND	ACTIVE COND	NAVY TYPE NO. (SEE NOTE-5)	FROM LOCATION	FROM EQUIPMENT	FROM CABLE CONN TYPE (SEE NOTE-6)	TO LOCATION	TO EQUIPMENT	TO CABLE CONN TYPE (SEE NOTE-6)
W1		COAX	1	RG-58/U	J2205	CABINET ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER) NO. 1	UG-88/U		WWV MIXER	
W2		COAX	1	RG-58/U	J2200		UG-88/U	E3502	CABINET ELECTRICAL EQUIPMENT CY-1466/FPA-2	UG-88/U
W3		COAX	1	RG-58/U	J2201		UG-88/U	E3501		UG-88/U
W4		COAX	1	RG-58/U	J2203		UG-88/U	E3503		UG-88/U
W5		COAX	1	RG-58/U	J2204		UG-88/U	E3504		UG-88/U
W6		COAX	1	RG-58/U	J2206		UG-88/U	E3506		UG-88/U
W7		COAX	1	RG-58/U	J2202		UG-88/U	E3505		UG-88/U
W8	G15-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO. 18 WIRE, NO. 6 STUD	TB3501 & 2		LUG, NO. 18 WIRE, NO. 6 STUD
W9	G15-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO. 18 WIRE, NO. 6 STUD	P2601	REC AMMETER-1	* PLUG
W10	G15-C-16850	2	2	RHDL NO. 12	TB2204		LUG, NO. 12 WIRE, 1/4" STUD		VOLT REG-1	LUG, NO. 12 WIRE, 1/4" STUD
W11		1	1	COPPER STRAP 3" MAX. WIDTH	GROUND PLATE				STATION GROUND	
W12	G15-C-10955-5	8	6	TTRS-4	TB2201				KEYING UNIT-1	
W13	G15-C-16850	2	2	RHDL NO. 12-		VOLT REG-1	LUG, NO. 12 WIRE, 1/4" STUD	TB3301	CABINET ELECTRICAL EQUIPMENT CY-1466/FPA-2	LUG, NO. 12 WIRE, 1/4" STUD
W14		COAX	1	RG-58/U	J2200	CABINET ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER) NO. 3	UG-88/U	E3514		UG-88/U
W15		COAX	1	RG-58/U	J2201		UG-88/U	E3513		UG-88/U
W16		COAX	1	RG-58/U	J2205		UG-88/U		WWV MIXER	
W17		COAX	1	RG-58/U	J2203		UG-88/U	E3515	CABINET ELECTRICAL EQUIPMENT CY-1466/FPA-2	UG-88/U
W18		COAX	1	RG-58/U	J2204		UG-88/U	E3516		UG-88/U
W19		COAX	1	RG-58/U	J2206		UG-88/U	E3518		UG-88/U
W20		COAX	1	RG-58/U	J2202		UG-88/U	E3517		UG-88/U
W21	G15-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO. 18 WIRE, NO. 6 STUD	TB3501 & 2		LUG, NO. 18 WIRE, NO. 6 STUD
W22	G15-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO. 18 WIRE, NO. 6 STUD	P2601	REC AMMETER-3	* PLUG
W23	G15-C-16850	2	2	RHDL NO. 12	TB2204		LUG, NO. 12 WIRE, 1/4" STUD		VOLT REG-3	LUG, NO. 12 WIRE, 1/4" STUD
W24		1	1	COPPER STRAP 3" MAX. WIDTH	GROUND PLATE				STATION GROUND	
W25	G15-C-10955-5	8	6	TTRS-4	TB2201		LUG, NO. 18 WIRE, NO. 6 STUD		KEYING UNIT-3	
W26	G15-C-16850	2	2	RHDL NO. 12		VOLT REG-2	LUG, NO. 12 WIRE, 1/4" STUD	TB3301	CABINET ELECTRICAL EQUIPMENT CY-1466/FPA-2	LUG, NO. 12 WIRE, 1/4" STUD
W27		COAX	1	RG-58/U	J2200	CABINET ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER) NO. 2	UG-88/U	E3508		UG-88/U
W28		COAX	1	RG-58/U	J2201		UG-88/U	E3507		UG-88/U
W29		COAX	1	RG-58/U	J2203		UG-88/U	E3509		UG-88/U
W30		COAX	1	RG-58/U	J2204		UG-88/U	E3510		UG-88/U
W31		COAX	1	RG-58/U	J2206		UG-88/U	E3512		UG-88/U
W32		COAX	1	RG-58/U	J2202		UG-88/U	E3511		UG-88/U
W33	G15-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO. 18 WIRE, NO. 6 STUD	TB3501 & 2		LUG, NO. 18 WIRE, NO. 6 STUD
W34	G15-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO. 18 WIRE, NO. 6 STUD	P2601	REC AMMETER-1	* PLUG
W35		COAX	1	RG-58/U	J2205		UG-88/U		WWV MIXER	
W36	G15-C-16850	2	2	RHDL NO. 12	TB2204		LUG, NO. 12 WIRE, 1/4" STUD		VOLT REG-2	LUG, NO. 12 WIRE, 1/4" STUD
W37		1	1	COPPER STRAP 3" MAX. WIDTH	GROUND PLATE				STATION GROUND	
W38	G15-C-10955-5	8	6	TTRS-4	TB2201		LUG, NO. 18 WIRE, NO. 6 STUD		KEYING UNIT-2	
W39	G15-C-16850	2	2	RHDL NO. 12		VOLT REG-2	LUG, NO. 12 WIRE, 1/4" STUD	TB3301	CABINET ELECTRICAL EQUIPMENT CY-1466/FPA-2	LUG, NO. 12 WIRE, 1/4" STUD
W40		COAX	1	RG-58/U	J2200	CABINET ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER) NO. 4	UG-88/U	E3520		UG-88/U
W41		COAX	1	RG-58/U	J2201		UG-88/U	E3519		UG-88/U
W42		COAX	1	RG-58/U	J2203		UG-88/U	E3521		UG-88/U
W43		COAX	1	RG-58/U	J2204		UG-88/U	E3522		UG-88/U
W44		COAX	1	RG-58/U	J2206		UG-88/U	E3524		UG-88/U
W45		COAX	1	RG-58/U	J2202		UG-88/U	E3523		UG-88/U
W46	G15-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO. 18 WIRE, NO. 6 STUD	TB3501 & 2		LUG, NO. 18 WIRE, NO. 6 STUD
W47	G15-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO. 18 WIRE, NO. 6 STUD	P2601	REC AMMETER-3	* PLUG
W48		COAX	1	RG-58/U	J2205		UG-88/U		WWV MIXER	
W49	G15-C-16850	2	2	RHDL NO. 12	TB2204		LUG, NO. 12 WIRE, 1/4" STUD		VOLT REG-4	LUG, NO. 12 WIRE, 1/4" STUD
W50		1	1	COPPER STRAP 3" MAX. WIDTH	GROUND PLATE				STATION GROUND	
W51	G15-C-10955-5	8	6	TTRS-4	TB2201		LUG, NO. 18 WIRE, NO. 6 STUD		KEYING UNIT-4	
W52	G15-C-16850	2	2	RHDL NO. 12		VOLT. REG-4	LUG, NO. 12 WIRE, 1/4" STUD	TB3301	SAME AS W2	LUG, NO. 12 WIRE, 1/4" STUD
W53	G15-C-10955	4	4	TTRS-2	TB2201	TIMER NO. 1	LUG, NO. 18 WIRE, NO. 6 STUD	TB2201	TIMER NO. 2	LUG, NO. 18 WIRE, NO. 6 STUD
W54	G15-C-10955	4	4	TTRS-2	TB2201	TIMER NO. 3	LUG, NO. 18 WIRE, NO. 6 STUD	TB2201	TIMER NO. 4	LUG, NO. 18 WIRE, NO. 6 STUD

NOTES:

1 NOTE THAT BOTH ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 (TIMERS) NOS. 1 AND 2 ARE CONNECTED TO RECORDER NO. 1 IN PARALLEL AND THEREFORE THESE TWO SHOULD NOT BOTH BE SELECTED SIMULTANEOUSLY AS OPERATING TIMERS. WHEN ONE IS OPERATING, THE OTHER SHOULD BE STANDBY. SIMILARLY BOTH ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 (TIMERS) NOS. 3 AND 4 ARE CONNECTED TO RECORDER NO. 3 AND SHOULD NOT BOTH BE SELECTED SIMULTANEOUSLY AS OPERATING. RECORDERS NOS. 2 AND 4 ARE SPARES. IN THE SPECIAL CASE WHERE A RECORDER MUST BE USED WITH ONLY ONE TIMER, CABLE NO. 53 OR NO. 54 IS NOT REQUIRED AND A JUMPER MUST BE CONNECTED BETWEEN TB2201-10 AND TB2201-11 OF THE TIMER.

2 AT A SINGLE PULSED STATION TIMERS NOS. 3 AND 4, VOLTAGE REGULATORS NOS. 3 AND 4, RECORDERS NOS. 3 AND 4, AND KEYING UNITS NOS. 3 AND 4 WILL NOT BE USED.

3 UNITS DRAWN IN DASHED LINES ARE NOT PART OF LORAN TIMER SET AN/FPN-30.

4 INTERCONNECTING CABLE TYPES AND THE CONDUCTOR GROUPING MAY VARY AMONG INSTALLATIONS. REFER TO THE APPLICABLE SHIP OR STATION PLANS TO DETERMINE THE CORRECT CABLING FOR ANY SPECIFIC INSTALLATION.

5 THE FOLLOWING COMBINATIONS OF CONNECTORS AND ADAPTERS SHOULD BE USED WITH RG-58/U CABLE.
(1) TO CONNECT RG-58/U CABLE TO TYPE N RECEPTACLE USE BNC CONNECTOR UG-88/U WITH UG-201A/U ADAPTER.
(2) TO CONNECT RG-58/U CABLE TO TYPE UHF RECEPTACLE USE BNC CONNECTOR UG-88/U WITH UG-273/U ADAPTER OR UHF CONNECTOR 49190 WITH UG-175/U ADAPTER.

6 THE LOCAL AND REMOTE SIGNAL LEADS TO J2203 AND J2204 ON ANY ONE TIMER MUST BE THE SAME LENGTH AND OF THE SAME TYPE CABLE.

7 TTRS-4, AND TTRS-2 TYPE CABLES PER MIL-C-915A (SHIPS) 30, JULY 1952. RHDL NO. 12 TYPE CABLE IS PER FEDERAL GOVERNMENT SPECIFICATION J-C-103

LIST OF CONNECTORS SUPPLIED BY MANUFACTURER AS PART OF LORAN TIMER SET AN/FPN-30.
9 ADAPTERS, N RIGHT ANGLE TYPE UG-27C/U
10 ADAPTERS, TYPE UG-201A/U (TO MATE BNC MALE AND N FEMALE)
10 PLUGS, BNC TYPE UG-88/U
10 PLUGS, N TYPE UG-21D/U
1 ADAPTER, TEE TYPE UG-107B/U
2 TERMINAL LUGS NO. 8 WIRE, 1/4" STUD SUPPLIED ON CABINET, ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER)
* 1 CONNECTOR, PLUG SUPPLIED ON RECORDING AMMETER

LIST OF CONNECTORS TO BE SUPPLIED BY INSTALLING ACTIVITY
ALL TERMINAL LUGS FOR TTRS-4 TYPE CABLES
ALL TERMINAL LUGS FOR RHDL NO. 12 TYPE CABLES
ALL COAX FITTINGS EXCEPT THOSE SUPPLIED BY MANUFACTURER
ALL CABLES ARE TO BE SUPPLIED BY INSTALLING ACTIVITY

REFERENCES

TITLE	FIGURE NO.
PICTORIAL SYSTEM DIAGRAM	3-1
INTERCONNECTION RUNNING SHEET	3-9
OUTLINE DRAWING OF CABINET CY-1437/FPN-30	3-4
OUTLINE DRAWING OF RECORDING AMMETER ME-84/FPN-30	3-7
OUTLINE DRAWING OF VOLTAGE REGULATOR CN-235/FPN-30	3-6
METHOD OF ASSEMBLING BNC AND N CONNECTORS	3-12
METHOD OF ASSEMBLING UHF CONNECTORS	3-12

Figure 3–8. Interconnection Diagram of Loran Timer Set AN/FPN–30 at Station Employing Loran Switching Equipment Type AN/FPA–2

SYMBOL	NAVY STOCK NUMBER	NAVY TYPE NUMBER (See note 2)	NUMBER OF ACTIVE COND.	COLOR	FROM				TO				FUNCTION	COND. AMPS
					LOCATION	COAX. CONN.	TERM. BOARD	PIN NO.	LOCATION	COAX. CONN.	TERM. BOARD	PIN NO.		
W1		RG-58/U	1	-	ELECTRICAL EQUIPMENT CABINET CY-1437/FPN-30 (TIMER) NO. 1	J2205	-	-	WWV MIXER		-	-	100 KC FREQ. CHECK	Less than 1
W2		RG-58/U	1	-		J2200	-	-	CABINET ELECTRICAL EQUIPMENT CY-1466/FPA-2	E3502	-	-	XMTR 100 KC	Less than 1
W3		RG-58/U	1	-		J2201	-	-		E3501	-	-	XMTR TRIGGER	Less than 1
W4		RG-58/U	1	-		J2203	-	-		E3503	-	-	LOCAL SIGNAL	Less than 1
W5		RG-58/U	1	-		J2204	-	-		E3504	-	-	REMOTE SIGNAL	Less than 1
W6		RG-58/U	1	-		J2206	-	-		E3506	-	-	BLANKING IN	Less than 1
W7		RG-58/U	1	-		J2202	-	-		E3505	-	-	BLANKING OUT	Less than 1
W8	G15-C-10955-5	TTRS-4	6			-	TB2202	4		-	TB3502	11	ALARM BUZZER	Less than 1
						-		5		-		12	SYNC. ERROR ALARM	Less than 1
						-		6		-		3	OFF SYNC. ALARM	Less than 1
						-		7		-		4	ALARM COMMON	Less than 1
						-		8		-	TB3501	7	STANDBY - OPERATE	Less than 1
						-		9		-		8	CONTROL	Less than 1
W9	G15-C-10955-5	TTRS-4	6			-	TB2202	10		-	P2601	1	PEN & MOTOR	Less than 1
													COMMON	
						-		11	RECORDING AMMETER NO. 1	-		4	DRIVE MOTOR	Less than 1
						-		12		-		7	LOCAL BLINK PEN	Less than 1
						-		13		-		10	OFF SYNC PEN	Less than 1
						-		14		-		13	(+) DC METER	Less than 1
						-		15		-		16	(-) DC METER	Less than 1
W10	G15-C-16850	RHDL #12	2	WH		-	TB2204	1	VOLTAGE REGULATOR NO. 1	-	OUTPUT		115 V. AC POWER	11
				BLK		-		2		-	OUT. COMMON			11
W11		3" MAX	1	-	(GND PLATE)	-	-	-	STATION GROUND	-			CABINET	
		WIDTH								-			CY-1437/FPN-30	
		Copper Strap											NO. 1 GROUND	
W12	G15-C-10955-5	TTRS-4	6			-	TB2201	3		-			EXT. KEY & LOAD	Less than 1
													COM	
						-		4	KEYING UNIT NO. 1	-			EXTERNAL LOAD	Less than 1
						-		5		-			B-2 KEY	Less than 1
						-		6		-			B-3 KEY	Less than 1
						-		7		-			B-4 KEY	Less than 1
						-		8		-			B-5 KEY	Less than 1
W13	G15-C-16850	RHDL #12	2	WH	VOLTAGE REGULATOR NO. 1	-	INPUT		CABINET ELECTRICAL EQUIPMENT CY-1466/FPA-2	-	TB3301	1	115 V. AC POWER	11
				BLK		-	IN. COMMON			-		2		11
W14		RG-58/U	1	-	ELECTRICAL EQUIPMENT CABINET CY-1437/FPN-30 (TIMER) NO. 3	J2200	-	-		E3514	-	-	XMTR 100 KC	Less than 1
W15		RG-58/U	1	-		J2201	-	-		E3513	-	-	XMTR TRIGGER	Less than 1
W16		RG-58/U	1	-		J2205	-	-	WWV MIXER		-	-	100 KC FREQ. CHECK	Less than 1
W17		RG-58/U	1	-		J2203	-	-	CABINET ELECTRICAL EQUIPMENT CY-1466/FPA-2	E3515	-	-	LOCAL SIGNAL	Less than 1
W18		RG-58/U	1	-		J2204	-	-		E3516	-	-	REMOTE SIGNAL	Less than 1
W19		RG-58/U	1	-		J2206	-	-		E3518	-	-	BLANKING IN	Less than 1
W20		RG-58/U	1	-		J2202	-	-		E3517	-	-	BLANKING OUT	Less than 1
W21	G15-C-10955-5	TTRS-4	6			-	TB2202	4			TB3502	7	ALARM BUZZER	Less than 1
						-		5				8	SYNC. ERROR ALARM	Less than 1
						-		6			TB3501	11	OFF SYNC. ALARM	Less than 1
						-		7				12	ALARM COMMON	Less than 1
						-		8				3	STANDBY-OPERATE	Less than 1
						-		9				4	CONTROL	Less than 1
W22	G15-C-10955-5	TTRS-4	6			-	TB2202	10		-	P2601	1	PEN & MOTOR COM.	Less than 1
						-		11	RECORDING AMMETER NO. 3	-		4	DRIVE MOTOR	Less than 1
						-		12		-		7	LOCAL BLINK PEN	Less than 1
						-		13		-		10	OFF SYNC PEN	Less than 1
						-		14		-		13	(+) DC METER	Less than 1
						-		15		-		16	(-) DC METER	Less than 1
W23	G15-C-16850	RHDL #12	2	WH		-	TB2204	1	VOLTAGE REGULATOR NO. 3	-	OUTPUT		115 V. AC POWER	11
				BLK		-		2		-	OUT. COMMON			11
W24		3" MAX.	1	-	(GND PLATE)	-	-	-	STATION GROUND	-			CABINET CY-	
		WIDTH											1437/FPN-30 NO. 3	
		Copper Strap											GROUND	
W25	G15-C-10955-5	TTRS-4	6			-	TB2201	3		-			EXT. KEY & LOAD	Less than 1
													COM.	
						-		4	KEYING UNIT NO. 3	-			EXTERNAL LOAD	Less than 1
						-		5		-			B-2 KEY	Less than 1
						-		6		-			B-3 KEY	Less than 1
						-		7		-			B-4 KEY	Less than 1
						-		8		-			B-5 KEY	Less than 1
W26	G15-C-16850	RHDL #12	2	WH	VOLTAGE REGULATOR NO. 3	-	INPUT		CAB. ELECT. EQUIP. CY-1466/FPA-2	-	TB3301	5	115 V. AC POWER	11
				BLK		-	IN. COMMON			-				11

ALL CABLES SUPPLIED BY INSTALLING ACTIVITY

SYMBOL	NAVY STOCK NUMBER	NAVY TYPE NUMBER (See note 2)	NUMBER OF ACTIVE COND.	COLOR	FROM				TO				FUNCTION	COND. AMPS
					LOCATION	COAX. CONN.	TERM. BOARD	PIN NO.	LOCATION	COAX. CONN.	TERM. BOARD	PIN NO.		
W27		RG-58/U	1	-	ELECTRICAL EQUIPMENT CABINET CY-1437/FPN-30 (TIMER) NO. 2	J2200	-	-	CABINET ELECTRICAL EQUIPMENT CY-1466/FPA-2	E3508	-	-	XMTR 100 KC	Less than 1
W28		RG-58/U	1	-		J2201	-	-		E3507	-	-	XMTR TRIGGER	Less than 1
W29		RG-58/U	1	-		J2203	-	-		E3509	-	-	LOCAL SIGNAL	Less than 1
W30		RG-58/U	1	-		J2204	-	-		E3510	-	-	REMOTE SIGNAL	Less than 1
W31		RG-58/U	1	-		J2206	-	-		E3512	-	-	BLANKING IN	Less than 1
W32		RG-58/U	1	-		J2202	-	-		E3511	-	-	BLANKING OUT	Less than 1
W33	G15-C-10955-5	TTRS-4	6			-	TB2202	4		-	TB3502	5	ALARM BUZZER	Less than 1
						-		5		-		6	SYNC ERROR ALARM	Less than 1
						-		6		-	TB3501	9	OFF SYNC ALARM	Less than 1
						-		7		-		10	ALARM COMMON	Less than 1
						-		8		-		1	STANDBY - OPERATE	Less than 1
						-		9		-		2	CONTROL	Less than 1
W34	G15-C-10955-5	TTRS-4	6			-	TB2202	10		-	P2601	2	PEN & MOTOR COM.	Less than 1
						-		11	RECORDING AMMETER NO. 1	-		5	DRIVE MOTOR	Less than 1
						-		12		-		8	LOCAL BLINK PEN	Less than 1
						-		13		-		11	OFF SYNC PEN	Less than 1
						-		14		-		14	(+) DC METER	Less than 1
						-		15		-		17	(-) DC METER	Less than 1
W35		RG-58/U	1	-		J2205	-	-	WWV MIXER		-	-	100 KC FREQ. CHECK	Less than 1
W36	G15-C-16850	RHDL #12	2	WH		-	TB2204	1	VOLTAGE REGULATOR NO. 2	-	OUTPUT		115 V. AC POWER	11
				BLK		-		2		-	OUT. COMMON			11
W37		3" MAX.	1	-	(GND PLATE)	-	-	-	STATION GROUND	-			CABINET	
		WIDTH											CY-1437/FPN-30	
		Copper Strap											NO. 2 GROUND	
W38	G15-C-10955-5	TTRS-4	6			-	TB2201	3		-			EXT. KEY & LOAD	Less than 1
													COM.	
						-		4	KEYING UNIT NO. 2	-			EXTERNAL LOAD	Less than 1
						-		5		-			B-2 KEY	Less than 1
						-		6		-			B-3 KEY	Less than 1
						-		7		-			B-4 KEY	Less than 1
						-		8		-			B-5 KEY	Less than 1
W39	G15-C-16850	RHDL #12	2	WH	VOLTAGE REGULATOR NO. 2	-	INPUT		CABINET ELECTRICAL EQUIPMENT CY-1466/FPA-2	-	TB3301	3	115 V. AC POWER	11
				BLK		-	IN. COMMON			-		4		11
W40		RG-58/U	1	-	ELECTRICAL EQUIPMENT CABINET CY-1437/FPN-30 (TIMER) NO. 4	J2200	-	-		E3520	-	-	XMTR 100 KC	Less than 1
W41		RG-58/U	1	-		J2201	-	-		E3519	-	-	XMTR TRIGGER	Less than 1
W42		RG-58/U	1	-		J2203	-	-		E3521	-	-	LOCAL SIGNAL	Less than 1
W43		RG-58/U	1	-		J2204	-	-		E3522	-	-	REMOTE SIGNAL	Less than 1
W44		RG-58/U	1	-		J2206	-	-		E3524	-	-	BLANKING IN	Less than 1
W45		RG-58/U	1	-		J2202	-	-		E3523	-	-	BLANKING OUT	Less than 1
W46	G15-C-10955-5	TTRS-4	6			-	TB2202	4		-	TB3502	9	ALARM BUZZER	Less than 1
						-		5		-		10	SYNC ERROR ALARM	Less than 1
						-		6		-		1	OFF SYNC ALARM	Less than 1
						-		7		-		2	ALARM COMMON	Less than 1
						-		8		-	TB3501	5	STANDBY - OPERATE	Less than 1
						-		9		-		6	CONTROL	Less than 1
W47	G15-C-10955-5	TTRS-4	6			-	TB2202	10		-	P2601	2	PEN & MOTOR COM.	Less than 1
						-		11	RECORDING AMMETER NO. 3	-		5	DRIVE MOTOR	Less than 1
						-		12		-		8	LOCAL BLINK PEN	Less than 1
						-		13		-		11	OFF SYNC PEN	Less than 1
						-		14		-		14	(+) DC METER	Less than 1
						-		15		-		17	(-) DC METER	Less than 1
W48		RG-58/U	1	-		J2205	-	-	WWV MIXER		-	-	100 KC FREQ. CHECK	Less than 1
W49	G15-C-16850	RHDL #12	2	WH		-	TB2204	1	VOLTAGE REGULATOR NO. 4	-	OUTPUT		115 V. AC POWER	11
				BLK		-		2			OUT. COMMON			11
W50		3" MAX.	1	-	(GND PLATE)	-	-	-	STATION GROUND	-			CABINET	
		WIDTH											CY-1437/FPN-30	
		Copper strap											NO. 4 GROUND	
W51	G15-C-10955-5	TTRS-4	6			-	TB2201	3		-			EXT. KEY & LOAD	Less than 1
													COM.	
						-		4	KEYING UNIT NO. 4	-			EXTERNAL LOAD	Less than 1
						-		5		-			B-2 KEY	Less than 1
						-		6		-			B-3 KEY	Less than 1
						-		7		-			B-4 KEY	Less than 1
						-		8		-			B-5 KEY	Less than 1
W52	G15-C-16850	RHDL #12	2	WH	VOLTAGE REGULATOR NO. 4	-	INPUT		CAB. ELECT. EQUIP. CY-1466/FPA-2	-	TB3301	7	115 V. AC POWER	11
				BLK		-	IN. COMMON					8		11

ALL CABLES SUPPLIED BY INSTALLING ACTIVITY

SYMBOL	NAVY STOCK NUMBER	NAVY TYPE NUMBER (See note 2)	NUMBER OF ACTIVE COND.	COLOR	FROM				TO				FUNCTION	COND. AMPS
					LOCATION	COAX. CONN.	TERM. BOARD	PIN NO.	LOCATION	COAX. CONN.	TERM. BOARD	PIN NO.		
W53	G15-C-10955	TTRS-2	4		ELECTRICAL EQUIP. CABINET CY-1437/FPN-30 (TIMER) NO. 1	-	TB2201	10	ELECTRICAL EQUIP. CABINET CY-1437/FPN-30 (TIMER) NO. 2	-	TB2201	12	K2201 INTERLOCK	Less than 1
						-		11		-		13		Less than 1
						-		12		-		10		Less than 1
						-		13		-		11		Less than 1
W54	G15-C-10955	TTRS-2	4		ELECTRICAL EQUIP. CABINET CY-1437/FPN-30 (TIMER) NO. 3	-	TB2201	10	ELECTRICAL EQUIP. CABINET CY-1437/FPN-30 (TIMER) NO. 4	-	TB2201	12	K2201 INTERLOCK	Less than 1
						-		11		-		13		Less than 1
						-		12		-		10		Less than 1
						-		13		-		11		Less than 1

ALL CABLES SUPPLIED BY INSTALLING ACTIVITY

Figure 3–9. Running List, Loran Timer Set AN/FPN–30 at Station Employing Loran Switching Equipment Type AN/FPA–2

SYMBOL	NAVY STOCK NUMBER	NAVY TYPE NUMBER (See note 2)	NUMBER OF ACTIVE COND.	COLOR	FROM LOCATION	FROM COAX. CONN.	FROM TERM. BOARD	FROM PIN NO.	TO LOCATION	TO COAX. CONN.	TO TERM. BOARD	TO PIN NO.	FUNCTION	COND. AMPS
W1		RG-58/U	1	-		J2205	-	-	WWV MIXER		-	-	100 KC FREQ. CHECK	Less than 1
W2		RG-58/U	1	-		J2200	-	-		E3502	-	-	XMTR 100 KC	Less than 1
W3		RG-58/U	1	-		J2201	-	-		E3501	-	-	XMTR TRIGGER	Less than 1
W4		RG-58/U	1	-		J2203	-	-		E3503	-	-	LOCAL SIGNAL	Less than 1
W5		RG-58/U	1	-		J2204	-	-		E3504	-	-	REMOTE SIGNAL	Less than 1
W6		RG-58/U	1	-		J2206	-	-	CABINET	E3506	-	-	BLANKING IN	Less than 1
W7		RG-58/U	1	-		J2202	-	-	ELECTRICAL	E3505	-	-	BLANKING OUT	Less than 1
W8	G15-C-10955-5	TTRS-4	6			-	TB2202	4	EQUIPMENT	-	TB3502	11	ALARM BUZZER	Less than 1
						-		5	CY-1466/FPA-2	-		12	SYNC. ERROR ALARM	Less than 1
						-		6		-		3	OFF SYNC. ALARM	Less than 1
						-		7		-		4	ALARM COMMON	Less than 1
					ELECTRICAL	-		8		-	TB3501	7	STANDBY - OPERATE	Less than 1
					EQUIPMENT	-		9		-		8	CONTROL	Less than 1
W9	G15-C-10955-5	TTRS-4	6		CABINET	-	TB2202	10		-	P2601	1	PEN & MOTOR	Less than 1
					CY-1437/FPN-30								COMMON	
					(TIMER) NO. 1	-		11	RECORDING	-		4	DRIVE MOTOR	Less than 1
						-		12	AMMETER	-		7	LOCAL BLINK PEN	Less than 1
						-		13	NO. 1	-		10	OFF SYNC PEN	Less than 1
						-		14		-		13	(+) DC METER	Less than 1
						-		15		-		16	(-) DC METER	Less than 1
W10	G15-C-16850	RHDL #12	2	WH		-	TB2204	1	VOLTAGE	-	OUTPUT		115 V. AC POWER	11
				BLK		-		2	REGULATOR NO. 1	-	OUT. COMMON			11
W11		3" MAX	1	-	(GND PLATE)	-	-	-	STATION GROUND	-			CABINET	
		WIDTH								-			CY-1437/FPN-30	
		Copper Strap											NO. 1 GROUND	
W12	G15-C-10955-5	TTRS-4	6			-	TB2201	3		-			EXT. KEY & LOAD	Less than 1
													COM	
						-		4		-			EXTERNAL LOAD	Less than 1
						-		5	KEYING UNIT	-			B-2 KEY	Less than 1
						-		6	NO. 1	-			B-3 KEY	Less than 1
						-		7		-			B-4 KEY	Less than 1
						-		8		-			B-5 KEY	Less than 1
W13	G15-C-16850	RHDL #12	2	WH	VOLTAGE	-	INPUT		CABINET	-	TB3301	1	115 V. AC POWER	11
				BLK	REGULATOR NO. 1	-	IN. COMMON		ELECTRICAL	-		2		11
W14		RG-58/U	1	-		J2200	-	-	EQUIPMENT	E3514	-	-	XMTR 100 KC	Less than 1
W15		RG-58/U	1	-		J2201	-	-	CY-1466/FPA-2	E3513	-	-	XMTR TRIGGER	Less than 1
W16		RG-58/U	1	-		J2205	-	-	WWV MIXER		-	-	100 KC FREQ. CHECK	Less than 1
W17		RG-58/U	1	-		J2203	-	-		E3515	-	-	LOCAL SIGNAL	Less than 1
W18		RG-58/U	1	-		J2204	-	-		E3516	-	-	REMOTE SIGNAL	Less than 1
W19		RG-58/U	1	-		J2206	-	-	CABINET	E3518	-	-	BLANKING IN	Less than 1
W20		RG-58/U	1	-		J2202	-	-	ELECTRICAL	E3517	-	-	BLANKING OUT	Less than 1
W21	G15-C-10955-5	TTRS-4	6			-	TB2202	4	EQUIPMENT		TB3502	7	ALARM BUZZER	Less than 1
						-		5	CY-1466/FPA-2			8	SYNC. ERROR ALARM	Less than 1
					ELECTRICAL	-		6			TB3501	11	OFF SYNC. ALARM	Less than 1
					EQUIPMENT	-		7				12	ALARM COMMON	Less than 1
					CABINET	-		8				3	STANDBY-OPERATE	Less than 1
					CY-1437/FPN-30	-		9				4	CONTROL	Less than 1
W22	G15-C-10955-5	TTRS-4	6		(TIMER) NO. 3	-	TB2202	10		-	P2601	1	PEN & MOTOR COM.	Less than 1
						-		11	RECORDING	-		4	DRIVE MOTOP	Less than 1
						-		12	AMMETER	-		7	LOCAL BLINK PEN	Less than 1
						-		13	NO. 3	-		10	OFF SYNC PEN	Less than 1
						-		14		-		13	(+) DC METER	Less than 1
						-		15		-		16	(-) DC METER	Less than 1
W23	G15-C-16850	RHDL #12	2	WH		-	TB2204	1	VOLTAGE	-	OUTPUT		115 V. AC POWER	11
				BLK		-		2	REGULATOR NO. 3	-	OUT. COMMON			11
W24		3" MAX.	1	-	(GND PLATE)	-	-	-	STATION GROUND	-			CABINET CY-	
		WIDTH											1437/FPN-30 NO. 3	
		Copper Strap											GROUND	
W25	G15-C-10955-5	TTRS-4	6			-	TB2201	3		-			EXT. KEY & LOAD	Less than 1
													COM.	
						-		4		-			EXTERNAL LOAD	Less than 1
						-		5	KEYING UNIT	-			B-2 KEY	Less than 1
						-		6	NO. 3	-			B-3 KEY	Less than 1
						-		7		-			B-4 KEY	Less than 1
						-		8		-			B-5 KEY	Less than 1
W26	G15-C-16850	RHDL #12	2	WH	VOLTAGE	-	INPUT		CAB. ELECT.	-	TB3301	5	115 V. AC POWER	11
				BLK	REGULATOR NO. 3	-	IN. COMMON		EQUIP.	-				11
									CY-1466/FPA-2					

ALL CABLES SUPPLIED BY INSTALLING ACTIVITY

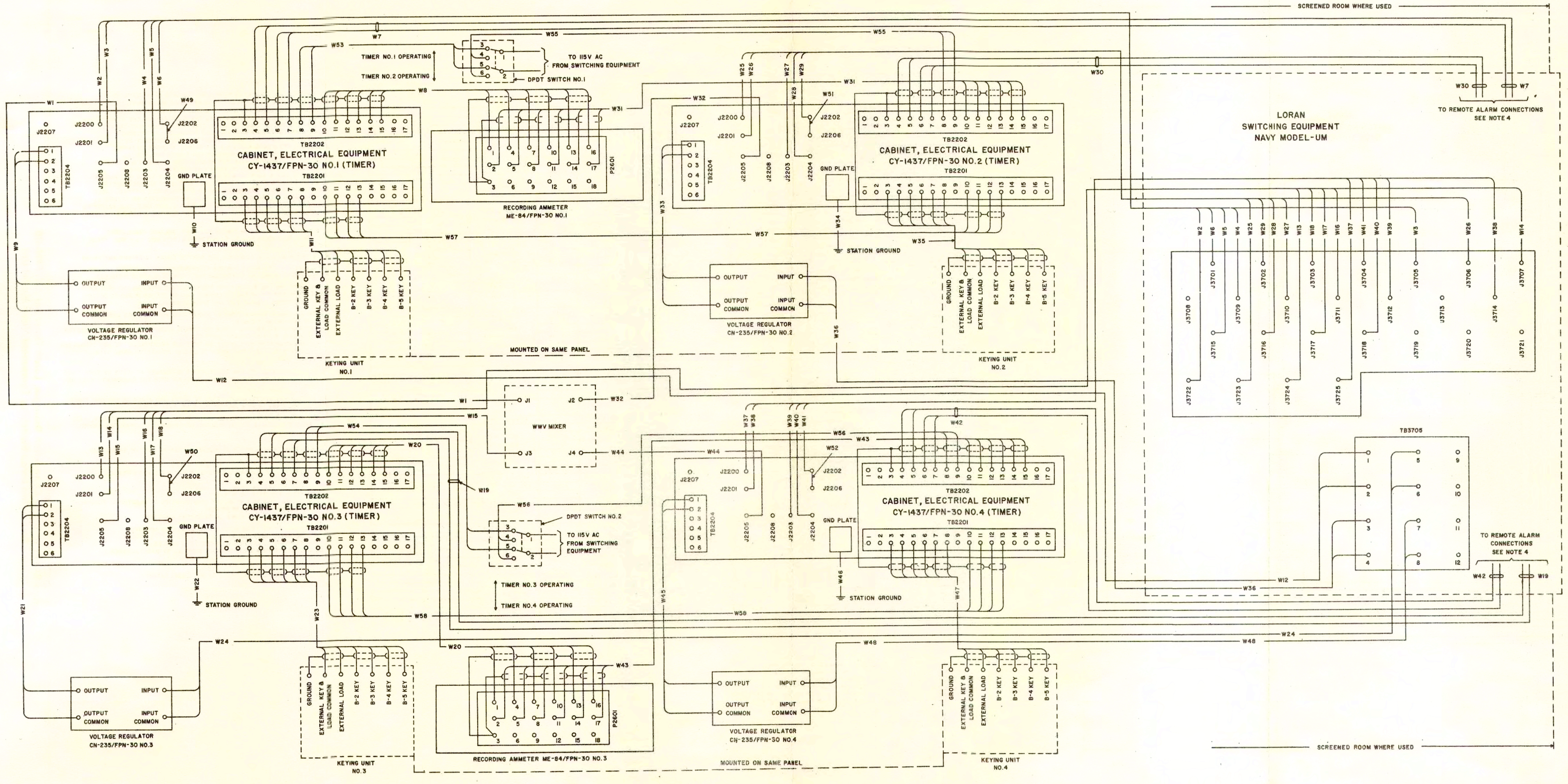
SYMBOL	NAVY STOCK NUMBER	NAVY TYPE NUMBER (See note 2)	NUMBER OF ACTIVE COND.	COLOR	FROM LOCATION	FROM COAX. CONN.	FROM TERM. BOARD	FROM PIN NO.	TO LOCATION	TO COAX. CONN.	TO TERM. BOARD	TO PIN NO.	FUNCTION	COND. AMPS
W27		RG-58/U	1	-		J2200	-	-		E3508	-	-	XMTR 100 KC	Less than 1
W28		RG-58/U	1	-		J2201	-	-		E3507	-	-	XMTR TRIGGER	Less than 1
W29		RG-58/U	1	-		J2203	-	-		E3509	-	-	LOCAL SIGNAL	Less than 1
W30		RG-58/U	1	-		J2204	-	-	CABINET	E3510	-	-	REMOTE SIGNAL	Less than 1
W31		RG-58/U	1	-		J2206	-	-	ELECTRICAL	E3512	-	-	BLANKING IN	Less than 1
W32		RG-58/U	1	-		J2202	-	-	EQUIPMENT	E3511	-	-	BLANKING OUT	Less than 1
W33	G15-C-10955-5	TTRS-4	6			-	TB2202	4	CY-1466/FPA-2	-	TB3502	5	ALARM BUZZER	Less than 1
						-		5		-		6	SYNC ERROR ALARM	Less than 1
						-		6		-	TB3501	9	OFF SYNC ALARM	Less than 1
						-		7		-		10	ALARM COMMON	Less than 1
					ELECTRICAL	-		8		-		1	STANDBY - OPERATE	Less than 1
					EQUIPMENT	-		9		-		2	CONTROL	Less than 1
W34	G15-C-10955-5	TTRS-4	6		CABINET	-	TB2202	10		-	P2601	2	PEN & MOTOR COM.	Less than 1
					CY-1437/FPN-30	-		11	RECORDING	-		5	DRIVE MOTOR	Less than 1
					(TIMER) NO. 2	-		12	AMMETER	-		8	LOCAL BLINK PEN	Less than 1
						-		13	NO. 1	-		11	OFF SYNC PEN	Less than 1
						-		14		-		14	(+) DC METER	Less than 1
						-		15		-		17	(-) DC METER	Less than 1
W35		RG-58/U	1	-		J2205	-	-	WWV MIXER		-	-	100 KC FREQ. CHECK	Less than 1
W36	G15-C-16850	RHDL #12	2	WH		-	TB2204	1	VOLTAGE	-	OUTPUT		115 V. AC POWER	11
				BLK		-		2	REGULATOR NO. 2	-	OUT. COMMON			11
W37		3" MAX.	1	-	(GND PLATE)	-	-	-	STATION	-			CABINET	
		WIDTH							GROUND				CY-1437/FPN-30	
		Copper Strap											NO. 2 GROUND	
W38	G15-C-10955-5	TTRS-4	6			-	TB2201	3		-			EXT. KEY & LOAD	Less than 1
													COM.	
						-		4		-			EXTERNAL LOAD	Less than 1
						-		5	KEYING UNIT	-			B-2 KEY	Less than 1
						-		6	NO. 2	-			B-3 KEY	Less than 1
						-		7		-			B-4 KEY	Less than 1
						-		8		-			B-5 KEY	Less than 1
W39	G15-C-16850	RHDL #12	2	WH	VOLTAGE	-	INPUT			-	TB3301	3	115 V. AC POWER	11
				BLK	REGULATOR NO. 2	-	IN. COMMON			-		4		11
W40		RG-58/U	1	-		J2200	-	-		E3520	-	-	XMTR 100 KC	Less than 1
W41		RG-58/U	1	-		J2201	-	-		E3519	-	-	XMTR TRIGGER	Less than 1
W42		RG-58/U	1	-		J2203	-	-	CABINET	E3521	-	-	LOCAL SIGNAL	Less than 1
W43		RG-58/U	1	-		J2204	-	-	ELECTRICAL	E3522	-	-	REMOTE SIGNAL	Less than 1
W44		RG-58/U	1	-		J2206	-	-	EQUIPMENT	E3524	-	-	BLANKING IN	Less than 1
W45		RG-58/U	1	-		J2202	-	-	CY-1466/FPA-2	E3523	-	-	BLANKING OUT	Less than 1
W46	G15-C-10955-5	TTRS-4	6			-	TB2202	4		-	TB3502	9	ALARM BUZZER	Less than 1
						-		5		-		10	SYNC ERROR ALARM	Less than 1
						-		6		-		1	OFF SYNC ALARM	Less than 1
						-		7		-		2	ALARM COMMON	Less than 1
						-		8		-	TB3501	5	STANDBY - OPERATE	Less than 1
						-		9		-		6	CONTROL	Less than 1
W47	G15-C-10955-5	TTRS-4	6		ELECTRICAL	-	TB2202	10		-	P2601	2	PEN & MOTOR COM.	Less than 1
					EQUIPMENT	-		11	RECORDING	-		5	DRIVE MOTOR	Less than 1
					CABINET	-		12	AMMETER	-		8	LOCAL BLINK PEN	Less than 1
					CY-1437/FPN-30	-		13	NO. 3	-		11	OFF SYNC PEN	Less than 1
					(TIMER) NO. 4	-		14		-		14	(+) DC METER	Less than 1
						-		15		-		17	(-) DC METER	Less than 1
W48		RG-58/U	1	-		J2205	-	-	WWV MIXER		-	-	100 KC FREQ. CHECK	Less than 1
W49	G15-C-16850	RHDL #12	2	WH		-	TB2204	1	VOLTAGE	-	OUTPUT		115 V. AC POWER	11
				BLK		-		2	REGULATOR NO. 4		OUT. COMMON			11
W50		3" MAX.	1	-	(GND PLATE)	-	-	-	STATION GROUND	-			CABINET	
		WIDTH											CY-1437/FPN-30	
		Copper strap											NO. 4 GROUND	
W51	G15-C-10955-5	TTRS-4	6			-	TB2201	3		-			EXT. KEY & LOAD	Less than 1
													COM.	
						-		4		-			EXTERNAL LOAD	Less than 1
						-		5	KEYING UNIT	-			B-2 KEY	Less than 1
						-		6	NO. 4	-			B-3 KEY	Less than 1
						-		7		-			B-4 KEY	Less than 1
						-		8		-			B-5 KEY	Less than 1
W52	G15-C-16850	RHDL #12	2	WH	VOLTAGE	-	INPUT		CAB. ELECT.	-	TB3301	7	115 V. AC POWER	11
				BLK	REGULATOR NO. 4	-	IN. COMMON		EQUIP.			8		11
									CY-1466/FPA-2					

ALL CABLES SUPPLIED BY INSTALLING ACTIVITY

SYMBOL	NAVY STOCK NUMBER	NAVY TYPE NUMBER (See note 2)	NUMBER OF ACTIVE COND.	COLOR	FROM LOCATION	FROM COAX. CONN.	FROM TERM. BOARD	FROM PIN NO.	TO LOCATION	TO COAX. CONN.	TO TERM. BOARD	TO PIN NO.	FUNCTION	COND. AMPS
W53	G15-C-10955	TTRS-2	4		ELECTRICAL	-	TB2201	10	ELECTRICAL	-	TB2201	12		Less than 1
					EQUIP. CABINET	-		11	EQUIP. CABINET	-		13	K2201	Less than 1
					CY-1437/FPN-30	-		12	CY-1437/FPN-30	-		10	INTERLOCK	Less than 1
					(TIMER) NO. 1	-		13	(TIMER) NO. 2	-		11		Less than 1
W54	G15-C-10955	TTRS-2	4		ELECTRICAL	-	TB2201	10	ELECTRICAL	-	TB2201	12		Less than 1
					EQUIP. CABINET	-		11	EQUIP. CABINET	-		13	K2201	Less than 1
					CY-1437/FPN-30	-		12	CY-1437/FPN-30	-		10	INTERLOCK	Less than 1
					(TIMER) NO. 3	-		13	(TIMER) NO. 4	-		11		Less than 1

ALL CABLES SUPPLIED BY INSTALLING ACTIVITY

Figure 3–9. Running List, Loran Timer Set AN/FPN–30 at Station Employing Loran Switching Equipment Type AN/FPA–2



SYMBOL	NAVY STOCK NO.	NUMBER COND.	ACTIVE COND.	NAVY TYPE NO. (SEE NOTES 4 & 6)	FROM LOCATION	FROM EQUIPMENT	FROM CABLE CONN. TYPE (SEE NOTE 6)	TO LOCATION	TO EQUIPMENT	TO CABLE CONN. TYPE (SEE NOTE 6)
W1		COAX	1	RG-58/U	J2205	CABINET ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER) NO.1	UG-88/U		WWV MIXER	
W2		COAX	1	RG-58/U	J2200		UG-88/U	J3722	LORAN SWITCHING EQUIPMENT NAVY MODEL-UM	UG-88/U
W3		COAX	1	RG-58/U	J2201		UG-88/U	J3705		UG-88/U
W4		COAX	1	RG-58/U	J2203		UG-88/U	J3709		UG-88/U
W5		COAX	1	RG-58/U	J2204		UG-88/U	J3715		UG-88/U
W6		COAX	1	RG-58/U	J2202		UG-88/U	J3701		UG-88/U
W7	GI5-C-10955	4	4	TTRS-2	TB2202		LUG, NO.18 WIRE, NO.6 STUD		REMOTE ALARM	
W8	GI5-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO.18 WIRE, NO.6 STUD	P2601	REC. AMMETER-1	* PLUG
W9	GI5-C-16850	2	2	RHDL NO.12	TB2204		LUG, NO.12 WIRE, 1/4" STUD		VOLT. REGULATOR-1	LUG, NO.12 WIRE, 1/4" STUD
W10		1	1	COPPER STRAP 3" MAX. WIDTH	GROUND PLATE				STATION GROUND	
W11	GI5-C-10955-5	8	6	TTRS-4	TB2201		LUG, NO.18 WIRE, NO.6 STUD		KEYING UNIT-1	
W12	GI5-C-16850	2	2	RHDL NO.12		VOLT. REG.-1	LUG, NO.12 WIRE, 1/4" STUD	TB3705	LORAN SWITCH. EQUIP. NAVY MODEL-UM	LUG, NO.12 WIRE, 1/4" STUD
W13		COAX	1	RG-58/U	J2200	CABINET ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER) NO.3	UG-88/U	J3724		UG-88/U
W14		COAX	1	RG-58/U	J2201		UG-88/U	J3707		UG-88/U
W15		COAX	1	RG-58/U	J2205		UG-88/U		WWV MIXER	
W16		COAX	1	RG-58/U	J2203		UG-88/U	J3711	LORAN SWITCH. EQUIP. NAVY MODEL-UM	UG-88/U
W17		COAX	1	RG-58/U	J2204		UG-88/U	J3717		UG-88/U
W18		COAX	1	RG-58/U	J2202		UG-88/U	J3703		UG-88/U
W19	GI5-C-10955	4	4	TTRS-2	TB2202		LUG, NO.18 WIRE, NO.6 STUD		REMOTE ALARM	
W20	GI5-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO.18 WIRE, NO.6 STUD	P2601	REC. AMMETER-3	* PLUG
W21	GI5-C-16850	2	2	RHDL NO.12	TB2204		LUG, NO.12 WIRE, 1/4" STUD		VOLT. REGULATOR-3	LUG, NO.12 WIRE, 1/4" STUD
W22		1	1	COPPER STRAP 3" MAX. WIDTH	GROUND PLATE				STATION GROUND	
W23		8	6	TTRS-4	TB2201		LUG, NO.18 WIRE, NO.6 STUD		KEYING UNIT-3	
W24	GI5-C-16850	2	2	RHDL NO.12		VOLT. REG.-3	LUG, NO.12 WIRE, 1/4" STUD	TB3705	LORAN SWITCHING EQUIPMENT NAVY MODEL-UM	LUG, NO.12 WIRE, 1/4" STUD
W25		COAX	1	RG-58/U	J2200	CABINET ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER) NO.2	UG-88/U	J3723		UG-88/U
W26		COAX	1	RG-58/U	J2201		UG-88/U	J3706		UG-88/U
W27		COAX	1	RG-58/U	J2203		UG-88/U	J3710		UG-88/U
W28		COAX	1	RG-58/U	J2204		UG-88/U	J3716		UG-88/U
W29		COAX	1	RG-58/U	J2202		UG-88/U	J3702		UG-88/U
W30	GI5-C-10955	4	4	TTRS-2	TB2202		LUG, NO.18 WIRE, NO.6 STUD		REMOTE ALARM	
W31	GI5-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO.18 WIRE, NO.6 STUD	P2601	REC. AMMETER-1	* PLUG
W32		COAX	1	RG-58/U	J2205				WWV MIXER	
W33	GI5-C-16850	2	2	RHDL NO.12	TB2204		LUG, NO.12 WIRE, 1/4" STUD		VOLT. REGULATOR-2	LUG, NO.12 WIRE, 1/4" STUD
W34		1	1	COPPER STRAP 3" MAX. WIDTH	GROUND PLATE				STATION GROUND	
W35	GI5-C-10955-5	8	6	TTRS-4	TB2201		LUG, NO.18 WIRE, NO.6 STUD		KEYING UNIT-2	
W36	GI5-C-16850	2	2	RHDL NO.12		VOLT. REG.-2	LUG, NO.12 WIRE, 1/4" STUD	TB3705	LORAN SWITCHING EQUIPMENT NAVY MODEL-UM	LUG, NO.12 WIRE, 1/4" STUD
W37		COAX	1	RG-58/U	J2200	CABINET ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER) NO.4	UG-88/U	J3725		UG-88/U
W38		COAX	1	RG-58/U	J2201		UG-88/U	J3714		UG-88/U
W39		COAX	1	RG-58/U	J2203		UG-88/U	J3712		UG-88/U
W40		COAX	1	RG-58/U	J2204		UG-88/U	J3718		UG-88/U
W41		COAX	1	RG-58/U	J2202		UG-88/U	J3704		UG-88/U
W42	GI5-C-10955	4	4	TTRS-2	TB2202		LUG, NO.18 WIRE, NO.6 STUD		REMOTE ALARM	
W43	GI5-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO.18 WIRE, NO.6 STUD	P2601	REC. AMMETER-3	* PLUG
W44		COAX	1	RG-58/U	J2205		UG-88/U		WWV MIXER	
W45	GI5-C-16850	2	2	RHDL NO.12	TB2204		LUG, NO.12 WIRE, 1/4" STUD		VOLT. REGULATOR-4	LUG, NO.12 WIRE, 1/4" STUD
W46		1	1	COPPER STRAP 3" MAX. WIDTH	GROUND PLATE				STATION GROUND	
W47	GI5-C-10955-5	8	6	TTRS-4	TB2201		LUG, NO.18 WIRE, NO.6 STUD		KEYING UNIT-4	
W48	GI5-C-16850	2	2	RHDL NO.12		VOLT. REG.4	LUG, NO.12 WIRE, 1/4" STUD	TB3705	SAME AS W2	LUG, NO.12 WIRE, 1/4" STUD
W49		COAX	1	RG-58/U	J2202	TIMER NO.1	UG-88/U	J2206	TIMER NO.1	UG-88/U
W50		COAX	1	RG-58/U	J2202	TIMER NO.3	UG-88/U	J2206	TIMER NO.3	UG-88/U
W51		COAX	1	RG-58/U	J2202	TIMER NO.2	UG-88/U	J2206	TIMER NO.2	UG-88/U
W52		COAX	1	RG-58/U	J2202	TIMER NO.4	UG-88/U	J2206	TIMER NO.4	UG-88/U
W53	GI5-C-10955	4	2	TTRS-2	TB2202	TIMER NO.1	LUG, NO.18 WIRE, NO.6 STUD		DPDT SWITCH-1	
W54	GI5-C-10955	4	2	TTRS-2	TB2202	TIMER NO.3	LUG, NO.18 WIRE, NO.6 STUD		DPDT SWITCH-2	
W55	GI5-C-10955	4	2	TTRS-2	TB2202	TIMER NO.2	LUG, NO.18 WIRE, NO.6 STUD		DPDT SWITCH-1	
W56	GI5-C-10955	4	2	TTRS-2	TB2202	TIMER NO.4	LUG, NO.18 WIRE, NO.6 STUD		DPDT SWITCH-2	
W57	GI5-C-10955	4	4	TTRS-2	TB2201	TIMER NO.1	LUG, NO.18 WIRE, NO.6 STUD	TB2201	TIMER NO.2	LUG, NO.18 WIRE, NO.6 STUD
W58	GI5-C-10955	4	4	TTRS-2	TB2201	TIMER NO.3	LUG, NO.18 WIRE, NO.6 STUD	TB2201	TIMER NO.4	LUG, NO.18 WIRE, NO.6 STUD

REFERENCES

TITLE	FIGURE NO.
PICTORIAL SYSTEM DIAGRAM	3-2
INTERCONNECTION RUNNING SHEET	3-11
OUTLINE DRAWING OF CABINET CY-1437/FPN-30	3-4
OUTLINE DRAWING OF RECORDING AMMETER ME-84/FPN-30	3-7
OUTLINE DRAWING OF VOLTAGE REGULATOR CN-235/FPN-30	3-6
METHOD OF ASSEMBLING BNC AND N CONNECTORS	3-12
METHOD OF ASSEMBLING UHF CONNECTORS	

NOTES

1. NOTE THAT BOTH ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 (TIMERS) NOS. 1 & 2 ARE CONNECTED TO RECORDER NO.1 IN PARALLEL AND THEREFORE THESE TWO SHOULD NOT BOTH BE SELECTED SIMULTANEOUSLY AS OPERATING TIMERS. WHEN ONE IS OPERATING, THE OTHER SHOULD BE STANDBY. SIMILARLY, BOTH ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 (TIMERS) NOS. 3 & 4 ARE CONNECTED TO RECORDER NO.3 AND SHOULD NOT BOTH BE SELECTED SIMULTANEOUSLY AS OPERATING. RECORDERS NOS. 2 & 4 ARE SPARES. IN ORDER TO PERMIT RECORDER NO.1 TO CONTINUOUSLY MONITOR TIMERS NOS. 1 & 2, AS THEY ARE ALTERNATELY SELECTED AS OPERATING TIMERS, IT IS NECESSARY TO INSTALL THE DPDT SWITCH (RATED AT 115V. 1 AMP.) AS SHOWN. WHERE THE ABOVE SWITCHING IS NOT DESIRED, ONLY TIMER NO.1 SHOULD BE CONNECTED TO RECORDER NO.1; TIMER NO.2 MUST BE DISCONNECTED FROM RECORDER NO.1 AND CONNECTED TO RECORDER NO.2 INSTEAD; CABLE NO.57 MUST BE REMOVED; TB2202-1 MUST BE CONNECTED TO TB2202-8; AND TB2202-2 MUST BE CONNECTED TO TB2201-11. SIMILARLY, THIS SWITCHING PROCEDURE APPLIES TO TIMERS NOS. 3 & 4 AND RECORDERS NOS. 3 & 4 WHERE SUPPLIED.
2. AT A SINGLE PULSED STATION TIMERS NOS. 3 & 4, VOLTAGE REGULATORS NOS. 3 & 4, RECORDERS NOS. 3 & 4, AND KEYING UNITS NOS. 3 & 4 WILL NOT BE USED.
3. UNITS DRAWN IN DASHED LINES ARE NOT PART OF LORAN TIMER SET AN/FPN-30.
4. INSTALLING ACTIVITY SHALL PROVIDE LEAD THROUGH FACILITIES FOR CABLES W7 AND W30 IN MODEL UM SWITCHGEAR WHEN REMOTE ALARM IS INSTALLED.
5. INTERCONNECTING CABLE TYPES AND THE CONDUCTOR GROUPING MAY VARY AMONG INSTALLATIONS. REFER TO THE APPLICABLE SHIP OR STATION PLANS TO DETERMINE THE CORRECT CABLING FOR ANY SPECIFIC INSTALLATION.
6. (A) THE FOLLOWING COMBINATIONS OF CONNECTORS AND ADAPTERS SHOULD BE USED WITH RG-58/U CABLE.
   (1) TO CONNECT RG-58/U CABLE TO TYPE N RECEPTACLE USE BNC CONNECTOR UG-88/U WITH UG-201A/U ADAPTER.
   (2) TO CONNECT RG-58/U CABLE TO TYPE UHF RECEPTACLE USE BNC CONNECTOR UG-88/U WITH UG-273/U ADAPTER OR UHF CONNECTOR 49190 WITH UG-175/U ADAPTER.
   (B) TO ACCOMMODATE THE TWO CONNECTIONS NECESSARY AT J2202 ON EACH TIMER, THE TEE ADAPTER TYPE UG-107B/U (SUPPLIED WITH THE EQUIPMENT) MUST BE USED.
7. THE LOCAL AND REMOTE SIGNAL LEADS TO J2203 AND J2204 ON ANY ONE TIMER MUST BE THE SAME LENGTH AND OF THE SAME TYPE CABLE.
8. TTRS-2 AND TTRS-4 TYPE CABLES ARE PER MIL-C-915A (SHIPS) 30 JULY, 1952. RHDL NO.12 TYPE CABLE IS PER FEDERAL GOVERNMENT SPECIFICATION J-C-103.

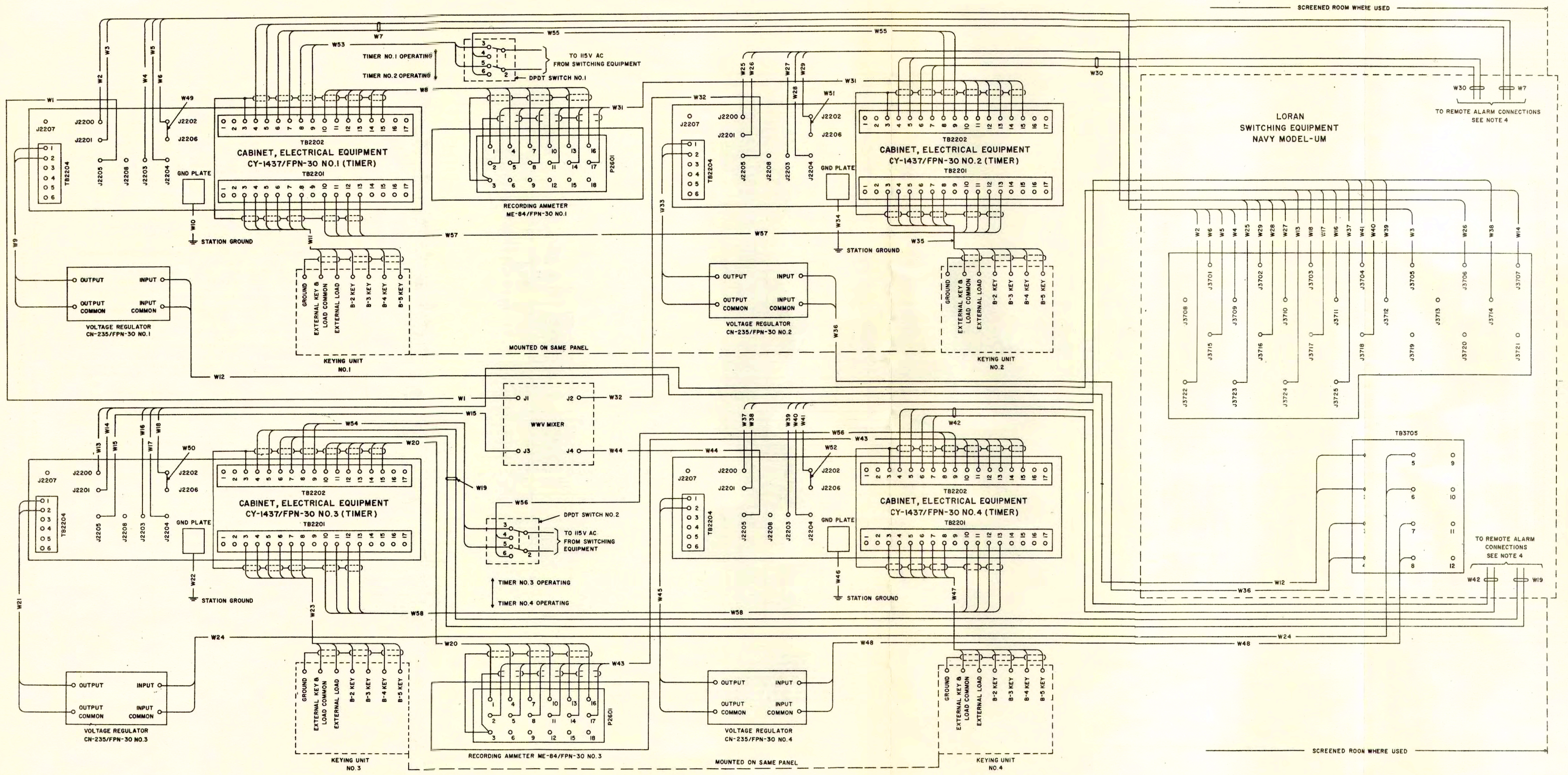
LIST OF CONNECTORS SUPPLIED BY MANUFACTURER AS PART OF EACH LORAN TIMER SET AN/FPN-30.
- 9 ADAPTERS, N RIGHT ANGLE TYPE UG-27C/U
- 10 ADAPTERS, TYPE UG-201A/U (TO MATE BNC MALE AND N FEMALE)
- 10 PLUGS, BNC TYPE UG-88/U
- 10 PLUGS, N TYPE UG-21D/U
- 1 ADAPTER, TEE TYPE UG-107B/U
- 2 TERMINAL LUGS NO.8 WIRE, 1/4" STUD SUPPLIED ON ELECTRICAL EQUIPMENT CABINET CY-1437/FPN-30 (TIMER)

* 1 CONNECTOR, PLUG SUPPLIED ON RECORDING AMMETER.

LIST OF CONNECTORS TO BE SUPPLIED BY INSTALLING ACTIVITY
- ALL TERMINAL LUGS FOR TTRS-4 AND TTRS-2 TYPE CABLES
- ALL TERMINAL LUGS FOR RHDL NO.12 TYPE CABLES
- ALL COAX FITTINGS EXCEPT THOSE SUPPLIED BY MANUFACTURER

ALL CABLES ARE TO BE SUPPLIED BY INSTALLING ACTIVITY.

Figure 3–10. Interunit Connection Diagram, Loran Timer Set AN/FPN–30 at Station Employing Loran Switching Equipment Navy Model UM



SYMBOL	NAVY STOCK NO.	NUMBER COND.	ACTIVE COND.	NAVY TYPE NO. (SEE NOTES 4 & 6)	FROM LOCATION	FROM EQUIPMENT	FROM CABLE CONN. TYPE (SEE NOTE 6)	TO LOCATION	TO EQUIPMENT	TO CABLE CONN. TYPE (SEE NOTE 6)
W1		COAX	1	RG-58/U	J2205	CABINET ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER) NO.1	UG-88/U		WWV MIXER	
W2		COAX	1	RG-58/U	J2200		UG-88/U	J3722	LORAN SWITCHING EQUIPMENT NAVY MODEL-UM	UG-88/U
W3		COAX	1	RG-58/U	J2201		UG-88/U	J3705		UG-88/U
W4		COAX	1	RG-58/U	J2203		UG-88/U	J3709		UG-88/U
W5		COAX	1	RG-58/U	J2204		UG-88/U	J3715		UG-88/U
W6		COAX	1	RG-58/U	J2202		UG-88/U	J3701		UG-88/U
W7	GI5-C-10955	4	4	TTRS-2	TB2202		LUG, NO.18 WIRE, NO.6 STUD		REMOTE ALARM	
W8	GI5-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO.18 WIRE, NO.6 STUD	P2601	REC. AMMETER-1	* PLUG
W9	GI5-C-16850	2	2	RHDL NO.12	TB2204		LUG, NO.12 WIRE, 1/4" STUD		VOLT. REGULATOR-1	LUG, NO.12 WIRE, 1/4" STUD
W10		1	1	COPPER STRAP 3" MAX. WIDTH	GROUND PLATE				STATION GROUND	
W11	GI5-C-10955-5	8	6	TTRS-4	TB2201		LUG, NO.18 WIRE, NO.6 STUD		KEYING UNIT-1	
W12	GI5-C-16850	2	2	RHDL NO.12		VOLT. REG.-1	LUG, NO.12 WIRE, 1/4" STUD	TB3705	LORAN SWITCH. EQUIP. NAVY MODEL-UM	LUG, NO.12 WIRE, 1/4" STUD
W13		COAX	1	RG-58/U	J2200	CABINET ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER) NO.3	UG-88/U	J3724		UG-88/U
W14		COAX	1	RG-58/U	J2201		UG-88/U	J3707		UG-88/U
W15		COAX	1	RG-58/U	J2205		UG-88/U		WWV MIXER	
W16		COAX	1	RG-58/U	J2203		UG-88/U	J3711	LORAN SWITCH. EQUIP. NAVY MODEL-UM	UG-88/U
W17		COAX	1	RG-58/U	J2204		UG-88/U	J3717		UG-88/U
W18		COAX	1	RG-58/U	J2202		UG-88/U	J3703		UG-88/U
W19	GI5-C-10955	4	4	TTRS-2	TB2202		LUG, NO.18 WIRE, NO.6 STUD		REMOTE ALARM	
W20	GI5-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO.18 WIRE, NO.6 STUD	P2601	REC. AMMETER-3	* PLUG
W21	GI5-C-16850	2	2	RHDL NO.12	TB2204		LUG, NO.12 WIRE, 1/4" STUD		VOLT. REGULATOR-3	LUG, NO.12 WIRE, 1/4" STUD
W22		1	1	COPPER STRAP 3" MAX. WIDTH	GROUND PLATE				STATION GROUND	
W23		8	6	TTRS-4	TB2201		LUG, NO.18 WIRE, NO.6 STUD		KEYING UNIT-3	
W24	GI5-C-16850	2	2	RHDL NO.12		VOLT. REG.-3	LUG, NO.12 WIRE, 1/4" STUD	TB3705	LORAN SWITCHING EQUIPMENT NAVY MODEL-UM	LUG, NO.12 WIRE, 1/4" STUD
W25		COAX	1	RG-58/U	J2200	CABINET ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER) NO.2	UG-88/U	J3723		UG-88/U
W26		COAX	1	RG-58/U	J2201		UG-88/U	J3706		UG-88/U
W27		COAX	1	RG-58/U	J2203		UG-88/U	J3710		UG-88/U
W28		COAX	1	RG-58/U	J2204		UG-88/U	J3716		UG-88/U
W29		COAX	1	RG-58/U	J2202		UG-88/U	J3702		UG-88/U
W30	GI5-C-10955	4	4	TTRS-2	TB2202		LUG, NO.18 WIRE, NO.6 STUD		REMOTE ALARM	
W31	GI5-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO.18 WIRE, NO.6 STUD	P2601	REC. AMMETER-1	* PLUG
W32		COAX	1	RG-58/U	J2205				WWV MIXER	
W33	GI5-C-16850	2	2	RHDL NO.12	TB2204		LUG, NO.12 WIRE, 1/4" STUD		VOLT. REGULATOR-2	LUG, NO.12 WIRE, 1/4" STUD
W34		1	1	COPPER STRAP 3" MAX. WIDTH	GROUND PLATE				STATION GROUND	
W35	GI5-C-10955-5	8	6	TTRS-4	TB2201		LUG, NO.18 WIRE, NO.6 STUD		KEYING UNIT-2	
W36	GI5-C-16850	2	2	RHDL NO.12		VOLT. REG.-2	LUG, NO.12 WIRE, 1/4" STUD	TB3705	LORAN SWITCHING EQUIPMENT NAVY MODEL-UM	LUG, NO.12 WIRE, 1/4" STUD
W37		COAX	1	RG-58/U	J2200	CABINET ELECTRICAL EQUIPMENT CY-1437/FPN-30 (TIMER) NO.4	UG-88/U	J3725		UG-88/U
W38		COAX	1	RG-58/U	J2201		UG-88/U	J3714		UG-88/U
W39		COAX	1	RG-58/U	J2203		UG-88/U	J3712		UG-88/U
W40		COAX	1	RG-58/U	J2204		UG-88/U	J3718		UG-88/U
W41		COAX	1	RG-58/U	J2202		UG-88/U	J3704		UG-88/U
W42	GI5-C-10955	4	4	TTRS-2	TB2202		LUG, NO.18 WIRE, NO.6 STUD		REMOTE ALARM	
W43	GI5-C-10955-5	8	6	TTRS-4	TB2202		LUG, NO.18 WIRE, NO.6 STUD	P2601	REC. AMMETER-3	* PLUG
W44		COAX	1	RG-58/U	J2205		UG-88/U		WWV MIXER	
W45	GI5-C-16850	2	2	RHDL NO.12	TB2204		LUG, NO.12 WIRE, 1/4" STUD		VOLT. REGULATOR-4	LUG, NO.12 WIRE, 1/4" STUD
W46		1	1	COPPER STRAP 3" MAX. WIDTH	GROUND PLATE				STATION GROUND	
W47	GI5-C-10955-5	8	6	TTRS-4	TB2201		LUG, NO.18 WIRE, NO.6 STUD		KEYING UNIT-4	
W48	GI5-C-16850	2	2	RHDL NO.12		VOLT. REG.4	LUG, NO.12 WIRE, 1/4" STUD	TB3705	SAME AS W2	LUG, NO.12 WIRE, 1/4" STUD
W49		COAX	1	RG-58/U	J2202	TIMER NO.1	UG-88/U	J2206	TIMER NO.1	UG-88/U
W50		COAX	1	RG-58/U	J2202	TIMER NO.3	UG-88/U	J2206	TIMER NO.3	UG-88/U
W51		COAX	1	RG-58/U	J2202	TIMER NO.2	UG-88/U	J2206	TIMER NO.2	UG-88/U
W52		COAX	1	RG-58/U	J2202	TIMER NO.4	UG-88/U	J2206	TIMER NO.4	UG-88/U
W53	GI5-C-10955	4	2	TTRS-2	TB2202	TIMER NO.1	LUG, NO.18 WIRE, NO.6 STUD		DPDT SWITCH-1	
W54	GI5-C-10955	4	2	TTRS-2	TB2202	TIMER NO.3	LUG, NO.18 WIRE, NO.6 STUD		DPDT SWITCH-2	
W55	GI5-C-10955	4	2	TTRS-2	TB2202	TIMER NO.2	LUG, NO.18 WIRE, NO.6 STUD		DPDT SWITCH-1	
W56	GI5-C-10955	4	2	TTRS-2	TB2202	TIMER NO.4	LUG, NO.18 WIRE, NO.6 STUD		DPDT SWITCH-2	
W57	GI5-C-10955	4	4	TTRS-2	TB2201	TIMER NO.1	LUG, NO.18 WIRE, NO.6 STUD	TB2201	TIMER NO.2	LUG, NO.18 WIRE, NO.6 STUD
W58	GI5-C-10955	4	4	TTRS-2	TB2201	TIMER NO.3	LUG, NO.18 WIRE, NO.6 STUD	TB2201	TIMER NO.4	LUG, NO.18 WIRE, NO.6 STUD

REFERENCES

TITLE	FIGURE NO.
PICTORIAL SYSTEM DIAGRAM	3-2
INTERCONNECTION RUNNING SHEET	3-11
OUTLINE DRAWING OF CABINET CY-1437/FPN-30	3-4
OUTLINE DRAWING OF RECORDING AMMETER ME-84/FPN-30	3-7
OUTLINE DRAWING OF VOLTAGE REGULATOR CN-235/FPN-30	3-6
METHOD OF ASSEMBLING BNC AND N CONNECTORS	3-12
METHOD OF ASSEMBLING UHF CONNECTORS	

NOTES

1. NOTE THAT BOTH ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 (TIMERS) NOS. 1 & 2 ARE CONNECTED TO RECORDER NO.1 IN PARALLEL AND THEREFORE THESE TWO SHOULD NOT BOTH BE SELECTED SIMULTANEOUSLY AS OPERATING TIMERS. WHEN ONE IS OPERATING, THE OTHER SHOULD BE STANDBY. SIMILARLY, BOTH ELECTRICAL EQUIPMENT CABINETS CY-1437/FPN-30 (TIMERS) NOS. 3 & 4 ARE CONNECTED TO RECORDER NO. 3 AND SHOULD NOT BOTH BE SELECTED SIMULTANEOUSLY AS OPERATING. RECORDERS NOS. 2 & 4 ARE SPARES. IN ORDER TO PERMIT RECORDER NO.1 TO CONTINUOUSLY MONITOR TIMERS NOS. 1 & 2, AS THEY ARE ALTERNATELY SELECTED AS OPERATING TIMERS, IT IS NECESSARY TO INSTALL THE DPDT SWITCH (RATED AT 115V. 1 AMP.) AS SHOWN. WHERE THE ABOVE SWITCHING IS NOT DESIRED, ONLY TIMER NO.1 SHOULD BE CONNECTED TO RECORDER NO.1; TIMER NO. 2 MUST BE DISCONNECTED FROM RECORDER NO.1 AND CONNECTED TO RECORDER NO.2 INSTEAD; CABLE NO.57 MUST BE REMOVED; TB2202-1 MUST BE CONNECTED TO TB2202-8; AND TB2202-2 MUST BE CONNECTED TO TB2201-11. SIMILARLY, THIS SWITCHING PROCEDURE APPLIES TO TIMERS NOS. 3 & 4 AND RECORDERS NOS. 3 & 4 WHERE SUPPLIED.
2. AT A SINGLE PULSED STATION TIMERS NOS. 3 & 4, VOLTAGE REGULATORS NOS. 3 & 4, RECORDERS NOS. 3 & 4, AND KEYING UNITS NOS. 3 & 4 WILL NOT BE USED.
3. UNITS DRAWN IN DASHED LINES ARE NOT PART OF LORAN TIMER SET AN/FPN-30.
4. INSTALLING ACTIVITY SHALL PROVIDE LEAD THROUGH FACILITIES FOR CABLES W7 AND W30 IN MODEL UM SWITCHGEAR WHEN REMOTE ALARM IS INSTALLED.
5. INTERCONNECTING CABLE TYPES AND THE CONDUCTOR GROUPING MAY VARY AMONG INSTALLATIONS. REFER TO THE APPLICABLE SHIP OR STATION PLANS TO DETERMINE THE CORRECT CABLING FOR ANY SPECIFIC INSTALLATION.
6. (A) THE FOLLOWING COMBINATIONS OF CONNECTORS AND ADAPTERS SHOULD BE USED WITH RG-58/U CABLE.
   (1) TO CONNECT RG-58/U CABLE TO TYPE N RECEPTACLE USE BNC CONNECTOR UG-88/U WITH UG-201A/U ADAPTER.
   (2) TO CONNECT RG-58/U CABLE TO TYPE UHF RECEPTACLE USE BNC CONNECTOR UG-88/U WITH UG-273/U ADAPTER OR UHF CONNECTOR 49190 WITH UG-175/U ADAPTER.

   (B) TO ACCOMMODATE THE TWO CONNECTIONS NECESSARY AT J2202 ON EACH TIMER, THE TEE ADAPTER TYPE UG-107B/U (SUPPLIED WITH THE EQUIPMENT) MUST BE USED.
7. THE LOCAL AND REMOTE SIGNAL LEADS TO J2203 AND J2204 ON ANY ONE TIMER MUST BE THE SAME LENGTH AND OF THE SAME TYPE CABLE.
8. TTRS-2 AND TTRS-4 TYPE CABLES ARE PER MIL-C-915A (SHIPS) 30 JULY, 1952. RHDL NO.12 TYPE CABLE IS PER FEDERAL GOVERNMENT SPECIFICATION J-C-103.

LIST OF CONNECTORS SUPPLIED BY MANUFACTURER AS PART OF EACH LORAN TIMER SET AN/FPN-30.
- 9 ADAPTERS, N RIGHT ANGLE TYPE UG-27C/U
- 10 ADAPTERS, TYPE UG-201A/U (TO MATE BNC MALE AND N FEMALE)
- 10 PLUGS, BNC TYPE UG-88/U
- 10 PLUGS, N TYPE UG-21D/U
- 1 ADAPTER, TEE TYPE UG-107B/U
- 2 TERMINAL LUGS NO.8 WIRE, 1/4" STUD SUPPLIED ON ELECTRICAL EQUIPMENT CABINET CY-1437/FPN-30 (TIMER)

* 1 CONNECTOR, PLUG SUPPLIED ON RECORDING AMMETER.

LIST OF CONNECTORS TO BE SUPPLIED BY INSTALLING ACTIVITY
- ALL TERMINAL LUGS FOR TTRS-4 AND TTRS-2 TYPE CABLES
- ALL TERMINAL LUGS FOR RHDL NO.12 TYPE CABLES
- ALL COAX FITTINGS EXCEPT THOSE SUPPLIED BY MANUFACTURER

ALL CABLES ARE TO BE SUPPLIED BY INSTALLING ACTIVITY.

Figure 3–10. Interunit Connection Diagram, Loran Timer Set AN/FPN-30 at Station Employing Loran Switching Equipment Navy Model UM

SYMBOL	NAVY STOCK NUMBER	NAVY TYPE NUMBER (See note 2)	NUMBER OF ACTIVE COND.	COLOR	FROM LOCATION	FROM COAX. CONN.	FROM TERM. BOARD	FROM PIN NO.	TO LOCATION	TO COAX. CONN.	TO TERM. BOARD	TO PIN NO.	FUNCTION	COND. AMPS
W1		RG-58/U	1	-	ELECTRICAL EQUIPMENT CABINET CY-1437/FPN-30 (TIMER) NO. 1	J2205	-	-	WWV MIXER		-	-	100 KC FREQ. CHECK	Less than 1
W2		RG-58/U	1	-		J2200	-	-	LORAN SWITCHING EQUIPMENT NAVY MODEL - UM	J3722	-	-	XMTR 100 KC	Less than 1
W3		RG-58/U	1	-		J2201	-	-		J3705	-	-	XMTR TRIGGER	Less than 1
W4		RG-58/U	1	-		J2203	-	-		J3709	-	-	LOCAL SIGNAL	Less than 1
W5		RG-58/U	1	-		J2204	-	-		J3715	-	-	REMOTE SIGNAL	Less than 1
W6		RG-58/U	1	-		J2202	-	-		J3701	-	-	BLANKING TO UM	Less than 1
W7	G15-C-10955	TTRS-2	4			-	TB2202	4	REMOTE ALARM	-			ALARM BUZZER	Less than 1
						-		5		-			SYNC ERROR ALARM	Less than 1
						-		6		-			OFF SYNC ALARM	Less than 1
						-		7		-			ALARM COMMON	Less than 1
W8	G15-C-10955-5	TTRS-4	6			-	TB2202	10	RECORDING AMMETER NO. 1	-	P2601	1	PEN & MOTOR COM.	Less than 1
						-		11		-		4	DRIVE MOTOR	Less than 1
						-		12		-		7	LOCAL BLINK PEN	Less than 1
						-		13		-		10	OFF SYNC PEN	Less than 1
						-		14		-		13	(+) DC METER	Less than 1
								15		-		16	(-) DC METER	Less than 1
W9	G15-C-16850	RHDL #12	2	WH		-	TB2204	1	VOLTAGE REGULATOR NO. 1	-	OUTPUT		115 V. AC POWER	11
				BLK				2		-	OUT. COMMON			11
W10		Copper strap 3" MAX WIDTH	1	-	(GND PLATE)	-	-	-	STATION GROUND	-			CABINET CY-1437/FPN-30 NO. 1 GROUND	
W11	G15-C-10955-5	TTRS-4	6			-	TB2201	3	KEYING UNIT NO. 1	-			EXT. KEY & LOAD COM.	Less than 1
						-		4		-			EXTERNAL LOAD	Less than 1
						-		5		-			B-2 KEY	Less than 1
						-		6		-			B-3 KEY	Less than 1
						-		7		-			B-4 KEY	Less than 1
						-		8		-			B-5 KEY	Less than 1
W12	G15-C-16850	RHDL #12	2	WH	VOLTAGE REGULATOR NO. 1	-	INPUT		LORAN SWITCHING EQUIPMENT NAVY MODEL - UM	-	TB3705	1	115 V. AC POWER	11
				BLK		-	IN. COMMON			-		2		11
W13		RG-58/U	1	-	ELECTRICAL EQUIPMENT CABINET CY-1437/FPN-30 (TIMER) NO. 3	J2200	-	-		J3724	-	-	XMTP 100 KC	Less than 1
W14		RG-58/U	1	-		J2201	-	-		J3707	-	-	XMTR TRIGGER	Less than 1
W15		RG-58/U	1	-		J2205	-	-	WWV MIXER		-	-	100 KC FREQ. CHECK	Less than 1
W16		RG-58/U	1	-		J2203	-	-	LORAN SWITCH. EQUIP. NAVY MODEL - UM	J3711	-	-	LOCAL SIGNAL	Less than 1
W17		RG-58/U	1	-		J2204	-	-		J3717	-	-	REMOTE SIGNAL	Less than 1
W18		RG-58/U	1	-		J2202	-	-		J3703	-	-	BLANKING TO UM	Less than 1
W19	G15-C-10955	TTRS-2	4			-	TB2202	4	REMOTE ALARM	-			ALARM BUZZER	Less than 1
						-		5		-			SYNC ERROR ALARM	Less than 1
						-		6		-			OFF SYNC ALARM	Less than 1
						-		7		-			ALARM COMMON	Less than 1
W20	G15-C-10955-5	TTRS-4	6			-	TB2202	10	RECORDING AMMETER NO. 3	-	P2601	1	PEN & MOTOR COM.	Less than 1
						-		11		-		4	DRIVE MOTOR	Less than 1
						-		12		-		7	LOCAL BLINK PEN	Less than 1
						-		13		-		10	OFF SYNC PEN	Less than 1
						-		14		-		13	(+) DC METER	Less than 1
						-		15		-		16	(-) DC METER	Less than 1
W21	G15-C-16850	RHDL #12	2	WH		-	TB2204	1	VOLTAGE REGULATOR NO. 3	-	OUTPUT		115 V. AC POWER	11
				BLK		-		2		-	OUT. COMMON			11
W22		Copper strap 3" MAX	1	-	(GND PLATE)	-	-	-	STATION GROUND	-			CABINET CY-1437/FPN-30 NO. 3 GROUND	
W23	G15-C-10955-5	TTRS-4	6			-	TB2201	3	KEYING UNIT NO. 3	-			EXT. KEY & LOAD COM.	Less than 1
						-		4		-			EXTERNAL LOAD	Less than 1
						-		5		-			B-2 KEY	Less than 1
						-		6		-			B-3 KEY	Less than 1
						-		7		-			B-4 KEY	Less than 1
						-		8		-			B-5 KEY	Less than 1
W24	G15-C-16850	RHDL #12	2	WH	VOLTAGE REGULATOR NO. 3	-	INPUT		LORAN SWITCH. EQUIP. NAVY MODEL - UM	-	TB3705	5	115 V. AC POWER	11
				BLK		-	IN. COMMON			-		6		11
W25		RG-58/U	1	-	ELECTRICAL EQUIPMENT CABINET CY-1437/FPN-30 (TIMER) NO. 2	J2200	-	-	LORAN SWITCHING EQUIPMENT NAVY MODEL - UM	J3723	-	-	XMTR 100 KC	Less than 1
W26		RG-58/U	1	-		J2201	-	-		J3706	-	-	XMTR TRIGGER	Less than 1
W27		RG-58/U	1	-		J2203	-	-		J3710	-	-	LOCAL SIGNAL	Less than 1
W28		RG-58/U	1	-		J2204	-	-		J3716	-	-	REMOTE SIGNAL	Less than 1
W29		RG-58/U	1	-		J2202	-	-		J3702	-	-	BLANKING TO UM	Less than 1
W30	G15-C-10955	TTRS-2	4			-	TB2202	4	REMOTE ALARM	-			ALARM BUZZER	Less than 1
						-		5		-			SYNC. ERROR ALARM	Less than 1
						-		6		-			OFF SYNC ALARM	Less than 1
						-		7		-			ALARM COMMON	Less than 1
W31	G15-C-10955-5	TTRS-4	6			-	TB2202	10	RECORDING AMMETER NO. 1	-	P2601	2	PEN & MOTOR COM.	Less than 1
						-		11		-		5	DRIVE MOTOR	Less than 1
						-		12		-		8	LOCAL BLINK PEN	Less than 1
						-		13		-		11	OFF SYNC PEN	Less than 1
						-		14		-		14	(+) DC METER	Less than 1
						-		15		-		17	(-) DC METER	Less than 1
W32		RG-58/U	1	-		J2205	-	-	WWV MIXER		-	-	100 KC FREQ. CHECK	Less than 1
W33	G15-C-16850	RHDL #12	2	WH		-	TB2204	1	VOLTAGE REGULATOR NO. 2	-	OUTPUT		115 V. AC POWER	11
				BLK		-		2		-	OUT. COMMON			11
W34		Copper strap 3" MAX WIDTH	1	-	(GND PLATE)	-	-	-	STATION GROUND	-			CABINET CY-1437/FPN-30 NO. 2 GROUND	
W35	G15-C-10955-5	TTRS-4	6			-	TB2201	3	KEYING UNIT NO. 2	-			EXT. KEY & LOAD COM.	Less than 1
						-		4		-			EXTERNAL LOAD	Less than 1
						-		5		-			B-2 KEY	Less than 1
						-		6		-			B-3 KEY	Less than 1
						-		7		-			B-4 KEY	Less than 1
						-		8		-			B-5 KEY	Less than 1
W36	G15-C-16850	RHDL #12	2	WH	VOLTAGE REGULATOR NO. 2	-	INPUT		LORAN SWITCHING EQUIPMENT NAVY MODEL - UM	-	TB3705	3	115 V. AC POWER	11
				BLK		-	IN. COMMON			-		4		11
W37		RG-58/U	1	-	ELECTRICAL EQUIPMENT CABINET CY-1437/FPN-30 (TIMER) NO. 4	J2200	-	-		J3725	-	-	XMTR 100 KC	Less than 1
W38		RG-58/U	1	-		J2201	-	-		J3714	-	-	XMTR TRIGGER	Less than 1
W39		RG-58/U	1	-		J2203	-	-		J3712			LOCAL SIGNAL	Less than 1
W40		RG-58/U	1	-		J2204	-	-		J3718	-	-	REMOTE SIGNAL	Less than 1
W41		RG-58/U	1	-		J2202	-	-		J3704	-	-	BLANKING TO UM	Less than 1
W42	G15-C-10955	TTRS-2	4			-	TB2202	4	REMOTE ALARM	-			ALARM BUZZER	Less than 1
						-		5		-			SYNC ERROR ALARM	Less than 1
						-		6		-			OFF SYNC ALARM	Less than 1
						-		7		-			ALARM COMMON	Less than 1
W43	G15-C-10955-5	TTRS-4	6			-	TB2202	10	RECORDING AMMETER NO. 3	-	P2601	2	PEN & MOTOR COM.	Less than 1
						-		11		-		5	DRIVE MOTOR	Less than 1
						-		12		-		8	LOCAL BLINK PEN	Less than 1
						-		13		-		11	OFF SYNC PEN	Less than 1
						-		14		-		14	(+) DC METER	Less than 1
						-		15		-		17	(-) DC METER	Less than 1
W44		RG-58/U	1	-		J2205	-	-	WWV MIXER		-	-	100 KC FREQ. CHECK	Less than 1
W45	G15-C-16850	RHDL #12	2	WH		-	TB2204	1	VOLTAGE REGULATOR NO. 4	-	OUTPUT		115 V. AC POWER	11
				BLK		-		2			OUT. COMMON			11
W46		Copper strap 3" MAX WIDTH	1	-	(GND PLATE)	-	-	-	STATION GROUND	-			CABINET CY-1437/FPN-30 NO. 4 GROUND	
W47	G15-C-10955-5	TTRS-4	6			-	TB2201	3	KEYING UNIT NO. 4	-			EXT. KEY & LOAD COM.	Less than 1
						-		4		-			EXTERNAL LOAD	Less than 1
						-		5		-			B-2 KEY	Less than 1
						-		6		-			B-3 KEY	Less than 1
						-		7		-			B-4 KEY	Less than 1
						-		8		-			B-5 KEY	Less than 1
W48	G15-C-16850	RHDL #12	2	WH	VOLTAGE REGULATOR NO. 4	-	INPUT		LORAN SWITCH. EQUIP. NAVY MODEL - UM	-	TB3705	7	115 V. AC POWER	11
				BLK		-	IN. COMMON			-		8		11
W49		RG-58/U	1	-	TIMER NO. 1	J2202	-	-	TIMER NO. 1	J2206	-	-	BLANKING TO TIMER	Less than 1
W50		RG-58/U	1	-	TIMER NO. 3	J2202	-	-	TIMER NO. 3	J2206	-	-	BLANKING TO TIMER	Less than 1
W51		RG-58/U	1	-	TIMER NO. 2	J2202	-	-	TIMER NO. 2	J2206	-	-	BLANKING TO TIMER	Less than 1
W52		RG-58/U	1	-	TIMER NO. 4	J2202	-	-	TIMER NO. 4	J2206	-	-	BLANKING TO TIMER	Less than 1
W53	G15-C-10955	TTRS-2	2		TIMER NO. 1	-	TB2202	8	DPDT SWITCH NO. 1	-		3	STANDBY - OPERATE	Less than 1
						-		9		-		5	CONTROL	Less than 1
W54	G15-C-10955	TTRS-2	2		TIMER NO. 3	-	TB2202	8	DPDT SWITCH NO. 2	-		3	STANDBY - OPERATE	Less than 1
						-		9		-		5	CONTROL	Less than 1
W55	G15-C-10955	TTRS-2	2		TIMER NO. 2	-	TB2202	8	DPDT SWITCH NO. 1	-		4	STANDBY - OPERATE	Less than 1
						-		9		-		6	CONTROL	Less than 1
W56	G15-C-10955	TTRS-2	2		TIMER NO. 4	-	TB2202	8	DPDT SWITCH NO. 2	-		4	STANDBY - OPERATE	Less than 1
						-		9		-		6	CONTROL	Less than 1
W57	G15-C-10955	TTRS-2	4		ELECTRICAL EQUIP. CABINET CY-1437/FPN-30 (TIMER) NO. 1	-	TB2201	10	ELECTRICAL EQUIP. CABINET CY-1437/FPN-30 (TIMER) NO. 2	-	TB2201	12	K2201	Less than 1
						-		11		-		13		Less than 1
						-		12		-		10	INTERLOCK	Less than 1
						-		13		-		11		Less than 1
W58	G15-C-10955	TTRS-2	4		ELECTRICAL EQUIP. CABINET CY-1437/FPN-30 (TIMER) NO. 3	-	TB2201	10	ELECTRICAL EQUIP. CABINET CY-1437/FPN-30 (TIMER) NO. 4	-	TB2201	12	K2201	Less than 1
						-		11		-		13		Less than 1
						-		12		-		10	INTERLOCK	Less than 1
						-		13		-		11		Less than 1

ALL CABLES SUPPLIED BY INSTALLING ACTIVITY

Figure 3–17. Running List, Loran Timer Set AN/FPN–30 at Station Employing Loran Switching Equipment Navy Model UM

SYMBOL	NAVY STOCK NUMBER	NAVY TYPE NUMBER (See note 2)	NUMBER OF ACTIVE COND.	COLOR	FROM				TO				FUNCTION	COND. AMPS
					LOCATION	COAX. CONN.	TERM. BOARD	PIN NO.	LOCATION	COAX. CONN.	TERM. BOARD	PIN NO.		
W1		RG-58/U	1	-	ELECTRICAL EQUIPMENT CABINET CY-1437/FPN-30 (TIMER) NO. 1	J2205	-	-	WWV MIXER		-	-	100 KC FREQ. CHECK	Less than 1
W2		RG-58/U	1	-		J2200	-	-	LORAN SWITCHING EQUIPMENT NAVY MODEL - UM	J3722	-	-	XMTR 100 KC	Less than 1
W3		RG-58/U	1	-		J2201	-	-		J3705	-	-	XMTR TRIGGER	Less than 1
W4		RG-58/U	1	-		J2203	-	-		J3709	-	-	LOCAL SIGNAL	Less than 1
W5		RG-58/U	1	-		J2204	-	-		J3715	-	-	REMOTE SIGNAL	Less than 1
W6		RG-58/U	1	-		J2202	-	-		J3701	-	-	BLANKING TO UM	Less than 1
W7	G15-C-10955	TTRS-2	4			-	TB2202	4	REMOTE ALARM	-			ALARM BUZZER	Less than 1
						-		5		-			SYNC ERROR ALARM	Less than 1
						-		6		-			OFF SYNC ALARM	Less than 1
						-		7		-			ALARM COMMON	Less than 1
W8	G15-C-10955-5	TTRS-4	6			-	TB2202	10	RECORDING AMMETER NO. 1	-	P2601	1	PEN & MOTOR COM.	Less than 1
						-		11		-		4	DRIVE MOTOR	Less than 1
						-		12		-		7	LOCAL BLINK PEN	Less than 1
						-		13		-		10	OFF SYNC PEN	Less than 1
						-		14		-		13	(+) DC METER	Less than 1
						-		15		-		16	(-) DC METER	Less than 1
W9	G15-C-16850	RHDL #12	2	WH		-	TB2204	1	VOLTAGE REGULATOR NO. 1	-	OUTPUT		115 V. AC POWER	11
				BLK		-		2		-	OUT. COMMON			11
W10		Copper strap 3" MAX WIDTH	1	-	(GND PLATE)	-	-	-	STATION GROUND	-			CABINET CY-1437/FPN-30 NO. 1 GROUND	
W11	G15-C-10955-5	TTRS-4	6			-	TB2201	3	KEYING UNIT NO. 1	-			EXT. KEY & LOAD COM.	Less than 1
						-		4		-			EXTERNAL LOAD	Less than 1
						-		5		-			B-2 KEY	Less than 1
						-		6		-			B-3 KEY	Less than 1
						-		7		-			B-4 KEY	Less than 1
						-		8		-			B-5 KEY	Less than 1
W12	G15-C-16850	RHDL #12	2	WH	VOLTAGE REGULATOR NO. 1	-	INPUT		LORAN SWITCHING EQUIPMENT NAVY MODEL - UM	-	TB3705	1	115 V. AC POWER	11
				BLK		-	IN. COMMON					2		11
W13		RG-58/U	1	-	ELECTRICAL EQUIPMENT CABINET CY-1437/FPN-30 (TIMER) NO. 3	J2200	-	-		J3724	-	-	XMTP 100 KC	Less than 1
W14		RG-58/U	1	-		J2201	-	-		J3707	-	-	XMTR TRIGGER	Less than 1
W15		RG-58/U	1	-		J2205	-	-	WWV MIXER		-	-	100 KC FREQ. CHECK	Less than 1
W16		RG-58/U	1	-		J2203	-	-	LORAN SWITCH. EQUIP. NAVY MODEL - UM	J3711	-	-	LOCAL SIGNAL	Less than 1
W17		RG-58/U	1	-		J2204	-	-		J3717	-	-	REMOTE SIGNAL	Less than 1
W18		RG-58/U	1	-		J2202	-	-		J3703	-	-	BLANKING TO UM	Less than 1
W19	G15-C-10955	TTRS-2	4			-	TB2202	4	REMOTE ALARM	-			ALARM BUZZER	Less than 1
						-		5		-			SYNC ERROR ALARM	Less than 1
						-		6		-			OFF SYNC ALARM	Less than 1
						-		7		-			ALARM COMMON	Less than 1
W20	G15-C-10955-5	TTRS-4	6			-	TB2202	10	RECORDING AMMETER NO. 3	-	P2601	1	PEN & MOTOR COM.	Less than 1
						-		11		-		4	DRIVE MOTOR	Less than 1
						-		12		-		7	LOCAL BLINK PEN	Less than 1
						-		13		-		10	OFF SYNC PEN	Less than 1
						-		14		-		13	(+) DC METER	Less than 1
						-		15		-		16	(-) DC METER	Less than 1
W21	G15-C-16850	RHDL #12	2	WH		-	TB2204	1	VOLTAGE REGULATOR NO. 3	-	OUTPUT		115 V. AC POWER	11
				BLK		-		2		-	OUT. COMMON			11
W22		Copper strap 3" MAX	1	-	(GND PLATE)	-	-	-	STATION GROUND	-			CABINET CY-1437/FPN-30 NO. 3 GROUND	
W23	G15-C-10955-5	TTRS-4	6			-	TB2201	3	KEYING UNIT NO. 3	-			EXT. KEY & LOAD COM.	Less than 1
						-		4		-			EXTERNAL LOAD	Less than 1
						-		5		-			B-2 KEY	Less than 1
						-		6		-			B-3 KEY	Less than 1
						-		7		-			B-4 KEY	Less than 1
						-		8		-			B-5 KEY	Less than 1
W24	G15-C-16850	RHDL #12	2	WH	VOLTAGE REGULATOR NO. 3	-	INPUT		LORAN SWITCH. EQUIP. NAVY MODEL - UM	-	TB3705	5	115 V. AC POWER	11
				BLK		-	IN. COMMON					6		11

ALL CABLES SUPPLIED BY INSTALLING ACTIVITY

SYMBOL	NAVY STOCK NUMBER	NAVY TYPE NUMBER (See note 2)	NUMBER OF ACTIVE COND.	COLOR	FROM				TO				FUNCTION	COND. AMPS
					LOCATION	COAX. CONN.	TERM. BOARD	PIN NO.	LOCATION	COAX. CONN.	TERM. BOARD	PIN NO.		
W25		RG-58/U	1	-	ELECTRICAL EQUIPMENT CABINET CY-1437/FPN-30 (TIMER) NO. 2	J2200	-	-	LORAN SWITCHING EQUIPMENT NAVY MODEL - UM	J3723	-	-	XMTR 100 KC	Less than 1
W26		RG-58/U	1	-		J2201	-	-		J3706	-	-	XMTR TRIGGER	Less than 1
W27		RG-58/U	1	-		J2203	-	-		J3710	-	-	LOCAL SIGNAL	Less than 1
W28		RG-58/U	1	-		J2204	-	-		J3716	-	-	REMOTE SIGNAL	Less than 1
W29		RG-58/U	1	-		J2202	-	-		J3702	-	-	BLANKING TO UM	Less than 1
W30	G15-C-10955	TTRS-2	4			-	TB2202	4	REMOTE ALARM	-			ALARM BUZZER	Less than 1
						-		5		-			SYNC. ERROR ALARM	Less than 1
						-		6		-			OFF SYNC ALARM	Less than 1
						-		7		-			ALARM COMMON	Less than 1
W31	G15-C-10955-5	TTRS-4	6			-	TB2202	10	RECORDING AMMETER NO. 1	-	P2601	2	PEN & MOTOR COM.	Less than 1
						-		11		-		5	DRIVE MOTOR	Less than 1
						-		12		-		8	LOCAL BLINK PEN	Less than 1
						-		13		-		11	OFF SYNC PEN	Less than 1
						-		14		-		14	(+) DC METER	Less than 1
						-		15		-		17	(-) DC METER	Less than 1
W32		RG-58/U	1	-		J2205	-	-	WWV MIXER	-	-	-	100 KC FREQ. CHECK	Less than 1
W33	G15-C-16850	RHDL #12	2	WH		-	TB2204	1	VOLTAGE REGULATOR NO. 2	-	OUTPUT		115 V. AC POWER	11
				BLK		-		2		-	OUT. COMMON			11
W34		Copper strap 3" MAX WIDTH	1	-	(GND PLATE)	-	-	-	STATION GROUND	-			CABINET CY-1437/FPN-30 NO. 2 GROUND	
W35	G15-C-10955-5	TTRS-4	6			-	TB2201	3	KEYING UNIT NO. 2	-			EXT. KEY & LOAD COM.	Less than 1
						-		4		-			EXTERNAL LOAD	Less than 1
						-		5		-			B-2 KEY	Less than 1
						-		6		-			B-3 KEY	Less than 1
						-		7		-			B-4 KEY	Less than 1
						-		8		-			B-5 KEY	Less than 1
W36	G15-C-16850	RHDL #12	2	WH	VOLTAGE REGULATOR NO. 2	-	INPUT		LORAN SWITCHING EQUIPMENT NAVY MODEL - UM	-	TB3705	3	115 V. AC POWER	11
				BLK		-	IN. COMMON			-		4		11
W37		RG-58/U	1	-	ELECTRICAL EQUIPMENT CABINET CY-1437/FPN-30 (TIMER) NO. 4	J2200	-	-		J3725	-	-	XMTR 100 KC	Less than 1
W38		RG-58/U	1	-		J2201	-	-		J3714	-	-	XMTR TRIGGER	Less than 1
W39		RG-58/U	1	-		J2203	-	-		J3712			LOCAL SIGNAL	Less than 1
W40		RG-58/U	1	-		J2204	-	-		J3718	-	-	REMOTE SIGNAL	Less than 1
W41		RG-58/U	1	-		J2202	-	-		J3704	-	-	BLANKING TO UM	Less than 1
W42	G15-C-10955	TTRS-2	4			-	TB2202	4	REMOTE ALARM	-			ALARM BUZZER	Less than 1
						-		5		-			SYNC ERROR ALARM	Less than 1
						-		6		-			OFF SYNC ALARM	Less than 1
						-		7		-			ALARM COMMON	Less than 1
W43	G15-C-10955-5	TTRS-4	6			-	TB2202	10	RECORDING AMMETER NO. 3	-	P2601	2	PEN & MOTOR COM.	Less than 1
						-		11		-		5	DRIVE MOTOR	Less than 1
						-		12		-		8	LOCAL BLINK PEN	Less than 1
						-		13		-		11	OFF SYNC PEN	Less than 1
						-		14		-		14	(+) DC METER	Less than 1
						-		15		-		17	(-) DC METER	Less than 1
W44		RG-58/U	1	-		J2205	-	-	WWV MIXER		-	-	100 KC FREQ. CHECK	Less than 1
W45	G15-C-16850	RHDL #12	2	WH		-	TB2204	1	VOLTAGE REGULATOR NO. 4	-	OUTPUT		115 V. AC POWER	11
				BLK		-		2		-	OUT. COMMON			11
W46		Copper strap 3" MAX WIDTH	1	-	(GND PLATE)	-	-	-	STATION GROUND	-			CABINET CY-1437/FPN-30 NO. 4 GROUND	
W47	G15-C-10955-5	TTRS-4	6			-	TB2201	3	KEYING UNIT NO. 4	-			EXT. KEY & LOAD COM.	Less than 1
						-		4		-			EXTERNAL LOAD	Less than 1
						-		5		-			B-2 KEY	Less than 1
						-		6		-			B-3 KEY	Less than 1
						-		7		-			B-4 KEY	Less than 1
						-		8		-			B-5 KEY	Less than 1
W48	G15-C-16850	RHDL #12	2	WH	VOLTAGE REGULATOR NO. 4	-	INPUT		LORAN SWITCH. EQUIP. NAVY MODEL - UM	-	TB3705	7	115 V. AC POWER	11
				BLK		-	IN. COMMON			-		8		11
W49		RG-58/U	1	-	TIMER NO. 1	J2202	-	-	TIMER NO. 1	J2206	-	-	BLANKING TO TIMER	Less than 1
W50		RG-58/U	1	-	TIMER NO. 3	J2202	-	-	TIMER NO. 3	J2206	-	-	BLANKING TO TIMER	Less than 1
W51		RG-58/U	1	-	TIMER NO. 2	J2202	-	-	TIMER NO. 2	J2206	-	-	BLANKING TO TIMER	Less than 1
W52		RG-58/U	1	-	TIMER NO. 4	J2202	-	-	TIMER NO. 4	J2206	-	-	BLANKING TO TIMER	Less than 1
W53	G15-C-10955	TTRS-2	2		TIMER NO. 1	-	TB2202	8	DPDT SWITCH NO. 1	-		3	STANDBY - OPERATE	Less than 1
						-		9		-		5	CONTROL	Less than 1
W54	G15-C-10955	TTRS-2	2		TIMER NO. 3	-	TB2202	8	DPDT SWITCH NO. 2	-		3	STANDBY - OPERATE	Less than 1
						-		9		-		5	CONTROL	Less than 1

ALL CABLES SUPPLIED BY INSTALLING ACTIVITY

SYMBOL	NAVY STOCK NUMBER	NAVY TYPE NUMBER (See note 2)	NUMBER OF ACTIVE COND.	COLOR	FROM				TO				FUNCTION	COND. AMPS
					LOCATION	COAX. CONN.	TERM. BOARD	PIN NO.	LOCATION	COAX. CONN.	TERM. BOARD	PIN NO.		
W55	G15-C-10955	TTRS-2	2		TIMER NO. 2	-	TB2202	8	DPDT SWITCH NO. 1	-		4	STANDBY - OPERATE	Less than 1
						-		9		-		6	CONTROL	Less than 1
W56	G15-C-10955	TTRS-2	2		TIMER NO. 4	-	TB2202	8	DPDT SWITCH NO. 2	-		4	STANDBY - OPERATE	Less than 1
						-		9		-		6	CONTROL	Less than 1
W57	G15-C-10955	TTRS-2	4		ELECTRICAL EQUIP. CABINET CY-1437/FPN-30 (TIMER) NO. 1	-	TB2201	10	ELECTRICAL EQUIP. CABINET CY-1437/FPN-30 (TIMER) NO. 2	-	TB2201	12		Less than 1
						-		11		-		13	K2201	Less than 1
						-		12		-		10	INTERLOCK	Less than 1
						-		13		-		11		Less than 1
W58	G15-C-10955	TTRS-2	4		ELECTRICAL EQUIP. CABINET CY-1437/FPN-30 (TIMER) NO. 3	-	TB2201	10	ELECTRICAL EQUIP. CABINET CY-1437/FPN-30 (TIMER) NO. 4	-	TB2201	12		Less than 1
						-		11		-		13	K2201	Less than 1
						-		12		-		10	INTERLOCK	Less than 1
						-		13		-		11		Less than 1

ALL CABLES SUPPLIED BY INSTALLING ACTIVITY

Figure 3-11. Running List, Loran Timer Set AN/FPN-30 at Station Employing Loran Switching Equipment Navy Model UM

14. APPLICATION OF POWER AND ADJUSTMENT OF POWER SUPPLIES.

At the start of the following procedures, it is assumed that all switches listed in paragraph 12 have been operated to the proper positions, indicated there. Now perform the steps listed below in the order given.

a. APPLICATION OF POWER TO VOLTAGE REGULATOR CN–235/FPN–30.

(1) Operate the MAIN POWER LINE 1 and MAIN POWER LINE 2 circuit breakers on Loran Switching Equipment AN/FPA–2 (or corresponding power-on switches on the Model UM Loran Switching Equipment, if used) to their ON positions.

(2) Operate the main power circuit breaker on Voltage Regulator CN–235/FPN–30, associated with the particular timer set being adjusted, to the ON position.

(3) Check that the power on indicator lamp on the voltage regulator unit lights.

b. CHECK AND ADJUSTMENT OF VOLTAGE REGULATOR TYPE CN–235/FPN–30. — Note that since the units of the timer cabinet are not energized at this time, the following checks and adjustments are being made under no-load condition of the voltage regulator. Accordingly, these checks and adjustments may have to be repeated after the normal load will have been applied.

(1) Operate the meter switch on the voltage regulator unit to the LINE VOLTAGE position. (Note that when the switch knob is released, the switch is spring-returned to the REGULATED VOLTAGE position.) Observe the meter, and check that the input voltage reading is between 98 and 132 volts. This is the operating range of the voltage regulator.

(2) Release the meter switch and use a screwdriver to adjust the (upper) OUTPUT VOLTAGE control on the voltage regulator panel until the meter reads 115 volts.

(3) Using a screwdriver, slowly rotate the SENSITIVITY (lower) control in the clockwise direction, until the servo system within the voltage regulator starts hunting. This is evidenced by continued audible clicking (chatter) of the relays inside the unit. Now, back off the SENSITIVITY control slightly (counterclockwise) to just stop the servo system from hunting. The voltage regulator unit is now adjusted for operation at maximum useful sensitivity.

c. APPLICATION OF POWER TO UNITS WITHIN TIMER CABINET.

(1) Operate the MAIN POWER circuit breaker on Power Supply Type PP–959/FPN–30 to the ON position.

(2) Check that the red MAIN POWER indicator lamp lights.

(3) Since the INTERLOCKED POWER ON-OFF switch (S2004) on Power Supply Type PP–959/FPN–30, and the SCOPE HIGH VOLTAGES ON-OFF switch (S2101) on Power Supply Type PP–957/FPN–30 are already in their ON positions (paragraph 12 of this section), check also that the corresponding indicator lamps, INTERLOCKED POWER (I2008) and SCOPE HIGH VOLTAGES respectively, are also lit.

(4) Allow a warm-up period of about 15 minutes.

(5) With the voltage regulator now operating under normal load conditions, recheck the OUTPUT VOLTAGE and SENSITIVITY control adjustments. See paragraphs 14 *b* (2) and 14 *b* (3), above.

d. CHECK AND ADJUSTMENT OF POWER SUPPLY OUTPUT VOLTAGES.—The DC METER switch (S2002) on Power Supply Type PP–959/FPN–30 connects the significant output circuits of the three power supplies in the timer cabinet to the meter on the PP–959/FPN–30 panel to permit checking the output voltages. Each switch position is labeled with the nominal output voltage reading, the full-scale reading of the meter for that switch position, and the nomenclature of the unit from which the particular voltage is derived. Thus, for the PP–959/FPN–30 switch position marked +300 V (FS–400V), the required reading is 300 volts, the full-scale reading is 400 volts, and the voltage being measured comes from Power Supply Type PP–959/FPN–30. Proceed as follows:

(1) Check that the a-c meter on the panel of Power Supply Type PP–959/FPN–30 indicates that the voltage regulator output (115 volts ac) is being fed into the input circuits of the PP–959/FPN–30 unit.

(2) Starting with the extreme counterclockwise position of the DC METER switch, turn the switch successively to each one of its positions. For each position obtain the meter reading and compare it with the required nominal output voltage marked on the panel for that switch position, and with the corresponding data listed in the table, below.

(3) For some of the switch positions listed in the following table, the readings obtained should be within the limits shown. These output voltages are not adjustable. If, for these switch positions, the readings obtained are outside the specified limits, perform the trouble-shooting procedures given in Section 7, tables 7–10, 7–11, or 7–12, for the particular power supply unit involved. For the remaining switch positions, limits are not shown in the table. Instead, for these switch positions, an adjustment control is listed. If the nominal required reading for such a switch position is not obtained, adjust the corresponding control, until the proper output voltage reading is obtained. To gain access to the adjustment control, open the particular power supply drawer part of the way. (Refer to discussion of interlock switch arrangement in paragraph 13, above.) The potentiometer is mounted on a bakelite strip in back of the panel. See figures 4–11, 4–12, and 4–13.

DC METER SWITCH POSITION	NOMINAL READING (PANEL MARKING)	FULL-SCALE EQUIVALENT	POWER SUPPLY TYPE	LIMITS, ADJUSTMENT CONTROLS AND REMARKS
1	+ 150V	200 volts	PP–959	Use +150 V ADJ potentiometer (R2022) to adjust. (Note 1.)
2	− 30V	40 volts	PP–959	Use −30 V ADJ potentiometer (R2033) to adjust.
3	− 108V	200 volts	PP–959	Reading may be between 100 to 116 volts (not adjustable).
4	+ 300V	400 volts	PP–958	Use +300 V ADJ potentiometer (R1922) to adjust. (Note 2.)
5	+ 135V	200 volts	PP–958	Use +135 V ADJ potentiometer (R1933) to adjust.
6	+1,000V	2,000 volts	PP–958	Reading may be between 850 to 1,150 volts (not adjustable).
7	+ 150V	200 volts	PP–957	Use +150 V ADJ potentiometer (R2122) to adjust.
8	−1,800V	4,000 volts	PP–957	Reading may be between 1,500 to 2,100 volts (not adjustable).

Notes

1. Always adjust the −30-volt output of Power Supply Type PP–959/FPN–30 after the +150-volt supply of that unit has been adjusted, since adjustment of the +150 V ADJ potentiometer affects both the +150-volt and the −30-volt outputs.

2. Always adjust the +135-volt output of Power Supply Type PP–958/FPN–30 after the +300-volt supply of that unit has been adjusted, since adjustment of the +300 V ADJ potentiometer affects both the +300-volt and the +135-volt outputs.

(4) Check the voltage drop across the cathode current metering resistors in each regulator tube section of each power supply unit. Use the test leads, provided for this purpose with the timer set, to plug in a Simpson Model 260 voltmeter, or equivalent, between the COMMON jack and each one of the cathode jacks. Use the 2.5-volt scale. The COMMON jack is also labeled — (minus). Each cathode jack is labeled with + and the tube reference symbol. The jacks are located on the power supply chassis. Refer to figures 4–11, 4–12, and 4–13 for location of the jacks in the PP–959/FPN–30, PP–958/FPN–30, and PP–957/FPN–30 power supply units, respectively. Compare the reading obtained at each cathode jack with the value listed for the particular power supply unit in the following table. Each reading should be greater than the value shown in the table for the particular unit. If any of the readings obtained falls below that minimum value, the associated tube is probably defective and should be replaced.

POWER SUPPLY TYPE	MINIMUM METER READING (VOLTS)
PP–959/FPN/30	0.5
PP–958/FPN–30	0.7
PP–957/FPN–30	0.4

CAUTION

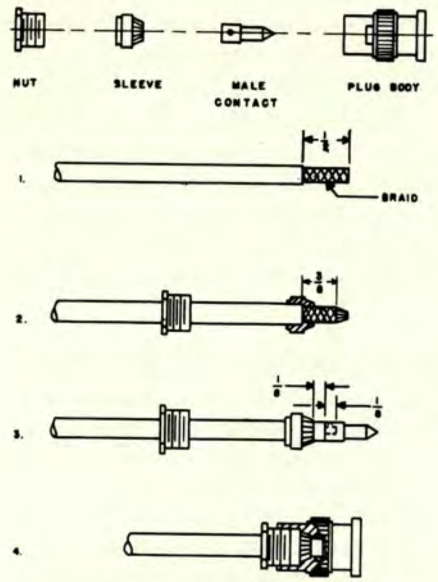
The contacts of the test jacks are above ground by the B+ potential. Be careful to avoid grounding either test lead. Otherwise damage to the meter may result.

15. INITIAL ADJUSTMENTS OF RADIO FREQUENCY OSCILLATOR TYPE O–202/FPN–30.

a. INSTALLATION OF FREQUENCY CORRECTOR CABLE.—Perform either step (1) or step (2), below, depending on whether the station being adjusted is a master station or a slave station, respectively.

(1) MASTER STATION.—Check that connector P1402 is ***not*** attached to FREQ. CORR. connector J1402 on the rear apron of the oscillator chassis, and is, instead, stored in the fuse clip above J1402. It is important to ascertain that the cable is not attached at a master station. The oscillator at a master station serves as the frequency standard for the entire loran system. It must not, therefore, be controlled by Synchronization Control Unit Type C–1238/FPN–30, and must not be subjected to the possibility of spurious or accidental frequency correction.

(2) SLAVE STATION. — Check that connector P1402 is attached to FREQ. CORR. connector J1402 on the rear apron of the oscillator chassis. This connects

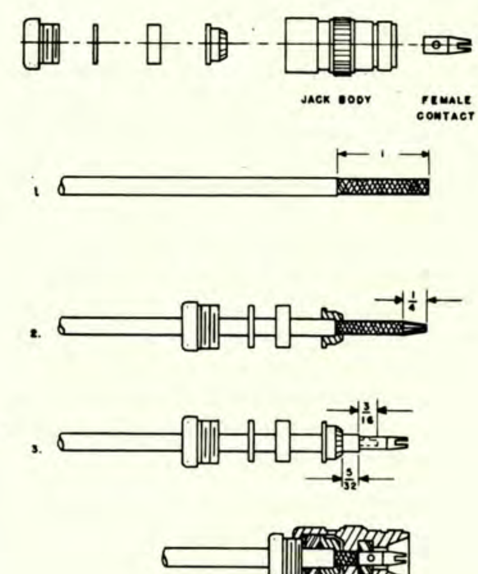


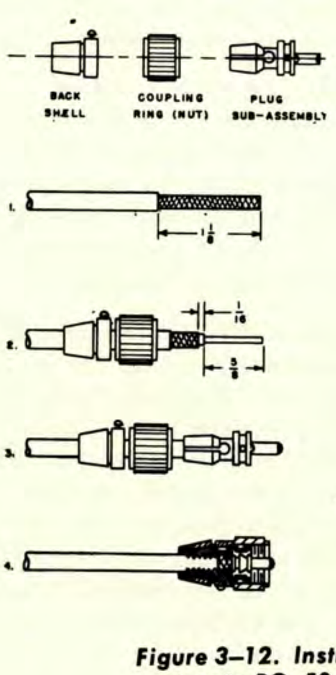
PROCEDURE FOR TYPE "BNC" CONNECTORS

1 Cut off jacket 1/2" from end being careful not to nick braid.
2 Cut off inner insulation and wire under braid 3/8" from end of jacket, taper braid. Slide sleeve and nut on to cable. Inner shoulder of sleeve must fit squarely against end of cable jacket.
3 With sleeve in place comb out braid, fold back smooth and trim 3/32" from end. Cut inner dielectric 1/8" from braid, being careful not to nick inner conductor and cut off inner conductor 1/8" from end of dielectric. Tin inside hole of contact. Tin center conductor of cable, slip contact in place and solder. Be sure cable dielectric is not heated excessively and swollen so as to prevent dielectric entering body.
4 Push body in as far as it will go, then slide nut into body and screw into place with wrench, until moderately tight. Hold cable and shell rigidly and rotate nut. This assembly applies to "BNC" plugs. The assembly of jacks is the same except use female contacts and jack body.

PROCEDURE FOR TYPE "N" CONNECTORS

1 Cut off jacket 1" from end being careful not to nick braid.
2 Push back braid and cut off 1/4" of cable dielectric, pull braid forward and taper toward center conductor. Insert part 1 and follow with parts 2, 3 & 4. Be sure part 4 clears all braid wires and its internal shoulder rests squarely against end of cable jacket.
3 Unbraid shield wires and lay back on part 4 without wires crossing each other. Trim braid. Cut off cable dielectric 5/32" from end of braid wires. Do not nick center conductor. Cut center conductor 3/16" from end of cable dielectric and tin. Tin contact, slide in place, and solder. Be sure cable dielectric is not heated excessively and swollen so as to prevent dielectric entering body.
4 Insert cable into body as far as it will go, then slide parts 2 & 3 into body and tighten part 1 with wrench until moderatly tight. Hold cable rigidly and rotate nut. This assembly applies to "N" jacks. The assembly of plugs is the same except use male contact and plug body.





PROCEDURE FOR TYPE 83-1 SPN CONNECTORS

1 Cut end of cable even. Remove vinyl jacket 1-1/8".
2 Bare 5/8" of center conductor. Tin exposed conductor & braid. Slide back shell & coupling ring on cable.
3 Screw the plug sub-assembly on cable. Solder this assembly to braid through solder holes. Solder center conductor to contact. Do not use excessive heat.
4 For final assembly, slide coupling ring over plug sub-assembly, then position back shell with sufficient clearance to permit free rotation of coupling nut, and tighten set screw

Figure 3-12. Instructions for Assembly of Type BNC and Type N Connectors to RG-58/U and RG-8/U Coaxial Cables and for Assembly of Type 83-1 SPN Plug to RG-8/U Coaxial Cables

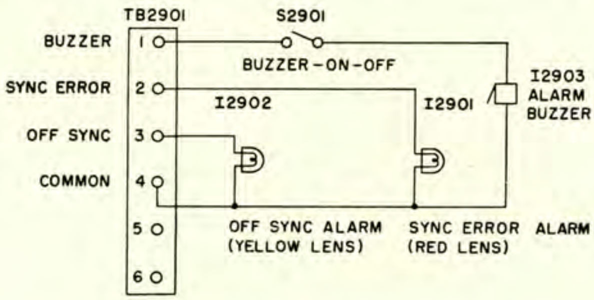


Figure 3–13. Schematic Arrangement for a Suitable Remote Synchronization Alarm Unit

the frequency correcting capacitor C120, located in Synchronization Control Unit Type C–1238/FPN–30, to the oscillator frequency determining circuits.

b. PRELIMINARY CHECKS AND OBSERVATIONS.

(1) Make a preliminary operating check by noting the readings of the meter (M1401) as the METER SWITCH (S1402) is successively set to each of its positions. For each position, except OFF and HEATER, the meter should read at approximately midscale. A steady reading should be obtained on all points. The exact values of the meter readings, when the unit is first placed in operation, are not important as long as the reading for the OSC OUT position of the switch is between 50 and 150 microamperes. For the HEATER position of the switch, the meter will read off scale for some hours after power is applied to the unit, as the heater is working to raise the temperature of the crystal oven to its proper operating point.

(2) Approximately 24 hours after being turned on, the crystal oscillator will stabilize. This condition will be recognized by the fact that the reading of the meter, with the METER SWITCH in the HEATER position, will drop to a value of about 100 $\pm$40 microamperes, indicating that the heater has attained its stable operating condition. The meter reading should not fluctuate appreciably after this point is reached, though the exact reading will change somewhat with variations in ambient temperature. The meter readings for all other positions of the METER SWITCH should be 100 $\pm$40 microamperes. Because of the wide variations permitted in vacuum tubes, readings slightly outside the above range may be obtained. If the unit continues to operate satisfactorily under such conditions, the out-of-limit readings may be disregarded, provided the vacuum tubes are checked from time to time in a suitable vacuum tube test set. It should be noted, however, that a normal meter reading does not necessarily insure that the vacuum tube is in perfect condition.

(3) Record all readings obtained as indicated in step (2), above, for future reference in operator's checks and maintenance.

c. INITIAL FREQUENCY ADJUSTMENTS.—Partially withdraw the oscillator unit drawer from the cabinet and note the factory-determined settings of the COARSE FREQUENCY dials. These settings have been very accurately determined at the factory, and represent the precise 100-kc settings of the dials at the time of shipment. The settings are written on the cover for the large tuning capacitor, just behind the front panel. Manually operate the COARSE FREQUENCY and FINE FREQUENCY dials to the positions determined above.

d. FINAL FREQUENCY ADJUSTMENTS. — For the initial installation and adjustment of the other units of the timer, greater precision in the adjustment of the oscillator than that obtained by the setting of the frequency dials to the factory predetermined settings (as indicated in paragraph 15*c*, above) is unnecessary. Also, the amount of frequency instability introduced by using the oscillator before the equipment is fully warmed up is sufficiently small to make reliable adjustment of all other timer circuits, except those of the automatic synchronization control system, practical and possible. Accordingly, the procedures described in paragraphs 16 through 28 of this section may be made immediately after the frequency dials have been set at both master and slave stations, as described in paragraph 15*c*, above. Before making adjustments on the automatic synchronization system, and before introducing the station into the loran system, the power should be on for a period of about 24 hours. At the end of this period, final precise adjustment of the crystal oscillator frequency should be made, and the automatic synchronization system may then be adjusted. Accordingly, proceed as follows, performing step (1) at a master station, and step (2) at a slave station.

(1) MASTER STATION. — After the 24-hour warm-up period, adjust the crystal oscillator frequency against a signal from radio station WWV. If a signal from WWV is not available for this adjustment, the frequency dial settings at the master station may be left as arrived at in 15*c*, above. The percentage error resulting from such settings is negligible.

(2) SLAVE STATION.—Perform the adjustments described in paragraphs 16 through 24. Wait until the master station has made its adjustments of the oscillator, as indicated in paragraph 15*d* (1), above, and until a warm-up period of 24 hours has elapsed, before proceeding with the adjustments of the synchronization control circuits, as described in paragraph 25. The slave station oscillator frequency is adjusted at the appropriate point of the synchronization control circuit adjustments. The synchronization control circuits will then take over the function of maintaining the frequency of the slave station in synchronization with the frequency of the master station.

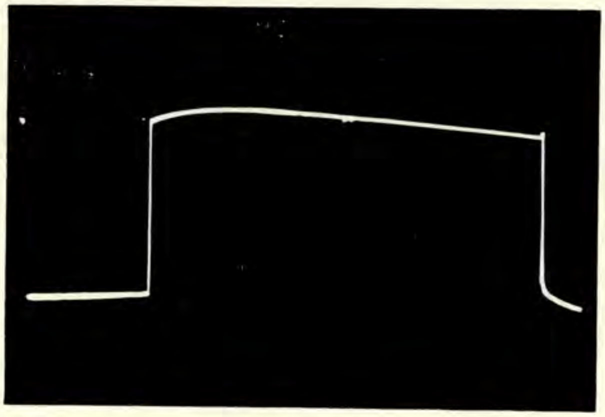


Figure 3–14. Square Wave Observed with GAIN SELECTOR in LOW Position and Circuit Correctly Adjusted

g. CHECK AND ADJUSTMENT OF ATTENUATION.—The following steps serve to insure distortionless attenuation of the incoming test signal for the LOW position of the GAIN SELECTOR switch (S1704).

(1) Observe the waveform displayed on the oscilloscope screen, and check that it has neither excessive overshoot nor excessive rise time. Refer to figure 3–14 for a properly adjusted waveform.

(2) If necessary, use a screwdriver to adjust the attenuation control, ATTEN ADJ capacitor (C1723), until the above requirement is met. This capacitor is located on the top of the oscilloscope chassis, directly behind the front panel.

h. ADJUSTMENT OF TEST PROBE.—Adjustment of the test probe serves to insure that incoming test signals are attenuated uniformly when the test probe is used for making the test connection, and the GAIN SELECTOR switch is in the HIGH position. Since proper compensation is not provided when the switch is in the LOW position, the probe should not, as a rule, be used for that switch position. Note, however, that whenever the probe is used in making tests, the GAIN SELECTOR switch will generally be turned to the HIGH position, to compensate for the attenuation introduced by the probe. To check and adjust the probe, proceed as follows:

(1) Disconnect the test cable from the EXTERNAL SIGNAL jack (J1706) and plug the probe into it. Connect the clip end of the probe to the free end of the test cable. (The other end of the cable is still connected to the SQUARE WAVE OUTPUT jack.)

(2) Turn the GAIN SELECTOR switch to the HIGH position. Readjust the SIGNAL GAIN control to obtain a waveform height convenient for observation. With the delay control still in the positions left in paragraphs 16 *c* (1) and 16 *e* (2), above, a positive-going edge of a square wave should appear on the oscilloscope screen.

(3) Check the waveform against figure 3–15, and determine that it has neither excessive overshoot nor excessive rise time.

(4) If the above requirement is not met, use a small screwdriver to adjust the capacitor in the probe until the correct waveform is obtained (figure 3–15). The capacitor is accessible through a small hole on the probe.

i. CHECK OF DELAY BIAS ADJUSTMENT (R1752).

(1) Turn the 1000-μs STEPS delay control in the counterclockwise direction slowly, until the positive-going edge of the square wave is moved as far to the left end of the sweep as possible.

(2) Switch the COARSE SWEEP SPEED control to position 2, and vary the FINE SWEEP SPEED control (R1790) to bring the edge of the square wave to the right-hand end of the sweep.

(3) Rotate the CONTINUOUS delay control (R1736) slowly in the counterclockwise direction, and observe the motion of the edge of the square wave. It should move uniformly toward the left, and should continue to do so over the entire range of the CONTINUOUS delay control.

(4) If the requirement of step (3), above, is not met, refer to Section 7, paragraph 4*b* (2), and adjust the DELAY BIAS potentiometer (R1752), as described there.

(5) Disconnect test leads.

j. WHEN TO READJUST 1000-GATE WIDTH AND 100-GATE WIDTH CONTROLS.—The chassis-mounted 1000-GATE WIDTH and 100-GATE WIDTH controls are factory-adjusted, and should, normally, require no further adjustment at this time. Readjustment of these controls becomes necessary if either one of the two trouble conditions listed below is encountered while the test oscilloscope is being used. Readjustment, if necessary, should be made as described in Section 7, paragraph 4*b* (1). The trouble indicating conditions are:

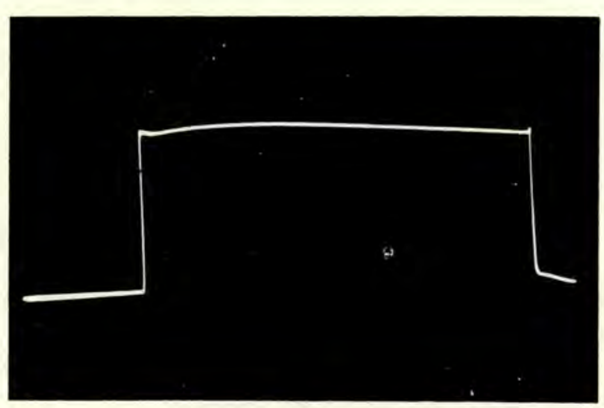


Figure 3–15. Square Wave Observed with Properly Adjusted Low Capacity Test Probe

(1) The sweep disappears intermittently as the delay controls on the test oscilloscope panel are varied.

(2) Two sweeps appear on the test oscilloscope screen for fast sweep speeds.

17. EMPLOYMENT OF TEST OSCILLOSCOPE TYPE OS–39/FPN–30.

The following paragraphs discuss the methods and procedures for using the switches and controls of the test oscilloscope in checking and adjusting the timer units. THE INFORMATION CONTAINED IN THIS PARAGRAPH IS BASIC AND VERY IMPORTANT TO THE PROCEDURES IN THE REMAINING PARTS OF THIS BOOK. THEY MUST THEREFORE BE THOROUGHLY UNDERSTOOD BEFORE ANY FURTHER ADJUSTMENTS OF THE TIMER ARE UNDERTAKEN.

a. SELECTION OF APPROPRIATE SYNCHRONIZING SIGNAL.—Selection of the synchronizing trigger for the test oscilloscope is accomplished by setting the SYNC SELECTOR switch to the proper one of its seven positions. The rules governing the selection of the particular position are given in the following paragraphs.

(1) SQUARE WAVE ϕ 1 and SQUARE WAVE ϕ 2 POSITIONS.—The combination of these two positions of the SYNC SELECTOR switch permits selection of any portion of the loran cycle, one position for each half-cycle, with some overlap between them, for display on the oscilloscope screen. Each position provides one trigger per loran cycle. These positions are used for almost all timer waveform observations and adjustments. UNLESS OTHERWISE SPECIFICALLY CALLED FOR IN THE PROCEDURES DESCRIBED IN THE REMAINDER OF THIS BOOK, IT WILL BE ASSUMED THAT THE OPERATOR WILL SELECT ONE OR THE OTHER OF THESE TWO POSITIONS FOR CHOOSING THE SYNCHRONIZING TRIGGER, AS REQUIRED FOR THE PARTICULAR CONDITION. If the desired signal cannot be made visible with the SYNC SELECTOR switch in the one position, turn it to the other position. It will then be possible to make the signal come into view. Note that all sweep delay circuits are connected when the SYNC SELECTOR switch is in the SQUARE WAVE ϕ 1 and in the SQUARE WAVE ϕ 2 positions, to permit observation of any part of the loran cycle at any sweep speed.

(2) 1000's AND 100's POSITIONS.—As a rule, these positions are used only for observation of waveforms coming from the Frequency Divider Type CV–274/FPN–30 in the case of failure of the square waves. These positions of the SYNC SELECTOR switch can also be used to intensify the waveforms of repetitive signals, such as the 100-kc sine wave or the markers. All delay circuits are disconnected when the SYNC SELECTOR switch is in either the 1000's or in the 100's position.

(3) EXTERNAL + AND EXTERNAL − POSITIONS.—These positions of the SYNC SELECTOR switch permit the test scope to be triggered by positive or negative excursions of external signals connected to the EXTERNAL SYNC jack. All delays are in the circuit for these switch positions. The two positions are most commonly used when the timer being adjusted has failed, and a trigger is obtained by connecting the square-wave output of an adjacent timer to the EXTERNAL SYNC jack. In this case, selection of either the + or − position provides full loran cycle coverage, similar to that provided by the selection of the SQUARE WAVE ϕ 1 or SQUARE WAVE ϕ 2 position.

(4) PEDESTAL POSITION. — This position of the SYNC SELECTOR switch provides two sweeps per loran cycle. The sync triggers are the same as those which drive the VIDEO SCOPE and RF SCOPE of Synchronization Indicator Type IP–238/FPN–30. The triggers are the mixed outputs of the A and B delay circuits, so that sweeps begin at the same time as the slow scope pedestals. The sweeps are subject to delay by the CONTINUOUS delay control only. Note that the time of the pedestals with respect to the test scope sweeps may also be varied by means of the video sweep delay controls. The PEDESTAL position is used specifically when adjusting Electrical Synchronizer Type SN–117/FPN–30 for master station operation. It may also be used for observation of other signals occurring at the time of the pedestals.

b. USE OF GAIN SELECTOR AND SIGNAL GAIN CONTROLS.—For proper observation of test signals on the test oscilloscope, it is necessary to insure that high-level incoming signals do not overload the cathode follower input circuits of the oscilloscope. When test signals selected by means of the TEST SIGNAL SELECTOR switches are observed, the signal voltage magnitudes are normally such that the HIGH position of the GAIN SELECTOR switch may be used with safety. However, for probing at test points at which voltages of unknown magnitudes exist, turn the switch initially to the LOW position, and then, only if necessary, to the HIGH position. For this reason, it is recommended that the GAIN SELECTOR switch be set as follows:

(1) Normally, and unless otherwise specified, perform checks with the GAIN SELECTOR in the LOW position.

(2) Use the HIGH position of the GAIN SELECTOR switch only when insufficient signal amplitude is obtained by adjustment of the SIGNAL GAIN control with the GAIN SELECTOR in the LOW position.

(3) Use the HIGH position of the GAIN SELECTOR switch whenever the low capacity probe is used for making test connections. Sufficient attenuation is provided by the probe to prevent overloading the input stage.

c. USE OF MARKER SELECTOR AND MARKER HEIGHT CONTROLS.

(1) To select markers for measurements of time intervals by means of the test oscilloscope, set the MARKER SELECTOR switch (S1703) to the appropriate position.

(2) To adjust the markers selected in (1), above, to the desired amplitude, use the MARKER HEIGHT control.

Note

The amplitude of the markers is not affected by the SIGNAL GAIN control. Conversely, the amplitude of the incoming test signal is not affected by the MARKER HEIGHT control.

d. USE OF SWEEP SPEED CONTROLS. — Two sweep speed controls are provided. The COARSE SWEEP SPEED control selects the particular range out of four possible ranges. The FINE SWEEP SPEED control provides for continuous variation of sweep speed within the range selected by the COARSE SWEEP SPEED control. The available ranges (approximate) of the COARSE SWEEP SPEED control are listed below for the four positions of the switch.

COARSE SWEEP SPEED CONTROL POSITION	SWEEP SPEED RANGE (MICROSECONDS)
1	4,500 to 30,000
2	500 to 4,500
3	70 to 500
4	12 to 100

Note

For the high repetition rate, when using sweep speeds about 28,000 microseconds long, or longer, the sweep generator will respond only to alternate triggers. This will evidence itself as a slight flicker of the waveform on the scope screen. This is perfectly normal and need not be taken as an indication of trouble.

e. USE OF SWEEP DELAY CONTROLS.—Three delay controls are provided, two stepped delays, 1000-μs STEPS and 100-μs STEPS, and one continuous delay. The ranges covered by the three controls are listed below.

DELAY CONTROL	APPROXIMATE RANGE	REMARKS
1,000-μs STEPS	30,000 μs	
100-μs STEPS	1,500 μs	The overlap is provided to permit interpolation between 1,000-μs steps.
CONTINUOUS	150 μs	The overlap is provided to permit interpolation between 100-μs steps.

The complexity of the delay system is necessary to permit the use of fast sweeps without jitter. Owing to the characteristics of the circuit, the sweep may on rare occasions appear to jitter. This is caused by 1,000-microsecond and 100-microsecond gates just barely selecting markers. To correct this condition, move the 1000-μs STEPS or the 100-μs STEPS delay control slightly.

f. ADJUSTMENT OF SWEEP DELAY CONTROLS, BASIC RULES.—The delay controls are used to start the scope sweep speed at any desired point in the loran cycle. Since proper adjustment of the delay controls underlies many of the checks and adjustments described in this book, mastery of the procedure and understanding of the principles underlying the procedure are very important. This is particularly true when a narrow pulse is to be observed on the scope at fast sweep speeds. The step-by-step procedure for adjusting the delay controls is given in paragraph 17 *g,* below. The principles of operation of the delay controls are discussed in Section 2. Mastery of the procedures can be achieved, after some practice, by carefully observing the basic rules outlined below.

(1) Before increasing sweep speed, always move the signal as far as possible to the left end of the sweep, using the appropriate delay control.

(2) Never vary any delay control to a point where the signal is off the screen.

(3) Increase sweep speed gradually, never allowing the signal to go off the right-hand end of the sweep.

Note

An increase in sweep speed is equivalent to a reduction in the duration, in microseconds, of the sweep. In terms of the sweep speed controls, the sweep speed is increased when either control is rotated in the clockwise direction. Refer to the table of sweep speed ranges given in paragraph 17 *d,* above.

g. DELAY CONTROL ADJUSTMENT — EXAMPLE.—To familiarize personnel with the adjustments of the delay controls so that the desired signal may be viewed on the test oscilloscope at the fastest available sweep speed, the following procedure is given as an example. The example utilizes the transmitter trigger test signal derived from the time delay unit.

(1) Arrange the TEST SIGNAL switch on the unit from which the signal is to be obtained and the SIGNAL SELECTOR switch of the test oscilloscope so that the desired signal is fed into the oscilloscope. In the example:

(*a*) turn the TEST SIGNAL switch on the time delay unit to TRANSMITTER TRIGGER, and

(*b*) turn the SIGNAL SELECTOR switch on the test oscilloscope to TIME DELAY.

(2) Turn the SYNC SELECTOR switch on the test oscilloscope to the SQUARE WAVE ϕ 1 position.

(3) Set the following test oscilloscope controls, as indicated:

(*a*) COARSE SWEEP SPEED control to position 1.

(*b*) FINE SWEEP SPEED control to approximately 25 percent of its rotation range away from the extreme counterclockwise end of its rotation.

(*c*) 100-μs STEPS and CONTINUOUS delay controls to the extreme clockwise positions.

(4) Vary the 1000-μs STEPS control to bring the test signal into view on the oscilloscope screen. Adjust the amplitude of the signal to a level convenient for observation.

(5) Continue to vary the 1000-μs STEPS delay control to shift the signal as far as possible to the left end of the sweep.

(6) If adjustment of the 1000-μs STEPS delay control cannot shift the signal to the left end of the sweep before it disappears from the screen, turn the SYNC SELECTOR switch to change the phase of the sweep trigger (i.e., to change from SQUARE WAVE φ 1 to SQUARE WAVE φ 2) and repeat the adjustment of the 1000-μs STEPS delay control to shift the signal to the extreme left end of the sweep. (See basic rule (1), in 17 *f*, above.)

(7) Turn the COARSE SWEEP SPEED control to position 2, and use the 100-μs STEPS delay control to shift the signal to the extreme left end of the sweep. Do not shift the signal beyond the point where it will go off the screen.

Note

If the 100-μs STEPS control does not have enough range to shift the signal to the extreme left end of the sweep, step (6), above, has not been fully completed. In this case, proceed as follows:

(*a*) Return the COARSE SWEEP SPEED control to position 1.

(*b*) Turn the 100-μs STEPS control to the extreme clockwise position.

(*c*) Vary the 1000-μs STEPS control slowly in the counterclockwise direction to bring the signal as far as possible to the left end of the sweep, before the signal goes off the screen.

(*d*) Return the COARSE SWEEP SPEED control to position 2, and again use the 100-μs STEPS control to complete the shifting of the signal to the left end of the sweep.

(8) Turn the COARSE SWEEP SPEED control to position 3, and use the CONTINUOUS control to shift the signal to the left end of the sweep, before going off the screen.

Note

If the CONTINUOUS control does not have enough range to meet the requirement of step (8), above, step (7) has not been fully completed. In this case, proceed as follows:

(*a*) Return the COARSE SWEEP SPEED control to position 2.

(*b*) Turn the CONTINUOUS delay control to the extreme clockwise position.

(*c*) Use the 100-μ STEPS control to shift the signal as far as possible to the left end of the sweep, before going off the screen.

(*d*) Return the COARSE SWEEP SPEED control to position 3.

(*e*) Use the CONTINUOUS delay control to complete the process of shifting the signal to the left end of the screen.

(9) Turn the COARSE SWEEP SPEED control to position 4, and use the CONTINUOUS delay control, as before.

(10) Turn the FINE SWEEP SPEED control in the clockwise direction, until either

(*a*) the extreme clockwise end of the control is reached, or

(*b*) the signal tends to go off the right-hand end of the sweep.

(11) Depending on the condition obtained in step (10), above, proceed with either (*a*) or (*b*), below.

(*a*) If the extreme clockwise end of the FINE SWEEP SPEED control is reached before the signal goes off the screen at the right-hand end of the sweep, turn the CONTINUOUS delay control to position the signal on the desired point on the sweep.

(*b*) If the signal goes off the right-hand end of the sweep before the FINE SWEEP SPEED control reaches the extreme clockwise end of its rotation:

1. turn the CONTINUOUS delay control to bring the signal further to the left,

2. turn the FINE SWEEP SPEED control to the extreme clockwise end of its rotation, and

3. use the CONTINUOUS delay control to position the signal on the desired point of the sweep.

18. INITIAL CHECKS AND ADJUSTMENTS OF SYNCHRONIZATION CONTROL UNIT TYPE C–1238/FPN–30.

The checks and adjustments described in the following paragraphs cover the initial settings of controls and switches, and the checks of the 100-kc circuit sections of the unit. The 60-cycle and motor control circuit checks and adjustments are given in paragraphs 28 and 29 as part of the adjustments of the automatic synchronization circuits.

a. INITIAL SWITCH AND CONTROL SETTINGS.—The following steps list the settings of controls and switches pertinent to the checks described in paragraphs 18 *b* through 18 *d* below.

(1) At both master and slave stations turn the FREQUENCY CORRECTOR switch (S103) to the OUT position. Check that the FREQUENCY CORRECTOR indicator lamp (I104) goes on.

(2) Turn the FREQUENCY CORRECTOR dial (C120) to the 0 (zero) position. At a master station this dial has no function, since capacitor C120 is not in the circuit.

Note

The FREQUENCY CORRECTOR switch must be turned to the OUT position whenever the setting of the FREQUENCY CORRECTOR dial is to be changed manually. With the switch in the IN position, the shaft of tuning capacitor C120 is engaged to the clutch of the motor drive mechanism, and manual adjustment of the FREQUENCY CORRECTOR dial should not be attempted.

(3) Operate the FREQUENCY CORRECTOR switch (S103) to the IN position.

(4) Turn the STATION SELECTOR switch (S101), on the chassis, to either the MASTER or the SLAVE position, depending on whether a master or slave station, respectively, is being adjusted.

b. CHECKS OF 100-KC CIRCUITS.

(1) Operate the SIGNAL SELECTOR switch on the test oscilloscope panel to the SYNC CONTROL position, the GAIN SELECTOR switch on the test scope to the HIGH position, the COARSE SWEEP SPEED control to position 3, and the SYNC SELECTOR switch to the 100's position.

(2) Operate the TEST SIGNAL switch (S107) on the synchronization control unit successively to each one of its four positions (100 KC INPUT, ϕ SHIFTER OUTPUT, 100 KC TO XMTR, and 100 KC TO FREQ DIV), and observe that a 100-kc signal is present on the test scope screen for each position of the switch. Typical waveforms are shown in figures 7–1 through 7–4.

(3) If for any position of the TEST SIGNAL switch (S107) the pattern is not obtained, refer to Section 7, Corrective Maintenance, for information for locating the defective stage and for correcting the fault.

(4) Return SYNC SELECTOR switch to ϕ 1 position.

c. CHECK OF FREQUENCY ALARM CIRCUITS.—This check is important at a slave station only. At a master station this check should be omitted, since the circuit is not in use at a master station. At a slave station proceed as follows:

(1) Operate the FREQUENCY CORRECTOR switch to the OUT position.

(2) Rotate the FREQUENCY CORRECTOR dial to the left and then to the right of the 0 mark.

(3) Check that the FREQUENCY WARNING indicator lamp (I105) goes on when the dial is between 3-3/4 and 4 calibration markings on each side of the 0 mark.

(4) If the above requirement is not met, refer to Section 7, paragraph 4*b* (2), for the appropriate adjustment procedures.

(5) After completing the above checks satisfactorily, return the FREQUENCY CORRECTOR dial to the 0 mark and the FREQUENCY CORRECTOR switch to the IN position.

19. INITIAL ADJUSTMENTS OF FREQUENCY DIVIDER TYPE CV–274/FPN–30.

a. INITIAL SWITCH SETTINGS.—Set the following switches as indicated. Settings of switches and controls not listed below are covered in later paragraphs of this section.

(1) Make sure to set the TEST COUNT INSERT switch (S201) to the OFF (counter normal) position. This control is located behind the door on the right side of the front panel.

(2) Set the BASIC RATE (S205) and SPECIFIC RATE (S202) switches to the positions corresponding to the basic and specific rates, respectively, assigned to the station.

b. CHECKS AND ADJUSTMENTS.

(1) Set the COUNTER BIAS control (R282) to 50 on the dial.

Note

This initial setting of the COUNTER BIAS control is sufficiently accurate for the following steps. Determination of range of this control and setting it to the center of that range will be performed as a fine adjustment at a later point in the procedures.

(2) Turn the SIGNAL SELECTOR switch (S1702) on the test oscilloscope to the FREQ DIVIDER position.

(3) Rotate the TEST SIGNAL switch on the frequency divider unit to each one of its positions (10's, 100's, 1000's, and 50), and for each position observe whether appropriate markers appear on the test oscilloscope screen. Typical waveforms are shown in figures 7–5 through 7–8.

(4) If the patterns are not obtained for any position of the TEST SIGNAL switch, refer to the troubleshooting information given in table 7–4, and perform the checks and procedures given there for the frequency divider circuits involved.

20. INITIAL CHECKS AND ADJUSTMENTS OF SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30.

a. INITIAL SWITCH SETTINGS.

(1) Turn the VIDEO SWEEP SPEED control (R813) to the extreme counterclockwise position, to

provide wide pedestals on the SLOW SCOPE screen.

(2) Turn the COARSE RF GAIN control (R1228) located on the panel of the radio receiver unit, to the extreme counterclockwise position. This prevents signals from the receiver from being applied to the circuits of the synchronization indicator unit.

(3) Open the hinged panel of the synchronization indicator unit to gain access to the controls located there, to be used in the following procedures.

b. INITIAL ADJUSTMENTS OF SLOW SCOPE.—Some of the SLOW SCOPE controls listed below are located on Frequency Divider Type CV–274/FPN–30.

(1) Adjust the SLOW SCOPE INTENSITY control (R842) on the synchronization indicator unit to the desired brightness of the waveforms appearing on the SLOW SCOPE screen.

(2) Set the SLOW MARKERS switch (S206) on the frequency divider unit to the ON position, to bring the markers into view on the SLOW SCOPE screen.

(3) Adjust the SLOW SCOPE FOCUS control (R845) on the synchronization indicator unit, so that the traces on the SLOW SCOPE screen are sharp.

(4) Adjust the SLOW SIZE control (R275) on the frequency divider unit so that the sweep is about 2-1/2 inches wide. Lock the control in the adjusted position.

(5) Use the SLOW HOR CENT control (R255) on the frequency divider unit to center the traces horizontally on the SLOW SCOPE screen. Turn this control slowly, since a long time constant is involved. After adjustment lock the control in position.

(6) Use the SLOW SEP control (R264) on the frequency divider unit to adjust the separation between the upper and lower sweeps to about 1/2 inch. Lock the control in the adjusted position.

(7) Use the SLOW VERT CTR control (R950) on the synchronization indicator unit to adjust the positioning of the sweeps so that the upper sweep appears at the middle of the SLOW SCOPE screen.

(8) Observe the pattern appearing on the SLOW SCOPE screen. A typical pattern for a *high specific* rate is shown in figure 3–16.

(9) If two pedestals, one on the upper sweep and one on the lower sweep, do not appear on the SLOW SCOPE screen, proceed as follows:

(*a*) Check to make sure that the B-preset selector switch, located behind the door on the panel of the time delay unit, is in the NORMAL position. Successively observe (on the test oscilloscope) the A1000, B1000, B100, and B10 gates, brought into view on that scope for the corresponding positions of the TEST SIGNAL switch (S503) on Time Delay Unit Type TD–92/FPN–30. For comparison refer to the waveforms shown in figures 3–17, 3–18, and 3–19.

(*b*) For each gate brought into view on the test oscilloscope screen, as in (*a*), above, observe that a marker is being pushed up.

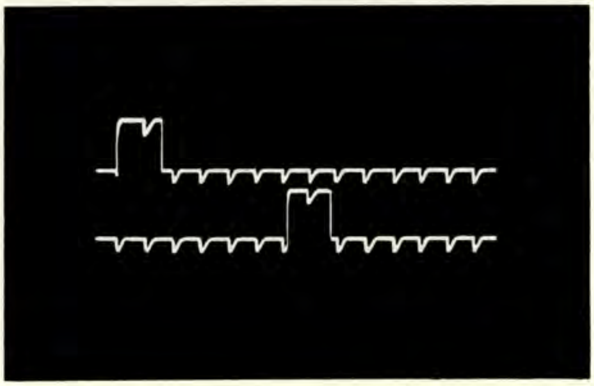


Figure 3–16. Typical SLOW SCOPE Presentation, High Basic Rate

(*c*) If necessary, adjust the corresponding delay control, A1000 DELAY (R502), B1000 DELAY (R532), B100 DELAY (R561), or B10 DELAY (R581), on the Time Delay Unit Type TD–92/FPN–30, until a marker is pushed up.

Note

If two pedestals appear on the same trace of the SLOW SCOPE, the A1000 DELAY or the B1000 DELAY control on the time delay unit has been set for too great a delay. The control should be readjusted to reduce the delay sufficiently to place one pedestal on each of the two traces.

(*d*) If, after the adjustments indicated above, the required pattern is still not observed, i.e., if one pedestal still does not appear on the trace, refer to table 7–5, symptoms 4 and 14 of Section 7, for the trouble-shooting procedures required to remedy this condition.

c. INITIAL ADJUSTMENTS OF VIDEO SCOPE SCREEN.

(1) Adjust the VIDEO SCOPE INTENSITY control (R877) for the desired brightness of the sweeps.

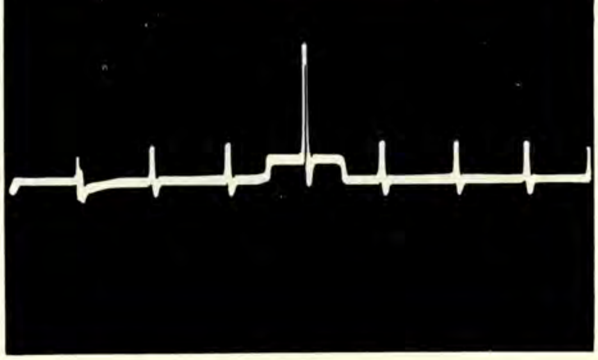


Figure 3–17. A1000 or B1000 Waveform as Displayed on Test Scope

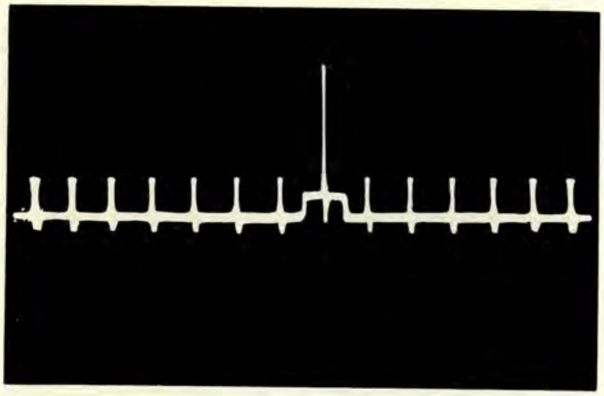


Figure 3–18. B100 Waveform as Displayed on Test Scope

(2) Turn the VIDEO SWEEP SPEED control (R813) on the synchronization indicator unit to its midposition.

(3) Turn the VIDEO PRESENTATION switch (S804) on the synchronization indicator to the CAL position, to display markers on the VIDEO SCOPE screen.

(4) Turn the VIDEO SEPARATION control (R852) so that the upper and lower sweeps are separated by about two inches.

(5) If necessary, advance the MARKERS HEIGHT control (R876) until markers are clearly visible on the VIDEO SCOPE screen.

(6) Adjust the VIDEO SCOPE HORIZONTAL CENTER (R836) and VERTICAL CENTER (R863) controls to center the upper and lower sweeps about the center of the screen.

(7) Adjust the VIDEO SCOPE main FOCUS control (R882) for sharp waveforms.

(8) If adjustment of the main FOCUS control does not produce simultaneous focusing of both the horizontal and vertical portions of the waveforms, readjust the AUX FOCUS control (R839). Adjust the control a little at a time, to find the setting of R839 for which adjustment of the main FOCUS control causes both the horizontal and vertical portions of the waveforms to come into focus simultaneously.

(9) Adjust the VIDEO SIZE control (R824) to obtain sweeps approximately 3-1/2 to 4 inches wide.

(10) Adjust the marker heights. When properly adjusted, the waveforms obtained on the VIDEO SCOPE screen will correspond to those shown in figure 3–20. Proceed as follows:

Note

In all the following, marker heights (amplitudes) are measured from the top of the trace.

(*a*) Turn the VIDEO SWEEP SPEED control to the extreme counterclockwise position.

(*b*) Turn the VIDEO MARKER HEIGHT control (R876), mounted on the panel of the synchronization indicator unit, to the extreme counterclockwise position.

(*c*) Use the 1 MARKER HEIGHT control (R967) to adjust the 1-microsecond markers to a height of about 1/8 inch. This control is mounted on the chassis.

(*d*) Adjust the VIDEO MARKER HEIGHT control until the 100-microsecond and 1,000-microsecond markers come into view, and until the amplitudes of the 100-microsecond markers are about 2/3 of the amplitudes of the 1,000-microsecond markers.

(*e*) Adjust the 10 MARKER HEIGHT control (R868) until the 10-microsecond marker amplitudes are about twice the amplitudes of the 1-microsecond markers. This control is chassis-mounted.

(11) To check that the 10-microsecond and 1-microsecond markers coincide, turn the VIDEO SWEEP SPEED control (R813) to its extreme clockwise position to obtain a fast sweep speed, and vary the tuning slug in the secondary winding of the 500-kc transformer (Z201) to determine that the 10-microsecond markers appearing on the VIDEO SCOPE screen are at maximum amplitude. Maximum amplitude of the 10-microsecond markers represents the desired coincidence of the 10- and 1-microsecond markers. Transformer Z201 is the one nearest to the front panel of the frequency divider unit. The tuning slug in the secondary winding of Z201 may be reached from the bottom of the chassis (figure 7–251). Use the special alignment tool, provided for this purpose, to vary the slug. (Refer to figure 7–240.) If satisfactory adjustment cannot be obtained, retune the entire 1-microsecond marker circuit, as described in Section 7, paragraph 4*c* (1).

(12) The range of sweep delay, as observed on the VIDEO SCOPE screen, should be at least 90 microseconds. To check this, vary the VIDEO SWEEP DELAY control, observe the motions of the upper and lower sweeps, and count the passage of markers past a refer-

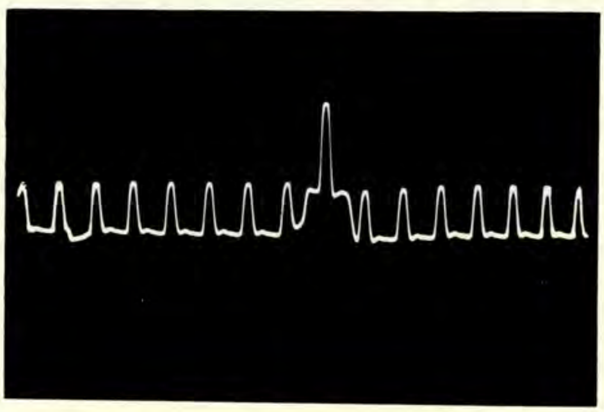


Figure 3–19. B10 Waveform as Displayed on Test Scope

ence line to determine that the markers are shifted by a delay of at least 90 microseconds. If this condition is not met, refer to Section 7, paragraph 4 *e* (1), for the procedure for readjusting the VIDEO DELAY BIAS control (R959).

(13) To check video sweep speed, turn the VIDEO SWEEP SPEED control (R813) to the extreme clockwise (fastest sweep) position, and count the number of markers to determine that the sweep speed is about 75 microseconds. If this condition is not met, adjust the chassis-mounted VIDEO FAST SWEEP SPEED control (C868) for the desired 75-microsecond sweep speed.

d. INITIAL ADJUSTMENTS OF RF SCOPE.

CAUTION

During adjustment and operation of the equipment, care should be taken not to advance the INTENSITY control to the point where a bright spot is seen at the left end of the trace. The screen of the cathode-ray tube used for the RF SCOPE is subject to greater likelihood of damage, caused by excessive spot intensity, than are the screens of the other timer oscilloscopes.

(1) Adjust RF SCOPE INTENSITY control (R907) for the desired brightness of the waveform.

(2) Turn the RF SWEEP SPEED control (R926) on the synchronization indicator unit to its mid-position.

(3) Turn the RF PRESENTATION control (S805) to the CAL position.

(4) Adjust the RF SEPARATION control (R898) until the upper and lower traces appearing on the RF SCOPE screen are separated from each other by about two inches.

(5) If necessary, advance the RF MARKER HEIGHT control until 1-microsecond markers are visible. The waveform appearing on the RF SCOPE screen should be similar to that shown in figure 3–21.

(6) Adjust the RF SCOPE HORIZONTAL CENTER (R945) and VERTICAL CENTER (R902) controls to center the upper and lower sweeps about the center of the screen.

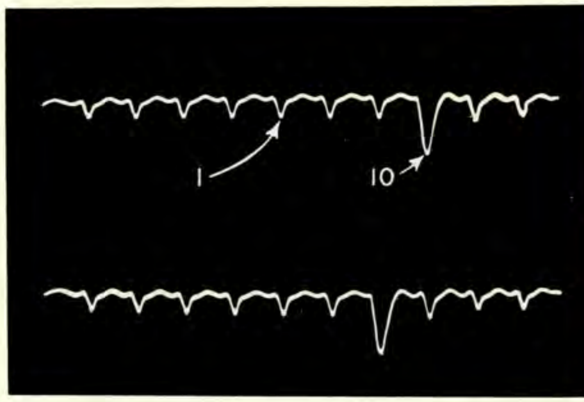


Figure 3–21. Typical Marker rresentation, RF SCOPE

(7) Adjust the RF SCOPE main FOCUS control (R910) for a sharp waveform.

(8) If adjustment of the main FOCUS control does not produce simultaneous focusing of both the horizontal and vertical portions of the waveforms, readjust the RF SCOPE AUX FOCUS control (R948). Adjust the control a little at a time, to find the setting of R948 for which adjustment of the main FOCUS control causes both the horizontal and vertical portions of the waveforms to come into focus simultaneously.

(9) Adjust the RF SCOPE SIZE control (R929) to obtain sweeps approximately 3-1/2 to 4 inches wide.

(10) The range of sweep delay, as observed on the RF SCOPE screen, should be at least 90 microseconds. To check that, vary the RF SWEEP DELAY control, observe the motion of the upper and lower traces, and count the passage of the 1- and 10-microsecond markers past a reference line to determine that the markers are shifted by a delay of at least 90 microseconds. If this condition is not met, refer to Section 7, paragraph 4*e* (2).

(11) To check RF SWEEP SPEED, turn the RF SWEEP SPEED control (R926) to the extreme clockwise (fastest sweep) position, and count the number of markers to determine that the sweep speed is about 5 microseconds. If this condition is not met, adjust the chassis-mounted RF FAST SWEEP SPEED ADJ control (C844) for the desired 5-microsecond sweep speed.

e. FINAL SETTING OF COUNTER BIAS CONTROL (R282) IN FREQUENCY DIVIDER UNIT.

(1) Observe the SLOW SCOPE presentation, and slowly vary the COUNTER BIAS control in the clockwise direction.

(2) Note the dial reading at which the SLOW SCOPE sweep shows some change. This change may manifest itself as a small or considerable shortening of the sweep, or as an erratic behavior of the sweep. Return the control to a point at which a normal sweep presentation is obtained.

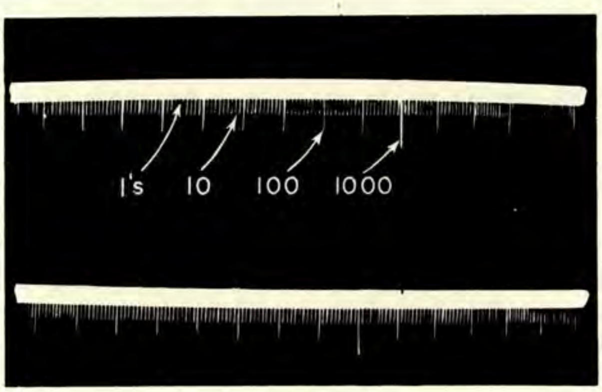


Figure 3–20. Typical Marker Presentation, VIDEO SCOPE

(3) Starting from a normal sweep presentation, turn the COUNTER BIAS control slowly in the counterclockwise direction.

(4) Again note the dial reading at which the SLOW SCOPE shows some change.

(5) Set the dial to the midpoint of the two dial readings obtained in (2) and (4), above. The two dial readings obtained in (2) and (4), above, should be recorded on page 6–8 for use in preventive maintenance. (Refer to Section 6, paragraph 5*a*, step 5.)

21. INITIAL CHECKS AND ADJUSTMENTS OF TIME DELAY UNIT TYPE TD–92/FPN–30.

a. GENERAL.—The objectives of the procedures described in the following paragraphs are to adjust the various controls associated with the delay circuits to attain maximum stability and to adjust the various auxiliary circuits, such as the blinking circuit and the blanking circuit. The adjustments must be made as carefully as possible. Adjustments are made on the basis of direct observations of the gate and marker patterns on the test oscilloscope, and of the marker presentations on the synchronization indicator scopes. Adjustment of the delay circuits to obtain the specified reference delay (normal) is described in paragraph 22. The procedure for adjusting the preset B delays is described in paragraph 23. The blinking and blanking circuit adjustments are given in paragraph 24.

b. INITIAL SWITCH AND CONTROL SETTINGS.

(1) Operate the PRESET B DELAY SELECTOR switch (S504) to the NORMAL position. This switch is located behind the hinged door on the front panel. Accordingly, all references in the following paragraphs to delay controls are to the NORMAL, front panel, controls. Adjustment of the preset B-delay controls is described in paragraph 23.

(2) Operate the STATION SELECTOR switch (S501), located on the chassis, to either the MASTER or the SLAVE position, depending on whether a master or a slave station, respectively, is being adjusted.

(3) Operate the B DELAY output switch (S502), on the chassis, to the B10 position.

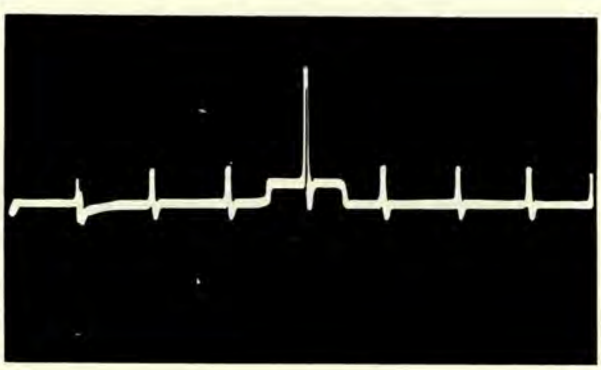


Figure 3–22. Typical Setting of A1000 or B1000 Gate

(4) Operate the SIGNAL SELECTOR switch on the test scope to the TIME DELAY position.

c. CRITERION FOR ADJUSTING BIAS CONTROLS.—The BIAS controls are adjusted at the factory, and should require no further adjustment at this time. If, however, in the process of adjusting the delay circuits, a circuit is found to be free-running, that is, if the SLOW SCOPE shows many moving pedestals, or if the adjustment range of a control proves to be inadequate to meet the specified requirement, the corresponding bias adjustment potentiometer, A1000 BIAS, B1000 BIAS, B100 BIAS, B10 BIAS, or B CONTINUOUS BIAS, needs adjustment. Refer to Section 7, paragraph 4*d*, for the proper adjustment procedure.

d. ADJUSTMENT OF GATE WIDTH CONTROLS —GENERAL.—The gate widths are adjusted at this time to optimum values, to insure that when the delays specified for the station are set, maximum stability is obtained. Optimum adjustment of the gate width is obtained when the gate width is approximately equal to the distance between two adjacent markers, without overlapping the marker on either side of the gate. When the gate width is thus adjusted, maximum drift is allowed for, before the desired marker is lost, or before an undesired marker is picked up. In adjusting gate width, any two adjacent markers, not including the first one, may be used, since the gate width tends to shrink slightly in the vicinity of the first marker. The procedures for adjusting the various gate width controls are given in subparagraphs *e* through *h*, below.

e. ADJUSTMENT OF A1000 GATE WIDTH CONTROL.

(1) Turn the VIDEO SWEEP SPEED control on the synchronization indicator unit to the extreme counterclockwise position, to provide wide pedestals on the SLOW SCOPE screen.

(2) Vary the A1000 DELAY potentiometer (R502) on the time delay unit to shift the leading edge of the A pedestal to the third marker from the left, on the upper trace of the SLOW SCOPE.

(3) Turn the TEST SIGNAL switch (S503) on the time delay unit to the A1000 position.

(4) Vary the GAIN, SWEEP SPEED, and 1000-μs STEPS controls on the test scope to bring the A1000 gate into view on the oscilloscope screen. (Refer to paragraph 17.) A pattern similar to that shown in figure 3–22 should be obtained.

(5) Check the setting of the A1000 GATE WIDTH control by slowly rotating the A1000 DELAY control and observing that one marker just drops off the gate while the adjacent marker just rises on the gate. If necessary, readjust the A1000 GATE WIDTH control until this condition is obtained as the A1000 DELAY control is rotated.

(6) Center the gate about a marker.

f. ADJUSTMENT OF B1000 GATE WIDTH CONTROL.

(1) Vary the B1000 NORMAL DELAY potentiometer (R532) on the time delay unit to shift the leading edge of the B pedestal to about the third marker from the left, on the lower trace of the SLOW SCOPE.

(2) Turn the TEST SIGNAL switch (S503) on the time delay unit to the B1000 position.

(3) Turn the SYNC SELECTOR switch to the SQ WAVE ϕ 2 position, to bring the B1000 gate into view on the oscilloscope screen. A pattern similar to that shown in figure 3–22 should be obtained.

(4) Check the setting of the B1000 GATE WIDTH control (R545) by slowly rotating the B1000 DELAY control and observing that one marker just drops off the gate while the adjacent marker just rises on the gate. If necessary, readjust the B1000 GATE WIDTH control until this condition is obtained as the B1000 NORMAL DELAY control is rotated.

(5) Turn the B1000 DELAY control to the extreme counterclockwise position. If the gate on the test scope screen is not pushing up a marker, turn the control until the first marker to the right of the gate is pushed up. This procedure should have put the leading edge of the B pedestal between the first and the second marker on the lower trace of the SLOW SCOPE.

g. ADJUSTMENT OF B100 GATE WIDTH CONTROL.

(1) Turn the B100 DELAY potentiometer (R561) to its extreme counterclockwise position.

(2) Turn the TEST SIGNAL switch (S503) on the time delay unit to the B100 position.

(3) Vary the sweep speed and delay controls on the test scope to bring the B100 gate into view on the oscilloscope screen. A pattern similar to that shown in figure 3–23 should be obtained. Note that the small negative spike to the left of the gate is the start of the B100 delay. Vary the B100 DELAY control to push up the third marker to the right of the spike.

Note

If the spike is not easily visible, return the TEST SIGNAL switch to B1000 and note the position of the pushed-up marker. The spike should be coincident with the marker.

(4) Check the setting of the B100 GATE WIDTH control (R555) by slowly rotating the B100 DELAY control, and observing that one marker just drops off the gate while the adjacent marker just rises on the gate. If necessary, readjust the B100 GATE WIDTH control until this condition is obtained as the B100 DELAY control is rotated.

(5) Turn the B100 DELAY control to the extreme counterclockwise position. If the gate on the test scope screen is not pushing up a marker, turn the control until the first marker to the right of the gate is pushed up.

h. ADJUSTMENT OF B10 GATE WIDTH CONTROL.

(1) Turn the B10 DELAY potentiometer to its extreme counterclockwise position.

(2) Turn the TEST SIGNAL switch on the time delay unit to the B10 position.

(3) Vary the sweep speed and delay controls on the test scope to bring the B10 gate into view on the oscilloscope screen. A pattern similar to that shown in figure 3–24 should be obtained. Note that the small negative spike to the left of the gate is the start of the B10 delay.

(4) Vary the B10 DELAY control to push up the third marker to the right of the spike.

Note

If the spike is not easily visible, return the TEST SIGNAL switch to B100 and note the position of the pushed-up marker. The spike should be coincident with the marker.

(5) Observe the bottom trace on the VIDEO SCOPE screen to determine proper adjustment of the gate width. Slowly rock the B10 DELAY control be-

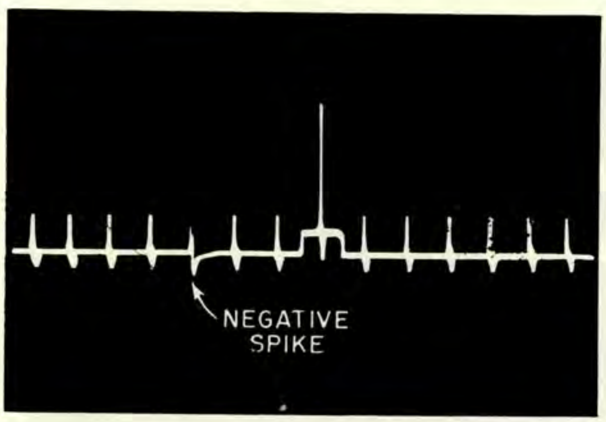


Figure 3–23. Typical Setting of B100 Selector Gate

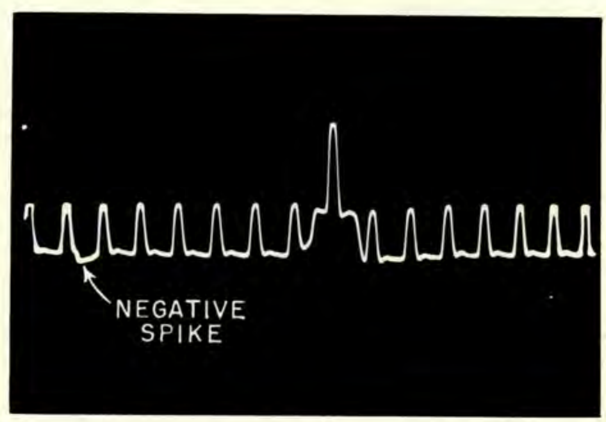


Figure 3–24. Correct Setting of B10 Selector Gate

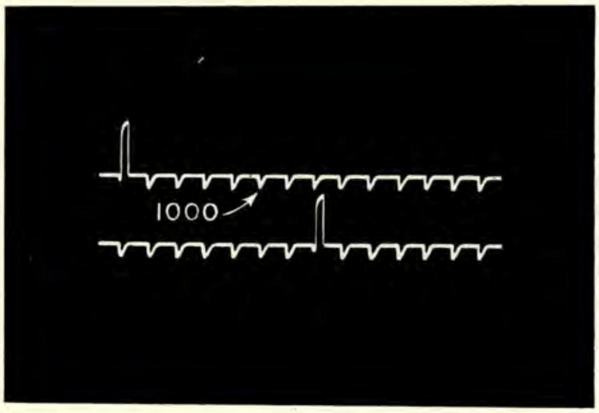


Figure 3–25. Identification of Markers on SLOW SCOPE

tween the third and fourth markers to the right of the negative spike. Note that the lower sweep on the VIDEO SCOPE screen just barely disappears as the gate passes from one marker to the other. If this condition is met, the B10 gate width is satisfactory. This procedure is used because the markers are wide relative to the interval between them, and greater accuracy is obtainable by this method than would be obtainable if the method given for the adjustment of the B1000 and B100 gate widths were used here. If necessary, readjust the B10 GATE WIDTH control so that the condition given above is obtained.

(6) Turn the B10 DELAY control to its extreme counterclockwise position. If the gate on the test scope is not pushing up a marker, turn the control until the first marker to the right of the gate is pushed up.

i. ALIGNMENT OF TRANSMITTER TRIGGERS.—This adjustment must be made before any attempt is made to adjust the DELAY controls for setting up the reference delays. Make the adjustment even if the B OUTPUT DELAY switch is not to be in the B10 position for the reference delay adjustments. Proceed as follows:

(1) Verify that the B OUTPUT DELAY switch is in the B10 position.

(2) Set up the RF SCOPE for alignment of the transmitter triggers as follows:

(a) Turn the RF PRESENTATION control to the CAL position.

(b) Turn the RF SEPARATION control to the extreme counterclockwise position.

(c) Turn the RF SWEEP SPEED control to the extreme clockwise position.

(d) Adjust the RF SWEEP DELAY control to place a 10-microsecond marker approximately at the center of the RF SCOPE screen.

(3) Observe the pattern on the oscilloscope screen. If the markers of the upper and lower traces do not coincide, adjust the ALIGN TRIG potentiometer (R520) until this condition is met. The ALIGN TRIG control is located on the chassis of the time delay unit. Lock the control in the adjusted position.

(4) Turn the RF SEPARATION control for about a 1-inch separation between traces.

22. SETTING UP REFERENCE DELAY.

a. PRELIMINARY REMARKS.—Setting up the reference delay assigned to the station is done by means of the DELAY controls on Time Delay Unit Type TD–92/FPN–30. The object is to position the two pedestals which are visible on the SLOW SCOPE of the synchronization indicator unit, so that the lower one is displaced to the right of the upper one (i. e., delayed) by the number of microseconds given by the reference delay specified for the particular station. As defined in Section 2, the reference delay is the B delay *minus* the A delay. At a *slave* station, this delay is called the *coding delay*. At a master station, the reference delay is equal to the coding delay *plus* twice the transmission time between stations. When the pedestal on the lower trace has been displaced with respect to the pedestal on the upper trace of the SLOW SCOPE by the specified reference delay, the two sweeps on each one of the two fast scopes (VIDEO SCOPE and RF SCOPE) automatically assume such a time relationship that when the local station signal on one trace and the remote station signal on the other trace are superposed, they are properly timed with respect to each other.

The procedure for setting up the reference delay is very important and must be done carefully so that an accurate setting of reference delay is obtained. The procedure, explained below, uses the markers which appear on the synchronization indicator scopes as the time-measuring system. The only markers appearing on the SLOW SCOPE are the 1,000-microsecond markers. All markers (1,000's, 100's, 10's and 1's) appear on the VIDEO SCOPE. Only the 10's and 1's appear on the RF SCOPE. Selection of the particular scope for making the adjustments for the 1,000, 100, 10, and continuous delays is made accordingly. The various markers are identified by their relative heights. Figures 3–25, 3–26, and 3–27 show the ap-

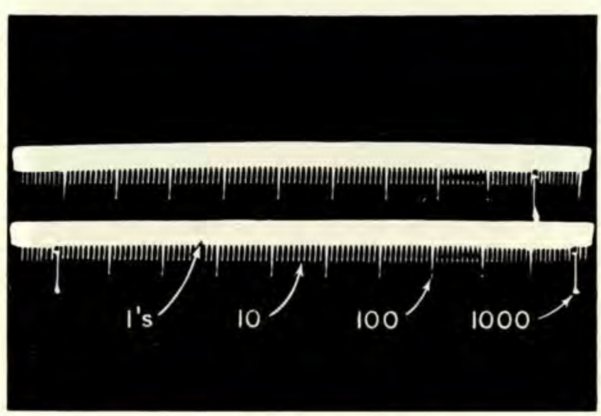


Figure 3–26. Identification of Markers on VIDEO SCOPE

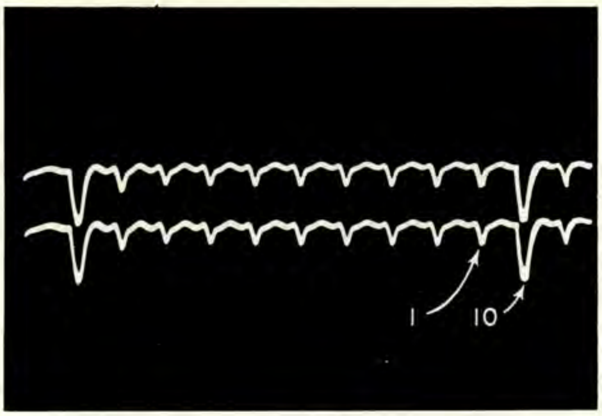


Figure 3–27. Identification of Markers on RF SCOPE

pearances of the markers, on the difference oscilloscopes, for purposes of identification. The reference delay is set up to the correct number of thousands by moving the pedestals with reference to the 1,000-microsecond markers on the SLOW SCOPE. The VIDEO SCOPE and RF SCOPE (the fast scopes) are then used to set up the balance of the specified reference delay. After the reference delay has been set up properly, the DELAY controls must be adjusted to their most stable positions. This is done by observing the selector gates on the test scope, and adjusting each DELAY control (except the B CONTINUOUS control, if used) to center the particular gate about the particular marker. *Do not omit this part of the procedure.*

b. DETERMINING DELAY CONTROL SETTINGS.—The reference delay assigned to a loran station generally consists of four digits. (When a five-digit reference delay is used, the 10,000's and 1,000's are taken together as 1,000's. Thus, for 12,955, the thousand digit is 12.) Figure 3–28 shows such a typical reference delay and indicates the delay controls used in setting up the delay for the particular digit. *At a slave station,* the unit digit of the reference delay will usually be zero. In such cases, the B DELAY OUTPUT switch (S502) on Time Delay Type TD–92/FPN–30 will be in the B10 position, and the continuous delay circuit will be disconnected. *At a master station,* the unit digit of the reference delay may be any number from 0 to 9, the B DELAY OUTPUT switch will generally be in the B CONT position, and the continuous delay circuit will be connected.

6 9 5 5

Thousands digit varied by B1000 DELAY control (6)

Hundreds digit varied by B100 DELAY control (9)

Tens digit varied by B10 DELAY control (5)

Unit digit varied by B CONTINUOUS DELAY control (5)

Figure 3–28. Typical Reference Delay

Note

When the unit digit of the reference delay is zero, the B DELAY OUTPUT switch should be in the B10 position. The B-continuous circuit is then disconnected, and the B CONTINUOUS DELAY control requires no adjustment.

(1) GENERAL RULE.—The following rule applies to the cases of:

(a) reference delays with the last three digits between 110 and 999, inclusive, when the B CONTINUOUS DELAY control is used, and

(b) reference delays with the last three digits between 100 and 999, inclusive, when B CONTINUOUS DELAY control is NOT used. The above represent the majority of the cases.

Rule: The digit of the reference delay indicates the number of markers by which the B gate is to be delayed with respect to the A gate, using the delay control associated with that digit.

Example: In the reference delay shown in figure 3–28 the 1,000-digit 6 means that the B pedestal on the SLOW SCOPE is to be delayed (shifted to the right of the A pedestal) by six 1,000-microsecond markers or 6,000 microseconds, using the B1000 DELAY control. Similarly, the B100 DELAY control is used to shift the B100 gate away from the selected 1,000-microsecond marker so that the B gate is further delayed by nine 100-microsecond markers, or by 900 microseconds.

(2) SPECIAL RULE.—The following rule applies in those exceptional cases, in which

(a) the reference delay has the last three digits between 000 and 109, inclusive, when the B CONTINUOUS DELAY control *is* used, and

(b) the reference delay has the last three digits between 000 and 099, inclusive, when the B CONTINUOUS DELAY control *is not* used.

Exceptions to the general rule given in (1), above, come from the fact that a certain amount of minimum delay is inherent in the delay circuits. The minimum delays responsible for these exceptions are: (a) the 100-microsecond delay inherent in the B100 delay circuit, and (b) a 10-microsecond delay associated with the B10 delay circuit when the B-continuous delay circuit is used.

(When the B-continuous delay circuit is not used, the 10-microsecond delay associated with the B10 delay is cancelled out.) The rule follows:

Rule: To avoid confusion in setting the controls under the conditions outlined *above, proceed as follows:* Subtract the *minimum delay* from the *reference delay,* to obtain the *"net delay"*. The digits of the *net delay* represent the increments of delay to be inserted by means of the delay controls. These increments of delay plus the minimum delays will give the total required reference delay.

Example: For a reference delay of 4,101 microseconds, the net delay would be 4,101 — 110 = 3,991. Use the delay controls to insert 3,000, 900, 90 and 1 microseconds.

For a more detailed explanation of minimum delay, and its effect on the adjustment of reference delay, refer to Section 2, paragraph 4 *d* (2) (*e*).

(3) The procedures for adjusting the delay circuits for a specified normal reference delay are described in detail in paragraphs 22 *c* through 22 *g*, below. The procedures in paragraphs 22 *c*, *d*, and *g* apply to all normal reference delay adjustments. The procedure given in paragraph 22 *e* applies to reference delays which follow the general rule of paragraph 22 *b* (1), above. The corresponding procedure given in paragraph 22 *f* applies only to those reference delays which follow the special rule of paragraph 22 *b* (2), above. Adjustment of the PRESET B DELAYS is described in paragraph 23.

Note

For the following adjustments it is assumed that the gate widths have been checked and adjusted as described in paragraph 21, and the DELAY controls have been left in their *minimum delay* positions, as described there.

c. ADJUSTMENT OF A1000 DELAY CONTROL.

Note

The maximum delay range of approximately 30,000 microseconds provided by the A-delay circuits is far greater than will usually be required. If an A delay of less than 15,000 microseconds is needed, greater circuit stability and ease of adjustment will be obtained if one of the A1000 timing capacitors C503 or C504 is removed. To do that, open and tilt the time delay unit to gain access to the bottom of the chassis, remove the two nuts and washers holding capacitors C503 and C504 together (figure 7–253), and remove the top capacitor. Retain this capacitor as a spare part. Return the lock washers and nuts and tighten. Return the drawer to its normal operating position.

Adjustment of the A1000 DELAY control serves to establish a point from which the reference delay to the B gate can be measured. The adjustment is observed on the SLOW SCOPE screen.

(1) Turn the VIDEO SWEEP SPEED control (R813) on the synchronization indicator unit to the counterclockwise position, to provide a wide pedestai on the SLOW SCOPE screen.

(2) Adjust the A1000 DELAY control to shift the leading edge of the A pedestal to the first marker (1,000 microseconds) from the left end of the sweep on the SLOW SCOPE screen. The appearance of the upper trace under these conditions is shown in figure 3–29.

(3) Determine the range of the A1000 DELAY control over which the desired pedestal position holds. Set the control to the approximate center of that range. For the present, lock the control in this position.

Note

The centering adjustment will be made accurately later, when the time delay is set up completely, by observation of the selector gate on the test scope.

d. ADJUSTMENT OF MINIMUM DELAY IN B-CONTINUOUS DELAY CIRCUIT TO INTEGRAL 10 MICROSECONDS.—The minimum delay inherent in the B-continuous delay circuit is given as *approximately* 10 microseconds, but will actually be some number less than 10. To simplify the procedure of adjusting the B delays, the minimum delay of the B-continuous circuit is adjusted to exactly 10 microseconds at this point. Omit this procedure if the unit digit of the reference delay is zero, since the B-continuous circuit is then not used. If, as in the example to be described later, the unit digit of the reference delay is *not* zero, turn the B DELAY OUTPUT switch to the B-CONT position and proceed as follows:

(1) Adjust the RF SWEEP SPEED control (R926) on the synchronization indicator unit until about twelve 1-microsecond markers are visible on the RF SCOPE screen.

(2) Adjust the RF SWEEP DELAY control to place a 10-microsecond marker approximately at the center of the upper trace.

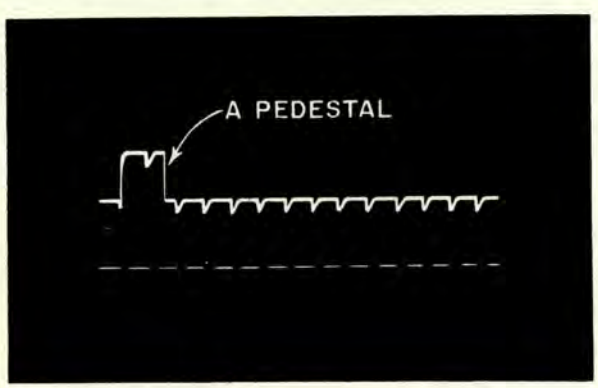


Figure 3–29. A Pedestal Located at 1,000 Miscroseconds

(3) Adjust the RF SEPARATION control so that the traces coincide.

(4) Starting at the extreme counterclockwise position, slowly vary the B CONTINUOUS DELAY control until the 10-microsecond marker on the lower trace coincides with the 10-microsecond marker on the upper trace. The B-continuous delay is now exactly 10 microseconds. From this point on, and until the unit of the reference delay is to be adjusted for, all counting can be done in integral 10's.

(5) Adjust the RF SEPARATION control for about a 1-inch separation between traces.

Note

Paragraphs 22 *e* and 22 *f*, below, describe the B-delay adjustment procedure for the two possible cases mentioned in paragraph 22*b* (3), above. The following consideration applies to both cases: The maximum delay range of approximately 30,000 microseconds provided by the B-delay circuits is far greater than will usually be required. If none of the five possible B1000 delays (NORMAL, 2, 3, 4, 5) exceed 15,000 microseconds, one of the B1000 timing capacitors (C517 or C518) on the bottom of the time delay chassis should be removed, to obtain greater circuit stability and ease of adjustment. To remove the capacitor, open and tilt the time delay unit drawer to gain access to the bottom of the chassis. Remove the locknuts and lock washers holding C517 and C518 together (figure 7–253) and remove the top capacitor. Retain this capacitor as a spare part. Return and tighten the lock washers and nuts, and restore the drawer to its normal operating condition.

e. ADJUSTMENT OF B-DELAY CONTROLS, LAST THREE DIGITS BETWEEN 100 AND 999 WHEN B CONTINUOUS DELAY CONTROL IS NOT USED, OR LAST THREE DIGITS BETWEEN 110 AND 999 WHEN B CONTINUOUS CONTROL

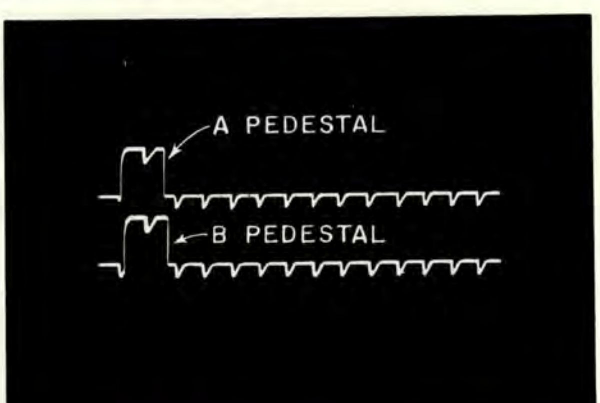


Figure 3–30. Preliminary Setting of B Pedestal Below A Pedestal

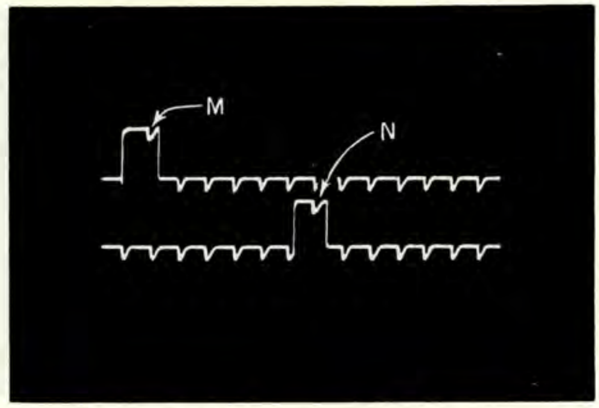


Figure 3–31. B Pedestal, Located 6,000 Microseconds to the Right of the A Pedestal

IS USED. (*Example:* 6,955)—To illustrate the procedure for adjusting the B DELAY controls, the reference delay of 6,955 microseconds is taken as an example of those cases where the last three digits are between 110 and 999, inclusive, and the general rule given in paragraph 22 *b* (1), above, applies. For this example, where the unit digit is ***not*** zero, the B DELAY OUTPUT switch should be in the B-CONT position, and the procedure of paragraph 22 *d*, above, followed. The minimum B delay is 110 microseconds. Follow the procedure in the order indicated.

(1) Adjust the B1000 DELAY control. To do that:

(a) Vary the B1000 DELAY control so that the B pedestal on the lower trace of the SLOW SCOPE screen is directly under the A pedestal. The SLOW SCOPE traces will now appear as shown in figure 3–30.

Note

Strictly speaking, the B pedestal is ***not directly*** below the A pedestal, because of the minimum delay of 110 microseconds obtained in the B-delay circuits (22 *b* (2), above). In figure 3–30 the B pedestal is shown to start a little ***after*** the first 1,000-microsecond marker, while the A pedestal appears to start together with the first marker.

(b) Advance the setting of the B1000 DELAY control so that the B pedestal jumps to the right as many steps as there are thousands in the specified reference delay. In the example selected to illustrate this procedure, 6,955 microseconds, the B pedestal is set 6,000 microseconds, or six 1,000-microsecond markers, to the right of the A pedestal. This is shown in figure 3–31.

(c) Determine the range of the B1000 DELAY control over which the desired pedestal position holds. Set the control in the approximate center of that range. For the present, lock the control in this position.

Note

The centering adjustment will be made accurately later, after the time delay has been set

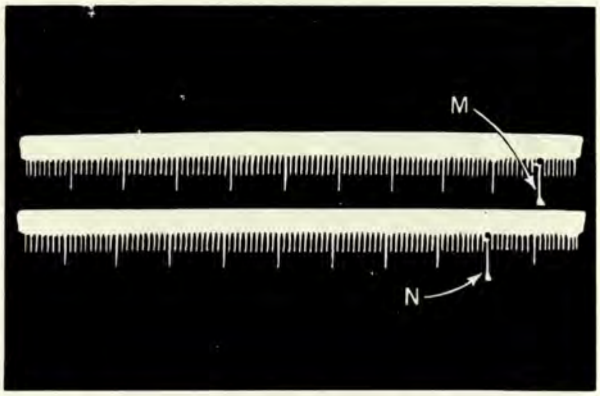


Figure 3–32. Appearance of VIDEO SCOPE Traces for Setting Up 100's (Typical Example)

up completely, by observation of the selector gate on the test scope.

(2) Adjust the B100 DELAY control. This adjustment is observed on the VIDEO SCOPE screen. Proceed as follows:

(a) Turn the VIDEO SWEEP DELAY control to the extreme clockwise (DELAY OUT) position.

(b) Adjust the VIDEO SWEEP SPEED control to bring the 1,000-microsecond markers near the right-hand end of the sweeps.

(c) Adjust the VIDEO SEPARATION control so that the 1,000-microsecond marker on the upper trace just barely touches the lower trace. The VIDEO SCOPE traces will appear as shown in figure 3–32.

(d) Observe the pattern on the VIDEO SCOPE screen. With the B100 and B10 DELAY controls in their minimum delay positions (paragraph 21), and the B CONTINUOUS DELAY control (used, in this example) adjusted as in paragraph 22 *d*, above, the pattern will be like that shown in figure 3–32. The 1,000-microsecond markers, M and N, are the same ones identified in figure 3–31. Because they are within their respective pedestals, they must appear, of course, on their respective VIDEO SCOPE traces. Note that the minimum delays in the B-delay circuits have resulted in marker N being to the left of marker M by the amount of that minimum delay. *A motion of the markers on the lower trace to the left thus represents an increase in delay.* At this sweep speed, the minimum delay of the B-delay circuit is more apparent. If the B delay were zero, the lower trace marker (N) would be directly below the upper trace marker (M). By counting 100-microsecond markers and 10-microsecond markers, it can be seen that marker N is delayed by 110 microseconds with respect to marker M.

(e) Vary the B100 DELAY control so that the 1,000-microsecond marker (N) on the lower trace on the video scope moves to the left, jumping in 100-microsecond steps. Move the lower trace marker so that the delay between it and the upper trace 1,000-microsecond marker is equal to the 100's specified by the 100's digit of the reference delay. In the example used here, 6,955 microseconds, the interval between the lower trace 1,000-microsecond marker and the upper trace 1,000-microsecond marker should be nine 100-microsecond intervals, or 900 microseconds. The result will be as shown in figure 3–33 where the lower marker, N, is moved the distance indicated by the dotted arrow, yielding nine 100-microsecond intervals between the M and N markers. To count, start at N, and refer directly to the upper trace at that point. Count the 100-microsecond marker directly above the N marker as zero, and progress to the right from there. The ninth count is at M, so that the delay in integral 100's is 900 microseconds. Added to the delay established in step (1), above, this yields a total delay obtained, up to this point, of 6,900 microseconds (plus the minimum delay of 10 microseconds in the B10 delay circuit).

Note

The B100 delay circuit minimum delay of 100 microseconds has now been included as part of the total required 900-microsecond delay called for in the 100's digit of the specified (6,955) reference delay, and so no longer enters into the considerations from this point on.

(f) Determine the range of the B100 DELAY control over which the adjustment obtained in paragraph 22 *e* (2) *(e)*, above, holds. Set the control to the approximate center of that range. For the present lock the control in this position.

Note

The centering adjustment will be made accurately later, when the time delay is completely set up, by observation of the selector gate on the test scope.

(3) Adjust the B10 DELAY control. This adjustment is observed on the VIDEO SCOPE screen.

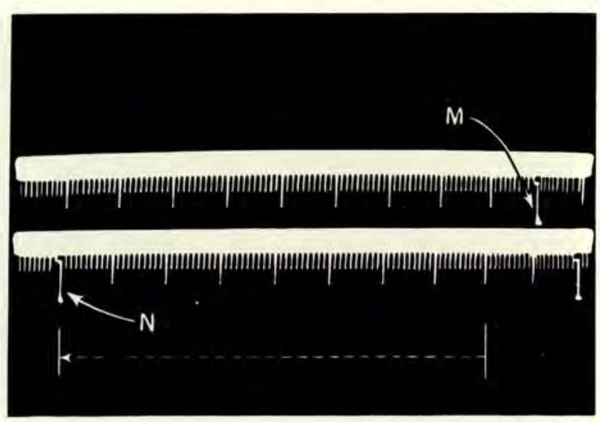


Figure 3–33. Locating the 1,000-Microsecond Marker to Obtain the Specified Reference Delay in 100's

(a) Vary the VIDEO SWEEP SPEED until the sweep is about 120 microseconds long. This will allow one 100-microsecond marker to appear on the upper sweep and one 100-microsecond (or a 1,000-microsecond) marker to appear on the lower sweep.

(b) Adjust the VIDEO SEPARATION control so that the 100-microsecond marker on the upper trace just about touches the lower trace.

(c) Observe the pattern on the VIDEO SCOPE screen. It will be very nearly like that shown in figure 3–34. The upper trace will be identical when the video sweep delay control is in the DELAY OUT position. The appearance of the lower trace will vary with different set-ups. The major difference is that marker R may be a 100-microsecond marker instead of a 1,000-microsecond marker. (It will be a 1,000-microsecond marker only if the time delay setting, in 100's, is 900 microseconds.) In the example used here, 6,955 microseconds, it will be a 1,000-microsecond marker.

Note

If a 1,000-microsecond marker does appear, as it does in this case, it will be coincident with a 100-microsecond marker, and can be considered as such for this adjustment.

(d) The 100-microsecond markers observed in paragraph 22 *e* (3) *(a)*, above, are identified as P and R on figure 3–34. With the B CONTINUOUS DELAY control used, and adjusted as in paragraph 22 *d*, above, marker R is 10 microseconds to the left of marker P, that is, the minimum delay of the B10 delay circuit. If the last digit of the reference delay were zero, the minimum delay remaining would be zero and the 100-microsecond marker R would be directly under the 100-microsecond marker P. In the example used here, 6,955 microseconds, the delay up to this point is 6,910 microseconds, i.e., 6,000 microseconds by adjustment of the B1000 DELAY control, 900 microseconds by adjustment of the B100 DELAY control, and 10 microseconds minimum delay in the B10 delay circuit.

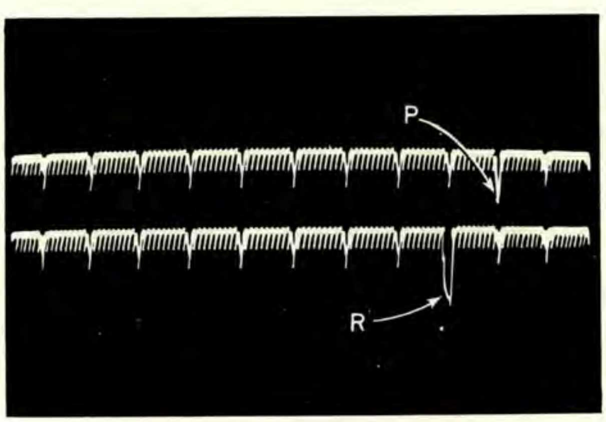


Figure 3–34. Appearance of Traces for Setting Up 10's (Typical Example)

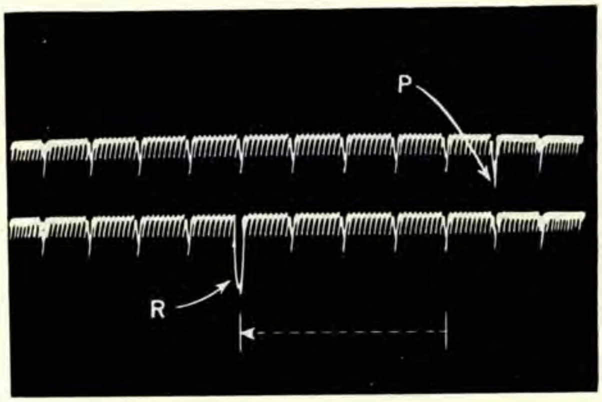


Figure 3–35. Locating the 100-Microsecond Marker to Obtain Specified Reference Delay in 10's

(e) Vary the B10 DELAY control so that the 100-microsecond marker (R) on the lower trace on the VIDEO SCOPE moves to the left, jumping in 10-microsecond steps. Move the lower trace marker so that the delay between it and the upper trace 100-microsecond marker (P) corresponds to the 10's specified by the 10's digit of the delay. In the example used here, 6,955, the interval between the lower trace 100-microsecond marker, R, and the upper trace 100-microsecond marker, P, should be five 10-microsecond intervals or 50 microseconds. The result will be as shown in figure 3–35, where the lower marker, R, is moved the distance indicated by the dotted arrow, yielding five 10-microsecond intervals between markers R and P. To count, start at R, and refer directly to the upper trace at this point. Count the 10-microsecond marker directly above R as zero, and progress to the right from there. The fifth count is at P, so that the delay is 50 microseconds.

Note

The B10 delay circuit minimum delay has now been included as part of the total required 50-microsecond delay, called for in the 10's digit of the specified reference delay (6,955 microseconds), and so no longer enters into the considerations from this point on.

(f) Determine the range of the B10 DELAY control over which the adjustment obtained in paragraph 22 *e* (3) *(e)*, above, holds. Set the control to the approximate center of that range. For the present lock the control in this position.

Note

The centering adjustment will be made accurately later, after the time delay has been completely set up, by observation of the selector gate on the test scope.

(4) Adjust the B CONTINUOUS DELAY control. This adjustment is observed on the RF SCOPE screen.

(a) Adjust the RF SWEEP SPEED control on the synchronization indicator unit until about twelve

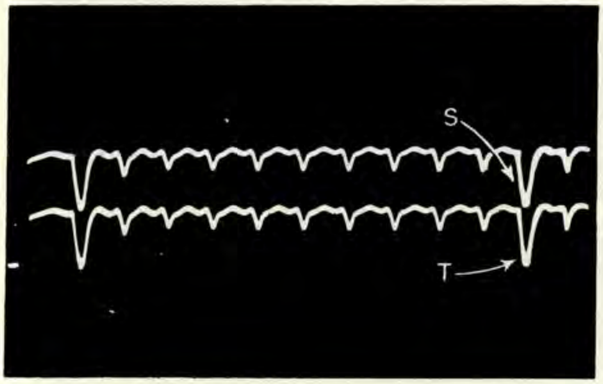


Figure 3–36. Appearance of RF SCOPE Traces for Setting Up Units (Typical Example)

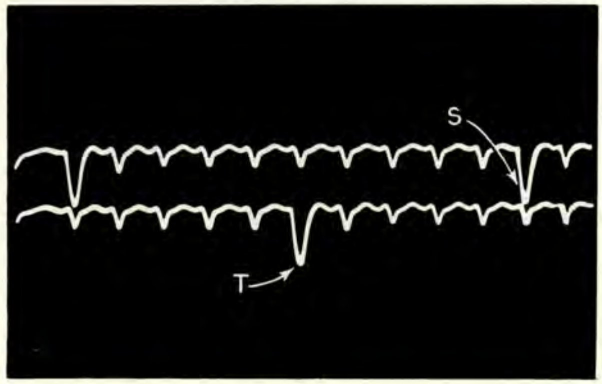


Figure 3–37. Unit Delay Set-Up for 5 Microseconds

1-microsecond markers are visible on the RF SCOPE screen.

(*b*) Adjust the RF SWEEP DELAY control to place a 10-microsecond marker near the right edge of the upper sweep.

(*c*) Adjust the RF SEPARATION control so that the 10-microsecond markers on the upper trace just barely touch the lower trace.

(*d*) Observe the pattern on the RF SCOPE screen. The pattern will be nearly like that shown in figure 3–36. Select the right-hand pair of 10-microsecond markers, S and T, on figure 3–36, one on each trace, by means of which the delay in units is to be measured and set up.

(*e*) Adjust the B CONTINUOUS delay control so that the 10-microsecond marker on the lower trace moves to the left. It will move smoothly. Adjust it so that the delay between the upper trace and lower trace 10-microsecond markers, S and T, corresponds with the unit digit in the specified reference delay. In the example used here, 6,955 microseconds, the adjustment is made as indicated in figure 3–37, to obtain an interval of five microseconds (five 1-microsecond markers) between the lower trace marker (T) and the upper trace marker (S). To count, start at T, and refer directly to the upper trace at this point. Count the 1-microsecond marker directly above T as zero and progress to the right from there. The fifth count is at S, so that the delay is 5 microseconds. This completes the process of setting up the reference delay.

(5) Make a rough check of the proper adjustment of the specified reference delay. To do that, observe the positions of the pedestals on the SLOW SCOPE screen. The narrow pedestals will appear in their proper relative positions. The approximate delay in figure 3–38 appears to be almost 7,000 microseconds, because the seventh 1,000-microsecond marker to the right of the A pedestal on the lower trace is contained within the pedestal. This checks roughly with the set-up of 6,955 microseconds.

f. ADJUSTMENT OF B-DELAY CONTROLS—LAST THREE DIGITS LESS THAN 110 WHEN B CONTINUOUS DELAY CONTROL IS USED, OR LAST THREE DIGITS LESS THAN 100 WHEN B CONTINUOUS DELAY CONTROL IS NOT USED. (*Example: 4,101.*)—The following procedure applies to those reference delays, the last three digits of which are less than the minimum delay inherent in the B-delay circuits. This includes all reference delays with the last three digits between 000 and 109, inclusive, when the B CONTINUOUS DELAY control is used, and all reference delays with the last three digits between 000 and 099, inclusive, when the B CONTINUOUS DELAY control is not used. The special rule cited in paragraph 22 *b* (2), above, applies to these cases. For convenience, the special rule is repeated below.

Special Rule: Subtract the minimum delay from the reference delay to obtain the net delay. The digits of the net delay represent the increments of delay to be inserted by means of the delay controls. These increments of delay plus the minimum delays will give the total required reference delay.

The reference delay of 4,101 microseconds is taken as an example of cases to which the rule cited above, and the following procedure, apply. In this example, the unit digit is not zero, and the minimum delay in the B-delay circuit is, therefore, 110 microseconds, as described in *b*, above. The last three digits are less than 110. Therefore, subtract 110 from 4,101, obtaining 3,991 as the net delay. The adjustment procedure follows.

(1) Adjust the B1000 DELAY control, as follows:

(*a*) Vary the B1000 DELAY control so that the B pedestal on the lower trace of the SLOW SCOPE screen is directly under the A pedestal. The SLOW SCOPE traces will appear as shown in figure 3–39.

Note

Strictly speaking, the B pedestal is *not directly* under the A pedestal, because of the minimum delay of 110 microseconds contained in the

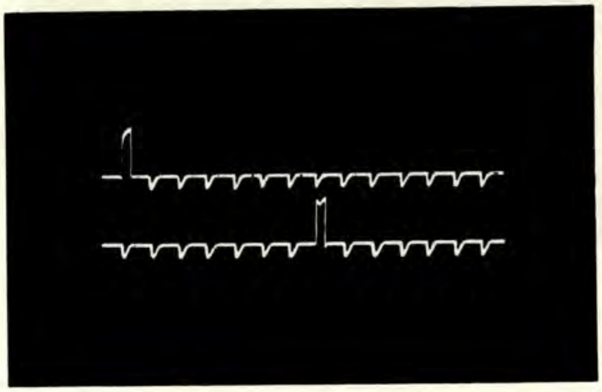


Figure 3–38. Rough Check of Proper Adjustment of Reference Delay 6,955 Microseconds on Slow Scope

B-delay circuits (paragraph 22 *b* (2), above). In figure 3–39 the B pedestal is shown to start a little *after* the first 1,000-microsecond marker, while the A pedestal appears to start together with the first marker.

(*b*) Advance the setting of the B1000 DELAY control so that the B pedestal jumps to the right by as many steps as there are thousands in the net delay. In the example used here (net delay of 3,991 microseconds) set the B pedestal to 3,000 microseconds (three 1,000-microsecond markers to the right of the A pedestal). This is shown in figure 3–40.

(*c*) Determine the range of the B1000 DELAY control over which the desired pedestal position holds. Set the control to the approximate center of that range. Lock the control in this position.

Note

The centering adjustment will be made accurately later, after the time delay has been completely set up, by observation of the selector gate on the test scope.

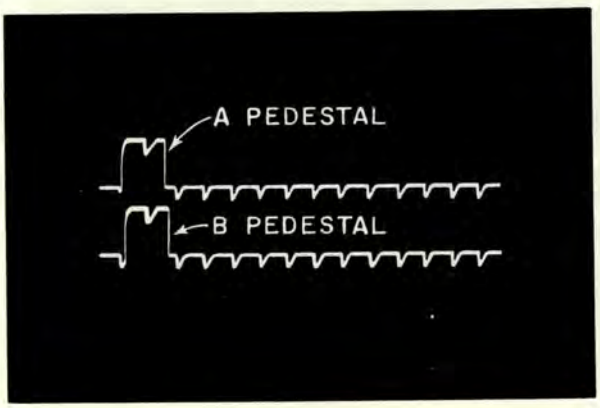


Figure 3–39. Preliminary Setting of B Pedestal Below A Pedestal

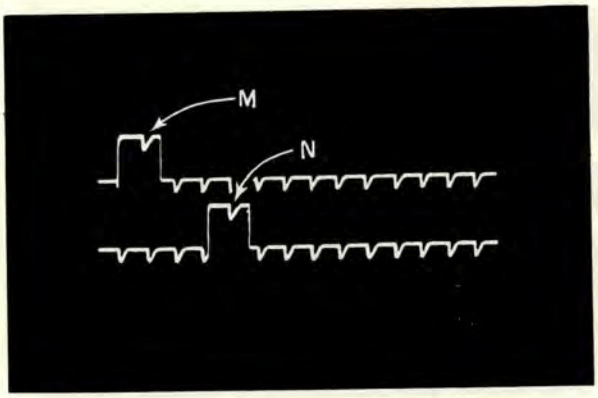


Figure 3–40. B Pedestal Located 3,000 Microseconds to the Right of the A Pedestal

(2) Adjust the B100 DELAY control. This adjustment is observed on the VIDEO SCOPE screen. Proceed as follows:

(*a*) Turn the VIDEO SWEEP DELAY control to the extreme clockwise (DELAY OUT) position.

(*b*) Adjust the VIDEO SWEEP SPEED control to bring the 1,000-microsecond markers near the right-hand end of the sweeps.

(*c*) Adjust the VIDEO SEPARATION control so that the 1,000-microsecond marker on the upper trace just barely touches the lower trace. The VIDEO SCOPE traces will appear as shown in figure 3–41.

(*d*) Observe the pattern on the VIDEO SCOPE screen. With the B100 and B10 DELAY controls in their minimum delay positions (paragraph 21), and the B CONTINUOUS DELAY control (used in this example) adjusted as in paragraph 22 *d*, above, the pattern will be like that shown in figure 3–41. The 1,000-microsecond markers, M and N, are the same ones identified in figure 3–40. Because they are within their respective pedestals, they must, of course, appear on their respective VIDEO SCOPE traces. Note that the minimum delays in the B-delay circuits have re-

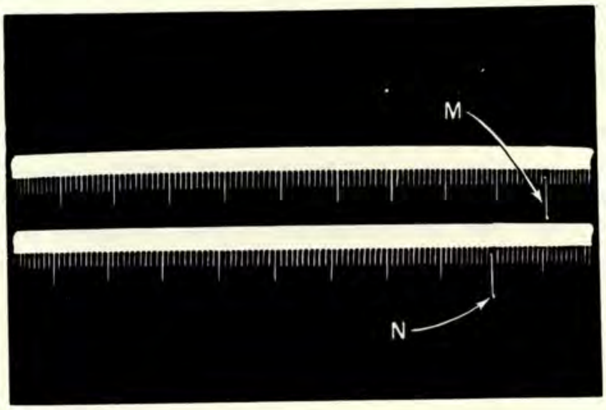


Figure 3–41. Appearance of VIDEO SCOPE Traces for Setting Up Hundreds (Typical Example)

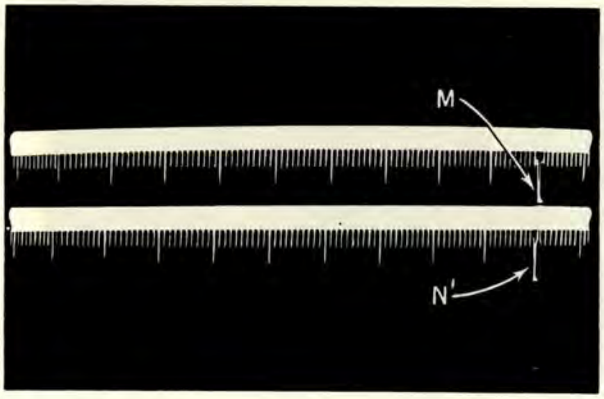


Figure 3–42. Appearance of VIDEO SCOPE After Adjustment of B100 Delay

sulted in marker N being to the left of marker M by the amount of the minimum delay. *A motion of the markers on the lower trace to the left thus represents an increase in delay.* At this sweep speed, the minimum delay of the B-delay circuits is more apparent. If the minimum delay were zero, the lower trace marker (N) would be directly below the upper trace marker (M). It can be seen, however, that it is delayed by 110 microseconds (100 microseconds if unit digit is zero).

(*e*) Adjust the B100 DELAY control as follows: Vary the B100 DELAY control so that the 1,000-microsecond marker (N) on the lower trace on the VIDEO SCOPE screen moves to the left, jumping in 100-microsecond steps. Move this marker by the number of increments equal to that specified by the hundreds digits of the *net delay*. In the example used here (net delay of 3,991), this will be nine. At the end of this step, marker N will disappear and marker N will appear almost directly under marker M, as shown in figure 3–42. This happens because the nine 100-microsecond increments plus the 100-microsecond minimum B100 delay add to 1,000 microseconds.

(*f*) Determine the range of the B100 DELAY control over which this adjustment holds. Set the control to the approximate center of that range. The centering adjustment will be made more accurately later, after the time delay is completely set up, by observation of the selector gate on the test scope.

(3) Adjust the B10 DELAY control. Observe the adjustment on the VIDEO SCOPE screen.

(*a*) Vary the VIDEO SWEEP SPEED control until the sweep is about 120 microseconds long. This will allow one 100-microsecond marker to appear on the upper trace, and one 100-microsecond (or a 1,000-microsecond) marker to appear on the lower trace.

(*b*) Adjust the VIDEO SEPARATION control so that the 100-microsecond marker on the upper trace just about touches the lower trace.

(*c*) Observe the pattern on the VIDEO SCOPE screen. It will be very nearly like that shown in figure 3–43. The upper trace will be identical when the video sweep delay control is in the DELAY OUT position. The appearance of the lower trace will vary with different set-ups. The major difference is that marker R may be a 1,000-microsecond marker instead of a 100-microsecond marker. (It will be a 1,000-microsecond marker only if the net delay hundreds digit is 8.) In the example used here (net delay of 3,991 microseconds) it will be a 100-microsecond marker, not a 1,000-microsecond marker.

Note

If a 1,000-microsecond marker does appear, it will be coincident with a 100-microsecond marker, and, for purposes of this adjustment, can be considered as such.

(*d*) The 100-microsecond markers are identified as P and R of figure 3–43. With the B CONTINUOUS DELAY control used, marker R is 10 microseconds to the left of marker P. The delay between the markers chosen for reference is thus 10 microseconds, that is, the minimum delay of the B10 circuit. If the last digit of the reference delay were zero, the B CONTINUOUS DELAY control would not be used, and the minimum delay remaining would be zero. The 100-microsecond marker R would thus be directly under the 100-microsecond upper-trace marker P. In the example used here (net delay of 3,991 microseconds) the unit digit is not zero, a minimum delay of 10 microseconds is present, and R is one 10-microsecond interval to the left of P.

(*e*) Vary the B10 DELAY control so that the 100-microsecond marker R on the lower trace moves to the left, jumping in 10-microsecond steps. Move this marker a number of increments equal to that specified by the 10's digit of the net delay. In the example used here (net delay of 3,991 microseconds) this will be nine. At the end of this step marker R will disappear and marker R' will appear directly under marker P, as shown in figure 3–44. This happens because the nine 10-microsecond increments plus the 10-microsecond minimum B10 delay add to 100-microsecond delay.

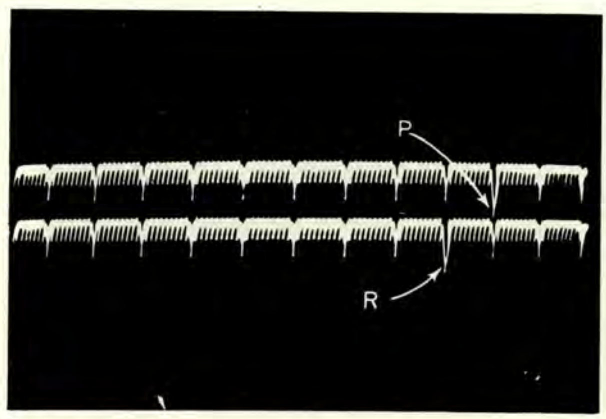


Figure 3–43. Appearance of VIDEO SCOPE Traces for Setting Up 10's (Typical Example)

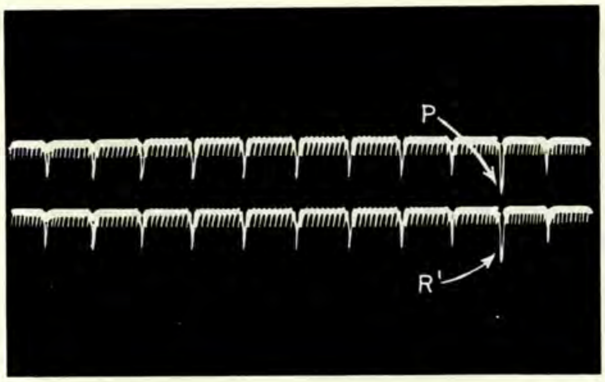


Figure 3–44. Appearance of VIDEO SCOPE After Adjustment of B10 Delay

(*f*) Determine the range of the B10 DELAY control over which the adjustment in paragraph 22 *f* (2) (*e*), above, holds. Set the control to the approximate center of that range. For the present lock the control in the adjusted position.

Note

The centering adjustment will be made accurately later, when the time delay is completely set up, by observation of the selector gate on the test scope screen.

(4) Adjust the B CONTINUOUS DELAY control. Observe the pattern on the RF SCOPE, proceeding as follows (OMIT THIS STEP IF THE UNIT DIGIT OF THE REFERENCE DELAY IS ZERO):

(*a*) Adjust the RF SWEEP SPEED control on the synchronization indicator unit until about twelve 1-microsecond markers are visible on the RF SCOPE screen.

(*b*) Adjust the RF SWEEP DELAY control to place a 10-microsecond marker near the right edge of the upper sweep.

(*c*) Adjust the RF SEPARATION control so that the 10-microsecond markers on the upper trace just barely touch the lower trace.

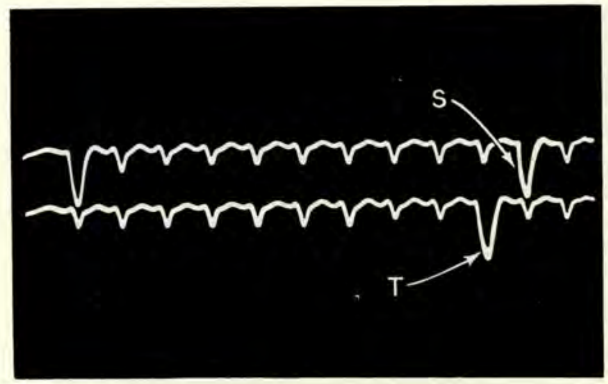


Figure 3–46. Unit Delay Set Up for 1 Microsecond

(*d*) Observe the pattern on the RF SCOPE screen. The pattern will be nearly like that shown in figure 3–45. Select the right-hand pair of 10-microsecond markers, S and T on figure 3–45, one on each trace, by means of which the delay in units is to be measured and set up.

(*e*) Adjust the B CONTINUOUS DELAY control so that the 10-microsecond marker on the lower trace moves to the left. It will move *smoothly*. Adjust it so that the delay between the upper trace and lower trace 10-microsecond markers, S and T, corresponds to the unit digit of the specified reference delay. In the example used here (net delay of 3,991 microseconds) the adjustment is made as indicated in figure 3–46, to obtain an interval of 1 microsecond between the lower trace (S) and upper trace (T) 10-microsecond markers. Lock the control in the adjusted position. This completes the adjustment of the reference delay.

(5) Make a *rough* check of the proper adjustment of the reference delay, by observing the SLOW SCOPE screen, counting the number of 1,000-microsecond intervals by which the lower trace B pedestal is to the right of the upper trace A pedestal, and estimating the portion of the 1,000-microsecond interval overlapped by the pedestal. The approximate delay in

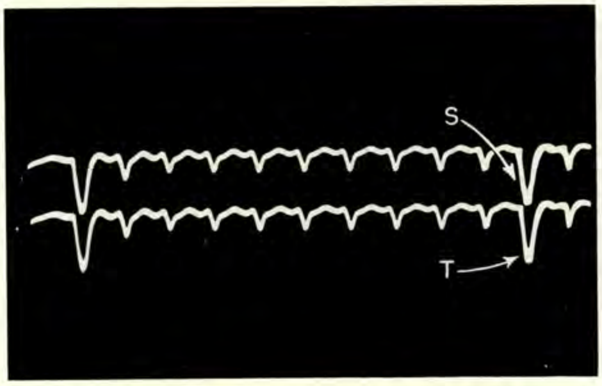


Figure 3–45. Appearance of RF SCOPE for Setting Up Units

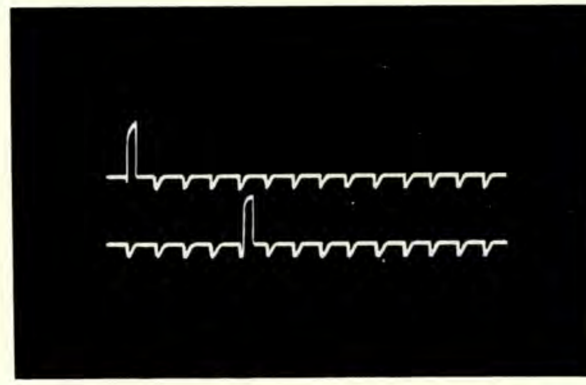


Figure 3–47. Rough Check of Adjustment of Reference Delay 4,101 Microseconds

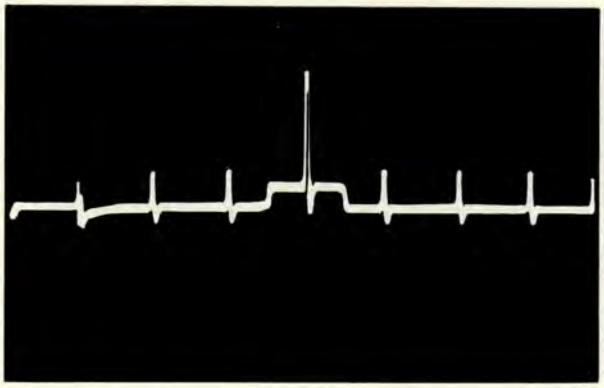


Figure 3–48. A1000 or B1000 Gate Centered Properly Beneath Selected Marker

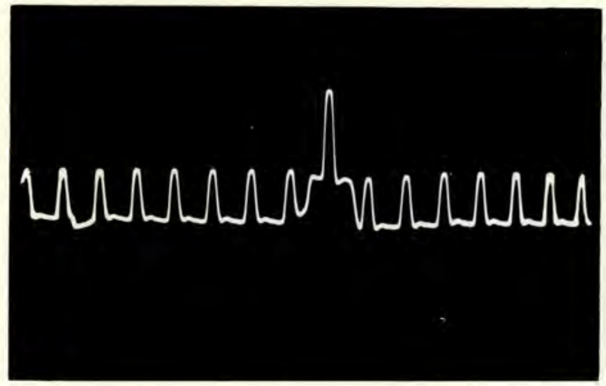


Figure 3–50. B10 Gate Centered Properly Beneath a Marker

figure 3–47 appears to be a little over 4,000 microseconds. This checks roughly with the set-up of 4,101 microseconds in the example used here.

g. CENTERING GATES.—In setting up the A1000, B1000, B100, and B10 DELAY controls, corresponding selector gates were moved beneath their proper markers to produce the required delay. To obtain the highest degree of stability, these gates must be centered carefully beneath the markers. The procedures described above produced only approximate centering, because the gates were not observed during these adjustments. As soon as the required delay has been set up, however, the gates must be centered accurately, by observing the gates and markers on the test oscilloscope, and refining the settings of the DELAY controls. Proceed as follows:

(1) Turn the SIGNAL SELECTOR switch on the test oscilloscope to the TIME DELAY position.

(2) Turn the TEST SIGNAL switch on the time delay unit to the A1000 position.

(3) Adjust the test oscilloscope controls for proper observation of the gate and markers, as described in paragraph 16.

(4) Vary the A1000 DELAY control on the time delay unit *slowly* to center the gate about the desired marker, as shown in figure 3–48. MAKE CERTAIN THAT THE SELECTED MARKER IS NOT CHANGED WHEN THIS IS DONE. Do that by observing the SLOW SCOPE, and verifying that the A pedestal is at the desired position on the upper trace.

(5) LOCK THE A1000 DELAY CONTROL IN THE ADJUSTED POSITION.

(6) Turn the TEST SIGNAL switch on the time delay unit to the B1000 position.

(7) Turn the SYNC SELECTOR switch to SQ WAVE ϕ 2 and set the controls on the test oscilloscope to bring the selector gate into view.

(8) Vary the B1000 DELAY control on the time delay unit *slowly* to center the gate about the selected marker as shown in figure 3–48. MAKE CERTAIN THAT THE SELECTED MARKER IS NOT CHANGED WHEN THIS IS DONE. Do that by observing the SLOW SCOPE and vertifying that the B pedestal is displaced to the right of the A pedestal by the number of markers determined in the adjustment procedure in paragraph 22 *e* or 22 *f*, above. Lock the B1000 DELAY control in the adjusted position.

(9) Turn the TEST SIGNAL switch on the time delay unit to the B100 position.

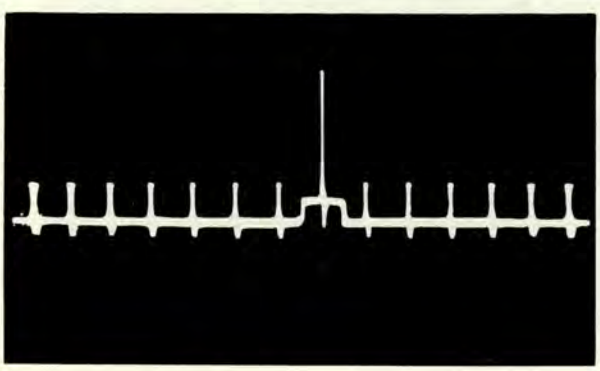


Figure 3–49. B100 Gate Centered Properly Beneath a Marker

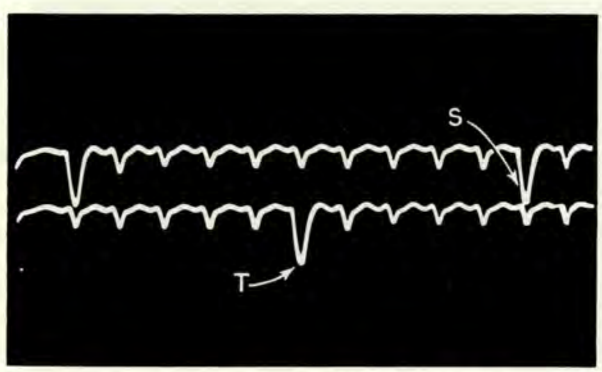


Figure 3–51. Appearance of RF SCOPE Pattern for Checking Delay in Units of Microseconds

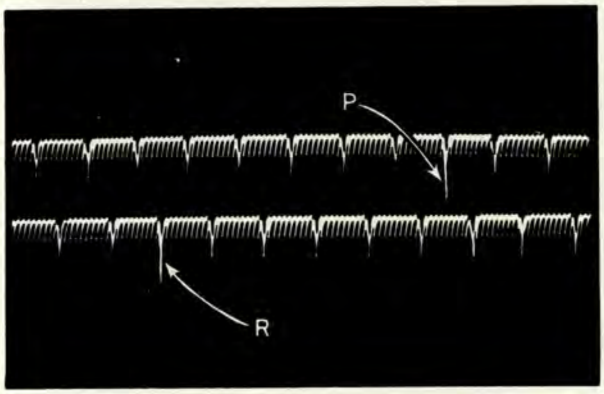


Figure 3–52. Appearance of VIDEO SCOPE Pattern for Checking Delay in Tens of Microseconds

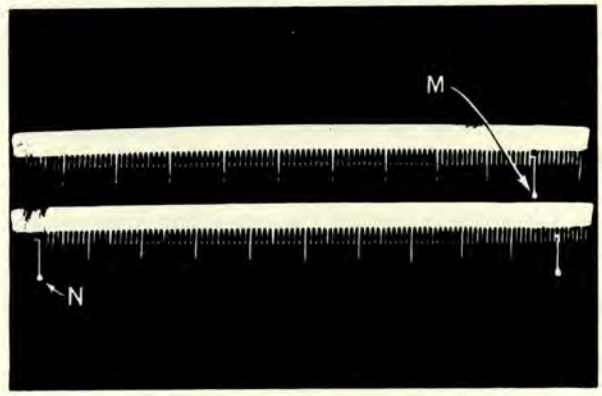


Figure 3–53. Appearance of VIDEO SCOPE Pattern for Checking Delay in Hundreds of Microseconds

(10) Vary the sweep speed and delay controls on the test scope to bring the B100 gate into view.

(11) Vary the B100 DELAY control on the time delay unit to center the gate about the pushed-up marker, as shown in figure 3–49. Make certain that the selected marker is not changed when this is done. Do that by observing the delay between the lower trace and upper trace 1,000-microsecond markers on the VIDEO SCOPE screen. Lock the B100 DELAY control in the adjusted position.

(12) Turn the TEST SIGNAL switch on the time delay unit to the B10 position.

(13) Vary the sweep speed and delay controls on the test scope to bring the B10 gate into view.

(14) Vary the B10 DELAY control on the time delay unit to center the gate about the pushed-up marker, as shown in figure 3–50. Make certain that the selected marker is not changed when this is done. Do that by observing the delay between the lower trace and upper trace 100-microsecond markers on the VIDEO SCOPE screen. Lock the B10 DELAY control in the adjusted position.

b. CHECKING REFERENCE DELAY.—The following procedure is an accurate method for checking the reference delay. The reference delay, 6,955 microseconds, is used here to illustrate the procedure. The procedure may be used after the adjustments of the preceding subparagraphs have been completed or whenever the reference delay is to be checked.

(1) Turn the RF PRESENTATION control on the synchronization indicator unit to the CAL position.

(2) Adjust the RF SWEEP SPEED control on the synchronization indicator unit until about twelve 1-microsecond markers are visible on the RF SCOPE screen.

(3) Adjust the RF SWEEP DELAY control to place a 10-microsecond marker near the right edge of the upper sweep.

(4) Adjust the RF SEPARATION control so that the 10-microsecond markers on the upper trace just barely touch the lower trace.

(5) Observe the 10-microsecond marker S, on the right-hand end of the upper trace, and marker T directly under or to the left of S, on the lower trace. See figure 3–51. Determine, by counting unit intervals, the number of microseconds of delay between the 10-microsecond markers S and T. Mark down the figure obtained as the unit digit (in this case, five microseconds) of the existing reference delay.

(6) Turn the VIDEO SWEEP DELAY control to the extreme clockwise (DELAY OUT) position.

(7) Adjust the VIDEO SWEEP SPEED control until the sweep on the VIDEO SCOPE screen is about 120 microseconds long. This will allow at least one 100-microsecond marker to appear on each trace. If a 1,000-marker appears, consider that marker as a 100-marker for this purpose.

(8) Adjust the VIDEO SEPARATION control so that the 100-microsecond marker on the upper trace just about touches the lower trace.

(9) Observe the 100-microsecond markers, equivalent to markers P and R in figure 3–52. Determine the number of 10-microsecond *intervals* between the two markers thus selected for reference. Ignore the additional fraction of an interval. Count complete intervals, not markers. Mark down the figure thus obtained as the "ten digit" in the time delay (in this case five, making 55).

(10) Adjust the VIDEO SWEEP SPEED control counterclockwise to bring a 1,000-microsecond marker near the right-hand end of the upper sweep.

(11) Adjust the VIDEO SEPARATION control so that the 1,000-microsecond marker on the upper trace just barely touches the lower trace.

(12) Using the 1,000-microsecond marker on the upper trace (M in figure 3–53) and the first 1,000-microsecond marker to its left, N, on the lower trace, count the 100-microsecond *intervals* between them, ignoring the fractional 100-microsecond interval (i.e., tens and units). Count complete intervals, not markers. Mark down the figure obtained as the "hundred digit" in the time delay (in this case nine, making 955).

(13) Turn the VIDEO SWEEP SPEED control on the synchronization indicator unit to the extreme clockwise position, to provide narrow pedestals on the SLOW SCOPE screen.

(14) Observe the positions of the pedestals on the SLOW SCOPE. Count the number of 1,000-microsecond *intervals* between their leading edges. Do not count the markers themselves, count the intervals between them. Mark down the number obtained as the number of 1,000's in the time delay. (In this case the number is six, making a total delay of 6,955 microseconds.) The measurement of time delay is now complete.

Note

In cases where the desired reference delay is very nearly an integral thousand, the leading edge of the B pedestal is very close to or contains a 1,000-microsecond marker. In such cases, estimate the total delay on the SLOW SCOPE to the nearest 1,000 microseconds, then coordinate this approximate value to the figures already obtained. Thus, in the example illustrated, the figures already obtained are 955, whereas the delay on the SLOW SCOPE is approximately 7,000 microseconds. (See figure 3–54.) Thus, the actual delay must be 6,955 microseconds, because this figure is much closer to 7,000 than is 7,955.

i. CHECK OF TRANSMITTER TRIGGER.—After the last delay control has been adjusted, as described above, turn the TEST SIGNAL switch (S503) on the time delay unit to the TRANSMITTER TRIGGER position. Observe the transmitter trigger pulse on the test scope screen. A typical waveform is shown in figure 3–55. For a MASTER station, the transmitter trigger should occur about 10 microseconds after the push-up A1000 marker. For a SLAVE station, if the B DELAY OUTPUT switch is in the B10 position, it will nominally occur at the same time as the selected B10 marker. If the B DELAY OUTPUT switch is in the B CONT position, the transmitter trigger will occur between 10 and 20 microseconds after the selected B10 marker.

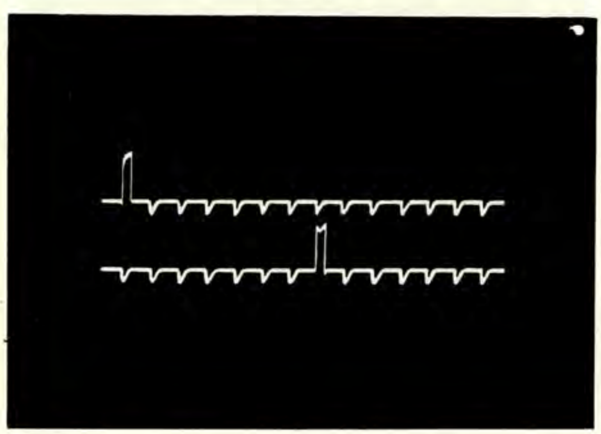


Figure 3–54. SLOW SCOPE Pedestals with a Delay Between Them of Nearly 7,000 Microseconds

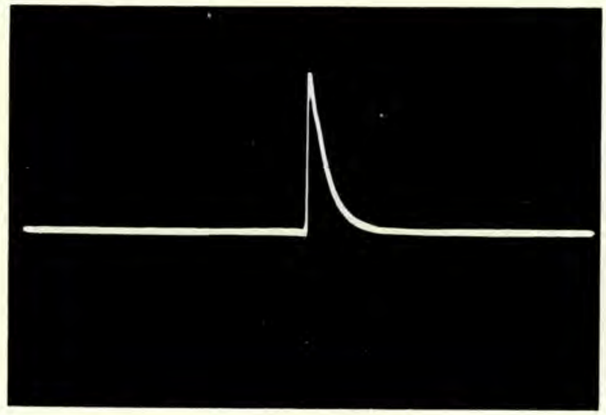


Figure 3–55. Typical Transmitter Trigger Waveform

23. ADJUSTMENT OF PRESET B DELAY CONTROLS.

a. GENERAL.—If, in addition to the NORMAL reference delay, other reference delays have been assigned to the loran station, it will be necessary to adjust the preset delays (B2 through B5) accordingly. In general, the procedure for adjusting the PRESET B2 through B5 DELAY controls is similar to the procedures described for the NORMAL delays in paragraph 22, above. Separate adjustment of gate widths is not required and is not provided for. The gate width adjustments made in accordance with paragraph 21 apply, once made, to both the NORMAL and the PRESET delay adjustments. Note that for each setting of the PRESET B DELAY SELECTOR switch (S504), there is a set of B1000, B100, and B10 DELAY controls. The B CONTINUOUS DELAY control is common to the NORMAL and the PRESET B delay adjustments. Once this control has been adjusted for the NORMAL delays, as described in paragraph 22, further adjustment, when setting up the PRESET delays, is not necessary. Similarly, no separate A1000 DELAY controls are provided for the adjustment of the preset delays. Once this control has been adjusted as described in paragraph 22 *c*, above, for the normal reference delay set-up, it should be left undisturbed for the B2 through B5 PRESET reference delay adjustments. The PRESET B DELAY selector switch and the PRESET B DELAY controls are located behind the hinged door on the time delay unit panel.

b. ADJUSTMENT OF PRESET B2 REFERENCE DELAY.

Note

If, in the adjustment of the normal reference delay, the B CONTINUOUS DELAY control has been used, it will have been set up in accordance with the procedure outlined in paragraph 22 *e* or 22 *f* for the NORMAL reference delay. Therefore, when the preset B delay is being adjusted, a small B continuous delay of less than 10 microseconds (the unit digit delay of the B normal reference delay) will always be present, will show up on the oscilloscope screens, and should be recognized as such as the adjustment is being made. Note, however, that the normal and preset reference delays assigned to the station will always have the same unit digit.

(1) Turn the PRESET B DELAY switch (S504) to the B2 position.

(2) Determine, by consideration of the last three digits of the required reference delay, which rule (the general rule of paragraph 22 *b* (1) or the special rule of paragraph 22 *b* (2)) applies. If the general rule applies make the adjustment called for in paragraph 22 *e*, steps (1) through (3), and step (5), using the B2-1000, B2-100, and B2-10 DELAY controls. If the special rule applies use the B2-1000, B2-100, and B2-10 DELAY controls to perform the adjustments called for in paragraph 22 *f*, steps (1), (2), (3), and (5).

(3) After completing the adjustments called for in paragraph 23 *b* (2), above, center the B2-1000, B2-100, and B2-10 gates as described in paragraph 22 *g*, steps (1) through (4), (6) through (14).

(4) Check the time delay set-up as described in (1) through (3), above, by using the procedure outlined in paragraph 22 *b*.

c. ADJUSTMENT OF B3, B4, AND B5 PRESET B DELAYS.—To adjust the B3, B4, and B5 PRESET DELAY controls, turn the PRESET B SELECTOR switch to the corresponding preset delay position, and, using the associated PRESET B DELAY controls, follow the procedure outlined in paragraph 23 *b*, above.

Note

If, in the course of adjusting the delay circuits, the adjustment range of the control is not large enough, the corresponding bias potentiometer needs adjustment. Refer to Section 7, paragraph 4*d* (1), for the DELAY BIAS adjustment procedures.

24. ADJUSTMENT OF BLINKING AND BLANKING CIRCUITS.

The adjustment of the blinking and blanking circuits should be made after the correct time delay has been set up. The blinking circuit represents a means of shifting, when required, of either the A1000 delay at a master station or the B1000 delay at a slave station, back and forth at a slow, predetermined, rate. When the BLINK SELECTOR switch (S802), on the synchronization indicator unit, is in the OFF position, this shift does not take place. The time delay remains fixed as it was set up. When the BLINK SELECTOR switch is in the MANUAL position, the blinking circuit is on, and either the A1000 delay at a master station or the B1000 delay at a slave station lengthens periodically. The BLINK DELAY control (R614) on the time delay unit and a motor-driven switch are provided to adjust the rate at which the blink is on and off, and the delay increases and decreases. The procedure for adjusting the control and the switch for a desired blink-to-no-blink ratio is described in paragraphs 23 *a* and 23 *b*, below. Adjustment of the blanking pulse width is described in paragraph 23 *c*, below. For a detailed description of the blinking and blanking circuits, refer to Section 2, paragraphs 4 *d* (6) and 4 *d* (8).

a. ADJUSTMENT OF BLINK DELAY.

(1) Turn the TEST SIGNAL switch on the time delay unit to the A1000 position at a master station or to the B1000 position at a slave station. Adjust the test scope controls to observe the selector gate on the test scope screen.

(2) Adjust the test scope SWEEP SPEED control until about four or five 1,000-microsecond markers appear on the screen, with the pushed-up marker a little to the left of center.

(3) Carefully check the centering of the gate about the pushed-up marker, and readjust, if necessary.

(4) Turn the BLINK SELECTOR switch (S802) on the synchronization indicator panel to the MANUAL position.

(5) Observe the pattern on the test scope screen. The gate should move to the right periodically, once per second, and, when in that position, should be centered about the 1,000-microsecond marker adjacent to the original pushed-up marker.

(6) If the blinked gate is not centered about this marker, adjust the chassis-mounted BLINK DELAY control (R614) on the time delay unit to obtain this result.

(7) Turn the BLINK SELECTOR switch to OFF. Check and readjust, if necessary, the centering of the gate.

(8) Repeat steps (6) and (7) until the gate is centered about the corresponding 1,000-microsecond marker in both the blink and the no-blink positions.

(9) Check the centering of each preset B1000 gate with the BLINK SELECTOR switch OFF and readjust, if necessary. Note that once the blink delay has been adjusted for one delay it does not require further adjustment for the other delays.

b. ADJUSTMENT OF BLINK ON DUTY CYCLE. —The motor controlling the blink, no-blink cycle drives a cam which in turn operates a microswitch. This switch may be adjusted with respect to the cam to permit the blink period to occupy between 30 percent to 70 percent of the entire blink cycle. (The entire blink cycle consists of the blink and the no-blink periods.) This adjustment has been made at the fac-

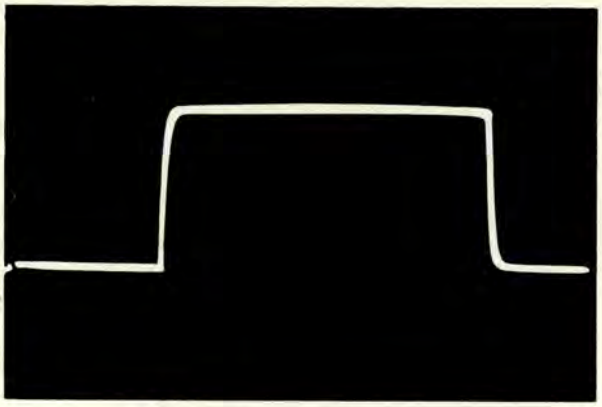


Figure 3–56. Blanking Pulse Pattern on Test Scope (Typical)

tory to provide a 50 percent blink and 50 percent no-blink period. For an accurate check of the blink duty cycle proceed as follows:

(1) Shut off the interlock power. Then loosen the screws holding the microswitch to its supporting bracket (as shown in figure 7–254), so that the switch is movable. To increase the blink period, move the switch toward the cam. To decrease the blink period, move the switch away from the cam. Shift the position of the switch a little at a time.

(2) Tighten the screws, restore power, and check adjustment by connecting a reliable 60 cps, 115 volt synchronous clock with a sweep second hand between terminals 1 or 2 on TB502 and one of the poles of the BLINK SWITCH S505. Operate blink motor for about four minutes (timed accurately by separate means) and note the elapsed time on the synchronous clock. Then move the clock connection to the other pole of S505 and repeat the foregoing procedure for the same length of time. If the elapsed times are equal on the synchronous clock, the duty cycle is correctly adjusted to 50 per cent. If the elapsed times do not agree, repeat steps *a* and *b*.

Note

The foregoing procedure is valid only if S505 is wired as shown in figure 7–276. Some equipment have the connections of S505 reversed. If this condition exists, correct wiring to agree with schematic before proceeding. If other than a 50 per cent duty is desired, an oscilloscope with a triggered slow sweep is required. Use of synchronous clock for other duty cycles will give variable errors due to the inertia of the clock.

(3) After the adjustment has been completed, turn the BLINK SELECTOR switch (S802) to the OFF position.

c. BLANKING PULSE WIDTH ADJUSTMENT.—The lead resistor of the blanking pulse output stage of the timer is not provided within the time delay unit, but outside the timer equipment. For the following adjustment, it is necessary, therefore, to provide a proper termination for that stage.

(1) Provide a termination for the blanking output stage, as described in either paragraph 24 *b* (1) (*a*), 24 *b* (1) (*b*), or 24 *b* (1) (*c*), below.

(*a*) If the station being adjusted is the first timer to be placed into operation at the station, and that timer is associated with an AN/FPA–2 Switching Unit, the switching unit controls will have been set to select the particular timer as the operating timer, and the proper termination will thus have been provided for. Refer to the instruction book for AN/FPA–2 Loran Switching Group, and to paragraph 11, preceding, for more detailed information.

(*b*) If the station at which adjustments are being made is a stand-by timer, and other timers of the station have already been placed into operation, and an AN/FPA–2 Loran Switching Group is being used, the timer being adjusted must be temporarily terminated with an external resistor. To do that, connect a 15,000-ohm, 1-watt, composition resistor between connector J507 (center conductor) and ground.

(*c*) If a type UM switchgear is employed at the station, the circuit is always automatically terminated, regardless of operating or stand-by status, and no additional resistor is needed.

(2) Operate the TEST SIGNAL switch on the time delay unit to the TRANSM TRIGGER position.

(3) Manipulate the test scope controls to permit observation of the transmitter trigger, as shown in figure 3–56.

(4) Turn the MARKER SELECTOR switch on the test scope to the 100's position, Adjust the MARKER HEIGHT control so that the 100's are easily observed.

(5) Turn the time delay unit TEST SIGNAL switch to the BLANKING position.

(6) Manipulate the test scope controls so that the transmitter trigger is at the left end of the trace and so that the trace is about 700 microseconds long.

(7) By means of the BLANKING WIDTH control (R529) mounted on the chassis of the time delay unit, adjust the blanking pulse so that it terminates about 500 microseconds to the right of the transmitter trigger. Lock R529 in the adjusted position.

Note

Should it be found that the blanking pulse is too wide, for any reason, so that information preceding the trigger is blanked out, perform the change described in Section 7, paragraph 9.

d. LOCK CONTROLS.—After the steps outlined above have been performed, and all requirements called for have been met, the time delay unit adjustments are completed. Check that all controls are locked in the adjusted positions, and lock, if necessary.

25. RADIO RECEIVER AND AUTOMATIC SYNCHRONIZER CIRCUIT ADJUSTMENTS—GENERAL.

Up to this point, the adjustments of the timers have been made without the use of any received signals and entirely independently of the remote station. Except as indicated in the pertinent places, the procedures were substantially the same at a master and at a slave station, and could be performed simultaneously at each station. From this point on, however, the remaining timer adjustments must be made by means of signals from the distant station. In the case of the first timer (for each repetition rate at a double-pulsed station) of the station being placed into operation, a properly worked-out adjustment sequence at master and slave station timers is necessary. The sequence outlined in paragraph 25 *a,* below, is recommended and is used as the basis for adjustments of the radio receivers and automatic synchronizer circuits of the first timer to be placed into operation at the master and slave stations. Paragraph 25 *b* discusses departures from this sequence for adjustments of the radio receivers and automatic synchronizer circuits of stand-by timers of the master and slave stations.

a. SEQUENCE FOR ADJUSTING FIRST TIMER.—The following sequence assumes that adjustments are being made on the first timer to be placed into operation. The loran switching equipment will have been checked and adjusted, and will have been made available for use as indicated in outline form in paragraph 12 *g,* preceding.

(1) The master station places its operating transmitter on the air, using the operating timer adjusted as described in paragraphs 11 through 24 to drive the transmitter. The master station now *must wait* until the slave station will have completed the adjustments called for in (2), below.

(2) The slave station uses the signal transmitted from the master station to perform the adjustments of its radio receiver and automatic synchronizer circuits (paragraphs 26 and 28). To that end, the slave station goes on the air and thus has available for these adjustments two signals, i.e., the one from the master station and the locally transmitted signal. The slave station adjustments lock the slave signal in with the master station signal.

(3) *After* the slave station has completed its receiver and automatic synchronizer circuit adjustments, the master station, in turn, utilizes its own transmitted signal (already on the air, paragraph 25 *a* (1), above) and the locked-in signal from the slave station (paragraph 25 *a* (2) above), to adjust its radio receiver and automatic synchronizer circuits (paragraphs 26 and 29). The master station adjustments make it ready to monitor the slave station synchronism.

(4) Upon completion of the above adjustments, both stations are ready for operation in the loran system.

From the above outline of the procedures to follow, it is apparent that a carefully worked-out schedule of adjustments must be pre-established between the operators of the master and slave stations, so that proper coordination of efforts may be achieved. It is recommended, therefore, that such a schedule be worked out and meticulously followed. Note that any adjustments of the automatic synchronizer circuits at a slave station would be incorrect and unusable if the master station were making its own adjustments at the same time. Similarly, master station adjustments require the presence of a properly synchronized slave station signal.

b. CONSIDERATIONS OF STAND-BY TIMER ADJUSTMENTS.—For adjustments of the stand-by timers, it is assumed that a pair of operating timers is already available. No particular sequence of adjustments at a master or slave station need be followed. The stand-by timer may be adjusted at any time, utilizing the signals, already on the air, under control of the operating timers of the two stations. Except for the above consideration and minor differences pointed out at the pertinent places, the procedures for adjusting the first operating timer and stand-by timers are essentially the same (paragraphs 26 through 29).

c. ADJUSTMENT OF RADIO TRANSMITTERS.—The master and slave station radio transmitters should be adjusted at this time, using the transmitter trigger from the associated operating timer in accordance with the information given in the instruction book for the particular radio transmitter. After adjustment, the transmitters should be kept off the air until required by the following procedures.

26. RADIO RECEIVER TYPE R–564/FPN–30 ADJUSTMENTS.

a. PLACING MASTER STATION TRANSMITTER ON AIR.—At this point of the procedures, the master station operator should turn on the radio transmitter associated with the particular timer being adjusted. Refer to the instruction book for the particular transmitter being used. For adjustments of a stand-by timer or a master operating timer, the operating transmitter will already have been turned on, and this step is, therefore, unnecessary.

b. INSTALLATION OF RADIO RECEIVER TUNING COILS.—The radio receiver is designed to operate at any one of five fixed loran frequencies in the band between 1,750 and 1,950 megacycles. For each possible frequency, a separate set of tuning coils is provided. Each set consists of seven hermetically sealed plug-in transformers. The octal mounting sockets of these transformers are located on top of the receiver chassis. The transformers are shipped in a separate package. The mounting screws are stored in the tapped mounting holes on the receiver chassis. Proceed as follows:

(1) Shut off the interlocked power to the equipment. Open the radio receiver drawer and remove the mounting screws stored in the tapped holes adjacent to the transformer mounting sockets. (Refer to figure 4–5 for location of sockets.)

(2) Plug in each one of the seven transformers, provided for the particular operating frequency, in its proper socket. Use the screws to attach the mounting lugs of the can to the chassis. The transformer cans are marked: Z1202, Z1203/Z1204, Z1205/Z1206, and Z1201/Z1207. The units marked with the same double Z-number separated by a virgule (/) are identical and are interchangeable. Thus, for example, the two transformers provided, marked Z1203/Z1204, are identical and are interchangeable.

Note

The transformers are prealigned at the factory and are then hermetically sealed. No tuning adjustments are provided for.

(3) Close the receiver drawer.

c. PRELIMINARY CONTROL AND SWITCH SETTINGS.—Set the controls and switches on the radio receiver and on the synchronization indicator unit as listed below.

(1) Set the controls and switches on the radio receiver as follows:

(*a*) Turn the panel-mounted REMOTE SIGNAL switch (S1201) to the IN position.

(*b*) Turn the panel-mounted AMPLITUDE BALANCE switch (S1203) to the OUT position.

(*c*) Turn the chassis-mounted LIMITER switch (S1202) to the OUT position.

(*d*) Adjust the tuning knobs of the panel-mounted RF REJECTION NO. 1 and RF REJECTION NO. 2 filters (L1204 and L1205) to the extreme counterclockwise positions.

(2) Disconnect the lead going to the LOCAL INPUT jack, J2203, on the back of the cabinet, to temporarily open the local signal path to the receiver.

The radio receiver is now ready to receive a signal from the remote station.

(3) Preset the oscilloscope controls on the synchronization indicator unit as listed below. The controls are located behind the hinged door on the panel.

(*a*) Set the RF SWEEP DELAY control to dial calibration 5.

(*b*) Set the RF SWEEP SPEED control to the extreme counterclockwise position.

(*c*) Set the RF GAIN control on the front panel to its midposition.

(*d*) Set the VIDEO SWEEP DELAY control to dial calibration 5.

(*e*) Set the VIDEO SWEEP SPEED control to the extreme clockwise position.

(4) Turn the FREQUENCY CORRECTOR switch to the OUT position, and check that the FREQUENCY CORRECTOR dial is set to zero. Both controls are located on the synchronization control unit.

(5) Turn the interlocked power on. After a few minutes warm-up, manipulate the COARSE RF GAIN control (R1228) on the radio receiver panel to view the REMOTE signal on the SLOW SCOPE. The signal will appear as a narrow line. On the SLOW SCOPE the signal will appear stationary.

d. DRIFTING MASTER SIGNAL ONTO MASTER PEDESTAL AND STABILIZATION OF OSCILLATOR.—The following procedure applies specifically for both operating and stand-by timers at a SLAVE station, and with modifications, as indicated, to the stand-by timer at a master station. The procedure *must be omitted* for a master station operating timer.

(1) Drift the signal onto the master pedestal on the SLOW SCOPE. Use the DRIFT switch (S807), located on the panel of the synchronization indicator unit, to do that. Turn the switch to a left position or to a right position, depending on the direction in which the signal must travel to come near the pedestal. Initially, turn the switch to the fast position (in the selected direction) until the signal is near the pedestal. Then turn the switch to the slow position, to place the signal on the pedestal. Use the PHASE dial on the Synchronization Control Unit Type C–1238/FPN–30, if desired, to complete the placement of the signal on the pedestal. Rotate the dial in the clockwise or the counterclockwise direction, as necessary.

Note

The following applies wherever, in the following steps, reference to PHASE dial adjustments is made. At a MASTER station stand-by timer, the PHASE dial cannot be used to drift the signal onto the pedestal. In such cases, use the COARSE FREQUENCY switch on the master stand-by timer oscillator to do that. Turn the switch to the adjacent position, as required, leave it there until the signal drifts onto the pedestal, and then return the switch to the original position.

(2) Observe the RF SCOPE. An r-f pulse signal should now be present on the RF SCOPE screen. The pulse may be drifting rapidly. This is an indication that the timer oscillator frequencies differ by a considerable amount. The frequency of the oscillator under adjustment must be readjusted to bring the pulse to a standstill. To do that proceed as follows:

(*a*) Readjust the oscillator frequency by means of the frequency controls on the oscillator panel until the signal on the RF SCOPE screen appears almost stationary. Note that the clockwise rotation of the oscillator controls causes the signal to move to the right, while counterclockwise rotation of the controls causes it to move to the left.

Note

If the signal is drifting so rapidly that it goes off the RF SCOPE screen before the frequency adjustment can be made, reposition the signal by means of the PHASE dial as described in paragraph 26 *d* (1), above, or as described in the Note following paragraph 26 *d* (1), above.

(*b*) Using the PHASE dial, bring the peak of the r-f pulse to the left end of the sweep. (At a master station stand-by timer, use the COARSE FREQUENCY switch.)

(*c*) Turn the RF SWEEP SPEED control to the extreme clockwise position.

(*d*) Stop the motion of the r-f cycles by means of the oscillator FINE FREQ. ADJ. dial (PARTS PER 10^9 window indicator) until they appear stationary.

(*e*) Observe the signal to determine the amount of movement occurring in one minute. Turn the FINE FREQ. ADJ. dial 10 divisions at a time, and repeat the observation each time, to further stop the drift. The adjustment may be considered completed when in one minute the r-f cycles move less than the distance (on the sweep) occupied by one r-f cycle.

e. TUNING ADJUSTMENTS. — The following steps serve to provide the two required r-f tuning adjustments, namely, the tuning of the RF SCOPE amplifier, and the tuning of the receiver output cathode follower tuning coil, L1219, for maximum deflections on the RF SCOPE.

(1) Adjust the RF SCOPE tuning as follows:

(*a*) Return the RF SWEEP SPEED control to the extreme counterclockwise position.

(*b*) Adjust the PHASE dial to approximately center the pulse on the RF SCOPE screen.

(*c*) Turn the COARSE RF GAIN control on the receiver for about 2-inch peak-to-peak signal.

(*d*) Open the synchronization indicator drawer, and remove the panel on the right side of the chassis (figure 7–257) to gain access to the RF SCOPE tuning control.

(*e*) Using a screwdriver, adjust the RF SCOPE tuning control, C861, for a peak deflection of the r-f pulse on the RF SCOPE screen. If necessary, adjust the receiver gain to prevent the signal from going off the scope screen. Lock the control in the adjusted position.

(*f*) Replace the side panel and close the drawer.

(2) Adjust the radio receiver tuning, as follows:

(*a*) Use the scope RF GAIN control, and, if necessary, the receiver COARSE RF GAIN control (R1228) to adjust the zero-to-peak upward signal deflection to about three inches.

(*b*) Use the RF SCOPE VERTICAL CENTER control to approximately center this upward signal deflection on the scope screen.

(*c*) Use a screwdriver to adjust coil L1219, on the receiver chassis, for maximum deflection on the RF SCOPE screen.

f. LORAN SWITCHING EQUIPMENT INPUT ATTENUATOR.—Depending on the type of loran switching equipment used, perform either step (1) or step (2).

Either

(1) LORAN SWITCHING EQUIPMENT AN/FPA-2.—If the timer is being used in conjunction with Loran Switching Equipment AN/FPA–2, make tests on that equipment, to determine whether the 20-db pad provided in the associated ESU is to be left in or is to be disconnected from the circuit. Use the receiver signal presentation on the RF SCOPE as a criterion for this determination, following the procedures outlined in the instruction book for that equipment. If more than one timer is associated with a particular ESU in the switching equipment, the 20-db pad in that unit need be adjusted only once.

Or

(2) MODEL UM LORAN SWITCHING EQUIPMENT.—If the timer is being used in conjunction with Model UM loran switching equipment, select the antenna input attenuation in accordance with the information given in Section 3, paragraph 12 of the instruction book for that equipment. If more than one timer is associated with a particular antenna input attenuator in the switching equipment, that attenuator need be adjusted only once.

g. STANDARDIZING RECEIVER OUTPUT. — A signal generator, capable of supplying a signal at the frequency of the receiver and at a level between 1 and 100 millivolts, and a high-impedance r-f vacuum tube voltmeter are required for this adjustment.

(1) Adjust the signal generator to the receiver frequency and for a convenient output level, between 1 and 100 millivolts.

(2) Disconnect the cable from the REMOTE INPUT jack, J1201, and connect the signal generator to that jack. Use a type UG–274/U T-connector, to connect the vacuum tube voltmeter to the RF OUTPUT jack, J1208, in parallel with the cable normally connected to that jack. Access to jacks J1201 and J1208 mounted on the rear apron of the receiver chassis is obtained by either opening the rear door of the timer cabinet or by pulling out and tilting the receiver drawer.

(3) Adjust the COARSE RF GAIN control (R1228) to obtain about a 15-volt reading on the meter.

(4) Adjust the signal generator frequency to obtain a peak reading on the meter. Readjust the COARSE and FINE RF GAIN controls on the receiver for exactly 15 volts on the meter.

(5) Adjust the RF GAIN control on the synchronization indicator unit to provide exactly 2-inch peak-to-peak signal deflection on the RF SCOPE screen. Disregard the pulse that appears on the scope. It is caused by the blanking voltage modulating the CW signal.

(6) Disconnect the signal generator and the vacuum tube voltmeter, and restore the normal connections to the receiver.

(7) If necessary, drift the remote signal into view on the RF SCOPE. Adjust the receiver COARSE and FINE RF GAIN controls to obtain a 2-inch peak-to-peak deflection of the remote signal on the RF SCOPE screen.

(8) Adjust the VIDEO SWEEP SPEED control to obtain a sweep speed of about 200 microseconds.

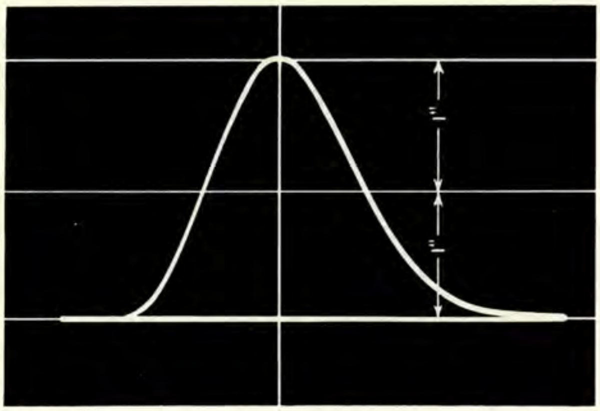


Figure 3–57. Video Signal Adjusted to Two-inch Height as 15-Volt Receiver Output Reference Level

(9) Adjust the video scope VERTICAL CENTER control to place the base line of the signal on the lowest reference line on the scope screen.

(10) Adjust the VIDEO GAIN control (R854) on the chassis of the synchronization indicator unit to adjust the video signal to a 2-inch zero-to-peak height. The properly adjusted signal will appear as shown in figure 3–57 which indicates the reference line on the scope screen providing a measure of the 2-inch height. Lock the control in the adjusted position. *The 2-inch zero-to-peak height of the video signal defines standard receiver output.* If at any time during operation the receiver output level changes, the receiver gain controls should be readjusted to establish this reference level, corresponding to a 15-volt receiver output.

(11) Turn the SIGNAL switch on the synchronization indicator unit to the DERIVATIVE position, and readjust the DERIVATIVE GAIN control (R846) on the chassis of that unit to obtain a 2-inch peak-to-peak signal on the oscilloscope screen. Lock the control in the adjusted position.

h. ATTENUATION ADJUSTMENTS. — The following adjustments must be made in conjunction with corresponding adjustments of the loran switching equipment, as referenced at the pertinent points in the following steps. The purpose of these adjustments is to equalize the local and remote signal amplitudes in the receiver. If the operating and stand-by timers are connected to the same ESU in the switching equipment, make the adjustments, as outlined below, on the operating timer. Then set the receiver attenuators in the stand-by timer to the same settings obtained for the attenuators in the operating timer. If the operating and stand-by timers (for the particular repetition rate at a double-pulsed station) are connected to separate ESU's in the switching equipment, adjust the attenuators in each timer individually, as described below. Proceed as follows:

(1) Shut off interlocked power.

(2) Reconnect the lead to the LOCAL INPUT jack, J2207, on the cabinet, to restore the local signal path to the receiver (disconnected in paragraph 26 *c* (2), above).

(3) Adjust the LOCAL GAIN control (R1209) to its midposition.

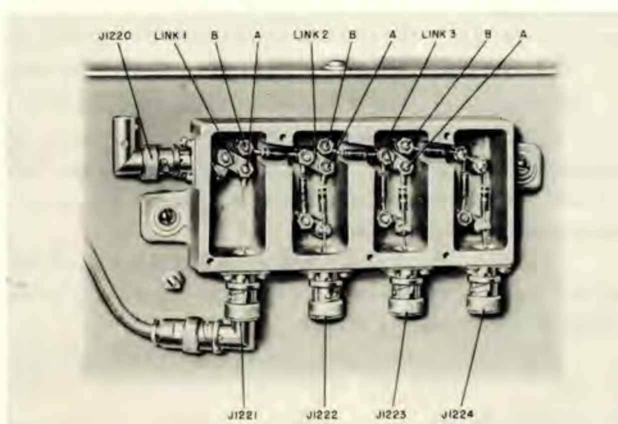
(4) Adjust the external attenuator for 0-db loss. To do that, connect the cable from jack J1210 to jack J1221, the 0 DB jack on the attenuator, and adjust the link straps on the attenuator to the 0-db connections, as shown in figure 3–58. The external attenuator is mounted on the back of the main receiver chassis.

(5) Adjust the loran switching equipment resistive attenuator associated with the particular timer being adjusted, for minimum attenuation, as described in the instruction book for that equipment.

The attenuators in the local signal path of the receiver and in the loran switching equipment are now set for minimum attenuation to the local signal. (The receiver internal attenuator has been preset at the factory for minimum attenuation.)

(6) Restore interlocked power, and allow a warm-up period of a few minutes.

(7) At this point of the procedure, the slave station operator should turn on the radio transmitter associated with the particular timer being adjusted. Refer to the instruction book for the particular transmitter being used. For adjustments of a stand-by timer or a master operating timer, the operating transmitter will already have been turned on, and this step is, therefore, unnecessary.



ATTENUATION	PLUG CABLE INTO	CONNECT LINK 1 TO	CONNECT LINK 2 TO	CONNECT LINK 3 TO
0 db	J1221	A	A or B	A or B
20 db	J1222	B	A	A or B
40 db	J1223	B	B	A
60 db	J1224	B	B	B

Figure 3–58. Procedure for Selecting Attenuation in Receiver External Attenuator

(8) Vary the COARSE RF GAIN control on the receiver until the remote station signal appears on the SLOW SCOPE screen.

(9) For the first timer (for each rate at a double-pulsed station) going on the air or for the stand-by timer at a slave station only, use the DRIFT switch on the synchronization indicator unit panel to drift the remote signal onto the upper trace pedestal.

(10) The amplitude of the local signal will be much greater than that of the remote signal. The objective now is to insert enough attenuation to make the amplitude of the local signal as nearly equal to that of the remote signal as possible. The attenuators (internal and external) in the receiver and in the loran switching equipment are used for this purpose. A 130-db attenuator, adjustable in 10-db steps, is provided in the loran switching equipment. The external attenuator in the receiver is adjustable in 20-db steps from 0 to 60 db. The receiver internal attenuator has one 20-db and one 40-db step. This attenuator is strapped at the factory for 20 db. When adding attenuation by means of the attenuators, the additions should be made in the following order, depending on whether or not the equipment is in a screen room:

Either

(*a*) If the equipment is *not in a screen room,* introduce attenuation in the following order: external attenuator, internal attenuator, attenuator in loran switching equipment.

Or

(*b*) If the equipment is *in a screen room,* introduce attenuation in the following order, as required: attenuator in loran switching equipment, external attenuator, internal attenuator.

The procedures for adjusting the external attenuator to the desired attenuation step are explained in figure 3–58. To adjust the internal attenuator, open the receiver drawer, remove the bottom cover plate, remove the cover of r-f chassis #1 located at the right side, front, of the chassis (figure 7–255), and shift the strip link on terminal board TB1205, from the factory preset 20-db position to the 40-db position. To adjust the attenuator in the loran switching equipment, refer to the instruction book for the particular equipment used (i.e., AN/FPA–2 or Model UM). Make the adjustments in the order indicated in either paragraph 26 *h* (10) (*a*) or 26 *h* (10) (*b*) until the local and remote signals are as nearly equal as possible in amplitude. This fact can best be observed by viewing the signals on the VIDEO SCOPE or RF SCOPE (for the first timer being placed into operation at a slave station, adjust the PHASE dial on the synchronization control unit to superpose the local and remote signals).

(11) If the last attenuator adjusted in accordance with the above is *not* the loran switching equipment attenuator, shift the connection on the switching equipment attenuator to the next step, and readjust the receiver external attenuator to determine whether or not any improvement is possible. If no improvement results, return the connections to their original positions.

(12) Adjust the receiver LOCAL GAIN control (R1209) to exactly equalize the local and remote signals.

27. MECHANICAL ADJUSTMENTS OF RECORDING AMMETER ME–84/FPN–30.

Recording Ammeter ME–84/FPN–30 contains a recorder instrument and two running time meters. The unit is shipped from the factory with these components mounted and interconnected. In addition, the following accessories are provided:

(1) 30 rolls of chart paper, each 103 feet long. (One roll of chart paper lasts about 15 days at a speed of 3 inches per hour.)

(2) An accessory kit, containing:

1 pint bottle of red ink.

1 pen filler

1 inkwell filler

3 spare glass pen points

The following paragraphs pertain to the preservice adjustment procedures for the recorder itself. No adjustments are required for the running time meters.

a. SETTING UP FOR USE.—To place the recorder into service, proceed as follows:

(1) Unlock the door and swing it open to provide access to the mechanism.

(2) To protect the instrument mechanism during shipment, a cardboard retainer is fitted over the drive roll and pen table, and extends into the movement compartment, where it engages the pen fork to prevent unnecessary swinging of the moving element. The pen element is carried by two ears on this cardboard cover. Remove the pen element and lay it aside. Pull out the cardboard according to the directions printed on it. The instrument is now ready for insertion of the record chart and for filling with ink, as described in paragraphs 27 *b* and 27 *c,* below.

b. INSERTING THE RECORD CHART.—The instruction plate on the chart drive gives brief instructions for threading the chart and operating the chart drive. These printed instructions should be read carefully before servicing the recorder with charts and ink. Refer to the threading diagram on the instruction plate and to figure 3–59, and then proceed as follows:

(1) Remove the chart reroll assembly by pressing down on the spring clip on either end and pulling outward.

(2) Lay the chart reroll aside and remove the arbor which is used to hold the new chart. This arbor comes out by lifting up and pulling forward.

(3) Hold the new chart in the left hand, with the time figures on the chart at the left, and push the arbor into the chart core with the right hand, until the hexagonal end pieces are about even with the ends of the chart.

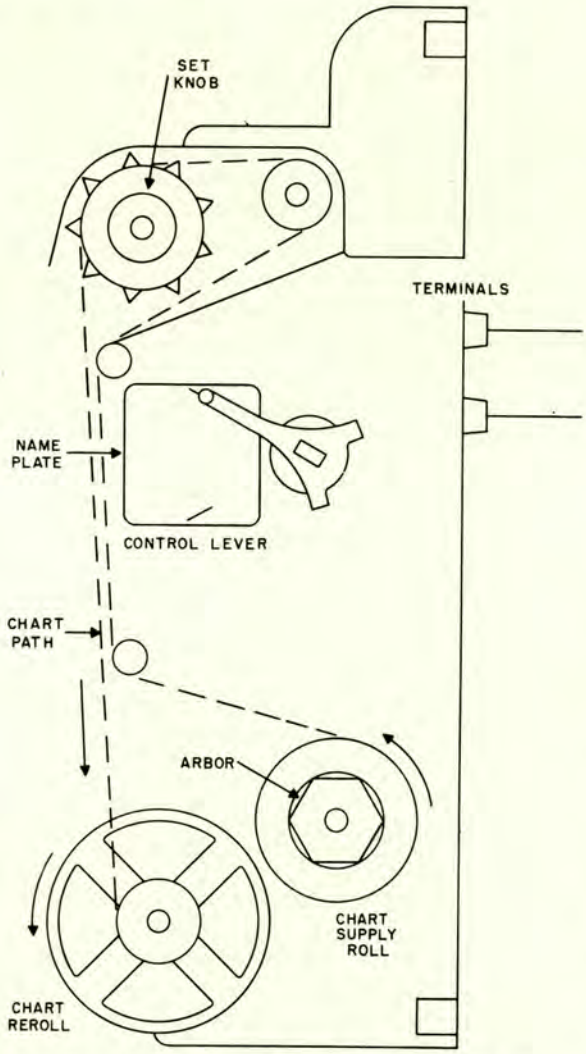


Figure 3–59. Record Chart Threading Path

(4) Push the chart supply roll and arbor back until the arbor pivots snap into place and the chart turns freely.

(5) Unwind the end of the chart, cut or tear to a point with an included angle of approximately 90°, and insert the end in the slot beneath the drive roll marked "INSERT END OF CHART HERE".

(6) Push the chart until the point appears over the pen table. Holding to the point on the chart, pull the chart over the drive roll, carefully engaging the chart perforations with the drive roll pins as shown in figure 3–60. Advance the chart by turning the set knob on the right end of the drive roll until the full width of chart reaches the position of the chart reroll.

(7) Insert chart reroll in place by holding it with the gear end to the left, lay the pivots on the clip springs, and snap the chart reroll in place. Note that this reroll assembly gear on the left-hand end engages a gear on the chart drive reroll train. The chart reroll is made in two pieces, the main tubular part which carries the gear and the removable plug on the right-hand end which can be pulled out to remove the used chart from the reroll. When this plug is pushed back in the tube BE SURE IT IS IN AS FAR AS IT WILL GO.

(8) Push the pointed end of the chart about one inch into the slot in the reroll tube, aligning the left edge of the chart with the chart between the supply roll and drive roll. Release reroll catch by giving chart reroll a part of a turn in the backward direction. Let chart reroll take up slack chart and set the chart to correct time. The portion of the chart from the drive roll to the reroll must be stretched tightly and it must be free from wrinkles or bulges on either side.

Note

The instruction plate back of the chart serves as a large writing surface for making notes on the chart.

c. CHART FEEDS.—The chart feed used on the recorder supplied as part of Recording Ammeter ME–84/FPN–30 uses a chart feed which can be switched to either inches per hour or to inches per minute. Shifting chart feed rate is accomplished by means of the CHART FEED lever located on the right side of the recorder. Normally, the lever is set to the HOUR FEED position. For special checks, as outlined in the following paragraphs, the lever is set to the minute feed position.

(1) HOURLY CHART FEEDS.—The most commonly used chart feed is three inches per hour. Change gears for other feeds, if required, will be found on a clip at the top of the left-hand side plate. The following table shows the combination of gears to obtain different chart feeds. To make it easy to select a set of gears for a given feed, pairs of gears used together are colored alike.

CHART FEEDS (INCHES PER HOUR OR MINUTE)	CHANGE GEARS		COLOR CODE
	NO. OF TEETH DRIVER*	NO. OF TEETH DRIVEN	
.75	18	72	Gold
1.50	30	60	Green
3.0	45	45	Red
6.0	60	30	Green
12.0	72	18	Gold

*Driver is the bottom gear.

To change the chart feed, proceed as follows:

(*a*) Remove the change gears in use.

(*b*) Select the proper gears from the extra gear clip and put the gears for the desired chart feed in place. The keyways in the gear hubs must engage the keys on the shafts.

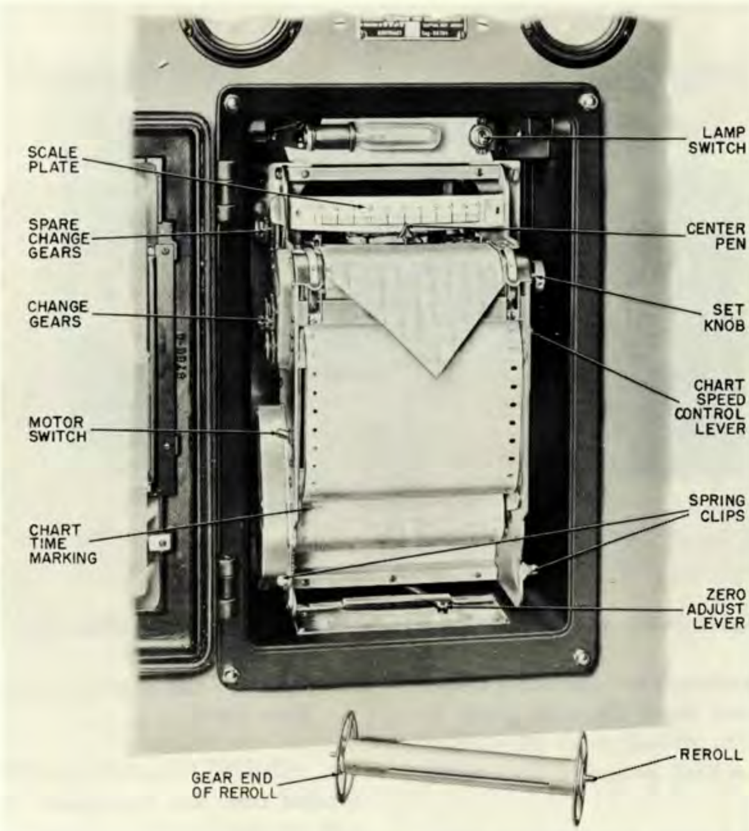


Figure 3–60. Recorder Chart, Partially Threaded

(*c*) To tighten the change gear nuts, it is necessary to hold the gear on one of the shafts, while the nut on the other shaft is being tightened. Gears are held by gripping the teeth with the fingers of the left hand, while screwing the change gear nut with the right hand.

CAUTION

Do not pry off the gears. Remove by a straight pull or the gear may be bent. Make the change gear nuts only fingertight. Note that the time calibration on the chart will be correct only when the chart feed is three inches per hour and the power line frequency is 60 cycles per second.

(2) MINUTE FEED.—Chart feeds in inches per minute, corresponding to the chart feeds in inches per hour, are obtained by moving the CHART SPEED control lever on the right-hand side plate from the HOUR FEED position down to the MINUTE FEED position.

d. FILLING RECORDER PEN WITH INK. — To fill the instrument with ink proceed as follows (refer to figure 3–61):

(1) Raise the scale plate, raise the pen element to clear the pen fork, and pull the pen out forward.

(2) Take out the inkwell by lifting the two handles and pulling it forward.

(3) Fill the inkwell through the pen opening, about three-quarters full, using the ink and the inkwell filler furnished with the accessory kit.

(4) Replace the inkwell, being careful that it is under the spring clips which hold it in place.

(5) Set the pen element in the pen fork properly, with the knife edges of the element seated in the slots in the fork. The pen element is correctly balanced at the factory when full of ink, and will stay off the chart until the pen is filled.

(6) Fill the pen by means of the pen filler, supplied in the accessory kit, proceeding as follows:

(*a*) Compress the bulb of the pen filler.

(*b*) Lay the flat side of the soft rubber tip on the chart.

(*c*) Insert the glass pen into the hole in the rubber tip, and let filler suck ink through the pen until no bubbles are visible in the glass pen.

(*d*) Remove the pen element from the filler. The pen should now rest lightly on the chart.

(7) Swing the pen across the chart several times. If it does not write properly, the pen probably has an air bubble in it. In this case, repeat the pen filling operation, outlined in step (6), above.

(8) Lower the scale plate, and make certain that the pen is properly seated in the pen fork and does not

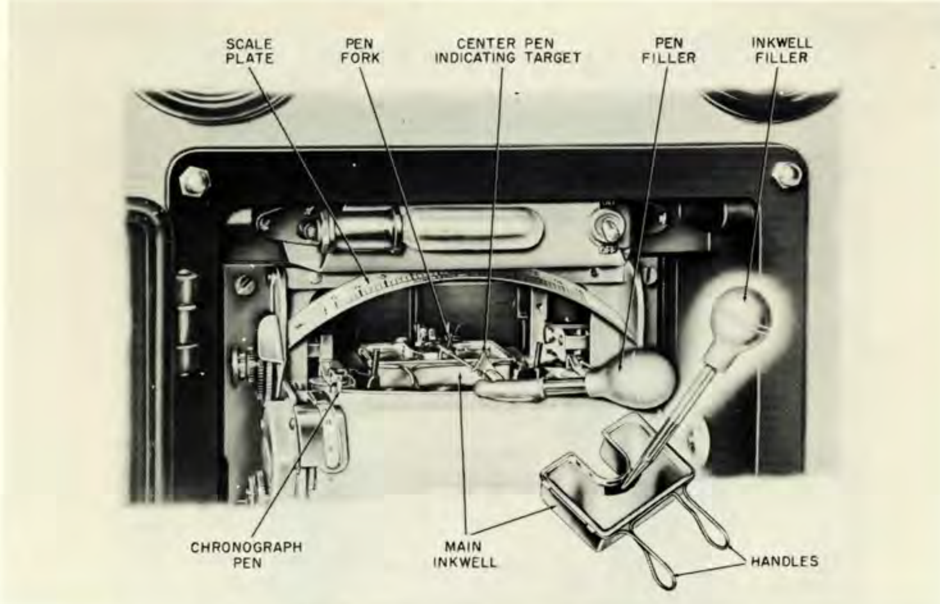


Figure 3–61. Method of Using Inkwell Filler (Insert) and Pen Filler

rub on the inkwell or scale plate. The indicating target above the glass pen must not touch the scale plate. If the pen is clean and properly primed, with all bubbles removed, it will write for a long period of time without further attention.

e. FILLING CHRONOGRAPH PEN WITH INK.—Instruments are shipped with the chronograph pen-inkwell assembly tied in place. Refer to figure 3–62.

(1) Remove the pen-inkwell assembly from the instrument, unscrew the knurled inkwell cover, and fill the inkwell to within about 1/4 inch of the top with the graphic meter ink, supplied with the kit of accessories. Replace the cover, taking care not to spill any ink.

(2) The glass pen is the same as the one used in the center pen element. Fill the pen element with ink, using the pen filler, supplied with the kit of accessories. Compress the pen filler bulb, insert the glass pen in the hole, and release the bulb slowly until ink appears in the glass pen. As soon as the ink reaches the tip of the glass pen, remove the filler. Do not remove too much ink from the well in the process of filling the pen.

(3) Replace the pen-inkwell assembly in the bracket, being careful that the tail of the pen-inkwell assembly engages the lever arm on the electromagnet. Push this lever arm over with the point of a pencil to see that the pen is writing properly. Be sure that there is no air bubble in the pen, or the pen will cease to write when the bubble reaches the point of the glass pen. If a bubble is present, refill the pen as indicated in step (2), above.

Note

The pen element and inkwell should be washed out with water and refilled frequently to insure a good record. The two small vent holes in the inkwell cover should always be kept open.

f. ADJUSTING RECORDER PEN ZERO.—A lever, located over the nameplate inside of the instrument case on the bottom, is used for mechanically setting the zero position of the recorder center pen. To set the zero, move the ZERO ADJUST lever, if necessary, while lightly tapping on the pen table to eliminate any friction between the pen and the chart. Move the lever in the same direction in which it is desired to move the pen. For this adjustment, the pen should be properly balanced. The zero adjustment described above sets the pen to the mechanical zero position at the center of the chart. Electrical zero adjustment against the timer equipment will be made in accordance with the procedures described at the proper points of paragraphs 28 and 29, below.

g. INSPECTING THE RECORD.—The record chart can be pulled from the reroll to examine the record. The reroll operates like a window shade. The chart should be pulled on each edge, using the thumb and fingers of both hands, and pulling straight out, not up. A sudden release of tension on the unrolled chart will lock the reroll, removing tension from the chart, and allowing it to be examined at leisure. To rewind the chart, first pull it forward slightly, to release the reroll catch, then let it wind slowly onto the reroll. Any amount of chart can be pulled from the reroll without damaging the mechanism.

h. REMOVING THE RECORD CHART.—To remove the rerolled chart, grasp the chart with the left hand and push down the spring clip which holds the pivot on the right end. Pull the chart reroll forward out of the instrument.

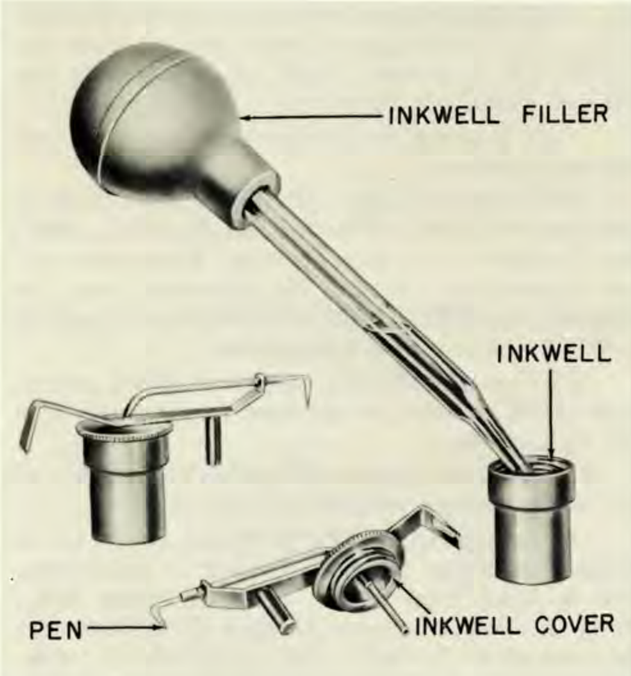


Figure 3–62. Chronograph Inkwell

To remove the chart from the reroll, pull the plug out of the right end with the disk, and then the chart can be pulled off the tube by holding to the disk on the gear end. If the chart sticks on the tube, twist the tube in the direction to unwind the chart as the tube is being withdrawn from the chart.

The chart is then ready for inspection and filing.

28. AUTOMATIC SYNCHRONIZER CIRCUIT ADJUSTMENTS—SLAVE STATION.

The purpose of the automatic synchronizer circuits at a slave station is to maintain synchronization of the master and slave signals, automatically, by making a phase comparison with each of the signals, and correcting any phase error. The procedures given below apply equally, except as noted in the pertinent places, to the first timer (for the particular repetition rate at a double-pulsed station) being placed on the air and to a standby timer. The adjustments are very important for the proper operation of the loran system, and must, therefore, be performed very carefully and in the order recommended in the following paragraphs.

a. INITIAL CONTROL SETTINGS.—During initial adjustments, frequent access to chassis-mounted controls is necessary. Before proceeding with the following adjustments (to prevent repeated loss of synchronization every time a drawer is opened): open all drawers, reset the interlocks, and leave the drawers open.

(1) Set the controls on Electrical Synchronizer Type SN–117/FPN–30, as indicated below. Except where otherwise mentioned, all controls listed below are front panel-mounted.

(*a*) Set the SYNC BIAS potentiometer (R1515) to its midposition.

(*b*) Set the SYNC BALANCE potentiometer (R1522) to the extreme counterclockwise position.

(*c*) Set the METER BALANCE potentiometer (R1538) to the midposition.

(*d*) Set the COARSE LOCAL DELAY potentiometer (R1544) to the midposition.

(*e*) Set the FINE LOCAL DELAY potentiometer (R1551) to the midposition.

Note

The settings of the COARSE and FINE REMOTE DELAY and of the DELAY RANGE controls are not pertinent to the adjustments described in this paragraph, since they are not used at a slave station. The DELAY BIAS control has been adjusted at the factory and should not require further adjustment at this time.

(*f*) Set the chassis-mounted SYNC ERROR SENSITIVITY potentiometer (R1534) to the extreme counterclockwise position.

(*g*) Set the chassis-mounted OFF SYNC SENSITIVITY potentiometer (R1555) to the extreme counterclockwise position.

(*h*) Turn the LOCAL SIGNAL switch (S1506) to the IN position.

(*i*) Turn the chassis-mounted STATION SELECTOR switch (S1505) to the SLAVE position. Check that the STATION SELECTOR switches (S101 and S501) on the chassis of the synchronization control and time delay units, respectively, are in the SLAVE positions.

(*j*) The chassis-mounted DERIVATIVE INPUT LEVEL potentiometer (R1510) is factory-adjusted. Leave this control in the adjusted position.

(*k*) The POWER ON-OFF switch (S1502) should have been in the ON position. If it is not, turn the switch to the ON position.

(2) Set the controls on Synchronization Control Type C–1238/FPN–30 as listed below. Unless otherwise indicated, the controls are front-panel mounted.

(*a*) The chassis-mounted RECORDER ZERO potentiometer (R145) has been adjusted at the factory. Leave this control in the adjusted position.

(*b*) The chassis-mounted RECORDER RANGE control (R142) has been adjusted at the factory. Leave this control in the adjusted position.

(*c*) Check that the AUTO SYNC switch (S104) is in the OFF position.

(*d*) The 60 ~ AMPL POWER switch (S102) should have been in the ON position. If it is not, turn the switch to the ON position.

(*e*) Turn the FREQUENCY CORRECTOR switch (S103) to the OUT position. The FREQUENCY CORRECTOR OUT indicator lamp (I104) should light.

(*f*) Turn the MAX MOTOR SPEED control (R157) to the extreme clockwise position.

(*g*) Partly open the synchronization control unit drawer to gain access to the MOTOR SPEED RANGE gear shift located on the cover of the gear box assembly, near the front panel (figure 4–2). Loosen the knurled knob, and slide the gear shift to the LOW position. The LOW RANGE indicator lamp (I107) on the front panel should light. Tighten the knurled knob and lock the gear shift in position.

Note

While shifting the gear shift it may be necessary to turn interlocked power on and the AUTO SYNC switch to the ON position, and thus permit the motor to turn and allow the gears to engage.

b. PRELIMINARY ADJUSTMENTS OF PHASE DIAL ASSEMBLY.

(1) *Disengage the mechanical stop on the PHASE dial shaft,* to permit the dial to rotate freely through the full 360° of rotation. To do that:

(*a*) SHUT OFF INTERLOCKED POWER. High voltages are present in the immediate vicinity of the stop when power is on.

(*b*) Loosen the two cam lock fasteners on the protective cover mounted flush against the rear of the front panel. Remove the cover to gain access to the stop screw. Refer to figures 4–2 and 7–249.

(*c*) Loosen the nut of the stop screw, and, using a screwdriver, turn the stop screw sufficiently to clear the stop on the dial shaft. This will permit the dial to rotate through 360°. Check this by rotating the dial.

(*d*) Tighten the nut on the stop screw to lock it in place. Replace the protective cover, and tighten the cam lock fasteners.

(2) Disable microswitch S108. Two cams mounted on the shaft of potentiometer R138, which, in turn, is coupled to the shaft of autosyn B101, driven by rotation of the PHASE dial (figure 2–55), are arranged to trip microswitch S108 when the dial is rotated. Refer to figure 4–2 for location of these parts. At a slave station, the microswitch, S108, is not used. Accordingly, proceed to slip the cams away so that they do not operate the switch as the dial is rotated. To do that, proceed as follows:

(*a*) Open the slide fasteners on the motor-autosyn-frequency corrector capacitor assembly, to gain access to the shaft of R138 and to the cams.

(*b*) Use a small multiple-spline wrench (supplied) to loosen the multiple-spline setscrews holding each of the two cams (figure 4–2) to the shaft of R138.

(*c*) Slip the cams toward the rear of the shaft, so that they do not engage the microswitch, when the PHASE dial is rotated. Check this by rotating the dial and noting that the switch is not tripped.

(*d*) Tighten the setscrews on the cams and replace the cover.

c. 60-CYCLE CIRCUIT TUNING.—The following procedure is an adjustment for line frequency which must be made at this time. If, at any future time, the line frequency is changed, the adjustment must be repeated. The INTERLOCKED POWER switch should be OFF at the start of this procedure.

(1) Turn the MOTOR SPEED RANGE control to the LOW position, as described in paragraph 27 *a* (2) (*g*), above.

(2) Turn the receiver COARSE RF GAIN control to the extreme counterclockwise position.

(3) Set the MAX MOTOR SPEED control to the extreme clockwise position. Connect a multimeter, such as Army Type IS–189 (Simpson Model 260), across the series-connected resistors R159, R160. Set the meter to the 2.5-volt (20,000 ohms/volt) d-c scale. To gain access to the resistors, remove the phase/frequency components cover (held by slide fasteners) which is located on top of the sync control chassis. The two resistors are connected between three standoff posts which are mounted on the chassis, alongside the sync control motor. Connect the meter to the two outside standoff posts.

(4) Turn the INTERLOCKED POWER switch ON and turn the AUTO SYNC switch ON. If the meter reads backwards, reverse the meter leads.

(5) Using a multiple-spline wrench, tune coil L102 for maximum motor speed, as indicated by a maximum reading of the meter.

(6) Disconnect the voltmeter and replace the cover removed in step (4).

d. CONNECTION AND INITIAL ADJUSTMENTS OF RECORDER.

(1) OPERATING TIMER.—In the case of an operating timer, the operating recorder will be used in the following procedures. The connections between the operating timer and the operating recorder will already have been made as described in paragraph 10.

(2) STAND-BY TIMER.—In the case of the stand-by timer, the spare recorder (supplied) will normally be used. (The recorder must always be supported in a vertical position so that the ink will not spill from the inkwell.) The connections between the stand-by timer and the spare recorder are made by means of test cable W2208, supplied. Connect the leads from the test cable to the proper terminals on the recorder, as shown in figure 3–63. The cable leads are identified by markers. The recorder panel wiring to the recorder terminals may be left connected. Connect the other end of the test cable to the EXTERNAL RECORDER connector (J105) on the panel of the synchronization control unit.

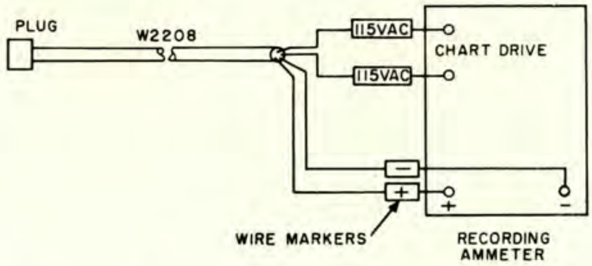


Figure 3–63. Spare Recorder Interconnections for Initial Adjustments

Note

If a spare recorder is not available, the operating recorder may be used by disconnecting plug P2601 from the connector containing the leads to the recorder and following the procedure outlined in paragraph 28 *d* (2), above. Note, however, that using the operating recorder in this way makes it unavailable for use with the operating timer.

e. CHECK OF RECORDER CALIBRATION AGAINST PHASE DIAL ROTATION.

(1) Turn on interlocked power and allow a warm-up period of 15 minutes before proceeding with the check.

(2) Turn the PHASE dial to the +4 mark. The recorder pen should indicate approximately +4 on the chart.

(3) Slowly rotate the PHASE dial in the counterclockwise direction toward the ±5-microsecond calibration mark. Slightly before the ±5-microsecond calibration mark on the PHASE dial is reached, the recorder pen should suddenly jump to the zero line on the chart. Continue rotating the PHASE dial in the counterclockwise direction, passing the ±5-microsecond mark, and continuing toward the —4-microsecond mark. The recorder pen should remain at zero as the ±5-microsecond mark on the PHASE dial scale is passed. Shortly thereafter the recorder pen should suddenly jump to the extreme left end of the chart (i.e., it should record a large negative deflection). As the PHASE dial rotation is continued, as indicated above, the pen should travel slowly toward the right.

(4) If the recorder pen was not at approximately zero when the PHASE dial was at the ±5-microsecond mark during the observations made above, potentiometer R138, coupled to the shaft of the autosyn, must be repositioned mechanically to center its no-resistance section (Section 2, Theory) about the ±5 mark on the PHASE dial scale. The procedure for making this adjustment is described in Section 7, paragraph 4 *b*.

(5) Turn the SPEED SELECTOR switch (figure 4–9) on the recorder to the MINUTE SPEED position. (This fast three-inches-per-minute chart speed is required for making the adjustments described below.)

(6) Turn the ON-OFF switch on the left side of the recorder (figure 4–9) to the ON position.

(7) Turn the PHASE dial to the 0 calibration mark on the scale. The recorder center pen should line up with the zero line at the center of the chart. If this requirement is not met, adjust the RECORDER ZERO potentiometer (R145) on the chassis of the synchronization control unit to bring the pen to the 0 mark on the scale. Lock the control in the adjusted position.

(8) Now turn the PHASE dial to the +4-microsecond calibration mark on the scale. Check that the recorder pen is on the +4-microsecond line on the chart. If this requirement is not met, adjust the RECORDER RANGE potentiometer (R142) to bring the pen to the +4-microsecond position on the chart. Lock the control in the adjusted position.

(9) Return the SPEED SELECTOR switch on the recorder to the HOUR FEED position (normal operating position), and turn the ON-OFF switch on the recorder to the OFF position.

(10) The recorder adjustments have now been completed. In the case of the stand-by timer, disconnect the spare recorder.

Note

If the operating recorder was used for the above adjustments of the stand-by timer, return that recorder to the normal operating condition.

f. SYNC BIAS AND SYNC BALANCE ADJUSTMENTS. — Unless otherwise indicated, the controls listed in the following steps are located on the electrical synchronizer unit panel. Check that the receiver RF GAIN controls are in the counterclockwise positions before proceeding with the following steps.

(1) Turn the METER SWITCH (S1504) to the OPERATE position.

(2) Use the METER BALANCE potentiometer (R1538) to bring the pointer of the SYNC TEST meter (M1501) to the 0 mark at the center of the scale.

(3) Turn the METER SWITCH to the ADJUST position.

(4) Adjust the SYNC BIAS potentiometer (R1515) to again bring the meter pointer to the 0 mark. This adjustment must be done very slowly, rotating the potentiometer shaft in small increments, since a long time constant is involved. Before considering the adjustment completed, watch the meter pointer for a few seconds. If any shift occurs, readjust the potentiometer, very little at a time, and alternately watch and adjust until the pointer remains on the 0 mark on the scale.

(5) Return the METER SWITCH to the OPERATE position.

(6) Turn the TEST SIGNAL selector switch (S1503) to the AC ERROR position.

(7) Turn the SIGNAL SELECTOR switch (S1702) on the test oscilloscope panel to the ELECT SYNC position.

(8) Turn the COARSE SWEEP SPEED switch (S1706) on the test oscilloscope panel to position 1. Adjust the FINE SWEEP SPEED potentiometer (R1709) on the test scope to the extreme counterclockwise position.

(9) Initially turn the SYNC BALANCE control in the clockwise direction at a rate which will provide complete range coverage in about 10 seconds. As the control is rotated, the signal on the test scope will suddenly go to minimum amplitude, and will rise again in amplitude. At this point back off the control and adjust for minimum signal amplitude. This adjustment must be made *very slowly,* and in small increments, since a long time constant is involved. Before considering the adjustment completed, watch the scope screen for a few seconds to determine whether any increase in signal amplitude occurs. Readjust the potentiometer, very little at a time, and alternately watch and adjust until the signal amplitude remains at minimum. Refer to figure 3–64 for a properly adjusted waveform.

Note

Except for certain specific rates at the slow basic rate, the signal appearing on the test scope screen will not be stationary.

g. PREPARATION FOR ADJUSTMENT OF SYNC GATE DELAY.

(1) FIRST TIMER TO BE PLACED INTO OPERATION.—If the first timer to be placed into operation for the particular repetition rate is being adjusted, omit the steps outlined in paragraph 28 *f* (2) below and proceed directly with the adjustment of the sync gate delay as described in paragraph 28 *h*.

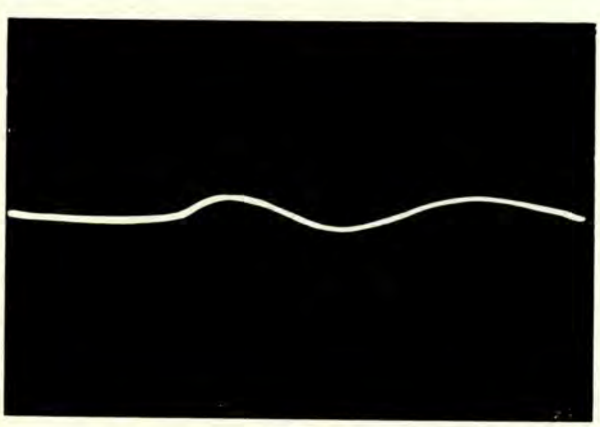


Figure 3–64. 60-Cycle Error Voltage Adjusted for Minimum

(2) STAND-BY TIMER.—If the stand-by timer is being adjusted, perform the steps outlined below before proceeding with the sync gate delay adjustments described in paragraph 28 *h*. The following steps assume that an operating timer is already on the air at the particular station and that the signals of the operating timer are, therefore, available for the adjustments of the stand-by timer. Proceed as follows:

(*a*) Disconnect the cable from the TEST SIGNAL jack (J506) at the rear of the time delay unit of the stand-by timer to be adjusted.

(*b*) Connect a cable equipped with suitable connectors between TEST SIGNAL jack (J506) of the stand-by timer time delay unit and the EXTERNAL SIGNAL jack (J1706) on the panel of the test oscilloscope of the operating timer.

(*c*) Turn the TEST SIGNAL switches (S503) on the time delay units of the operating *and* stand-by timers to the TRANSMITTER TRIGGER positions.

(*d*) Turn the SIGNAL SELECTOR switch (S1702) on the test oscilloscope panel of the operating timer to the TIME DELAY position.

(*e*) Use the controls of the test oscilloscope of the operating timer to locate the transmitter trigger pulse (of the operating timer) at the center of a 1,000-microsecond sweep on the scope screen.

(*f*) Turn the SIGNAL SELECTOR switch of the operating timer test scope to the EXTERNAL position. This introduces the transmitter trigger pulse from the stand-by timer into the test oscilloscope circuits of the operating timer. The transmitter trigger pulse from the stand-by timer should now appear on the screen of the test scope. If the stand-by trigger pulse fails to appear on the scope screen, drift it onto the screen by means of the LEFT-RIGHT drift switch of the *stand-by* timer.

(*g*) Now use the LEFT-RIGHT drift switch and the PHASE dial of the *stand-by* timer to drift the stand-by timer transmitter trigger pulse until it occurs in the same position on the screen as the transmitter trigger pulse from the operating timer. Continue adjusting the PHASE dial, and increasing the sweep speed until the two signals are superposed at the faster sweep speed of the test scope when the SIGNAL SELECTOR switch is turned alternately to the EXTERNAL and TIME DELAY positions.

Note

During the adjustment procedure to follow, it will be necessary to check that the two transmitter triggers remain superposed, and to make the adjustments as indicated in step (*g*), above, to keep them superposed.

h. ADJUSTMENT OF SYNC GATE DELAY.

(1) Turn the REMOTE SIGNAL switch (S1201) on the radio receiver to the OUT position.

(2) Adjust the COARSE and FINE RF GAIN controls on the radio receiver for a 2-inch local video signal deflection on the VIDEO SCOPE screen.

(3) Turn the SIGNAL SELECTOR switch on the test scope to the ELECT SYNC position, and the TEST SIGNAL switch on the electrical synchronizer unit to the 2ND DER position. Adjust the gain, sweep delay, and sweep speed controls on the test scope to bring the local signal into view.

(4) Use the test scope sweep delay and centering controls to bring the first zero cross-over of the signal to the intersection of the center vertical and horizontal reference lines on the scope screen, selected as the reference point. For this adjustment use a 100-microsecond sweep. Note that the waveform presented on the test scope screen is inverted with respect to the corresponding waveform as viewed on the VIDEO SCOPE screen. The waveform will appear as shown in figure 3–65.

(5) Turn the TEST SIGNAL switch on the electrical synchronizer unit to the LOCAL GATE position. Adjust the COARSE LOCAL DELAY control (R1544) until the leading edge of the gate appearing on the test scope screen occurs at the vertical reference line on the scope screen.

(6) Now turn the TEST SIGNAL switch to the AC ERROR position, and the COARSE SWEEP SPEED control on the test scope to position 1. Turn the FINE SWEEP SPEED control to the extreme counterclockwise position. Adjust the FINE LOCAL DELAY control for minimum 60-cycle error voltage on the test scope screen. This adjustment must be made very slowly and in small increments, since a long time constant is involved in the circuit. Before considering the adjustment completed, watch for a few seconds, repeat the adjustment a little at a time, and alternately watch and adjust until the 60-cycle error remains at the minimum. The appearance of the properly adjusted 60-cycle error voltage minimum is shown in figure 3–64.

(7) If, during the adjustment of step (6), above, it is found that the minimum 60-cycle error point lies outside the range of the FINE LOCAL DELAY control, and depending on whether the control is in its extreme clockwise or counterclockwise position, rotate the COARSE LOCAL DELAY control slightly clockwise or counterclockwise, respectively, and then readjust the FINE LOCAL DELAY control for minimum 60-cycle error voltage.

(8) Check that the sync gate is located at the first zero cross-over of the second derivative of the local signal. To do that:

(*a*) Turn the COARSE SWEEP control on the test scope to position 3.

(*b*) Turn the TEST SIGNAL switch on the electrical synchronizer to the 2ND DER position, and use the test scope controls to obtain the waveform illustrated in figure 3–65, as obtained by the adjustment of step (4), above. Then turn the TEST SIGNAL switch to the LOCAL GATE position, and note that the gate occurs approximately at the vertical reference line about which the first zero cross-over occurred.

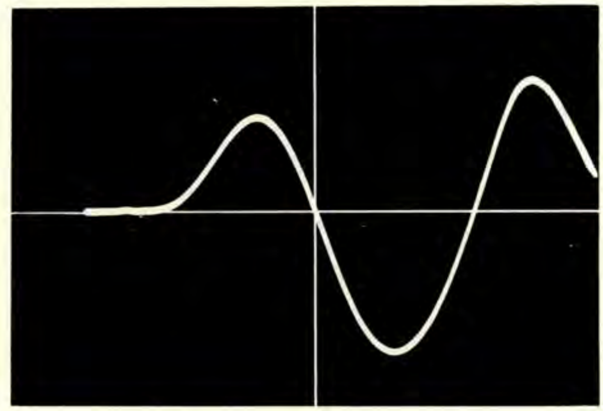


Figure 3–65. First Zero Cross-over of Local Signal Second Derivative Centered on Intersection of Center Vertical and Horizontal Reference Lines on Scope Screen

(*c*) If the gate does not occur approximately at the vertical reference line about which the first cross-over of the derivative signal occurred, the adjustment steps (1) through (7) above must be repeated.

(9) In the case of a stand-by timer, repeat the checks given in step (8), above, to view the superposition of the stand-by and operating timer transmitter triggers on the operating timer test scope. If the two triggers are separated by more than 2 microseconds, repeat the adjustments of steps (1) through (8), above. After the requirements of these checks are met, disconnect the test leads between the timers and restore the normal cable to connector J506 on the time delay unit of the stand-by timer.

i. ADJUSTMENT OF AUTOMATIC SYNCHRONIZATION CIRCUIT SENSITIVITY. — After the adjustments described in paragraph 28 *g*, above, have been completed, proceed as described in the following steps. Except as noted, the adjustment procedure applies to both operating and stand-by timers.

(1) At a stand-by timer, turn the LOCAL SIGNAL switch to the OUT position. Omit this step for an operating timer.

(2) Turn the REMOTE SIGNAL switch to the IN position. If necessary, use the DRIFT switch and the PHASE dial to bring the remote signal into view and to superpose it on the local signal. If required, readjust the signal amplitudes to obtain standard deflection.

(3) The MOTOR SPEED RANGE control should be in the LOW position, and the MAX MOTOR SPEED control should be set for 3 microseconds per minute.

(4) Turn the AUTO SYNC switch (S104) to the ON position. After the initial motion of the PHASE dial has stopped, turn the FREQUENCY CORRECTOR switch (S103) on the panel of the synchronization control unit to the IN position.

Note

The automatic synchronizer is now in operation and will maintain synchronization with the remote master signal.

(5) Allow at least 10 minutes for the oscillator of the timer being adjusted to lock in with the oscillator of the remote (master) station timer. If the oscillator has been correctly adjusted, as described in paragraph 26 *d* above, negligible correction will be necessary.

(6) Turn the AUTO SYNC switch (S104) to the OFF position.

(7) Turn the METER SWITCH (S1504) on the electrical synchronizer unit to the ADJUST position.

(8) SLOWLY turn the PHASE dial on the synchronization control unit to obtain a reading of zero on the SYNC TEST meter on the electrical synchronizer.

(9) Turn the PHASE dial through a 1-microsecond interval in the clockwise direction. Observe the reading of the SYNC TEST meter. A reading of 1 ma ±0.1 ma should be obtained. If this reading is not obtained, the DERIVATIVE INPUT LEVEL control (R1501) must be readjusted. This adjustment must be made very slowly, and in small increments, since a long time constant is involved in the circuit.

(10) Return the AUTO SYNC switch to the ON position. Wait until the FINE PHASE dial stops rotating. Then turn the AUTO SYNC switch to the OFF position.

(11) Repeat steps (8) through (10) to check the adjustment. This check must be made to insure that oscillator drift has not introduced errors.

(12) Return the METER SWITCH (S1504) to the OPERATE position.

(13) Return the AUTO SYNC switch to the ON position.

j. SYNC ERROR ALARM CIRCUIT ADJUSTMENTS.—At a slave station, the sync error alarm circuit is designed to provide an alarm indication whenever an error of 1 microsecond occurs. However, the circuit may be adjusted to provide an alarm indication for an error somewhat greater or smaller than the nominal 1 microsecond. The exact error for which adjustment is to be made will be determined by established Coast Guard procedure. For this adjustment, it is assumed that the timer being adjusted has been synchronized with the remote (master) station timer, as described in the preceding paragraphs. Proceed as follows:

(1) Turn the AUTO SYNC switch on the synchronization control unit to the OFF position.

(2) Turn the PHASE dial on the synchronization control unit through an interval of 1 microsecond in the clockwise direction, thereby introducing a corresponding synchronization error of 1 microsecond.

(3) Slowly turn the SYNC ERROR SENSITIVITY control (R1534) in the clockwise direction, until the SYNC ERROR indicator lamp (I804) on the panel of the synchronization indicator unit just lights.

(4) Turn the AUTO SYNC switch on the synchronization control unit to the ON position, to allow the timer to correct the error, as indicated by the fact that the SYNC ERROR lamp goes out and the FINE PHASE dial stops rotating.

(5) Adjust relay K1503 to the desired time delay setting.

Note

The adjustment of relay K1503, the time delay relay in the sync error indicating circuits, will be determined by Coast Guard procedure. This relay determines the interval of time between the occurrence of an error and the start of the alarm buzzer and of the local blink operation. To adjust the relay, turn the knurled knob until the pointers are set on the desired delay indicated on the relay dial. Note that the actual delay will be about 2 seconds greater than that indicated by the relay.

CAUTION

Relay K1503 should never be adjusted while it is operating, that is, while the SYNC ERROR indicator lamp is lit.

(6) Turn the AUTO SYNC switch to the OFF position. Introduce a 1-microsecond error by rotating the PHASE dial clockwise. The following indications should be obtained, as an indication of the proper operation of the alarm circuits and of proper adjustments, as outlined above.

(*a*) The SYNC ERROR lamp should go on.

(*b*) Relay K1503 should operate.

(*c*) After the time delay provided by relay K1503, the buzzer should sound, provided the BUZZER ON-OFF switch has been turned to the ON position. The local blink circuit should operate when the LOCAL BLINK switch is in the AUTO position.

(*d*) When the local blink operates, the LOCAL BLINK chronograph pen and the running time meter on the recorder should be energized.

Note

For a stand-by timer, the checks indicated above for the chronograph pen and the running time meter are not possible, since these items are not connected.

(7) Turn the REMOTE ALARM switch on the front panel of the electrical synchronizer unit to the IN position, and check the operation of the remote alarm circuits.

(8) Return the AUTO SYNC switch to the ON position.

k. OFF SYNC ERROR CIRCUIT ADJUSTMENTS.—For these adjustments, the timer should be in synchronism with the remote station timer, as established in paragraphs 28 *g* and 28 *h*, above.

(1) Very slowly turn the OFF SYNC SENSITIVITY control (R1555) on the electrical synchronizer in the clockwise direction, until the OFF SYNC lamp just goes on. Then return the control in the counterclockwise direction by *one* dial division (i.e., a half-interval between numbers). The OFF SYNC lamp should go out.

(2) Adjust relay K1505 to the desired time delay setting.

Note

The adjustment of relay K1505, the time delay relay in the off-sync indicating circuits, will be determined by Coast Guard procedure. This relay determines the interval of time between the occurrence of an error and the start of the alarm buzzer and of the local blink operation. To adjust the relay, turn the knurled knob until the pointers are set on the desired delay indicated on the relay dial.

CAUTION

Relay K1505 should never be adjusted while it is operating, that is, while the OFF SYNC lamp is lit.

(3) Turn the REMOTE SIGNAL switch on the receiver to the OUT position. The following indications should be obtained, as an indication of the proper operation of the off-sync alarm circuits, and of proper adjustments, as outlined above.

Note

For a stand-by timer, the checks indicated below for the chronograph pens and the running time meters are not possible, since these items are not connected.

(*a*) The OFF SYNC lamp should go on.

(*b*) Relay K1505 should operate.

(*c*) For an operating timer, the OFF SYNC chronograph pen and the running time meter on the recorder should be energized.

(*d*) After the time delay provided by relay K1505, the buzzer should sound, provided the BUZZER ON-OFF switch has been turned to the ON position. The local blink circuit should operate when the LOCAL BLINK switch is in the AUTO position.

(*e*) When the local blink operates, the LOCAL BLINK chronograph pen and the running time meter on the recorder should be energized.

(4) Turn the REMOTE ALARM switch on the front panel of the electrical synchronizer to the IN position, and check the operation of the remote alarm circuits.

(5) Return the REMOTE SIGNAL switch on the receiver to the IN position.

l. FINAL MOTOR SPEED ADJUSTMENTS.—The following additional steps remain for both the operating and stand-by timers of the station.

(1) Check that the gear shift control is in the LOW range position.

(2) Set the MAX MOTOR SPEED control (R157) on the synchronization control unit to 4 microseconds per minute. Lock the controls in the adjusted positions.

m. FINAL ADJUSTMENTS.—The adjustments described above complete the initial placement of the operating and stand-by timers at a slave station into service. Restore the cover on the autosyn-corrector assembly. Check that all connections, disturbed, made, or disconnected for these procedures, are returned to normal operating condition. Restore the electrical synchronizer unit drawer into the cabinet. If immediate operation of the station is contemplated, set the recorder chart for the correct time of day.

29. AUTOMATIC SYNCHRONIZER CIRCUIT ADJUSTMENTS—MASTER STATION.

The adjustments described in this paragraph serve to prepare the master station for monitoring slave station operation, utilizing both the remote and locally transmitted signals. When the adjustments will have been completed, automatic indications of synchronization error between the two stations will be obtained at the master station. In addition, alarm circuits will indicate excessive error, should the slave station go off synchronization. The procedures given below apply equally, except as noted in the pertinent places, to the first timer for the particular repetition rate (at a double-pulsed station) being placed on the air, and to a stand-by timer. The adjustments are very important for proper operation of the loran system, and must, therefore, be performed very carefully, and in the order recommended in the following paragraphs.

a. INITIAL CONTROL SETTINGS.—During initial adjustments, frequent access to chassis-mounted controls is necessary. To prevent repeated loss of synchronization by opening of the interlock every time the drawer is opened, open the drawer before proceeding with the following adjustments. Reset the interlock, and leave the drawer open until the adjustments are completed.

(1) Set the controls on Electrical Synchronizer Type SN–117/FPN–30, as indicated below. Except where otherwise noted, all controls listed below are front panel-mounted.

(*a*) Set the SYNC BIAS potentiometer (R1515) to its midposition.

(*b*) Set the SYNC BALANCE potentiometer (R1522) to the extreme counterclockwise position.

(*c*) Set the METER BALANCE potentiometer (R1538) to its midposition.

(*d*) Set the COARSE LOCAL DELAY potentiometer (R1544) to its midposition.

(*e*) Set the FINE LOCAL DELAY potentiometer (R1551) to its midposition.

(*f*) Set the COARSE REMOTE DELAY potentiometer (R1565) to its midposition.

(*g*) Set the FINE REMOTE DELAY potentiometer (R1517) to its midposition.

(*h*) The DELAY RANGE control (R1561) has been set at the factory. If the factory setting has been disturbed, set the control to a position about one-third away from the extreme counterclockwise end of its rotation.

(*i*) Set the chassis-mounted SYNC ERROR SENSITIVITY potentiometer (R1534) to the extreme counterclockwise position.

(*j*) Set the chassis-mounted OFF SYNC SENSITIVITY potentiometer (R1555) to the extreme counterclockwise position.

(*k*) Turn the LOCAL SIGNAL switch (S1506) to the IN position.

(*l*) Turn the chassis-mounted STATION SELECTOR switch (S1505) to the MASTER position. Check also that the STATION SELECTOR switches (S101 and S501) on the chassis of the synchronization control and time delay units, respectively, are in the MASTER positions.

(*m*) The chassis-mounted DERIVATIVE INPUT LEVEL potentiometer (R1501) has been adjusted at the factory. Leave this control in the adjusted position.

(*n*) The POWER ON-OFF switch (S1502) should have been in the ON position. If it is not, turn the switch to the ON position.

(2) Set the controls on the Synchronization Control Type C–1238/FPN–30 as listed below. Unless otherwise indicated, the controls are front panel-mounted.

(*a*) The chassis-mounted RECORDER ZERO potentiometer (R145) has been adjusted at the factory. Leave this control in the adjusted position.

(*b*) The chassis-mounted RECORDER RANGE control (R142) has been adjusted at the factory. Leave this control in the adjusted position.

(*c*) Check that the AUTO SYNC switch (S104) is in the OFF position.

(*d*) The 60 ~ AMPL POWER switch (S102) should have been in the ON position. If it is not, turn the switch to the ON position.

(*e*) Turn the MAX MOTOR SPEED control (R157) to the extreme clockwise position.

(*f*) Partly open the synchronization control unit drawer to gain access to the MOTOR SPEED RANGE gear shift located on the cover of the gear box assembly, near the front panel (figure 4–2). Loosen the knurled knob, and slide the gear shift to the LO position. The LO RANGE indicator lamp (I107) on the front panel should light. Tighten the knurled knob and lock the gear shift in position.

Note

While shifting the gear shift it may be necessary to turn the interlocked power on and the AUTO SYNC switch to the ON position, and thus permit the motor to turn and allow the gears to engage.

b. ADJUSTMENT OF MECHANICAL STOP ON PHASE DIAL SHAFT.—Adjust the mechanical stop on the shaft of the PHASE dial, as follows:

(1) SHUT OFF INTERLOCKED POWER. High voltages are present in the immediate vicinity of the stop when power is on.

(2) Loosen the two cam lock fasteners on the protective cover mounted flush against the rear of the front panel. Remove the cover to gain access to the stop screw. Refer to figure 4–2 for location of these parts.

(3) Loosen the nut of the stop screw, and, using a screwdriver, turn the stop screw in the clockwise direction until it just touches the stop on the shaft of the PHASE dial, as the dial is rotated. Move the stop away from the stop screw. Then turn the screw three additional full turns in the clockwise direction. Lock the stop screw in the adjusted position.

(4) Turn the PHASE dial to each end of its rotation range (i.e., until the stop hits the stop screw). Note the reading of the dial scale at each end. The reading at each end of rotation should be between 4.6 and 5.0 microseconds. The two readings should be equal to each other to within 0.05 microsecond (0.05 microsecond equals one-fourth of one small division). If these requirements are not met, readjustment in accordance with the information given in Section 7, paragraph 4 *b*, is necessary.

(5) Replace the protective cover.

c. 60-CYCLE CIRCUIT TUNING.—The following procedure is an adjustment for line frequency which must be made at this time. If, at any future time, the line frequency is changed, the adjustment must be repeated. The INTERLOCKED POWER switch should be OFF at the start of the procedure.

(1) Turn the MOTOR SPEED RANGE control to the LOW position, as described in paragraph 29 *a* (2) (*f*), above.

(2) Turn the receiver COARSE RF GAIN control to the extreme counterclockwise position.

(3) Set the MAX MOTOR SPEED control to the extreme clockwise position. Connect a multimeter, such as Army Type IS–189 (Simpson Model 260), across the series-connected resistors R159, R160. Set the meter to the 2.5-volt (20,000 ohms/volt) d-c scale. To

gain access to the resistors remove the phase/frequency components cover (held by slide fasteners) which is located on top of the sync control chassis. The two resistors are connected between three standoff posts which are mounted on the chassis, alongside the sync control motor. Connect the meter to the two outside standoff posts.

(4) Turn the INTERLOCKED POWER switch ON and turn the AUTO SYNC switch ON. If the meter reads backwards reverse the meter leads.

(5) Using a multiple-spline wrench, tune coil L102 for maximum motor speed, as indicated by a maximum reading of the meter.

(6) Disconnect the voltmeter and replace the cover removed in step (4).

d. CONNECTION AND INITIAL ADJUSTMENTS OF RECORDER.

(1) OPERATING TIMER.—In the case of an operating timer, the operating recorder will be used in the following procedures. The connections between the operating timer and the operating recorder will already have been made as described in paragraph 10.

(2) STAND-BY TIMER.—In the case of a stand-by timer, the spare recorder (supplied) will normally be used. (The recorder must always be supported in a vertical position so that the ink will not spill from the inkwell.) The connections between the stand-by timer and the spare recorder are made by means of cable W2208, supplied. Connect the leads from the test cable to the proper terminals on the recorder, as shown in figure 3–66. The cable leads are identified by markers. The recorder panel wiring to the recorder may be left connected. Connect the other end of the test cable to the EXTERNAL RECORDER connector (J105) on the panel of the synchronization control unit.

Note

If a spare recorder is not available, the operating recorder may be used by disconnecting plug P2601 from the connector containing the leads to the recorder, and following the procedure outlined in (2), above. Note, however, that using the operating recorder in this way makes it unavailable for use with the operating timer.

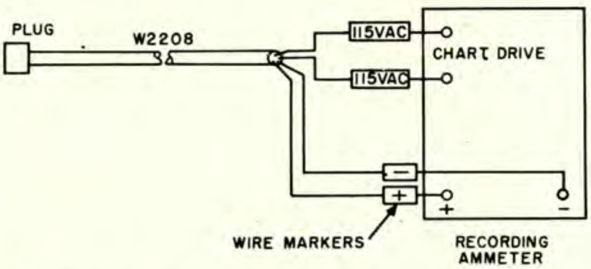


Figure 3–66. Spare Recorder Connections for Initial Adjustments

e. CHECK OF STOP, PHASE DIAL AND RECORDER CENTER PEN ALIGNMENT—AND RECORDER ZERO AND RANGE ADJUSTMENTS.

(1) Turn on interlocked power, and allow warm-up period of 15 minutes before proceeding with the check.

(2) Rotate the PHASE dial in the direction of increasing negative numbers (clockwise) until it hits the stop. Observe that the recorder center pen moves to the left and does not suddenly jump to the zero on the chart. Now rotate the PHASE dial in the opposite direction until it hits the stop, and observe that the recorder center pen moves to the right and does not suddenly jump to the chart zero.

(3) If the requirements of step (2), above, are not met, potentiometer R138, coupled to the shaft of the autosyn, must be repositioned mechanically with respect to the PHASE dial scale. The procedures for doing this are given in Section 7, paragraph 4 *b*.

(4) Turn the recorder SPEED SELECTOR switch to the MINUTE SPEED position. (This fast, three-inches-per-minute chart speed is required for making the adjustments described below.)

(5) Turn the ON-OFF switch on the left side of the recorder (figure 4–9) to the ON position.

(6) Turn the PHASE dial to the 0 calibration mark on the scale. The recorder center pen should line up with the zero line at the center of the chart. If this requirement is not met, adjust the RECORDER ZERO potentiometer (R145) on the chassis of the synchronization control unit to bring the pen to the 0 mark on the scale. Lock the control in the adjusted position.

(7) Now turn the PHASE dial to the +4-microsecond calibration mark on the scale. Check that the recorder pen is on the +4-microsecond line on the chart. If this requirement is not met, adjust the RECORDER RANGE potentiometer (R142) to bring the pen to the +4-microsecond position on the chart. Lock the control in the adjusted position.

(8) Return the SPEED SELECTOR switch on the recorder to the HOUR FEED position (normal operating position), and turn the ON-OFF switch on the recorder to the OFF position.

(9) The recorder adjustments have now been completed. In the case of the stand-by timer, disconnect the spare recorder.

Note

If the operating recorder was used for the above adjustments of the stand-by timer, return the recorder to the normal operating condition.

f. SYNC BIAS AND SYNC BALANCE ADJUSTMENTS.—Unless otherwise indicated, the controls listed in the following steps are located on the electrical synchronizer unit panel. Check that the receiver

RF GAIN controls are in the counterclockwise positions before proceeding with the following steps.

(1) Turn the METER SWITCH (S1504) to the OPERATE position.

(2) Use the METER BALANCE potentiometer (R1538) to bring the pointer of the SYNC TEST meter (M1501) to the 0 mark at the center of the scale.

(3) Turn the METER SWITCH to the ADJUST position.

(4) Adjust the SYNC BIAS potentiometer (R1515) to again bring the meter pointer to the 0 mark. This adjustment must be made very slowly, rotating the potentiometer shaft in small increments, since a long time constant is involved. Before considering the adjustment completed, watch the meter pointer for a few seconds. If any shift occurs, readjust the potentiometer, very little at a time, and alternately watch and adjust until the pointer remains on the 0 mark on the scale.

(5) Return the METER SWITCH to the OPERATE position.

(6) Turn the TEST SIGNAL selector switch (S1503) to the AC ERROR position.

(7) Turn the SIGNAL SELECTOR switch (S1702) on the test oscilloscope panel to the ELECT SYNC position.

(8) Turn the COARSE SWEEP SPEED switch (S1706) on the test oscilloscope panel to position 1. Adjust the FINE SWEEP SPEED potentiometer (R1709) on the test scope to the extreme counterclockwise position.

(9) Initially turn the SYNC BALANCE control clockwise, at a rate which will provide complete range coverage in about 10 seconds. As the control is rotated, the signal on the test scope will suddenly go to minimum amplitude and will rise again in amplitude. At this point, back off the control and adjust it for minimum signal amplitude. This adjustment must be made VERY SLOWLY, and in small increments, since a long time constant is involved. Before considering the adjustment completed, watch the scope screen for a few seconds, to determine whether any increase in signal amplitude occurs. Readjust the potentiometer, very little at a time, and alternately watch and adjust until the signal amplitude remains at a minimum. The properly adjusted waveform will appear as shown in figure 3–67.

Note

Except for certain specific rates at the slow basic rate, the signal appearing on the test scope screen will not be stationary.

g. PREPARATION FOR ADJUSTMENT OF SYNC GATE DELAY.

(1) FIRST TIMER TO BE PLACED INTO OPERATION.—If the first timer to be placed into operation (for the particular repetition rate at a

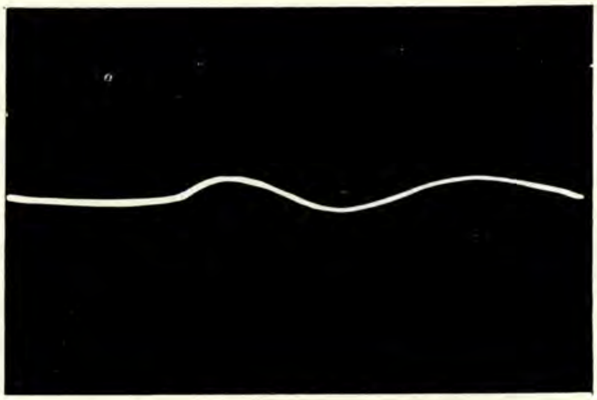


Figure 3–67. 60-Cycle Error Voltage Adjusted for Minimum

double-pulsed station) is being adjusted, omit the steps outlined in paragraph 29 *g* (2), below, and proceed directly with the adjustment of the sync gate delay as described in paragraph 29 *h*.

(2) STAND-BY TIMER.—If the stand-by timer is being adjusted, perform the steps outlined below before proceeding with the sync gate delay adjustments described in paragraph 29 *h*. The following steps assume that an operating timer is already on the air at the particular station, and that the signals of the operating timer are, therefore, available for the adjustments of the stand-by timer. Proceed as follows:

(*a*) Disconnect the cable from the TEST SIGNAL jack (J506), at the rear of the time delay unit of the stand-by timer to be adjusted.

(*b*) Connect a cable equipped with suitable connectors between TEST SIGNAL jack (J506) of the stand-by timer time delay unit and the EXTERNAL SIGNAL jack (J1706) on the panel of the test oscilloscope of the operating timer.

(*c*) Turn the TEST SIGNAL switches (S503) on the time delay units of the operating *and* stand-by timers to the TRANSMITTER TRIGGER positions.

(*d*) Turn the SIGNAL SELECTOR switch (S1702) on the test oscilloscope panel of the operating timer to the TIME DELAY position.

(*e*) Use the controls of the test oscilloscope of the operating timer to locate the transmitter trigger pulse (of the operating timer) at the center of a 1,000-microsecond sweep on the scope screen.

(*f*) Turn the SIGNAL SELECTOR switch of the operating timer test scope to the EXTERNAL position. This introduces the transmitter trigger pulse from the stand-by timer into the test scope circuits of the operating timer. The transmitter trigger pulse from the stand-by timer should now appear on the test scope screen. If the stand-by timer trigger pulse fails to appear on the scope screen, drift it onto the screen by means of the LEFT-RIGHT drift switch of the stand-by timer.

Note

At a master station, the PHASE dial cannot be used to drift the signal. In this case, the COARSE FREQUENCY control on the master station timer oscillator is used to do that.

(*g*) Now use the LEFT-RIGHT drift switch and the COARSE FREQUENCY (PARTS PER 10^6) selector switch (i.e., turn the switch to the adjacent position and return it to the original position) on the master stand-by timer oscillator to drift the stand-by timer trigger pulse, until it occurs in the same position on the screen as the transmitter trigger pulse from the operating timer. Continue switching the stand-by COARSE FREQUENCY (PARTS PER 10^6) switch back and forth, and increasing the sweep speed, until the two signals are superposed at the fastest sweep speed of the test scope, when the SIGNAL SELECTOR switch is turned alternately to the EXTERNAL and the TIME DELAY positions.

Note

During the adjustment procedure to follow, it will be necessary to check that the two transmitter triggers remain superposed, and to make the adjustments as described in step (*g*), above, to keep them superposed.

h. ADJUSTMENT OF LOCAL SYNC GATE DELAY.

(1) Turn the REMOTE SIGNAL switch (S1201) on the radio receiver to the OUT position.

(2) Adjust the COARSE and FINE RF GAIN controls on the radio receiver for a 2-inch local video signal deflection on the VIDEO SCOPE screen.

(3) Turn the SIGNAL SELECTOR switch on the test scope to the ELECT SYNC position, and the TEST SIGNAL switch on the electrical synchronizer unit to the 2ND DER position. Adjust the gain, sweep delay, and sweep speed controls on the test scope to bring the local signal into view.

(4) Use the test scope sweep delay and centering controls to bring the first zero cross-over of the signal to the intersection of the center vertical and horizontal reference lines on the scope screen, selected as the reference point. For this adjustment use a 100-microsecond sweep. Note that the waveform presented on the test scope screen is inverted with respect to the corresponding waveform as viewed on the VIDEO SCOPE screen. The waveform will appear as shown in figure 3–68.

(5) Turn the TEST SIGNAL switch on the electrical synchronizer unit to the LOCAL GATE position. Adjust the COARSE LOCAL DELAY control (R1544) until the leading edge of the gate appearing on the test scope screen occurs at the vertical reference line on the scope screen.

(6) Now turn the TEST SIGNAL switch to the AC ERROR position, and the COARSE SWEEP SPEED control on the test scope to position 1. Turn

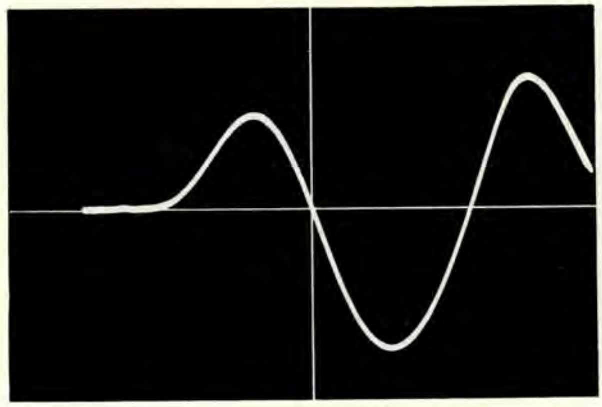


Figure 3–68. First Zero Cross-over of Local Signal Second Derivative Centered on Intersection of Center Vertical and Horizontal Reference Lines on Scope Screen

the FINE SWEEP SPEED control to the extreme counterclockwise position. Adjust the FINE LOCAL DELAY control for minimum 60-cycle error voltage on the test scope screen. This adjustment must be made very slowly and in small increments, since a long time constant is involved in the circuit. Before considering the adjustment completed, watch for a few seconds, repeat the adjustment a little at a time, and alternately watch and adjust until the 60-cycle error remains at the minimum. The appearance of the properly adjusted 60-cycle error voltage minimum is shown in figure 3–67.

(7) If, during the adjustment of step (6), above, it is found that the minimum 60-cycle error point lies outside the range of the FINE LOCAL DELAY control, and depending on whether the control is in the extreme clockwise or counterclockwise position, rotate the COARSE LOCAL DELAY control slightly clockwise or counterclockwise, respectively, and then readjust the FINE LOCAL DELAY control for minimum 60-cycle error voltage.

(8) Check that the local sync gate is located at the first zero cross-over of the second derivative of the local signal. To do that:

(*a*) Turn the COARSE SWEEP SPEED control on the test scope to position 3.

(*b*) Turn the TEST SIGNAL switch on the electrical synchronizer to the 2ND DER position, and use the test scope controls to obtain the waveform illustrated in figure 3–68, as obtained by the adjustment of step (4), above. Then turn the TEST SIGNAL switch to the LOCAL GATE position, and note that the gate occurs approximately at the vertical reference line about which the first zero cross-over occurred.

(*c*) If the gate does not occur approximately at the vertical reference line about which the first zero cross-over of the derivative signal occurred, the adjustment of steps (1) through (7), above, must be repeated.

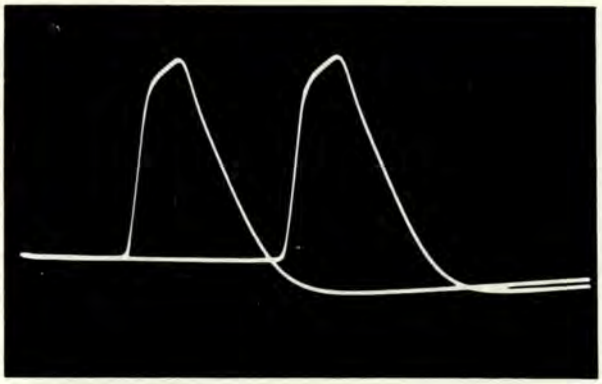


Figure 3-69. Typical Appearance of Mixed Gates on Test Scope Screen

(9) In the case of a stand-by timer, repeat the checks given in step (8), above, to view the superposition of the stand-by and operating timer transmitter triggers on the operating timer test scope. If the two triggers are separated by more than 2 microseconds, repeat the adjustments of steps (1) through (8), above. After the requirements of these checks are met, disconnect the test leads between the timers, and restore the normal cable to connector J506 on the time delay unit of the stand-by timer.

i. ADJUSTMENT OF REMOTE SYNC GATE DELAY.—The procedure outlined below applies equally to a timer being placed into operation, as well as to a stand-by timer at a master station. Proceed as follows:

(1) Check that the AUTO SYNC switch (S104) on the synchronization control unit is in the OFF position.

(2) Disconnect the cable normally connected to the 10 MKS jack (J1713) on the rear apron of the test oscilloscope chassis, to remove the 10-microsecond markers from the scope. This is done to avoid confusion due to the presence of 10-microsecond markers.

(3) Turn the SYNC SELECTOR switch (S1701) on the test scope to the PEDESTAL TRIGGER position.

(4) Turn the SIGNAL SELECTOR switch (S1702) on the test scope to the ELECT SYNC position.

(5) Turn the TEST SIGNAL switch (S1503) on the electrical synchronizer to the MIXED GATES position. Turn the CONTINUOUS DELAY control to the clockwise position. Turn the COARSE SWEEP SPEED control on the test scope to the 4 position. Turn the FINE SWEEP SPEED control to the counterclockwise position.

(6) Observe the test scope screen. Two gates should now be present on the test scope screen, as shown in figure 3-69.

(7) Turn the PHASE dial on the synchronization control unit to 0.

(8) Use the COARSE REMOTE DELAY (R1565) control to approximately superpose the gates. Use the test scope sweep speed and sweep delay controls to bring both gates into view at the fastest sweep speed. Finally, use the FINE REMOTE DELAY control (R1517) on the electrical synchronizer to exactly superpose the two gates on the fastest sweep speed of the test scope. The superposed gates will appear as shown in figure 3-70.

(9) Turn the SYNC SELECTOR switch on the test scope to the SQ WAVE ϕ 2 position.

(10) Turn the TEST SIGNAL switch on the electrical synchronizer to the REMOTE GATE position.

(11) Adjust the test scope sweep speed and delay controls to bring the remote gate near the left edge of the fastest scope speed.

(12) Turn the MARKER SELECTOR switch (S1703) to the 10's and 1's position.

(13) Temporarily remove the 10's markers from the test scope presentation (leaving only the 1's) by disconnecting the coaxial connection at 10 MKS jack J1713.

(14) Adjust the MARKER HEIGHT control (R1741) and the SIGNAL GAIN control (R1758) until the position of the gate with respect to the 1-microsecond markers can be noted by means of some "significant feature" of the marker push-up. This is done to provide an identifying feature, figure 3-71, on the gate waveform, for subsequent adjustment. By adjustment of the marker amplitude, with respect to the amplitude of the gate, it should be possible to make some portion of the gate waveform horizontal. This portion, when obtained, is an easy-to-use identifying feature. Observe which horizontal line of the calibrated scope screen is nearest to the identifying feature to help identify the feature in the next step.

(15) Turn the PHASE dial to the +4 position; simultaneously observe the test scope and note the movement of the gate. As the gate moves through each 1-microsecond interval to the right, the identifying

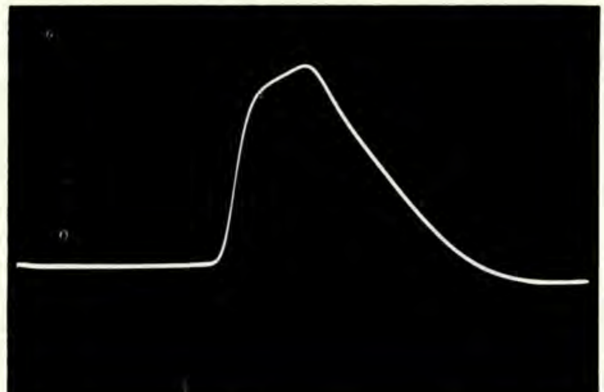


Figure 3-70. Appearance of Mixed Gates Superposed on Each Other on Test Scope Screen

feature will disappear and reappear. The feature will be a horizontal line when the same coincidence with a 1-microsecond marker obtained in step (14) above is obtained with each adjacent marker. Thus, if the significant feature moves through four markers, and the end result has exactly the same appearance as the initial result, the gate will have moved exactly 4 microseconds from the original position. If the gate has not moved 4 microseconds, the DELAY RANGE control (R1561) requires resetting. Use the DELAY RANGE control to move the gate to the 4-microsecond position.

(16) Return the PHASE dial to 0. Determine the position now occupied by the gate. Readjust the MARKER HEIGHT or SIGNAL GAIN control to obtain a significant feature. (Note that this significant feature may differ slightly from that obtained in step (14), above.)

(17) Repeat steps (15) and (16), above, until the gate moves a distance of 4 ±0.05 microseconds on the test scope screen, as the PHASE dial is moved from 0 to +4.

(18) Turn the MARKER SELECTOR switch on the test scope to the OFF position. Turn the SYNC SELECTOR switch on the test scope to the PEDESTAL position. Turn the TEST SIGNAL switch (S1503) on the electrical synchronizer to the MIXED GATES position. Return tne PHASE dial to 0. Adjust the CONTINUOUS DELAY control on the test scope until the gates again appear at the center of the screen. If necessary, adjust the FINE REMOTE DELAY control (R1517) on the electrical synchronizer to superpose the gates.

(19) Return the SYNC SELECTOR switch on the test scope to the SQ WAVE φ 2 position. Reconnect the coaxial cable to connector J1713 (10 MKS) on the rear apron of the test scope chassis.

(20) Return the REMOTE SIGNAL switch (S1201) on the radio receiver to the IN position.

j. ADJUSTMENT OF SYNCHRONIZATION CIRCUIT SENSITIVITY—FIRST TIMER TO BE PLACED INTO OPERATION.—For the first timer to be placed into operation, proceed with the adjustment of sensitivity, as described in the following steps. Corresponding adjustments for the stand-by timer should be made in accordance with the procedure outlined in paragraph 29 *k*, below.

For the following adjustments, the operating slave station timer must be maintaining synchronization.

(1) Turn the AUTO SYNC switch (S104) on the synchronization control unit to the ON position. The PHASE dial should read zero, or nearly zero, depending on how well the slave station is holding synchronization.

(2) Turn the METER SWITCH (S1504) on the electrical synchronizer unit to the ADJUST position.

(3) Turn the AUTO SYNC switch to the OFF position.

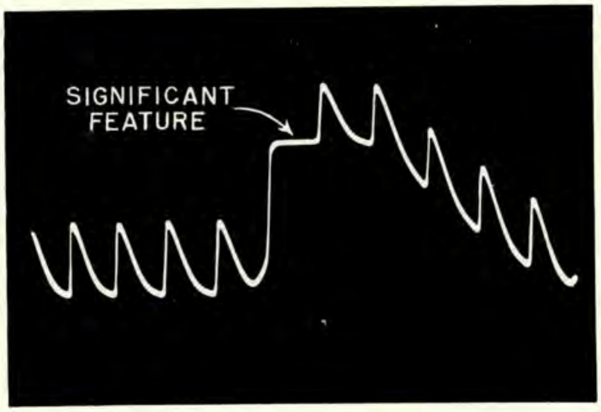


Figure 3–71. Typical Identifying "Significant Feature" on Gate Waveform

(4) Slowly turn the PHASE dial on the synchronization control unit to obtain a reading of zero on the SYNC TEST meter on the electrical synchronizer.

(5) Turn the PHASE dial through a 1-microsecond interval in the clockwise direction. Observe the reading of the SYNC TEST meter. A reading of 1 ma ±0.1 ma should be obtained. If this reading is not obtained, the DERIVATIVE INPUT LEVEL control (R1501) must be readjusted.

(6) Turn the AUTO SYNC switch to the ON position. The PHASE dial will now indicate synchronization error, and the recorder will make a permanent record of PHASE dial movements.

k. ADJUSTMENT OF SYNCHRONIZATION CIRCUIT SENSITIVITY—STAND-BY TIMER.—For this adjustment it will be necessary to determine by means of the check described in paragraph 29 *g* (2) (*g*), above, that the transmitter triggers from the operating and stand-by timers remain superposed. Proceed as follows:

(1) Turn the LOCAL SIGNAL switch on the stand-by timer to the OFF position. Turn the AUTO SYNC switch (S104) on the synchronization control unit of the stand-by timer to the ON position. The PHASE dial should read zero, or nearly zero, depending on how well synchronization is being maintained.

(2) Turn the METER SWITCH (S1504) on the stand-by timer electrical synchronizer unit to the ADJUST position. Repeat the check of paragraph 29 *g* (2) (*g*), above, to determine that the operating and stand-by transmitter triggers are superposed.

(3) Turn the AUTO SYNC switch to the OFF position.

(4) Slowly turn the PHASE dial on the synchronization control unit to obtain a reading of zero on the SYNC TEST meter on the electrical synchronizer.

(5) Turn the PHASE dial through a 1-microsecond interval in the clockwise direction. Observe the

reading of the SYNC TEST meter. A reading of 1 ma ±0.1 ma should be obtained. If this reading is not obtained, the DERIVATIVE INPUT LEVEL control (R1501) must be readjusted.

(6) Return the AUTO SYNC switch to the ON position. Wait until the FINE PHASE dial stops rotating. Then turn the AUTO SYNC switch to the OFF position.

(7) Repeat steps (4) through (6) to check the adjustment. This check must be made to insure that oscillator drift has not introduced errors.

(8) Return the METER SWITCH to the OPERATE position.

(9) Return the AUTO SYNC switch to the ON position.

l. SYNC ERROR ALARM CIRCUIT ADJUSTMENTS.—The sync error alarm circuit at a master station is designed to provide an alarm indication when a predetermined error is reached. This predetermined error is adjustable from 1 to 3 microseconds. Established Coast Guard procedure will determine the setting of the exact error for which alarm indications are to be given. The Coast Guard procedure will also determine the setting of the associated time delay relay, K1503. To adjust the circuits for a specified error, proceed as follows:

(1) Restore tube V1509 into its socket, if it has been removed for the initial adjustments (paragraph 12 *b*). Turn the AUTO SYNC switch on the synchronization control unit to the OFF position.

(2) There are two cams and a microswitch on the rear of the PHASE dial shaft. The cam further away from the front panel controls positive error indications. The cam closer to the front panel controls negative error indications. Check that, as the PHASE dial is rotated, the cams are positioned on the shaft so that they operate the microswitch. If not, loosen the setscrews of the cams with a multiple-spline wrench (provided), and position the cams to do that.

(3) Set the PHASE dial to the calibration mark corresponding to the specified positive error. Rotate the cams until the microswitch is not operated. Then rotate the cam which is further away from the front panel, in the counterclockwise direction, until it just operates the microswitch. Tighten the setscrews of that cam in the adjusted position.

(4) Set the PHASE dial to the calibration mark corresponding to the specified negative error. Rotate the cams until the microswitch is not operated. Then rotate the cam which is closer to the front panel, in the counterclockwise direction, until it just operates the microswitch. Tighten the setscrews of that cam in the adjusted position.

(5) Return the PHASE dial to the 0 position. Now rotate the dial in the clockwise direction, until the SYNC ERROR indicator lamp on the synchronization control unit just lights. Note the position of the dial for which the lamp lights. Rotate the dial in the counterclockwise direction from the 0 point, until the SYNC ERROR lamp lights again. Note the position of the dial for which this occurs. The lamp should light when the dial is within 0.1 microsecond of the specified error for the particular direction of rotation. If the above requirement is not met, repeat the adjustments described in steps (3) and (4), until the requirements for the positive and negative error indications are both met.

(6) Adjust relay K1503 to the desired time delay setting.

Note

The adjustment of relay K1503, the time delay relay in the sync error indicating circuits, will be determined by Coast Guard procedure. This relay determines the interval of time between the occurrence of an error and the start of the alarm buzzer and of the local blink operation. To adjust the relay, turn the knurled knob until the pointers are set on the desired delay indicated on the relay dial. Note that the actual delay will be about 2 microseconds greater than that indicated by the relay.

CAUTION

Relay K1503 should NEVER be adjusted while it is operating; that is, while the SYNC ERROR indicator lamp is lit.

Note

The setting of the SYNC ERROR SENSITIVITY control is not important for master station operation, since the circuit will be operated by the microswitch, regardless of the setting of this control.

(7) Turn the AUTO SYNC switch to the OFF position. Introduce the specified error by rotating the PHASE dial clockwise. The following indications should be obtained, as an indication of the proper operation of the alarm circuits, and of proper adjustments, as outlined above.

(*a*) The SYNC ERROR lamp should go on.

(*b*) Relay K1503 should operate.

(*c*) After the time delay provided by K1503, the buzzer should sound, provided the BUZZER ON-OFF switch has been turned to the ON position. The local blink circuit should operate when the LOCAL BLINK switch is in the AUTO position.

(*d*) When the local blink operates, the LOCAL BLINK chronograph pen and the running time meter on the recorder should be energized.

Note

For a stand-by timer the checks indicated above for the chronograph pen and the running time meter are not possible, since these items are not connected.

(8) Turn the REMOTE ALARM switch on the front panel of the electrical synchronizer unit to the IN position, and check the operation of the remote alarm circuits.

(9) Return the AUTO SYNC switch to the ON position.

m. CHECK AND ADJUSTMENT OF OFF-SYNC CIRCUITS.—Before making the checks and adjustments outlined below, on a stand-by timer, recheck that operating and stand-by timer transmitter triggers are superposed as described in paragraph 29 *g* (2) (*g*), above. It is assumed that the remote signal is present and that it is synchronized with the master timer signal. For both an operating and a stand-by timer proceed as follows:

(1) Very slowly turn the OFF SYNC SENSITIVITY control (R1555) on the electrical synchronizer in the clockwise direction, until the OFF SYNC lamp just goes on. Then return the control in the counterclockwise direction by *one* scale division (i.e., half interval between numbers). The OFF SYNC lamp should go out.

(2) Adjust relay K1505 to the desired time delay setting.

Note

The adjustment of relay K1505, the time delay relay in the off-sync indicating circuits, will be determined by Coast Guard procedure. This relay determines the interval of time between the occurrence of an error and the start of the alarm buzzer and of the local blink operation. To adjust the relay, turn the knurled knob until the pointers are set on the desired delay indicated on the relay dial.

CAUTION

Relay K1505 should never be adjusted while it is operating; that is, while the OFF SYNC lamp is lit.

(3) Turn the REMOTE SIGNAL switch on the receiver to the OUT position. The following indications should be obtained, as an indication of the proper operation of the off-sync alarm circuits, and of proper adjustments, as outlined above.

(*a*) The OFF SYNC lamp should go on.

(*b*) Relay K1505 should operate.

(*c*) For an operating timer, the OFF SYNC chronograph pen and running time meter on the recorder should be energized.

(*d*) After the time delay provided by relay K1505, the buzzer should sound, provided the BUZZER ON-OFF switch has been turned to the ON position. The local blink circuit should operate when the LOCAL BLINK switch is in the AUTO position.

(*e*) When the local blink operates, the LOCAL BLINK chronograph pen and running time meter on the recorder should be energized.

Note

For a stand-by timer, the checks indicated above for the chronograph pens and the running time meters are not possible, since these items are not connected.

(4) Turn the REMOTE ALARM switch on the front panel of the electrical synchronizer to the IN position, and check the operation of the remote alarm circuits.

(5) Return the REMOTE SIGNAL switch on the radio receiver to the IN position.

(6) To check OFF-SYNC sensitivity simulate remote station blink by first depressing and holding OFF-SYNC TEST switch (S507), then turn BLINK SELECTOR switch (S802) to the manual position. The LOCAL BLINK and OFF-SYNC lamps should light, followed, at a time delay dictated by the setting of relay K1505, by the sounding of the alarm buzzer. If the alarm circuit fails to work, it will be necessary to recheck the OFF-SYNC adjustment. Follow the reverse order of switching to terminate this test; first switch off the LOCAL BLINK, then release the OFF-SYNC TEST switch.

CAUTION

If, on the operating timer, the OFF-SYNC switch is released prior to switching off the LOCAL BLINK, the Loran Operating Rate will blink until the BLINK SELECTOR switch is returned to the OFF position.

n. ESTABLISHING STAND-BY TIMER PHASE REFERENCE.—The following adjustments are made to insure that when the stand-by timer at a master station is to be placed into operation, a minimum of synchronization effort will be expended by the slave timer. To establish the phase reference, proceed as follows:

(1) Turn the REMOTE SIGNAL switch on the radio receiver to the OUT position. Check that the VIDEO PRESENTATION switch on the synchronization indicator unit is in the REC position.

(2) Turn the SIGNAL switch on the synchronization indicator unit to the DERIVATIVE POSITION.

(3) Adjust the VERTICAL CENTER control to bring the base line of the waveform appearing on the VIDEO SCOPE screen to the horizontal reference line on the scope screen.

(4) Turn the VIDEO SWEEP SPEED control to the extreme clockwise position.

(5) Turn the VIDEO SWEEP DELAY control in the synchronization indicator unit until the first zero cross-over of the derivative local signal occurs at the intersection of the center horizontal and vertical reference lines on the VIDEO SCOPE screen. The properly adjusted waveform should appear as shown in figure 3–72.

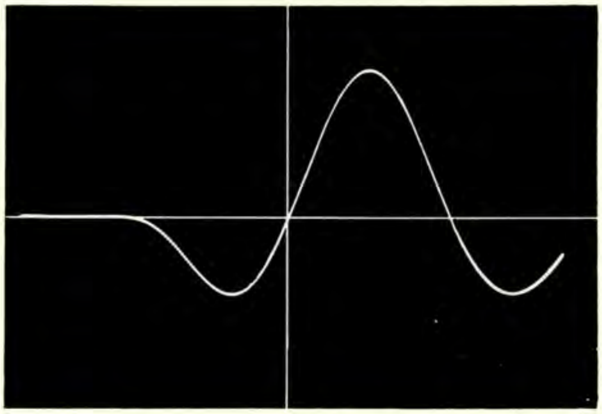


Figure 3–72. Properly Adjusted Waveform for Establishing Stand-by Timer Phase Reference

(6) Repeat the check of paragraph 29 *g* (2) (*g*), above, to insure that the transmitter triggers are superposed.

(7) Note and record the VIDEO SWEEP DELAY dial reading for which the properly adjusted reference is obtained. Note that to restore this phase reference at any time during operation turn the VIDEO SWEEP DELAY control to the dial reading thus recorded, turn the VIDEO SWEEP SPEED control to the extreme clockwise position, and turn the HORIZONTAL CENTER control to bring the signal to the reference point.

Note

Because of the fact that the stand-by and operating timer oscillators are not locked in, the derivative signal will tend to drift away from the reference point. To minimize the amount of drift after the reference has been restored, the FINE FREQUENCY dial on the stand-by oscillator should be readjusted from time to time.

o. FINAL MOTOR SPEED ADJUSTMENT.—The following additional steps remain for both the operating and stand-by timers of the station:

(1) Check that the gear shift control is in the LOW range position.

(2) Check that the MAX MOTOR SPEED control (R157) on the synchronization control unit is set to 3 microseconds per minute. Lock the controls in the adjusted positions.

p. FINAL ADJUSTMENTS.—The adjustments described above complete the initial placement of the operating and stand-by timers at a master station into service. Restore the cover on the autosyn-corrector assembly. Check that all connections disturbed, made, or disconnected for these procedures are returned to normal operating condition. Restore the electrical synchronizer drawer into the cabinet. If immediate operation of the station is contemplated, set the recorder chart for the correct time of day.

Operation Section 4

CG-273-15
(Volume 1)

INSTRUCTION BOOK

for

LORAN TIMER SET AN/FPN-30

SECTION 4 OPERATION

ITT *Federal Division*

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

Clifton, New Jersey, U.S.A.

FORMERLY

FEDERAL TELEPHONE AND RADIO COMPANY

TREASURY DEPARTMENT

U.S. COAST GUARD

Contracts: Tcg-38701(CG-20,181-A)
Tcg-39263(CG-27,298-A)
Tcg-40020(CG-35,978-A)
Tcg-41083 (CG-44,327-A)

Approved by C. G. Headquarters:
16 October 1959

TABLE OF SECTIONS

SECTION 4
OPERATION

1. GENERAL.

A loran station transmits signals which are used by navigators for determining geographical positions. In the interest of providing dependable service to these navigators, it is essential that the loran station be operated continuously so that signals are transmitted without interruption. Continuous operation is the responsibility of the operator. The timer is only one of several units essential to the transmissions, and operational routine of the timer must be coordinated with the operational routine for a complete station, as outlined in Loran Station Operating and Maintenance Instructions CG–155. The operation of the transmitting, switching, and auxiliary equipment is covered in their respective manuals. The normal operating routine for a timer includes stand-by-operate change-over procedures, active operation of the timer, and operational adjustments.

Under normal conditions, the timer will be operating for an extended period of time (as determined by an adopted time-sharing schedule between the operating and stand-by units), and little trouble may be expected from it. However, since the loran system requires that there be a minimum of time when no signal is transmitted, change-overs, whenever necessary, must be done promptly and efficiently. Change-over procedures therefore represent a small though important part of the operating routine.

Active operation consists principally of (1) observing the local and remote signals on the oscilloscopes of the synchronization indicator to establish that synchronization is being maintained, and (2) making the necessary correction to restore synchronization when an error in synchronization is observed. Since proper synchronization of the remote and local signals is the most important requirement of the loran system, the necessity of adequate monitoring cannot be overemphasized.

It is difficult to establish the tasks which make up routine operational adjustments of a timer, since there is no sharp distinction between routine adjustments, service adjustments, and minor repairs. The exact duties of any particular operator is a matter for the operating authority to decide and will be influenced by the relative skill of the operator. This section will be concerned with those checks, adjustments, and corrective procedures most often required in operating the timer.

2. OPERATING CONTROLS AND DEVICES.

Figures 4–1 through 4–13 and associated tables 4–1 through 4–13 locate and describe the function of the controls and devices in the timer and associated units.

Only a few of the many controls and devices within the reach of the operator are employed during routine operation. Some of the others must not be touched or a service interruption will result. It is expected that the operators will receive specific instructions, consistent with the duties assigned them and their knowledge of the equipment, regarding the controls and adjusters which they may or may not manipulate.

3. PREOPERATIONAL REQUIREMENTS.

At this point it is assumed that the timers of the station have been completely adjusted and placed in operational or stand-by service as described in Section 3, paragraphs 17 through 29. At a double-pulsed station, it is assumed that timers No. 1 and No. 2 (one operating and one stand-by) have been adjusted for one repetition rate, and timers No. 3 and No. 4 (one operating and one stand-by) have been adjusted for the other rate. At a single pulsed station, it is assumed both timers No. 1 and No. 2 (one operating and one stand-by) have been adjusted for the particular rate of the station. After initial adjustment, timers which are maintained in stand-by status will require practically no attention before being placed in operation; timers which are not maintained in stand-by status, although left energized, will require certain checks and adjustments to correct for any drifts or changes. On those occasions when it is necessary to remove all power from the timer for any length of time, in particular power from the oscillator unit, special warm-up periods must be observed before resuming operation. Warm-up periods are discussed in paragraph 5.

4. MODES AND CONDITIONS OF OPERATION.

a. GENERAL.—Two modes of operation (master and slave) are possible. The general difference between master and slave operation has been discussed in Section 2. In this section the two modes are treated as separate cases wherever operational differences exist.

The general status of a timer, whether master or slave, will fall into one of three categories, namely, shut-down, stand-by, or operational. The operator should become familiar with the timer in each of these three states so that the minimum time is taken for change-over.

b. SHUT-DOWN CONDITION.—This term defines the condition of complete removal of power from the timer so that even the oscillator and space heaters are inoperative. This condition is encountered when the timer is to be adjusted for the first time, for example, or when it has been taken out of service completely for some special reason. Because of the considerable warm-up period required to prepare the oscillator for satisfactory operation after a long period of shut-down, it is recommended that the equipment not be shut down for any length of time unless such shut-down is unavoidable.

Shut-down for only a few minutes is, of course, entirely permissible if it serves a purpose; inconvenience results only if the equipment is shut down long enough for the units to "cool off" and for the crystal oscillator oven to drop below its stable temperature. The heater reading on the oscillator can be used as a guide. If the meter reading (with the meter switch in the HEATER position) has not risen appreciably, the timer can be put back into service immediately.

c. STAND-BY CONDITION.—The term *stand-by condition* defines the condition of a timer when all preparatory steps for operation have been completed and when, therefore, the timer is ready for active use in the station. Before a timer can be considered to be in stand-by status, it must be completely adjusted as described in Section 3, paragraphs 17 through 29. Paragraphs 6 and 7 of this section include checking and adjustment procedures which should be made by the operator to insure that a timer is so adjusted. It is important that every effort be made to maintain the spare timer in stand-by status, so that a minimum of transmission time is lost in the event of failure of the operating timer.

d. OPERATING CONDITION. — This term defines the condition of full operation of the timer; that is, the timer is in control of an operating transmitter and is presumably in precise adjustment. If it does not happen to be in synchronization, it is still considered to be in full operation so long as it is in control of a transmitter which is "on the air."

(Text continued on page 4–44)

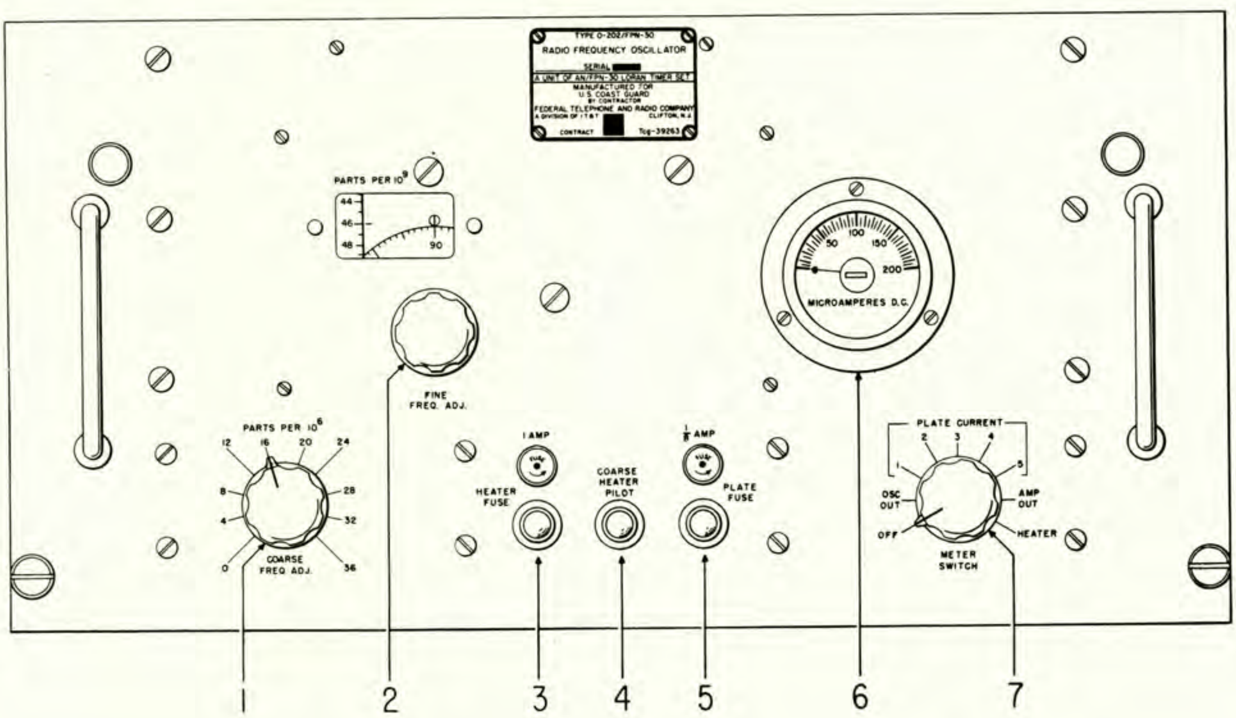


Figure 4–1. Radio Frequency Oscillator Type O–202/FPN–30, Control Locations

TABLE 4–1. CONTROLS AND DEVICES (RADIO FREQUENCY OSCILLATOR TYPE O–202/FPN–30)

FIG. 4–1 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
1	S1401	COARSE FREQ. ADJ. PARTS PER 10^6	10-position rotary switch.	Provides for coarse adjustment of oscillator frequency in steps of 4 parts per million.	Section 3, paragraphs 26*d*, 15*d* (1). Section 4, paragraph 11.
2	C1410	FINE FREQ. ADJ. PARTS PER 10^9	Adjuster (variable capacitor).	Provides fine (continuous) adjustment of crystal oscillator frequency over a range of 5 parts per million. Reference is made to window indicator dial, calibrated in parts per billion, and drum, calibrated in hundred parts per billion.	Section 3, paragraphs 26 *d*, 15*d* (1). Section 4, paragraphs 6*b* (12) and 11.
3	F1401 I1401	HEATER FUSE 1 AMP	Cartridge fuse (1 amp) and white jewel indicator with neon lamp NE–51.	Fuse protects coarse heater circuit. Lamp glows if corresponding fuse is open and circuit is otherwise complete and energized.	——
4	I1403	COARSE HEATER PILOT	White jewel indicator with neon lamp NE–51.	Indicates coarse heaters R1421 and R1434 are energized.	——
5	F1402 I1402	PLATE FUSE 1/8 AMP	Cartridge fuse (1/8 amp) and white jewel indicator with neon lamp NE–51.	Fuse protects vacuum tube plate circuits. Lamp glows if corresponding fuse is open and circuit is otherwise energized.	——
6	M1401	——	Microammeter.	Provides for monitoring operation of various circuits, as selected by METER SWITCH (S1402) below.	——
7	S1402	METER SWITCH	9-position rotary switch, positions marked as follows: OFF OSC OUT 1, 2, 3, 4, 5 } PLATE CURRENT AMP OUT HEATER	Connects selected test point to meter M1401 for monitoring circuit operation. Normally left on OFF position.	——

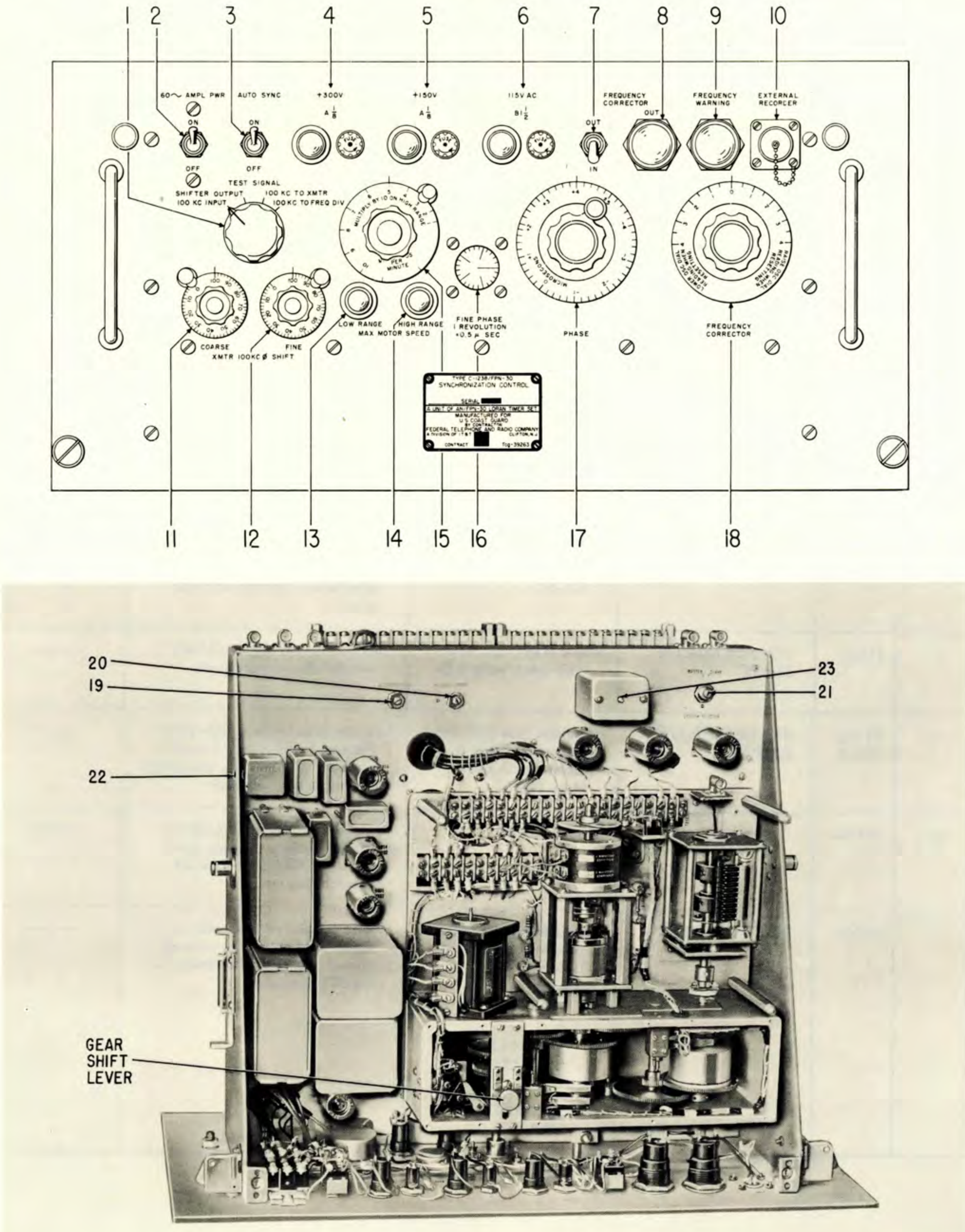


Figure 4–2. Synchronization Control Type C–1238/FPN–30, Control Locations

TABLE 4–2. CONTROLS AND DEVICES (SYNCHRONIZATION CONTROL TYPE C–1238/FPN–30)

FIG. 4–2 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
1	S107	TEST SIGNAL	4-position rotary switch, positions marked as follows: 100 KC INPUT SHIFTER OUTPUT 100 KC TO XMTR 100 KC TO FREQ DIV	Used in conjunction with SIGNAL SELECTOR switch (S1702) on test scope for obtaining scope presentations as follows: 100-kc input Output of phase shifter (S101) 100-kc output to transmitter 100-kc output to frequency divider	——
2	S102	60~ AMPL PWR ON-OFF	3PDT toggle switch.	Controls power to 60~ amplifier circuits and sync control motor B101. Normally in the ON position, unless electrical synchronizer is not used for any length of time.	——
3	S104	AUTO SYNC ON-OFF	DPDT toggle switch.	Permits manual or automatic synchronization. Placed in ON position for automatic sync. Placed in the OFF position for manual sync.	——
4	F101 I101	+300 V A1/8	Cartridge fuse (1/8 amp) and white jewel indicator with neon lamp NE–51.	Fuse protects +300-volt plate supply circuit. Lamp glows if fuse is open and circuit is otherwise energized.	——
5	F103 I103	+150 V A1/8	Cartridge fuse (1/8 amp) and white jewel indicator with neon lamp NE–51.	Fuse protects +150-volt plate supply circuit. Lamp glows if fuse is open and circuit is otherwise energized.	——
6	F102 I102	115 V AC BI 1/2	Cartridge fuse (1-1/2 amp) and white jewel indicator with neon lamp NE-51.	Fuse protects 115-volt a-c circuits. Lamp glows if fuse is open and circuit is otherwise energized.	——
7	S103	FREQUENCY CORRECTOR OUT-IN	DPDT toggle switch.	Permits resetting of FREQUENCY CORRECTOR (C120) by disengaging FREQUENCY CORRECTOR clutch. Normally left in IN position.	——
8	I104	FREQUENCY CORRECTOR OUT	Amber jewel indicator with 6S6–125 lamp.	Lights when FREQUENCY CORRECTOR switch (S103) is in the OUT position.	——
9	I105	FREQUENCY WARNING	Red jewel indicator with 6S6–125 lamp.	Lamp lights when FREQUENCY CORRECTOR (C120) has reached either limit of rotation, indicating that oscillator frequency must be readjusted and FREQUENCY CORRECTOR (C120) reset.	
10	J105	EXTERNAL RECORDER	4-pin receptacle.	Receptacle for connecting recording ammeter.	Section 3, paragraph 28*d*(2).
11	R127	XMTR 100 KC ϕ SHIFT COARSE	Adjuster (potentiometer).	Adjusts phase of 100-kc signal to transmitter.	Section 2, paragraph 3*b*(3).

TABLE 4–2. CONTROLS AND DEVICES (SYNCHRONIZATION CONTROL TYPE C–1238/FPN–30) (Cont'd)

FIG. 4–2 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
12	R128	XMTR 100 KC ϕ SHIFT FINE	Adjuster (potentiometer).	Refer to item 11.	Section 2, paragraph 3*b*(3).
13	I107	LOW RANGE	White jewel indicator with neon lamp NE–51.	Indicates automatic sync correction speed range as selected by MOTOR SPEED RANGE SELECTOR.	Section 3, paragraphs 28*l*, 29*o*.
14	I106	HIGH RANGE	White jewel indicator with neon lamp NE–51.	Works with I107.	Section 3, paragraphs 28*l*, 29*o*.
15	R157	MAX MOTOR SPEED	Adjuster (potentiometer).	Adjusts maximum speed of sync control motor by limiting output of 60~ amplifier circuits. Normally set for lowest value permitting satisfactory automatic synchronization.	Section 4, paragraph 10.
16		FINE PHASE 1 REVOLUTION =0.5 μSEC	Rotary indicator dial, geared to PHASE dial.	Fine indicator, geared to PHASE dial. Speed 20 times that of PHASE dial. One revolution equals 0.5 μsec.	———
17		PHASE	Rotary dial, geared to sync motor B101 and PHASE control B103.	Slave operation: Shifts phase of 100-kc output over a continuous range of 0° to 360°. One revolution equals 10 microseconds. May be operated automatically by sync motor B101 (AUTO SYNC switch in ON position) or manually (AUTO SYNC switch in OFF position). Master operation: Indicates sync error in loran signals.	Section 4, paragraph 7*b*(9).
18	C120	FREQUENCY CORRECTOR	Adjuster (capacitor).	Fine frequency control for oscillator geared to follow-up phase dial rotation. When dial reaches either limit of rotation, this dial and FINE FREQ. ADJ. on oscillator must be reset.	Section 4, paragraph 11.
			CHASSIS CONTROLS AND DEVICES		
19	R145	RECORDER ZERO	Screwdriver adjuster (potentiometer).	Lines up recording ammeter zero point. Adjusted in conjunction with RECORDER RANGE (R142).	Section 3, paragraph 28*e*.
20	R142	RECORDER RANGE	Screwdriver adjuster (potentiometer).	Adjusts range of recording ammeter. Used in conjunction with RECORDER ZERO (R145).	Section 3, paragraph 28*e*.
21	S101	STATION SELECTOR MASTER-SLAVE	2-position rotary switch. Positions marked: MASTER-SLAVE	Selects mode of operation of sync control unit as to MASTER or SLAVE operation.	———
22	L102	60~TUNING	Multiple spline wrench adjuster (inductor).	Tunes motor amplifier to power line frequency to minimize spurious motor rotation.	Section 3, paragraph 28*c*.
23	L103	100 KC TUNING	Screwdriver adjuster (inductor).	Tunes plate circuit of 100-kc output amplifier for maximum output.	Section 7, paragraph 4*b*(3).

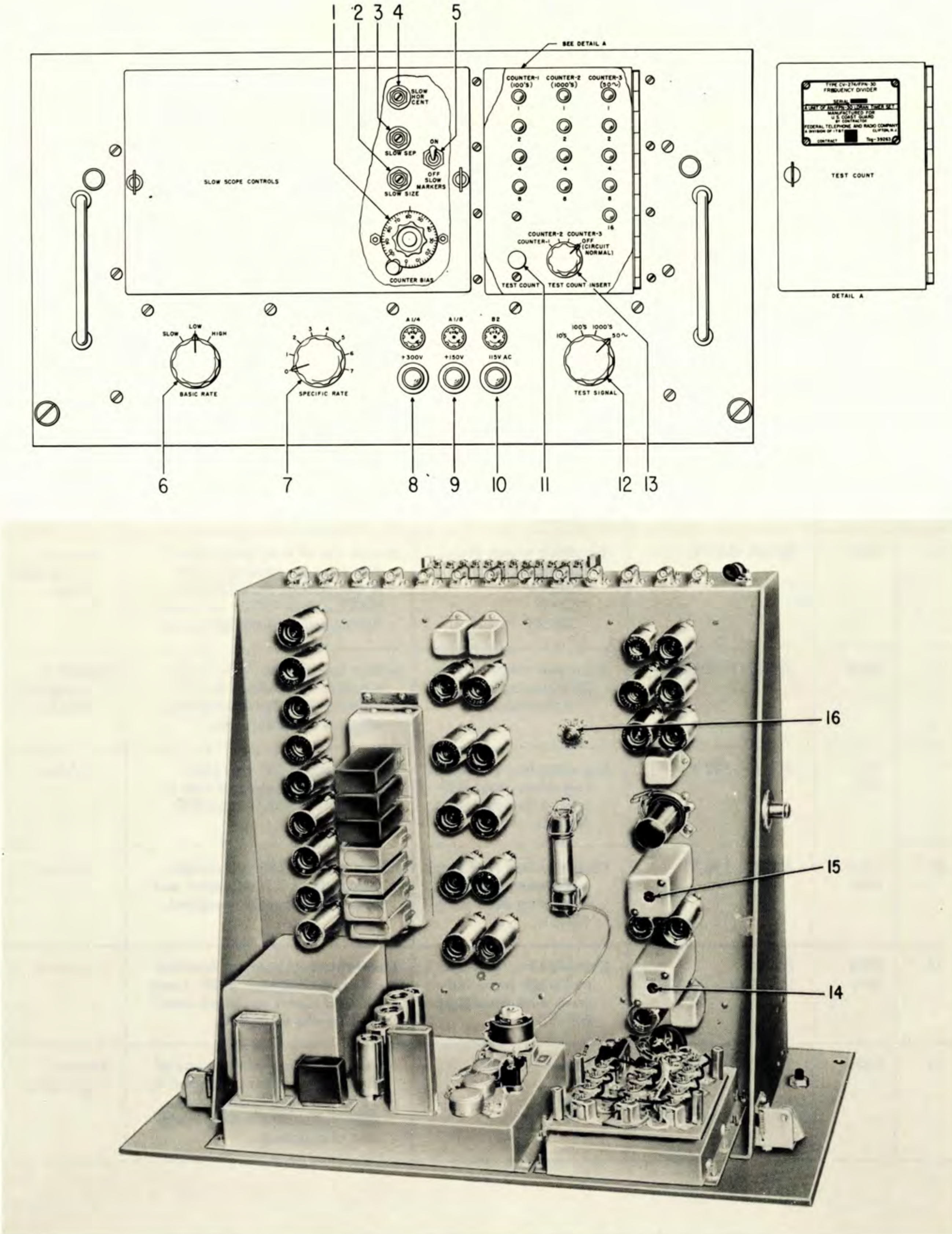


Figure 4–3. Frequency Divider Type CV–274/FPN–30, Control Locations

TABLE 4–3. CONTROLS AND DEVICES (FREQUENCY DIVIDER TYPE CV–274/FPN–30)

FIG. 4–3 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
1	R282	COUNTER BIAS	Adjuster (potentiometer).	Adjusts bias of binary counters.	Section 6, paragraph 5.
2	R275	SLOW SIZE	Screwdriver adjuster (potentiometer).	Adjusts size of SLOW SCOPE trace. Normally adjusted to provide a 2-1/2-inch trace.	Section 3, paragraph 20*b*(4).
3	R264	SLOW SEP	Screwdriver adjuster (potentiometer).	Adjusts separation of master and slave traces on SLOW SCOPE.	Section 3, paragraph 20*b*(6).
4	R255	SLOW HOR CENT	Screwdriver adjuster (potentiometer).	Adjusts horizontal position of SLOW SCOPE trace.	Section 3, paragraph 20*b*(5).
5	S206	SLOW MARKERS ON-OFF	SPDT toggle switch.	Controls 1,000-μsec markers on SLOW SCOPE. Normally in ON position.	———
6	S205	BASIC RATE	3-position rotary switch. Positions marked: SLOW LOW HIGH	Selects one of three basic repetition rates (as marked). Used in conjunction with SPECIFIC RATE switch (S202) for establishing assigned repetition rate.	Section 3, paragraph 19*a*(2).
7	S202	SPECIFIC RATE	8-position rotary switch. Positions marked: 0 through 8.	Selects specific rate. Used in conjunction with BASIC RATE switch (S205) for establishing assigned repetition rate.	Section 3, paragraph 19*a*(2).
8	F203 I203	A 1/4 +300 V	Cartridge fuse (1/4 amp) and white jewel indicator with neon lamp NE–51.	Fuse protects +300-volt plate circuits. Lamp glows if fuse is open and circuit is otherwise energized.	———
9	F202 I202	A 1/8 +150 V	Cartridge fuse (1/8 amp) and white jewel indicator with neon lamp NE–51.	Fuse protects +150-volt circuits. Lamp glows if fuse is open and circuit is otherwise energized.	———
10	F201 I201	B2 115 V AC	Cartridge fuse (2 amps) and white jewel indicator with neon lamp NE–51.	Fuse protects primary of filament supply transformer T205. Lamp glows if fuse is open and circuit is otherwise energized.	———
11	S204	TEST COUNT	Momentary switch.	Introduces pulses into any one of the three counters as selected by TEST COUNT insert switch (S201). Used for testing operation of counters.	Section 7, paragraph 7.

TABLE 4-3. CONTROLS AND DEVICES (FREQUENCY DIVIDER TYPE CV-274/FPN-30) (Cont'd)

FIG. 4-3 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
12	S203	TEST SIGNAL	4-position rotary switch. Positions marked: 10'S 100'S 1000'S 50~	Used in conjunction with SIGNAL SELECTOR switch (S1702) on test oscilloscope to obtain scope presentations as follows: 10-μsec markers output 100-μsec markers output 1,000-μsec markers output 50-cycle trigger of square-wave generator	———
13	S201	TEST COUNT INSERT	4-position rotary switch. Positions marked: COUNTER-1 COUNTER-2 COUNTER-3 OFF (CIRCUIT NORMAL)	Selects which counter receives test pulses provided by TEST COUNT switch (S204). Unless testing circuit, this switch is left in OFF (CIRCUIT NORMAL) position.	Section 7, paragraph 7.
CHASSIS CONTROLS AND DEVICES					
14	Z201	———	Tuned transformer (top and bottom adjusters).	Controls amplitude and phase of 1-μsec markers.	Section 7; paragraph 4c(1).
15	Z202	———	Tuned transformer (top and bottom adjusters).	Control amplitude and phase of 1-μsec markers.	Section 7, paragraph 4c(1).
16	R329	DRIFT ADJUST	Screwdriver adjuster (potentiometer).	Controls shape of drift pulse.	Section 7, paragraph 4c(2).

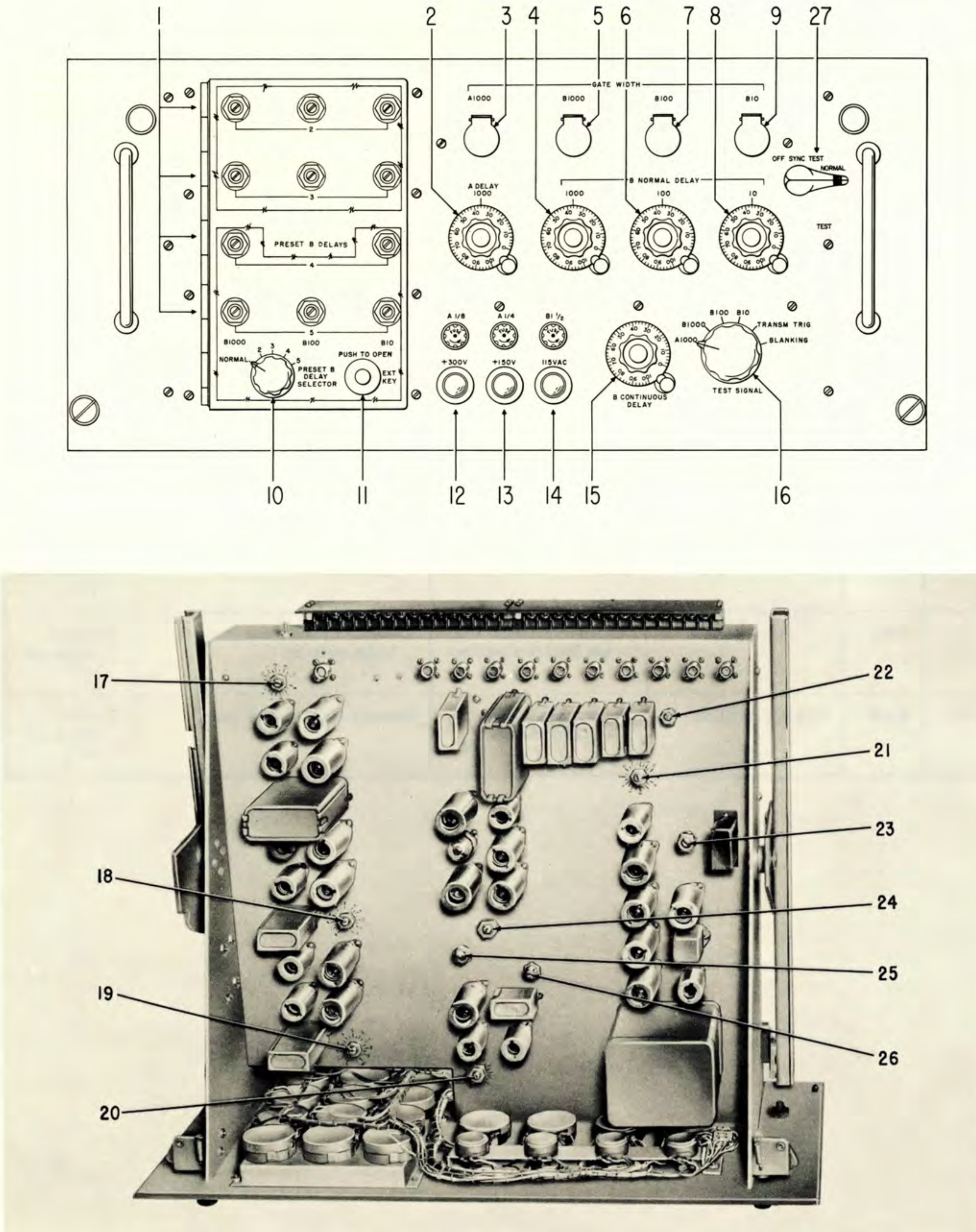


Figure 4-4. Time Delay Type TD-92/FPN-30, Control Locations

TABLE 4–4. CONTROLS AND DEVICES (TIME DELAY TYPE TD–92/FPN–30)

FIG. 4–4 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
1	R534 R562 R582	PRESET B DELAYS 2 {B1000 B100 B10}	Screwdriver adjusters (potentiometers).	Establish preset B 2 delay.	Section 3, paragraph 23.
	R536 R564 R584	PRESET B DELAYS 3 {B1000 B100 B10}	Screwdriver adjusters (potentiometers).	Establish preset B 3 delay.	Section 3, paragraph 23.
	R537 R566 R586	PRESET B DELAYS 4 {B1000 B100 B10}	Screwdriver adjusters (potentiometers).	Establish preset B 4 delay.	Section 3, paragraph 23.
	R538 R567 R587	PRESET B DELAYS 5 {B1000 B100 B10}	Screwdriver adjusters (potentiometers).	Establish preset B 5 delay.	Section 3, paragraph 23.
2	R502	A DELAY 1000	Adjuster (potentiometer).	Adjusts A delay. Range 25,000 to 30,000 μsec in 1,000-μsec steps.	Section 3, paragraph 22*c*.
3	R511	GATE WIDTH A1000	Screwdriver adjuster (potentiometer).	Adjusts width of A1000 selector gate.	Section 3, paragraph 21*e*.
4	R532	B NORMAL DELAY 1000	Adjuster (potentiometer).	Used in conjunction with B100, B10, and B CONTINUOUS DELAY controls (R561, R581, and R601) for establishing B-normal delay. Adjusts B-normal delay in 1,000-μsec steps.	Section 3, paragraph 22.
5	R545	GATE WIDTH B1000	Screwdriver adjuster (potentiometer).	Adjusts width of B1000 selector gate.	Section 3, paragraph 21*f*.
6	R561	B NORMAL DELAY 100	Adjuster (potentiometer).	Used in conjunction with B1000, B10, and B CONTINUOUS DELAY controls (R432, R581, and R601) for establishing B-normal delay. Adjusts B-normal delay in 100-μsec steps.	Section 3, paragraph 22.
7	R557	GATE WIDTH B100	Screwdriver adjuster (potentiometer).	Adjusts width of B100 selector gate.	Section 3, paragraph 21*g*.
8	R581	B NORMAL DELAY 10	Adjuster (potentiometer).	Used in conjunction with B1000, B100, and B CONTINUOUS DELAY controls (R532, R561, and R601) for establishing B-normal delay. Adjusts B-normal delay in 10-μsec steps.	Section 3, paragraph 22.
9	R574	GATE WIDTH B10	Screwdriver adjuster (potentiometer).	Adjusts width of B10 selector gate.	Section 3, paragraph 21*h*.

TABLE 4-4. CONTROLS AND DEVICES (TIME DELAY TYPE TD-92/FPN-30) (Cont'd)

FIG. 4-4 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
10	S504	PRESET B DELAY SELECTOR	5-position rotary switch. Positions marked: NORMAL 2 3 4 5	Selects any one of five established B delays (one normal, four preset) for the operating B delay.	Section 3, paragraph 23.
11	S506	EXT KEY	Momentary switch.	Disconnects external keying line.	———
12	F503 I503	A 1/8 +300 V	Cartridge fuse (1/8 amp) and white jewel indicator with neon lamp NE-51.	Fuse protects 300-volt plate supply circuits. Lamp lights if fuse is open and circuit is otherwise energized.	———
13	F502 I502	A 1/4 +150 V	Cartridge fuse (1/4 amp) and white jewel indicator with neon lamp NE-51.	Fuse protects +150-volt plate supply circuits. Lamp lights if fuse is open and circuit is otherwise energized.	———
14	F501 I501	B 1-1/2 115 V AC	Cartridge fuse (1-1/2 amps) and white jewel indicator with neon lamp NE-51.	Fuse protects filament supply transformer T501. Lamp lights if fuse is open and circuit is otherwise energized.	———
15	R601	B CONTINUOUS DELAY	Adjuster (potentiometer).	Used in conjunction with B NORMAL DELAY controls (R532, R561, and R581) and PRESET B DELAY controls for establishing B-normal and B-preset delays.	Section 3, paragraph 22.
16	S503	TEST SIGNAL	6-position rotary switch, positions marked: A1000 B1000 B100 B10 TRANSM TRIG BLANKING	Used in conjunction with SIGNAL SELECTOR switch (S1702) on test oscilloscope for obtaining scope presentations as follows: A1000 selector gate B1000 selector gate B100 selector gate B10 selector gate Transmitter trigger output Blanking pulse output	———
CHASSIS CONTROLS AND DEVICES					
17	R610	B1000 BIAS	Screwdriver adjuster (potentiometer).	Establishes optimum suppressor bias for V508 (5725).	Section 7, paragraph 4*d*(1).
18	R629	B100 BIAS	Screwdriver adjuster (potentiometer).	Establishes optimum suppressor bias for V511 (5725).	Section 7, paragraph 4*d*(1).
19	R630	B10 BIAS	Screwdriver adjuster (potentiometer).	Establishes optimum suppressor bias for V513 (5725).	Section 7, paragraph 4*d*(1).
20	R631	B CONT BIAS	Screwdriver adjuster (potentiometer).	Establishes optimum suppressor bias for V516 (5725).	Section 7, paragraph 4*d*(2).

TABLE 4-4. CONTROLS AND DEVICES (TIME DELAY TYPE TD-92/FPN-30) (Cont'd)

FIG. 4-4 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
21	R609	A1000 BIAS	Screwdriver adjuster (potentiometer).	Establishes optimum suppressor bias for V502 (5725).	Section 7, paragraph 4*d*(1).
22	R529	BLANKING WIDTH	Screwdriver adjuster (potentiometer).	Adjusts blanking pulse width.	Section 3, paragraph 24*c*.
23	R614	BLINK DELAY	Screwdriver adjuster (potentiometer).	Adjusts blink delay. Normally adjusted to provide a 1,000-μsec change of timing.	Section 3, paragraph 24*a*.
24	S501	STATION SELECTOR	2-position rotary switch, positions marked: MASTER SLAVE	Selects mode of operation of time delay unit as to MASTER or SLAVE operation.	———
25	S502	B DELAY OUTPUT	SPDT toggle switch, positions marked: B10 B CONT	Provides for disconnecting (B10 position) B continuous delay circuit when required; B delay is then multiple of 10 μsec (no units digit). B CONT position: B continuous delay circuit included in B delay circuits. B10 position: B continuous delay not included in B delay circuits.	Section 3, paragraph 22.
26	R520	ALIGN TRIGGERS	Screwdriver adjuster (potentiometer).	Used to align markers on VIDEO and RF SCOPES when B continuous delay circuit is disconnected from B delay circuit (B DELAY OUTPUT switch S502 in B10 position). Otherwise alignment is to be made with B CONTINUOUS DELAY control (R601).	Section 3, paragraph 21*i*.
27	S507	OFF-SYNC TEST	2-position spring return make-before-brake miniaturized rotary switch.	Interchanges blink of A and B pedestals to permit independent simulation of remote station blink.	Section 3, paragraph 24*b*.

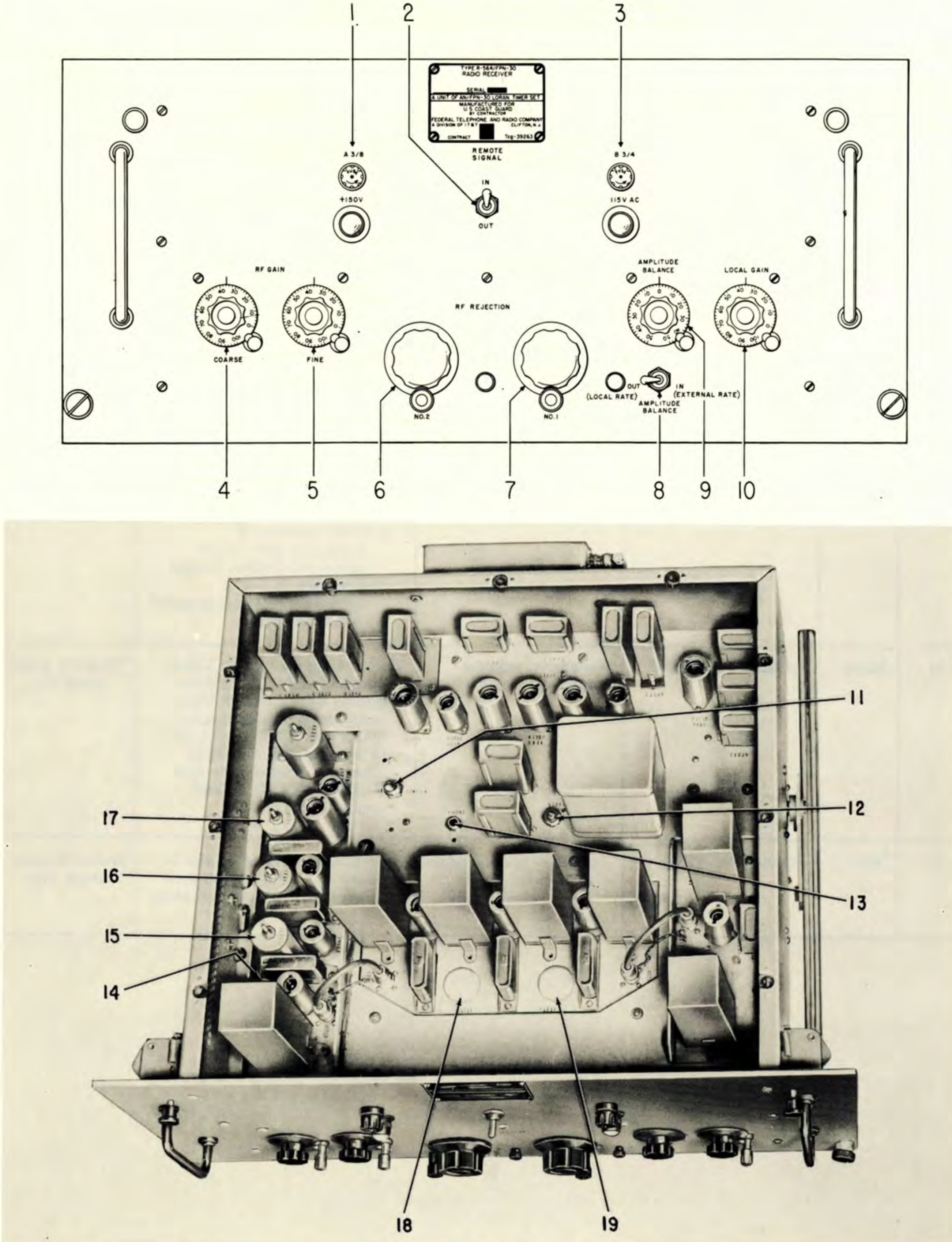


Figure 4–5. Radio Receiver Type R–564/FPN–30, Control Locations

TABLE 4–5. CONTROLS AND DEVICES (RADIO RECEIVER TYPE R–564/FPN–30)

FIG. 4–5 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
1	F1202 I1202	A 3/8 +150 V	Cartridge fuse (3/8 amp) and white jewel indicator with neon lamp NE–51.	Fuse protects +150-volt plate supply circuits. Lamp glows if fuse is open and circuit is otherwise energized.	——
2	S1201	REMOTE SIGNAL	SPDT toggle switch. Positions marked: IN OUT	Provides for disconnecting the remote lòran signal. IN position: Normal position. Remote signal is available at receiver outputs. OUT position: Remote signal not available at receiver outputs.	——
3	F1201 I1201	B 3/4 115 V AC	Cartridge fuse (3/4 amp) and white jewel indicator with neon lamp NE–51.	Fuse protects filament supply transformer T1201. Lamp glows if fuse is open and circuit is otherwise energized.	——
4	R1228	RF GAIN COARSE	Adjuster (potentiometer).	Varies gain of r-f amplifier stages. Used in conjunction with FINE RF GAIN control (R1229) to provide a signal presentation as shown in figure 4–16 or figure 4–17.	Section 4, paragraph 6*b*(10).
5	R1229	RF GAIN FINE	Adjuster (potentiometer).	Varies gain of r-f amplifier stages. Used in conjunction with COARSE RF GAIN control (R1228). See 4 above.	Section 4, paragraph 6*b*(10).
6	L1205	RF REJECTION NO. 2	Adjuster (slug tuner).	Tunes frequency of rejection trap No. 2 for the purpose of rejecting an interfering signal. Can be used alone or together with RF REJECTION No. 1 for maximum rejection of a single interfering carrier.	Section 4, paragraph 9*a*.
7	L1204	RF REJECTION NO. 1	Adjuster (slug tuner).	Tunes frequency of rejection trap No. 1 for the purpose of rejecting an interfering signal. See 6 above.	Section 4, paragraph 9*a*.
8	S1203	AMPLITUDE BALANCE	SPDT toggle switch. Positions marked: OUT (LOCAL RATE) IN (EXTERNAL RATE)	Connects amplitude balance circuit which allows differential gain (see AMPLITUDE BALANCE control 9) between local and remote signal inputs to receiver. OUT (LOCAL RATE) position: Amplitude balance circuit disconnected. AMPLITUDE BALANCE inoperative. IN (EXTERNAL RATE) position: Amplitude balance circuit connected allowing amplitude of local and remote signals to be equalized via AMPLITUDE BALANCE control.	——

TABLE 4-5. CONTROLS AND DEVICES (RADIO RECEIVER TYPE R-564/FPN-30) (Cont'd)

FIG. 4-5 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
9	R1303	AMPLITUDE BALANCE	Adjuster (potentiometer).	Permits amplitude of local and remote signals to be equalized provided that AMPLITUDE BALANCE switch (S1203) is in IN (EXTERNAL RATE) position.	——
10	R1209	LOCAL GAIN	Adjuster (potentiometer).	Adjusts amplitude of local loran signal fed into receiver. Normally adjusts to provide a local signal input of the same level as the remote signal input (for pulse match).	Section 4, paragraph 6*b*(10).
CHASSIS CONTROLS AND DEVICES					
11	S1202	LIMITER	SPDT toggle switch. Positions marked: IN-OUT.	Provides for connecting a noise limiting circuit to video circuits during noisy reception. IN position: Limiter connected into circuit. OUT position: Normal position. Limiter disconnected.	Section 4, paragraph 9*b*.
12	R1289	LIMITER ADJ.	Adjuster (potentiometer).	Adjusts limiter. See S1202 above. Normally adjusted to give maximum limiting without signal distortion.	Section 4, paragraph 9*b*.
13	J1209	PHONE	Jack	Provides for monitoring interfering signals.	Section 4, paragraph 9*a*.
14	L1212	——	Screwdriver adjuster (inductor).	Broad tunes V1205 plate to center of loran band.	Section 7, paragraph 4*f*(3).
15	L1214	——	Screwdriver adjuster (inductor).	Broad tunes V1206 plate to center of loran band.	Section 7, paragraph 4*f*(3).
16	L1215	——	Screwdriver adjuster (inductor).	Broad tunes V1207 plate to center of loran band.	Section 7, paragraph 4*f*(3).
17	L1219	——	Screwdriver adjuster (inductor).	Broad tunes V1208 cathode to center of loran band.	Section 3, paragraph 26*e* (1)(*c*).
18	R1218	——	Screwdriver adjuster (potentiometer).	Permits adjustment of RF REJECTION NO. 1 trap for maximum rejection.	Section 7, paragraph 4*f*(4).
19	R1213	——	Screwdriver adjuster (potentiometer).	Permits adjustment of RF REJECTION NO. 2 trap for maximum rejection.	Section 7, paragraph 4*f*(4).

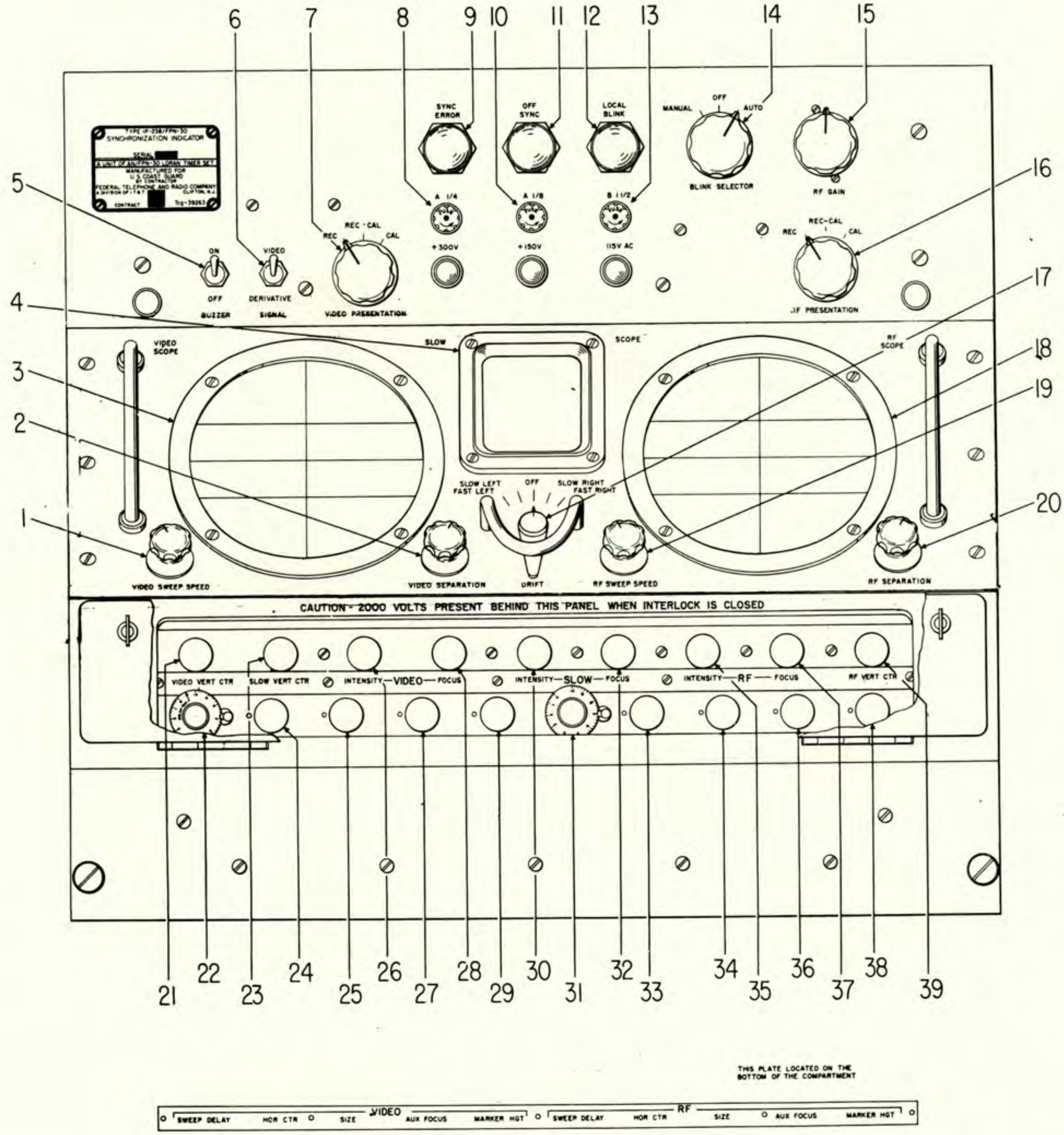


Figure 4–6. Synchronization Indicator Type IP–238/FPN–30, Control Locations (Part 1 of 3)

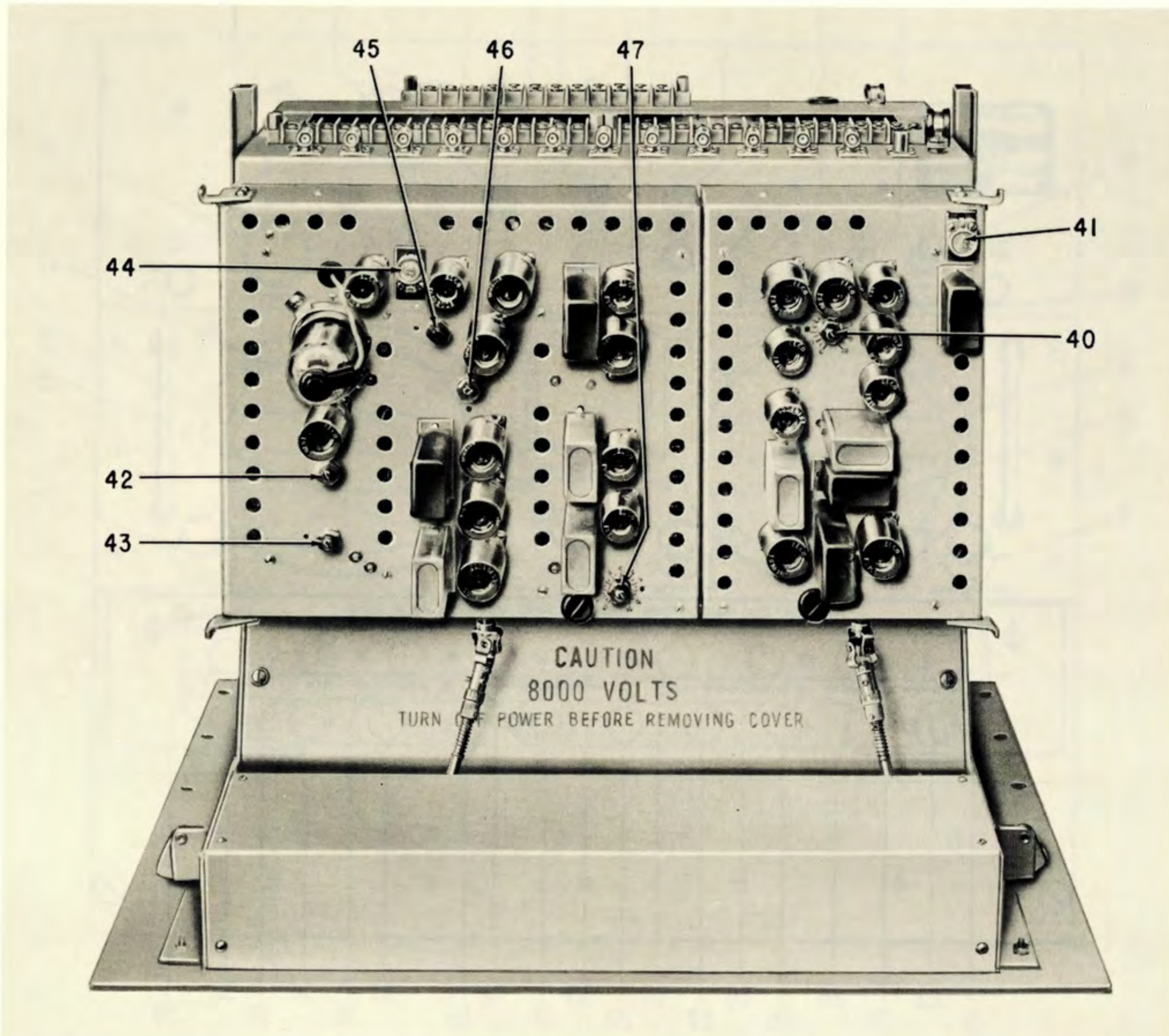


Figure 4–6. Synchronization Indicator Type IP–238/FPN–30, Control Locations (Part 2 of 3)

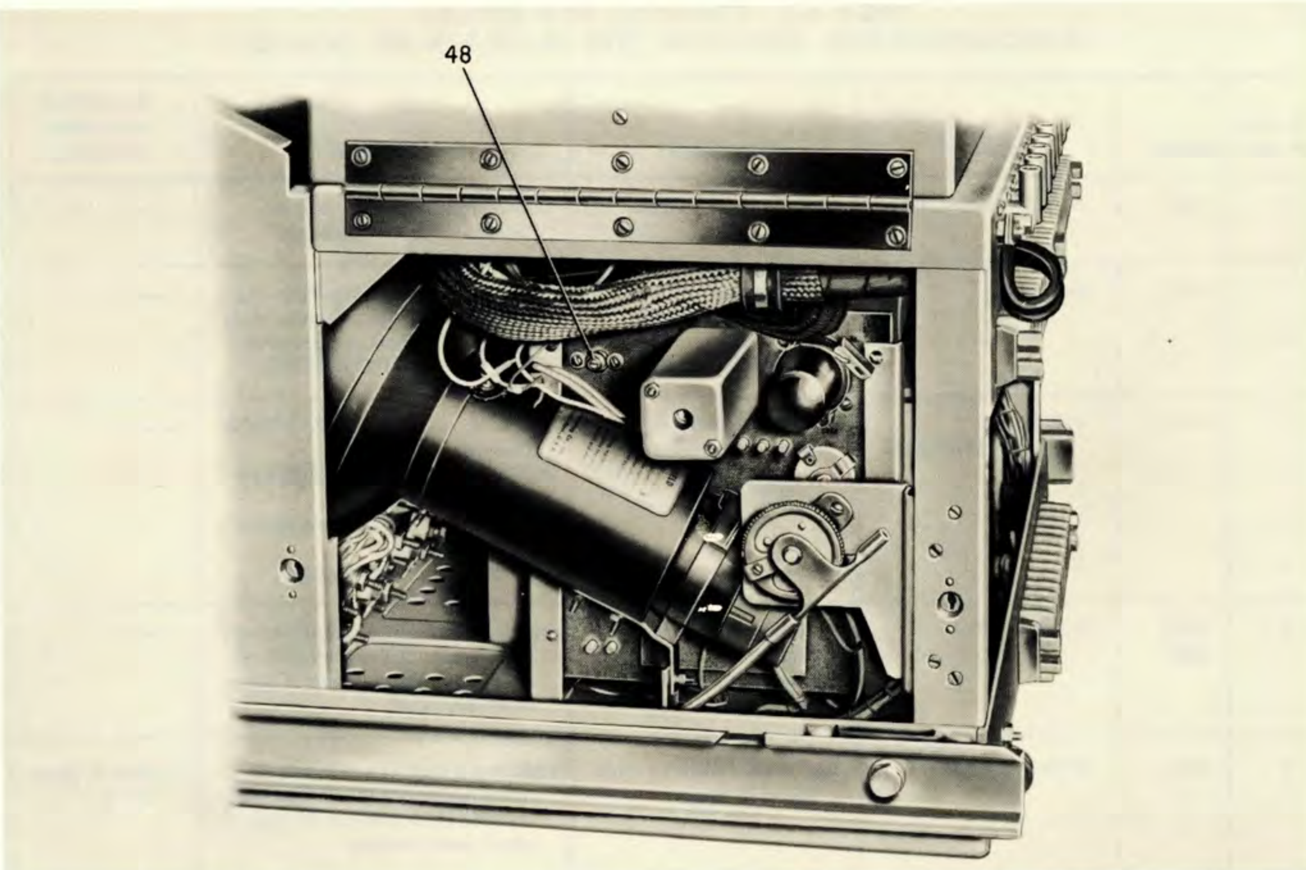


Figure 4-6. Synchronization Indicator Type IP-238/FPN-30, Control Locations (Part 3 of 3)

TABLE 4-6. CONTROLS AND DEVICES (SYNCHRONIZATION INDICATOR TYPE IP-238/FPN-30)

FIG. 4-6 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
1	R813	VIDEO SWEEP SPEED	Adjuster (potentiometer).	Adjusts sweep speed of traces on VIDEO SCOPE. Normally adjusted to provide a VIDEO SCOPE presentation as shown in figure 4-16 or figure 4-17.	——
2	R852	VIDEO SEPARATION	Adjuster (potentiometer).	Adjusts separation of master (upper) and slave (lower) traces on VIDEO SCOPE.	——
3	——	VIDEO SCOPE	Five-inch oscilloscope.	Presents, on two separate traces, portions of a loran cycle. Upper trace presents master pedestal time interval. Lower trace presents slave pedestal time interval. Presents either the video loran signals or second derivatives of video signals, as selected by SIGNAL switch (S803).	——
4	——	SLOW SCOPE	Three-inch oscilloscope.	Presents the full loran cycle in two separate traces.	——

TABLE 4–6. CONTROLS AND DEVICES (SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30) (Cont'd)

FIG. 4–6 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
5	S806	BUZZER ON-OFF	SPDT toggle switch.	Controls operation of buzzer. Normally in ON position.	———
6	S803	SIGNAL	SPDT toggle switch. Positions marked: VIDEO DERIVATIVE	Selects either the video loran signals or the second derivative of the loran signals for presentation on the VIDEO SCOPE.	———
7	S804	VIDEO PRESENTATION	3-position rotary switch. Positions marked: REC REC-CAL CAL	Selects signals for VIDEO SCOPE presentation. REC position: Loran signals only. (Normal position.) REC-CAL position: Loran signals and markers. CAL position: Markers only.	———
8	F803 I803	A 1/4 +300 V	Cartridge fuse (1/4 amp) and white jewel indicator with neon lamp NE–51.	Fuse protects +300-volt plate supply circuits. Indicator lights if fuse is open and circuit is otherwise energized.	———
9	I804	SYNC ERROR	Red jewel indicator with 6S6–125 lamp.	Indicates a sync error of one or more microseconds is detected by sync error circuits in electrical synchronizer.	Section 4, paragraph 8*b*.
10	F802 I802	A 1/8 +150 V	Cartridge fuse (1/8 amp) and white jewel indicator with neon lamp NE–51.	Fuse protects +150-volt plate supply circuits. Lamp lights if fuse is open and circuit is otherwise energized.	———
11	I805	OFF SYNC	Amber jewel indicator with 6S6–125 lamp.	Indicates that a large sync error, a lost remote signal, remote blinking, or operation on wrong zero cross-over is detected by off sync circuit in electrical synchronizer.	Section 4, paragraph 8*a*.
12	I806	LOCAL BLINK	Blue jewel indicator with 6S6–125 lamp.	Indicates that blinking has been initiated by electrical synchronizer (or manually) in response to detection of a sync error or off sync condition.	———
13	F801 I801	B 1-1/2 115 V AC	Cartridge fuse (1-1/2 amps) and white jewel indicator with neon lamp NE–51.	Fuse protects primary of filament supply transformer T801 and other 115-volt circuits. Lamp lights if fuse is open and circuit is otherwise energized.	———
14	S802	BLINK SELECTOR	3-position rotary switch. Positions marked: MANUAL OFF AUTO	Controls blinking. MANUAL position: Blinking is immediately initiated. OFF position: Blinking cannot be initiated. AUTO position: Blinking is initiated automatically by the alarm circuits.	———

TABLE 4–6. CONTROLS AND DEVICES (SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30) (Cont'd)

FIG. 4–6 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
15	C864	RF GAIN	Adjuster (capacitor).	Adjusts height of loran signals on RF SCOPE. Marker height not affected by this control.	Section 4, paragraphs 6*b*(10), 7*b*(9).
16	S805	RF PRESENTATION	3-position rotary switch. Positions marked: REC REC-CAL CAL	Selects presentation for RF SCOPE. REC position: Loran signals only. (Normal position.) REC-CAL position: Loran signals and markers. CAL position: Markers only.	———
17	S807	DRIFT	5-position momentary switch with center OFF position. Positions marked: FAST LEFT SLOW LEFT OFF SLOW RIGHT FAST RIGHT	Provides for momentary modification of repetition rate to establish approximate synchronization, that is to drift the remote signal towards a desired position on the loran cycle. Drift is observed on SLOW and/or VIDEO SCOPES.	Section 4, paragraphs 6*b*(10), 7*b*(9).
18	———	RF SCOPE	Five-inch oscilloscope.	Presents, on two separate traces, portions of loran cycle. Upper trace presents portion of master pedestal. Lower trace presents portion of slave pedestal. Presents the r-f loran signals.	———
19	R926	RF SWEEP SPEED	Adjuster (potentiometer).	Adjusts sweep speed of traces on RF SCOPE.	———
20	R898	RF SEPARATION	Adjuster (potentiometer).	Adjusts separation of master (upper) and slave (lower) traces on RF SCOPE.	———
21	R863	VIDEO VERT CTR	Adjuster (potentiometer).	Adjusts vertical position of traces on VIDEO SCOPE. Normally adjusted to provide a VIDEO SCOPE presentation as shown in figure 4–16 or 4–17.	———
22	R804	VIDEO SWEEP DELAY	Adjuster (potentiometer).	Adjusts delay between sync signals (A and B timing pulses) and start of sweep on VIDEO SCOPE. Normally adjusted to provide a VIDEO SCOPE presentation as shown in figure 4–16 or 4–17.	———
23	R950	SLOW VERT CTR	Adjuster (potentiometer).	Adjusts vertical position of SLOW SCOPE traces.	———
24	R836	VIDEO HOR CTR	Adjuster (potentiometer).	Adjusts horizontal position of VIDEO SCOPE traces. Normally adjusted to provide a VIDEO SCOPE presentation as shown in figure 4–16 or 4–17.	———

TABLE 4–6. CONTROLS AND DEVICES (SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30) (Cont'd)

FIG. 4–6 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
25	R824	VIDEO SIZE	Adjuster (potentiometer).	Adjusts size of VIDEO SCOPE traces. Normally adjusted to provide a VIDEO SCOPE presentation as shown in figure 4–16 or 4–17.	Section 3, paragraph 20*c*(9).
26	R879	VIDEO INTENSITY	Adjuster (potentiometer).	Adjusts brightness of VIDEO SCOPE trace.	———
27	R839	VIDEO AUX FOCUS	Adjuster (potentiometer).	Adjusts sharpness of VIDEO SCOPE trace.	Section 3, paragraph 20*c*(8).
28	R882	VIDEO FOCUS	Adjuster (potentiometer).	Adjusts sharpness of VIDEO SCOPE trace.	Section 3, paragraph 20*c*(7).
29	R876	VIDEO MARKER HGT	Adjuster (potentiometer).	Adjusts height of VIDEO SCOPE markers. Does not affect height of video signals.	Section 3, paragraph 20*c*(10).
30	R842	SLOW INTENSITY	Adjuster (potentiometer).	Adjusts brightness of SLOW SCOPE trace.	———
31	R918	RF SWEEP DELAY	Adjuster (potentiometer).	Adjusts delay between sync signal (A and B timing pulses) and start of sweep on RF SCOPE.	Section 4, paragraphs 6*b*(10), 7*b*(9).
32	R845	SLOW FOCUS	Adjuster (potentiometer).	Adjusts sharpness of SLOW SCOPE trace.	———
33	R945	RF HOR CTR	Adjuster (potentiometer).	Adjusts horizontal position of RF SCOPE trace.	———
34	R929	RF SIZE	Adjuster (potentiometer).	Adjusts size of RF SCOPE trace.	Section 3, paragraph 20*d*(9).
35	R907	RF INTENSITY	Adjuster (potentiometer).	Adjusts brightness of RF SCOPE trace.	———
36	R948	RF AUX FOCUS	Adjuster (potentiometer).	Adjusts sharpness of RF SCOPE trace.	Section 3, paragraph 20*d*(8).
37	R910	RF FOCUS	Adjuster (potentiometer).	Adjusts sharpness of RF SCOPE trace.	Section 3, paragraph 20*d*(7).
38	R966	RF MARKER HGT	Adjuster (potentiometer).	Adjusts height of markers on RF SCOPE. Does not affect height of r-f signals.	Section 3, paragraph 20*d*(5).
39	R902	RF VERT CTR	Adjuster (potentiometer).	Adjusts vertical position of RF SCOPE trace.	———

TABLE 4-6. CONTROLS AND DEVICES (SYNCHRONIZATION INDICATOR TYPE IP-238/FPN-30) (Cont'd)

FIG. 4-6 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
			RF CHASSIS CONTROLS AND DEVICES		
40	R960	RF DELAY BIAS	Screwdriver adjuster (potentiometer).	Establishes optimum bias on suppressor of V817 (5725).	Section 7, paragraph 4*e*(2).
41	C844	RF FAST SWEEP SPEED ADJ	Screwdriver adjuster (capacitor).	Establishes RF SWEEP SPEED control (R926) reference.	Section 3, paragraph 20*d*(11).
			VIDEO CHASSIS CONTROLS AND DEVICES		
42	R846	DERIV. GAIN	Screwdriver adjuster (potentiometer).	Adjusts gain of second derivative input.	Section 3, paragraph 26*g*(11).
43	R854	VIDEO GAIN	Screwdriver adjuster (potentiometer).	Adjusts gain of video input.	Section 3, paragraph 26*g*(10).
44	C868	VIDEO FAST SWEEP SPEED	Screwdriver adjuster (capacitor).	Establishes VIDEO SWEEP SPEED (R813) control reference.	Section 3, paragraph 20*c*(13).
45	R967	1 MARKER HEIGHT	Screwdriver adjuster (potentiometer).	Adjusts 1-μsec marker height.	Section 3, paragraph 20*c*(10).
46	R868	10 MARKER HEIGHT	Screwdriver adjuster (potentiometer).	Adjusts 10-μsec marker height.	Section 3, paragraph 20*c*(10).
47	R959	VIDEO DELAY BIAS	Screwdriver adjuster (potentiometer).	Establishes optimum bias on suppressor V803 (5725).	Section 7, paragraph 4*e*(1).
			RF AMPLIFIER CHASSIS CONTROLS AND DEVICES		
48	C861	RF TUNING	Screwdriver adjuster (capacitor).	Tunes r-f amplifier to station frequency.	Section 3, paragraph 26*e*(1)(*e*).

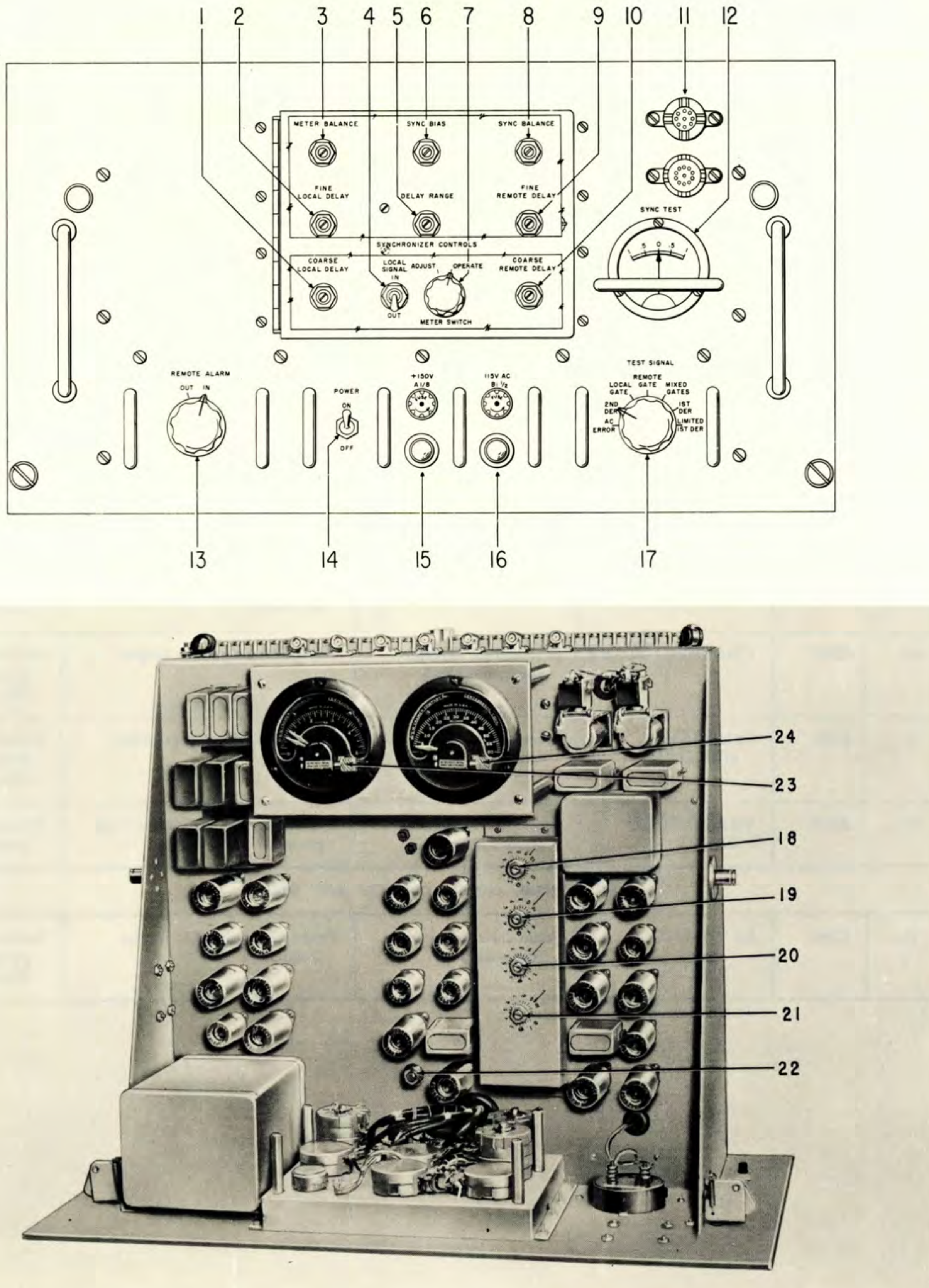


Figure 4–7. Electrical Synchronizer Type SN–117/FPN–30, Control Locations

TABLE 4-7. CONTROLS AND DEVICES (ELECTRICAL SYNCHRONIZER TYPE SN-117/FPN-30)

FIG. 4-7 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
1	R1544	COARSE LOCAL DELAY	Screwdriver adjuster (potentiometer).	MASTER OPERATION: Adjusts delay between A trigger and local (master) gate. SLAVE OPERATION: Adjusts delay between A and B triggers and remote (master) and local (slave) gates.	Section 3, paragraphs 28*b*, 29*b*.
2	R1551	FINE LOCAL DELAY	Screwdriver adjuster (potentiometer).	Fine adjuster used in conjunction with COARSE LOCAL DELAY control (R1544) above.	Section 3, paragraphs 28*b*, 29*b*.
3	R1538	METER BALANCE	Screwdriver adjuster (potentiometer).	Balances SYNC TEST meter (M1501).	Section 3, paragraphs 28*f*, 29*f*.
4	S1506	LOCAL SIGNAL IN-OUT	SPDT toggle switch.	IN position: Normal operating position. OUT position: Normal stand-by position. Disconnects 2nd derivative local signal. When using loran switch equipment AN/FPA-2 LOCAL SIGNAL IN-OUT switching, for stand-by-operate change-overs, is automatically done by the TIMER SELECTOR switches at the switching equipment and S1506 is set to IN.	———
5	R1561	DELAY RANGE	Screwdriver adjuster (potentiometer).	MASTER OPERATION: Adjust operating range of R138B, in sync control unit. Normally adjusted for 10-μsec range of gate position. SLAVE OPERATION: Disconnected from circuit.	Section 3, paragraph 29*i*.
6	R1515	SYNC BIAS	Screwdriver adjuster (potentiometer).	Adjusts bias on remote mixer V1502 (5275).	Section 3, paragraphs 28*f*, 29*f*.
7	S1504	METER SWITCH	2-position rotary switch, positions marked: ADJUST-OPERATE	ADJUST position: Connects error voltage to SYNC TEST meter for initial adjustments. OPERATE position: Normal position, meter connected to fixed reference voltage.	Section 3, paragraphs 28*f*, 29*f*.
8	R1522	SYNC BALANCE	Screwdriver adjuster (potentiometer).	Adjusts bias on local mixer V1504 (5725).	Section 3, paragraphs 28*f*, 29*f*:
9	R1517	FINE REMOTE DELAY	Screwdriver adjuster.	MASTER OPERATION: Adjusts delay between B trigger and remote (slave) gate. Used in conjunction with COARSE REMOTE DELAY (R1565). SLAVE OPERATION: Disconnected from circuit.	Section 3, paragraph 29*i*.

TABLE 4–7. CONTROLS AND DEVICES (ELECTRICAL SYNCHRONIZER TYPE SN–117/FPN–30) (Cont'd)

FIG. 4–7 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
10	R1565	COARSE REMOTE DELAY	Screwdriver adjuster (potentiometer).	Coarse adjuster: Used in conjunction with FINE REMOTE DELAY (R1517) above.	Section 3, paragraph 29*i*.
11	——	——	Vacuum tube pin straighteners.	——	——
12	M1501	SYNC TEST	Meter.	Test meter used for initial adjustment of electrical synchronizer.	——
13	S1501	REMOTE ALARM OUT-IN	2-position rotary switch.	OUT position: Disconnects remote alarm signals. Normal stand-by position when not using loran switching group AN/FPA–2. IN position: Normal operating position. Alarm signal provided for feeding remote alarm box.	——
14	S1502	POWER ON-OFF	DPDT toggle switch.	Controls plate and filament supply voltages to unit. Normal ON position.	——
15	F1502 I1505	+150 V AC 1/8	Cartridge fuse (1-1/2 amps) and white jewel indicator with neon lamp NE–51.	Fuse protects +150-volt plate supply circuits. Lamp glows if fuse is open and circuit is otherwise energized.	——
16	F1501 I1504	115 V AC B 1-1/2	Cartridge fuse (1-1/2 amps) and white jewel indicator with neon lamp NE–51.	Fuse protects filaments and a-c voltage supply transformer T1502. Lamp glows if fuse is open and circuit is otherwise energized.	——
17	S1503	TEST SIGNAL	7-position rotary switch. Positions marked: AC ERROR 2ND DER LOCAL GATE REMOTE GATE MIXED GATES 1ST DER LIMITED 1st DER	Used in conjunction with SIGNAL SELECTOR switch (S1702) on test oscilloscope for presenting test signals as follows: AC error voltage output 2nd derivative input Local gate Remote gate Mixed gates 1st derivative input Limited 1st derivative	——
			CHASSIS CONTROLS AND DEVICES		
18	R1592	DELAY BIAS	Screwdriver adjuster (potentiometer).	Establishes optimum suppressor bias for V1517 (5725).	Section 7, paragraph 4*g*(1).
19	R1501	DERIVATIVE INPUT LEVEL	Screwdriver adjuster (potentiometer).	Adjusts level of 2nd derivative input.	Section 3, paragraphs 28*i*, 29*k*.

TABLE 4–7. CONTROLS AND DEVICES (ELECTRICAL SYNCHRONIZER TYPE SN–117/FPN–30) (Cont'd)

FIG. 4–7 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
20	R1555	OFF SYNC SENSITIVITY	Screwdriver adjuster (potentiometer).	Adjusts sensitivity of OFF SYNC alarm V1514 (2D21W).	Section 3, paragraphs 28*j*, 29*l*.
21	R1534	SYNC ERROR SENSITIVITY	Screwdriver adjuster (potentiometer).	Adjusts sensitivity of sync error alarm V1509 (2D21W).	Section 3, paragraphs 28*j*, 29*l*.
22	S1505	STATION SELECTOR MASTER-SLAVE	2-position rotary switch.	Selects mode of operation of electrical synchronizer as to MASTER or SLAVE operation.	———
23	K1503	SYNC ERROR	Knurled adjuster (time delay relay).	Adjusts delay period of SYNC ERROR alarm.	Section 3, paragraphs 28*j*(5), 29*l*(6).
24	K1505	OFF SYNC	Knurled adjuster (time delay relay).	Adjusts delay period of OFF SYNC alarm.	Section 3, paragraphs 28*k* (2), 29*m*(2).

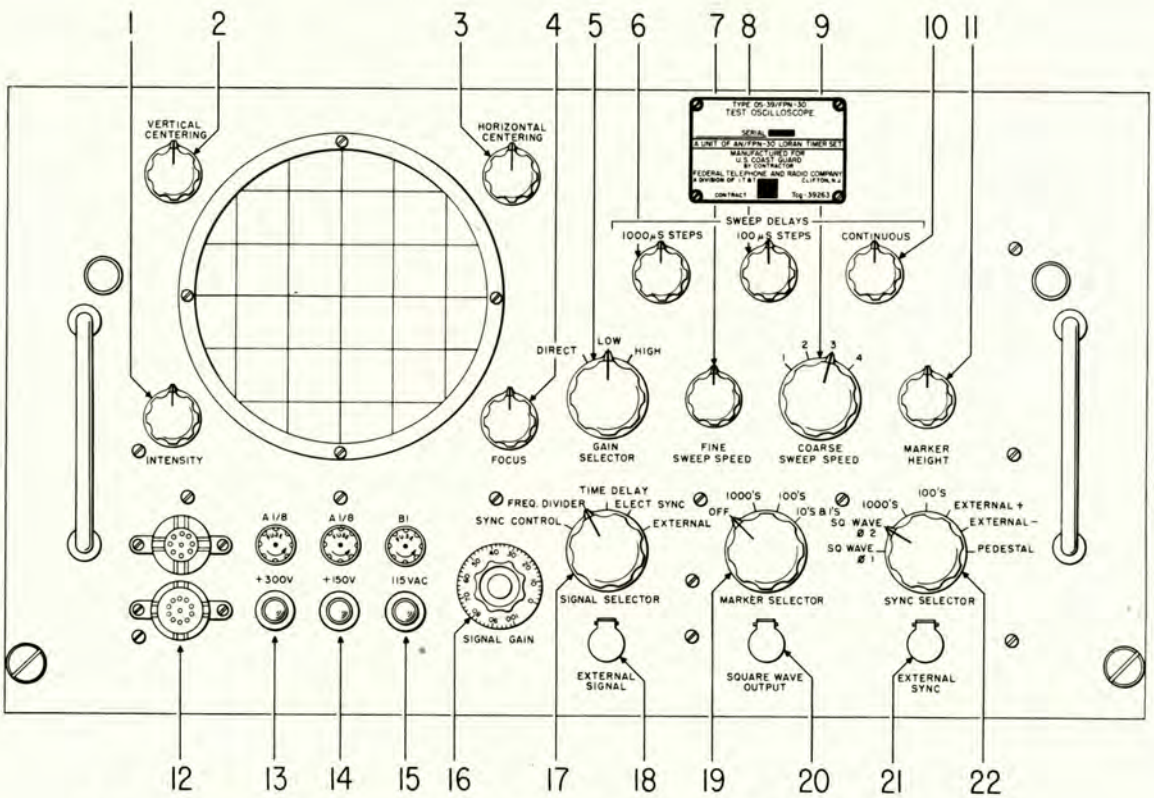


Figure 4–8. Test Oscilloscope Type OS–39/FPN–30, Control Locations (Part 1 of 2)

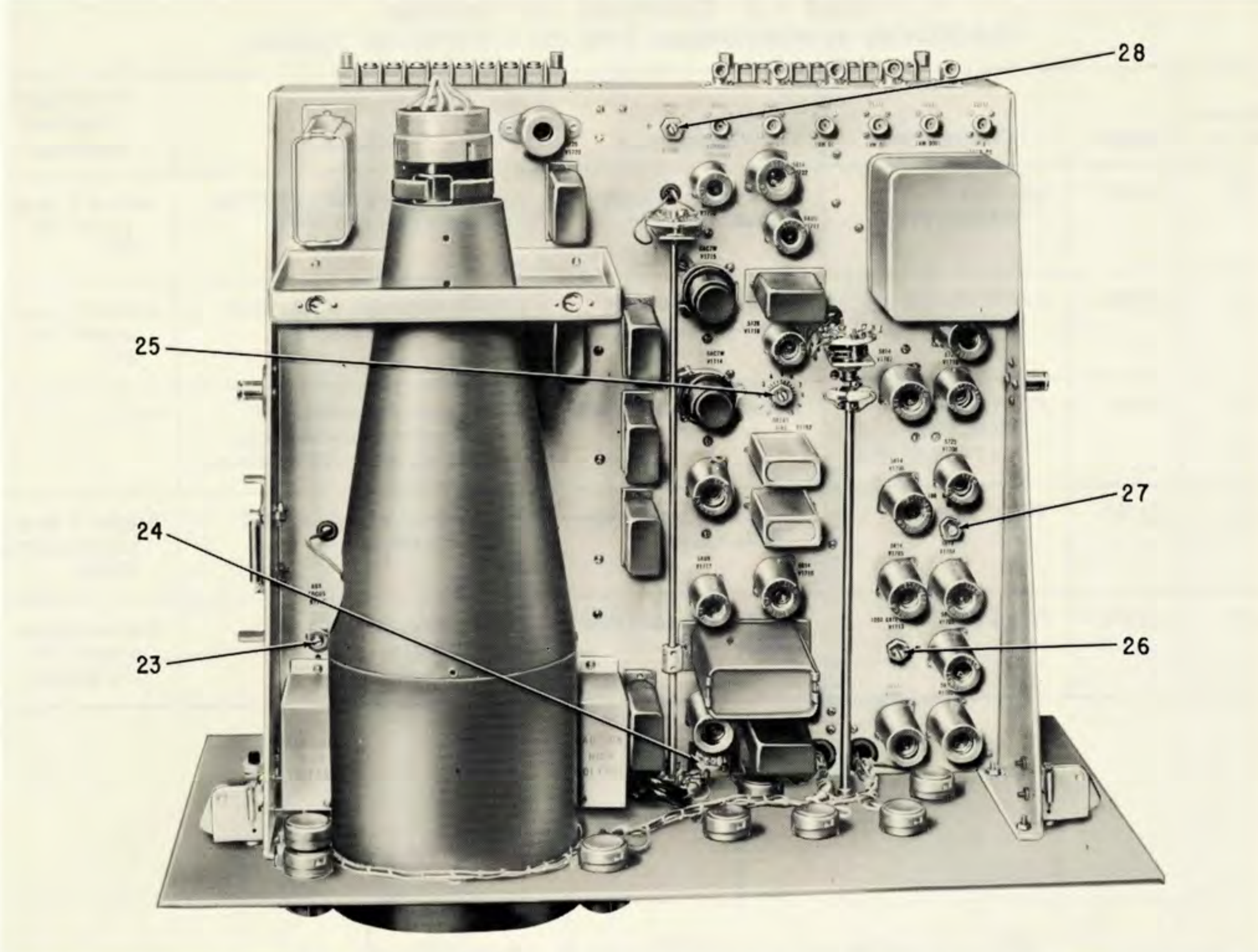


Figure 4–8. Test Oscilloscope Type OS–39/FPN–30, Control Locations (Part 2 of 2)

TABLE 4–8. CONTROLS AND DEVICES (TEST OSCILLOSCOPE TYPE OS–39/FPN–30)

FIG. 4–8 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
1	R1781	INTENSITY	Adjuster (potentiometer).	Adjusts brightness of scope trace.	———
2	R1776	VERTICAL CENTERING	Adjuster (potentiometer).	Adjusts vertical position of scope trace.	Section 3, paragraph 16*e*(4).
3	R1806	HORIZONTAL CENTERING	Adjuster (potentiometer).	Adjusts horizontal position of scope trace.	Section 3, paragraph 16*e*(4).
4	R1780	FOCUS	Adjuster (potentiometer).	Adjusts sharpness of scope trace.	Section 3, paragraph 16*e*(5).
5	S1704	GAIN SELECTOR	3-position rotary switch. Positions marked: DIRECT, LOW, and HIGH.	Provides for coarse adjustment of scope signal amplitude. In DIRECT position, input signal applied directly to vertical plates of scope.	Section 3, paragraph 17*b*.

TABLE 4–8. CONTROLS AND DEVICES (TEST OSCILLOSCOPE TYPE OS–39/FPN–30) (Cont'd)

FIG. 4–8 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
6	R1707	SWEEP DELAYS 1000 μS STEPS	Adjuster (potentiometer).	The SWEEP DELAYS (items 6, 8 and 10) provide for a desired delay between sync signal and start of horizontal sweep. Used in conjunction with SWEEP SPEED controls R1790 and R1706 to present any portion of scope trace. This control adjusts delay in steps of 1,000 μsec. Maximum range is 25,000 μsec.	Section 3, paragraphs 17*e*, 17*f*, 17*g*.
7	R1790	FINE SWEEP SPEED	Adjuster (potentiometer).	The SWEEP SPEED controls (items 7 and 9) provide for adjusting horizontal sweep speed over the range of 15 to 28,000 μsec. Used in conjunction with SWEEP DELAYS controls, R1707, R1720, and R1736, to present any desired portion of scope trace. Sweep speed range provided by the FINE SWEEP SPEED (R1790) for each position of COARSE SWFEP SPEED (R1706) is as follows: 1: 4,000 to 28,000 μsec. 2: 500 to 3,300 μsec. 3: 75 to 500 μsec. 4: 15 to 75 μsec.	Section 3, paragraph 17*d*.
8	R1720	SWEEP DELAYS 100 μS STEPS	Adjuster (potentiometer).	Adjusts delay of sweep in steps of 100 μsec up to 1,500 μsec. This delay is added to 1,000 μS STEPS delay.	Section 3, paragraphs 17*e*, 17*f*, 17*g*.
9	R1706	COARSE SWEEP SPEED	4-position rotary switch. Positions marked: 1, 2, 3, 4.	See 7, above.	Section 3, paragraph 17*d*.
10	R1736	SWEEP DELAYS CONTINUOUS	Adjuster (potentiometer).	Provides continuous adjustment of delay of sweep up to 150 μsec. This delay is added to 100 μS STEPS delay to provide total delay.	Section 3, paragraphs 17*e*, 17*f*, 17*g*.
11	R1741	MARKER HEIGHT	Adjuster (potentiometer).	Adjusts height of markers on scope trace. This control does not affect scope signal amplitude.	Section 3, paragraph 17*c*.
12	——	————	Vacuum tube pin straighteners.	————	Section 5, paragraph 2.
13	F1702 I1702	A1/8 +300V	Cartridge fuse (1/8 amp) and white jewel indicator with neon lamp NE–51.	Fuse protects +300-volt vacuum tube plate circuits. Lamp glows if fuse is open and circuit is otherwise energized.	——

TABLE 4–8. CONTROLS AND DEVICES (TEST OSCILLOSCOPE TYPE OS–39/FPN–30) (Cont'd)

FIG. 4–8 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
14	F1701 I1701	A1/8 +150V	Cartridge fuse (1/8 amp) and white jewel indicator with neon lamp NE–51.	Fuse protects +150-volt vacuum tube plate circuits. Lamp glows if fuse is open and circuit is otherwise energized.	———
15	F1703 I1703	B1 115 V AC	Cartridge fuse (1 amp) and white jewel indicator with neon lamp NE–51.	Fuse protects primary of filament transformer T1701. Lamp glows if fuse is open and circuit is otherwise energized.	———
16	R1758	SIGNAL GAIN	Adjuster (potentiometer).	Adjusts scope signal amplitude, provided that GAIN SELECTOR switch (S1704) is in the LOW or HIGH position. Does not affect marker height.	Section 3, paragraph 17*k*.
17	S1702	SIGNAL SELECTOR	5-position rotary switch, positions marked: SYNC CONTROL FREQ. DIVIDER TIME DELAY ELEC SYNC EXTERNAL	Selects any one of four timer units (as marked) or external sources, as test signal sources. Used in conjunction with TEST SIGNAL switches on corresponding units for test signal selection in particular unit.	———
18	J1706	EXTERNAL SIGNAL	Jack	Receptacle for external test signal. See 17.	———
19	S1703	MARKER SELECTOR	4-position rotary switch, positions marked: OFF 1000'S 100'S 10'S & 1'S	Selects desired markers for presentation on scope.	Section 3, paragraph 17*c*.
20	J1704	SQUARE WAVE OUTPUT	Jack	Provides square wave ϕ 1 signal for external test purposes.	
21	J1701	EXTERNAL SYNC	Receptacle	Input jack for external sync signal. See S1701.	
22	S1701	SYNC SELECTOR	7-position rotary switch, positions marked: SQ WAVE ϕ 1 SQ WAVE ϕ 2 1000'S 100'S EXTERNAL + EXTERNAL – PEDESTAL	Selects any one of five pulses (as marked) for horizontal sweep sync signals or EXTERNAL signal of either phase. Normally in SQ WAVE ϕ 1 or SQ WAVE ϕ 2 position.	Section 3, paragraph 17*a*.
			CHASSIS CONTROLS AND DEVICES		
23	R1779	AUX FOCUS	Screwdriver adjuster (potentiometer).	Auxiliary focus control for adjusting sharpness of scope trace.	Section 3, paragraph 16*e*(6).
24	C1723	ATTEN ADJ	Screwdriver adjuster (capacitor).	Provides for correcting attenuator circuit response due to stray capacitance.	Section 3, paragraph 16 *g*.

TABLE 4–8. CONTROLS AND DEVICES (TEST OSCILLOSCOPE TYPE OS–39/FPN–30) (Cont'd)

FIG. 4–8 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
25	R1752	DELAY BIAS	Screwdriver adjuster (potentiometer).	Establishes optimum suppressor bias for V1708 (5725).	Section 7, paragraph 4*b*(2).
26	R1713	1000 GATE WIDTH	Screwdriver adjuster (potentiometer).	Adjusts selector gate width of 1,000-μsec delay circuit.	Section 7, paragraph 4*b*(1).
27	R1729	100 GATE WIDTH	Screwdriver adjuster (potentiometer).	Adjusts selector gate width of 100-μsec delay circuit.	Section 7, paragraph 4*b*(1).
28	R1795	SWEEP SIZE	Screwdriver adjuster (potentiometer).	Adjusts length of horizontal sweep across scope.	Section 3, paragraph 16*f*.
PROBE CONTROLS AND DEVICES					
	C2203	————	Screwdriver adjuster (capacitor).	Provides for corresponding attenuator circuit (in probe) response due to stray capacitance.	Section 3, paragraph 16*b*.

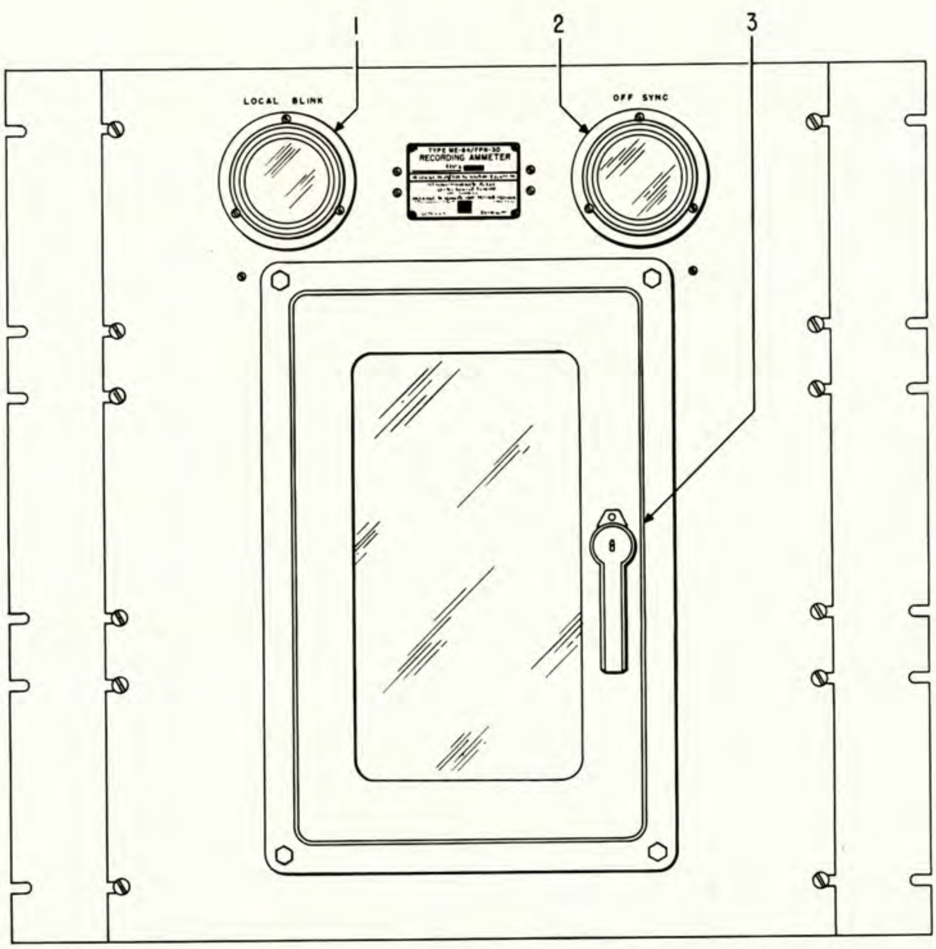


Figure 4–9. Recording Ammeter Type ME–84/FPN–30, Control Locations (Part 1 of 2)

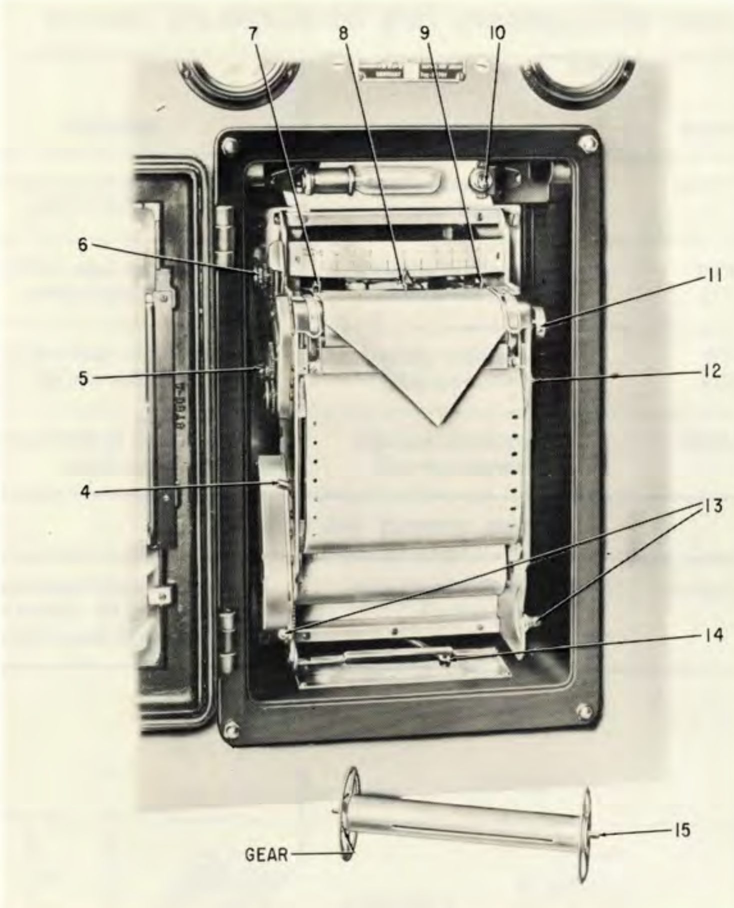


Figure 4–9. Recording Ammeter Type ME–84/FPN–30, Control Locations (Part 2 of 2)

TABLE 4–9. CONTROLS AND DEVICES (RECORDING AMMETER TYPE ME–84/FPN–30)

FIG. 4–9 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
1	M2602	LOCAL BLINK	Running time meter.	Indicates total time during local blink circuit which has been activated.	Section 4, paragraph 12.
2	M2601	OFF SYNC	Running time meter.	Indicates total time during which OFF SYNC lamp has been on.	Section 4, paragraph 12.
3	—	—	Door for chart drive.	Permits access to chart drive assembly for loading chart, making pencil notations on chart, and for servicing assembly.	—
4	—	ON-OFF	Motor switch.	Activates chart drive and reroll take-up motors.	—
5	—	—	Change gears (operating).	Controls speed of chart drive.	Section 3, paragraph 27*c*(1).

TABLE 4–9. CONTROLS AND DEVICES (RECORDING AMMETER TYPE ME–84/FPN–30) (Cont'd)

FIG. 4–9 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
6	—	————	Change gears (spares).	Permit different chart drive speeds.	Section 3, paragraph 27*c*(1).
7	—	————	Local blink pen.	Writes local blink record.	———
8	—	————	Center pen.	Writes error record.	———
9	—	————	Off sync pen.	Writes off sync record.	———
10	—	ON-OFF	Lamp switch.	Turns chart lamp on and off.	———
11	—	————	Set knob.	Permits chart to be moved by hand.	Section 3, paragraph 27*b*(6).
12	—	HOUR FEEDS MIN FEED	Shift lever.	Permits changing chart speed from inches per hour to inches per minute.	Section 3, paragraph 27*c*(2).
13	—	————	Reroll catches.	Latch reroll in operating position.	———
14	—	————	Center pen position lever.	Permits centering of center pen.	Section 3, paragraph 27*f*.
15	—	————	Chart reroll.	Take-up spool for chart.	Section 3, paragraph 27*b*(7).

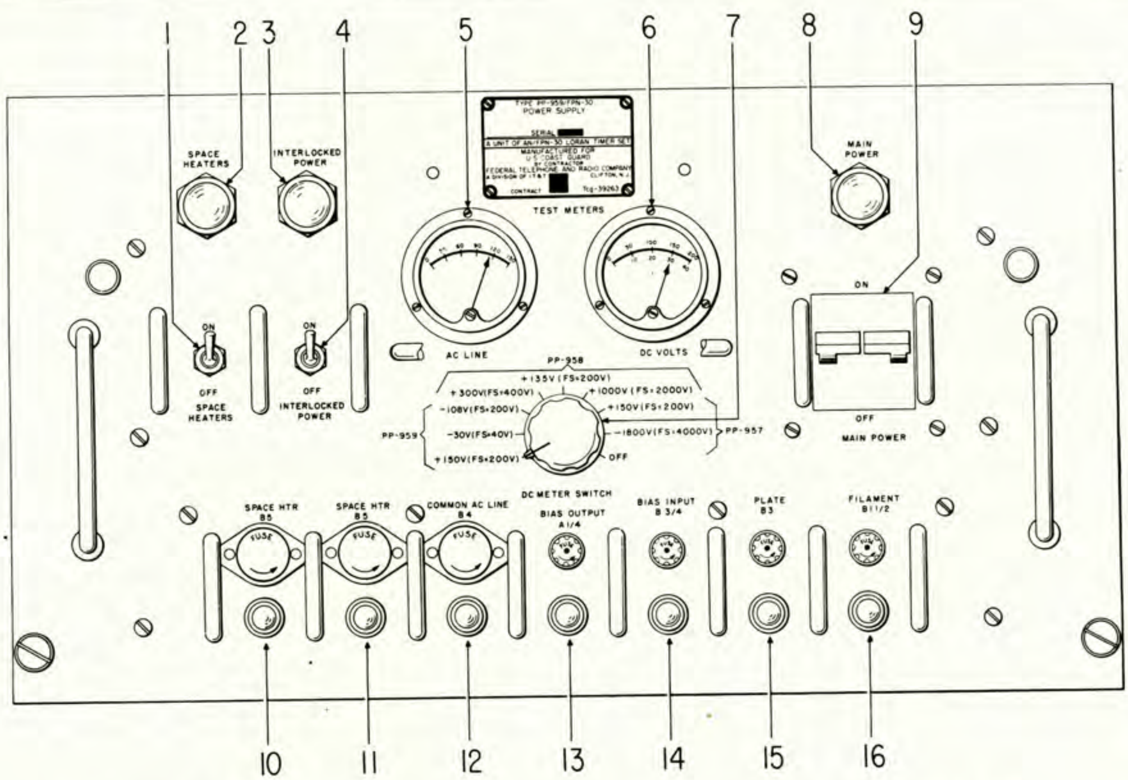


Figure 4–10. Power Supply Type PP–959/FPN–30, Control Locations (Part 1 of 2)

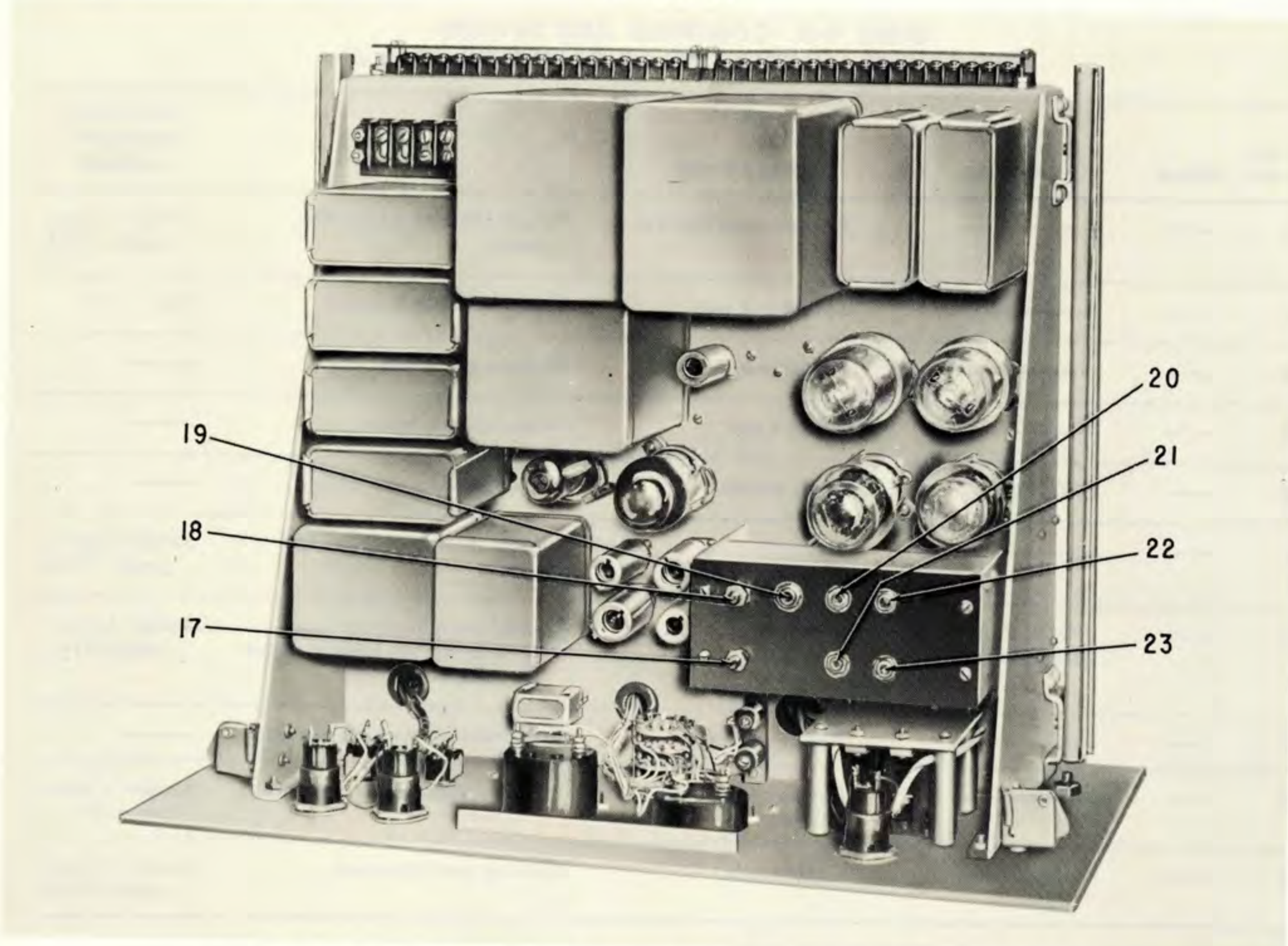


Figure 4–10. Power Supply Type PP–959/FPN–30, Control Locations (Part 2 of 2)

TABLE 4–10. CONTROLS AND DEVICES (POWER SUPPLY TYPE PP–959/FPN–30)

FIG. 4–10 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
1	S2003	SPACE HEATERS ON-OFF	DPDT toggle switch.	Controls power to space heaters. Normally in the ON position.	———
2	I2010	SPACE HEATERS	Red jewel indicator with 6S6–125 lamp.	Indicates that space heaters are energized.	———
3	I2008	INTERLOCKED POWER	Red jewel indicator with 6S6–125 lamp.	Indicates that INTERLOCKED POWER switch (S2004) is in ON position and power is being supplied to interlocked circuits.	———
4	S2004	INTERLOCKED POWER ON-OFF	SPDT toggle switch.	Supplies power to interlocked circuits which include all units in timer except Power Supply Type PP–959/FPN–30 and Radio Frequency Oscillator O–202/FPN–30.	———
5	M2002	AC LINE	A-c voltmeter. Weston model S17.	Monitors input power line voltage. Should normally read 115 volts ac.	———

TABLE 4–10. CONTROLS AND DEVICES (POWER SUPPLY TYPE PP–959/FPN–30) (Cont'd)

FIG. 4–10 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
6	M2001	DC VOLTS	D-c voltmeter. Weston model S06.	Monitors voltage of various power supply output circuits as selected by DC METER SWITCH (S2002).	Section 3, paragraph 14*d*.
7	S2002	DC METER SWITCH	9-position rotary switch, positions marked: PP–959 +150V (FS=200V) −30V (FS=40V) −108V (FS=200V) PP–958 +300V (FS=400V) +135V (FS=200V) +1,000V (FS=2000V) PP–957 +150V (FS=200V) −1,800V (FS=4000V) OFF	Connects the selected power supply output voltage circuit to DC LINE voltmeter (M2001).	Section 3, paragraph 14*d*.
8	I2009	MAIN POWER	Red jewel indicator with 6S6–125 lamp.	Indicates MAIN POWER circuit breaker switch (S2001) is in the power ON position and a-c power is being supplied to timer.	———
9	S2001	MAIN POWER ON-OFF	Magnetically tripped with manual reset; 20A, maximum current.	Controls a-c power to Power Supply PP–959, Radio Frequency Oscillator O–202/FPN–30, and interlocked circuits. See INTERLOCKED POWER switch (S2004) above. Magnetic overload device opens breaker if load current exceeds 20 amps.	———
10	F2007 I2007	SPACE HTR B 5	Cartridge fuse (5 amps) and white jewel indicator with NE–51 neon lamp.	Fuse protects space heater circuit. Lamp glows if corresponding fuse is open and circuit is otherwise complete and energized.	———
11	F2006 I2006	SPACE HTR B 5	Cartridge fuse (5 amps) and white jewel indicator with NE–51 neon lamp.	Fuse protects space heater circuit. Lamp glows if corresponding fuse is open and circuit is otherwise complete and energized.	———
12	F2005 I2005	COMMON AC LINE B 4	Cartridge fuse (4 amps) and white jewel indicator with NE–51 neon lamp.	Fuse protects Power Supply PP–959/FPN–30 and Radio Frequency Oscillator O–202/FPN–30 a-c circuits, and interlocked circuits. Indicator glows if corresponding fuse is open and circuits are otherwise complete and energized.	———
13	F2004 I2004	BIAS OUTPUT A1/4	Cartridge fuse (1/4 amp) and white jewel indicator with NE–51 neon lamp.	Fuse protects bias supply output voltage circuits. Indicator glows if corresponding fuse is open and circuits are otherwise complete and energized.	———

TABLE 4–10. CONTROLS AND DEVICES (POWER SUPPLY TYPE PP–959/FPN–30) (Cont'd)

FIG. 4–10 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
14	F2003 I2003	BIAS INPUT B3/4	Cartridge fuse (3/4 amp) and white jewel indicator with NE–51 neon lamp.	Fuse protects primary of bias supply transformer T2003. Indicator glows if corresponding fuse is open and circuit is otherwise complete and energized.	——
15	F2001 I2001	PLATE B 3	Cartridge fuse (3 amps) and white jewel indicator with NE–51 neon lamp.	Fuse protects primary of plate supply transformer T2001. Indicator glows if corresponding fuse is open and circuit is otherwise complete and energized.	——
16	F2002 I2002	FILAMENT B1 1/2	Cartridge fuse (1-1/2 amps) and white jewel indicator with NE–51 neon lamp.	Fuse protects primary of filament transformer T2002. Indicator glows if corresponding fuse is open and circuit is otherwise complete and energized.	——
CHASSIS MOUNTED CONTROLS AND DEVICES REGULATOR BALANCE TEST BOARD					
17	R2022	+150 V ADJ	Screwdriver adjuster (potentiometer).	Provides for adjusting +150-volt regulated power supply output voltage. In adjusting reference is made to DC LINE meter.	Section 3, paragraph 14*d*.
18	R2033	−30 V ADJ	Screwdriver adjuster (potentiometer).	Provides for adjusting −30-volt regulated power supply output voltage. In adjusting reference is made to DC LINE meter.	Section 3, paragraph 14*d*.
19	J2007	COMMON	1-pin test jack.	Common (negative) jack for testing operation of voltage regulator tubes V2003 (6AS7G) and V2004 (6AS7G).	Section 3, paragraph 14*d*.
20	J2003	V2004 A	1-pin test jack.	Jack for testing cathode current of voltage regulator tube V2004 (6AS7G), section A. Used in conjunction with COMMON—jack (J2007).	Section 3, paragraph 14*d*(4).
21	J2004	V2004 B	1-pin test jack.	Jack for testing cathode current of voltage regulator tube V2004 (6AS7G), section B. Used in conjunction with COMMON—jack (J2007).	Section 3, paragraph 14*d*(4).
22	J2001	V2003 A	1-pin test jack.	Jack for testing cathode current of voltage regulator tube V2003 (6AS7G), section A. Used in conjunction with COMMON—jack (J2007).	Section 3, paragraph 14*d*(4).
23	J2002	V2003 B	1-pin test jack.	Jack for testing cathode current of voltage regulator tube V2003 (6AS7G), section B. Used in conjunction with COMMON—jack (J2007).	Section 3, paragraph 14*d*(4).

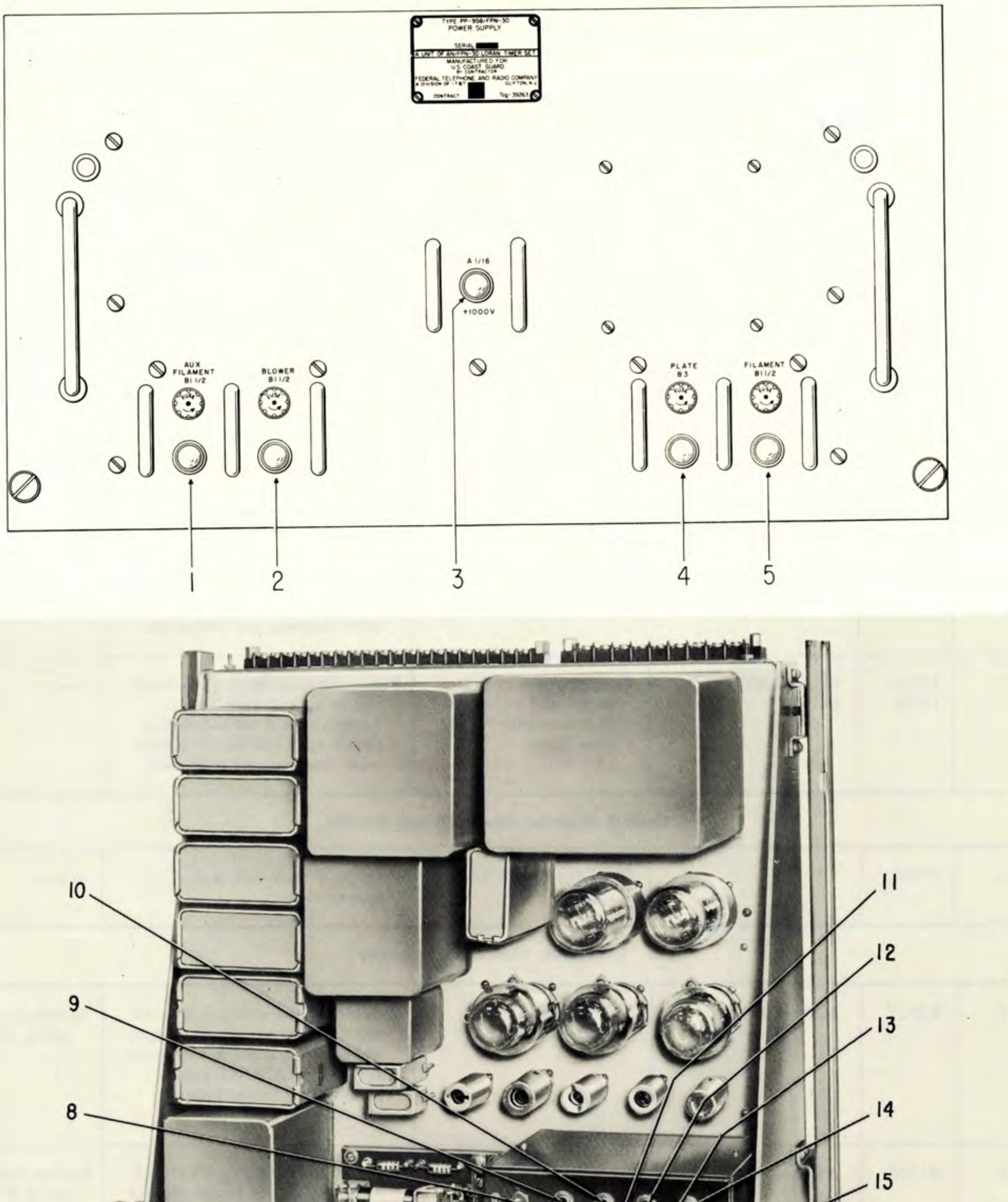


Figure 4–11. Power Supply Type PP–958/FPN–30, Control Locations

TABLE 4–11. CONTROLS AND DEVICES (POWER SUPPLY TYPE PP–958/FPN–30)

FIG. 4–11 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
1	F1903 I1903	AUX FILAMENT B1 1/2	Cartridge fuse (1-1/2 amps) and white jewel indicator with NE–51 neon lamp.	Fuse protects primary of auxiliary filament transformer T1903. Lamp glows if corresponding fuse is open and circuit is otherwise energized.	——
2	F1904 I1904	BLOWER B1 1/2	Cartridge fuse (1-1/2 amps) and white jewel indicator with NE–51 neon lamp.	Fuse protects blower circuits. Lamp glows if corresponding fuse is open and circuits are otherwise complete and energized.	——
3	I1905	A1/16 +1000V	White jewel indicator with NE–51 neon lamp.	Lamp glows if corresponding fuse F1905 (chassis mounted) is open and —1,000-volt power supply circuit is otherwise energized.	——
4	F1901 I1901	PLATE B3	Cartridge fuse (3 amps) and white jewel indicator with NE–51 neon lamp.	Fuse protects primary of plate supply transformer T1901. Lamp glows if corresponding fuse is open and circuit is otherwise complete and energized.	——
5	F1902 I1902	FILAMENT B1 1/2	Cartridge fuse (1-1/2 amps) and white jewel indicator with NE–51 neon lamp.	Fuse protects primary of filament supply transformer T1902. Lamp glows if corresponding fuse is open and circuit is otherwise complete and energized.	——
CHASSIS MOUNTED CONTROLS AND DEVICES					
6	F1905		Cartridge fuse (1/16 amp)	Protects +1,000-volt power supply circuits.	——
REGULATOR BALANCE TEST BOARD					
7	R1922	+300 V ADJ	Screwdriver adjuster (potentiometer).	Provides for adjusting +300-volt regulated power supply output voltage. In adjusting, reference is made to DC LINE meter (M2001) on Power Supply PP–959/FPN–30.	Section 3, paragraph 14*d*.
8	R1933	+135 V ADJ	Screwdriver adjuster (potentiometer).	Provides for adjusting +135-volt regulated power supply output voltage. In adjusting, reference is made to DC LINE meter (M2001) on Power Supply PP–959/FPN–30.	Section 3, paragraph 14*d*.
9	J1907	COMMON	1-pin test jack.	Common (negative) jack for testing operation of +300-volt voltage regulator tubes V1903 (6AS7G), V1904 (6AS7G) and V1905 (6AS7G).	Section 3, paragraph 14*d*.

TABLE 4–11. CONTROLS AND DEVICES (POWER SUPPLY TYPE PP–958/FPN–30) (Cont'd)

FIG. 4–11 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
10	J1905	V1905 A	1-pin test jack.	Jack for testing cathode current of voltage regulator tube V1905 (6AS7G), section A. Used in conjunction with COMMON— jack (J1907).	Section 3, paragraph 14*d*.
11	J1906	V1905 B	1-pin test jack.	Jack for testing cathode current of voltage regulator tube V1905 (6AS7G), section B. Used in conjunction with COMMON— jack (J1907).	Section 3, paragraph 14*d*.
12	J1903	V1904 A	1-pin test jack.	Jack for testing cathode current of voltage regulator tube V1904 (6AS7G), section A. Used in conjunction with COMMON— jack (J1907).	Section 3, paragraph 14*d*.
13	J1904	V1904 B	1-pin test jack.	Jack for testing cathode current of voltage regulator tube V1904 (6AS7G), section B. Used in conjunction with COMMON— jack (J1907).	Section 3, paragraph 14*d*.
14	J1901	V1903 A	1-pin test jack.	Jack for testing cathode current of voltage regulator tube V1904 (6AS7G), section A. Used in conjunction with COMMON— jack (J1907).	Section 3, paragraph 14*d*.
15	J1902	V1903 B	1-pin test jack.	Jack for testing cathode current of voltage regulator tube V1904 (6AS7G), section A. Used in conjunction with COMMON— jack (J1907).	Section 3, paragraph 14*d*.

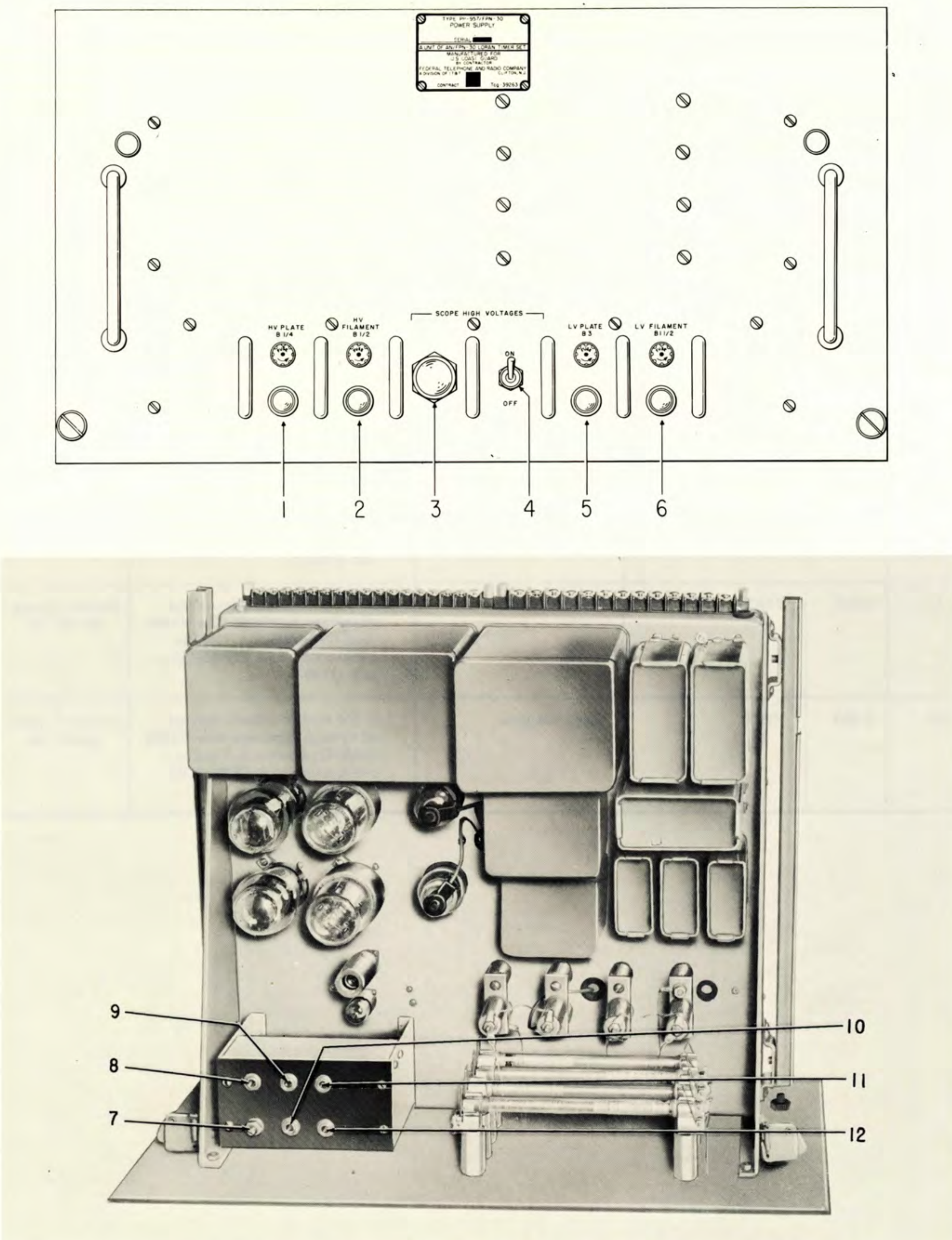


Figure 4–12. Power Supply Type PP–957/FPN–30, Control Locations

TABLE 4–12. CONTROLS AND DEVICES (POWER SUPPLY TYPE PP–957/FPN–30)

FIG. 4–12 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
1	F2101 I2101	HV PLATE B1/4	Cartridge fuse (1/4 amp) and white jewel indicator with neon lamp NE–51.	Fuse protects primary of high voltage transformer T2101. Lamp glows if fuse is open and circuit is otherwise complete and energized.	——
2	F2102 I2102	HV FILAMENT B1/2	Cartridge fuse (1/2 amp) and white jewel indicator with neon lamp NE–51.	Fuse protects primary of filament transformer T2102. Lamp glows if fuse is open and circuit is otherwise complete and energized.	——
3	I2105	SCOPE HIGH VOLTAGES	Red jewel indicator with 6S6–125 lamp.	Indicates 115-volt a-c power is being supplied to scope high-voltage rectifier circuits (SCOPE HIGH VOLTAGES switch (S2101) in ON position).	——
4	S2101	SCOPE HIGH VOLTAGES ON-OFF	DPDT toggle switch, position marked ON-OFF.	Controls 115-volt a-c power to scope high-voltage rectifier circuits. Normally in ON position.	——
5	F2103 I2103	LV PLATE B 3	Cartridge fuse (3 amps) and white jewel indicator with neon lamp NE–51.	Fuse protects primary of low-voltage plate transformer T2103. Lamp glows if fuse is open and circuit is otherwise energized.	——
6	F2104 I2104	LV FILAMENT B1-1/2	Cartridge fuse (1-1/2 amps) and white jewel indicator with neon lamp NE–51.	Fuse protects primary of low-voltage filament transformer T2104. Lamp glows if fuse is open and circuit is otherwise energized.	——
			CHASSIS CONTROLS AND DEVICES BALANCE TEST BOARD		
7	R2122	+150 V ADJ	Screwdriver adjuster (potentiometer).	Provides for adjusting +150-volt regulated power supply output voltage. In adjusting, reference is made to DC LINE meter (M2001) on Power Supply PP–959/FPN–30.	Section 3, paragraph 14*d*.
8	J2107	COMMON	1-pin test jack.	Common (negative) jack for testing operation of +150-volt voltage regulator tubes V2106 (6AS7G) and V2107 (6AS7G).	Section 3, paragraph 14*d*.
9	J2105	V2107 A	1-pin test jack.	Jack for testing cathode current of voltage regulator tube V2107 (6AS7G), section A. Used in conjunction with COMMON—jack (J2107).	Section 3, paragraph 14*d*.

TABLE 4–12. CONTROLS AND DEVICES (POWER SUPPLY TYPE PP–957/FPN–30) (Cont'd)

FIG. 4–12 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
10	J2106	V2107 B	1-pin test jack.	Jack for testing cathode current of voltage regulator tube V2107 (6AS7G), section B. Used in conjunction with COMMON—jack (J2107).	Section 3, paragraph 14*d*.
11	J2103	V2106 A	1-pin test jack.	Jack for testing cathode current of voltage regulator tube V2106 (6AS7G), section A. Used in conjunction with COMMON—jack (J2107).	Section 3, paragraph 14*d*.
12	J2104	V2106 B	1-pin test jack.	Jack for testing cathode current of voltage regulator tube V2106 (6AS7G), section B. Used in conjunction with COMMON—jack (J2107).	Section 3, paragraph 14*d*.

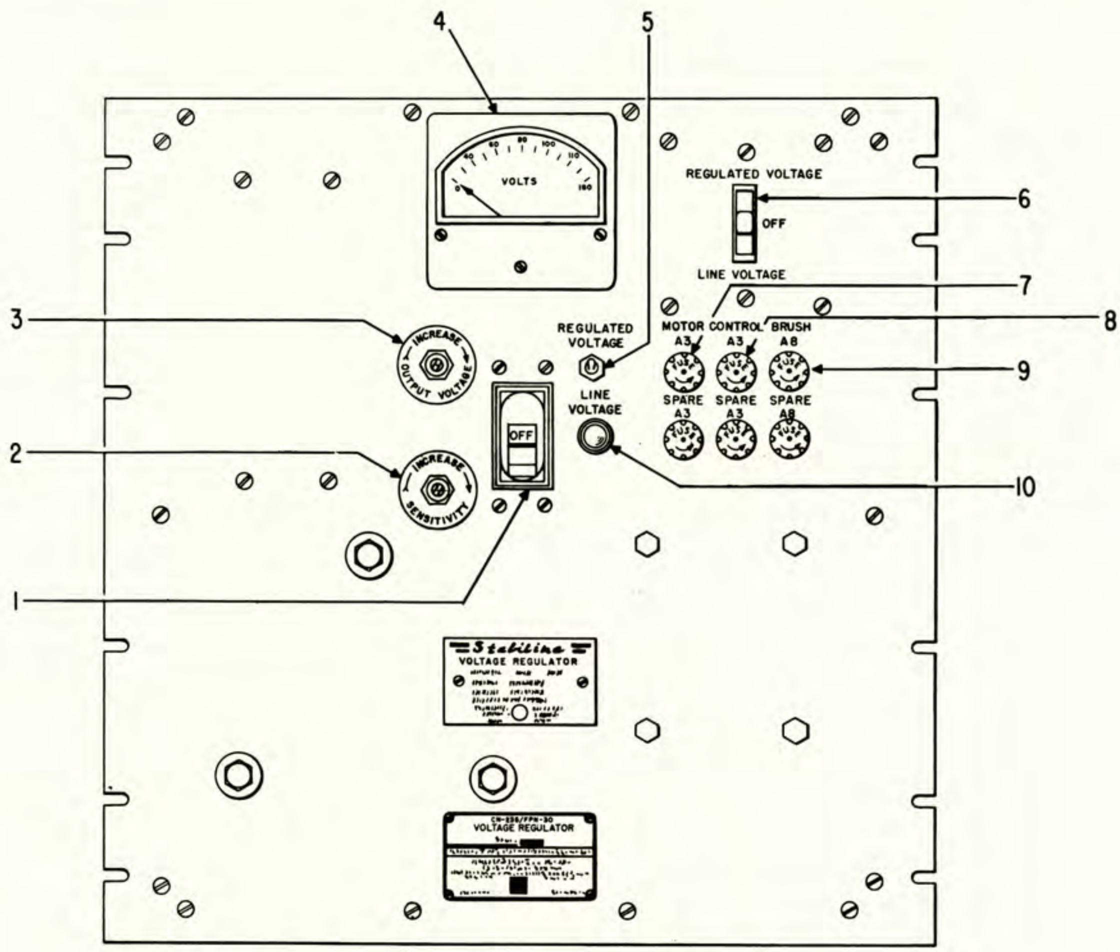


Figure 4–13. Voltage Regulator Type CN–235/FPN–30, Control Locations

TABLE 4–13. CONTROLS AND DEVICES (VOLTAGE REGULATOR TYPE CN–235/FPN–30)

FIG. 4–13 REF. NO.	SYMBOL	MARKING	DESCRIPTION	FUNCTION	ADJUSTMENT PROCEDURE REFERENCE
1	K2301	ON-OFF	Magnetically tripped circuit breaker. 20A rating. Manually reset.	Main power switch. Magnetic overload device opens breaker if load current exceeds 20 amperes.	——
2	R2303	SENSITIVITY	Screwdriver adjuster (potentiometer).	Controls sensitivity of voltage regulator. Normally adjusted to a point just before the voltage regulator "hunts".	Section 3, paragraph 14*b*(3).
3	R2302	OUTPUT VOLTAGE	Screwdriver adjuster (potentiometer).	Presets regulated output voltage. Adjusted to provide 115 volts ac out.	Section 3, paragraph 14*b*(2).
4	M2301	——	Voltmeter.	Reads line voltage input or regulated voltage output as selected by meter switch (S2304).	——
5	S2304	——	SPDT toggle switch, positions marked: REGULATED VOLTAGE LINE VOLTAGE	Selects either the REGULATED VOLTAGE output or the LINE VOLTAGE input for monitoring on voltmeter. REGULATED VOLTAGE normal position.	——
6	S2303	——	3-position toggle switch, positions marked: REGULATED VOLTAGE OFF LINE VOLTAGE	Selects voltage regulator output. REGULATED VOLTAGE position: Normal position. Output obtained from voltage regulator circuits. OFF position: Output and input disconnected from voltage regulator. LINE VOLTAGE position: Output voltage obtained directly from input line voltage, bypassing voltage regulator.	——
7	F2303	MOTOR A3 SPARE A3	Cartridge fuse (3 amps) and spare.	Protects correction motor B2301.	——
8	F2302	CONTROL A3 SPARE A3	Cartridge fuse (3 amps) and spare.	Protects control transformer T2303.	——
9	F2301	BRUSH A8	Cartridge fuse (8 amps) and spare.	Protects brush contact on T2301.	——
10	I2301	——	White jewel indicator with neon lamp NE–51.	Power on indicator.	——

5. WARM-UP PERIODS.

a. NORMAL CONDITIONS.—It is important that consideration be given to the warm-up requirements for the timer when the equipment is turned on after a period of shut-down; otherwise, frequency error and drift will result. This imposes a severe burden upon the equipment and the operator in attempting to maintain synchronization and may result in the transmission of signals which are incorrectly timed. In short, if the timer oscillator is not warmed up properly, the results can be highly unsatisfactory.

The oscillator should be permitted a warm-up period of 24 hours (from a cold start). During the early part of such a period, frequency drift will be pronounced. The drift, incidentally, is extremely small when considered in terms of usual standards (broadcast, for example), although it is great when the order of accuracy specified for loran transmission is taken into account.

Note

An INTERLOCKED POWER switch is provided on Power Supply PP–959 which controls power to all units in the timer except the oscillator and Power Supply PP–959. Power can be supplied during the initial warm-up period, or thereafter, for the oscillator without supplying power to the remaining units of the timer. This is accomplished by placing the INTERLOCKED POWER switch in the OFF position and the MAIN POWER switch in the ON position. Power may be supplied to the balance of the timer at any time by placing the INTERLOCKED POWER switch in the ON position.

When the oscillator is first turned on, and for the first few hours thereafter, the panel meter will read off-scale (with the meter switch in the HEATER position). This action results because the crystal oven is cold and the heater bridge must deliver far more heat than normal. Approximately 24 hours after being turned on, the oscillator will stabilize. This condition will be recognized by the fact that the reading of the panel meter (with the switch in the HEATER position) will have dropped to a value of about 100 $\pm$40 microamperes.

The balance of the timer requires about 15 minutes of warm-up. Because of the longer time of warm-up for the oscillator, the warm-up of the other timer units may be increased conveniently, in most cases, to an hour.

b. EMERGENCY CONDITIONS.—In emergencies, the recommended warm-up periods can be shortened, although this practice should be restricted to only specially authorized cases.

The oscillator can be placed in active service after a minimum of about five hours. This will require special attention on the part of the operator. At a master station, frequent frequency checks must be made against a signal from radio station WWV, followed by a slow correction, so that the slave station will not lose synchronization. At a slave station, close monitoring and frequent resetting of the FREQUENCY CORRECTOR on the synchronization control unit will be required.

The remaining units of the timer can be placed in active service after a minimum of about one minute. In this case, close monitoring must be maintained for a period of about 15 minutes (provided that the oscillator has undergone the recommended warm-up). A good rule to follow in this case is that it is better to delay transmission for a few minutes than it is to transmit a signal of questionable value.

6. EMPLOYMENT OF A MASTER TIMER.

a. PLACING A SHUT-DOWN MASTER TIMER INTO STAND-BY STATUS.—To place a shut-down master timer into stand-by status, use the following procedure:

(1) INITIAL SETTING OF SWITCHES.—Check that the switches of the timer are set as shown in table 4–14 below.

Note

It is assumed that, except for the switches listed in table 4–14, the various controls on the timer are adjusted as described in Section 3, paragraphs 17 through 29. Should the timer have been shut down for repair of a unit, it is assumed that at the conclusion of the service operation the particular unit will be readjusted accordingly.

(2) APPLYING POWER.

Step 1. Place the main power circuit breaker on the associated voltage regulator to the ON position. Check that the meter on the voltage regulator reads 115 volts ac.

Step 2. Place the MAIN POWER circuit breaker switch on Power Supply PP–959 to the ON position. Check that the MAIN POWER indicator lamp lights.

(3) STAND-BY CHECKING PROCEDURE. — Verify that the timer is in stand-by condition by following the stand-by checking procedure outlined in the next paragraph.

TABLE 4–14. INITIAL SETTING OF SWITCHES FOR PLACING A MASTER TIMER INTO STAND-BY STATUS

UNIT	MARKING	SYMBOL	POSITION
Radio Receiver Type R–564/FPN–30	REMOTE SIGNAL	S1201	IN
	AMPLITUDE BALANCE	S1203	OUT
Synchronization Indicator Type IP–238/FPN–30	BUZZER	S806	OFF
	VIDEO SEPARATION	R852	Extreme counterclockwise
	RF SEPARATION	R898	Extreme counterclockwise
	BLINK SELECTOR	S802	OFF
Electrical Synchronizer Type SN–117/FPN–30	POWER	S1502	ON
	REMOTE ALARM	S1501	OUT
	LOCAL SIGNAL	S1506	IN
Power Supply Type PP–957/FPN–30	SCOPE HIGH VOLTAGES	S2101	ON
Frequency Divider CV–274/FPN–30	TEST COUNT INSERT	S201	OFF (CIRCUIT NORMAL)
Synchronization Control Type C–1238/FPN–30	60~ AMPL PWR	S102	ON
	MOTOR RANGE	——	LOW
	MAX MOTOR SPEED	R157	4 μsec per minute
	AUTO SYNC	S104	OFF
	FREQUENCY CORRECTOR	S103	IN
Power Supply Type PP–959/FPN–30	SPACE HEATERS	S2003	ON
	INTERLOCKED POWER	S2004	ON
	MAIN POWER	S2001	OFF
Voltage Regulator Type CN–235/FPN–30	——	S2303	REGULATED
	ON-OFF	K2301	OFF

b. STAND-BY CHECKING PROCEDURE: MASTER TIMER.—This paragraph outlines a checking procedure to determine whether a master timer is in stand-by status; that is, completely adjusted and ready to be switched into operation at a moment's notice. These checks must be made whenever there is the possibility that drifts or changes may have occurred in the timer circuits or after a service operation on any of the timer units. On those occasions when power is removed from the timer to perform the service operation, it is assumed that the operator will observe the proper warm-up periods before the checks are made—namely, a 15-minute warm-up should be observed before the checks on the units other than the oscillator are made, and a 24-hour warm-up should be observed before the final checks on the oscillator are made.

(1) SELECTOR GATE CENTERING.

Step 1. Turn the SIGNAL SELECTOR switch on the test scope to the TIME DELAY position. Turn the TEST SIGNAL switch on the time delay unit consecutively to the A1000, B1000, B100 and B10 positions. In each case, check to see that the selector gate is centered beneath the pushed-up marker. If necessary, center the position of the gate by means of the corresponding delay control on the time delay unit.

Step 2. Check for centered B preset delay gates if used.

(2) TRANSMITTER TRIGGER AND BLANKING PULSE.—With the SIGNAL SELECTOR switch on the test scope still in the TIME DELAY position, check for the presence of the transmitter trigger and the blanking pulse by turning the TEST SIGNAL switch on the time delay unit to the TRANSM TRIG and BLANKING positions, respectively.

(3) SLOW SCOPE PRESENTATION. — Check that the SLOW SCOPE presentation on the synchronization indicator unit is normal. If necessary, refer to the presentation on the operating timer or refer to figure 3–16, which shows a typical SLOW SCOPE presentation for a HIGH specific rate.

(4) MARKER COINCIDENCE.

Step 1. Place the VIDEO PRESENTATION switch on the synchronization indicator unit in the CAL position. Turn the VIDEO SWEEP SPEED control to the extreme clockwise position.

Step 2. Observe that a 10-microsecond marker is coincident with a 1-microsecond marker on the VIDEO SCOPE. Normal coincidence may be observed in figure 3–34. The 1's are the shortest markers in the figure. If the markers are not coincident, then make them coincident, as described in Section 3, paragraph 20 *c* (11).

(5) REFERENCE DELAY.—Check the B normal reference delay, as described in Section 5, paragraph 4. Check the B preset reference delays if used.

(6) BLINKING.—Turn the BLINK SELECTOR switch on the synchronization indicator unit to the MANUAL position. Check that the master pedestal on the SLOW SCOPE cyclically moves 1,000 microseconds to the right. Restore the BLINK SELECTOR switch to the OFF position.

(7) SYNC BALANCE.

Step 1. Turn the COARSE RF GAIN control on the receiver to the extreme counterclockwise position. Place the TEST SIGNAL switch on the electrical synchronizer to the AC ERROR position and the SIGNAL SELECTOR switch on the test scope to the ELECT SYNC position.

Step 2. Place the COARSE SWEEP SPEED control on the test scope to the 1 position. Place the FINE SWEEP SPEED control in the extreme counterclockwise position.

Step 3. Adjust the SYNC BALANCE control on the electrical synchronizer until the a-c error signal appearing on the test scope is at a minimum. Note that this adjustment must be made very slowly because of the large time constants involved.

(8) SYNC GATES.

Step 1. Check that the PHASE dial on the sync control unit is in the zero position. With the SIGNAL SELECTOR switch on the test scope still in the ELECT SYNC position, place the SYNC SELECTOR switch on the test scope to the PEDESTAL position, the MARKER SELECTOR switch to the 10's and 1's position, and the TEST SIGNAL switch on the electrical synchronizer to the MIXED GATES position.

Step 2. Turn the COARSE SWEEP SPEED control on the test scope to the No. 4 position and the FINE SWEEP SPEED control to the extreme clockwise position. Adjust the MARKER HEIGHT control so that the 1-microsecond markers are clearly visible on the oscilloscope. Adjust the CONTINUOUS SWEEP DELAY control on the test scope so that the electrical synchronizer selector gates are visible.

Step 3. Check the superposition of the local and remote gates. If the gates are separated, but by less than 0.5 microsecond, adjust the REMOTE FINE DELAY control on the electrical synchronizer to superpose them. If they are separated by more than 0.5 microsecond, check the delay range adjustment as described in Section 3, paragraph 29 *i*.

Step 4. Turn the MARKER SELECTOR switch on the test scope to the OFF position.

(9) OSCILLATOR STABILIZATION.

Step 1. Check that the VIDEO and RF PRESENTATION switches in the synchronization indicator are in the REC position. Place the RF SWEEP SPEED control in the extreme counterclockwise position.

Step 2. Place the REMOTE SIGNAL switch on the receiver in the OUT position. Adjust the RF GAIN controls on the receiver until the local signal is visible on the SLOW SCOPE.

Step 3. By means of the DRIFT switch on the synchronization indicator and the COARSE FREQ. ADJ. control on the oscillator, drift the local signal onto the RF SCOPE. The local signal may drift off the RF SCOPE rapidly. This is an indication that the timer oscillator frequency differs a considerable amount from the operating timer oscillator frequency. If such is the case, readjust the oscillator frequency by means of the frequency controls on the oscillator until the local signal on the RF SCOPE appears almost stationary.

Step 4. Using the COARSE FREQUENCY switch on the oscillator, bring the peak of the r-f pulse to the left end of the sweep.

Step 5. Turn the RF SWEEP SPEED control on the synchronization indicator to the extreme clockwise position.

Step 6. Readjust the FINE FREQ. ADJ. control on the oscillator 10 divisions at a time, until the r-f drift, in a period of one minute, is less than the distance (on the sweep) occupied by one r-f cycle.

Step 7. Restore the REMOTE SIGNAL switch on the receiver to the IN position and the RF SWEEP SPEED control on the synchronization indicator to the extreme counterclockwise position.

(10) SIGNAL STANDARDIZATION.

Step 1. Check that the RF SWEEP SPEED control on the synchronization indicator unit is in the extreme counterclockwise position. Adjust the VIDEO SWEEP SPEED control to provide a sweep of about 100 microseconds on the VIDEO SCOPE.

Step 2. If necessary, drift the local and remote signals onto the VIDEO and RF SCOPES by means of the DRIFT switch on the synchronization indicator unit and the COARSE FREQ. ADJ. control on the oscillator. Adjust the VIDEO or RF SWEEP DELAY controls on the synchronization indicator unit so that the signals are visible on both scopes simultaneously. If the local and remote signals are synchronized and if the reference delay on the timer is properly adjusted, the two signals will be superposed.

Step 3. Readjust the RF VERTICAL CTR control and the RF GAIN control on the synchronization indicator unit to provide centered zero-to-positive-peak signals of about three-inch height on the RF SCOPE.

Step 4. Check amplitude equality of signals on the RF SCOPE. If necessary, adjust by means of the LOCAL GAIN control on the receiver.

Step 5. Adjust the RF GAIN COARSE and FINE controls on the receiver and the VIDEO VERTICAL CTR control on the synchronization indicator unit to provide video signals of two-inch zero-to-positive-peak height, as shown in figure 4–14. The two-inch zero-to-positive-peak height of the video signals defines standard receiver output. The RF GAIN control on the RF SCOPE may now be adjusted for a convenient signal amplitude.

(11) RESTORING REFERENCE.—It is important that the trigger of a stand-by master timer be in phase with the trigger of the operating timer, so that when the stand-by timer is placed in operation, a minimum of effort will be required by the slave timer to maintain synchronization. During the initial adjustment of the stand-by timer, a reference was established which defined the condition that the triggers of the two timers were in phase. The reference is defined by the position of the VIDEO SWEEP DELAY dial on the synchronization indicator when the VIDEO SWEEP SPEED control is in the extreme clockwise position and the first zero cross-over of the derivative of the local signal is coincident with the vertical line on the VIDEO SCOPE. To restore the reference, that is, to bring the trigger of the stand-by timer in phase with the trigger of the operating timer, perform the following steps:

Step 1. Place the REMOTE SIGNAL switch on the receiver to the OUT position. Check that the VIDEO PRESENTATION switch on the synchronization indicator is in the REC position. Place the SIGNAL switch on the synchronization indicator to the DERIVATIVE POSITION.

Step 2. Turn the VIDEO SWEEP SPEED control on the synchronization indicator to the extreme clockwise position. Turn the VIDEO SWEEP DELAY control to the reference established in the initial adjustments, Section 3, paragraph 29 *k*. Lock the control in place.

Step 3. By means of the VIDEO VERTICAL CTR control on the synchronization indicator and the COARSE FREQ. ADJ. control on the oscillator, adjust the position of the local derivative signal so that the base line of the signal is vertically centered and the first zero cross-over coincides with the vertical line on the scope. The properly adjusted signal should appear as shown in figure 4–15.

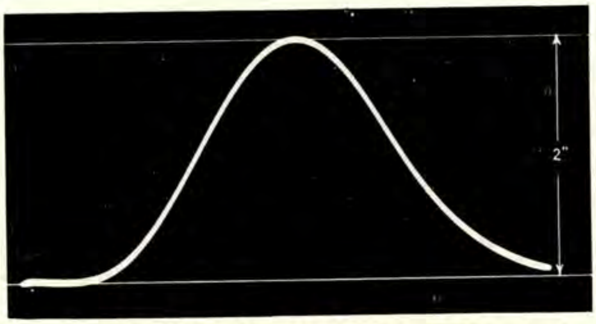


Figure 4–14. Video Signals Adjusted to Two-inch Height Defining Standard Receiver Output

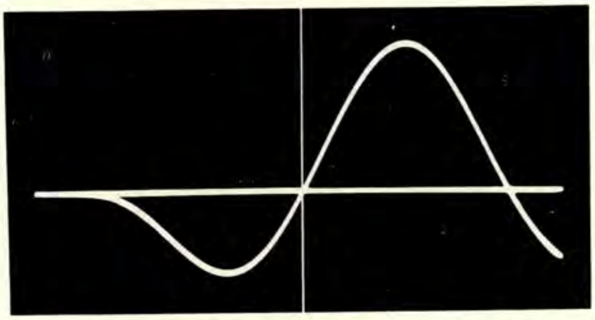


Figure 4–15. Local Signal Second Derivative Adjusted for Stand-by Timer Phase Difference

(12) OSCILLATOR READJUSTMENTS. — To minimize drift from the reference recheck the oscillator frequency from time to time as follows:

Step 1. Place the REMOTE SIGNAL switch on the receiver in the OUT position. Place the RF SWEEP SPEED control in the extreme clockwise position.

Adjust the RF SWEEP DELAY until the maximum sized r-f cycles (peak of envelope) are visible on the RF SCOPE.

Step 2. Check that in one minute the r-f cycle drift is less than the distance on the sweep occupied by one r-f cycle. If necessary, adjust the FINE FREQ. ADJ. control on the oscillator, 10 divisions at a time, until it is.

Step 3. Return the REMOTE SIGNAL switch on the receiver to the IN position.

(13) SUMMARY.—When the checks and adjustments prescribed in the previous paragraphs have been completed, the timer is in stand-by condition and is ready for service as an operating timer. It may be placed in service by making the appropriate change-overs at the switching equipment and the final adjustments explained in the next paragraph.

c. STAND-BY-OPERATE CHANGE-OVER PROCEDURE: MASTER TIMER.—This paragraph outlines the procedure for changing over operation of two associated timers; that is, for placing the stand-by timer in operation and the operating timer in stand-by.

Step 1. Check the phase reference on the stand-by timer. The local derivative signal should appear as shown in figure 4–15 when the VIDEO SWEEP SPEED control on the synchronization indicator is in the extreme clockwise position and VIDEO SWEEP DELAY is set to the reference determined in Section 3, paragraph 29 *k*. If necessary, adjust the position of the local derivative signal by means of the COARSE FREQ. ADJ. control on the oscillator.

Note

The reference is restored so that when the timer is switched into operation a minimum of effort will be required at the slave station to maintain synchronization. In case of an emergency, however, this step may be omitted and the stand-by timer immediately switched into operation as described in the next step.

Step 2. Connect the stand-by timer to the assigned exciter of the operating transmitter by setting the appropriate operating transmitter switch on the loran switching equipment to the corresponding timer position. This places the stand-by timer into operation—i.e., in control of the operating transmitter—and it will henceforth be referred to as the operating timer.

Step 3. Connect the previously operating timer to the assigned exciter of the stand-by transmitter by setting the appropriate stand-by transmitter switch on the loran switching equipment to the corresponding timer position.

Step 4. If the timers are used with the loran switching equipment Model UM and an auxiliary switch has been installed for changing over operation of the recording ammeter, operate this switch accordingly. When using loran switching equipment AN/FPA–2, this step is unnecessary, since the recording ammeter is automatically transferred to the operating timer when the timer is switched into operation.

Step 5. Adjust the local and remote synchronizer gate delays of the newly operating timer. These gates can be exactly adjusted only when the timer is operating. This adjustment, however, does not interfere with timer operation. To adjust the synchronizer gate delays, perform the following:

(1) Check that the PHASE control on the sync control unit is in the zero position and the AUTO SYNC switch is in the OFF position. Turn the REMOTE SIGNAL switch on the receiver to the OUT position. Place the SIGNAL SELECTOR switch on the test scope to the ELECT SYNC position and the TEST SIGNAL switch on the electrical synchronizer to the AC ERROR position.

(2) Place the COARSE SWEEP SPEED control on the test scope to the 1 position. Place the FINE SWEEP SPEED control in the extreme counterclockwise position.

(3) Adjust the FINE LOCAL DELAY control on the electrical synchronizer until the a-c error signal appearing on the test scope is at a minimum. Note that this adjustment must be made very slowly because of the long time constants involved.

(4) Place the SYNC SELECTOR switch on the test scope to the PEDESTAL POSITION, and the TEST SIGNAL switch on the electrical synchronizer to the MIXED GATES position.

(5) Turn the COARSE SWEEP SPEED control on the test scope to the No. 4 position and the FINE SWEEP SPEED control to the extreme clockwise position. Adjust the CONTINUOUS SWEEP DELAY control on the test scope so that the synchronizer gates are visible.

(6) Check the superposition of the local and remote gates. If necessary, adjust the FINE REMOTE DELAY or COARSE REMOTE DELAY controls on the electrical synchronizer to superpose them.

(7) Restore the REMOTE SIGNAL switch on the receiver to the IN position. This completes the adjustment of the local and remote synchronizer gate delays.

Step 6. Place the AUTO SYNC switch on the sync control unit of the newly operating timer to the ON position. Turn the BUZZER switch on the synchronization indicator to the ON position. Place the BLINK SELECTOR switch to the AUTO position.

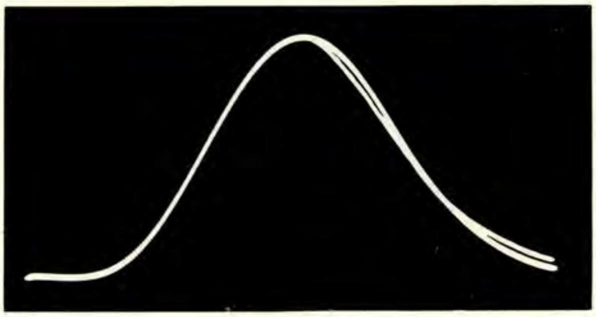


Figure 4–16. Properly Matched Video Signals

Place the REMOTE ALARM switch to the IN position. The PHASE dial and recording ammeter should now indicate any deviation from correct synchronization.

Step 7. Place the AUTO SYNC switch on the sync control unit on the new stand-by timer to the OFF position. Turn the BUZZER switch on the synchronization indicator to the OFF position. Place the BLINK SELECTOR switch to the OFF position. Place the REMOTE ALARM switch to the OUT position.

Step 8. Establish reference on the new standby timer as described in paragraph 6 *b* (11) of this section.

d. ACTIVE OPERATION: MASTER TIMER. — Once operation is underway, the principal operational duties at a master station are to monitor synchronization and to perform the periodic checks called for in Section 5, Operator's Maintenance, as modified by station instructions. The correction of synchronization is not performed at a master timer.

Properly synchronized signals are evidenced on the VIDEO SCOPE of the synchronization indicator when the leading edges of the local and remote video signals are coincident or when the first zero cross-overs of the signals are coincident. Properly matched signals are shown in figures 4–16 and 4–17, respectively. Monitoring may be done automatically or manually.

(1) AUTOMATIC MONITORING.—In automatic monitoring the duty of the operator is to respond to the various automatic error alarms and monitoring devices provided by a properly adjusted and operating electrical synchronizer. These alarms and monitoring devices include a SYNC ERROR alarm circuit, an OFF SYNC alarm circuit, PHASE dial indications on the synchronization control unit, and a recording ammeter. In addition, automatic blinking (BLINK SELECTOR switch on the synchronization indicator in the AUTO position) is employed, wherein blinking is initiated by the alarm circuits.

The SYNC ERROR alarm circuit responds to an error of 1 microsecond or more, and the OFF SYNC alarm circuit responds to remote blinking, a large sync error, a lost signal, and operating on the wrong zero cross-over of the derivative signal. Associated with the alarm circuits are a SYNC ERROR alarm indicator lamp, an OFF SYNC alarm indicator lamp, and a BUZZER which is common to both alarm circuits. The indicator lamp lights almost immediately after the corresponding alarm circuit detects the error. The BUZZER operates after a preset delay interval associated with each alarm circuit. A delay (which is initially adjusted to between five seconds and one minute) is provided in the SYNC ERROR ALARM circuit before the BUZZER operates, and a delay (which is initially adjusted to between 15 seconds and five minutes) is provided in the OFF SYNC alarm circuit. Simultaneously with the BUZZER, the alarm circuits will initiate blinking, provided that the BLINK SELECTOR switch is in the AUTO position.

When an alarm operates, first check that the reason for the error is not local. Although the maintenance of synchronization is the function of the slave, the slave cannot maintain synchronization if the master station equipment is operating improperly. Frequently occurring causes for alarms, and procedures for correction of these causes, are described in paragraph 8 of this section. If the cause of the alarm is found to be local and it cannot be immediately remedied, then switch to a stand-by unit. This should correct the condition so that the slave can restore synchronization after a brief interval.

If the cause of the alarm is the failure of the slave to maintain synchronization, and if the slave is not blinking and blinking has not been initiated automatically, then initiate blinking by placing the BLINK SELECTOR switch to the MANUAL position. If the slave is blinking, or as soon as the slave starts to blink, place the BLINK SELECTOR switch in the OFF position so that the slave station can correct the error.

When the slave operator has corrected the error to his satisfaction, he will stop blinking. When this happens, check the situation carefully. If the error has been corrected satisfactorily, restore the BLINK SELECTOR switch to the AUTO position and proceed with normal operation.

If the error has not been corrected, place the BLINK SELECTOR switch in the MANUAL position again and repeat the procedure outlined immediately above.

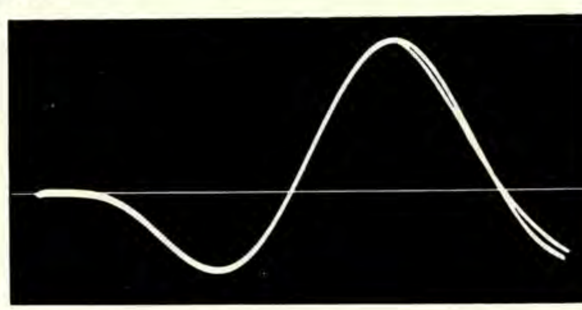


Figure 4–17. Properly Matched Derivatives of Video Signals

The general procedure described above comprises the basic operations of a master station when monitoring automatically. In addition to this, the operator must be familiar with the operation of the recording ammeter and with operation of the receiver and electrical synchronizer against noise and interference. Information relative to these is given in paragraphs 9, 10, and 12 of this section.

(2) MANUAL MONITORING. — In manual monitoring, the electrical synchronizer is not employed (POWER switch on the electrical synchronizer in the OFF position, 60 ~ AMPL PWR switch on the sync control unit in the OFF position, and the BLINK SELECTOR switch on the synchronization indicator in the OFF position). In this case the operator must observe the local and remote video or derivative signals on the VIDEO SCOPE with special care and check that the signals are properly matched. Properly matched signals are shown in figures 4–16 and 4–17.

As soon as an error greater than the allowed tolerance is observed, check to see whether the cause of the error is local. Frequently occurring causes for alarms, and procedures for the correction of these causes, are described in paragraph 8 of this section. If the cause of the error is found to be local and it cannot be remedied immediately, then switch to a stand-by unit. This should correct the condition, and the slave should be able to restore synchronization after a brief interval.

If the error is not local and the slave is not blinking, throw the BLINK SELECTOR switch to the MANUAL position and wait for the slave to start blinking. If the slave is blinking or as soon as the slave starts to blink, place the BLINK SELECTOR switch in the OFF position to allow the slave to correct the error.

When the slave operator has corrected this to his satisfaction, he will stop blinking. When this happens, check the situation carefully. If the error has been corrected satisfactorily, proceed with normal operation.

If the error has not been corrected, place the BLINK SELECTOR switch in the MANUAL position and repeat the procedure outlined immediately above.

The general procedure described above comprises the basic operations of a master station when monitoring automatically. In addition to this, the operator must be familiar with the operation of the recording ammeter and with operation of the receiver and electrical synchronizer against noise and interference. Information relative to these is given in paragraphs 9, 10, and 12 of this section.

7. EMPLOYMENT OF A SLAVE TIMER.

a. PLACING A SHUT-DOWN TIMER INTO STAND-BY STATUS.—To place a shut-down slave timer into stand-by status, use the following procedure:

(1) INITIAL SETTING OF SWITCHES. — Check that the switches on the timer are set as shown in table 4–15 below.

Note

It is assumed that, except for the switches listed in table 4–15, the various controls on the timer are adjusted as described in Section 3, paragraphs 17 through 29. Should the timer have been shut down for repair of a unit, it is assumed that at the conclusion of the service operation the particular unit will be readjusted accordingly.

(2) APPLYING POWER.

Step 1. Place the main power circuit breaker on the associated voltage regulator to the ON position. Check that the meter on the voltage regulator reads 115 volts ac.

Step 2. Place the MAIN POWER circuit breaker switch on Power Supply PP–959 to the ON position. Check that the MAIN POWER indicator lamp lights.

(3) STAND-BY CHECKING PROCEDURE. — Verify that the timer is in stand-by condition by following the stand-by checking procedure outlined in the next paragraph.

b. STAND-BY CHECKING PROCEDURE: SLAVE TIMER.—This paragraph outlines a checking procedure to determine whether a slave timer is in stand-by status; that is, completely adjusted and ready to be switched into operation at a moment's notice. These checks must be made whenever there is the possibility that drifts or changes may have occurred in the timer circuits; for example, if the timer has not been maintained in synchronization for any length of time or if it was necessary to perform a service operation on any of the timer units. On those occasions when it is necessary to remove power from the timer to perform the service operation, it is assumed that the operator will observe the proper warm-up periods before the checks are made—namely, a 15-minute warm-up should be observed before the checks on the units other than the oscillator are made and a 24-hour warm-up should be observed before the final checks on the oscillator are made.

(1) SELECTOR GATE CENTERING.

Step 1. Turn the SIGNAL SELECTOR switch on the test scope to the TIME DELAY position. Turn the TEST SIGNAL switch on the time delay unit consecutively to the A1000, B1000, B100, and B10 positions. In each case check to see that the selector gate is centered beneath the pushed-up marker. If necessary, center the position of the gate by means of the corresponding delay control on the time delay unit.

Step 2. Check for centered B preset delay gates (if used).

(2) TRANSMITTER TRIGGER AND BLANKING PULSE.—With the SIGNAL SELECTOR switch on the test scope still in the TIME DELAY position,

TABLE 4–15. INITIAL SETTING OF SWITCHES FOR PLACING A SHUT-DOWN SLAVE TIMER INTO STAND-BY STATUS

UNIT	MARKING	SYMBOL	POSITION
Radio Receiver Type R–564/FPN–30	REMOTE SIGNAL	S1201	IN
	AMPLITUDE BALANCE	S1203	OUT
Synchronization Indicator Type IP–238/FPN–30	BUZZER	S806	OFF
	VIDEO SEPARATION	R852	Extreme counterclockwise
	RF SEPARATION	R898	Extreme counterclockwise
	BLINK SELECTOR	S802	OFF
Electrical Synchronizer Type SN–117/FPN–30	POWER	S1502	ON
	REMOTE ALARM	S1501	OUT
	LOCAL SIGNAL	S1506	OUT
Power Supply Type PP–957/FPN–30	SCOPE HIGH VOLTAGES	S2101	ON
Frequency Divider Type CV–274/FPN–30	TEST COUNT INSERT	S201	OFF (CIRCUIT NORMAL)
Synchronization Control Type C–1238/FPN–30	60~ AMPL PWR	S102	ON
	MOTOR RANGE	——	LOW
	MAX MOTOR SPEED	R157	4 μsec per minute
	AUTO SYNC	S104	OFF
	FREQUENCY CORRECTOR	S103	OUT
Power Supply Type PP–959/FPN–30	SPACE HEATERS	S2003	ON
	INTERLOCKED POWER	S2004	ON
	MAIN POWER	S2001	OFF
Voltage Regulator Type CN–235/FPN–30	——	S2303	REGULATED
	ON-OFF	K2301	OFF

check for the presence of the transmitter trigger and the blanking pulse by turning the TEST SIGNAL switch on the time delay unit to the TRANSM TRIG and BLANKING positions, respectively.

(3) SLOW SCOPE PRESENTATION. — Check that the SLOW SCOPE presentation on the synchronization indicator unit is normal. Refer to the presentation on the operating timer if necessary, or refer to figure 3–16 which shows a typical SLOW SCOPE presentation for a HIGH specific rate.

(4) MARKER COINCIDENCE.

Step 1. Place the VIDEO PRESENTATION switch on the synchronization indicator unit in the CAL position. Turn the VIDEO SWEEP SPEED control to the extreme clockwise position.

Step 2. Observe that a 10-microsecond marker is coincident with a 1-microsecond marker on the VIDEO SCOPE. Normal coincidence may be observed in figure 3–34. The 1's are the shortest markers in this figure. If the markers are not coincident, make them coincident, as described in Section 3, paragraph 20 *c* (11).

(5) REFERENCE DELAY. — Check the B normal reference delay as described in Section 3, subparagraph 22 *b*. Check the B preset reference delays if used.

(6) BLINKING.—Turn the BLINK SELECTOR switch on the synchronization indicator unit to the MANUAL position. Check that the slave pedestal on

the SLOW SCOPE cyclically moves 1,000 microseconds to the right. Restore the BLINK SELECTOR switch to the OFF position.

(7) SYNC BALANCE.

Step 1. Turn the COARSE RF GAIN control on the receiver to the extreme counterclockwise position. Place the TEST SIGNAL switch on the electrical synchronizer to the AC ERROR position and the SIGNAL SELECTOR switch on the test scope to the ELECT SYNC position.

Step 2. Place the COARSE SWEEP SPEED control on the test scope to the 1 position. Place the FINE SWEEP SPEED control in the extreme counterclockwise position.

Step 3. Adjust the SYNC BALANCE control on the electrical synchronizer until the a-c error signal appearing on the test scope is at a minimum. Note that this adjustment must be made very slowly because of the large time constants involved.

(8) OSCILLATOR STABILIZATION.

Step 1. Check that the VIDEO and RF PRESENTATION switches in the synchronization indicator are in the REC position. Place the RF SWEEP control in the extreme counterclockwise position.

Step 2. Place the REMOTE SIGNAL switch on the receiver in the OUT position. Adjust the RF GAIN controls on the receiver until the local signal is visible on the SLOW SCOPE.

Step 3. By means of the DRIFT switch on the synchronization indicator and the PHASE CONTROL on the sync control unit, drift the local signal onto the RF SCOPE. The local signal may drift off the RF SCOPE rapidly. This is an indication that the timer oscillator frequency differs a considerable amount from the operating timer oscillator frequency. If such is the case, readjust the oscillator frequency by means of the frequency controls on the oscillator until the local signal on the RF SCOPE appears almost stationary.

Step 4. Using the PHASE CONTROL on the sync control unit, bring the peak of the r-f pulse to the left end of the sweep.

Step 5. Turn the RF SWEEP SPEED control on the synchronization indicator to the extreme clockwise position.

Step 6. Readjust the FINE FREQ. ADJ. control on the oscillator, 10 divisions at a time, until the r-f drift, in a period of one minute, is less than the distance (on the sweep) occupied by one r-f cycle.

Step 7. Restore the REMOTE SIGNAL switch on the receiver to the IN position and the RF SWEEP SPEED control on the synchronization indicator to the extreme counterclockwise position.

(9) SIGNAL STANDARDIZATION.

Step 1. Set the RF SWEEP SPEED control on the synchronization indicator to the extreme counterclockwise position. Adjust the VIDEO SWEEP SPEED control to provide a sweep of about 100 microseconds on the VIDEO SCOPE.

Step 2. If necessary, drift the local and remote signals onto the video and r-f scopes by means of the DRIFT switch on the synchronization indicator and the PHASE DIAL on the sync control unit. Adjust the VIDEO or RF SWEEP DELAY controls on the synchronization indicator, if necessary, so that the signals are visible on both scopes simultaneously. If the local and remote signals are synchronized and if the reference delay on the timer is properly adjusted, the two signals will be superposed.

Step 3. Readjust the RF VERTICAL CTR control and the RF GAIN control on the synchronization indicator to provide centered zero-to-positive-peak signals of about three-inch height on the RF SCOPE.

Step 4. Check amplitude equality of signals on the RF SCOPE. If necessary, adjust by means of the LOCAL GAIN controls on the receiver.

Step 5. Adjust the COARSE and FINE RF GAIN controls on the receiver and the VIDEO VERTICAL CTR control on the synchronization indicator to provide video signals of two-inch zero-to-positive-peak height, as shown in figure 4–14. The two-inch zero-to-positive-peak height of the video signals defines standard receiver output. The RF GAIN control on the RF SCOPE may now be adjusted for a convenient signal amplitude.

(10) ESTABLISHING APPROXIMATE SYNC ON THE REMOTE SIGNAL—A properly adjusted stand-by slave timer has the facilities for maintaining approximate swnchronization with the remote master. (Exact sync is established during operation.) It is desirable that this approximate synchronization be maintained so that if the stand-by timer must be switched into operation a minimum of inaccurately timed loran signals will be transmitted. To establish sync on the remote master signal, proceed as follows:

Step 1. Check that the AUTO SYNC switch on the sync control unit is in the OFF position, the FREQUENCY CORRECTOR switch is in the OUT position, and the LOCAL SIGNAL switch on the electrical synchronizer is in the OUT position.

Step 2. Place the SIGNAL SELECTOR switch on the test scope in the ELECT SYNC position and the TEST SIGNAL switch on the electrical synchronizer in the REMOTE GATE position.

Step 3. Adjust the COARSE and FINE SWEEP SPEED controls on the test scope to provide a sweep of about 200 microseconds. Adjust the SWEEP DELAY controls to place the remote gate at the center reference line of the oscilloscope screen.

Step 4. Place the TEST SIGNAL switch on the electrical synchronizer to the 2ND DER position. Verify that the signal on the test scope is the remote signal by observing the signal disappear when the REMOTE SIGNAL switch on the receiver is momentarily turned to the OUT position.

Step 5. By means of the VERTICAL CENTERING control on the test scope and the PHASE control on the sync control unit, adjust the position of the second derivative signal on the test scope so that the base line of the signal is vertically centered and the first zero cross-over coincides with the center vertical reference line. A properly adjusted signal is shown in figure 4-18.

Step 6. Turn the AUTO SYNC switch on the sync control unit to the ON position. The sync motor should now operate to correct any error, and the stand-by timer will be maintained in approximate synchronization with the remote master signal.

Step 7. Place the FREQUENCY CORRECTOR switch on the IN position.

(11) SUMMARY.—When the checks and adjustments prescribed in the previous paragraphs have been completed, the timer is in stand-by condition and is ready for service as an operating timer. It may be placed in service by making the appropriate change-overs at the switching equipment and making the final adjustments explained in the next paragraph.

c. STAND-BY-OPERATE CHANGE-OVER PROCEDURE.—This paragraph outlines the procedure for changing over operation of two associated timers; that is, for placing the stand-by timer in operation and the operating timer in stand-by.

Step 1. Connect the stand-by timer to the assigned exciter of the operating transmitter by setting the appropriate operating transmitter switch on the loran switching equipment to the corresponding timer position. This places the stand-by timer in operation —i.e., in control of the operating transmitter—and it will henceforth be referred to as the operating timer.

Step 2. Connect the previously operating timer to the assigned exciter of the stand-by transmitter by placing the appropriate stand-by transmitter switch in the loran switching equipment to the corresponding timer position.

Step 3. If the timers are used with Loran Switching Group AN/FPA-2, omit this step. With Loran Switching Equipment Navy Model UM, where an auxliary switch has been installed to operate the transfer circuits for feeding the recording ammeter, operate this switch to make the required transfer. If the auxiliary switch has not been installed, place the LOCAL SIGNAL switch on the operating timer on the IN (normal) position and the LOCAL SIGNAL switch on the stand-by timer in the OUT position.

Step 4. If the timer has been in previous use as an operating timer, and has been operating satisfactorily, omit this step and go on to step 5. If the timer is being placed on the air for the first time, or if the synchronizer circuits have been repaired or adjusted, proceed as follows:

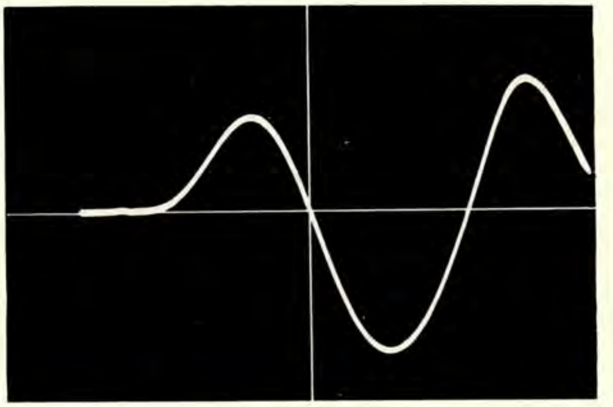


Figure 4-18. Remote Derivative Signal Adjusted on Test Oscilloscope for Establishing Approximate Synchronization of a Stand-by Slave Timer

Adjust the synchronizer gate delay on the newly operating timer. This delay can be exactly adjusted only when the timer is operating. Since the adjustment requires the removal of the remote signal, monitoring will be impossible for the duration of the adjustment procedure. However, since the adjustment procedure requires only a short time to complete, under normal conditions, the adjustment will not cause a noticeable error in synchronization. To adjust the synchronizer gate delay, perform the following.

(1) Turn the SIGNAL SELECTOR switch on the test scope to the ELECT SYNC position and the TEST SIGNAL switch on the electrical synchronizer to the AC ERROR position.

(2) Turn the COARSE SWEEP SPEED control on the test scope to the 1 position. Place the FINE SWEEP SPEED control in the extreme counterclockwise position.

(3) Place the AUTO SYNC switch on the sync control unit to the OFF position. By means of the PHASE dial on the sync control unit on the newly operating timer, manually establish synchronization, i.e., adjust so that the local and remote signals are matched as shown in figure 4-16 or figure 4-17. Place the REMOTE SIGNAL switch on the receiver in the OUT position.

(4) Adjust the FINE LOCAL DELAY control on the electrical synchronizer until the a-c error signal appearing on the test scope is at a minimum. Note that this adjustment must be made slowly because of the long time constants involved.

(5) Restore the REMOTE SIGNAL switch on the receiver to the IN position and the AUTO SYNC switch on the sync control unit to the ON position. This completes the adjustment of the gates on the electrical synchronizer, and the timer should now automatically maintain exact synchronization with the remote master signal.

Step 5. Place the BUZZER switch on the synchronization indicator on the newly operating timer to the ON position, the BLINK SELECTOR switch to the AUTO position, and the REMOTE ALARM switch to the IN position.

Step 6. Place the BUZZER switch on the new stand-by timer to the OFF position, the BLINK SELECTOR switch to the OFF position, and the REMOTE ALARM switch to the OUT position.

Step 7. Establish approximate synchronization of the new stand-by timer as described in paragraph 7 *b* (9) of this section.

d. ACTIVE OPERATION: SLAVE TIMER.—The principal task to be performed during operation of a slave station is to make whatever phase and frequency corrections are necessary to maintain synchronization with the master station. Properly synchronized signals are evidenced on the VIDEO SCOPE of the synchronization indicator when the leading edges of the video signals are matched as shown in figure 4–16 or when the first zero cross-overs of the derivative signals coincide, as shown in figure 4–17.

While the timer was in stand-by, shifting phase (in any manner) caused both local and remote signals to shift. Now that the timer is in control of the local transmitter, the local signal (lower trace) remains stationary and shifting phase causes only the remote pulse to shift. To maintain proper synchronization from this point on, it is only necessary to make the phase and frequency corrections required to match the remote signal with the local signal. These phase and frequency corrections can be made automatically, by the electrical synchronizer, or manually.

(1) AUTOMATIC SYNCHRONIZATION.—In automatic synchronization, the principal task of maintaining synchronization is delegated to the fully adjusted and operating electrical synchronizer. If the stand-by timer was properly adjusted and was maintaining approximate synchronization with the remote signal when the timer was switched into operation, and if the synchronized gate delay was adjusted in accordance with paragraph 7 *c* (4), the electrical synchronizer will immediately be able to take over and maintain synchronization. The duty of the operator then is to monitor the operation of the electrical synchronizer and to respond to the automatic alarm devices which the electrical synchronizer provides. The alarm devices include a SYNC ERROR alarm circuit and an OFF SYNC alarm circuit. The automatic alarms can be used to initiate automatic blinking. The SYNC ERROR alarm circuit responds to an error of 1 microsecond or more, and the OFF SYNC alarm circuit responds to remote blinking, a large sync error, a lost signal, and operating on the wrong zero cross-over of the derivative signal. Associated with the alarm circuits are a SYNC ERROR alarm indicator lamp, an OFF SYNC alarm indicator lamp, and a BUZZER which is common to both alarm circuits. The indicator lamps light almost immediately after the corresponding alarm circuit detects the error. The BUZZER operates after a preset delay interval associated with each alarm circuit. A delay (which is initially adjusted to between five seconds and one minute) is provided in the SYNC ERROR alarm circuit before the BUZZER operates, and a delay (which is initially adjusted to between 15 seconds and five minutes) is provided in the OFF SYNC alarm circuit. Simultaneously with the BUZZER the alarm circuits will initiate blinking, provided that the BLINK SELECTOR switch is in the AUTO position.

As soon as an alarm operates, either the indicator lamp or the buzzer, place the BLINK SELECTOR switch in the MANUAL position. Blinking must be maintained until the condition is corrected. Next check the synchronization indicator for an indication of the cause of the alarm. Frequently occurring causes for alarms, and procedures for the correction of these causes, are discussed in paragraph 8 of this section. If it is decided that the condition cannot be immediately corrected (assuming the fault is not with the remote timer), place the stand-by timer in operation. This should correct the condition and normal operation can continue.

If the cause of the alarm is remote blinking, the remote operator is signaling the fact that an error is observed. He will stop blinking when blinking is initiated locally.

Most corrective procedures require that synchronization be restored manually. To restore synchronization in an operating timer after an alarm has operated, perform the following:

Step 1. Place the FREQUENCY CORRECTOR switch on the sync control unit in the OUT position.

Step 2. Place the AUTO SYNC switch on the sync control unit in the OFF position.

Step 3. By means of the DRIFT switch on the synchronization indicator and the PHASE dial on the sync control unit, adjust the position of the remote signal until the leading edges of the video remote and local signals are matched as shown in figure 4–16 or until the first zero cross-over points of the derivative signals coincide as shown in figure 4–17.

Step 4. Place the AUTO SYNC switch on the sync control unit in the ON position. The sync control motor should now be operated to automatically maintain synchronization.

Step 5. Turn the FREQUENCY CORRECTOR switch to the IN position.

After synchronization has been established and a check has indicated that operation is proceeding satisfactorily, restore the BLINK SELECTOR switch to the AUTO position and proceed with normal operation.

From time to time, the FREQUENCY CORRECTOR dial on the sync control unit may have to be reset to zero as a result of extensive or accumulated PHASE correction in one predominant direction. The procedure for resetting the control is described in detail in paragraph 11 of this section. The operator should reset the FREQUENCY CORRECTOR dial *before* it reaches one or the other limit, because frequency follow-up of PHASE corrections is possible only *between* the end limits of the dial. The FREQUENCY WARNING indicator on the sync control unit lights when either limit of the FREQUENCY CORRECTOR dial is reached, thus calling the operator's attention to the fact that the FREQUENCY CORRECTOR dial must be reset.

The general procedure described above comprises the basic operations of a slave station when operating automatically. The operation of the electrical synchronizer is recorded by the recording ammeter, as discussed in paragraph 12. In addition to this, the operator must be familiar with the operation of the receiver and the electrical synchronizer against noise and interference. Information relative to this is given in paragraphs 9 and 10 of this section.

(2) MANUAL SYNCHRONIZATION.—In manual synchronization the electrical synchronizer is not employed (POWER switch on the electrical synchronizer in the OFF position, 60∼ AMPL PWR switch on the sync control unit in the OFF position, AUTO SYNC switch on the electrical synchronizer in the OFF position, and BLINK SELECTOR switch on the synchronization indicator in the OFF position). The operator must watch the presentation of the video or derivative signals on the VIDEO SCOPE almost constantly. When the pulses depart from perfect match, the operator must make a compensating adjustment of the PHASE dial on the sync control unit. The local (slave) pulse appears to be fixed and errors in synchronization are observed as drift of the master pulse. Thus the object is to move the master pulse so as to keep it matched with the slave. If the master pulse drifts towards the left, it is moved back towards the right by turning the PHASE dial to the "right" (clockwise) and vice versa.

As soon as an error in synchronization is observed (other than the normal drifts off synchronization described above), place the BLINK SELECTOR switch in the MANUAL position. The blink must be left on until the error is corrected. If it is decided that the error cannot be immediately corrected (assuming the fault is not with the remote timer), place the stand-by timer in operation. This should correct the condition, and operation should continue smoothly.

If the master starts to blink, he is signaling the fact that an error is observed. He will cease blinking when blinking is initiated locally.

At various times, the operator will have to reset the FREQUENCY CORRECTOR dial on the sync control unit as a result of extensive or accumulated PHASE correction in one predominant direction. The procedure for resetting this control is described in paragraph 11 of this section. The operator should reset the FREQUENCY CORRECTOR dial before it reaches one or the other limits, because frequency follow-up of PHASE corrections is possible only between the end limits of the dial. The FREQUENCY WARNING indicator on the sync control unit lights when either limit of the FREQUENCY CORRECTOR dial is reached, thus calling the operator's attention to the fact that the FREQUENCY CORRECTOR dial *must* be reset.

The general procedure described above comprises the basic operation of a slave station when operating manually. The operation of the electrical synchronizer is recorded by the recording ammeter, as discussed in paragraph 12. In addition to this, the operator must be familiar with the operation of the receiver against noise and interference. Information relative to this is given in paragraph 9 of this section.

8. CAUSES FOR ALARM INDICATIONS AND THEIR CORRECTIVE MEASURES.

Note

The corrective procedures recommended in this paragraph may be superseded by the Coast Guard instructions for the particular installation concerned.

a. OFF SYNC ALARM.—The OFF SYNC alarm will respond to a lost signal, a large sync error, operating on the wrong zero cross-over, and remote blinking.

(1) LOST REMOTE SIGNAL.—A lost remote signal is probably caused by an inoperative remote station. However, it is possible that the fault lies in the local timer or switchgear. The first thing to do is to check the SLOW SCOPE of the stand-by timer. If the remote signal is not lost on the stand-by timer, the trouble is definitely local (in either the operating timer or operating electronic switch unit (AN/FPA–2) or discriminator (Model UM)), and the operator should switch to stand-by units. If the remote signal is also lost on the stand-by timer, the fault may be in the switching group, in which case switch to the stand-by electronic switch (AN/FPA–2) or stand-by discriminator (Model UM).

(2) LOST LOCAL SIGNAL.—A lost local signal itself will not initiate an alarm. However, it will appear as a lost remote signal at the remote station so that the remote operator will be warned and in turn warn the local operator through blinking.

If the local signal is lost, the cause is most likely a defective timer or defective transmitter. Unless the defective equipment is readily obvious (as indicated by abnormal pilot light operations, etc.), switch to the stand-by timer, and if trouble then persists, switch to the stand-by transmitter.

(3) LARGE SYNC ERROR.—A large sync error can be caused by a jump in timing in the frequency divider. Whether the jump in timing occurs in the master timer or at the slave timer, as always it is the function of the slave to correct the error. The slave should correct the error manually by means of the DRIFT switch and the PHASE control, as described in paragraph 7*d*(1) of this section. If synchronization cannot be immediately restored in this manner, and if it is evident that the master timer is operating normally, the slave operator should switch to the stand-by timer.

(4) OPERATING ON THE WRONG ZERO CROSS-OVER.—Operating on the wrong zero cross-over occurs only when automatic synchronization is employed. It defines the condition whereby the synchronization gate in the electrical synchronizer of the slave timer is sampling the remote signal in the neighborhood of the wrong zero cross-over of the derivative signal. Since the electrical synchronizer cannot distinguish between one or another zero cross-over, it will maintain synchronization about this point, producing a sync error of about 50 microseconds. This error will be readily apparent on the scopes. As in the case of a large sync error, the slave operator should restore synchronization manually by means of the DRIFT switch and the PHASE control, as explained in paragraph 7 *d* (1).

(5) REMOTE BLINKING.

(*a*) MASTER STATION.—Remote blinking at a master station is a signal by the remote slave operator that he has observed an abnormal operating condition. During the course of the remote blinking, the slave operator will be attempting to restore normal operation. However, the slave operator will not be able to correct the condition if the fault is caused by, say, an inoperative master transmitter or erratic operation of the master timer. Therefore, when remote blinking is observed at the master station, the operator should carefully check his own operating equipment and if necessary switch to stand-by units.

(*b*) SLAVE STATION.—Remote blinking at a slave station indicates that the master operator has observed an abnormal operating condition and is signaling the fact to the slave station. The remote master station will cease blinking as soon as blinking is initiated at the slave station.

b. SYNC ERROR ALARM.—The sync error alarm circuit responds to small sync errors of from 1 to about 20 microseconds. Under normal operating conditions this alarm should seldom go off, for the electrical synchronizer will automatically correct the error before it can become as large as 1 microsecond or, if the error is a jump off sync, it will generally correct the error before the time delay associated with the sounding of the buzzer can elapse. The alarm will operate, however, if the electrical synchronizer has become inoperative and is unable to correct a sync error, or if, during noisy reception, the time delay associated with the operation of the buzzer is made so short that the electrical synchronizer cannot correct an error in time to avert the sounding of the buzzer.

If the fact that time delay is too short causes such alarms to occur frequently, the operator should lengthen the time delay associated with the initiation of the buzzer and automatic blinking in accordance with station instructions. The procedure for adjusting this delay circuit is given in Section 3, paragraph 28 *j*. If at a slave station the cause of the alarm is failure of the electrical synchronizer to maintain synchronization, the operator should switch to the stand-by timer.

9. OPERATING RECEIVER AGAINST INTERFERENCE OR EXCESSIVE NOISE.

The receiver is provided with two rejection traps to help minimize interference from r-f carriers and a video limiter circuit to limit the amplitude of large noise bursts.

a. ADJUSTING REJECTION TRAPS.—When adjusting the rejection traps, continuous monitoring of the interfering signal must be made. The interfering signal can be most easily observed on the RF SCOPE as a signal whose r-f cycles drift back and forth in a random fashion. To help identify the interfering signal, earphones can be plugged into the PHONE output jack (J1209) on the receiver chassis (see figure 5-11).

To adjust the rejection traps, simply tune the rejection traps until the interfering signal is at a minimum. The rejection traps can both be tuned to the same frequency for maximum rejection of a signal interfering carrier, or they can be tuned separately for rejection of two interfering signals.

When not in use, the rejection traps should be left in the extreme counterclockwise position.

b. ADJUSTING VIDEO LIMITER.—The video limiter circuit is used to reduce the peak of large noise bursts to a level comparable to the video signal amplitude. To adjust the limiter circuit, place the LIMITER IN-OUT switch on the receiver chassis to the IN position, and while observing the loran signals on the VIDEO SCOPE, slowly turn the LIMITER ADJ control on the receiver chassis in the clockwise direction until just before the loran signals begin to distort.

Note

Keep the LIMITER IN-OUT switch in the OUT position except when it is necessary to use the video limiter circuit during noisy reception.

10. OPERATING THE ELECTRICAL SYNCHRONIZER AGAINST NOISE.

Automatic synchronization, when properly adjusted, can keep sync more accurately than manual synchronization on a clean signal, and is much better than manual synchronization in the presence of noise. This improved operation will be obtained provided the following rules are observed:

Rule 1. Reduce the effects of noise to a minimum by optimum operation of the receiver, as discussed in the previous paragraph.

Rule 2. HIGH RANGE operation of the gear shift in the sync control unit should never be used when the timer is operating.

Rule 3. When signals are clean, or the noise is negligible, use a setting of about 4 microseconds per minute on the MAX MOTOR SPEED control. When noise is present, synchronization will be improved by using a lower speed (counterclockwise). The slower the speed the more the effects of noise will be minimized. A slower speed has the effect of integrating the noise over longer periods before the effect of the noise is allowed to influence the operation of the sync control unit.

Rule 4. Maintain close visual monitoring of the operation of the timer.

11. FREQUENCY CORRECTION.

The frequency adjustments described in this paragraph apply only to a slave station.

The crystal in the crystal oscillator unit will age so that its natural frequency gradually increases. This and other effects will cause the FREQUENCY CORRECTOR dial to stray from its center position towards one of the other limits of rotation. Thus from time to time the FREQUENCY CORRECTOR dial will have to be reset to zero or center position so that frequency correction can always be made in the proper direction. This is done by first determining the amount of correction needed to return the FREQUENCY CORRECTOR dial to zero, then making the correction by means of the FINE FREQ. ADJ. control on the crystal oscillator, and finally resetting the FREQUENCY CORRECTOR dial to zero.

The FREQUENCY CORRECTOR dial covers a range of about ± 4 parts per 10^7 and has eight major divisions; thus each major division represents 1 part per 10^7. The FINE FREQ. ADJ. control on the crystal oscillator has a range of approximately 50 parts per 10^7 which is broken up into 50 drum divisions (each drum division is broken up into 100 dial divisions). Thus each drum division also represents 1 part per 10^7 and drum divisions on the FINE FREQ. ADJ. are approximately equal to major divisions of the FREQUENCY CORRECTOR dial.

The direction the FINE FREQ. ADJ. control must be adjusted to compensate for setting the FREQUENCY CORRECTOR dial is determined by the markings on the FREQUENCY CORRECTOR dial closest to the reading. One end of the FREQUENCY CORRECTOR dial is marked with RAISE OSC DIAL READING WHEN RESETTING and the other end of the dial is marked with LOWER OSC DIAL READING WHEN RESETTING.

The procedure for resetting the FREQUENCY CORRECTOR dial is as follows:

Step 1. Adjust the FINE FREQ. ADJ. drum reading for an equal number of divisions as the reading on the FREQUENCY CORRECTOR dial, raising or lowering the drum reading in accordance with the marking on the FREQUENCY CORRECTOR dial.

Step 2. Place the FREQUENCY CORRECTOR switch in the OUT position.

Step 3. Reset the FREQUENCY CORRECTOR dial to zero.

Step 4. Return the FREQUENCY CORRECTOR switch to the IN position.

Since the correspondence between FREQUENCY CORRECTOR dial readings and FINE FREQ. ADJ. drum readings is only approximate, the frequency of the oscillator after resetting may differ a little from the frequency before resetting. When using automatic synchronization, this will not interfere with normal operation, since the electrical synchronizer will immediately operate to maintain synchronization and will eventually readjust the oscillator frequency (via the FREQUENCY CORRECTOR dial) to the proper value. Thus active operation of the electrical synchronizer after frequency correction is a normal occurrence. When operating manually, the operator must closely monitor the operation of the timer after resetting and make the necessary adjustments by means of the PHASE dial to maintain synchronization. This will eventually adjust the oscillator frequency to the proper value.

The wide range of the COARSE FREQ. ADJ. control on the crystal oscillator is provided to allow compensation for the aging of the crystal for many years. As the crystal ages, it will be necessary to turn this control, step by step, counterclockwise. Most frequency adjustments will be made with the FINE FREQ. ADJ. control, and only when this control runs off range will it be necessary to change the COARSE FREQ. ADJ. control.

Each step of the COARSE FREQ. ADJ. control represents 4 parts per 10^6 or 40 parts per 10^7. Since each drum division represents 1 part per 10^7, each step of the COARSE FREQ. ADJ. switch represents approximately 40 drum divisions. The procedure for adjusting the COARSE FREQ. ADJ. control, when the FINE FREQ. ADJ. drum runs off range, is as follows:

Either

Case 1. FINE FREQ. ADJ. drum reading runs off range at the low end of the drum calibration (around zero).

Step 1. Lower the COARSE FREQ. ADJ. control reading by 4 parts per 10^6, by turning the control one step counterclockwise.

Step 2. Raise the FINE FREQ. ADJ. drum reading by 40 divisions,

Or

Case 2. FINE FREQ. ADJ. drum reading runs off range at the high end of the drum calibration (around 50).

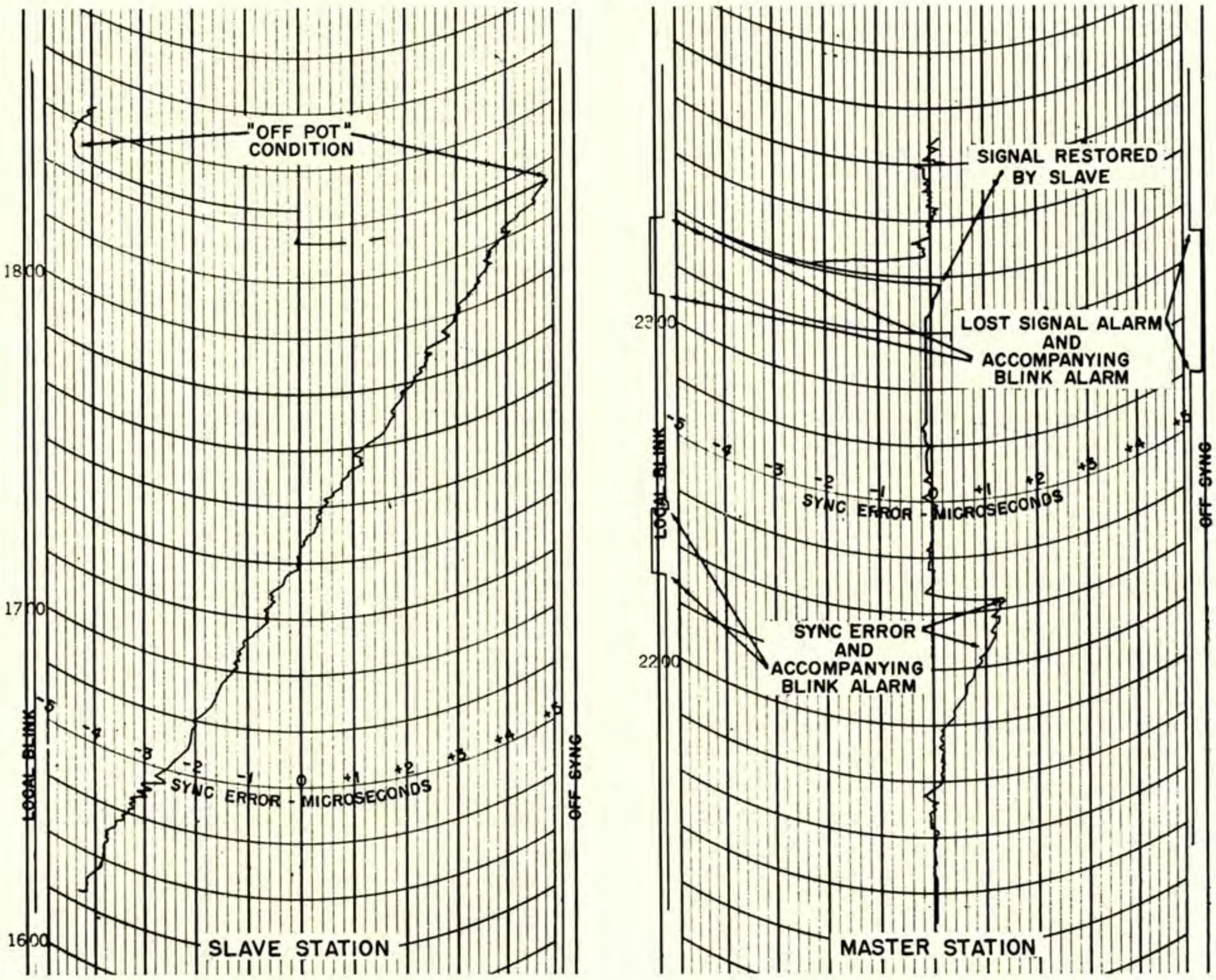


Figure 4–19. Chart Deviations Caused by an "Off Pot" Condition of the PHASE Dial

Step 1. Raise the COARSE FREQ. ADJ. control reading by 4 parts per 10^6 by turning the control one step clockwise.

Step 2. Lower the FINE FREQ. ADJ. drum reading by 40 divisions.

Since the correspondence between FINE FREQ. ADJ. readings and the COARSE FREQ. ADJ. reading is only approximate, the frequency of the oscillator after resetting may differ from the frequency before resetting. Thus the same frequency correcting action which is required after resetting of the FREQUENCY CORRECTOR dial, as discussed above, will also be required after resetting of the FINE FREQ. ADJ. and COARSE FREQ. ADJ. dials. Either the electrical synchronizer will operate actively, when automatic synchronization is being used, or, for manual synchronization, nominal adjustments will have to be made.

12. OPERATION OF THE RECORDING AMMETER.

The recording ammeter is provided as a means for recording station efficiency. At each station, one operating recording ammeter is used for the timers (one operating, one stand-by) associated with each loran rate. The recording ammeter is always connected to the operating timer through a transfer circuit controlled by the STANDBY-OPERATE relays of the two timers. Thus a continuous record is made regardless which of the two timers is controlling the rate.

A record is made, on a moving paper chart, of when operation is normal and when it is not normal. This record provides a permanent log of station operation and may be used by the Coast Guard administrative authority to review station operation. The chart record provides three separate indications of timer operation. A graph drawn in the center area of the chart records the excursions of the PHASE dial, at either a master or slave station, and thus provides a continuous and detailed record of the condition of synchronization or lack of synchronization of the paired stations (master and slave) of a given rate. The center area is calibrated in microseconds of error for use at a master station only. At a slave station any chart reading may represent zero error. A line drawn along the left margin of the chart follows the operation of the local blink circuit. Normally this line is straight and continuous. However, whenever the local blink circuit is actuated, either by placing the BLINK SELECTOR switch in the MANUAL position or through the operation of the alarm circuits (when the BLINK SELECTOR switch is on AUTO), the line jumps to the left approximately one-eighth of an inch. A similar line, drawn along the right margin, jumps to the right to indicate the periods when the OFF SYNC alarm lamp is lighted. Thus, by analysis of the three lines drawn on the chart, the operating state of the timer, at any time or for any period of time, may be determined.

In addition to the indications provided by the two outside lines, two running time meters, on the front panel of the recording ammeter, indicate the total amount of time that the local blink circuit has been actuated and that the off sync alarm circuit has been actuated. These meters are appropriately designated LOCAL BLINK and OFF SYNC and, together, provide a rapid summary of station efficiency. The readings of these two meters are to be reported to the appropriate Coast Guard authority at regular intervals in accordance with local instructions.

Operating personnel should make every effort to maintain an accurate log, with the aid of the recording ammeter, of the station's operation. If an abnormal operating condition occurs, open the writing door and note on the chart (1) the time when the abnormality starts, (2) the cause of the abnormality (if known), and (3) the time when it is over. Aside from noting such abnormalities, the only other attention the operator will be required to pay the recording ammeter is to check the chart periodically to make sure the operation is normal. If the chart is changed and the inkwells filled in accordance with a regular schedule, as listed in Section 5, no trouble should be encountered. Chart-loading, inkwell filling, and pen-filling procedures are given in Section 3, paragraph 27.

At a master station, the normal indications shown on the chart will be a line near the center (zero error) position of the chart and two straight lines at each side of the chart, on the inside of each margin.

At a slave station, the PHASE dial may be rotated to any position as synchronization is adjusted to maintain zero error. The recorder center line will follow the motion of the PHASE dial and may therefore move to any position of the chart for a zero error condition. When operation is normal, the center line will be a gradually varying line which follows the motion of the PHASE dial as oscillator drift causes the dial to rotate. Abnormal operation will usually be indicated by a sharp deflection in the line.

There is one normal condition which can also cause a sharp deflection of the line. This condition results because the pen which draws the center line is operated through a potentiometer ganged to the PHASE dial, and the winding of this potentiometer is not continuous over the 360° of PHASE dial rotation. The discontinuity of the potentiometer winding is required to bring out connecting terminals. As the arm of the potentiometer is driven to the open portion of the winding, current to the pen will be interrupted, and the pen will jump from one side of the chart to chart center. As the arm of the potentiometer is driven to the far side of the open portion of the winding, the pen will move from chart center to the other side of the chart. The "off pot" condition described above is easily recognized.

Figure 4–19 is a portion of an actual chart record and illustrates an off-pot condition as well as several other typical conditions.

NOTES

Operator's Maintenance
Section 5

CG-273-15
(Volume 1)

INSTRUCTION BOOK

for

LORAN TIMER SET
AN/FPN-30

SECTION 5
OPERATOR'S MAINTENANCE

ITT *Federal Division*

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

Clifton, New Jersey, U.S.A.

FORMERLY
FEDERAL TELEPHONE AND RADIO COMPANY

TREASURY DEPARTMENT
U.S. COAST GUARD

Contracts: Tcg-38701(CG-20,181-A)
Tcg-39263(CG-27,298-A)
Tcg-40020(CG-35,978-A)
Tcg-41083 (CG-44,327-A)

Approved by C. G. Headquarters:
16 October 1959

TABLE OF SECTIONS

SECTION 5
OPERATOR'S MAINTENANCE

1. PURPOSE AND SCOPE OF THIS SECTION.

To maintain continuity of service, it will be necessary for the operator to make periodic adjustments to insure that the controls do not drift from their normal settings. This section outlines (largely in table form) the routine checks to be made by the operator, and gives brief instructions for those adjustments which may have to be made while the equipment is in operation.

Also included here are data concerning the vacuum tubes employed in the equipment: their location, function, identification, and clamping.

Finally, this section lists the fuses that protect each circuit and indicates their location, identification, and symptom of failure.

Perform the checks of tables 5–1 and 5–2 weekly, or oftener, as determined by operating experience.

2. VACUUM TUBE REPLACEMENT DATA.

a. GENERAL.—It is not recommended that tubes be replaced at any stated intervals. On a percentage basis, the most likely time for a tube to fail is soon after it is first put into use; an old tube in good operating condition has a greater life expectancy than a brand new tube.

Experience has shown that the most common cause of faulty equipment operation is defective vacuum tubes. If failure occurs, look for a defective tube. This should be done by replacement and trial rather than by testing in a tube tester and acceptance of the tube tester indication as final. Some tubes may test well in an ordinary tube tester but still be unsuited for service. A tube which checks defective on a tube tester should, as a general rule, be rejected.

b. TUBE CLAMPS.—All the tubes in the timer, except type 2X2A high-voltage rectifiers, are equipped with some form of locking or clamping device. In most cases, the method of releasing the clamps for tube removal is obvious. Each characteristic type will be described, nevertheless, to preclude the possibility of damage caused by improper handling.

(1) The spring collar type clamp consists of a spring collar whose circumference is changed by means of a form of buckle. A screwdriver slot is punched in the side of some of the buckles to make release easy. When the clamp is locked, the spring-loaded collar grips the tube firmly. Refer to figure 5–1.

(2) The tab type clamp consists of a metal tab held in place by a screw. The end of the tab rests on the base of the tube so that when the screw is tightened the tube is locked firmly in place. To remove the tube, loosen the screw and swing the tab clear. Refer to figure 5–2.

(3) The shield-type clamp serves a dual purpose. In addition to holding the tube in place, it also shields the tube. This type of clamp is used on all the miniature tubes in the timer. To release the clamp, push the shield down, twist to the left, and raise. Refer to figure 5–3.

c. TUBE PIN STRAIGHTENERS.—The pins of the miniature tubes used in the timer are susceptible to bending during removal from their sockets. When a tube's pins are bent, it is difficult to restore the tube to its socket. To overcome this difficulty, tube pin straighteners (7 pin and 9 pin) are supplied, mounted on the front of the timer. The tube pins are straightened by plugging the tube into the *correct* straightener, and then removing it carefully.

d. REPLACEMENT OF CATHODE-RAY TUBES.—Instructions for the removal and replacement of the cathode-ray tubes used in the timer follow. The pro-

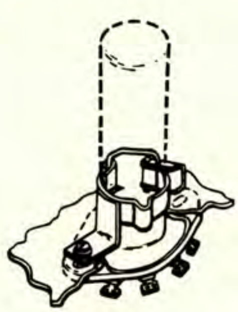


Figure 5–1. Tube Clamp, Spring Collar Type

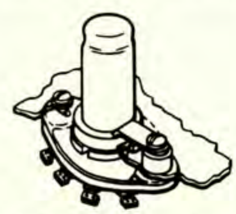


Figure 5–2. Tube Clamp, Tab Type

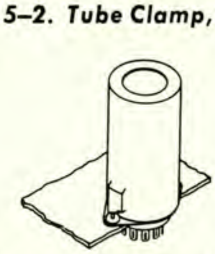


Figure 5–3. Tube Clamp, Shield Type

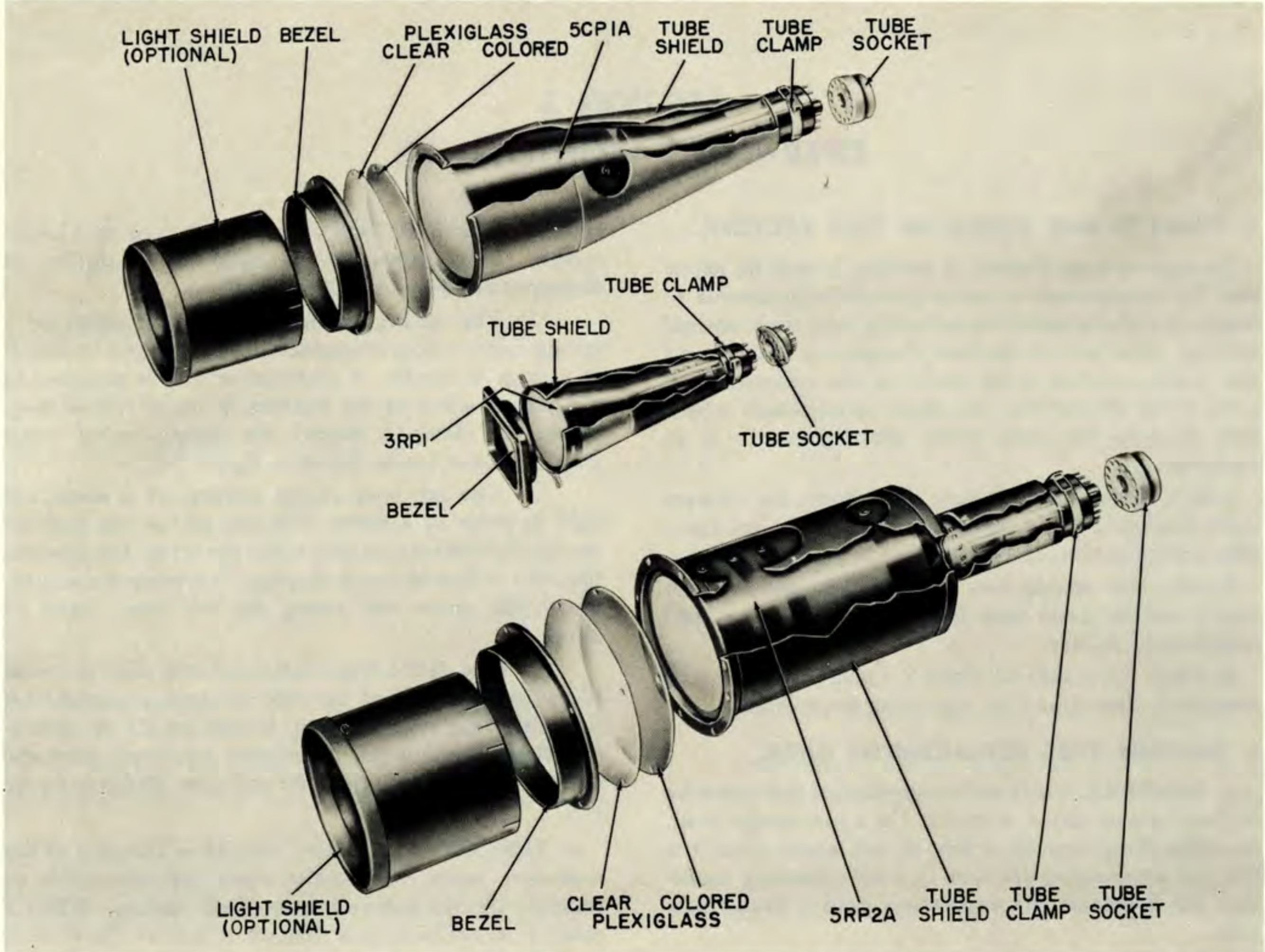


Figure 5–4. Mounting Assembly of Cathode-ray Tubes

cedures are simple and straightforward. Three different tube types are used and therefore three separate procedures are given. Refer to figure 5–4.

WARNING

Before touching anything inside the enclosure of either the synchronization indicator or the test scope, discharge all high-voltage capacitors as described immediately below.

To discharge the high-voltage capacitors in the synchronization indicator, first pull the unit forward on its slides, swing the two subchassis aside, and remove all shields. Refer to figure 7–256. Using a probe which is securely connected to the chassis, ground the following high-voltage points: the terminals of R858, R857, and R856 (in the order listed), the case of C838, both ends of R944, both ends of the composition resistor (R906) mounted between terminals on the phenolic supporting board for C838, and all terminals of TB801, TB802, and TB803, and the barrier strips mounted on the rear of the chassis. Remove the bottom plate from the synchronization indicator (refer to figure 7–259) and discharge all exposed capacitors. Be sure to hold the grounding probe to each point for at least one second to allow ample time to discharge through circuit time constants.

To discharge the high-voltage capacitors in the test scope, first pull the unit forward on its slides and tilt up to gain access to the bottom of the chassis. Refer to figure 7–265. Using a probe which is securely connected to the chassis, ground the following high-voltage points: Terminals 3, 6, and 7, of TB1702, and all terminals of TB1701, the barrier strips mounted on the rear of the chassis, and all contacts of tube socket XV1720. Be sure to hold the grounding probe to each point for at least one second to allow ample time to discharge through circuit time constants.

WARNING

During removal and replacement, handle the cathode-ray tubes lightly, but firmly, using suitable protective globes and goggles. Avoid touching the tube surface.

TABLE 5-1. ROUTINE CHECKS—OPERATING TIMER AND STAND-BY TIMER

WHAT TO CHECK	HOW TO CHECK	REMARKS
RF gain.	Measure the zero-to-peak deflection of the video signal on the VIDEO SCOPE.	Adjust the r-f gain controls (coarse and/or fine) on the receiver to maintain standard deflection of two inches zero-to-peak of the video signal on the VIDEO SCOPE.
Local gain.	Observe amplitudes of local and received signals.	Adjust the LOCAL GAIN control to equalize the amplitudes of the local signal and the remote signal.
Centering of selector (push-up) gates.	Observe the waveforms of each of the gates (A1000, B1000, B100, B10) on the test oscilloscope and check that the gate is approximately centered about the marker.	The position of the gates is fixed by the settings of their respective delay controls, which must be adjusted to center the gates under their markers. Care must be exercised not to change the equipment timing by the accidental selection of another marker in place of the original. Refer to Section 3, paragraph 22*g*.
Reference delay.	Use the procedure of Section 5, paragraph 4.	
FREQUENCY CORRECTOR dial on synchronization control unit (slave station only).	Observe if the dial reading is approaching either extreme of its range.	After resetting the dial to zero, a compensating correction must be made at the FINE FREQUENCY dial on the oscillator. Refer to Section 4, paragraph 6*a* (12) and 11.
Oscillator temperature.	Operate the meter switch at the oscillator to the HEATER position. The meter should read between 60 and 140 microamperes if the oscillator has stabilized.	An abnormal reading should be investigated by a competent technician.
Oscilloscope controls: INTENSITY FOCUS AUX FOCUS VERTICAL CENTERING HORIZONTAL CENTERING SWEEP SIZE SWEEP SEPARATION SWEEP SPEED	These controls should be adjusted at the discretion of the operator.	Minor drift of these controls will not deteriorate station operation.
Marker heights.	Check to see that the time markers (1000's, 100's, 10's and 1's) are easily distinguished.	Adjust the marker height control on the front panel. If the VIDEO SCOPE markers cannot be properly adjusted with the front panel height control, wait until the timer is placed in stand-by before adjusting the internal controls.

(1) REPLACING THE 5RP2A.—To replace the 5RP2A cathode-ray tube (used in the RF SCOPE), proceed as follows:

Step 1. Remove the light shield (if used) by pulling forward with a slight twisting motion.

Step 2. Remove the four screws that attach the bezel to the front of the panel. When the four screws have been removed, the bezel, the clear plexiglass, and the filter plexiglass will fall away and expose the face of the cathode-ray tube.

Step 3. After having discharged all high-voltage capacitors, as described above, remove the connections to the terminals designated A, B, E, C, and D at the neck of the tube and E, F, G, and H at the side of the tube. Remove the tube socket.

Step 4. Loosen the tube clamp and remove the tube through the front opening.

Step 5. If it is desired to remove the magnetic metal shield from the unit, remove the two nuts and bolts that secure the rear of the shield to the shield

TABLE 5–2. ROUTINE CHECKS—STAND-BY TIMER ONLY

WHAT TO CHECK	HOW TO CHECK	REMARKS
Centering of preset selector (push-up) gates.	Observe the waveforms of each of the preset gates (A1000, B1000, B100, B10) on the test oscilloscope and check that the gate is approximately centered about the marker.	The position of the gates is fixed by the settings of their respective delay controls, which must be adjusted to center the gates under their markers. Care must be exercised not to change the equipment timing by the accidental selection of another marker in place of the original. Refer to Section 3, paragraph 22*g*.
Preset reference delay.	Use the procedure of Section 5, paragraph 4.	
Master reference.	At a master station only, check the phase of the stand-by timer according to instructions listed in Section 4, paragraph 6*b* (11) and (12).	
Sync error alarm.	Introduce a sync error of 1 μsec or more to the timer and see that the SYNC ERROR alarm indicator lamp goes on almost immediately. Prolong the error slightly longer than the time delay that has been set up. At the end of the time delay, the alarm BUZZER should sound, the local blink should operate if the BLINK SELECTOR is in the AUTO position, and the LOCAL BLINK chronograph pen on the recorder should operate.	If the alarm circuit does not operate properly, refer to Section 7, table 7–8, symptom 5.
Off sync.	Operate the REMOTE SIGNAL switch, on the receiver, to OUT. The off sync alarm indicator lamp and the OFF SYNC chronograph pen on the recorder should operate almost immediately. At the end of the time delay, the alarm BUZZER should sound, the local blink should operate if the BLINK SELECTOR is in the AUTO position, and the LOCAL BLINK chronograph pen should operate on the recorder.	If the alarm circuit does not operate properly, refer to Section 7, table 7–8, symptom 6.
Blink operation (manual).	Operate the BLINK SELECTOR switch to MANUAL and observe the effect on the "local" pedestal at the SLOW SCOPE. It should jump back and forth 1,000 microseconds and the relative lengths of blink and no-blink should agree with that specified for the station. Observe the A1000 or B1000 gate (whichever is blinking) on the test scope and observe its centering during blink.	The magnitude of the pedestal shift is adjustable by means of the BLINK DELAY control in the time delay unit. The adjustment should be made so that the gate jumps to the proper marker and is centered about this marker. Refer to Section 3, paragraph 24*a*.
Oscillator frequency (master only).	Check frequency against WWV.	The crystal oscillator should have been in continuous operation for the preceding 24-hour period.

support and remove the four screws that were exposed when the bezel was removed. Pull the shield out through the opening in the front panel.

Step 6. To install a new cathode-ray tube, insert the tube in the shield and rotate the tube so that the tube terminal A lines up with the marking for terminal D on the magnetic metal shield. Connect the appropriate lead to terminal A. Rotate the tube to bring tube terminal B in alignment with shield terminal D and connect the lead for terminal B. Continue in the same way, connecting leads to terminals E, C, and D. After terminal D has been connected, the tube will be in proper position for connecting the leads to terminals F, G, and H. Clamp the tube and make the connections. Replace the tube socket, fold the subchassis back into position, push the synchronization indicator back into the cabinet to close the interlock switch, and turn the INTERLOCKED POWER switch back on. After the equipment has warmed up, adjust the controls for proper intensity, focus and centering of the trace. Using a piece of sticky tape, or marking crayon, mark a horizontal reference line over the trace. Turn the INTERLOCKED POWER switch OFF; pull the drawer forward, discharge all high-voltage capacitors as described above, temporarily replace the bezel and two pieces of plexiglass; loosen the tube clamp and position the tube with the face flush against the plexiglass and, with the horizontal reference line parallel with the horizontal lines scribed on the plexiglass, tighten the clamp. Remove the bezel and plexiglass, clean the surface of the tube, and replace both pieces of plexiglass, the bezel, all mounting screws, and the light shield (if used). Restore the unit to normal operation. Any slight error in aligning the horizontal reference line may be corrected by loosening the bezel screws and rotating the filter over the small range which is made possible through the use of the slotted mounting holes.

(2) REPLACING THE 5CP1A.—To replace the 5CP1A cathode-ray tube (used in the VIDEO SCOPE and in the test scope), proceed as follows:

Step 1. Remove the light shield (if used) by pulling forward with a slight twisting motion.

Step 2. Remove the four screws that attach the bezel to the magnetic metal shield and the front of the panel. When the four screws have been removed, the bezel, the clear plexiglass, and the filter plexiglass will fall away and expose the face of the cathode-ray tube.

Step 3. After having discharged all high-voltage capacitors as described above, remove the anode high-voltage lead from the side of the 5CP1A and remove the tube socket.

Step 4. Loosen the tube clamp and remove the tube through the front opening.

Step 5. If it is desired to remove the magnetic metal shield from the unit, remove the two nuts and bolts that secure the rear of the shield to the shield support and remove the four screws that were exposed when the bezel was removed. Pull the shield out through the opening in the front panel.

Step 6. To install a new cathode-ray tube, insert the tube in the shield and tighten the tube clamp. Replace the tube socket and the anode high-voltage lead, temporarily push the unit back into the cabinet to close the interlock switch, and turn the INTERLOCKED POWER switch back on. After the equipment has warmed up, adjust the controls for proper intensity, focus, and centering of the trace. Using a piece of sticky tape, or marking crayon, mark a horizontal reference line over the trace. Turn the INTERLOCKED POWER switch OFF; pull the drawer forward; discharge all high-voltage capacitors as described above; temporarily replace the bezel and two pieces of plexiglass; loosen the tube clamp and position the tube with the face flush against the plexiglass and, with the horizontal reference line parallel with the horizontal lines scribed on the plexiglass, tighten the clamp. Remove the bezel and plexiglass, clean the surface of the tube, and replace both pieces of plexiglass, the bezel, all mounting screws, and the light shield (if used). Restore the unit to normal operation. Any slight error in aligning the horizontal reference line may be corrected by loosening the bezel screws and rotating the filter over the small range which is made possible through the use of the slotted mounting holes.

(3) REPLACING THE 3RP1. — To replace the 3RP1 cathode-ray tube (used in the SLOW SCOPE), proceed as follows:

Step 1. Remove the four screws at the corners of the rectangular bezel and pull the bezel away from the panel.

Step 2. After having discharged all high-voltage capacitors, as described above, remove the tube socket from the tube, loosen the clamp, and remove the tube through the front opening.

Step 3. If it is desired to remove the magnetic metal shield from the unit, remove the four screws that were exposed when the bezel was removed and pull the shield through the opening in the front panel.

Step 4. To install a new cathode-ray tube, insert the tube in the shield and tighten the tube clamp. Replace the tube socket, fold the subchassis back into position, push the synchronization indicator back into the cabinet to close the interlock switch, and turn the INTERLOCKED POWER switch back on. After the equipment has warmed up, adjust the controls for proper intensity, focus, and centering of the trace. Using a piece of sticky tape, or marking crayon, mark a horizontal reference line over the trace. Turn the INTERLOCKED POWER switch OFF, pull the drawer forward, discharge all high-voltage capacitors as described above, temporarily replace the bezel, loosen the tube clamp, and position the tube with the face flush with the plastic window in the bezel and with

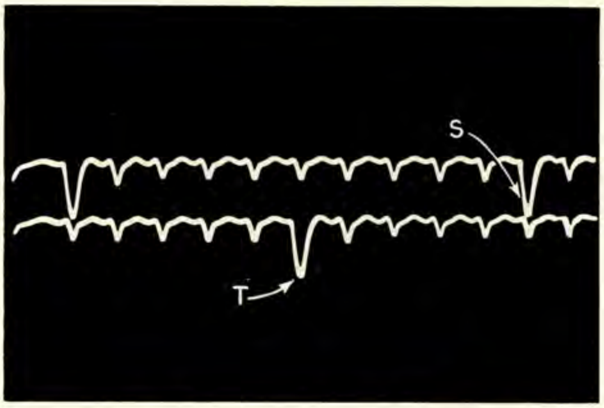


Figure 5-5. Appearance of RF SCOPE Pattern for Checking Delay in Units of Microseconds

the horizontal reference line parallel with the horizontal borders of the bezel; tighten the clamp. Remove the bezel, clean the face of the tube, and restore the bezel permanently in place. Restore the synchronization indicator to normal operation.

3. RECORDING MILLIAMMETER.

The inking system should be inspected once a week. Fresh ink should be added to the inkwell; any dirt, lint, or dried ink should be removed from the glass pen point, and some ink should be drawn through the pen element by means of the pen filler. Once a month the inkwells and pen elements should be emptied, washed, and refilled.

To clean the main inkwell, pry off the cover and wash the parts in water. See that the vent holes in the cover are open and that the cover is not bent when removing it. The same procedure applies to the chronograph inkwells except that the covers screw off. The pen element is best cleaned by blowing water through it with a pen filler. Intermittent writing, failure of the pen to write on sudden swings, a dark purplish color of the record line instead of the normal bright red, or a tendency of the ink to spread in the paper and produce a broad, fuzzy line—these are all indications that the ink in the inkwell has thickened and oxidized and that the inking system should be serviced more often.

Instruments are shipped with the pen elements properly balanced when full of ink and the balance adjustment should not be changed unless necessary. The pen balance should be such that, when the chart is tapped lightly with one finger, the pen will bounce up and down on the chart. Too heavy a pen pressure on the chart will cause the pen to drag toward the center of the chart or will noticeably reduce the speed of response of the pen. Accordingly, if maximum response speed is desired, the pen pressure must be no greater than is necessary for satisfactory inking. Handle the pen element carefully; a bent element will cause incorrect readings. The writing tip of the glass pen must be exactly 4-3/8 inches from the knife edge. The arc line, drawn by the pen, is approximately one-eighth inch in front of the curved edge of the chart feeder which extends over the pen table.

The record chart should be changed every 15 days if a chart feed of three inches per hour is used. Refer to Section 3, paragraph 27, for instructions on replacing the ink and recording chart in the recording milliammeter.

4. CHECKING REFERENCE DELAY.

a. PROCEDURE. — The following procedure is an accurate method for checking the reference delay. A reference delay of 6,955 microseconds is used here to illustrate the procedure. The procedure should be used whenever the reference delay (either B normal or B preset) is to be checked.

(1) Turn the RF SWEEP SPEED control on the synchronization indicator unit to the CAL position.

(2) Adjust the RF SWEEP SPEED control on the synchronization indicator unit until about 12 one-microsecond markers are visible on the RF SCOPE screen.

(3) Adjust the RF SWEEP DELAY control to place a 10-microsecond marker near the right edge of the upper sweep.

(4) Adjust the RF SEPARATION control so that the 10-microsecond markers on the upper trace just barely touch the lower trace.

(5) Observe the 10-microsecond marker S, on the right-hand end of the upper trace, and marker T directly under or to the left of S, on the lower trace. See figure 5-5. Determine, by counting unit intervals, the number of microseconds of delay between the 10-microsecond markers S and T. Mark down the figure obtained as the unit digit (in this case, five microseconds) of the existing reference delay.

(6) Turn the VIDEO SWEEP DELAY control to the extreme clockwise (DELAY OUT) position.

(7) Adjust the VIDEO SWEEP SPEED control until the sweep on the VIDEO SCOPE screen is about 120 microseconds long. This will allow at least one

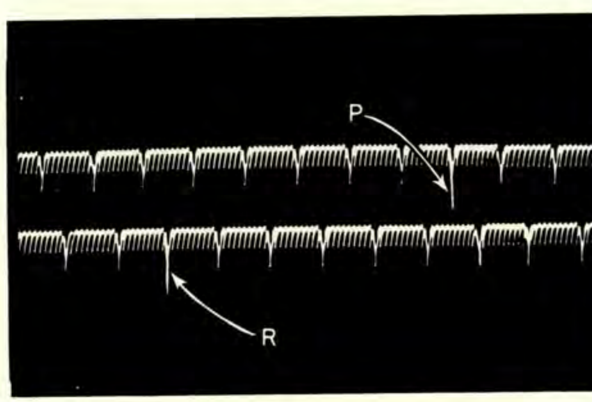


Figure 5-6. Appearance of VIDEO SCOPE Pattern for Checking Delay in Tens of Microseconds

100-microsecond marker to appear on each trace. If a 1,000-microsecond marker appears, consider that marker a 100-microsecond marker for this purpose.

(8) Adjust the VIDEO SEPARATION control so that the 100-microsecond marker on the upper trace just about touches the lower trace.

(9) Observe the 100-microsecond markers equivalent to markers P and R in figure 5-6. Determine the number of 10-microsecond *intervals* between the two markers thus selected for reference. Ignore the additional fraction of an interval. Count complete intervals, not markers. Mark down the figure thus obtained as the "ten-digit" in the time delay (in this case five, making 55).

(10) Adjust the VIDEO SWEEP SPEED control counterclockwise to bring a 1,000-microsecond marker near the right-hand end of the upper sweep.

(11) Adjust the VIDEO SEPARATION control so that the 1,000-microsecond marker on the upper trace just barely touches the lower trace.

(12) Using the 1,000-microsecond marker on the upper trace (M in figure 5-7) and the first 1,000-microsecond marker to its left, N, on the lower trace, count the 100-microsecond *intervals* between them, ignoring the fractional 100-microsecond interval (i.e., tens and units). Count complete intervals, not markers. Mark down the figure obtained as the "hundred digit" in the time delay (in this case nine, making 955).

(13) Turn the VIDEO SWEEP SPEED control on the synchronizatior indicator unit to the extreme clockwise position, to provide narrow pedestals on the SLOW SCOPE screen.

(14) Observe the positions of the pedestals on the SLOW SCOPE. Count the number of 1,000-microsecond *intervals* between their leading edges. Do not count the markers themselves, count the intervals between them. Mark down the number obtained as the number of thousands in the time delay. (In this case the number is six, making a total delay of 6,955 microseconds.) The measurement of time delay is now complete.

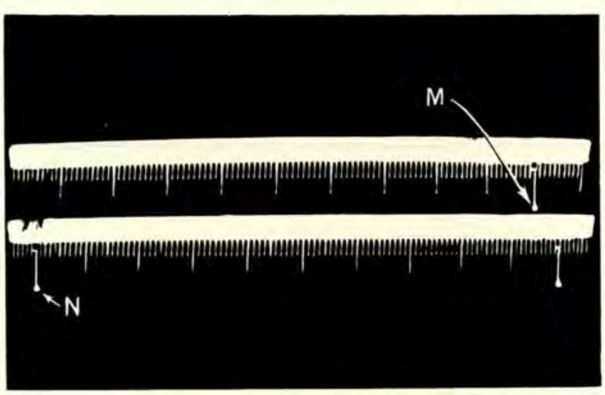


Figure 5-7. Appearance of VIDEO SCOPE Pattern for Checking Delay in Hundreds of Microseconds

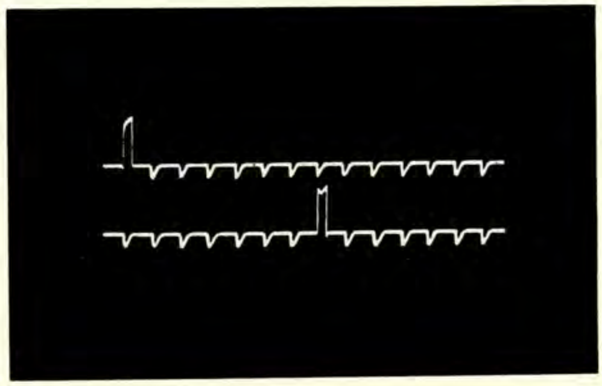


Figure 5-8. SLOW SCOPE Pedestals with a Delay Between Them of Nearly 7,000 Microseconds

Note

In cases where the desired reference delay is very nearly an integral thousand, the leading edge of the B pedestal is very close to or contains a 1,000-microsecond marker. In such cases, estimate the total delay on the SLOW SCOPE to the nearest 1,000 microseconds, then coordinate this approximate value to the figures already obtained. Thus, in the example illustrated, the figures already obtained are 955, whereas the delay on the SLOW SCOPE is approximately 7,000 microseconds. (See figure 5-8.) Thus, the actual delay must be 6,955 microseconds, because this figure is much closer to 7,000 than is 7,955.

5. EMERGENCY MAINTENANCE.

Notice to Operators

Operators shall not perform any of the following emergency maintenance procedures without proper authorization.

a. REPLACEMENT OF FUSES.—All fuses in Loran Timer Set AN/FPN-30 (except those in Voltage Regulator Type CN-235/FPN-30) are equipped with blown fuse indicator lights which glow if the associated fuse is blown and the circuit is otherwise normally energized. The detection of a blown fuse is therefore a relatively simple matter. Table 5-15, page 5-27, lists the symptoms of fuse failure in the voltage regulator to aid in the detection of a blown fuse in that unit. Table 5-16 and associated figure 5-21 show the locations of all fuses. The table indicates the components protected by each fuse and describes the correct replacement fuse to be used. Spare fuses are stored in the drawer underneath the operator's shelf.

WARNING

Never replace a fuse with one of higher rating unless continued operation of the equipment is more important than probable damage. If a fuse burns out immediately after replacement, do not replace it a second time until the cause has been corrected.

b. REPLACEMENT OF TUBES. — Tube locations are shown in figures 5–9 through 5–20. Tube functions are described in accompanying tables 5–3 through 5–14. Because of unavoidable tolerances in tube manufacture, many circuits will require readjustment if the associated tube is replaced. Those controls which may require readjustment, after replacement of a particular tube, are listed in the table. Always consult the table, when replacing a tube, to determine which controls (if any) should be adjusted. Control locations and references to the correct adjustment procedures are given in the tables headed Controls and Devices in Section 4.

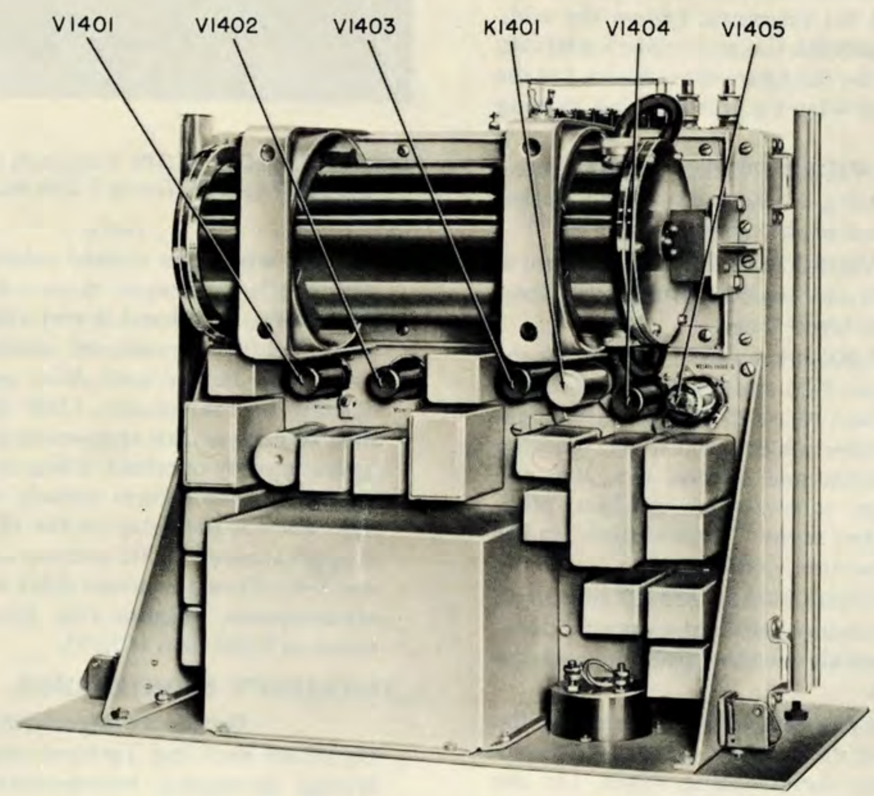


Figure 5–9. Radio Frequency Oscillator Type O–202/FPN–30, Location and Identification of Tubes

TABLE 5–3. FUNCTIONS OF TUBES (RADIO FREQUENCY OSCILLATOR TYPE O–202/FPN–30)

SYMBOL	TYPE	FUNCTION	AFTER REPLACING READJUST
V1401	6AC7	Crystal amplifier	
V1402	6AC7	Crystal amplifier	
V1403	6AC7	Crystal isolation amplifier	
V1404	6AC7	Heater amplifier	
V1405	6V6GT/G	Heater output amplifier	

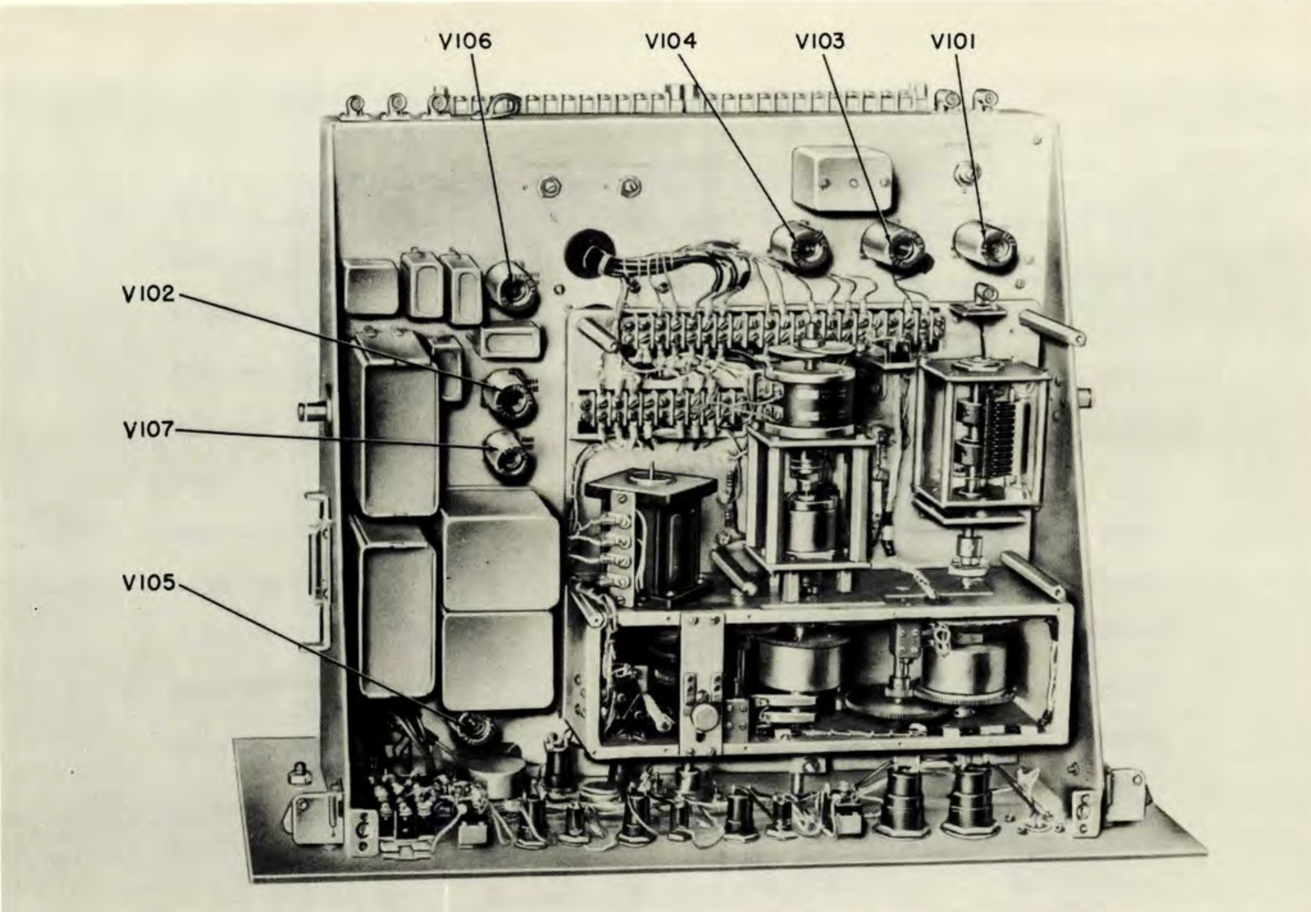


Figure 5–10. Synchronization Control Type C–1238/FPN–30, Location and Identification of Tubes

TABLE 5–4. FUNCTIONS OF TUBES (SYNCHRONIZATION CONTROL TYPE C–1238/FPN–30)

SYMBOL	TYPE	FUNCTION	AFTER REPLACING READJUST
V101A/B	5814	Phase shifter driver	
V102A	5814	Motor speed cathode follower	
V102B	5814	60-cps amplifier	
V103A/B	5814	100-kc amplifier	
V104A	5814	100-kc output amplifier	R128 (Sect. 3, par. 28*d* (2))
V104B	5814	100-kc output cathode follower	
V105A	5814	Transmitter phase shifter	R128 (Sect. 3, par. 28*d* (2))
V105B	5814	Transmitter cathode follower	
V106A	5814	Not used	
V106B	5814	Test signal cathode follower	
V107	6005	Motor amplifier	

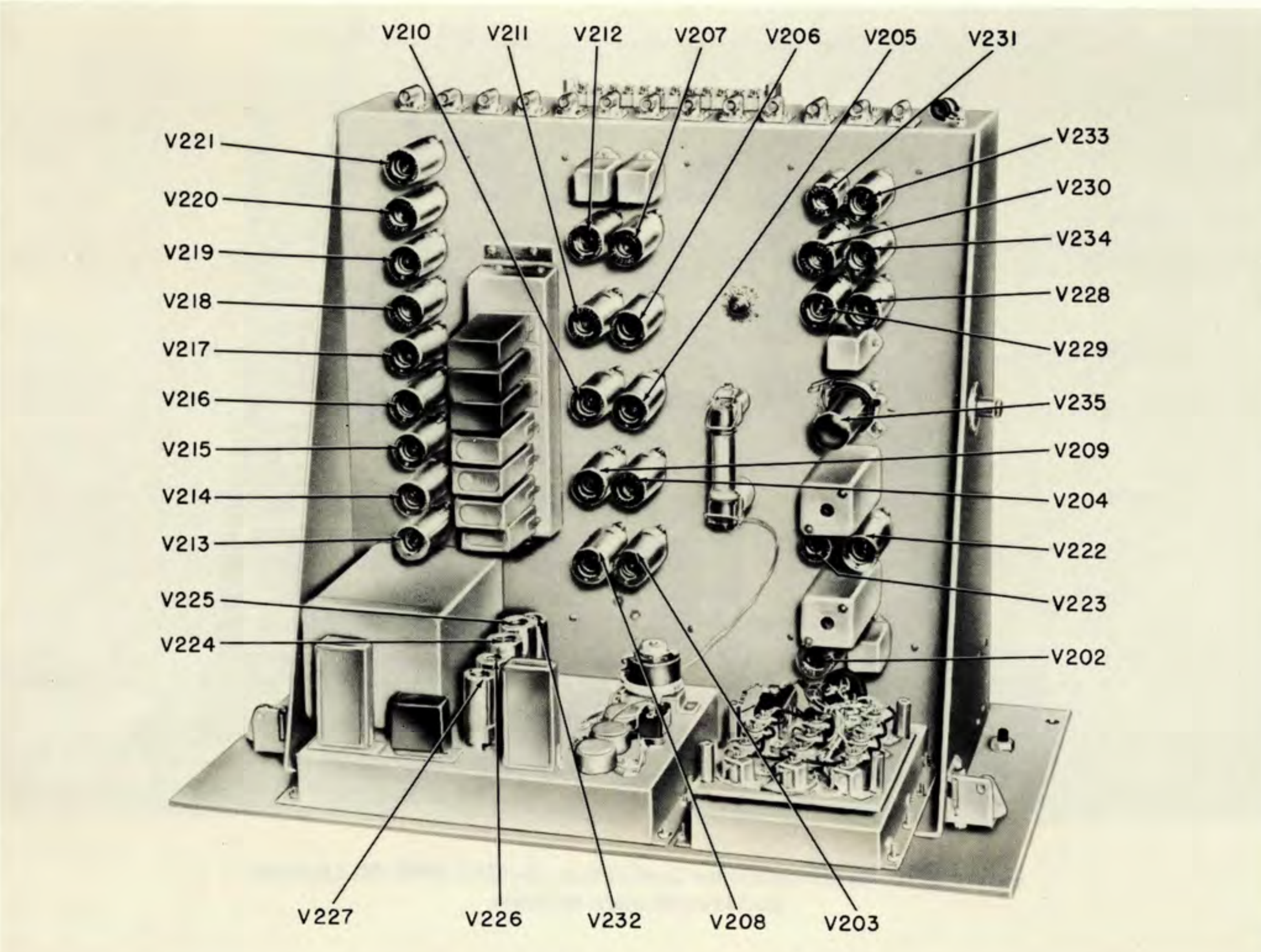


Figure 5–11. Frequency Divider Type CV–274/FPN–30, Location and Identification of Tubes

TABLE 5–5. FUNCTIONS OF TUBES (FREQUENCY DIVIDER TYPE CV–274/FPN–30)

SYMBOL	TYPE	FUNCTION	AFTER REPLACING READJUST
V201		Not used	
V202A	5814	Test signal cathode follower	
V202B	5814	10-μsec blocking oscillator	
V203A/B	5814	Counter 1 1 stage	R282 (Sect. 6, par. 5)
V204A/B	5814	Counter 1 2 stage	R282 (Sect. 6, par. 5)
V205A/B	5814	Counter 1 4 stage	R282 (Sect. 6, par. 5)
V206A/B	5814	Counter 1 8 stage	R282 (Sect. 6, par. 5)
V207A/B	5814	100-μsec marker blocking oscillator	R282 (Sect. 6, par. 5)

TABLE 5–5. FUNCTIONS OF TUBES (FREQUENCY DIVIDER TYPE CV–274/FPN–30) (Cont'd)

SYMBOL	TYPE	FUNCTION	AFTER REPLACING READJUST
V208A/B	5814	Counter 2 1 stage	R282 (Sect. 6, par. 5)
V209A/B	5814	Counter 2 2 stage	R282 (Sect. 6, par. 5)
V210A/B	5814	Counter 2 4 stage	R282 (Sect. 6, par. 5)
V211A/B	5814	Counter 2 8 stage	R282 (Sect. 6, par. 5)
V212A/B	5814	1,000-μsec marker blocking oscillator	R282 (Sect. 6, par. 5)
V213A/B	5814	Counter 3 1 stage	R282 (Sect. 6, par. 5)
V214A/B	5814	Counter 3 2 stage	R282 (Sect. 6, par. 5)
V215A/B	5814	Counter 3 4 stage	R282 (Sect. 6, par. 5)
V216A/B	5814	Counter 3 8 stage	R282 (Sect. 6, par. 5)
V217A/B	5814	Counter 3 16 stage	R282 (Sect. 6, par. 5)
V218A/B	12AT7	Preset No. 1 amplifier	R282 (Sect. 6, par. 5)
V219A	5814	Preset No. 2 delay diode	R282 (Sect. 6, par. 5)
V219B	5814	Preset No. 2 blocking oscillator	R282 (Sect. 6, par. 5)
V220A/B	5814	SQ wave generator	
V221A/B	5814	Output amplifier	
V222A	5814	500-kc multiplier	Z201 (Sect. 7, par. 4*c*)
V222B	5814	1-mc multiplier	Z201 (Sect. 7, par. 4*c*)
V223	6AU6	1-mc clipper	
V224A	5814	Slow scope marker amplifier	
V224B	5814	50-cps output gate	
V225A/B	5814	Slow trace separation and pedestal mixer	
V226	6AU6	Slow sweep generator	R275, R255 (Sect. 3, par. 20*b* (4) and (5))
V227	6AU6	Paraphase amplifier	R275, R255 (Sect. 3, par. 20*b* (4) and (5))
V228A/B	5814	Left-right amplifier	
V229A	5814	Left-right delay diode	R329 (Sect. 7, par. 4*c* (2))
V229B	5814	Slow and fast right blocking oscillator	
V230A	12AT7	Slow left amplifier	R329 (Sect. 7, par. 4*c* (2))
V230B	12AT7	Fast-slow isolation cathode follower	
V231A	5726	V223 isolation diode	
V231B	5726	Preset No. 2 clamp	
V232	2D21W	Test count generator	
V233A/B	5814	Left-right divider 1 stage	
V234A/B	5814	Left-right divider 2 stage	
V235	6AG7	1-μsec marker cathode follower	

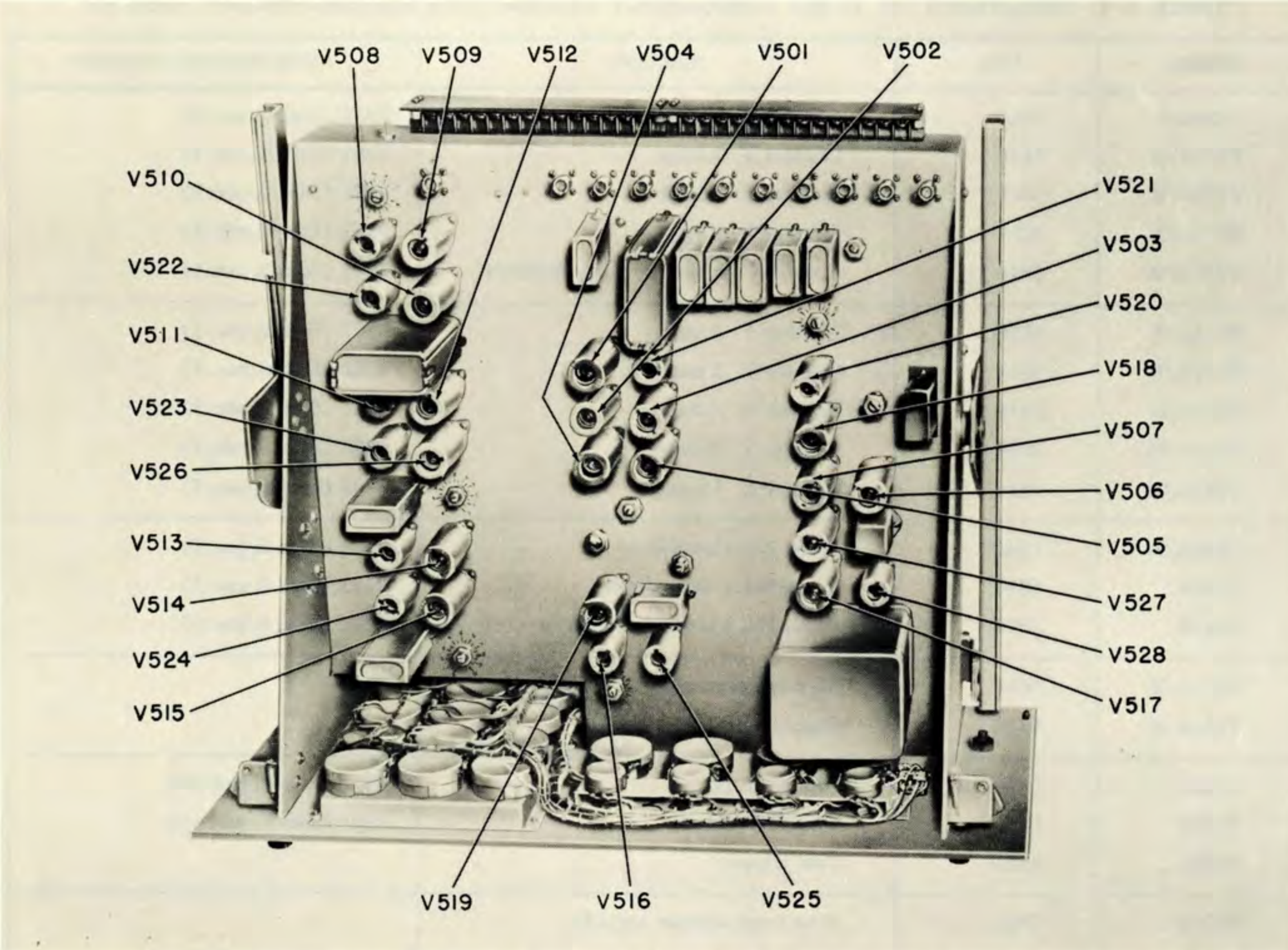


Figure 5–12. Time Delay Type TD–92/FPN–30, Location and Identification of Tubes.

TABLE 5–6. FUNCTIONS OF TUBES (TIME DELAY TYPE TD–92/FPN–30)

SYMBOL	TYPE	FUNCTION	AFTER REPLACING READJUST
V501A	5814	Square wave φ 1 clipper	*R502, R532 (Sect. 3, par. 22)
V501B	5814	Square wave φ 2 clipper	
V502	5725	A1000 delay	R609, R502 (Sect. 3, par. 22*c* and Sect. 7, par. 4*d* (2))
V503A/B	5814	A1000 push-up	R511 (Sect. 3, par. 21*e*)
V504A/B	12AT7	A10 push-up	R520 (Sect. 3, par. 21*i*)
V505A	5814	Clamp	R520 (Sect. 3, par. 21*i*)
V505B	5814	A1000 marker clipper	
V506A/B	5814	Blanking pulse generator	R529 (Sect. 3, par. 24*c*)
V507A	5814	Blanking pulse cathode follower	
V507B	5814	V506 input clipper	

* If B preset controls are used, check the preset control adjustment.

TABLE 5-6. FUNCTIONS OF TUBES (TIME DELAY TYPE TD-92/FPN-30) (Cont'd)

SYMBOL	TYPE	FUNCTION	AFTER REPLACING READJUST
V508	5725	B1000 delay	*R610, R532 (Sect. 3, par. 22 and Sect. 7, par. 4*d* (1))
V509A/B	5814	B1000 marker push-up	R545 (Sect. 3, par. 21*f*)
V510A V510B	5814 5814	B1000 marker clipper Clamp	*R532, R561 (Sect. 3, par. 22)
V511	5725	B100 delay	*R629 (Sect. 7, par. 4*d* (1))
V512A/B	5814	B100 marker push-up	R557 (Sect. 3, par. 21*g*)
V513	5725	B10 delay	*R630 (Sect. 7, par. 4*d* (1))
V514A/B	12AT7	B10 marker push-up	R574 (Sect. 3, par. 21*h*)
V515A V515B	5814 5814	B10 marker clipper Clamp	R601 (Sect. 3, par. 22)
V516	5725	B continuous delay	R601, R631 (Sect. 3, par. 22 and Sect. 7, par. 4*d* (1))
V517A/B	5814	Scope trigger mixer	
V518A V518B	5814 5814	Trigger clipper Trigger limiter	
V519A V519B	5814 5814	B continuous inverter Clamp	R601 (Sect. 3, par. 22)
V520	2D21W	Transmitter trigger generator	
V521A/B	5726	Clamp	*R502 (Sect. 3, par. 22*c*)
V522A/B	5726	Clamp	*R532 (Sect. 3, par. 22)
V523A/B	5726	Clamp	*R561 (Sect. 3, par. 22)
V524A/B	5726	Clamp	*R581 (Sect. 3, par. 22)
V525A/B	5726	Clamp	R601 (Sect. 3, par. 22)
V526A V526B	5814 5814	B100 marker clipper Clamp	R561, R581 (Sect. 3, par. 22)
V527A V527B	5814 5814	Test signal cathode follower Electrical synchronizer trigger generator	
V528A/B	5726	Trigger limiter	

* If B preset controls are used, check the preset control adjustment.

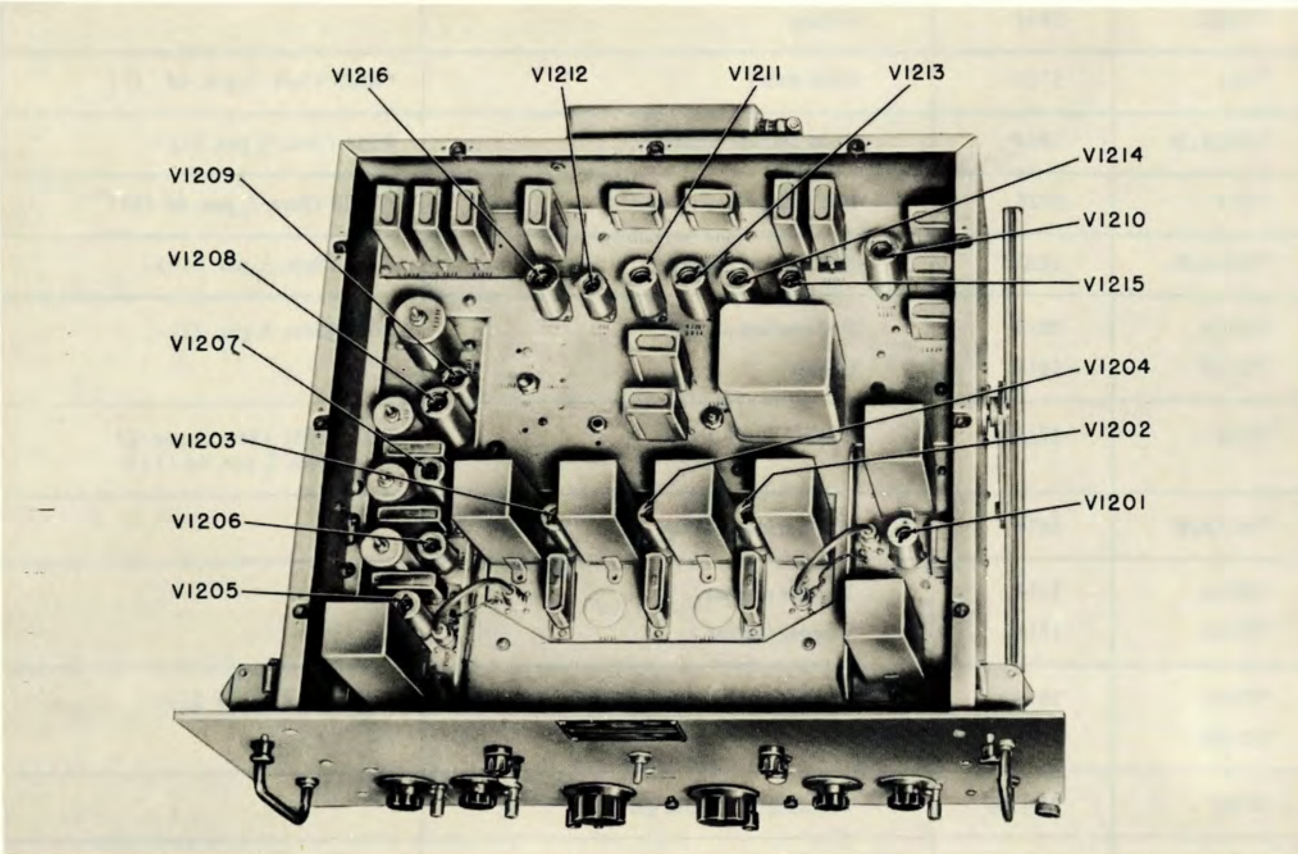


Figure 5–13. Radio Receiver Type R–564/FPN–30, Location and Identification of Tubes

TABLE 5–7. FUNCTIONS OF TUBES (RADIO RECEIVER TYPE R–564/FPN–30)

SYMBOL	TYPE	FUNCTION	AFTER REPLACING READJUST
V1201	5749	Antenna discriminator	
V1202	5749	1st r-f amplifier	
V1203	5749	2nd r-f amplifier	
V1204	5749	3rd r-f amplifier	
V1205	5749	4th r-f amplifier	
V1206	5654	5th r-f amplifier	
V1207	6005/6AQ5W	6th r-f amplifier	
V1208	6CL6	Cathode follower	
V1209A/B	5726	Video detector	
V1210A/B	5814	Attenuator bias driver and differential gain amplifier	
V1211A	5814	Limiter	
V1211B	5814	1st derivative inverter	
V1212	5654	First differentiator	
V1213A	5814	First derivative amplifier	
V1213B	5814	Blanking clamp	
V1214A	5814	Cathode follower	
V1214B	5814	Cathode follower	
V1215	5654	2nd differentiator	
V1216A	5814	Cathode follower	
V1216B	5814	Cathode follower	

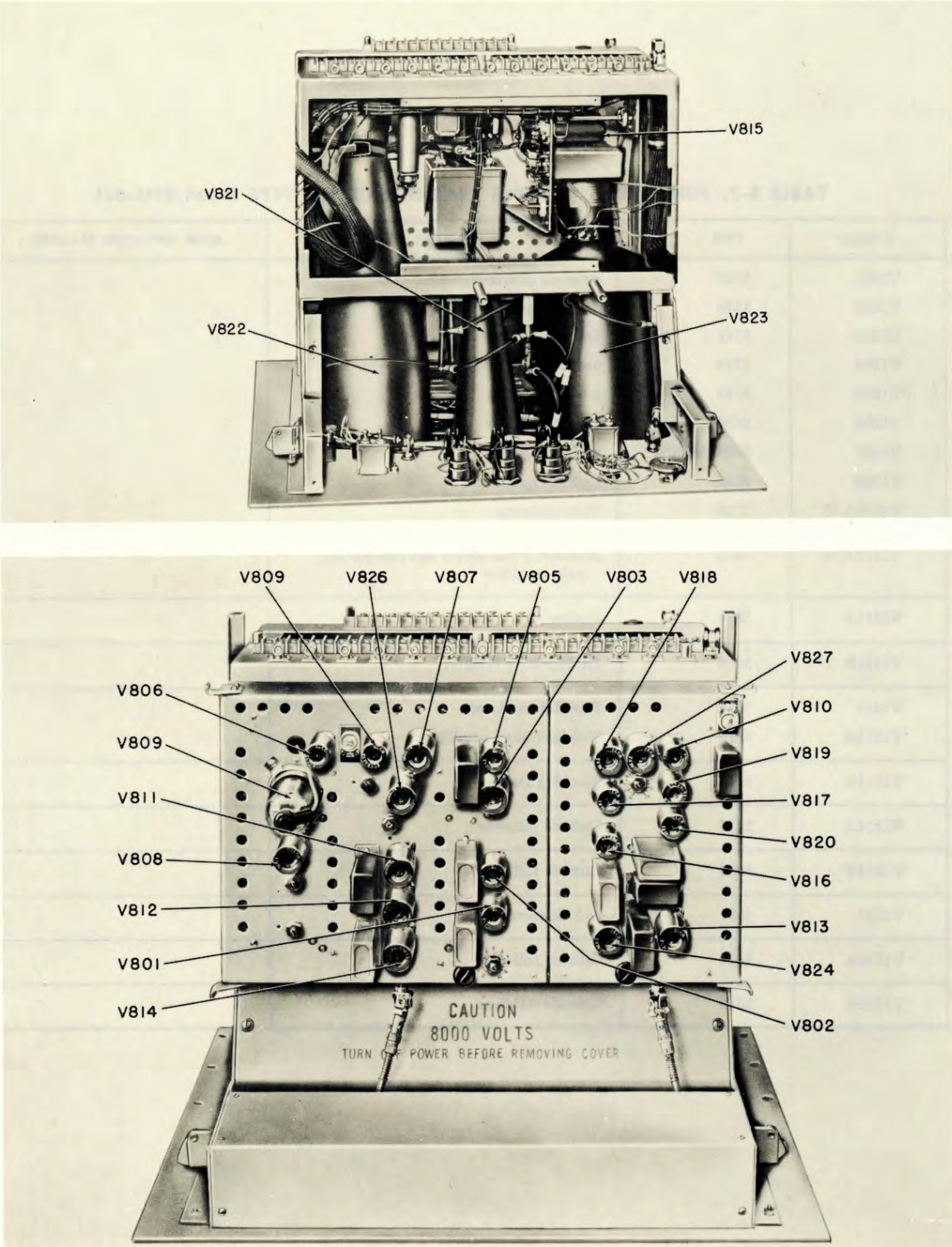


Figure 5–14. Synchronization Indicator Type IP–238/FPN–30, Location and Identification of Tubes

TABLE 5–8. FUNCTIONS OF TUBES (SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30)

SYMBOL	TYPE	FUNCTION	AFTER REPLACING READJUST
V801A/B	5726	Clamp	
V802	5725	Sweep delay	R959 (Sect. 7, par. 4*e* (1))
V803A	5814	Clamp	
V803B	5814	Cathode follower	
V804	6AU6	Sweep generator	R813, R824, R835 (Sect. 7, par. 20*c* (9))
V805A/B	5726	Limiter	
V806	6AU6	Paraphase amplifier	R824, R836 (Sect. 7, par. 20*c* (9))
V807A	5814	Trigger diode	
V807B	5814	Cathode follower	
V808A	5814	Video preamplifier	R854, R846 (Sect. 3, par. 26*g* (10) and (11))
V808B	5814	Slow scope amplifier	
V809	5933	Video amplifier	R854, R846 (Sect. 3, par. 26*g* (10) and (11))
V810	6AU6	Paraphase amplifier	R929, R945 (Sect. 3, par. 20*d* (9))
V811A	5814	1,000-μsec marker amplifier	R868, R876, R967 (Sect. 3, par. 20*c* (10) and (13))
V811B	5814	10-μsec marker amplifier	R868, R876, R967 (Sect. 3, par. 20*c* (10) and (13))
V812A	5814	Marker injector	R868, R967, R876 (Sect. 3, par. 20*c* (10) and (13))
V812B	5814	1-μsec marker amplifier	
V813A	5814	Marker mixer	R966 (Sect. 3, par. 20*d* (5))
V813B	5814	Marker injector	
V814A/B	5814	Marker mixer	R876, R967 (Sect. 3, par. 20*c* (10), (13))
V815	6AG7	R-f amplifier	C861, C864 (Sect. 4, par. 6*b* (10) (*e*), 7*b*, (9) and Sect. 7, par. 26*e* (1) (*e*))
V816	5726	Clamp	
V817	5725	Sweep delay	R960 (Sect. 7, par. 4*b* (12))
V818A	5814	Trigger diode	
V818B	5814	Cathode follower	
V819	6AU6	Sweep generator	C844, R929, R945 (Sect. 3, par. 20*d* (9), (11))

TABLE 5-8. FUNCTIONS OF TUBES (SYNCHRONIZATION INDICATOR TYPE IP-238/FPN-30) (Cont'd)

SYMBOL	TYPE	FUNCTION	AFTER REPLACING READJUST
V820A/B	5726	Limiter	
V821	3RP1	Slow scope	R950, R842, R845
V822	5CP1A	Video scope	R863, R836, R839, R879, R882, (Sect. 3, par. 20*c* (7))
V823	5RP2A	R-f scope	R945, R902, R948, R907, R910 (Sect. 3, par. 20*d* (7) and (8))
V824A V824B	12AT7 12AT7	10-μsec marker amplifier 1-μsec marker amplifier	R966 (Sect. 3, par. 20*d* (5))
V825		Not used	
V826A V826B	5814 5814	100-μsec marker amplifier Not used	R868, R967, R876 (Sect. 3, par. 20*c* (10))
V827A V827B	5814 5814	R-f pulse intensification cathode follower R-f delay clamp	

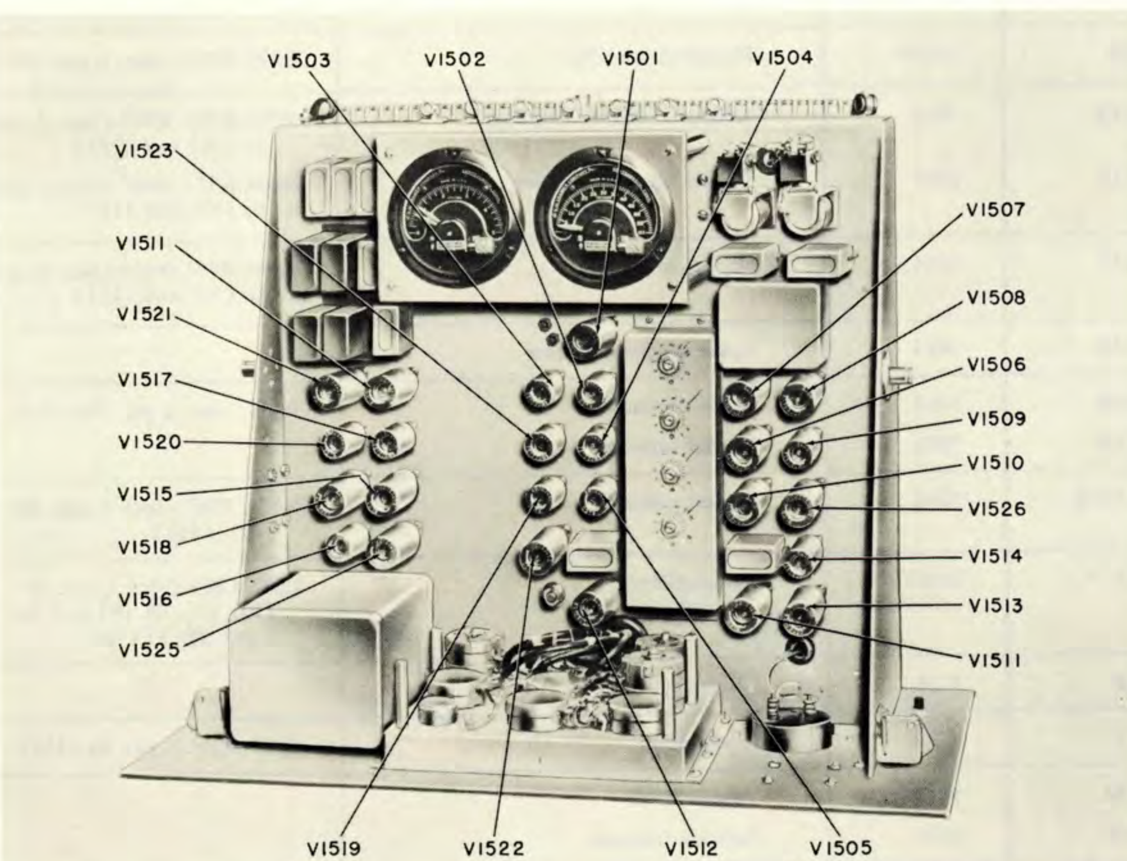


Figure 5-15. Electrical Synchronizer Type SN-117/FPN-30, Location and Identification of Tubes

TABLE 5–9. FUNCTIONS OF TUBES (ELECTRICAL SYNCHRONIZER TYPE SN–117/FPN–30)

SYMBOL	TYPE	FUNCTION	AFTER REPLACING READJUST
V1501A	5814	Second derivative input	R1501 (Sect 3, par. 28*i*, and 29*k*)
V1501B	5814	Not used	
V1502	5725	Remote mixer	R1515, R1522 (Sect. 3, pars. 28*f* and 29*f*)
V1503A	5726	Remote gate clamp	R1515, R1522 (Sect. 3, pars. 28*f* and 29*f*)
V1503B	5726	Remote gate discharge diode	
V1504	5725	Local mixer	R1515, R1522 (Sect. 3, pars. 28*f* and 29*f*)
V1505A/B	5726	Sync charging diode	R1515, R1522 (Sect. 3, pars. 28*f* and 29*f*)
V1506A/B	5814	A-c error generator	R1515, R1522 (Sect. 3, pars. 28*f* and 29*f*)
V1507A	12AT7	Not used	
V1507B	12AT7	A-c amplifier	R1534 (Sect. 3, pars. 28*j* and 29*l*)
V1508A	5814	Sync error cathode follower	R1534 (Sect. 3, pars. 28*j* and 29*l*)
V1508B	5814	A-c rectifier	
V1509	2D21W	Sync error alarm	R1534 (Sect. 3, pars. 28*j* and 29*l*)
V1510A	5814	Meter amplifier	R1538 (Sect. 3, pars. 28*f* and 29*f*)
V1510B	5814	Test signal cathode follower	
V1511A	5814	First derivative clipper	R1555 (Sect. 3, pars. 28*j* and 29*l*)
V1511B	5814	First derivative limiter	R1555 (Sect. 3, pars. 28*j* and 29*l*)
V1512A/B	5814	Alarm mixer	R1555 (Sect. 3, pars. 28*j* and 29*l*)
V1513A	5814	Alarm charging diode	R1555 (Sect. 3, pars. 28*j* and 29*l*)
V1513B	5814	Alarm amplifier	R1555 (Sect. 3, pars. 28*j* and 29*l*)
V1514	2D21W	Off sync alarm	R1555 (Sect. 3, pars. 28*j* and 29*l*)
V1515A	5814	Not used	
V1515B	5814	V1517 suppressor clamp	R1592, R1551 (also R1517 at a master station) (Sect. 3, pars. 28*f* and 29*f* and *i* and Sect. 7, par. 4*g* (1))
V1516A	5726	V1517 bottom clamp	R1551 (also R1517 at a master station) (Sect. 3, pars. 28*f*, 29*f* and *i*)
V1516B	5726	V1517 top plate clamp	

TABLE 5–9. FUNCTIONS OF TUBES (ELECTRICAL SYNCHRONIZER TYPE SN–117/FPN–30) (Cont'd)

SYMBOL	TYPE	FUNCTION	AFTER REPLACING READJUST
V1517	5725	Gate delay phantastron	R1551 (also R1517 at a master station) (Sect. 3, pars. 28*f*, 29*f* and *i*)
V1518A	5814	Trigger diode	R1551 (also R1517 at a master station) (Sect. 3, pars. 28*f*, 29*f* and *i*)
V1518B	5814	Delay cathode follower	
V1519A/B	5726	Gate separator	R1515, R1522 (Sect. 3, pars. 28*f* and 29*f*)
V1520A/B	5726	Square wave diode	R1551 (also R1517 at a master station) (Sect. 3, pars. 28*f*, 29*f* and *i*)
V1521A/B	5814	Square wave amplifier	R1551 (also R1517 at a master station) (Sect. 3, pars. 28*f*, 29*f* and *i*)
V1522A/B	5814	Square wave amplifier	R1515, R1522 (Sect. 3, pars. 28*f* and 29*f*)
V1523A	5726	Local gate clamp	R1515, R1522 (Sect. 3, pars. 28*f* and 29*f*)
V1523B	5726	Local gate discharge diode	
V1524		Not used	
V1525A	12AT7	Gate cathode follower	R1515, R1522 (Sect. 3, pars. 28*f* and 29*f*)
V1525B	12AT7	Gate generator	R1515, R1522 (Sect. 3, pars. 28*f* and 29*f*)
V1526A	5814	Meter cathode follower	R1538 (Sect. 3, pars. 28*f* and 29*f*)
V1526B	5814	Meter cathode follower	R1538 (Sect. 3, pars. 28*f* and 29*f*)

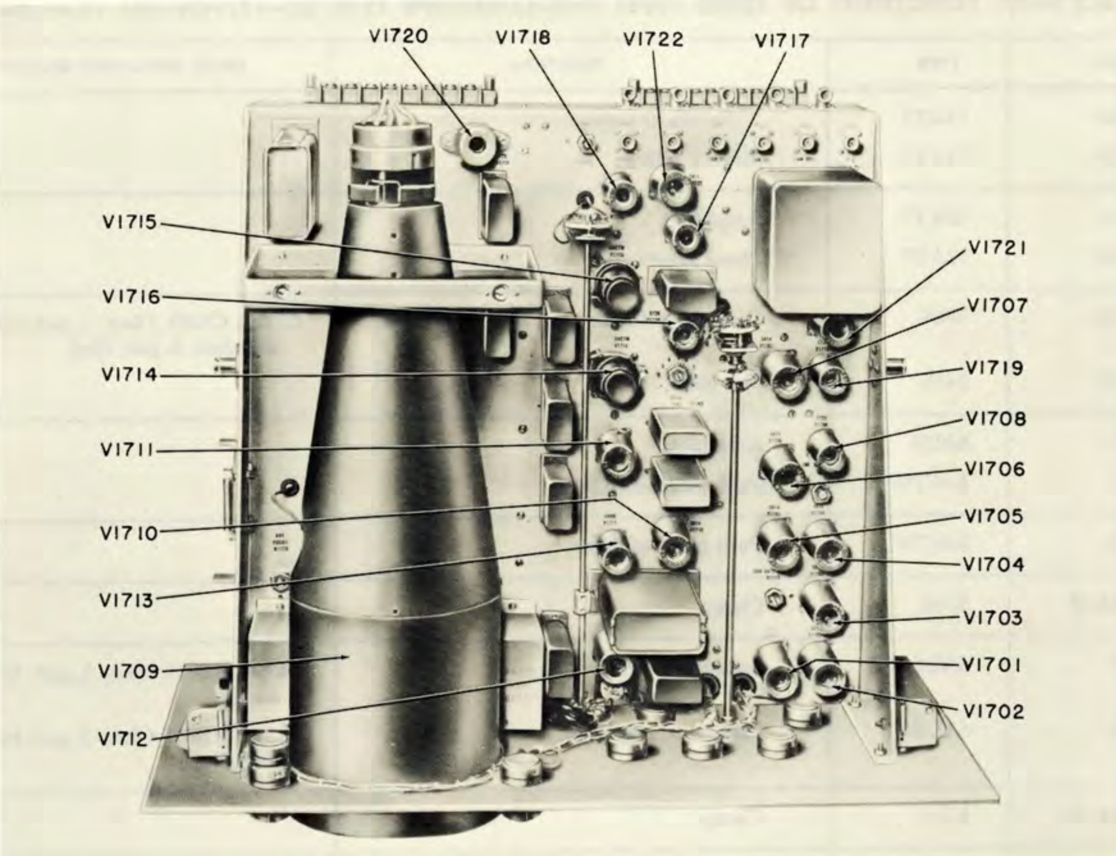


Figure 5–16. Test Oscilloscope Type OS–39/FPN–30, Location and Identification of Tubes

TABLES 5–10. FUNCTIONS OF TUBES (TEST OSCILLOSCOPE TYPE OS–39/FPN–30)

SYMBOL	TYPE	FUNCTION	AFTER REPLACING READJUST
V1701A	5814	Negative sync amplifier	
V1701B	5814	Positive sync amplifier	
V1702A/B	5814	1,000-μsec delay	
V1703A/B	5814	1,000-μsec marker push-up	R1713 (Sect. 7, par. 4*b* (1))
V1704A	5814	1,000-μsec clipper	
V1704B	5814	100-μsec clipper	
V1705A/B	5814	100-μsec delay	
V1706A/B	5814	100-μsec marker push-up	R1729 (Sect. 7, par. 4*b* (1))
V1707A	5814	Clamp	
V1707B	5814	Trigger cathode follower	
V1708	5725	Continuous delay	R1752 (Sect. 7, par. 4*b* (1))
V1709	5CP1A	Test scope	R1776, R1806, R1781, R1795, R1780, R1779 (Sect. 3, pars. 16*l* (4), (5) and (6) and 16*f*)

TABLE 5–10. FUNCTIONS OF TUBES (TEST OSCILLOSCOPE TYPE OS–39/FPN–30) (Cont'd)

SYMBOL	TYPE	FUNCTION	AFTER REPLACING READJUST
V1710A	12AT7	1000-100-10-1 μsec	
V1710B	12AT7	Marker mixer	
V1711A	12AT7	Amplifier	
V1711B	12AT7	Phase inverter	
V1712A	5814	Cathode follower	C1723, C2203 (Sect. 7, par. 16*b* and Sect. 3, par. 16*g*)
V1712B	5814	Not used	
V1713	6AU6	Amplifier	
V1714	6AC7W	Push-pull amplifier	
V1715	6AC7W	Push-pull amplifier	
V1716A/B	5726	Clamp	
V1717	6AU6	Sweep generator	R1795, R1806 (Sect. 3, par. 16*e* and *f*)
V1718	6AU6	Paraphase amplifier	R1795, R1806 (Sect. 3, par. 16*e* and *f*)
V1719A/B	5726	Clamp	
V1720A/B	5726	Clamp	
V1721A	5814	Cathode follower	
V1721B	5814	Trigger-diode	
V1722A	5814	Cathode follower	
V1722B	5814	Not used	

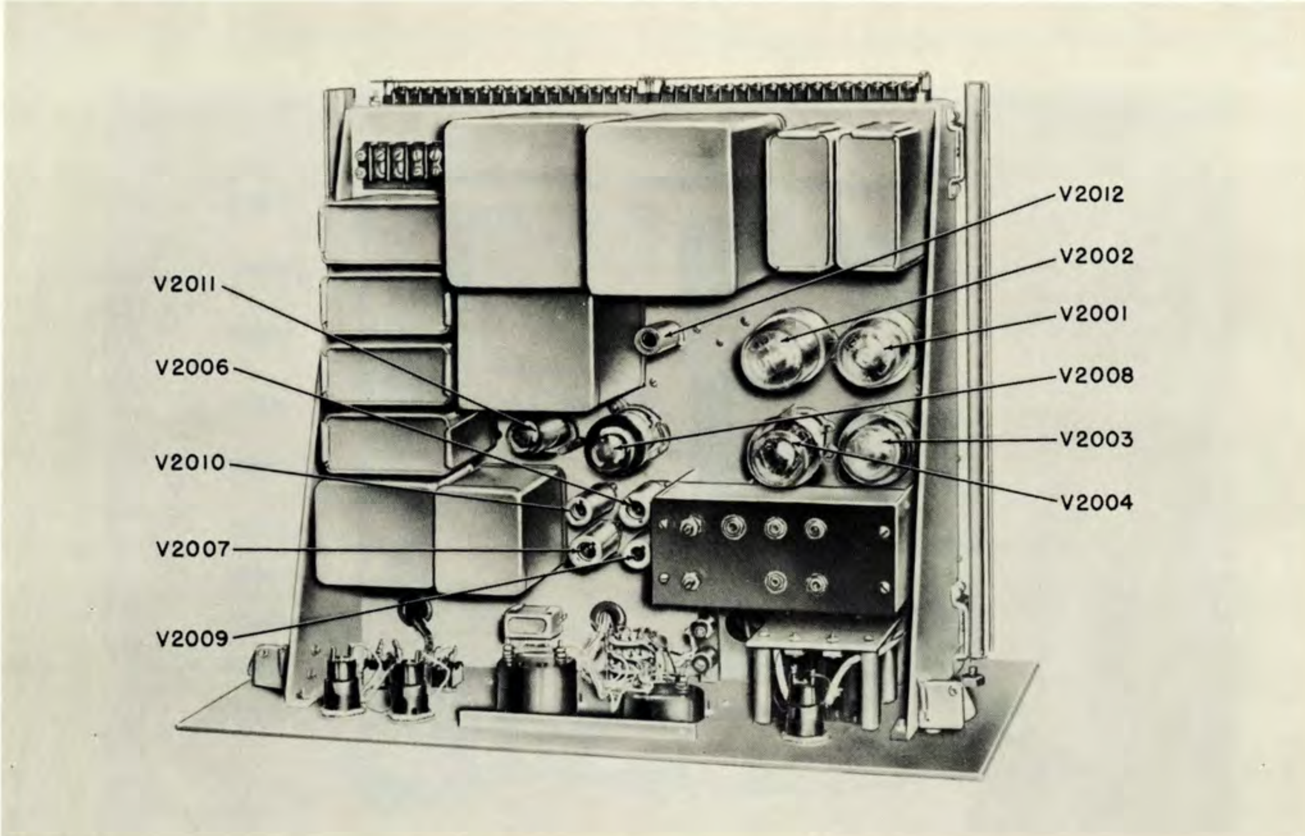


Figure 5–17. Power Supply Type PP-959/FPN-30, Location and Identification of Tubes

TABLE 5–11. FUNCTIONS OF TUBES (POWER SUPPLY TYPE PP-959/FPN-30)

SYMBOL	TYPE	FUNCTION	AFTER REPLACING READJUST
V2001	5R4WGY	Rectifier	
V2002	5R4WGY	Rectifier	
V2003A/B	6AS7G	+150 v regulator	R2022 (Sect. 3, par. 14*d*)
V2004A/B	6AS7G	+150 v regulator	R2022 (Sect. 3, par. 14*d*)
V2005		Not used	
V2006A/B	12AT7	+150 v control amplifier	R2022 (Sect. 3, par. 14*d*)
V2007A/B	5814	−30 v control amplifier	R2033 (Sect. 3, par. 14*d*)
V2008	6Y6G	−30 v regulator	R2033 (Sect. 3, par. 14*d*)
V2009	5651	Reference tube	R2022 (Sect. 3, par. 14*d*)
V2010	OB2	−108 v regulator	
V2011	5Y3WGT	−230 v rectifier	
V2012	OA2	Reference tube	

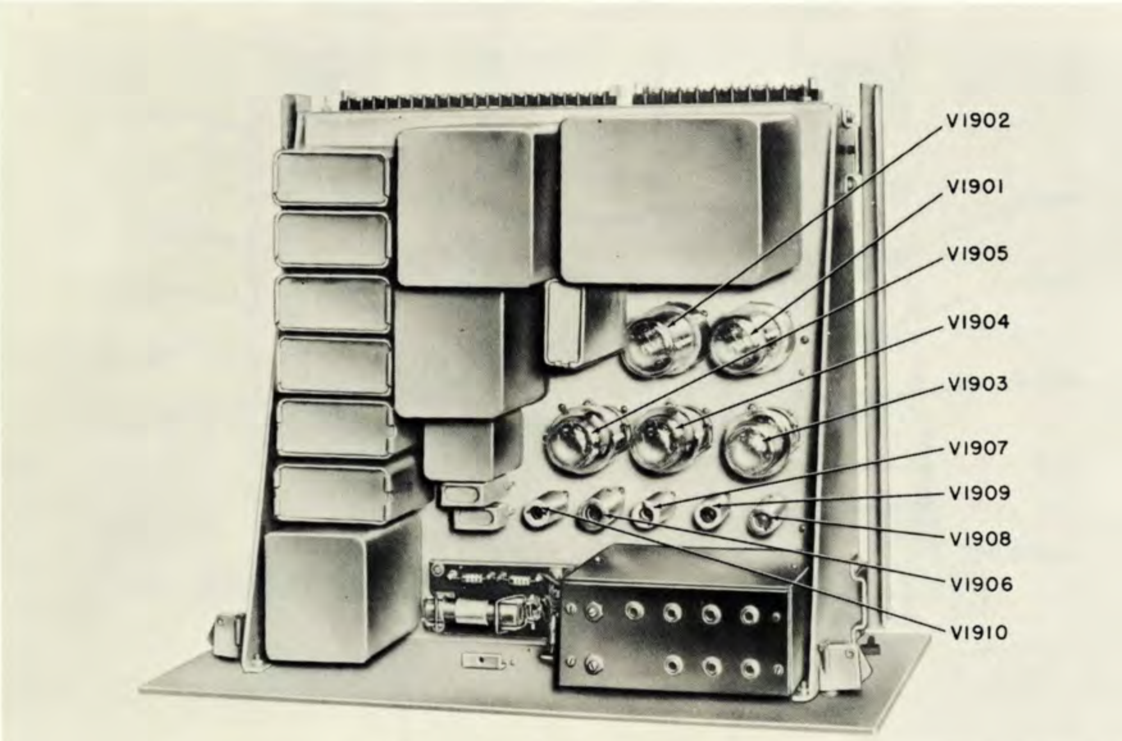


Figure 5–18. Power Supply Type PP–958/FPN–30, Location and Identification of Tubes

TABLE 5–12. FUNCTIONS OF TUBES (POWER SUPPLY PP–958/FPN–30)

SYMBOL	TYPE	FUNCTION	AFTER REPLACING READJUST
V1901	5R4WGY	Rectifier	
V1902	5R4WGY	Rectifier	
V1903A/B	6AS7G	+300 v regulator	R1922 (Sect. 3, par. 14*d*)
V1904A/B	6AS7G	+300 v regulator	R1922 (Sect. 3, par. 14*d*)
V1905A/B	6AS7G	+300 v regulator	R1922 (Sect. 3, par. 14*d*)
V1906A/B	12AT7	+300 v control amplifier	R1922 (Sect. 3, par. 14*d*)
V1907	5651	Reference tube	R1922 (Sect. 3, par. 14*d*)
V1908	6005	+135 v regulator	R1933 (Sect. 3, par. 14*d*)
V1909	6AU6	+135 v control amplifier	R1933 (Sect. 3, par. 14*d*)
V1910	5651	Reference tube	R1933 (Sect. 3, par. 14*d*)

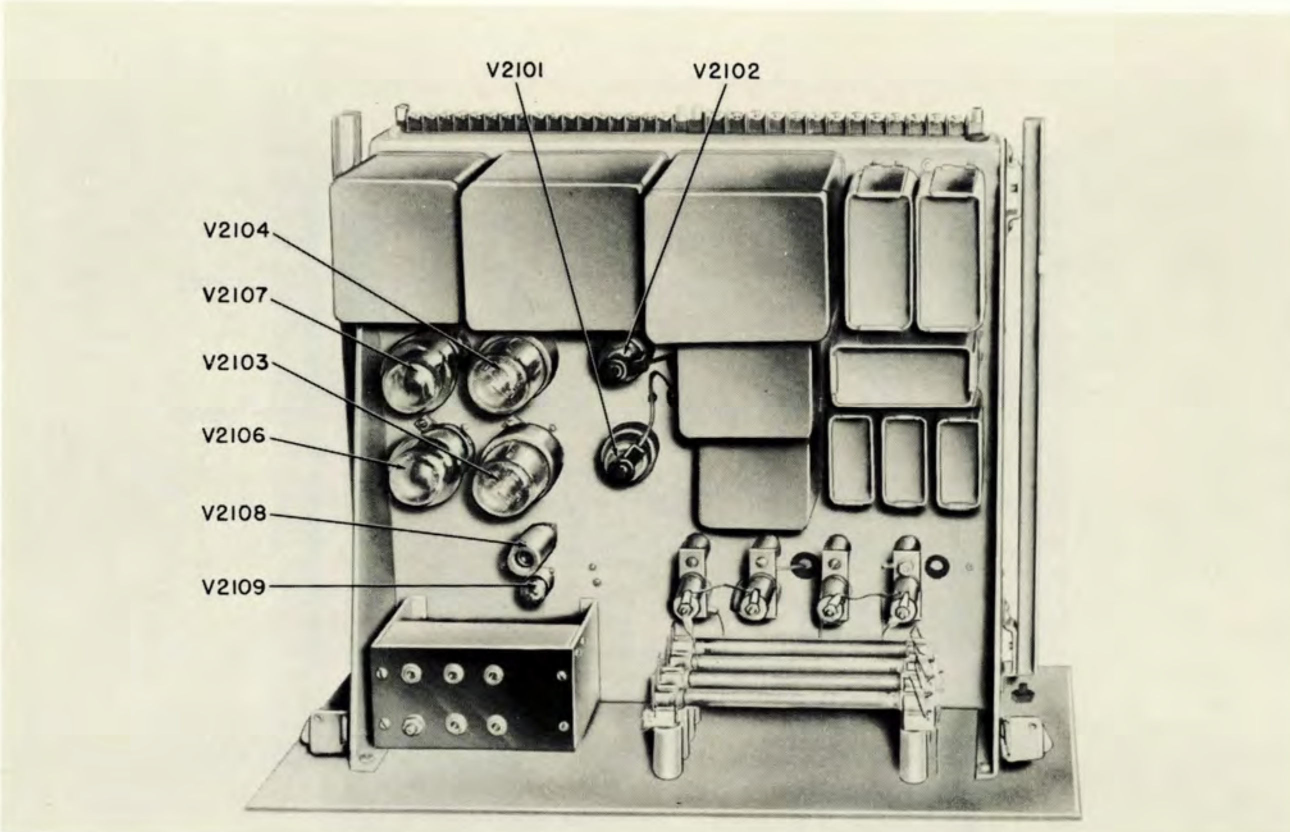


Figure 5-19. Power Supply Type PP-957/FPN-30, Location and Identification of Tubes

TABLE 5-13. FUNCTIONS OF TUBES (POWER SUPPLY PP-957/FPN-30)

SYMBOL	TYPE	FUNCTION	AFTER REPLACING READJUST
V2101	2X2A	High voltage rectifier	
V2102	2X2A	High voltage rectifier	
V2103	5R4WGY	Rectifier	
V2104	5R4WGY	Rectifier	
V2105		Not used	
V2106A/B	6AS7G	+150 v regulator	R2122 (Sect. 3, par. 14*d*)
V2107A/B	6AS7G	+150 v regulator	R2122 (Sect. 3, par. 14*d*)
V2108A/B	12AT7	+150 v control amplifier	R2122 (Sect. 3, par. 14*d*)
V2109	5651	Reference tube	R2122 (Sect. 3, par. 14*d*)

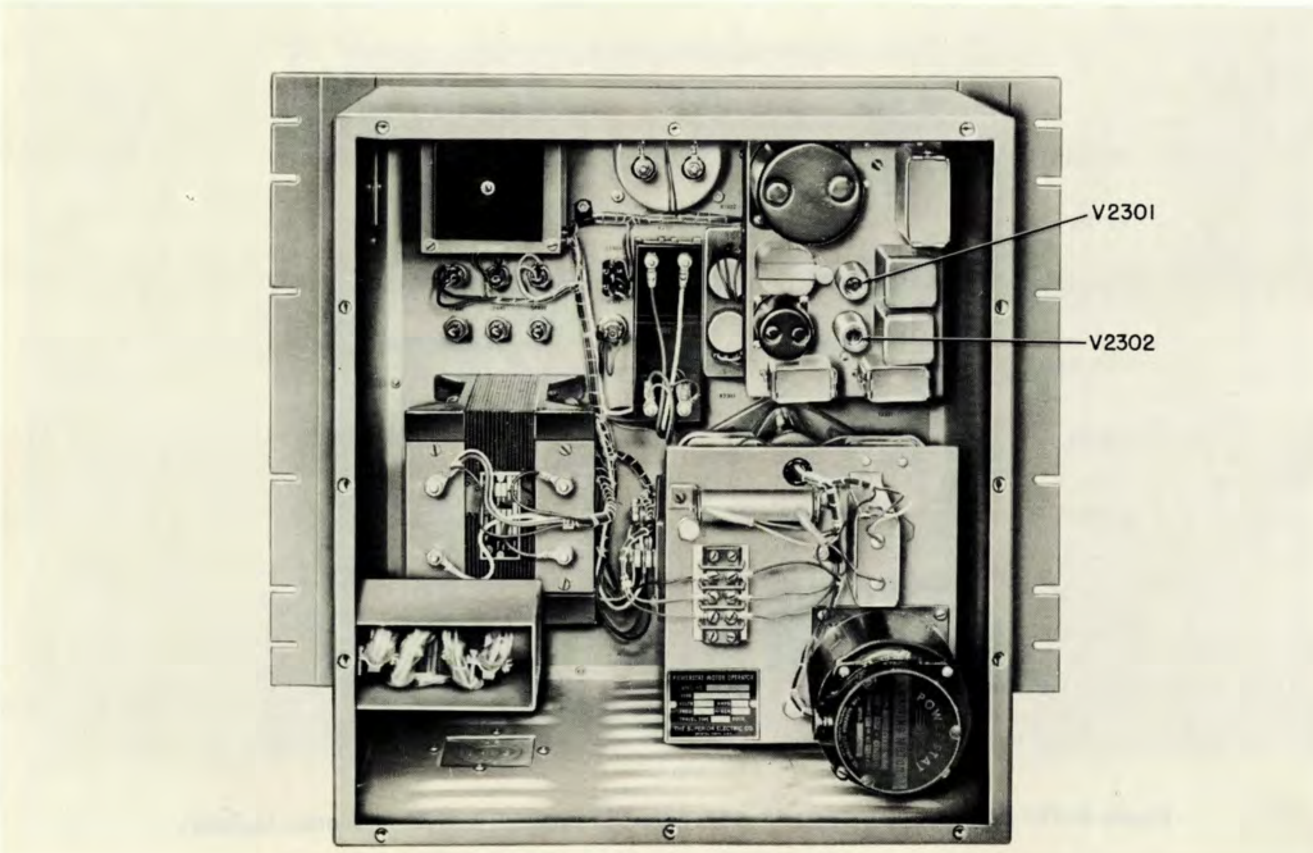


Figure 5–20. Voltage Regulator Type CN–235/FPN–30, Location and Identification of Tubes

TABLE 5–14. FUNCTIONS OF TUBES (VOLTAGE REGULATOR TYPE CN–235/FPN–30)

SYMBOL	TYPE	FUNCTION	AFTER REPLACING READJUST
V2301	2D21W	Control circuit thyratron	R2302 (Sect. 3, par. 14*b* (2))
V2302	2D21W	Control circuit thyratron	R2303 (Sect. 3, par. 14*b* (3))

TABLE 5–15. SYMPTOMS OF FUSE FAILURE

IDENTIFICATION OF BLOWN FUSE			SYMPTOMS						
UNIT	FUSE	VALUE (AMPS)	PANEL SIGNAL LIGHT	SLOW SCOPE	VIDEO SCOPE	RF SCOPE	MAINTENANCE OF SYNCHRONIZATION	TRANSMITTER PULSE	REMARKS
Radio frequency oscillator	115 v a-c line input fuse F1401	B1	White light ON —COARSE HEATER PILOT OFF	Normal	Normal	Normal	Normal	Normal	Timer will operate normally until oscillator oven cools off.
Radio frequency oscillator	+135 v input fuse F1402	B1/8	White light ON	Bright spot	No trace	No trace	None	No trigger or exciter pulse	
Synchronization control	+300 v fuse F101	A1/8	White light ON	No local signal	No local signal	No local signal	None	No 100 kc to transmitter	If transmitter is not self-excited, local signal will not appear on scopes.
Synchronization control	115 v a-c fuse F102	B1-1/2	White light ON	Bright spot	No trace	No trace	None	No trigger pulse	
Synchronization control	+150 v fuse F103	B1/8	White light ON	Bright spot	No trace	No trace	None	No trigger pulse	
Frequency divider	A-c line fuse F201	B2	White light ON	Bright spot	No trace	No trace	Normal	No trigger pulse	
Frequency divider	+150 v fuse F202	A1/8	White light ON	Bright spot	No trace	No trace	Normal	No trigger pulse	
Frequency divider	+300 v fuse F203	A1/4	White light ON	Bright spot	No trace	No trace	Normal	No trigger pulse	
Time delay	115 v a-c fuse F501	B1-1/2	White light ON	No pedestal	No trace	No trace	Normal	No trigger pulse	
Time delay	+150 v fuse F502	A1/4	White light ON	No pedestal	No trace	No trace	Normal	No trigger pulse	
Time delay	+300 v fuse F503	A1/8	White light ON	Excessive amplitude for local signal	Excessive amplitude for local signal	Excessive amplitude for local signal	Normal		No blanking pulse.
Radio receiver	A-c line fuse F1201	B3/4	White light ON	Normal trace	Normal trace	Normal trace	Normal	Normal	No received signal.
Radio receiver	B+ line fuse F1202	B3/8	White light ON	Normal trace	Normal trace	Normal trace	Normal	Normal	No received signal.
Synchronization indicator	Filament power fuse F801	B1-1/2	White light ON	No pedestal	No trace	No trace	Normal	Normal	
Synchronization indicator	+150 v fuse F802	A1/8	White light ON	No pedestal	No trace	No trace	Normal	Normal	

TABLE 5–15. SYMPTOMS OF FUSE FAILURE (Cont'd)

IDENTIFICATION OF BLOWN FUSE			SYMPTOMS						
UNIT	FUSE	VALUE (AMPS)	PANEL SIGNAL LIGHT	SLOW SCOPE	VIDEO SCOPE	RF SCOPE	MAINTENANCE OF SYNCHRONIZATION	TRANSMITTER PULSE	REMARKS
Synchronization indicator	+300 v fuse F803	A1/4	White light ON	No pedestal	No trace	No trace	Normal	Normal	
Electrical synchronizer	A-c line fuse F1501	B1-1/2	White light ON	Normal	Normal	Normal	None	Normal	
Electrical synchronizer	+150 v fuse F1502	A1/8	White light ON	Normal	Normal	Normal	None	Normal	
Test oscilloscope	+150 v fuse F1701	A1/8	White light ON	Normal	Normal	Normal	Normal	Normal	No trace on test scope except when sync selector is on 1,000's or 100's.
Test oscilloscope	+300 v fuse F1702	A1/8	White light ON	Normal	Normal	Normal	Normal	Normal	No trace on test scope.
Test oscilloscope	Filament power fuse F1703	B1	White light ON	Normal	Normal	Normal	Normal	Normal	No trace on test scope.
Power Supply Type PP–959/FPN–30	Plate power fuse F2001	B3	White light ON	Bright spot	No trace	No trace	Normal	No trigger pulse	
Power Supply Type PP–959/FPN–30	Filament power fuse F2002	B1-1/2	White light ON	Bright spot	No trace	No trace	Normal	No trigger pulse	
Power Supply Type PP–959/FPN–30	Bias input supply fuse F2003	B3/4	White light ON—MAIN POWER INDICATOR OFF	No trace	No trace	No trace	Normal	No trigger pulse	SPACE HEATER power indicator will also go out.
Power Supply Type PP–959/FPN–30	B205 output fuse F2004	A1/4	White light ON	No trace	No trace	No trace	Normal	No trigger pulse	
Power Supply Type PP–959/FPN–30	Common a-c line fuse F2005	B4	White light ON—MAIN POWER INDICATOR OFF	No trace	No trace	No trace	None	No trigger pulse	
Power Supply Type PP–959/FPN–30	Space heater power fuse F2006	B5	White light ON—SPACE HEATER power indicator OFF	Normal	Normal	Normal	Normal	Normal	Space heaters will not operate.

Power Supply Type PP–959/FPN–30	Space heater power fuse F2007	B5	White light ON—SPACE HEATER power indicator OFF	Normal	Normal	Normal	Normal	Normal	Space heaters will not operate.
Power Supply Type PP–958/FPN–30	Plate power fuse F1901	B3	White light ON	Bright spot	No trace	No trace	None	No pulse	Meter will not read 300 v.
Power Supply Type PP–958/FPN–30	Filament power fuse F1902	B1-1/2	White light ON	Bright spot	No trace	No trace	None	No pulse	
Power Supply Type PP–958/FPN–30	Auxiliary filament power fuse F1903	B1-1/2	White light ON	Normal	Normal	Normal	Normal	Normal	Any auxiliary equipment filaments connected to transformer T1903 will be inoperative.
Power Supply Type PP–958/FPN–30	Blower power fuse F1904	B1-1/2	White light ON	Normal	Normal	Normal	Normal	Normal	**WARNING** Blower not operating, timer may overheat.
Power Supply Type PP–958/FPN–30	1,000-volt fuse F1905	A1/16	White light ON	Normal	Normal	No r-f pulse display	Normal	Normal	
Power Supply Type PP–957/FPN–30	High-voltage plate supply fuse F2101	B1/4	White light ON—H. V. POWER indicator OFF	No trace	No trace	No trace	Normal	Normal	
Power Supply Type PP–957/FPN–30	High-voltage filament supply fuse F2102	B1/2	White light ON	No trace	No trace	No trace	Normal	Normal	
Power Supply Type PP–957/FPN–30	Low-voltage plate supply fuse F2103	B3	White light ON	No trace	No trace	No trace	Normal	Normal	
Power Supply Type PP–957/FPN–30	Low-voltage filament supply fuse F2104	B1-1/2	White light ON	No trace	No trace	No trace	Normal	Normal	
Voltage regulator	T2301 brush fuse F2301	A8	None	Normal	Normal	Normal	Normal	Normal	Line voltage to timer unregulated.
Voltage regulator	Control circuit fuse F2302	A3	POWER ON pilot lamp—OFF	Normal	Normal	Normal	Normal	Normal	Line voltage to timer unregulated.
Voltage regulator	B2301 motor fuse F2303	A3	None	Normal	Normal	Normal	Normal	Normal	Line voltage to timer unregulated.

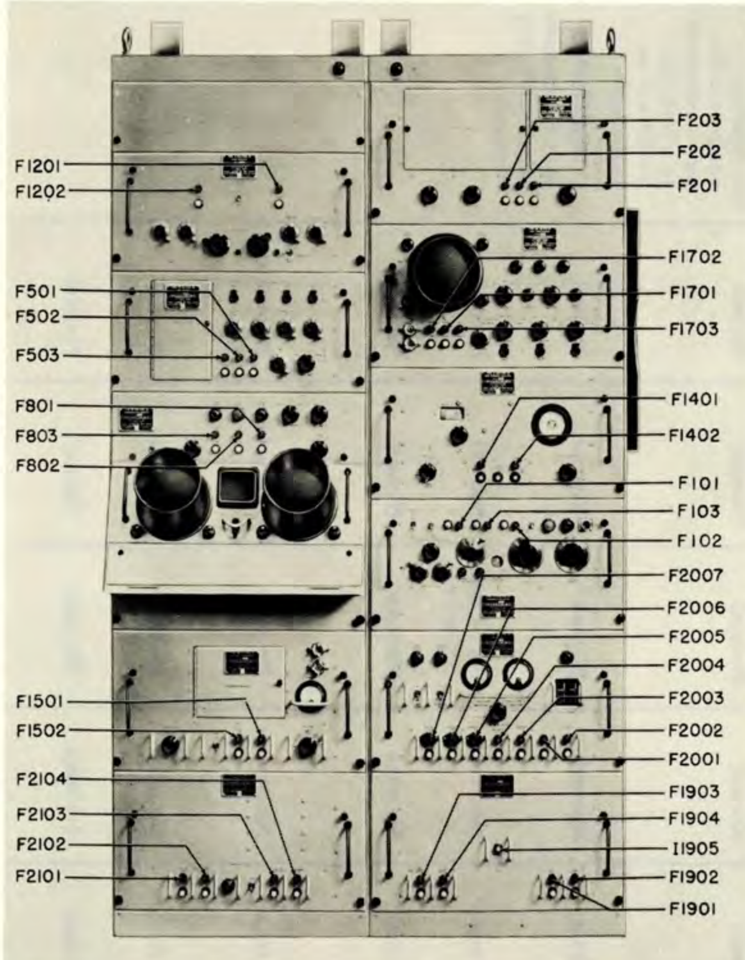


Figure 5–21. Fuse Locations, Symbol Numbers, and Values

TABLE 5–16. FUSE LOCATIONS

The fuses used in the timer are of two types, instantaneous, and slow-blow. In this table, and on the equipment, the prefix A is used, before the fuse value, to indicate the instantaneous type and B to indicate the slow-blow type.

SYMBOL	LOCATION	PROTECTS	AMPS	VOLTS	NUMBER
F101	Synchronization control	Plate circuits of V105	A1/8	250	17–F–16302–250
F102	Synchronization control	Motor B103, primary of T101 and frequency warning circuit	B1-1/2	125	17–F–16280–900
F103	Synchronization control	Plate circuits of V103, V104 and V106	A1/8	250	17–F–16302–250
F201	Frequency divider	Primary of T205	B2	125	17–F–14308–200
F202	Frequency divider	Output amplifier, screen grid circuit of V227 and plate circuits of V207, V222, V223, V235 and V224A	A1/8	250	17–F–16302–250
F203	Frequency divider	Plate circuits of counters	A1/4	250	17–F–16302–45
F501	Time delay	Primary of T501	B1-1/2	125	17–F–16280–900
F502	Time delay	Plate circuits of V502 to V504 and V508 to V519	A1/4	250	17–F–16302–45
F503	Time delay	Plate circuits of blanking pulse generator	A1/8	250	17–F–16302–250
F801	Synchronization indicator	Primary of T801	B1-1/2	125	17–F–16280–900

TABLE 5-16. FUSE LOCATIONS (Cont'd)

SYMBOL	LOCATION	PROTECTS	AMPS	VOLTS	NUMBER
F802	Synchronization indicator	Screen grid circuit of V819 and V804 and plate circuit of V808A	A1/8	250	17-F-16302-250
F803	Synchronization indicator	Plate circuits of V813, V815, V808B and V812B	A1/4	250	17-F-16302-45
F1201	Radio receiver	Primary of T1201	B3/4	250	17-F-14310-372
F1202	Radio receiver	Plate circuits of all tubes	A3/8	250	17-F-16302-52
F1401	Radio frequency oscillator	Coarse heater circuit	B1	250	17-F-14310-380
F1402	Radio frequency oscillator	Plate circuits of all tubes	B1/8	120	17-F-14310-315
F1501	Electrical synchronizer	Primary of T1502	B1-1/2	125	17-F-16280-900
F1502	Electrical synchronizer	Plate circuits of all tubes	A1/8	250	17-F-16302-250
F1701	Test oscilloscope	Plate circuits of V1721A, V1701A, V1702 and V1722	A1/8	250	17-F-16302-250
F1702	Test oscilloscope	Plate circuits of V1701 to V1708	A1/8	250	17-F-16302-250
F1703	Test oscilloscope	Primary of T1701	B1	250	17-F-14310-382
F1901	Power Supply Type PP-958/FPN-30	Primary of T1901	B3	125	17-F-16280-1500
F1902	Power Supply Type PP-958/FPN-30	Primary of T1902	B1-1/2	125	17-F-16280-900
F1903	Power Supply Type PP-958/FPN-30	Primary of T1903	B1-1/2	125	17-F-16280-900
F1904	Power Supply Type PP-958/FPN-30	Blower circuit	B1-1/2	125	17-F-16280-900
F1905	Power Supply Type PP-958/FPN-30	+1,000 v rectifier and filter circuit	A1/16	1,000	17-F-15509
F2001	Power Supply Type PP-959/FPN-30	Primary of T2001	B3	125	17-F-16280-1500
F2002	Power Supply Type PP-959/FPN-30	Primary of T2002	B1-1/2	125	17-F-16280-900
F2003	Power Supply Type. PP-959/FPN-30	Primary of T2003	B3/4	250	17-F-14310-372
F2004	Power Supply Type PP-959/FPN-30	Bias rectifier and filter circuit	A1/4	250	17-F-16302-45
F2005	Power Supply Type PP-959/FPN-30	Power input to timer	B4	250	17-F-14690-5850
F2006	Power Supply Type PP-959/FPN-30	Space heater circuit	B5	250	17-F-14690-5875
F2007	Power Supply Type PP-959/FPN-30	Space heater circuit	B5	250	17-F-14690-5875
F2101	Power Supply Type PP-957/FPN-30	Primary of T2101	B1/4	250	17-F-16303-825
F2102	Power Supply Type PP-957/FPN-30	Primary of T2102	B1/2	250	17-F-14310-360
F2103	Power Supply Type PP-957/FPN-30	Primary of T2103	B3	125	17-F-16280-1500
F2104	Power Supply Type PP-957/FPN-30	Primary of T2104	B1-1/2	125	17-F-16280-900
F2301	Voltage regulator	Primary of T2302	A8	250	17-F-14328-41
F2302	Voltage regulator	Control circuit	A3	250	17-F-14328-25
F2303	Voltage regulator	Motor B2301	A3	250	17-F-14328-25

CG-273-15
(Volume 1)

INSTRUCTION BOOK

for

LORAN TIMER SET AN/FPN-30

SECTION 6 PREVENTIVE MAINTENANCE

ITT *Federal Division*

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

Clifton, New Jersey, U.S.A.

FORMERLY

FEDERAL TELEPHONE AND RADIO COMPANY

TREASURY DEPARTMENT

U.S. COAST GUARD

Contracts: Tcg-38701(CG-20,181-A)
Tcg-39263(CG-27,298-A)
Tcg-40020(CG-35,978-A)
Tcg-41083 (CG-44,327-A)

Approved by C. G. Headquarters:
16 October 1959

Preventive Maintenance
Section 6

TABLE OF SECTIONS

SECTION 6
PREVENTIVE MAINTENANCE

1. INTRODUCTION.

Periodic inspection of the timer is necessary to maintain the equipment in good operating condition. This section outlines the maintenance schedule that should be followed. Daily and monthly checks are covered by the following tables. The lubrication of the moving parts of the timer is also covered in this section.

The operator of the equipment should be alert to any change in the operation of the potentiometers and switches in the timer. If the potentiometers do not operate smoothly and the switches do not make positive contact, they should be brought to the attention of the maintenance technician.

2. CLEANING.

Periodic cleaning of the timer is necessary to prevent breakdown of insulating surfaces. A thorough cleaning of the timer is recommended approximately once a month. Remove the dust with a lint-free cloth. If the dust and dirt have hardened, remove them by moistening the cleaning cloth with soap and water or with an approved solvent. (If water or a cleaning fluid is used, be sure the equipment is completely dry before restoring power.) If a vacuum cleaner or air hose is available, either may be used to remove the dust from places which cannot be reached with the cleaning cloth.

3. INSPECTION.

After the timer has been cleaned as outlined above, the equipment should be inspected thoroughly for loose or broken connections. Hand-test for tightness all exposed connections, vacuum tubes, plug and socket connections. Look for evidence of heating or breakdown such as carbonized surfaces, charred or discolored resistors, and oxidized or discolored metal parts. Even though there is no serious damage and the equipment functions properly, these may indicate potential trouble, and the cause of the above conditions should be investigated and corrected. The investigation of overheated parts involves checking the voltage and resistance associated with the part. Typical voltage and resistance values are given in tables 7-15 through 7-26.

4. ROUTINE MAINTENANCE SCHEDULE.

Routine checking of possible sources of trouble, in addition to the above general inspection, will often anticipate or detect faults. Therefore, the maintenance schedule (tables 6-1 and 6-2) lists a number of such points with information regarding them. This schedule should be regularly followed and additional checks added to it as experience dictates. The following checks are to be made during the period that the timer is in stand-by condition.

5. MARGINAL LIMITS TEST FOR PERFORMANCE OF COUNTER CIRCUITS IN FREQUENCY DIVIDER.

Trouble in the counter circuits may be anticipated through use of a marginal limits test. This test is used to determine that specific tubes in the frequency divider unit are approaching the end of their useful life and should be replaced. The test is made by varying the bias in the counter circuits to find the range of bias over which the circuits divide properly. When it is found that this range has narrowed below a specified limit, corrective measures must be taken. The test procedure, which is made by operating COUNTER BIAS control R282, and procedures for corrective action are given below.

a. COUNTER BIAS (R282) TEST.—To determine whether or not the frequency divider counter circuits are operating within safe limits for assured continuous performance, proceed as follows:

Step 1. Observe the SLOW SCOPE presentation and slowly vary the COUNTER BIAS control in the clockwise direction.

Step 2. Note the dial reading at which the SLOW SCOPE sweep shows some change. This change may manifest itself as a small or considerable shortening of the sweep, or as an erratic behavior of the sweep. Return the control to the original setting.

Step 3. Turn the COUNTER BIAS control slowly in the COUNTERCLOCKWISE direction.

Step 4, Again note the dial reading at which the SLOW SCOPE SWEEP shows some change. If the difference between the two readings is less than 20 dial divisions, corrective action, as described in paragraph 5*b*, below, should be taken.

Step 5. Set the dial to the midpoint of the two dial readings obtained in steps 2 and 4 above. Record the two dial readings for future reference. Make a continuous log of the COUNTER BIAS dial readings, taken weekly, on page 6-8. (An initial reading, in accordance with the procedure in Section 3, paragraph 20*e*, should have been previously logged.) By noting any marked changes in the readings, useful preventive maintenance information may be gained.

b. CORRECTIVE ACTION FOR DECREASED RANGE OF COUNTER BIAS CONTROL.—To determine which stage or stages are defective, use the following procedures.

First compare the readings taken in steps 2 and 4 of paragraph 5*a* above with previously logged readings to determine the direction in which the operating

TABLE 6-1. DAILY CHECKS OF TIMER

WHAT TO CHECK	HOW TO CHECK	REMARKS
Blower operation.	Listen for sound of blower and place hand behind exhaust vents to feel if air is passing through.	The cabinet thermostat should keep the blower on when the temperature is over 10°C. (50°F.).
A-c line voltage.	Observe a-c line meter.	If the voltage is not within two volts of 115 volts, adjust Voltage Regulator Type CN-235/FPN-30.
+150-volt output of Power Supply Type PP-959/FPN-30.	Use DC VOLTS meter to measure voltage.	If the output is not within three volts of +150 volts, adjust +150 V ADJ potentiometer. If this adjustment cannot be made, refer to table 7-10, symptom 1.
−30-volt output of Power Supply Type PP-959/FPN-30.	Use DC VOLTS meter to measure voltage.	If the voltage is not within one volt of −30 volts, adjust −30 V ADJ potentiometer. If this adjustment cannot be made, refer to table 7-10, symptom 6.
−108-volt output of Power Supply Type PP-959/FPN-30.	Use DC VOLTS meter to measure voltage.	This voltage is not adjustable. If it is not within eight volts of −108 volts, replace tube V2010. If tube replacement fails to cure the trouble, refer to table 7-10, symptom 5.
+300-volt output of Power Supply Type PP-958/FPN-30.	Use DC VOLTS meter to measure voltage.	If this voltage is not within six volts of +300 volts, adjust +300 V ADJ potentiometer. If this adjustment cannot be made, refer to table 7-11, symptom 1.
+135-volt output of Power Supply Type PP-958/FPN-30.	Use DC VOLTS meter to measure voltage.	If this voltage is not within two volts of +135 volts, adjust +135 V ADJ potentiometer. If this adjustment cannot be made, refer to table 7-11, symptom 3.
+1,000-volt output of Power Supply Type PP-959/FPN-30.	Use DC VOLTS meter to measure voltage.	This voltage is not adjustable. If it is not within 150 volts of 1,000 volts, refer to table 7-11, symptom 5.
+150-volt output of Power Supply Type PP-957/FPN-30.	Use DC VOLTS meter to measure voltage.	If this voltage is not within three volts of +150 volts, adjust +150 V ADJ potentiometer. If this adjustment fails, refer to table 7-12, symptom 1.
−1,800-volt output of Power Supply Type PP-957/FPN-30.	Use DC VOLTS meter to measure voltage.	This voltage is not adjustable. If it is not within 300 volts of −1,800 volts, refer to table 7-12, symptom 4.

range has shrunk. For example, if an initial reading (taken when the equipment was installed or taken after the last maintenance operation on the counter circuits, whichever is later) showed an operating range of 30 to 70, and the range has now shifted to between 37 and 55, the range has shrunk towards the lower numbers. On the other hand, if the range has now shifted to between 50 and 67, the range has shrunk towards the higher numbers.

Depending on the direction in which the range has shrunk (higher or lower), set the COUNTER BIAS dial to the higher or lower (respectively) number recorded in paragraph 5*a* above. For example, if the range has shrunk to between 50 and 67 (higher numbers), set the dial to 67. Make sure the dial is set just beyond the point where normal operation was obtained, so that the counter misbehaves.

Determine which counter is misbehaving as follows:

(1) LOCATING THE MALFUNCTIONING COUNTER.

Step 1. Set the PRESENTATION switch, on the VIDEO SCOPE, to CAL.

Step 2. Adjust the VIDEO SEPARATION control so that the traces are about one inch apart.

Step 3. Adjust the SWEEP SPEED control on the VIDEO SCOPE so that only two 100-microsecond markers are displayed on the upper trace. Observe whether they are spaced 100 microseconds apart (nine 10's between the 100's). If 100's are normal, counter 1 is probably operating normally. If this is the case, proceed to step 4. If counter 1 is not normal, proceed to paragraph 5*b* (2), below.

TABLE 6-2. MONTHLY CHECKS OF TIMER

WHAT TO CHECK	HOW TO CHECK	REMARKS
Ground connection.	Observe the condition of the ground clamp and the copper ribbon connected to the bottom rear of the cabinet.	If corrosion is visible, the ground strap and clamp should be removed and cleaned thoroughly with steel wool and fine sandpaper, front and back.
Relays.	Remove all power from the unit in which the relay is located. Inspect for pitted, corroded, or dirty contacts and for loose mechanical parts. See if coils show signs of having been overheated.	Refer to paragraph 5, this section, for information on relays.
Test leads and patch cords.	Inspect each lead and cord individually to see that there are no breaks in the insulation or loose connections at the plugs.	Test leads must not be hung over nails or narrow hooks because of the possibility of damage to the insulation. When not in use, place in proper compartment in the drawer of the operator's table. Clean dirty or corroded phone plugs with crocus cloth or No. 0000 sandpaper.
Chassis slide-and-tilt assemblies.	See that the slides pull out and push in freely, and that the tilt mechanism engages and releases freely. Check the alignment of the panel with the front of the cabinet and with the adjacent units for signs of sagging.	Poor action may be caused by collected dirt. Clean thoroughly if this is the case. Poor alignment indicates that readjustment is necessary. This is described in Section 7, paragraph 5*a*.
Blower rotors.	To gain access to a blower, either of the units at the top of the cabinet must be withdrawn. Refer to Section 7, paragraph 5*a* (3).	The rotors must be cleaned and dusted. Use a soft cloth and apply only enough pressure to remove the accumulation.
Interlocks.	Operate the INTERLOCKED POWER ON-OFF switch to the ON position and see that the INTERLOCKED POWER indicator lamp is on. Pull each unit from the cabinet and note that the INTERLOCKED POWER indicator lamp goes out. After the unit is pulled from the cabinet, pull the interlocked switch shaft outward and note that the indicator lamp lights. The same procedure applies to the rear door interlocks. Check the interlock switch behind the hinged control panel of the synchronization indicator in the same manner.	If the interlock switch does not operate properly, it must be replaced with a new one.
Duct-mounting brackets.	If mounting brackets are used, inspect for tightness of the mounting screws.	If any looseness is evident, retighten the screws.
Air filters.	Remove the air filters from their frames and inspect for dust that may clog the openings.	Remove the dust by rinsing in a hot solution of fresh water and dishwashing compound. After cleaning, place the filters in a pan of SAE 10 motor oil. Drain off the excess oil and replace the filters in their original positions. If the equipment is in a dusty location, more frequent checks are necessary.
Clutches.	Check the PHASE dial clutch by operating the AUTO SYNC ON-OFF switch to the ON position. The clutch should engage with the power on and release when the power is removed. The FREQUENCY CORRECTOR dial clutch is checked in the same manner except that the FREQUENCY CORRECTOR switch must be operated.	Verify that the clutches are released by seeing that the two controls turn easily. If the clutches are not released, the switches, through which power is applied to the clutches, should be checked.
Feedback generator.	Check the voltage from the generator. The feedback voltage varies according to frequency shift. Refer to Section 2, paragraph 4*g*.	If the voltage is too low, remove the generator from the sync control unit as described in Section 7, paragraph 5*c* (7). Clean the brushes and commutator with a crocus cloth. If the brushes are worn down to less than one-fourth inch, replace them.

Step 4. Adjust the VIDEO SWEEP DELAY control to the extreme counterclockwise (delay out) position. Change the setting of the SWEEP SPEED until a 1000 is at the right-hand edge of the sweep. Observe whether there are nine 100-microsecond markers to the left of the 1000 (nine 100's between the 1000's). If 1000's are normal, counter 2 is operating and the trouble is probably in counter 3. Proceed to paragraph 5*b* (2) below to locate the fault in counter 2 or counter 3.

(2) LOCATING THE MALFUNCTIONING STAGE.—The most direct way to locate a specific malfunctioning tube is to use the TEST COUNT push button to make the counter progress, under normal control, through each counting step. Use the procedures given in Section 7, paragraph 7, to find which tube, in the defective counter, is malfunctioning. When a stage is found that does not follow the correct counting sequence, replace the tube associated with that stage. The tube associated with each stage of each counter may be identified by referring to table 5–5, Functions of Tubes, Frequency Divider. If, as will happen in some cases, trouble cannot be located to a specific tube, replace all tubes in the malfunctioning counter. If this fails to cure the trouble, refer to table 7–4, symptom 2*b* for counter 1, symptom 3*b* for counter 2, and symptom 4*b* for counter 3.

It may happen that replacement of one tube will widen the operating range of the COUNTER BIAS control sufficiently so that the counters will operate normally with the control set as directed in the paragraph preceding (1) above and yet not widen to a range of at least 20 dial divisions. Therefore, as tubes are replaced, repeat the test of paragraph 5*a* above

TABLE 6–3. CONTROLS TO BE ADJUSTED—WEEKLY

PANEL MARKING	SYMBOL	UNIT	TABLE IN SECTION 4	REFERENCE NO. IN TABLE
COUNTER BIAS	R282	Frequency divider	4–3	1
DC VOLTS	M2001	PP–959	4–10	6
DC METER SWITCH	S2002	PP–959	4–10	7
+150 V ADJ	R2022	PP–959	4–10	17
−30 V ADJ	R2033	PP–959	4–10	18
COMMON−	J2007	PP–959	4–10	19
+V2004A	J2003	PP–959	4–10	20
+V2004B	J2004	PP–959	4–10	21
+V2003A	J2001	PP–959	4–10	22
+V2003B	J2002	PP–959	4–10	23
+300 V ADJ	R1922	PP–958	4–11	7
+135 V ADJ	R1933	PP–958	4–11	8
COMMON−	J1907	PP–958	4–11	9
+V1905A	J1905	PP–958	4–11	10
+V1905B	J1906	PP–958	4–11	11
+V1904A	J1903	PP–958	4–11	12
+V1904B	J1904	PP–958	4–11	13
+V1903A	J1901	PP–958	4–11	14
+V1903B	J1902	PP–958	4–11	15
+150 V ADJ	R2122	PP–957	4–12	7
COMMON−	J2107	PP–957	4–12	8
+V2107A	J2105	PP–957	4–12	9
+V2107B	J2106	PP–957	4–12	10
+V2106A	J2103	PP–957	4–12	11
+V2106B	J2104	PP–957	4–12	12

TABLE 6–4. CONTROLS TO BE ADJUSTED—MONTHLY

PANEL MARKING	SYMBOL	UNIT	TABLE IN SECTION 4	REFERENCE NO. IN TABLE
COARSE LOCAL DELAY	R1544	Electrical synchronizer	4–7	1
FINE LOCAL DELAY	R1551	Electrical synchronizer	4–7	2
METER BALANCE	R1538	Electrical synchronizer	4–7	3
DELAY RANGE	R1561	Electrical synchronizer	4–7	5
SYNC BIAS	R1515	Electrical synchronizer	4–7	6
SYNC BALANCE	R1522	Electrical synchronizer	4–7	8
FINE REMOTE DELAY	R1517	Electrical synchronizer	4–7	9
COARSE REMOTE DELAY	R1565	Electrical synchronizer	4–7	10
OFF SYNC SENSITIVITY	R1555	Electrical synchronizer	4–7	20
SYNC ERROR SENSITIVITY	R1534	Electrical synchronizer	4–7	21
SENSITIVITY	R2303	Voltage regulator	4–13	2
OUTPUT VOLTAGE	R2302	Voltage regulator	4–13	3

until a satisfactory range of operation is obtained. To achieve maximum stability, the procedure may be continued until an operating range approximately equal to that initially obtained (in accordance with the procedure in Section 3, paragraph 20*e*) is achieved.

6. CONTROLS THAT MAY NEED ADJUSTMENT.

The following tables list the controls that may need adjustment during the operation of the timer. Since the timer is very stable, it may not always be necessary to adjust the controls listed. The tables are to serve as a reminder to the operator to check the controls within the period of time stated at the head of the table. The tables include the table in Section 4 wherein the control is described, the reference number of the control in the table in Section 4, the panel marking, the symbol number, and the unit the control is located in.

7. RELAY MAINTENANCE.

a. GENERAL.—Two types of relays are used in the timer: the low-current relay, which resembles the telephone-type relay, and the high-current power relays. The relays should be repaired only if replacements are not available. The following checklist covers the inspection necessary to keep the relays in good operating condition.

b. MONTHLY CHECKLIST.—Inspect the relays to detect abnormalities, using the following checklist. Check to see that:

The assembly is free from dirt, dust, and other foreign matter.

The contacts are not burned, pitted, or corroded.

The contacts are lined up, correctly spaced, and make positive contact.

The contact springs are in good condition.

The moving parts travel freely and function in a satisfactory manner.

The connections to the relay are tight.

The wire insulation is not frayed or worn.

The relay assembly is securely mounted.

The coil shows no signs of overheating.

c. CLEANING RELAYS.—Wipe the exterior of the relay with a dry cloth or brush. If it is very dirty, clean it with a cloth or brush dipped in an approved solvent, and wipe the surface with a dry cloth to remove any film left by the solvent when it dries.

d. CONTACT CLEANING.—Clean dirty contacts by drawing a strip of thin, clean cloth or paper between them while holding them together. If necessary, moisten the cloth with dry-cleaning solvent.

TABLE 6-5. CONTROLS TO BE ADJUSTED—QUARTERLY

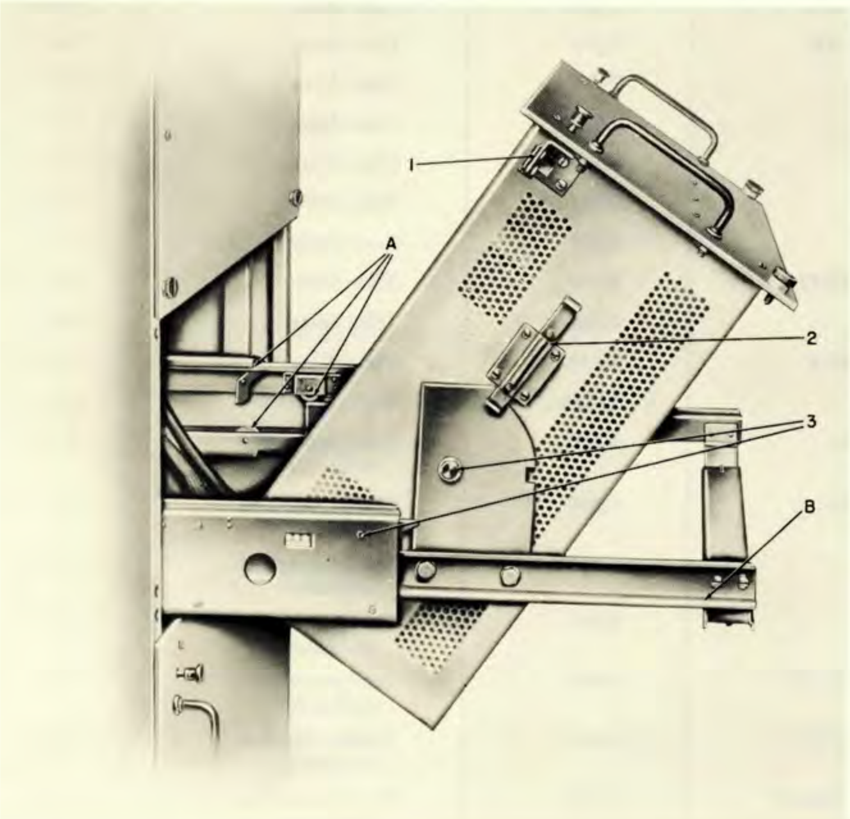
PANEL MARKING	SYMBOL	UNIT	TABLE IN SECTION 4	REFERENCE NO. IN TABLE
RECORDER ZERO	R145	Synchronization control	4-2	19
RECORDER RANGE	R142	Synchronization control	4-2	20
60 ~ TUNING	L102	Synchronization control	4-2	22
100 KC TUNING	L103	Synchronization control	4-2	23
GATE WIDTH A1000	R511	Time delay	4-4	3
GATE WIDTH B1000	R545	Time delay	4-4	5
GATE WIDTH B100	R557	Time delay	4-4	7
GATE WIDTH B10	R574	Time delay	4-4	9
B1000 BIAS	R610	Time delay	4-4	17
B100 BIAS	R629	Time delay	4-4	18
B10 BIAS	R630	Time delay	4-4	19
B CONT BIAS	R631	Time delay	4-4	20
A1000 BIAS	R609	Time delay	4-4	21
BLANKING WIDTH	R529	Time delay	4-4	22
BLINK DELAY	R614	Time delay	4-4	23
ALIGN TRIGGERS	R520	Time delay	4-4	26
————	L1219	Radio receiver	4-5	17
RF DELAY BIAS	R960	Synchronization indicator	4-6	40
RF FAST SWEEP SPEED ADJ	C844	Synchronization indicator	4-6	41
DERIV. GAIN	R846	Synchronization indicator	4-6	42
VIDEO GAIN	R854	Synchronization indicator	4-6	43
VIDEO FAST SWEEP SPEED	C868	Synchronization indicator	4-6	44
1 MARKER HEIGHT	R967	Synchronization indicator	4-6	45
10 MARKER HEIGHT	R868	Synchronization indicator	4-6	46
VIDEO DELAY BIAS	R959	Synchronization indicator	4-6	47
RF TUNING	C861	Synchronization indicator	4-6	48
DELAY BIAS	R1592	Electrical synchronizer	4-7	18
DERIVATIVE INPUT LEVEL	R1501	Electrical synchronizer	4-7	19
ATTEN ADJ	C1723	Test oscilloscope	4-8	24
DELAY BIAS	R1752	Test oscilloscope	4-8	25
1000 GATE WIDTH	R1713	Test oscilloscope	4-8	26
100 GATE WIDTH	R1729	Test oscilloscope	4-8	27
————	C2203	Test oscilloscope	4-8	—

e. CORRODED CONTACTS.—Dress the contacts first with a folded strip of crocus cloth. When the corrosion has been removed, wipe the contacts with a clean cloth moistened with an approved solvent, and polish with a dry folded cloth. Make certain that the shape of the contacts has not been altered.

f. BURNED OR PITTED CONTACTS.—As mentioned in paragraph 7*a* above, if the contacts of a relay are badly pitted, the relay should be replaced. If the replacement is not immediately available and it is necessary to repair the relay, proceed as follows: Obtain a piece of wood (or suitable equivalent material 2-1/2 inchs long, three-eighths inch wide, and one-sixteenth inch thick. Glue crocus cloth to the stick, making sure that both sides of the stick are covered. Place the stick in a vise until the glue hardens. The pieces of crocus cloth that extend over the back edge of the stick may be cut off. Never use emery cloth to clean contacts. Be sure to maintain the original shape of the contacts.

8. LUBRICATION.

The mechanical devices in the timer are designed to control its electronic functions automatically. They operate slowly and intermittently and therefore present little possibility of failure when the periodic preventive maintenance checks are made.



NAVY LUBRICANT			STANDARD NAVY STOCK NO.			NEAREST COMMERCIAL LUBRICANT
POINTS	SPECIFICATION	TITLE	4 oz	1 qt	5 gal	
1 to 3	MIL–L–644	Lubricating oil, Preservative, Special	W14–0–2833–944	W14–0–2834–10	W14–0–2834–15	SAE No. 30 motor oil
			8 oz	5 lb	25 lb	
A and B	MIL–G–3278	Grease, Aircraft and Instrument	W14–G–L11–5 R14–G–984–500	R14–G–984–20	R14–G–984–540	Beacon Lubricant No. 325

Figure 6–1. Lubrication of Drawer Slides and Catches

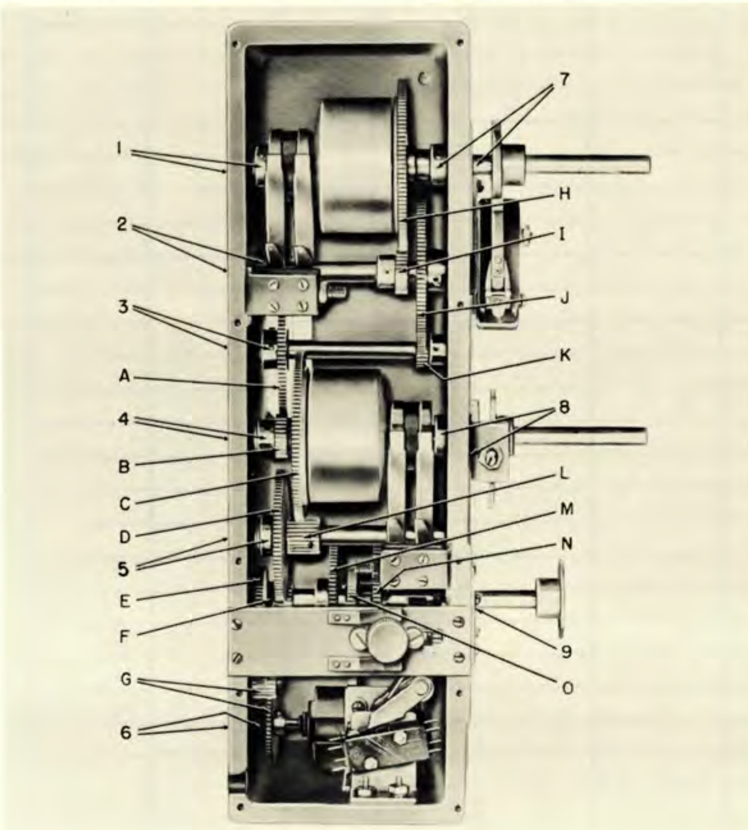
A minimum of lubrication will suffice to prevent the mechanical parts from wearing out. Moving electrical parts, such as potentiometers, variable resistors, variable capacitors, switches, etc., should not be lubricated, as an oil or grease film may cause shorts or act as an insulator against good electrical contact. Excessive lubrication collects dust and dirt that interfere with keeping the equipment in the spotless condition necessary for perfect operation. The lubricants used in the timer are SAE No. 30 motor oil (MIL-L-644) and Beacon Lubricant No. 325 (MIL-G-3278).

The parts listed below should be lubricated monthly with the lubricant indicated. Before applying the lubricant the parts should be cleaned with a clean cloth.

a. UNIT DRAWERS.—The latches, catches, and pivots of each drawer should be lubricated with a few drops of SAE No. 30 motor oil. Apply a small amount of Beacon Lubricant No. 325 to the runners and ball bearings with a brush or sharp stick. Refer to figure 6-1.

b. REAR DOOR.—The hinges and catches on the rear doors of the timer are to be lubricated with a few drops of SAE No. 30 motor oil.

c. SYNCHRONIZATION CONTROL GEAR TRAIN.—The gears lettered A through O, in figure 6-2, are covered with a very thin film of Beacon Lubricant No. 325. Apply the grease to the gears with a small stick. The bushings numbered 1 through 9, in figure 6-2, are lubricated with a drop of SAE No. 30 motor oil. The bushings are located at both ends of the gear shafts.



NAVY LUBRICANT			STANDARD NAVY STOCK NO.			NEAREST COMMERCIAL LUBRICANT
POINTS	SPECIFICATION	TITLE	4 oz	1 qt	5 gal	
1 to 9	MIL-L-644	Lubricating oil, Preservative, Special	W14-0-2833-994	W14-0-2834-10	W14-0-2834-15	SAE No. 30 motor oil
			8 oz	5 lb	25 lb	
A to O	MIL-G-3278	Grease, Aircraft and Instrument	W14-G-L11-5 R14-G-984-500	R14-G-984-20	R14-G-984-540	Beacon Lubricant No. 325

Figure 6-2. Lubrication of Synchronization Control Gear Train

RECORD OF MARGINAL LIMITS TESTS

Note

This form is provided as a suggested method for recording the marginal limits test data. If it is station practice to record all required data in one log book, this form may be copied into that book.

DATE	LIMITS		DIFFER-ENCE	DATE	LIMITS		DIFFER-ENCE	DATE	LIMITS		DIFFER-ENCE
	LOW	HIGH			LOW	HIGH			LOW	HIGH	

RECORD OF MARGINAL LIMITS TESTS (Cont'd)

DATE	LIMITS		DIFFER-ENCE	DATE	LIMITS		DIFFER-ENCE	DATE	LIMITS		DIFFER-ENCE
	LOW	HIGH			LOW	HIGH			LOW	HIGH	

CG-273-15
(Volume 1)

INSTRUCTION BOOK

for

LORAN TIMER SET AN/FPN-30

SECTION 7 CORRECTIVE MAINTENANCE

ITT *Federal Division*

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

Clifton, New Jersey, U.S.A.

FORMERLY

FEDERAL TELEPHONE AND RADIO COMPANY

TREASURY DEPARTMENT

U.S. COAST GUARD

Contracts: Tcg-38701(CG-20,181-A)
Tcg-39263(CG-27,298-A)
Tcg-40020(CG-35,978-A)
Tcg-41083 (CG-44,327-A)

Approved by C. G. Headquarters:
16 October 1959

Corrective Maintenance
Section 7

TABLE OF SECTIONS

FAILURE REPORTS

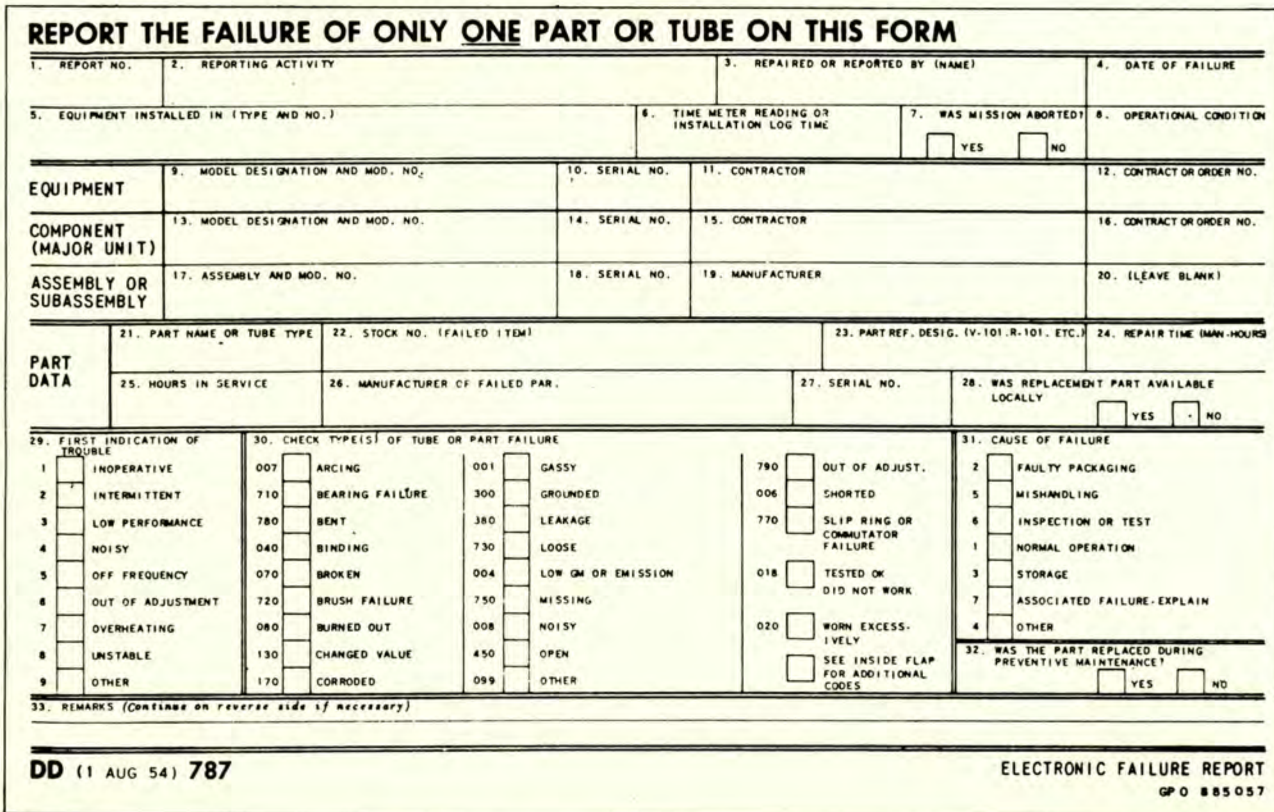
A FAILURE REPORT must be filled out for the failure of any part of the equipment whether caused by defective or worn parts, improper operation, or external influences. It should be made on Failure Report, Form DD–787, which has been designed to simplify this requirement (see figure 7–0). The form must be filled out and forwarded in accordance with existing instructions.

Use great care in filling out the form to make certain it carries adequate information. For example, under "Circuit Symbol" use the proper circuit identification taken from the schematic drawings, such as T–803, in the case of a transformer, or R–207, for a resistor. Do not substitute brevity for clarity. Use the back of the form to completely describe the cause of failure and attach an extra piece of paper if necessary.

The purpose of this report is to inform the Commandant of the cause and rate of failures. The information is used by the Commandant in the design of future equipment and in the maintenance of adequate supplies to keep the present equipment going. The forms you send in, together with those from other units, furnish a store of information permitting the Commandant to keep in touch with the performance of the equipment of your unit and all other units of the Coast Guard.

This report is not a requisition. You must request the replacement of parts in accordance with current instructions.

Make certain you have a supply of Failure Report Forms on board.



REPORT THE FAILURE OF ONLY ONE PART OR TUBE ON THIS FORM

1. REPORT NO.
2. REPORTING ACTIVITY
3. REPAIRED OR REPORTED BY (NAME)
4. DATE OF FAILURE
5. EQUIPMENT INSTALLED IN (TYPE AND NO.)
6. TIME METER READING OR INSTALLATION LOG TIME
7. WAS MISSION ABORTED? YES NO
8. OPERATIONAL CONDITION

EQUIPMENT: 9. MODEL DESIGNATION AND MOD. NO. 10. SERIAL NO. 11. CONTRACTOR 12. CONTRACT OR ORDER NO.

COMPONENT (MAJOR UNIT): 13. MODEL DESIGNATION AND MOD. NO. 14. SERIAL NO. 15. CONTRACTOR 16. CONTRACT OR ORDER NO.

ASSEMBLY OR SUBASSEMBLY: 17. ASSEMBLY AND MOD. NO. 18. SERIAL NO. 19. MANUFACTURER 20. (LEAVE BLANK)

PART DATA: 21. PART NAME OR TUBE TYPE 22. STOCK NO. (FAILED ITEM) 23. PART REF. DESIG. (V-101, R-101, ETC.) 24. REPAIR TIME (MAN-HOURS) 25. HOURS IN SERVICE 26. MANUFACTURER OF FAILED PAR. 27. SERIAL NO. 28. WAS REPLACEMENT PART AVAILABLE LOCALLY YES NO

29. FIRST INDICATION OF TROUBLE	30. CHECK TYPE(S) OF TUBE OR PART FAILURE			31. CAUSE OF FAILURE
1 INOPERATIVE	007 ARCING	001 GASSY	790 OUT OF ADJUST.	2 FAULTY PACKAGING
2 INTERMITTENT	710 BEARING FAILURE	300 GROUNDED	006 SHORTED	5 MISHANDLING
3 LOW PERFORMANCE	780 BENT	380 LEAKAGE	770 SLIP RING OR COMMUTATOR FAILURE	6 INSPECTION OR TEST
4 NOISY	040 BINDING	730 LOOSE		1 NORMAL OPERATION
5 OFF FREQUENCY	070 BROKEN	004 LOW GM OR EMISSION	018 TESTED OK DID NOT WORK	3 STORAGE
6 OUT OF ADJUSTMENT	720 BRUSH FAILURE	750 MISSING		7 ASSOCIATED FAILURE-EXPLAIN
7 OVERHEATING	080 BURNED OUT	008 NOISY	020 WORN EXCESSIVELY	4 OTHER
8 UNSTABLE	130 CHANGED VALUE	450 OPEN	SEE INSIDE FLAP FOR ADDITIONAL CODES	32. WAS THE PART REPLACED DURING PREVENTIVE MAINTENANCE? YES NO
9 OTHER	170 CORRODED	099 OTHER		

33. REMARKS *(Continue on reverse side if necessary)*

DD (1 AUG 54) **787** ELECTRONIC FAILURE REPORT
GPO 885057

Figure 7–0. Failure Report, Sample Form DD–787

SECTION 7
CORRECTIVE MAINTENANCE

1. INTRODUCTION.

This section provides information required to locate the cause of performance abnormalities and to repair trouble so that the timer will provide the extreme accuracy and stability required for loran service. Included are a discussion of the methods used for trouble shooting, socket voltage and resistance measurement data, and general reference data, including waveforms, to permit the technician to evaluate circuit performance against a standard. In addition, the adjustment procedure for those controls not previously described is given, and there is a description of those repair and adjustment procedures which are not immediately obvious by physical inspection.

The general techniques of trouble shooting and repair of any electronic equipment are applicable to Loran Timer Set AN/FPN-30. Trouble shooting should proceed in a logical manner, based on observation of the nature of the fault. The trouble-shooting charts, tables 7-1 through 7-13, have been arranged to help the technician to follow a direct line of action; they should be used as a guide to help locate trouble in the shortest possible time with a minimum of wasted effort.

The techniques provided in this section may not always reveal such defects as open capacitors or shorted turns in a coil; therefore this type of trouble, when suspected, should be isolated and eliminated by substitution of the suspected component. More difficult faults are those of an intermittent nature, those caused by more than one defective component, or those caused by general over-all component deterioration. In these cases persistency in observing and tracing the defect will eventually track down the offending components.

No attempt is made, in this section, to repeat information presented elsewhere in this book. The adjustment for most of the controls has been described in Section 3 and catalogued in Section 4. Information for replacement of tubes and fuses is given in Section 5. Lubrication and other preventive maintenance information is given in Section 6.

2. CAUTIONS AND PRECAUTIONS.

The maintenance technician is urged to become thoroughly familiar with certain potential hazards which may be encountered when repairing the timer, and the cautions and precautions which must be taken to avoid personal injury, or damage to the equipment, from these hazards.

a. HIGH VOLTAGES.—The timer circuits employ voltages as high as 8,000 volts. THESE VOLTAGES ARE EXTREMELY DANGEROUS. Adequate interlock and safety features are provided to prevent contact with the higher voltages. *Know these features!* Interlock switches are provided for almost every drawer unit, for the rear doors of the cabinet, and for a hinged panel in the synchronization indicator, so that dangerous timer voltages will be cut off. These switches and the INTERLOCKED POWER switch on the panel of PP-959 open the *interlocked power circuit.*

WHEN THE INTERLOCKED POWER CIRCUIT IS OPEN, the following voltages are still present at the following points in the timer cabinet:

- 115 v AC at the input terminal board for the cabinet (TB2204).
- The cabinet control connections terminal board (TB2202).
- Two terminal boards of PP-959 (TB2001, TB2002).
- A terminal board of PP-958 (TB1901).
- The terminal board for the oscillator (TB1401).
- All of the interlock switches, and the cabinet space heaters.
- 150 v DC at two terminal boards of PP/959 (TB2002, TB2003).
- The terminal board for the oscillator (TB1401).
- The +150-volt stand-by load resistor at the bottom of the cabinet, near the cabinet front.

In addition to the removal of voltages by means of the interlocked power circuit, a SCOPE HIGH VOLTAGES switch, S2101 on the panel of PP-957, permits turning off the −1,800 volts, +2,100 volts, and +8,000 volts used in the oscilloscopes. This feature will be found useful when signal-tracing low-voltage circuits of the synchronization indicator or the test scope.

WARNING

Special care must be used with regard to the interlock switch which is located behind the hinged control panel in the front of the synchronization indicator. Opening this panel, and turning on the interlock, energizes a 2,000-volt circuit which is exposed to easy contact by the service technician. If it is desired to work on the low-voltage circuits located behind this panel, be sure to turn off the SCOPE HIGH VOLTAGES switch before turning on the interlock.

A measure of protection against accidental contact with high-voltage points is provided by metal covers which form protective shields at strategic points on each unit. Whenever any of these shields is removed, turn the INTERLOCKED POWER switch off. Apply interlocked power only when necessary to measure voltages at points normally protected by the covers. DO NOT ATTEMPT TO MEASURE VOLTAGES IN EXCESS OF 1,000 VOLTS WITH FLEXIBLE TEST LEADS OR PROBES. The voltages exposed by removal of any cover are indicated by distinct markings on the cover.

WARNING

HIGH VOLTAGES MAY STILL BE PRESENT IN THE TIMER AFTER POWER HAS BEEN SHUT OFF. DISCHARGE CAPACITORS BY SHORTING TERMINALS TO GROUND, AND ALSO TO EACH OTHER, WITH AN INSULATED SCREWDRIVER BEFORE WORKING NEAR ANY HIGH-VOLTAGE WIRING.

The cathode-ray tube circuit of the test scope incorporates a diode clamp, V1720. The electrodes of this diode are at high voltage; therefore, the tube should never be removed or replaced, or measurements made, without first turning the SCOPE HIGH VOLTAGES switch off. As a safeguard, this tube is mounted in a special high-voltage socket and is protected from accidental contact by a phenolic cover. The tube is located within the high-voltage compartment of the test scope.

b. EXCESSIVE WEIGHTS.—Loran Timer Set AN/FPN–30 employs many iron core components which make the timer units heavy. If the timer cabinet is not anchored securely in place, the cabinet may tip over when several units are withdrawn at the same time. Severe injury to personnel and damage to the equipment can result.

Many of the units are too heavy to be safely handled by one man. The following units are heavier than 75 pounds and should be lifted only by two or more men: Radio Frequency Oscillator Type O–202/FPN–30, Synchronization Indicator Type IP–238/FPN–30, Power Supply Type PP–959/FPN–30, Power Supply Type PP–958/FPN–30, Power Supply Type PP–957/FPN–30, and Voltage Regulator Type CN–235/FPN–30.

3. METHODS OF TROUBLE SHOOTING.

The basic methods for trouble-shooting any electronic equipment are signal tracing, voltage measurement, and resistance measurement. Trouble shooting is initiated when the equipment gives some evidence of abnormal behavior. In the loran timer abnormal behavior will almost always be revealed by some unusual feature of the synchronization indicator oscilloscope presentations. Signal tracing is readily effected by means of the built-in test oscilloscope, and voltage and resistance measurements may be made with standard test meters and compared with the data presented in the tables following paragraph 3 *d* (4) of this section.

a. SYNCHRONIZATION INDICATOR ABNORMALITIES.—The oscilloscopes of the synchronization indicator display all significant timer signals. Any abnormal behavior of any important timer circuit will therefore be evident by a change in the synchronization indicator presentation. For example, if the frequency divider counter circuits start to misfunction, the repetition rate will change, the SLOW SCOPE time base will change, and the remote signal will appear to drift across the screen. If the divider stops counting, there will be no oscilloscope triggers, and the VIDEO SCOPE and RF SCOPE will become dark. If the signal path into and through the receiver is interrupted, the received signal will disappear. Thus, by watching the synchronization indicator, the operator will obtain the first clue to the cause of any operational abnormality. In addition to the oscilloscope indication, the abnormality may cause one or both of the alarm indicators to glow. Specific procedures, for various indications which may show up on the synchronization indicator, are given in the general trouble-shooting chart, table 7–1.

b. SIGNAL TRACING.—The basic technique of signal tracing is to use the test oscilloscope to follow suspect signals from their point of origin to their destination point in the timer. If a circuit is malfunctioning, the signal waveform will appear normal up to the input to that circuit and be abnormal, or missing, beyond that circuit. Signal tracing is a convenient method for tracing trouble to a specific circuit and, in some instances, to a specific component. Where the exact component causing trouble cannot be located by the signal-tracing method, the voltage and resistance measurement technique described in the next paragraph will usually pinpoint the trouble. Guides to signal tracing are given in paragraphs 3 *d* (1) and 3 *d* (2), below.

The waveforms shown in paragraph 3 *d* (2) may be divided into two groups. Figures 7–1 through 7–22 are waveforms which may be obtained by operation of the test scope SIGNAL SELECTOR switch, to select one of the timer units, and the TEST SIGNAL switch on the selected unit. Observation of this group of waveforms will isolate the trouble to a particular unit. The waveforms of figures 7–23 through 7–237 may be obtained by feeding a signal into the EXTERNAL SIGNAL jack of the test scope through either an unshielded test lead (clip lead) or the special shielded test lead (probe) which is equipped with an isolation network to minimize circuit loading. Observation of this group of waveforms will isolate trouble to a particular stage.

c. VOLTAGE AND RESISTANCE MEASUREMENT.—The techniques of locating a defective component by voltage and resistance measurement are easily applied. The socket connections to each suspected tube are probed with a voltmeter and the readings compared with a reading made under similar operating conditions for a properly functioning equipment. If the tube element is connected to a defective component, the reading will usually be markedly different from the normal reading (less than one-half or more than double). Readings which differ from the normal reading by as much as 20 percent do not necessarily indicate trouble. Because of component tolerances, tube aging, and metering inaccuracies, such variations are to be expected. Where trouble definitely has been isolated to a specific stage, through signal tracing, and a slightly abnormal voltage or resistance reading is obtained, component substitution is the only sure way of proving the fault. The voltage and resistance measurements should be used to cross-check each other in order to pinpoint the defective component.

Tables of voltage and resistance measurements, for a typical timer, are given in paragraph 3 *d* (4) below (tables 7–15 through 7–26).

d. REFERENCE DATA.—The reference data provided here is intended to guide the repair technician through the logical procedure of trouble shooting. The data includes a series of trouble-shooting charts, a set of waveform photographs, a table of tube characteristics, tables of voltage and resistance measurement, and a table of coil-winding data.

(1) HOW TO USE THE TROUBLE-SHOOTING CHARTS.—The trouble-shooting charts include a general trouble-shooting chart (table 7–1) and unit trouble-shooting charts (tables 7–2 through 7–13) for each major unit in the timer except the recording ammeter. The repair of the recording ammeter cannot properly be treated in chart form and is therefore covered separately in paragraph 6. The procedures given in the charts are based on the assumption that the normal operational procedures given in Sections 4 and 5 have been tried without success. Use the general trouble-shooting chart to locate trouble to a specific major unit. Once trouble has been isolated to a particular unit, refer to the chart for that unit to locate the specific circuit and circuit component at fault.

It must be remembered that charts such as these cannot include every conceivable cause of trouble; a list of all possible defects and their symptoms would necessarily be so large that the location of one specific fault, buried in so huge a chart, would be more time-consuming than an orderly check of every circuit in the timer. Accordingly, the technician should rely on the chart only as a guide to help determine the specific circuit group at fault. In almost every case, the first procedure suggested for any repair is to replace a tube or group of tubes. The chart has been organized in this way to help technicians with a minimum of training and experience locate trouble wherever possible. Because vacuum tubes are the largest single group of components which cause trouble, this first repair step will usually be all that is required; however, where further action is needed, the charts list specific steps for locating the fault as directly as possible. The generally employed technique is to locate the specific stage or circuit group at fault by signal tracing with the test scope and then locating the component by resistance and voltage measurements. The charts do not provide specific procedures beyond this step; however, the remaining technique of trouble shooting is straightforward.

The voltage and resistance measurements suggested by the chart will reveal such defects as improper resistance values, shorted or leaky capacitors, and wire and cable connection faults. Open coupling capacitors or wiring faults will be revealed by the test scope signal-tracing technique suggested by the chart; however, the chart does not carry this procedure to the ultimate end of tracing through every point. Where an open coupling capacitor is suspected, observe the waveform at the input and output of the capacitor to determine that the full signal is coupled through. An open bypass capacitor is best checked by shunting a duplicate capacitor across the suspected one; however, the detection of excessive amplitude of a signal at the "hot" end of such a capacitor may show the fault. An open waveshaping capacitor will produce waveform distortion which is easily detected on the test scope.

The chart suggests a check for hum as a possible cause for jitter or other circuit irregularities which may cause trouble. Possible causes of hum are excessive power supply ripple (refer to table 7–1, symptom 14), and a common impedance in the ground return for the tube socket of the offending stage. This common impedance, between the heater circuit and the signal circuit, may be reduced by tightening the screws which secure the ground lug to the chassis and to the tube socket.

The general trouble-shooting chart does not list such symptoms, as *VIDEO SCOPE dark,* or *failure of automatic synchronization system,* since the obvious cause of such failures is trouble in the circuits peculiar to the specific function. These failures are, however, listed in the unit trouble-shooting charts. The symptoms listed in the general trouble-shooting chart are grouped as specific indications which will be evident on the monitor oscilloscopes. The trouble-shooting procedure which is given for each of these indications, in both the general trouble-shooting chart and in the unit trouble-shooting charts, *must be* followed in the order given since the conclusions reached as the result of each check are generally based on normal indications for all previous checks grouped under one symptom. As a normal indication for each check is obtained, proceed with the next check in the group until trouble is located.

In those cases where the recommended cure is to replace all tubes in a given circuit group, it is not likely that all tubes will be defective. Once the cure proves effective, replace the original tubes, in the same sockets that they were removed from, one at a time until the faulty tube(s) is located. In this way, only defective tubes will be discarded and tubes which have passed the critical aging period, in which maximum failures occur, will be kept in service. The circuit adjustments associated with many tubes may require resetting when a tube is replaced. After replacing any tube refer to tables 5–3 through 5–14, which show the controls and adjustments associated with each tube and which reference any required adjustment procedure.

(Text continued on page 7–22)

TABLE 7–1. GENERAL TROUBLE-SHOOTING CHART

SYMPTOM	CHECK	RESULTS OF CHECK
1. No trace on any of the four scope screens.	*a.* MAIN POWER INDICATOR lamp on front of PP–959.	Dark lamp indicates either no input power (verify by reading AC LINE meter) or defective lamp.
	b. Meter readings on all positions of DC METER SWITCH on PP–959.	Abnormal reading indicates power supply circuit needs readjustment or circuit is defective. If adjustment cannot be made, trouble-shoot the indicated power circuit.
	c. Blown fuse indicators on front panels of all units.	Glowing indicator means blown fuse in associated fuse holder. If, upon replacement, fuse indicator glows again, trouble-shoot unit containing fuse.
	d. Meter reading on AMP OUT position of radio-frequency oscillator.	Low reading indicates defective oscillator unit. Trouble-shoot oscillator. Refer to table 7–2.
	e. Set SYNC SELECTOR switch on test scope to 100's position.	If trace is observed on the test scope, the trouble lies somewhere between the output of counter 1 and the output of the square-wave generator in the frequency divider. If no trace is observed, the trouble lies between the input of the sync control unit and the output of counter 1 in the frequency divider. In either case, obtain a test scope sync signal by connecting the SQUARE WAVE OUTPUT jack of the test scope on the operating timer to the EXTERNAL SYNC jack on the test scope of the defective timer. With the SYNC SELECTOR switch on EXTERNAL, signal-trace the indicated trouble by means of the test scope.
2. Received signals moving on scope screens.	*a.* Frequency divider. (For fast drift.)	Refer to table 7–4.
	b. Oscillator. (For very slow drift.)	Refer to table 7–2.
3. No B pedestal, no B trace on VIDEO SCOPE and RF SCOPE.	*a.* B-delay circuit. Use test scope to observe B1000, B100, and B10 outputs of time delay unit. (Figures 7–10, 7–11, 7–12.)	If markers are not centered, adjust B-delay controls. If any markers are missing or if B push-up gates are missing, trouble-shoot B-delay circuits on time delay unit. Refer to table 7–5.
4. No A pedestal, no A trace on VIDEO SCOPE and RF SCOPE.	*a.* A-delay circuit. Use test scope to observe A1000 output of time delay unit. (Figure 7–9.)	If marker is not centered, adjust A1000 control. If push-up gate or 1000's are missing, or if check is normal, trouble-shoot A-delay circuits on time delay unit.
5. No pedestals, no traces on VIDEO SCOPE and RF SCOPE.	*a.* Look for 1000's on VIDEO SCOPE.	If 1000's cannot be observed on VIDEO SCOPE, use test scope to determine presence of 1000's in output of 1000's generator on frequency divider (figure 7–7). If check is normal, trouble-shoot scope-trigger circuits on time delay unit (table 7–5).

TABLE 7–1. GENERAL TROUBLE-SHOOTING CHART (Cont'd)

SYMPTOM	CHECK	RESULTS OF CHECK
6. No pedestals, no traces on VIDEO SCOPE only.	*a.* Video sweep or sweep delay circuits in sync indicator unit.	Refer to table 7–7.
7. No local signals presented on any scope.	*a.* Observe monitor oscilloscope of the operating transmitter to determine whether signal is being transmitted.	If signal *is* being transmitted, localize trouble to either the receiver or the switchgear by observing the auxiliary timer and by switching ESU's (FPA–2) or discriminator units (UM). If signal is *not* being transmitted, determine that normal trigger pulse is being generated in the time delay; observe waveform (figure 7–13). If trigger is normal, trouble-shoot the transmitter.
8. No local and/or no remote signal presented on any scope.	*a.* Localize the trouble to either the receiver or the switchgear by observing the auxiliary timer and by switching ESU's (FPA–2) or discriminator units (UM).	Refer to table 7–6.
9. Abnormally large local signal.	*a.* Use test scope to observe output of blanking pulse generator on time delay unit. Refer to figure 7–14.	If check is normal, trouble-shoot blanking stages of switching equipment and receiver. If check is *not* normal, trouble-shoot time delay unit. Refer to table 7–5.
10. Inability to drift signal in all positions of DRIFT switch.	*a.* Drift circuits in frequency divider.	Refer to table 7–4.
11. SYNC ERROR alarm malfunctioning.	*a.* Sync error alarm circuits in electrical synchronizer.	Refer to table 7–8.
12. OFF SYNC alarm malfunctioning.	*a.* Off sync alarm circuits in electrical synchronizer.	Refer to table 7–8.
13. Blink circuit not operating.	*a.* Blink motor and adjustments in time delay unit.	Refer to table 7–5.
14. Jitter on two or more scopes.	*a.* Observe ripple voltage in all power supply outputs. Plug a double-ended phone plug cord *first* into the test scope EXTERNAL SIGNAL jack and *then* into the COMMON jack of the +150 supply on PP–959, of the +300 supply on PP–958, and of the +150 supply of PP–957. **CAUTION** Always remove the phone plug from the COMMON jack *before* removing the plug from the EXTERNAL SIGNAL jack. Observe the −30 and +108 supply outputs by applying the scope clip lead to terminals 6 and 7, respectively, of TB501 on the time delay unit.	The few millivolts of ripple present in the output of a properly operating power supply will provide a sine wave of such low amplitude as to be barely perceptible on the test scope with the gains at maximum. Excessive ripple will be readily detected by this test. If ripple is present in both the +150 supply and the −30 supply of PP–959, trouble-shoot the +150 supply; ripple in the +150 supply causes ripple in the −30 supply. If ripple is present in the +300 supply and the +135 supply, trouble-shoot the +300 supply; ripple in the +300 supply causes ripple in the +135 supply. Ripple detected in any other supply localizes the trouble to that supply; the other supplies do not affect each other's ripple.

TABLE 7–2. TROUBLE-SHOOTING CHART FOR RADIO FREQUENCY OSCILLATOR TYPE O–202/FPN–30

SYMPTOM	CHECK	RESULTS OF CHECK
1. Abnormal 100-kc output. (Meter reading in AMP OUT position of METER SWITCH abnormal.)	*a.* Normal reading for OSC OUT position of METER SWITCH.	Indicates defective V1403; verify by reading PLATE CURRENT 3 position of METER SWITCH. If plate current is abnormal, replace V1403.
	b. Abnormal reading for OSC OUT position of METER SWITCH.	Indicates defective V1401 or V1402. Verify by reading plate current for V1401 in PLATE CURRENT 1 switch position and V1402 in PLATE CURRENT 2 switch position. If plate current is abnormal, replace tube (s).
2. Frequency instability as evidenced by abnormal movement of remote signal (refer to symptom 2 in table 7–1) and possibly accompanied by abnormal operation of the COARSE HEATER pilot light.	*a.* Performance of fine heater as indicated by abnormal reading of meter with METER SWITCH in HEATER position.	Indicates defective fine heater oscillator or incorrect operating temperature for coarse heater. Check V1404 by reading PLATE CURRENT 4 position of switch and V1405 by reading PLATE CURRENT 5 position of switch. Replace tube (s). If tubes are normal,* refer to check *b*.
	b. Performance of fine heater by removing HEATER fuse F1401 in the coarse heater power circuit. Observe the meter reading, with the METER SWITCH in the HEATER position, for a period of two hours.	If the fine heater is in operating condition, the reading will gradually increase; if not, the reading will remain at zero. If the fine heater is operating, replace the fuse and adjust the coarse heater operating temperature as described in Section 7, paragraph 4 *a* (3). If the fine heater is not operating, refer to check *e*.
	c. Performance of coarse heater as indicated by prolonged off period of COARSE HEATER pilot and high reading for HEATER position of METER SWITCH.	Indicates defective relay K1401 or defective thermostat S1403. Replace K1401; if pilot fails to come on, replace S1403. Replace thermostat, only in emergency, with special authorization to open oven.
	d. Performance of coarse heater as indicated by prolonged on period of COARSE HEATER pilot.	If meter reading is high for HEATER position of METER SWITCH, this indicates defective coarse heater element. Refer to check *f*. Otherwise this check indicates defective K1401 or S1403; refer to *c*, above.
	e. Elements of fine heater bridge by measuring resistances at about 20°C.(68°F.). Turn the MAIN POWER switch OFF. Remove the connections from terminals 3 to 6 of TB1402, at the side nearest the front panel.	*Approximate resistance across terminals.* — *Remarks* 3–4, 5–6: 390 ohms — equal to each other within a few ohms 3–6, 5–4: 370 ohms — equal to each other within a few ohms 4–6, 5–3: slightly lower than values for 3–6 and 5–4. If trouble is clearly indicated, the connections to fine heater R1420, particularly at the resistance windings, should be carefully examined for an open or short and repaired if necessary.

* Meter readings, with the METER SWITCH in the HEATER position, will differ widely each time V1404 or V1405 is replaced; disregard meter readinges until the oscillator has had sufficient time to stabilize at the new point of equilibrium which results from the differences between tubes.

TABLE 7–2. TROUBLE-SHOOTING CHART FOR RADIO FREQUENCY OSCILLATOR TYPE O–202/FPN–30 (Cont'd)

SYMPTOM	CHECK	RESULTS OF CHECK
2. Continued	*f.* Resistance of coarse heater at 20°C.(68°F.). Turn the MAIN POWER switch OFF and measure the resistance across terminals 7 and 8 of TB1402.	If the measured resistance is not approximately 200 ohms, a defective coarse heater element is indicated.

TABLE 7–3. TROUBLE-SHOOTING CHART FOR SYNCHRONIZATION CONTROL TYPE C–1238/FPN–30

SYMPTOM	CHECK	RESULTS OF CHECK
1. No 100 KC INPUT waveform (refer to symptom 1 in table 7–1).	*a.* Oscillator output as indicated by normal meter reading for OSC OUT position of METER SWITCH.	If oscillator output is normal, examine cable connections between J101 and J1401.
2. No SHIFTER OUTPUT waveform.	*a.* Replace V101, V103. (V101 is not active at a master station.)	If tube replacement fails to cure the trouble, use probe to observe for 100-kc waveform at pins 2 and 3 of V101 (figure 7–27), and pins 2, 1, 7, and 6 of V102 (figure 7–35). At a slave station only, if 100 kc is present at pin 3 of V101, but not at pin 2 of V103, remove the top cover which encloses the autosyn and other sync control components and probe the waveform at the junction of C103 and R107 while rotating the PHASE dial. If no output is obtained, or if amplitude varies widely, check R107, C103, R110, C105, and autosyn B101. Replace defective components. If other waveforms are abnormal, measure voltages and resistances for malfunctioning tube and compare with data in table 7–16.
3. No 100 KC TO XMTR waveform and no 100 KC TO FREQ DIV waveform.	*a.* Replace V104.	If tube replacement fails to cure the trouble, measure voltages and resistances for V104 and compare with data in table 7–16.
4. No 100 KC TO FREQ DIV waveform.	*a.* Replace V104.	If tube replacement fails to cure the trouble, measure voltages and resistances for V104 and compare with data in table 7–16.
5. No 100 KC TO XMTR waveform.	*a.* Replace V105.	If tube replacement fails to cure the trouble, measure voltages and resistances for V105 and compare with the data in table 7–16.
6. Sync control motor fails to operate with high amplitude 60-cycle output from electrical synchronizer visible on test scope (figure 7–15).	*a.* Replace V102, V107.	If tube replacement fails to cure the trouble, use clip lead to observe the 60-cycle waveform at pins 7, 6, 2, and 3 of V102 and at pins 7 and 5 of V103. If a waveform is missing, measure the voltages and resistances for the malfunctioning tube and compare with data in table 7–16.
	b. Measure voltage at terminals 1 and 3 of sync control motor B103. (Remove rear cover on top of chassis to expose terminals.)	If 115 volts ac is not applied, trace circuit through S102. If voltage is applied, measure resistance across terminals 1 and 3 and terminals 2 and 4. If resistance is other than 250 ohms, in each case replace motor.
	c. Rotate motor shaft by hand. (Remove rear cover on top of chassis to gain access.)	If shaft requires excessive pressure to make it turn, examine gear train for defective gears or binding bearings.

TABLE 7–4. TROUBLE-SHOOTING CHART FOR FREQUENCY DIVIDER TYPE CV–274/FPN–30

SYMPTOM	CHECK	RESULTS OF CHECK
1. No square-wave output. (Refer to symptom 1*e*, of table 7–1).	*a.* Using a sync signal from the operating timer, observe the 10's, 100's, 1000's, and 50∼ waveforms provided by the TEST SIGNAL switch.	No 10's waveform indicates a defective V202B stage or a defective S201. Replace V202B. Check continuity through S201 with probe; if open contact is found, replace switch. No 100's indicates defective counter 1. No 1000's indicates defective counter 2. No 50∼ indicates defective counter 3. Refer to symptoms column for procedures.
2. No 100's.	*a.* Use TEST COUNT push button to insert counts into counter 1 via TEST COUNT INSERT switch.	On-off sequence of neon lamps should be as shown in table 7–28. When a point is found where a stage does not operate in sequence, replace the tube for that stage (V203, V204, V205, V206). In some instances, this check will not show the trouble. Refer to check *b.*
	b. Observe the waveforms at the output grid (pin 7, use probe) of each stage of counter 1. Compare with figures 7–42, 7–43, 7–44, 7–45.	Defective stage will be indicated by absence of output waveform. Replace tube.
3. No 1000's.	*a.* Use TEST COUNT push button to insert counts into counter 2 via TEST COUNT INSERT switch.	On-off sequence of neon lamps should be as shown in table 7–28. When a point is found where a stage does not operate in sequence, replace the tube for that stage (V208, V209, V210, V211). In some instances this check will not show the trouble; refer to check *b.*
	b. Observe the waveforms at the output grid (pin 7, use probe) of each stage of counter 2. Compare with figures 7–46, 7–47, 7–48, 7–49.	Defective stage will be indicated by absence of output waveform. Replace tube.
4. No 50∼.	*a.* Use TEST COUNT push button to insert counts into counter 3 via TEST COUNT INSERT switch.	On-off sequence of neon lamps should be as shown in tables 7–29, 7–30, 7–31. When a point is found where a stage does not operate in sequence, replace the tube for that stage (V213, V214, V215, V216, V217). Counter 3 includes the preset stages which drive the square-wave generator. In some instances the above check will not show the trouble in the counter stages and it will not locate the exact point of trouble in the preset or square-wave stages; refer to check *b.*
	b. Observe the waveforms at the output grid (pin 7, use probe) of each stage of counter 3. Compare with figures 7–50, 7–51, 7–52, 7–53, 7–54, 7–55. Observe the plate waveforms of each section of V218, V219, V220, and V221. Compare with figures 7–76, 7–77, 7–78, 7–79, 7–80, 7–81.	Defective stage will be indicated by absence of output waveform. Replace tube.

TABLE 7-4. TROUBLE-SHOOTING CHART FOR FREQUENCY DIVIDER TYPE CV-274/FPN-30 (Cont'd)

SYMPTOM	CHECK	RESULTS OF CHECK
5. Wrong rate. (Refer to symptom 2*a* of table 7-1).	*a.* Test count sequence as given in checks 2*a*, 3*a*, and 4*a* of this chart.	On-off sequence should be as shown in tables 7-29, 7-30, 7-31 for the rate in use. If a counter is found to go through the wrong sequence, replace all tubes in that counter.
	b. Waveforms as given in checks 2*b*, 3*b*, and 4*b* of this chart.	Defective stage is not necessarily the first one having an abnormal waveform since count is controlled by feedback from other stages. First replace all tubes in the suspected counter. If this fails to correct trouble, replace all tubes in counter 3 (V213 through V221).
6. Drift circuit does not work for one or both positions of right drift.	*a.* Observe right relay K201 while operating DRIFT switch between OFF and SLOW RIGHT and SLOW RIGHT and FAST RIGHT.	Inoperative relay in one switch position only indicates defective switch. Replace switch. Inoperative relay in both positions indicates defective relay circuit. If voltage is present at K201 coil terminals, replace K201.
	b. Replace right blocking oscillator tube V229. Hold DRIFT switch in FAST RIGHT position.	If tube replacement fails to correct trouble, use probe to observe output waveform at pin 6 of V229. If normal waveform (figure 7-90) is obtained, trace signal through contacts of S202D.
	c. Adjust DRIFT ADJUST control in accordance with Section 7, paragraph 4*c* (2).	
7. Drift circuit does not work for one or both positions of left drift.	*a.* Observe left relay K202 while operating drift switch between OFF and SLOW LEFT and SLOW LEFT and FAST LEFT.	Inoperative relay in one switch position only indicates defective switch. Replace switch. Inoperative relay in both positions indicates defective relay circuit. If voltage is present at K202 coil terminals, replace K202.
	b. Replace left amplifier tube V230. Hold DRIFT switch in FAST LEFT position.	If tube replacement fails to correct trouble, use clip lead to observe output waveform at pin 1 of V230. If normal waveform (figure 7-91) is obtained, trace signal through K202, K201, and S202D.
	c. Adjust DRIFT ADJUST control in accordance with Section 7, paragraph 4*c* (2).	
8. Drift circuit does not work in FAST positions of DRIFT switch.	*a.* Observe slow-fast relay K203 while operating DRIFT switch between OFF and FAST RIGHT and OFF and FAST LEFT.	Inoperative relay in one switch position only indicates defective switch. Replace switch. Inoperative relay in both positions indicates defective relay circuit. If voltage is present on K203 coil terminals, replace K203.
	b. Replace fast left-right cathode follower tube V230. Hold DRIFT switch in a FAST position.	If tube replacement fails to correct trouble, use clip lead to observe output waveform at pin 8 of V230. If normal waveform (figure 7-84) is obtained, trace signal through K203.
9. Drift circuit does not work in SLOW positions of DRIFT switch.	*a.* Replace V231, V233, and V234 in the left-right divider circuit.	If tube replacement fails to correct trouble, use clip lead to observe output waveform at pin 2 of V234. If normal waveform (figure 7-83) is obtained, trace signal through K203.

TABLE 7–4. TROUBLESHOOTING CHART FOR FREQUENCY DIVIDER TYPE CV–274/FPN–30 (Cont'd)

SYMPTOM	CHECK	RESULTS OF CHECK
10. Drift circuit does not work in any position of DRIFT switch.	*a.* Replace V228, V229.	If tube replacement fails to correct trouble, use clip lead to observe waveform at pin 3 of V229 (figure 7–89) and pin 1 of V228 (figures 7–87, 7–88).
	b. Adjust DRIFT ADJUST control in accordance with Section 7, paragraph 4*c* (2).	
11. Divider circuits operate normally but one of the markers is missing.	*a.* For missing 1's replace V222, V223, and V235.	If tube replacement fails to correct trouble, use probe to observe the waveforms in the 1's generator (figures 7–92, 7–93, 7–94, 7–95).
	b. For missing 100's replace V207.	If tube replacement fails to correct trouble, measure voltages and resistances for V207 and compare with data in table 7–17.
	c. For missing 1000's replace V212.	If tube replacement fails to correct trouble, measure voltages and resistances for V207 and compare with data in table 7–17.
12. Shortened trace on SLOW SCOPE.	*a.* Replace V227.	If tube replacement fails to correct trouble, use clip lead to observe output waveform of V227 (pin 5, figure 7–103). If waveform is abnormal, measure voltages and resistances for V227 and compare with data in table 7–17.
13. No trace on SLOW SCOPE; vertical line only.	*a.* Replace V226, V224.	If tube replacement fails to correct trouble, use clip lead to observe output waveforms of V226 (pin 5, figure 7–100) and V224 (pin 6, figure 7–99). If a waveform is abnormal, measure voltages and resistances for the malfunctioning tube and compare with data in table 7–17.
14. No trace separation and/or no pedestals on SLOW SCOPE.	*a.* Replace V225.	If tube replacement fails to correct trouble, use clip lead to observe waveforms at pins 2, 6, 7, and 8 of V225 (figure 7–97). If a waveform is abnormal, measure voltages and resistances for the malfunctioning tube and compare with data in table 7–17.
15. No 1000's on SLOW SCOPE.	*a.* Replace V224.	If tube replacement fails to correct trouble, use clip lead to observe waveforms at pins 1 and 2 of V224 (figure 7–96). If a waveform is abnormal, measure voltages and resistances for the malfunctioning tube and compare with data in table 7–17.

TABLE 7–5. TROUBLE-SHOOTING CHART FOR TIME DELAY TYPE TD–92/FPN–30

SYMPTOM	CHECK	RESULTS OF CHECK
1. No gate shown on A1000 waveform (refer to symptom 4 in table 7–1).	a. Replace V503, V502, V501, V505.	If tube replacement fails to correct trouble, use clip lead to observe waveforms at pins 1, 5, and 6 of V502 (figures 7–105, 7–106, 7–107), pin 2 of V501 (figure 7–104), and pins 1 and 2 of V503 (figures 7–109, 7–110). If a waveform is abnormal, measure voltages and resistances for the malfunctioning tube and compare with data in table 7–18.
2. A delay unstable. Excessive jitter in A1000 gate.	*a.* Replace V521, V501, and V505.	If tube replacement fails to correct trouble, measure voltages and resistances for V521, V501, and V505 and compare with the data in table 7–18. Check for hum.

TABLE 7–5. TROUBLE-SHOOTING CHART FOR TIME DELAY TYPE TD–92/FPN–30 (Cont'd)

SYMPTOM	CHECK	RESULTS OF CHECK
3. No 1000's shown on A1000 waveform (refer to symptom 4 in table 7–1).	*a.* Replace V503.	If tube replacement fails to correct trouble, use clip lead to observe waveform at pin 7 of V503. If 1000's are missing, use clip lead to signal-trace the circuit.
4. A1000 waveform normal but A pedestal and A trace on both VIDEO SCOPE and RF SCOPE missing. Transmitter trigger missing at master. (No A timing pulse.)	*a.* Replace V505, V504, V528.	If tube replacement fails to restore traces (and transmitter triggering at a master station) proceed immediately to check *b* below at a slave station. At a master station, use clip lead to observe the waveforms at pins 1 and 2 of V505 (figure 7–111), pins 1, 2, and 7 of V504 (figure 7–112), and pin 7 of V528. If a waveform is abnormal, measure voltages and resistances for the malfunctioning tube and compare with data in table 7–18.
	b. Replace V517.	If tube replacement fails to cure trouble, use clip lead to observe waveforms at V517 pins 7 and 6 (figure 7–129). If waveform at pin 7 is abnormal, proceed with waveform observations listed in *a*, above. If waveform at pin 6 is abnormal, measure voltages and resistances for V517 and compare with data in table 7–18.
5. No gate shown on B1000 waveform (refer to symptom 3 in table 7–11).	*a.* Replace V509, V508, V501, V510.	If tube replacement fails to correct trouble, use clip lead to observe waveforms at pins 1, 5, 6, and 7 of V508 (figures 7–114, 7–115), pin 7 of V501 (figure 7–113), and pins 1 and 2 of V509 (figure 7–116). If a waveform is abnormal, measure voltages and resistances for the malfunctioning tube and compare with data in table 7–18.
6. No 1000's shown on B1000 waveform (refer to symptom 3*b* in table 7–1).	*a.* Replace V509.	If tube replacement fails to correct trouble, use clip lead to observe waveform at pin 7 of V509. If 1000's are missing, use clip lead to signal-trace the circuit.
7. B delay unstable. Excessive jitter in B1000 gate.	*a.* Replace V522, V501, V510.	If tube replacement fails to correct trouble, measure voltages and resistances for V522, V501, and V510 and compare with data in table 7–18. Check for hum.
8. No gate shown on B100 waveform (refer to symptom 3 in table 7–1).	*a.* Replace V512, V511, V510.	If tube replacement fails to correct trouble, use clip lead to observe waveforms at pins 1, 5, and 6 of V511 (figure 7–117), pin 2 of V510, and pins 1 and 2 of V512 (figure 7–119). If a waveform is abnormal, measure voltages and resistances for the malfunctioning tube and compare with data in table 7–18.
9. No 100's on B100 waveform (refer to symptom 3*b* in table 7–1).	*a.* Replace V512.	If tube replacement fails to correct trouble, use clip lead to observe waveform at pin 7 of V512. If 100's are missing, use clip lead to signal-trace the circuit.
10. B delay unstable. Excessive jitter in B100 gate.	*a.* Replace V523, V510, V526.	If tube replacement fails to correct trouble, measure voltages and resistances for V523, V510, and V526 and compare with data in table 7–18. Check for hum.
11. No gate shown on B10 waveform (refer to symptom 3 in table 7–10).	*a.* Replace V514, V513, V526.	If tube replacement fails to correct trouble, use clip lead to observe waveforms at pins 1, 5, 6, and 7 of V513 (figures 7–120, 7–121), pin 2 of V526 (figure 7–11), and pins 1 and 2 of V514 (figure 7–122). If a waveform is abnormal, measure voltages and resistances for the malfunctioning tube and compare with data in table 7–18.

TABLE 7–5. TROUBLE-SHOOTING CHART FOR TIME DELAY TYPE TD–92/FPN–30 (Cont'd)

SYMPTOM	CHECK	RESULTS OF CHECK
12. No 10's on B10 waveform (refer to symptom 3*b* in table 7–1).	*a.* Replace V514.	If tube replacement fails to correct trouble, use clip lead to observe waveform at pin 7 of V514. If 10's are missing, use clip lead to signal-trace the circuit.
13. B delay unstable. Excessive jitter in B10 gate.	*b.* Replace V524, V526, V515.	If tube replacement fails to correct trouble, measure voltages and resistances for V524, V526, V515 and compare with data in table 7–18. Check for hum.
14. B10 waveform normal but B pedestal and B trace on both VIDEO SCOPE and RF SCOPE missing. (Applies only if B DELAY OUTPUT switch is on B CONT.)	*a.* Replace V515, V516, V519.	If tube replacement fails to restore traces, use clip lead to observe waveforms at pin 2 of V515 (figure 7–12), pins 1, 5, and 6 of V516 (figure 7–123), and pins 1, 7, and 6 of V519 (figure 7–124). If a waveform is abnormal, measure voltages and resistances for the malfunctioning tube and compare with data in table 7–18.
15. B delay unstable. Excessive jitter in B continuous output; B10 output stable.	*a.* Replace V515, V516, V519.	If tube replacement fails to cure the trouble, measure voltages and resistances for V515, V516, V519 and compare with data in table 7–18. Check for hum.
16. No scope triggers (refer to symptom 3, 4, or 5 in table 7–1).	*a.* Replace V517, V527.	If tube replacement fails to cure the trouble, use clip lead to observe waveforms at pins 2, 7, and 6 of V517 (figure 7–129) and pin 7 of V527. If a waveform is abnormal, measure voltages and resistances for V527 and V517 and compare with the data in table 7–18.
17. No transmitter trigger (refer to symptom 7 in table 7–1).	*a.* Replace V518, V520.	If tube replacement fails to cure the trouble, use clip lead to observe waveforms at pins 2, 1, 7, and 6 of V518 (figures 7–130, 7–131), and pins 2, 7, and 6 of V520, (figure 7–132). If a waveform is abnormal, measure voltages and resistances for the malfunctioning tube and compare with the data in table 7–18.
18. No blanking pulse (refer to symptom 9 in table 7–1).	*a.* Replace V506, V507.	If tube replacement fails to cure the trouble, use clip lead to observe waveforms at pins 1, 2, 7, and 8 of V507 (figures 7–125, 7–128) and pins 1, 3, 6, and 7 of V206 (figures 7–126, 7–127). If a waveform is abnormal, measure voltages and resistances for the malfunctioning tube and compare with data in table 7–18. If the blanking pulse circuit is not properly terminated, through the switching equipment, an abnormal waveform may be obtained. Refer to Section 3, paragraph 24*c*.
19. Blink circuit not operating.	*a.* Place BLINK SELECTOR in MANUAL position and observe that motor B501 operates microswitch S505 properly. These components are illustrated in figure 7–254.	If motor fails to operate, use voltmeter to determine that 115 volts ac appears at terminals on motor coil. If voltage appears replace motor. If voltage is missing, use meter to trace circuit through contacts of BLINK SELECTOR switch. If motor operates normally, proceed to check *b*.
	b. Observe that relay K501 follows the operating cycle of S505.	If relay fails to operate, use voltmeter to determine that 115 volts ac is applied to terminals 7 and 8 of K501 when S505 is closed. If voltage is missing, use meter to trace circuit through contacts of S505 and through BLINK SELECTOR switch. If relay follows blink cycle, trace path of d-c voltage through relay contacts, R614, and S501.

TABLE 7–6. TROUBLE-SHOOTING CHART FOR RADIO RECEIVER TYPE R–564/FPN–30

SYMPTOM	CHECK	RESULTS OF CHECK
1. Local signal received normally, no remote signal when remote transmitter is known to be on the air. (Refer to table 7–1, symptoms 7 and 8.)	*a.* Replace V1201.	If tube replacement fails to cure the trouble, measure voltages and resistances for V1201 and compare with data in table 7–19. If measurements are normal, replace Z1201. If trouble persists, replace C1208.
2. No received signals.	*a.* Replace V1202, V1203, V1204, V1205, V1207, V1208.	If tube replacement fails to cure the trouble, use the performance check of Section 7, paragraph 8, to isolate the fault to a particular stage. Measure voltages and resistances for the malfunctioning tube and compare with data in table 7–19. If measurements are normal, replace plug-in transformers and/or interstage coupling capacitors for the faulty stage.
3. No control of AMPLITUDE BALANCE.	*a.* Replace V1210, V1213.	Follow procedure of 1*a* above.
4. Normal r-f presentation, but no video or derivative presentation.	*a.* Replace V1209, V1216.	If tube replacement fails to cure the trouble, use probe to observe the signal at the output feedthrough of chassis No. 3. If signal is missing at this point, trace the circuit from pin 7 of V1209 through L1220, L1221, R1285, and C1300 to pins 7 and 8 of V1216. If video signal is normal at pin 7 of V1216, measure voltages and resistances for V1216 and compare with data in table 7–19.
5. Normal video presentation but no derivative presentation.	*a.* Observe the 1ST DER and 2ND DER waveforms provided through the TEST SIGNAL switch of the electrical synchronizer.	If the first derivative is normal and the second derivative is missing, proceed to check *b*. If the first derivative is missing, proceed to check *c*.
	b. Replace V1214 and V1215.	If tube replacement fails to cure the trouble, use clip lead to observe the waveforms at pins 2, 3, 7, and 8 of V1214 (figure 7–143), and pins 1 and 5 of V1215 (figures 7–144, 7–145). If a waveform is abnormal, measure voltages and resistances for the malfunctioning stage and compare with data in table 7–19.
	c. Replace V1211, V1212, V1213, and V1216.	If tube replacement fails to cure the trouble, use clip lead to observe the waveforms at pins 2 and 3 of V1216 (figure 7–138), pins 1 and 5 of V1212 (figures 7–139, 7–140), pins 7 and 6 of V1211 (figure 7–141), and pins 2 and 1 of V1213 (figure 7–142). If a waveform is abnormal, measure voltages and resistances for the malfunctioning stage and compare with data in table 7–19.
6. Normal video and derivative presentations, but abnormal or missing FIRST DERIVATIVE waveform in electrical synchronizer. (Refer to table 7–8, symptom 6.)	*a.* Replace V1213.	If tube replacement fails to cure the trouble, use clip lead to observe the waveforms at pins 2 and 1 of V1213 (figure 7–142). If a waveform is abnormal, measure voltages and resistances for V1213 and compare with the data in table 7–19.

TABLE 7–7. TROUBLE-SHOOTING CHART FOR SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30

SYMPTOM	CHECK	RESULTS OF CHECK
1. Video or derivative signals present on VIDEO SCOPE but video signal missing on SLOW SCOPE.	*a.* Replace V808.	If tube replacement fails to cure the trouble, use probe to observe the waveforms at pins 2 and 1 of V808. If the waveform is present at pin 2 but missing from pin 1, measure voltage and resistances for V808 and compare with data in table 7–20.
2. SLOW SCOPE dark.	*a.* Replace V821.	If tube replacement fails to cure the trouble, measure resistances for V821 and compare with data in table 7–20.
3. Video signal present on SLOW SCOPE but neither video signal or derivative shown on VIDEO SCOPE.	*a.* Replace V808, V809.	If tube replacement fails to cure the trouble, use probe to observe the waveforms at pins 7 and 6 of V808 and pin 3 of V809. If waveform is missing at pin 6 of V808, measure voltages and resistances for V808 and compare with data in table 7–20. If waveform is present up to pin 3 of V809, measure voltages and resistances for V809 and compare with data in table 7–20. If all checks are normal, replace C853. **CAUTION** Normal plate voltage for V809 is about 600 volts. This may rise to about 1,000 volts if the tube is not conducting.
	b. Trace signal through contacts of K802.	If faulty relay contacts are indicated, replace K802.
4. One or more markers missing from VIDEO SCOPE presentation.	*a.* Replace V811, V812, V814, V826.	If tube replacement fails to cure the trouble, use clip lead to observe the waveforms at pins 7, 6, 2, and 1 of V811 (figures 7–156, 7–158), pins 2 and 1 of V812 (figure 7–159), pins 2, 1, and 7 of V814, and 2 and 1 of V826 (figure 7–157). If a waveform is abnormal, measure voltages and resistances for the malfunctioning tube and compare with data in table 7–20.
5. No separation on video trace.	*a.* Replace V812.	If tube replacement fails to cure the trouble, use clip lead to signal-trace the circuit. If square wave appears at pin 7 of V812, but does not appear at pin 6, measure voltages and resistances for V812 and compare with data in table 7–20.
6. VIDEO SCOPE dark with delayed sweep but normal with direct sweep.	*a.* Replace V801, V802, V803.	If tube replacement fails to cure the trouble, measure voltages and resistances for V801, V802, V803. If these are normal, use clip lead to signal-trace the circuit through K801 and pins 5 and 7 of V802 (figures 7–147, 7–148).
7. VIDEO SCOPE dark.	*a.* Replace V803, V804, V805, V807.	If tube replacement fails to cure the trouble, use clip lead to observe the waveform at pin 8 of V807. If waveform is normal (figure 7–155), proceed to check *b.* If waveform is abnormal, check pins 6, 2, 5, and 1 of V804 (figures 7–151, 7–152, 7–153), pin 3 of V807, and pins 7 and 8 of V803 (figures 7–149, 7–150). If an abnormal waveform is found, measure voltages and resistances of the malfunctioning tube and compare with the data in table 7–20.
	b. Replace V822.	If tube replacement fails to cure the trouble, measure resistances for V822 and compare with the data in table 7–20.

TABLE 7–7. TROUBLE-SHOOTING CHART FOR SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30 (Cont'd)

SYMPTOM	CHECK	RESULTS OF CHECK
8. Shortened video trace.	*a.* Replace V806.	If tube replacement fails to cure the trouble, measure voltages and resistances for V806 and compare with data in table 7–20. If these are normal, use probe to observe the waveforms at pins 1 and 5 (figure 7–154).
9. Video trace blurred on left, dark on right.	*a.* Replace V805.	
10. Jitter in video trace.	*a.* Observe whether jitter is present for both direct and delayed sweeps.	If jitter exists with delayed sweep only, proceed to check *b.* If jitter exists with both direct and delayed sweep, proceed to check *c.*
	b. Replace V801, V802, V803.	If tube replacement fails to cure the trouble, measure voltages and resistances for V801, V802, V803 and compare with data in table 7–20. If measurements are normal, check for hum.
	c. Replace V803, V804, V805, V806, V807.	Follow procedure of *b*, above, for V803, V804, V805, V806, V807.
11. Video signal present on SLOW SCOPE but r-f signal not shown on RF SCOPE.	*a.* Replace V815.	If tube replacement fails to cure the trouble, use probe to observe the waveforms at pins 4 and 8 of V815. If signal is missing from pin 4, work probe back through S805 to the receiver. (Refer to table 7–6.) If waveform is normal at pin 4 but abnormal at pin 8, measure voltages and resistances for V815 and compare with data in table 7–20. If waveform is normal at pin 8, trace signal through Z801 and C835.
12. One or both markers missing from RF SCOPE presentation.	*a.* Replace V824, V813.	If tube replacement fails to cure the trouble, use clip lead to observe waveforms at pins 2, 1, 7, and 6 of V824 (figures 7–162, 7–163), and pins 2 and 1 of V813 (figure 7–164). If a waveform is abnormal, measure voltage and resistance for the malfunctioning stage and compare with data in table 7–20.
13. No separation on r-f trace.	*a.* Replace V813.	If tube replacement fails to cure the trouble, use clip lead to signal-trace the circuit. If square wave appears at pin 7 of V813, but does not appear at pin 6, measure voltages and resistances for V813 and compare with data in table 7–20.
14. RF SCOPE dark.	*a.* Turn the RF SWEEP SPEED control to the extreme counterclockwise position. Advance the INTENSITY control slowly clockwise.	If a bright vertical line appears, the sweep is malfunctioning; refer to check *b.* If a dim horizontal line appears, the 8,000-volt supply is not working; refer to table 7–12. If no line appears the CRT is defective; replace the CRT, V823.
	b. Replace V816, V817, V818, V819, V820, V827.	If tube replacement fails to cure the trouble, use clip lead to observe the waveform at pin 7 of V817. If V817 waveform is abnormal (figure 7–167) proceed to check *d.* If V817 waveform is normal, proceed to check *c.*
	c. Use clip lead to observe waveforms at pins 7, 8, 3, and 1 of V818 (figure 7–169), pins 5, 2, and 6 of V819 (figures 7–170, 7–171), and pin 3 of V827 (figure 7–172).	If a waveform is abnormal, measure the voltages and resistances for the malfunctioning tube and compare with data in table 7–20.

TABLE 7–7. TROUBLE-SHOOTING CHART FOR SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30 (Cont'd)

SYMPTOM	CHECK	RESULTS OF CHECK
14. RF SCOPE dark. (Cont'd)	*d.* Use clip lead to observe waveforms at pins 1 and 7 of V816 (figure 7–166), and pins 1 and 5 of V817 (figure 7–167).	Follow procedure of *c*, above.
15. Shortened r-f trace.	*a.* Replace V810.	If tube replacement fails to cure the trouble, measure voltages and resistances for V810 and compare with data in table 7–20. If these are normal, use clip lead to observe the waveforms at pins 1 and 5 (figure 7–173).
16. R-f trace blurred on left, dark on right.	*a.* Replace V820.	
17. Jitter on r-f trace.	*a.* Replace V816, V817, V827, V818, V819, V820.	If tube replacement fails to cure the trouble, measure voltages and resistances for all tubes replaced in check and compare with data in table 7–20. If measurements are normal, check for hum.

TABLE 7–8. TROUBLE-SHOOTING CHART FOR ELECTRICAL SYNCHRONIZER TYPE SN–117/FPN–30

SYMPTOM	CHECK	RESULTS OF CHECK
1. Failure of synchronizing system to follow sync errors.	*a.* Introduce a +3-μsec error by turning the PHASE dial three divisions away from the zero error position and observe the AC ERROR, 2ND DER, LOCAL GATE, and MIXED GATES waveforms.	If AC ERROR is normal (figure 7–15 or 7–16), refer to table 7–3, symptom 6. If the second derivative of the remote signal (figure 7–17) is abnormal or missing, refer to table 7–7, symptom 1, 2, or 5. If the MIXED GATES waveform (figure 7–20) is normal and the REMOTE GATE and/or the LOCAL GATE waveform (figures 7–18, 7–19) is abnormal or missing, refer to check *b*. If the MIXED GATES waveform is normal, refer to check *c* or *d*. If the gates are normal, refer to check *c*.
	b. Replace V1503, V1523, V1519, V1522.	If tube replacement fails to cure the trouble, use clip lead to observe waveforms at pins 2, 7, 5, and 1 of V1519 (figures 7–204, 7–205), and pins 2 and 7 of V1522 (figures 7–205, 7–206). If a waveform is abnormal, measure voltages and resistances for the replaced tubes and compare with the data in table 7–21.
	c. (Use at a master station.) Replace V1521, V1518, V1517, V1525.	If tube replacement fails to cure the trouble, use clip lead to observe the waveforms at pins 2, 7, 1, and 6 of V1521 (figures 7–192, 7–193), pins 3, 7, and 8 of V1518 (figures 7–196, 7–197), pins 1, 5, 7, and 6 of V1517 (figures 7–198, 7–200, 7–201), and pins 7, 6, 2, and 3 of V1525 (figures 7–202, 7–203). If a waveform is abnormal, measure voltages and resistances for the malfunctioning tube and compare with the data in table 7–21.
	d. (Use at a slave station.) Replace V1518, V1517, V1516, V1515, V1525.	If tube replacement fails to cure the trouble, use clip lead to observe the waveforms at pin 3 of V1518 (figure 7–197), pins 1, 5, 7, and 6 of V1517 (figures 7–199, 7–200, 7–201), and pins 7, 6, 2, and 3 of V1525 (figures 7–202, 7–203). If a waveform is abnormal, measure voltages and resistances for the malfunctioning tube and compare with data in table 7–21.

TABLE 7-8. TROUBLE-SHOOTING CHART FOR ELECTRICAL SYNCHRONIZER TYPE SN-117/FPN-30 (Cont'd)

SYMPTOM	CHECK	RESULTS OF CHECK
	e. Adjustment of R1515 and R1522 per Section 3, paragraph 28*f* or 29*f*. Replace V1501, V1502, V1504, V1505, V1506, V1507.	If tube replacement fails to cure the trouble, use clip lead to observe the waveforms at pins 2 and 1 of V1501 (figure 7-174), pins 7, 5, and 1 of both V1502 and V1504 (figures 7-175, 7-176, 7-177, 7-178), pin 2 of both V1503 and V1523, pins 1, 5, 7, and 2 of V1505 (figures 7-179, 7-180, 7-181, 7-182), pins 3, 2, 7, 1, and 6 of V1506 (figures 7-183, 7-184), and pins 7 and 6 of V1507 (figures 7-185, 7-186, 7-187, 7-188). If a waveform is abnormal, measure voltages and resistances for the malfunctioning tube and compare with data in table 7-21.
2. Constant operation of the sync control motor, in one direction, to drive the system away from zero error. (Note that the motor may continue rotation after PHASE dial rotation is arrested by the stop at a master station.)	*a.* Follow the procedure given for symptom 1*e*, above.	
3. Instability of synchronization caused by gate jitter.	*a.* Replace (V1520, V1521 at master station only), V1518, V1517, V1716.	If tube replacement fails to cure the trouble, measure voltages and resistances for the tubes replaced and compare with data in table 7-21. Check for hum.
4. Inability to zero set SYNC TEST meter by adjustment of R1538, with METER SWITCH on OPERATE.	*a.* Replace V1510, V1526.	If tube replacement fails to cure the trouble, measure voltages and resistances for V1510 and V1526 and compare with data in table 7-21.
5. Faulty operation of sync error alarm circuit.	*a.* Hold armature of relay K1501 closed by slight downward pressure.	If the SYNC ERROR lamp does not light and/or K1503 does not start operating, check the contacts of K1501 and the coil of K1503. If K1504 is not operated at the end of the K1503 cycle, check the contacts of K1503 and the coil of K1504. If the alarm buzzer and automatic blink circuits do not work, check the contacts of K1504. Refer to Section 6, paragraph 7, for relay service information.
	b. (Use at a slave station.) Replace V1508, V1509.	If tube replacement fails to cure the trouble, measure voltages and resistances for V1508, V1509 and compare with the data in table 7-21.
	c. (Use at a master station.) Replace V1509, check the operation of S108 in the sync control unit, and the sync error cam actuating S108.	If tube replacement fails to cure the trouble, measure voltages and resistances for V1509 and compare with the data in table 7-21.
6. Faulty operation of off sync alarm circuit.	*a.* Hold armature of relay K1502 closed by slight downward pressure.	If the OFF SYNC lamp does not light and/or K1505 does not start operating, check the contacts of K1502 and the coil of K1505. If K1506 is not operated at the end of the K1505 cycle, check the contacts of K1505 and the coil of K1506. If the alarm buzzer and automatic blink circuit do not work, check the contacts of K1506. Refer to Section 6, paragraph 7, for relay service information.

TABLE 7–8. TROUBLE-SHOOTING CHART FOR ELECTRICAL SYNCHRONIZER TYPE SN–117/FPN–30 (Cont'd)

SYMPTOM	CHECK	RESULTS OF CHECK
6. Faulty operation of off sync alarm circuit (Cont'd)	*b.* Observe the LIMITED FIRST DERIVATIVE waveform.	If waveform (figure 7–22) is abnormal or missing, observe the FIRST DERIVATIVE waveform. If first derivative is abnormal or missing, refer to table 7–7, symptom 6. If first derivative is normal and limited derivative is abnormal, refer to check *c.* If limited derivative is normal, refer to check *d.*
	c. Replace V1511.	If tube replacement fails to cure the trouble, use probe to observe the waveforms at pins 2, 1, 7, and 6 of V1511 (figures 7–208, 7–209, 7–210). If a waveform is abnormal, measure voltages and resistances for the malfunctioning tube and compare with the data in table 7–21.
	d. Replace V1512, V1513, and V1514.	If tube replacement fails to cure the trouble, use clip lead to observe the waveforms at pins 2, 3, 7, and 1 of V1512 (figures 7–211, 7–212, 7–213), and pins 3, 1, and 6 of V1513. If a waveform is abnormal, measure voltages and resistances for the malfunctioning tube and compare with the data in table 7–21.

TABLE 7–9. TROUBLE-SHOOTING CHART FOR TEST OSCILLOSCOPE TYPE OS–39/FPN–30

SYMPTOM	CHECK	RESULTS OF CHECK
		Use the test scope of another timer to observe waveforms.
1. No sweep in any position of SYNC SELECTOR S1701. (Dark screen.)	*a.* Set SYNC SELECTOR switch S1701 to 100 μsec MARKERS, position 4, turn COARSE SWEEP SPEED switch S1706 to position 1, turn FINE SWEEP SPEED control R1790 to the extreme counterclockwise position, and advance the INTENSITY knob slowly.	If a bright vertical line (or spot) appears, the sweep is malfunctioning; refer to check *b.* If no line (or spot) appears, the CRT is probably defective. Replace the CRT.
	b. Replace V1707, V1721, V1717, V1716, V1722.	If tube replacement fails to cure the trouble, use probe or clip lead to observe the waveforms at pins 7 and 8 of V1707 (figure 7–228), pins 8 and 6 of V1721 (figure 7–229), pins 1, 6, 2 and 5 of V1717 (figure 7–230), pins 1 and 2 of V1716 (figures 7–231, 7–232), and pins 2 and 3 of V1722 (figure 7–234). If a waveform is abnormal, measure voltages and resistances for all tubes and compare with the data in table 7–22.
2. Sweep in 1000 μ Sec MARKERS and 100 μ Sec MARKERS positions of SYNC SELECTOR S1701, but on no other positions of S1701.	*a.* Replace V1719, V1708, V1707.	If tube replacement fails to cure the trouble, use probe to observe the waveforms at pins 1, 6, 7 and 5 of V1708. Measure the voltages and resistances for all tubes replaced and compare with the data in table 7–22.

TABLE 7–9. TROUBLE-SHOOTING CHART FOR TEST OSCILLOSCOPE TYPE OS–39/FPN–30 (Cont'd)

SYMPTOM	CHECK	RESULTS OF CHECK
3. Sweep on 1000 μ Sec MARKERS, 100 μSec MARKERS, and PEDESTAL position of SYNC SELECTOR S1701, but no other positions of S1701.	*a.* Replace V1701, V1702, V1703, V1704, V1705, V1706.	If tube replacement fails to cure the trouble, use clip lead to observe the waveforms at pins 7 and 6 of V1701 (figure 7–218), pins 2, 1, 7, and 6 of V1702 (figure 7–219), pins 2, 6, and 7 of V1703 (figure 7–220), pins 2, 1, 7, and 6 of V1704 (figures 7–211, 7–224), pins 1, 7, 6, and 3 of V1705 (figure 7–222) and pins 2, 1, and 7 of V1706 (figure 7–223). If an abnormal waveform is found, measure the voltages and resistances for the malfunctioning tube and compare with the data in table 7–22.
4. Shortened trace and abnormal centering.	*a.* Replace V1718.	If tube replacement fails to cure the trouble, use probe to observe the waveforms at pins 1, 6, 2, and 5 of V1718 (figure 7–233). If waveform is abnormal, measure voltages and resistances for V1718 and compare with the data in table 7–22.
5. No output at SQ WAVE OUTPUT jack J1704.	*a.* Replace V1721.	If tube replacement fails to cure the trouble, use clip lead to observe the waveforms at pins 2 and 3 of V1721 (figure 7–216). Measure the voltages and resistances for V1721 and compare with the data in table 7–22.
6. Improper marker display.	*a.* Replace V1710 and V1711.	If tube replacement fails to cure the trouble, use probe to observe the waveforms at pins 2, 1, 7, and 6 of V1710 (figures 7–235, 7–236), and pins 2 and 1 of V1711 (figure 7–237).
7. No signal presentation, or signal distorts at low amplitudes.	*a.* Replace V1712, V1713, V1711, V1714, V1715.	If tube replacement fails to cure the trouble, use probe to signal-trace the signal path through pins 2 and 1 of V1712, pins 1 and 5 of V1713, pins 7, 6, and 8 of V1711, pins 4 and 8 of V1714 and pins 4 and 8 of V1715. If the signal path is broken at any point, measure the voltages and resistances of the tubes carrying the signal at that point and compare with the data in table 7–22.

TABLE 7–10. TROUBLE-SHOOTING CHART FOR POWER SUPPLY TYPE PP–959/FPN–30

SYMPTOM	CHECK	RESULTS OF CHECK
1. Abnormal +150-volt output; inability to adjust R2022.	*a.* Replace V2006, V2001, V2002, V2003, V2004, V2009.	If tube replacement fails to cure the trouble, measure voltages and resistances for the replaced tubes and compare with data in table 7–23.
2. Excessive ripple in +150-volt output. (Refer to symptom 14 in table 7–1.)	*a.* Replace V2006, V2001, V2002, V2003, V2004, V2009.	If tube replacement fails to cure the trouble, temporarily shunt (one at a time) C2002, C2004, and C2005 with duplicate capacitors. If an appreciable reduction of ripple is noted after shunting any capacitor, replace that capacitor.
3. Failure of all bias voltages.	*a.* Replace V2011.	If tube relacement fails to cure the trouble, measure the voltages and resistances for V2011 and compare with data in table 7–23.
4. Excessive ripple in all bias voltages.	*a.* Replace V2011, V2012.	If tube replacement fails to cure the trouble, temporarily shunt (one at a time) C2011 and C2012 with duplicate capacitors. If an appreciable reduction of ripple is noted after shunting any capacitor, replace that capacitor.

TABLE 7–10. TROUBLE-SHOOTING CHART FOR POWER SUPPLY TYPE PP–959/FPN–30 (Cont'd)

SYMPTOM	CHECK	RESULTS OF CHECK
5. Abnormal −108-volt output.	*a.* Replace V2010.	If tube replacement fails to cure the trouble, measure voltages and resistances for V2010 and compare with data in table 7–23.
6. Abnormal −30-volt output; inability to adjust R2033.	*a.* Replace V2007, V2008.	If tube replacement fails to cure the trouble, measure voltages and resistances for V2007, V2008 and compare with data in table 7–23.
7. Excessive ripple in −30-volt output (refer to symptom 14 in table 7–1). +150 supply normal.	*a.* Replace V2007, V2008.	If tube replacement fails to cure the trouble, temporarily shunt (one at a time) C2007, C2008, and C2010 with duplicate capacitors. If an appreciable reduction of ripple is noted after shunting any capacitor, replace that capacitor.

TABLE 7–11. TROUBLE-SHOOTING CHART FOR POWER SUPPLY TYPE PP–958/FPN–30

SYMPTOM	CHECK	RESULTS OF CHECK
1. Abnormal +300-volt output; inability to adjust R1922.	*a.* Replace V1901, V1902, V1903, V1904, V1905, V1906, V1907.	If tube replacement fails to cure the trouble, measure voltages and resistances for the replaced tubes and compare with data in table 7–24.
2. Excessive ripple in +300-volt output (refer to symptom 14 in table 7–1).	*a.* Replace V1901, V1902, V1903, V1904, V1905, V1906, V1907.	If tube replacement fails to cure the trouble, temporarily shunt (one at a time) C1905, C1906, C1907, C1908 with duplicate capacitors. If an appreciable reduction of ripple is noted after shunting any capacitor, replace that capacitor.
3. Abnormal +135-volt output; inability to adjust R1933.	*a.* Replace V1908, V1909, V1910.	If tube replacement fails to cure the trouble, measure voltages and resistances for V1908, V1909 and compare with data in table 7–24.
4. Excessive ripple in +135-volt output (refer to symptom 14 in table 7–1); +300-volt supply normal.	*a.* Replace V1908, V1909, V1910.	If tube replacement fails to cure the trouble, temporarily shunt (one at a time) C1909, C1910, C1911 with duplicate capacitors. If an appreciable reduction of ripple is noted after shunting any capacitor, replace that capacitor.
5. Abnormal +1,000-volt output.	*a.* Replace CR1901, CR1902.	If rectifier replacement fails to cure the trouble, measure resistances across R1941 and R1942, and across R1935, R1936, R1937 and compare with nominal values shown in schematic diagram, figure 7–281. **CAUTION** Do not measure voltages of 1,000-volt circuit with flexible test leads.
6. Excessive ripple in +1,000-volt output. (Shown by vertical jitter of VIDEO SCOPE presentation.)	*a.* Replace CR1901, CR1902.	If rectifier replacement fails to cure the trouble, temporarily shunt (one at a time) C1903, C1912, C1904 with duplicate capacitors. If an appreciable reduction of ripple is noted after shunting any capacitor, replace that capacitor. **CAUTION** Turn off INTERLOCKED POWER switch and discharge capacitors each time a capacitor is connected or removed.

TABLE 7–12. TROUBLE-SHOOTING CHART FOR POWER SUPPLY TYPE PP–957/FPN–30

SYMPTOM	CHECK	RESULTS OF CHECK
1. Abnormal +150-volt output; inability to adjust R2122.	*a.* Replace V2103, V2104, V2106, V2107, V2108, V2109.	If tube replacement fails to cure the trouble, measure voltages and resistances for the replaced tubes and compare with data in table 7–25.
2. Excessive ripple in +150-volt output (refer to symptom 14 in table 7–1).	*a.* Replace V2103, V2104, V2106, V2107, V2108, V2109.	If tube replacement fails to cure the trouble, temporarily shunt C2102, C2103, C2104, C2105 with duplicate capacitors. If an appreciable reduction of ripple is noted after shunting any capacitor, replace that capacitor.
3. Abnormal +2,100-volt supply.	*a.* Replace V2101.	If tube replacement fails to cure the trouble, measure resistance across R2129 with VTVM. **CAUTION** Turn off SCOPE HIGH VOLTAGES switch and discharge capacitors before changing any components of this circuit. If resistance is less than 15 megohms, replace C2101 or R2129. If voltage is low and ripple is excessive, replace C2101.
4. Abnormal −1,800-volt supply.	*a.* Replace V2102.	If tube replacement fails to cure the trouble, measure resistance of R2130, R2131. **CAUTION** Turn off SCOPE HIGH VOLTAGES switch and discharge capacitors before changing any components of this circuit. If either resistor differs from 47k by more than 20 percent, replace that resistor. If resistance across either capacitor C2108 or C2109 is less than 1 megohm, replace that capacitor. If voltage is low or ripple is high, temporarily shunt C2108 and C2109 with duplicate capacitors. If trouble is thus cured, replace the indicated capacitor.
5. Abnormal +8,000-volt supply.	*a.* Replace CR2101, CR2102, CR2103, CR2104. **CAUTION** Turn off SCOPE HIGH VOLTAGES switch and discharge capacitors before touching any components of this circuit.	If rectifier replacement fails to cure the trouble, replace C2110, C2111, C2112, C2113.

TABLE 7–13. TROUBLE-SHOOTING CHART FOR VOLTAGE REGULATOR TYPE CN–235/FPN–30

SYMPTOM	CHECK	RESULTS OF CHECK
1. Failure to regulate.	*a.* Replace V2301, V2302.	If tube replacement fails to cure the trouble, swing OUTPUT VOLTAGES control R2302 over its range and note whether relays operate properly. (An audible click should be heard from K2302 as R2302 is rotated counterclockwise from normal position and from K2303 as R2302 is rotated clockwise from normal position.) If relays operate normally, assume defective relay contacts, of K2302 if motor moves to raise voltage only, and of K2303 if motor moves to lower voltage only. If relays do not operate normally, replace Z2301. If trouble persists, measure voltages and resistances for V2301, V2302, and compare with data in table 7–26.

(2) HOW TO USE THE WAVEFORMS.—The waveforms shown in figures 7–1 through 7–237 represent typical waveforms which may be obtained from a properly functioning timer, at a LOW basic rate, under the conditions noted. Where a waveform will show an important difference at other rates, several waveforms are given for the different rates. By comparing the waveform obtained in a given circuit with the waveform shown for that circuit, the technician will usually be able to detect circuit malfunctions. The waveforms are arranged in signal path order, that is, the first waveforms are of oscillator circuits and the following waveforms are presented in the order of circuits through which the oscillator output flows to develop the square wave, markers, and timing pulses. Likewise, at an appropriate place, the signals picked up by the receiver are introduced and waveforms are presented to trace those signals through the synchronization indicator and electrical synchronizer. Waveforms are also presented for tracing signals through the test scope, using the test scope of another timer. The use of the test scope for observing waveforms has been discussed in Section 3, paragraph 17.

Procedures for tracing signals through the timer in a logical order have been given in the troubleshooting charts, tables 7–1 through 7–12; however, these procedures may be extended at will. For example, signal may be traced through the complete timer by starting with the first waveform and checking every waveform out through to the last. Waveforms are not always given for all signal elements of every stage; however, where significant, the first stage encountered of a particular type will have waveforms for all important elements. For example, figure 7–105 shows the plate waveform of the A-delay phantastron; the grid, screen, and suppressor waveforms for that stage are shown in the next three waveforms but only the plate waveform is shown for the other phantastrons. If trouble is found in one of the other phantastrons, observe the plate, grid, screen, and suppressor waveforms and compare with the waveforms shown for the A delay phantastron. The waveforms will be essentially the same except for sweep length.

The general treatment for delay adjustment covered in Section 3 applies to most of the waveforms presented here; however, one precaution needs to be taken for some waveforms. The preset output waveforms and the left-right drift waveforms contain unique information at the beginning of each sequence; that is, immediately following the ϕ 1 or ϕ 2 time reference point established by the 50-cycle trigger. Therefore, when adjusting the delay to observe preset output waveforms, or waveforms of the left-right drift circuit, set the delay to place the portion of the waveform immediately following the trigger near the left end of the trace. For the counter 1, 4 stage, waveforms shown for the drift condition, this will result in several stationary counting cycles at the extreme left end of the trace followed by a series of counting cycles which changes from one pattern to another as feedback pulses are applied through the drift circuit.

(Text continued on page 7–82)

TEST SIGNAL switch: 100 KC INPUT
GAIN settings: 60 HI
SWEEP SPEED: 100 #3
Notes:

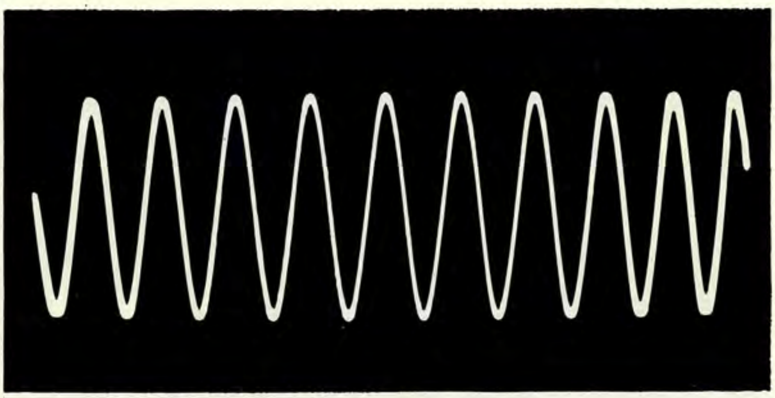


Figure 7–1. Sync Control Unit TEST SIGNAL Waveform

TEST SIGNAL switch: φ SHIFTER OUTPUT
GAIN settings: 65 HI
SWEEP SPEED: 100 #3
Notes:

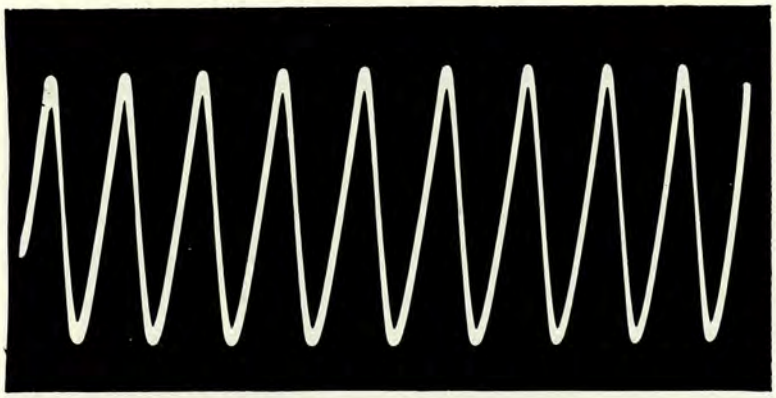


Figure 7–2. Sync Control Unit TEST SIGNAL Waveform

TEST SIGNAL switch: 100 KC to XMTR
GAIN settings: 60 HI
SWEEP SPEED: 100 #3
Notes:

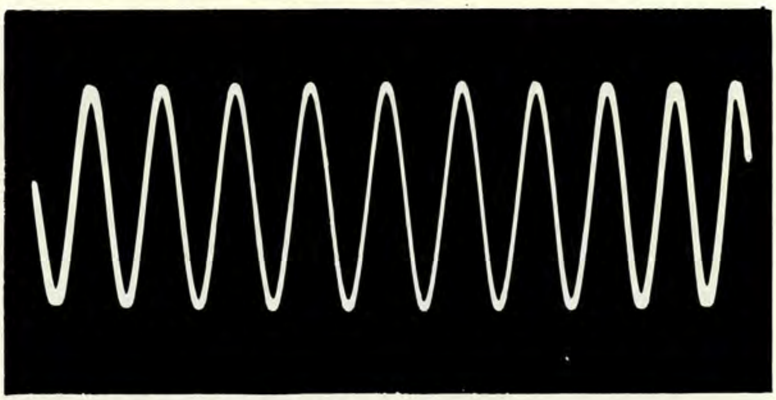


Figure 7–3. Sync Control Unit TEST SIGNAL Waveform

TEST SIGNAL switch: 100 KC to FREQ DIV
GAIN settings: 60 HI
SWEEP SPEED: 100 #3
Notes:

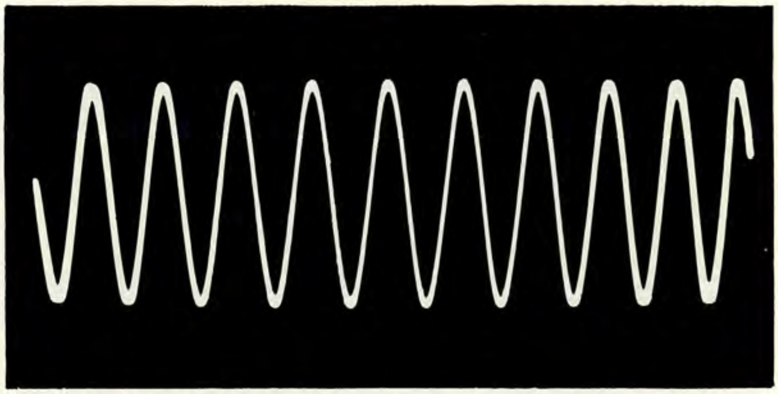
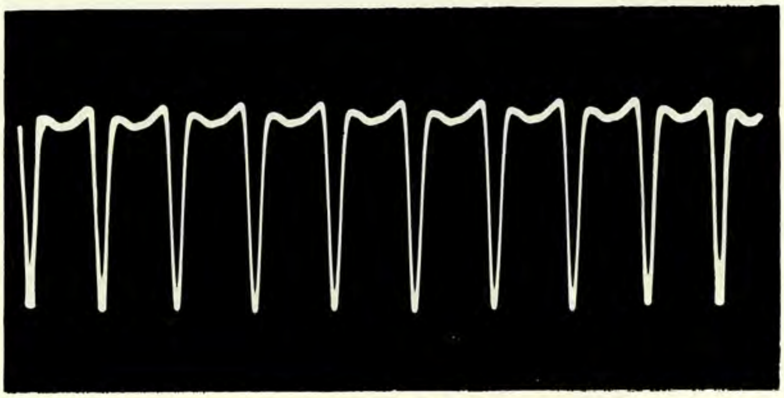
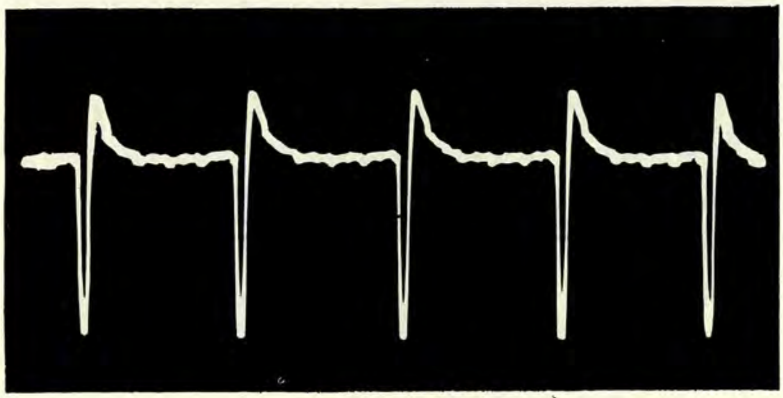


Figure 7–4. Sync Control Unit TEST SIGNAL Waveform



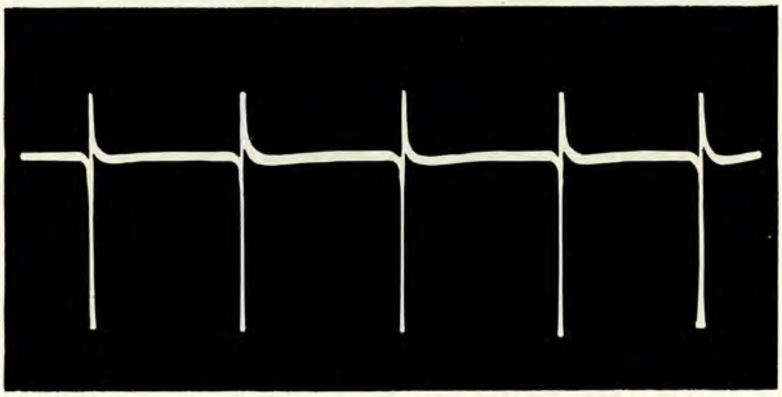
TEST SIGNAL switch: 10'S
GAIN settings: 60 HI
SWEEP SPEED: 100 #3
Notes:

Figure 7–5. Frequency Divider TEST SIGNAL Waveform



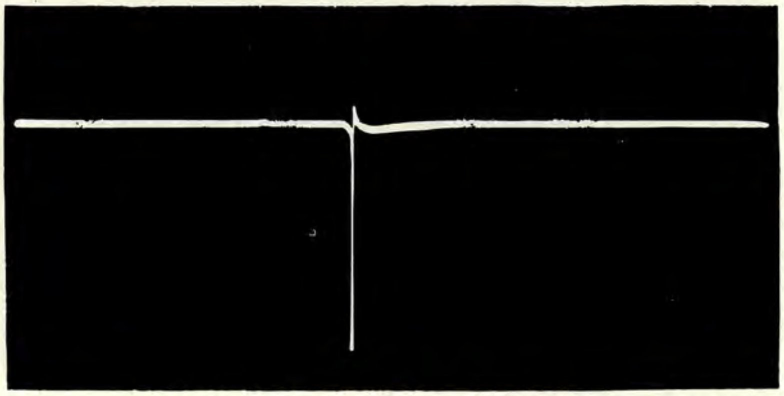
TEST SIGNAL switch: 100'S
GAIN settings: 60 HI
SWEEP SPEED: 500 #3
Notes:

Figure 7–6. Frequency Divider TEST SIGNAL Waveform



TEST SIGNAL switch: 1000'S
GAIN settings: 60 HI
SWEEP SPEED: 5,000 #1
Notes:

Figure 7–7. Frequency Divider TEST SIGNAL Waveform



TEST SIGNAL switch: 50~
GAIN settings: 42 HI
SWEEP SPEED: 5,000 #1
Notes:

Figure 7–8. Frequency Divider TEST SIGNAL Waveform

TEST SIGNAL switch: A1000 GATE
GAIN settings: 50 HI
SWEEP SPEED: 8,000 #1
Notes:

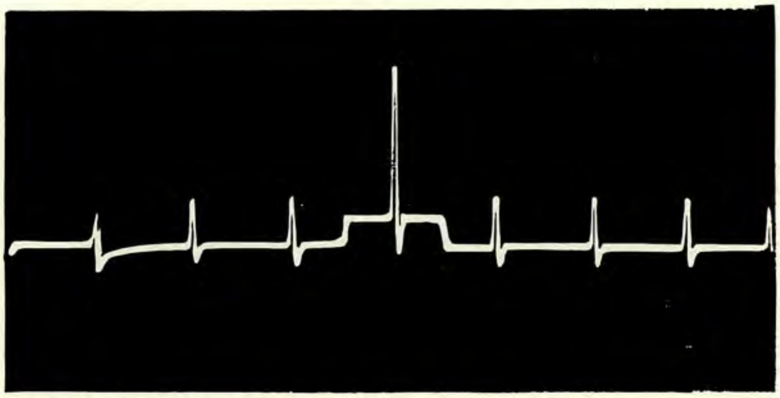


Figure 7–9. Time Delay Unit TEST SIGNAL Waveform

TEST SIGNAL switch: B1000 GATE
GAIN settings: 50 HI
SWEEP SPEED: 8,000 #1
Notes:

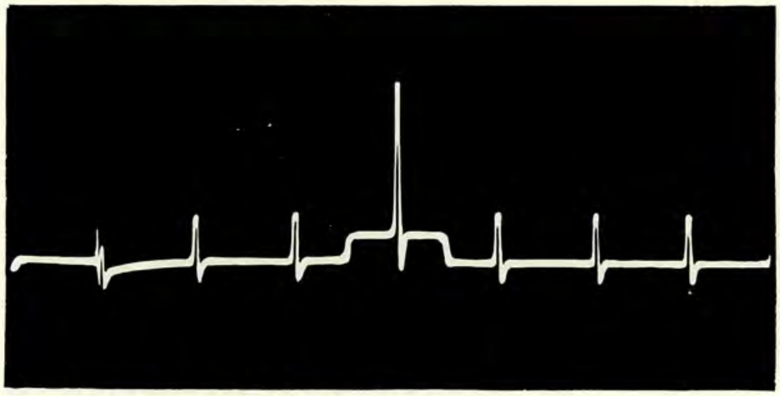


Figure 7–10. Time Delay Unit TEST SIGNAL Waveform

TEST SIGNAL switch: B100 GATE
GAIN settings: 50 HI
SWEEP SPEED: 1,500 #2
Notes:

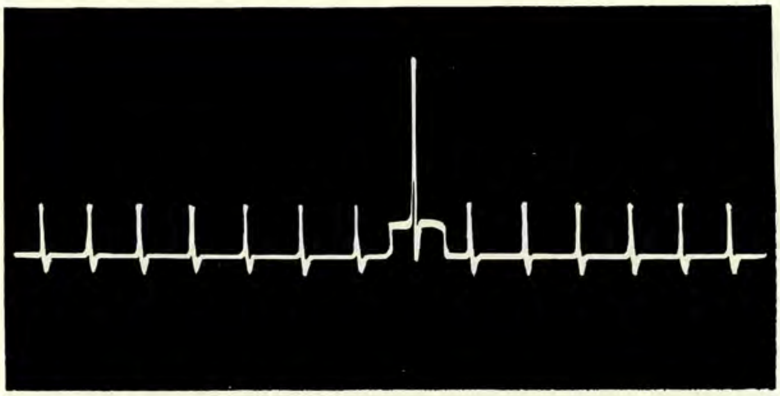


Figure 7–11. Time Delay Unit TEST SIGNAL Waveform

TEST SIGNAL switch: B10 GATE
GAIN settings: 60 HI
SWEEP SPEED: 200 #3
Notes:

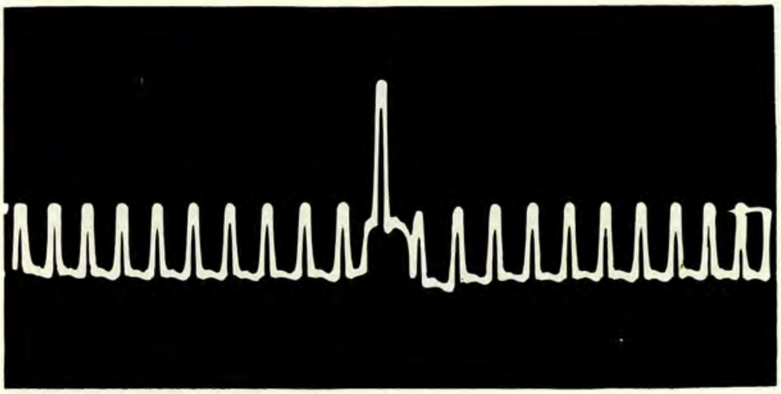
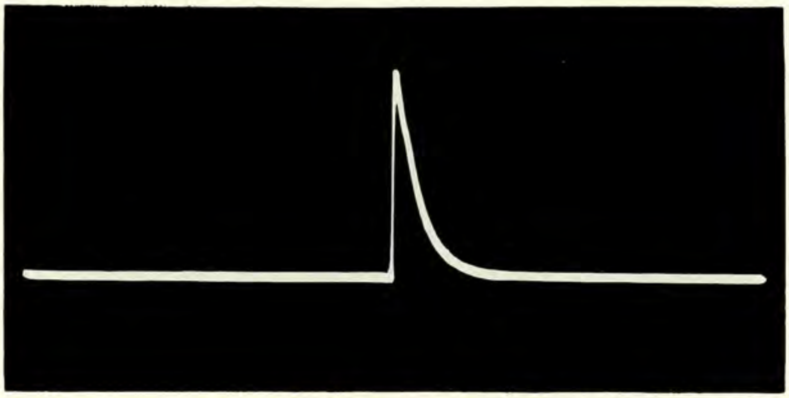


Figure 7–12. Time Delay Unit TEST SIGNAL Waveform



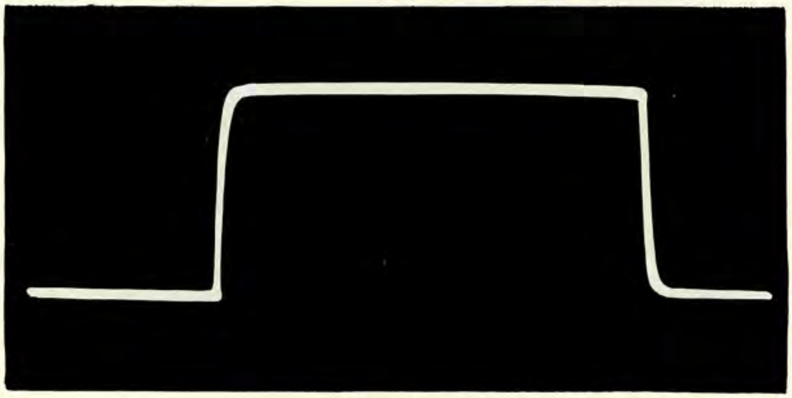
TEST SIGNAL switch: TRANSMITTER TRIG

GAIN settings: 54 HI

SWEEP SPEED: 200 #3

Notes:

Figure 7–13. Time Delay Unit TEST SIGNAL Waveform



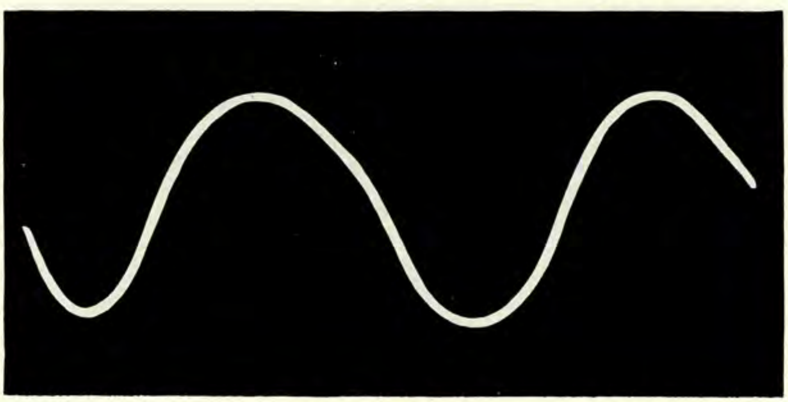
TEST SIGNAL switch: BLANKING PULSE

GAIN settings: 58 HI

SWEEP SPEED: 1,000 #2

Notes:

Figure 7–14. Time Delay Unit TEST SIGNAL Waveform



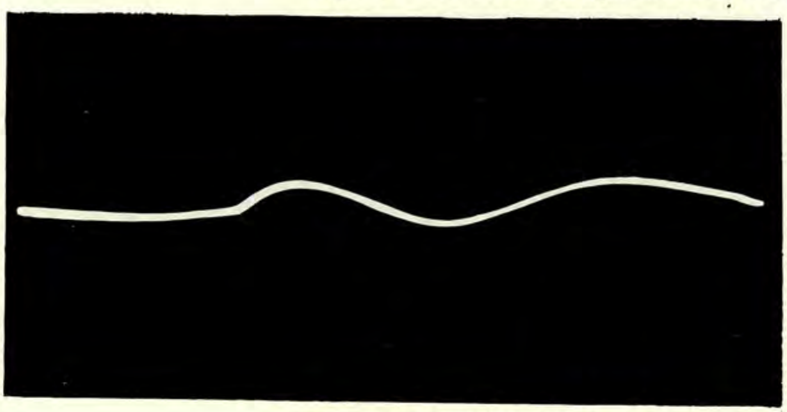
TEST SIGNAL switch: AC ERROR

GAIN settings: 40 HI

SWEEP SPEED: 32,000 #1

Notes: Large error; waveform will remain stationary only at some SLOW rates.

Figure 7–15. Electrical Synchronizer TEST SIGNAL Waveform



TEST SIGNAL switch: AC ERROR

GAIN settings: 40 HI

SWEEP SPEED: 32,000 #1

Notes: Minimum error; waveform will remain stationary only at some SLOW rates.

Figure 7–16. Electrical Synchronizer TEST SIGNAL Waveform

TEST SIGNAL switch: 2ND DERIVATIVE
GAIN settings: 58 HI
SWEEP SPEED: 200 #3
Notes:

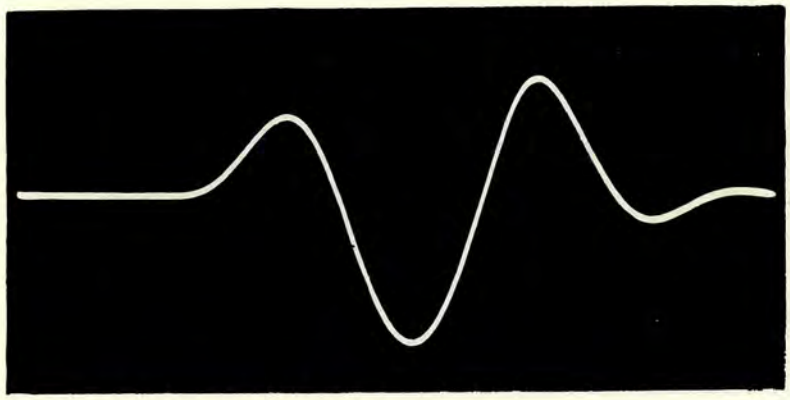


Figure 7–17. Electrical Synchronizer TEST SIGNAL Waveform

TEST SIGNAL switch: LOCAL GATE
GAIN settings: 50 HI
SWEEP SPEED: 100 #3
Notes:

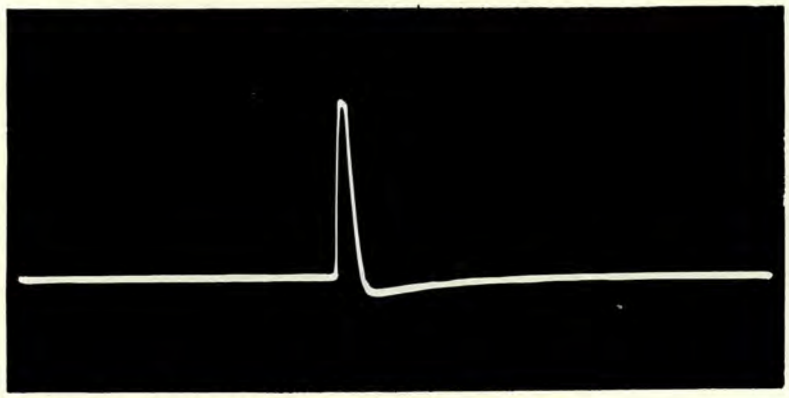


Figure 7–18. Electrical Synchronizer TEST SIGNAL Waveform

TEST SIGNAL swtich: REMOTE GATE
GAIN settings: 50 HI
SWEEP SPEED: 100 #3
Notes:

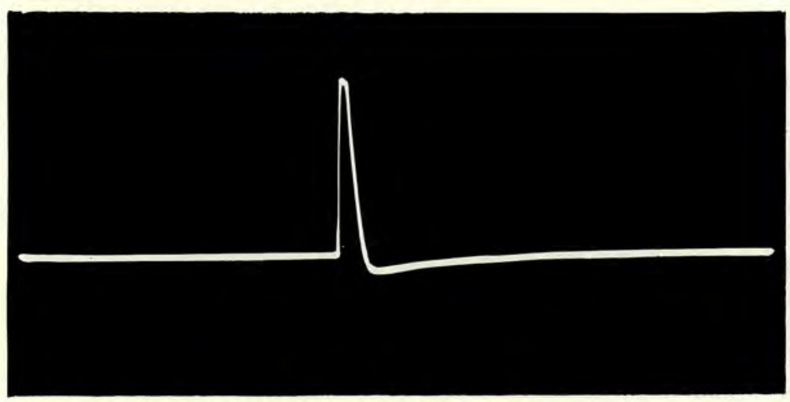


Figure 7–19. Electrical Synchronizer TEST SIGNAL Waveform

TEST SIGNAL switch: MIXED GATES
GAIN settings: 50 HI
SWEEP SPEED: 100 #3
Notes: Pedestal trigger. This waveform used only at a master station.

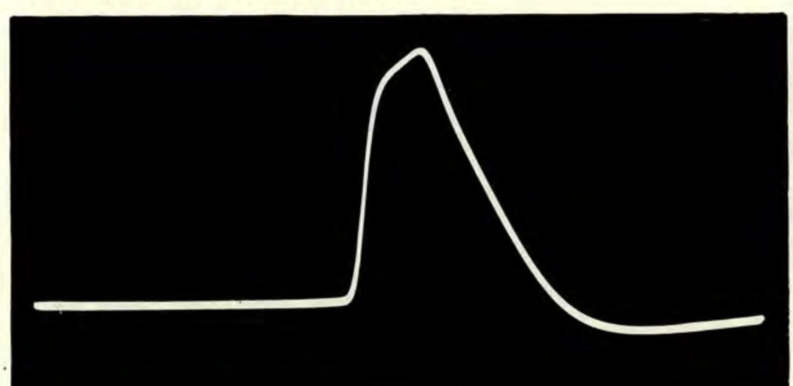
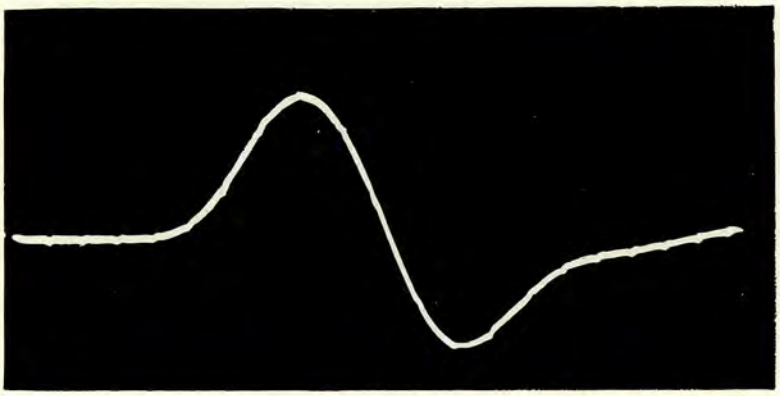
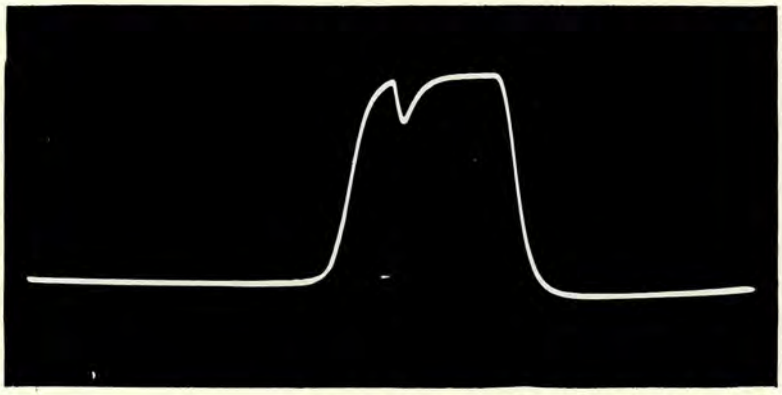


Figure 7–20. Electrical Synchronizer TEST SIGNAL Waveform



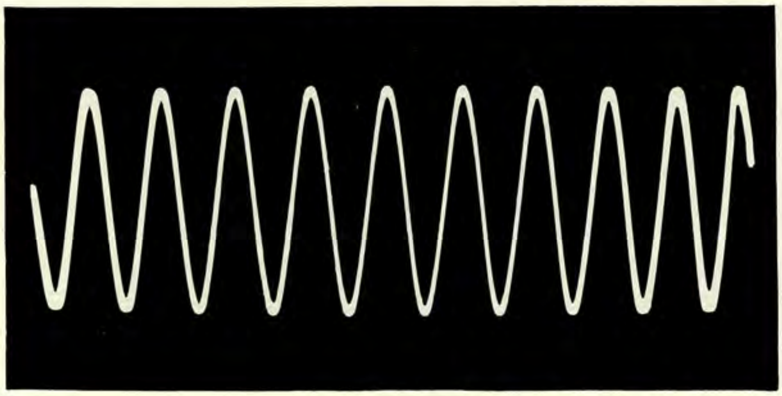
TEST SIGNAL switch: 1ST DERIVATIVE
GAIN settings: 50 HI
SWEEP SPEED: 200 #3
Notes:

Figure 7–21. Electrical Synchronizer TEST SIGNAL Waveform



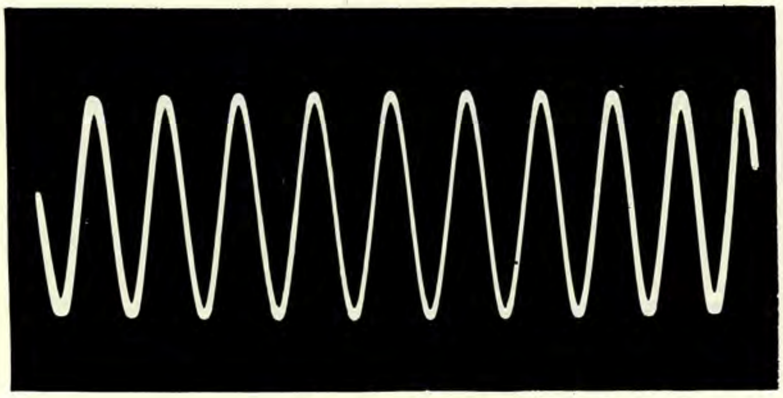
TEST SIGNAL switch: LIMITED 1ST DERIVATIVE
GAIN settings: 45 HI
SWEEP SPEED: 200 #3
Notes:

Figure 7–22. Electrical Synchronizer TEST SIGNAL Waveform



EXTERNAL test point: V1402 pin 8
GAIN settings: 38 HI
SWEEP SPEED: 100 #3
Notes: Use probe.

Figure 7–23. Oscillator, 2nd Amplifier Plate Waveform



EXTERNAL test point: V1403 pin 8
GAIN settings: 54 HI
SWEEP SPEED: 100 #3
Notes: Use probe.

Figure 7–24. Oscillator, Isolation Amplifier Plate Waveform

EXTERNAL test point: V1404 pin 8

GAIN settings: 65 HI

SWEEP SPEED: 10,000 #1

Notes: Waveform will not be stationary.

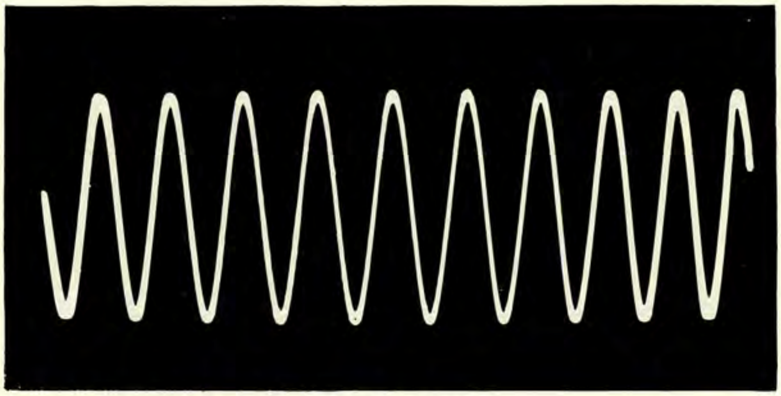


Figure 7–25. Oscillator, 1st Heater Amplifier Plate Waveform

EXTERNAL test point: V1405 pin 3

GAIN settings: 45 LO

SWEEP SPEED: 10,000 #1

Notes: Waveform will not be stationary.

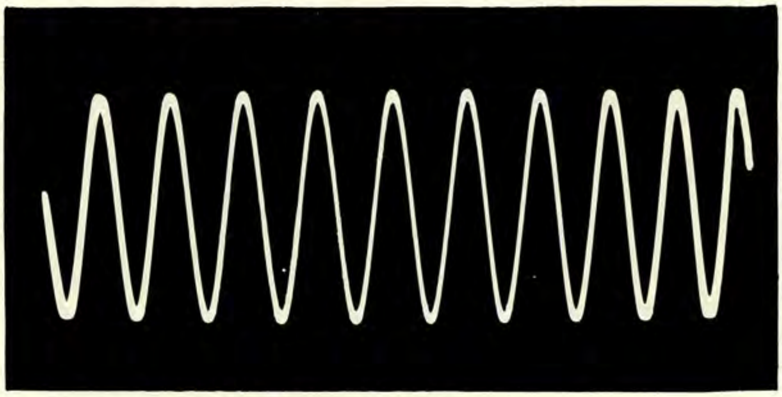


Figure 7–26. Oscillator, 2nd Heater Amplifier Plate Waveform

EXTERNAL test point: V101 pin 3

GAIN settings: 50 HI

SWEEP SPEED: 100 #3

Notes: This stage is used only at a slave station.

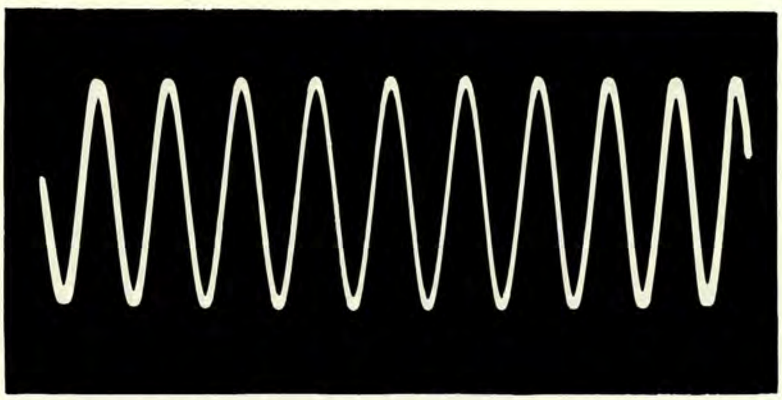


Figure 7–27. Sync Control Unit, Phase Shifter Driver Cathode Waveform

EXTERNAL test point: V103 pin 1

GAIN settings: 35 HI

SWEEP SPEED: 100 #3

Notes: S101 on MASTER.

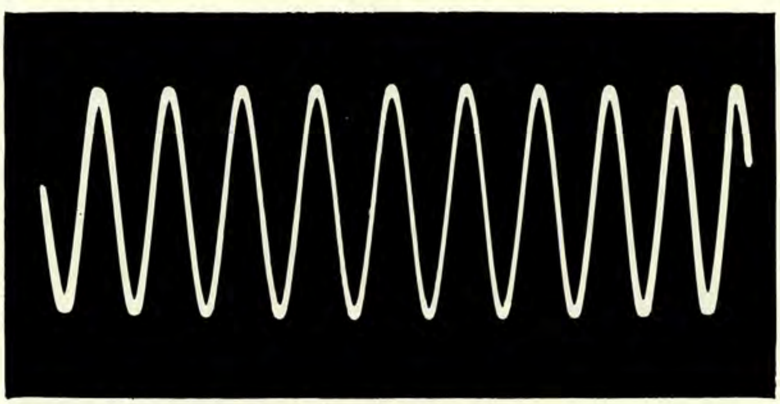
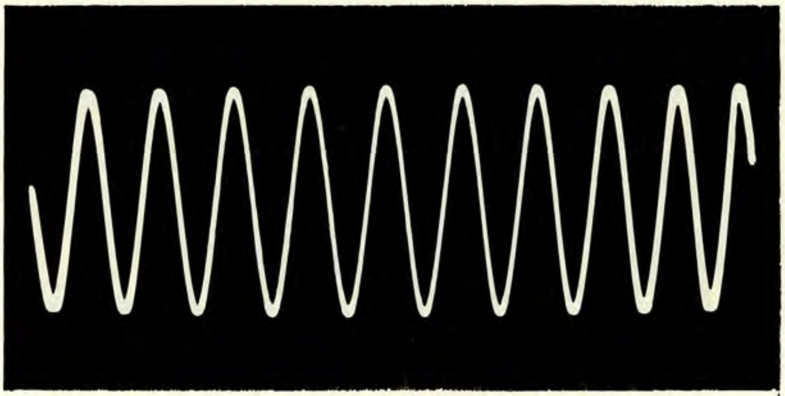
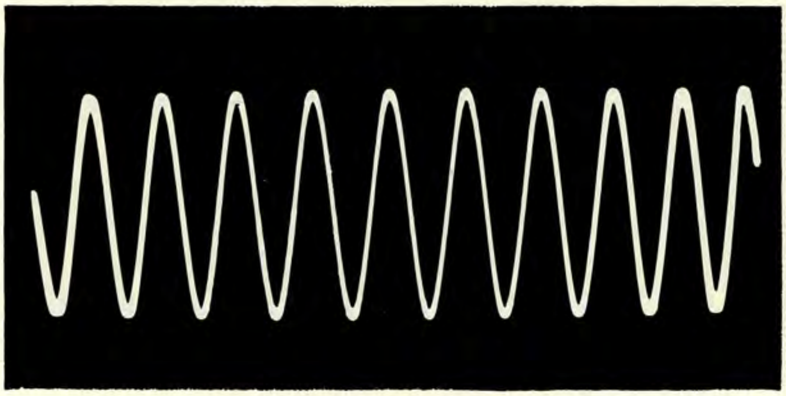


Figure 7–28. Sync Control Unit, 100-kc Amplifier 1st Plate Waveform



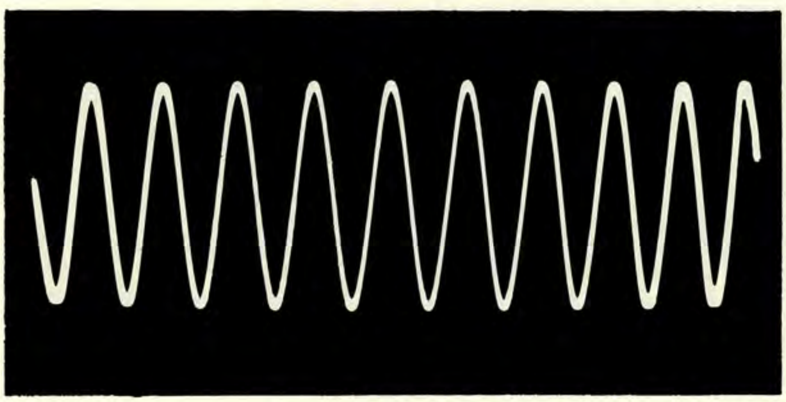
EXTERNAL test point: V103 pin 1
GAIN settings: 35 HI
SWEEP SPEED: 100 #3
Notes: S101 on SLAVE.

Figure 7–29. Sync Control Unit, 100-kc Amplifier 1st Plate Waveform



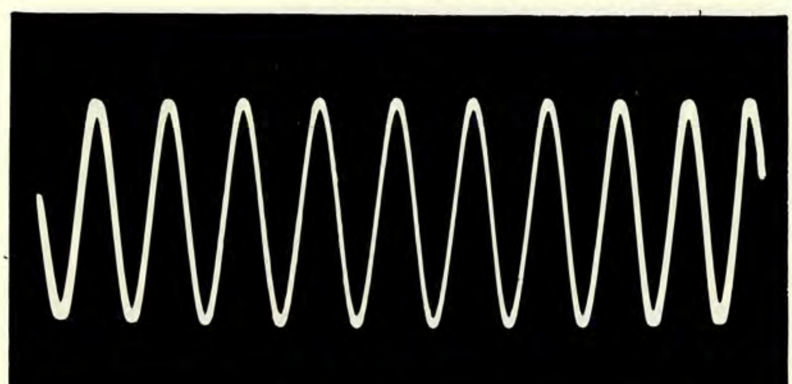
EXTERNAL test point: V103 pin 6
GAIN settings: 42 HI
SWEEP SPEED: 100 #3
Notes:

Figure 7–30. Sync Control Unit, 100-kc Amplifier 2nd Plate Waveform



EXTERNAL test point: V104 pin 1
GAIN settings: 42 LO
SWEEP SPEED: 100 #3
Notes:

Figure 7–31. Sync Control Unit, Output Amplifier Plate Waveform



EXTERNAL test point: V104 pin 8
GAIN settings: 48 LO
SWEEP SPEED: 100 #3
Notes:

Figure 7–32. Sync Control Unit, Output Follower Cathode Waveform

EXTERNAL test point: V105 pin 8
GAIN settings: 52 LO
SWEEP SPEED: 100 #3
Notes:

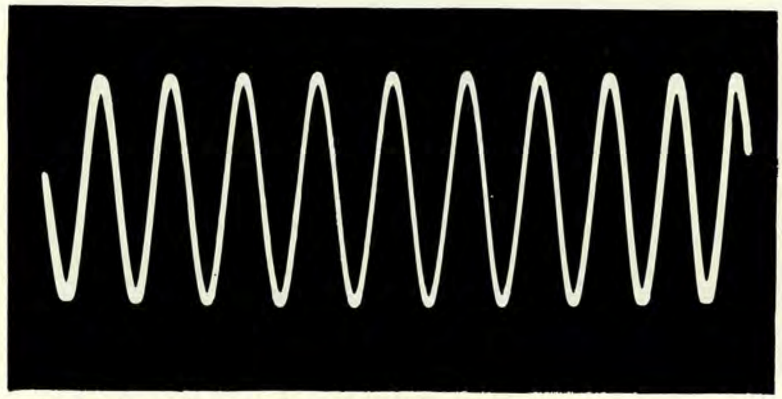


Figure 7–33. Sync Control Unit, Xmtr Phase Shifter Plate Waveform

EXTERNAL test point: V105 pin 1
GAIN settings: 58 LO
SWEEP SPEED: 100 #3
Notes:

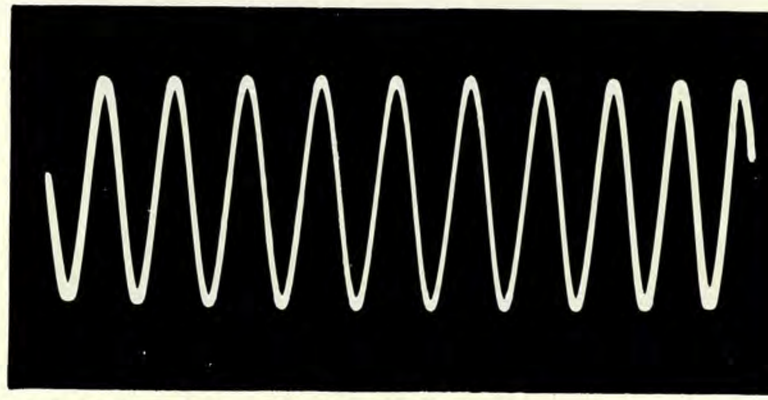


Figure 7–34. Sync Control Unit, Xmtr Follower Cathode Waveform

EXTERNAL test point: V102 pin 6
GAIN settings: 40 LO
SWEEP SPEED: 25,000 #1
Notes: Minimum sync error; waveform will remain stationary only at some SLOW rates.

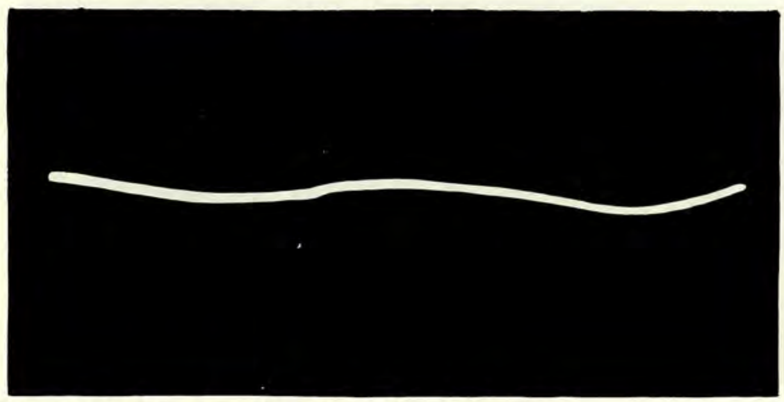


Figure 7–35. Sync Control Unit, 60~ Amplifier Plate Waveform

EXTERNAL test point: V102 pin 6
GAIN settings: 40 LO
SWEEP SPEED: 25,000 #1
Notes: Large sync error; waveform will remain stationary only at some SLOW rates.

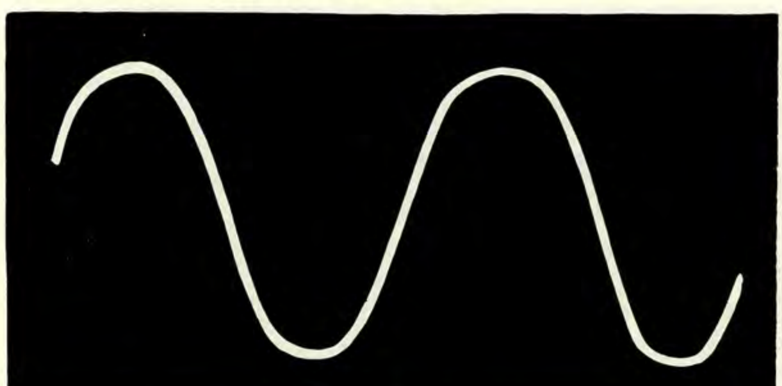
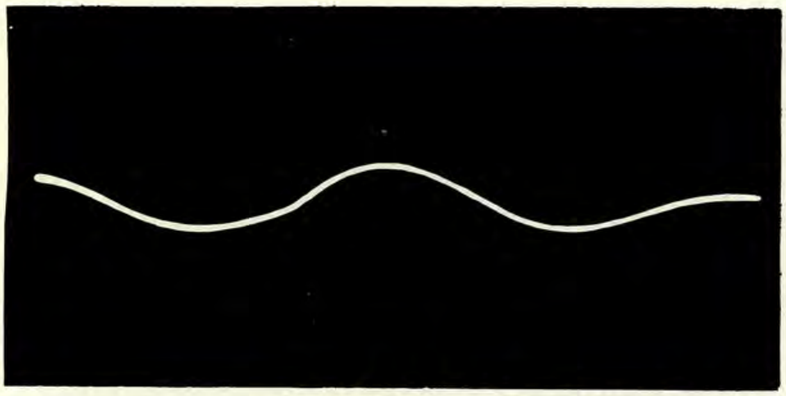


Figure 7–36. Sync Control Unit, 60~ Amplifier Plate Waveform



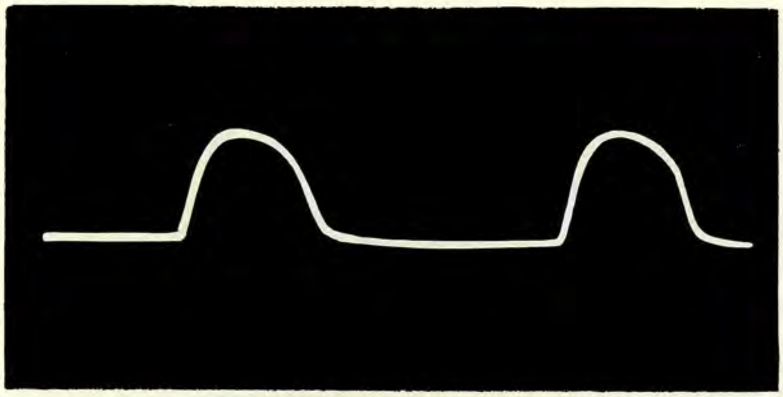
EXTERNAL test point: V102 pin 3

GAIN settings: 60 LO

SWEEP SPEED: 25,000 #1

Notes: Minimum sync error; waveform will remain stationary only at some SLOW rates.

Figure 7–37. Sync Control Unit, 60~Follower Cathode Waveform



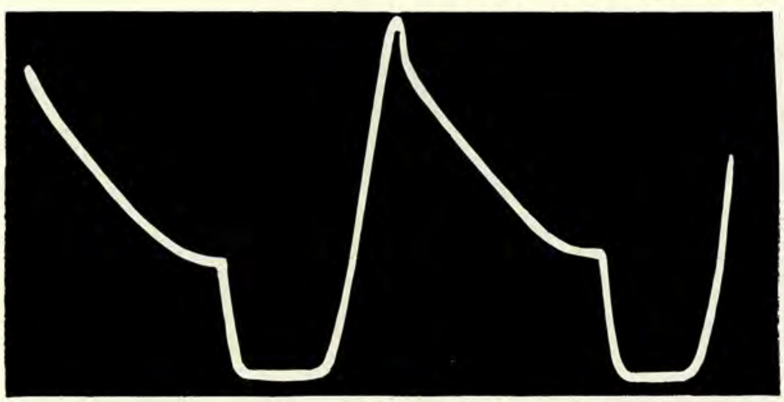
EXTERNAL test point: V102 pin 3

GAIN settings: 45 LO

SWEEP SPEED: 25,000 #1

Notes: MAXIMUM MOTOR SPEED control full clockwise, large sync error; waveform will remain stationary only at some SLOW rates.

Figure 7–38. Sync Control Unit, 60~Follower Cathode Waveform



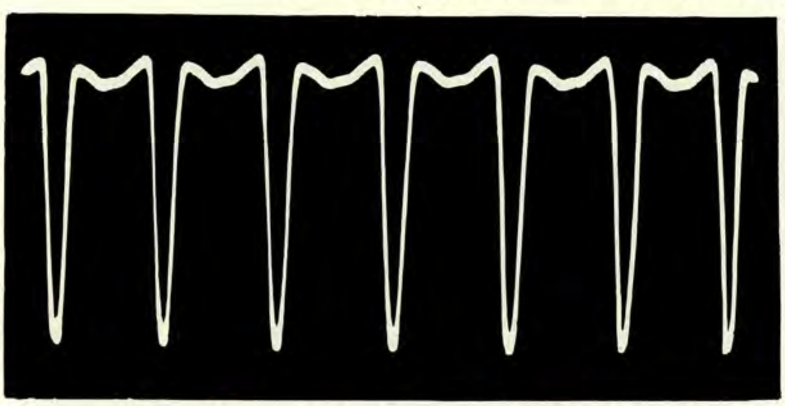
EXTERNAL test point: V107 pin 5

GAIN settings: 35 LO

SWEEP SPEED: 25,000 #1

Notes: MAXIMUM MOTOR SPEED control full clockwise, large sync error; waveform will remain stationary only at some SLOW rates.

Figure 7–39. Sync Control Unit, Motor Amplifier Plate Waveform



EXTERNAL test point: V202 pin 6

GAIN settings: 50 HI

SWEEP SPEED: 65 #4

Notes: Use probe.

Figure 7–40. Frequency Divider, 10-μs Blocking Oscillator Plate Waveform

EXTERNAL test point: V202 pin 7
GAIN settings: 30 HI
SWEEP SPEED: 200 #3
Notes:

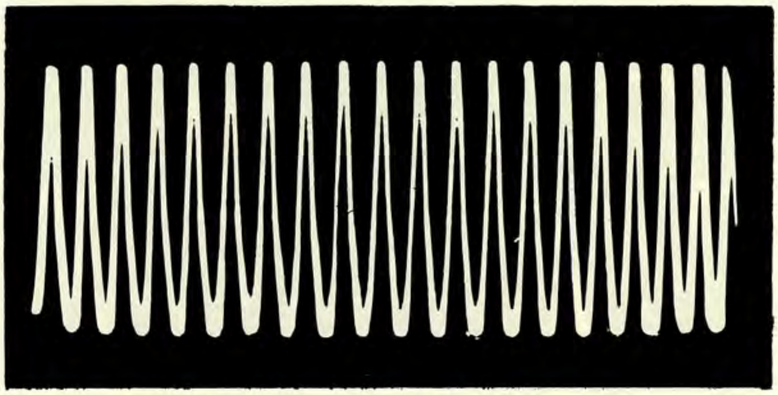


Figure 7–41. Frequency Divider, 10-μs Blocking Oscillator Grid Waveform

EXTERNAL test point: V203 pin 7
GAIN settings: 55 HI
SWEEP SPEED: 100 #3
Notes: Use probe.

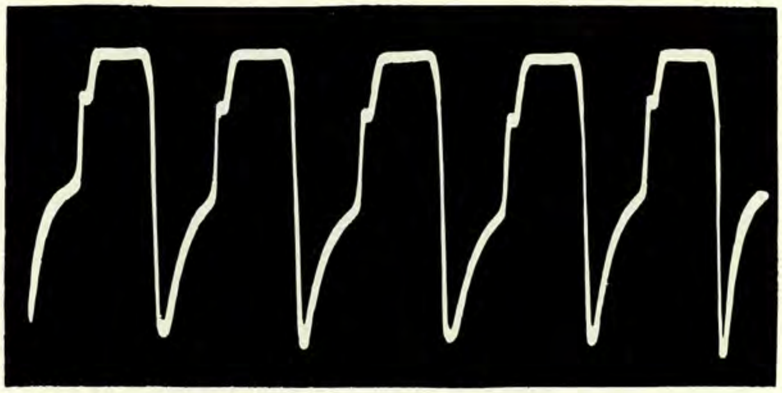


Figure 7–42. Frequency Divider, Counter 1, 1 Stage Output Waveform

EXTERNAL test point: V204 pin 7
GAIN settings: 50 HI
SWEEP SPEED: 100 #3
Notes: Use probe.

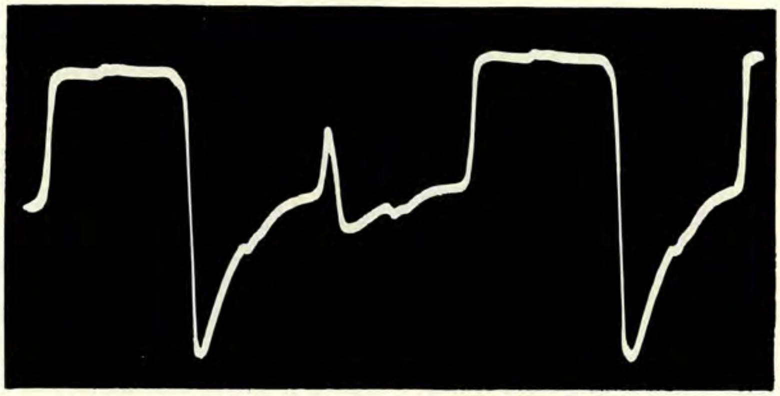


Figure 7–43. Frequency Divider, Counter 1, 2 Stage Output Waveform

EXTERNAL test point: V205 pin 7
GAIN settings: 60 HI
SWEEP SPEED: 150 #3
Notes: Use probe.

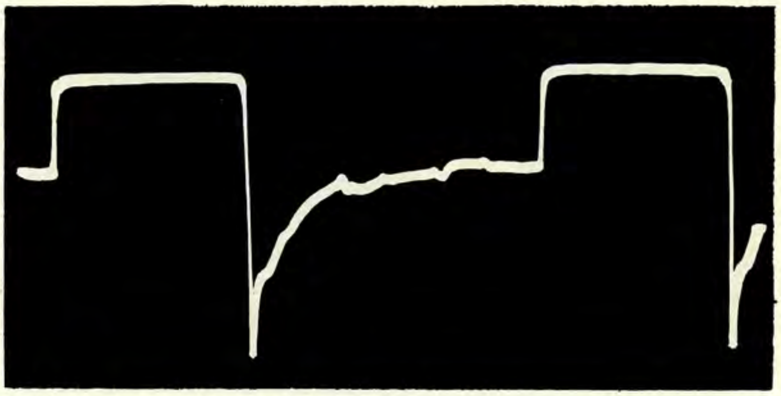
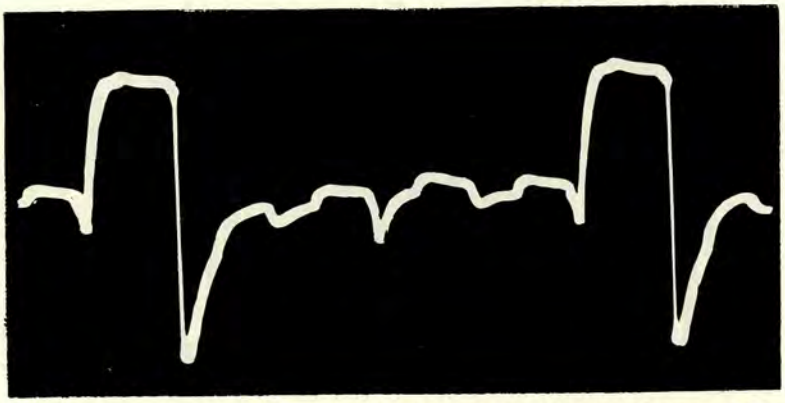
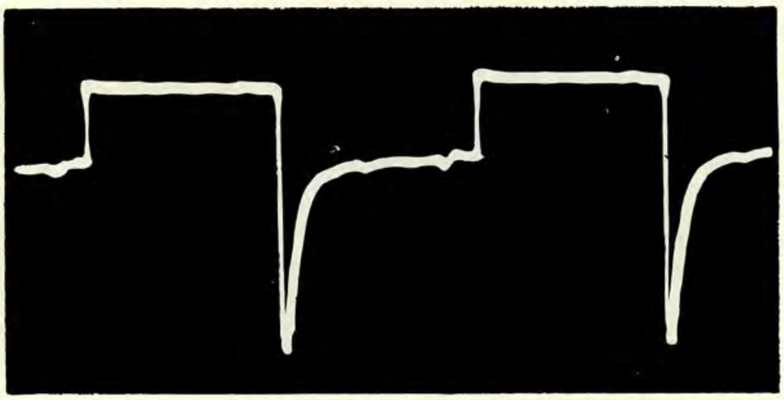


Figure 7–44. Frequency Divider, Counter 1, 4 Stage Output Waveform



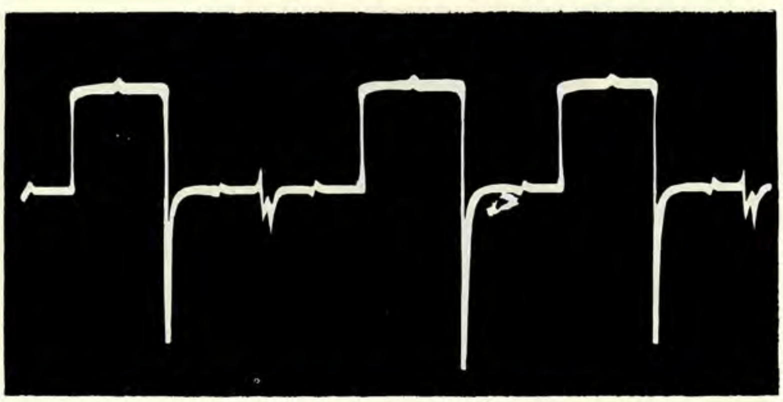
EXTERNAL test point: V206 pin 7
GAIN settings: 60 HI
SWEEP SPEED: 150 #3
Notes: Use probe.

Figure 7–45. Frequency Divider, Counter 1, 8 Stage Output Waveform



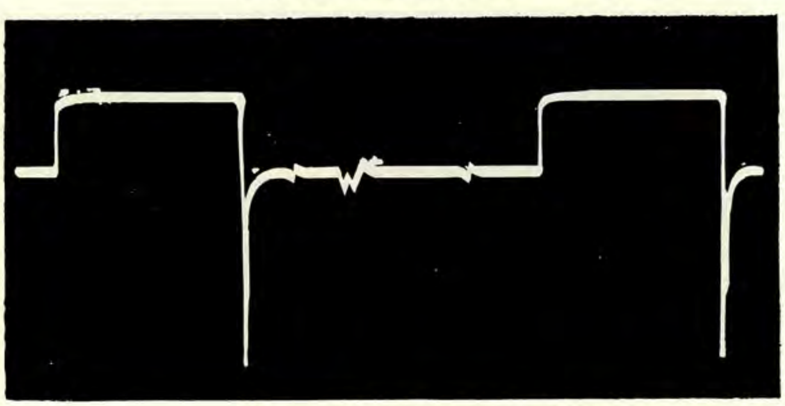
EXTERNAL test point: V208 pin 7
GAIN settings: 58 HI
SWEEP SPEED: 400 #3
Notes: Use probe.

Figure 7–46. Frequency Divider, Counter 2, 1 Stage Output Waveform



EXTERNAL test point: V209 pin 7
GAIN settings: 50 HI
SWEEP SPEED: 1,500 #2
Notes: Use probe.

Figure 7–47. Frequency Divider, Counter 2, 2 Stage Output Waveform



EXTERNAL test point: V210 pin 7
GAIN settings: 48 HI
SWEEP SPEED: 1,500 #2
Notes: Use probe.

Figure 7–48. Frequency Divider, Counter 2, 4 Stage Output Waveform

EXTERNAL test point: V211 pin 7

GAIN settings: 58 HI

SWEEP SPEED: 1,500 #2

Notes: Use probe.

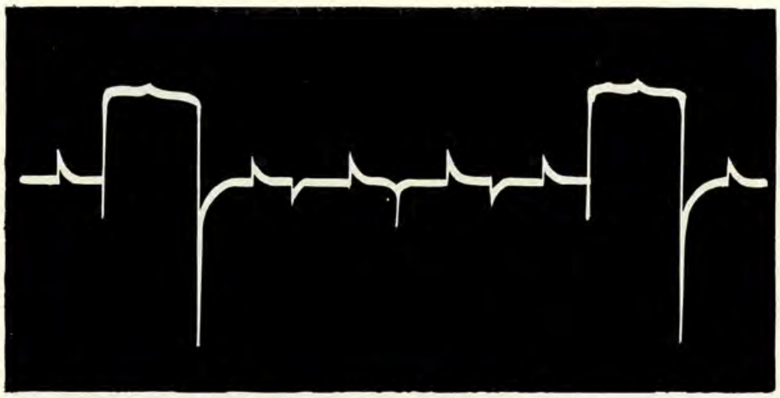


Figure 7–49. Frequency Divider, Counter 2, 8 Stage Output Waveform

EXTERNAL test point: V213 pin 7

GAIN settings: 50 HI

SWEEP SPEED: 4,000 #2

Notes: Waveform shown for HIGH rate; use probe.

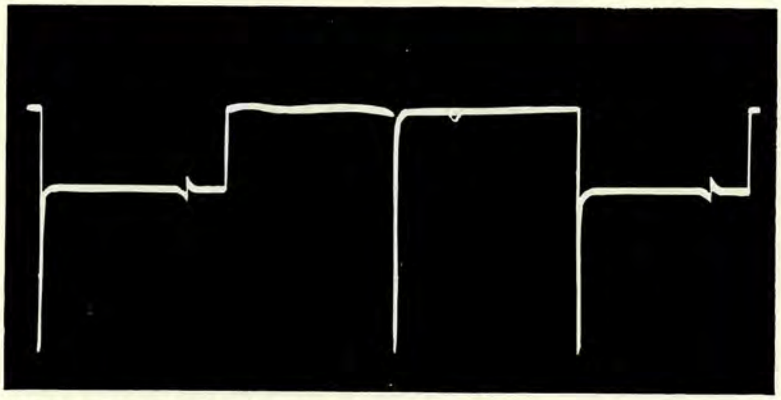


Figure 7–50. Frequency Divider, Counter 3, 1 Stage Output Waveform

EXTERNAL test point: V214 pin 7

GAIN settings: 55 HI

SWEEP SPEED: 10,000 #1

Notes: Waveform shown for HIGH rate; use probe.

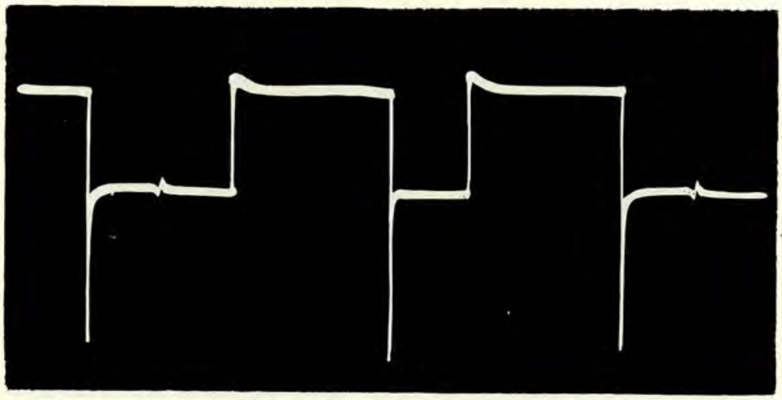


Figure 7–51. Frequency Divider, Counter 3, 2 Stage Output Waveform

EXTERNAL test point: V215 pin 7

GAIN settings: 55 HI

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for HIGH rate; use probe.

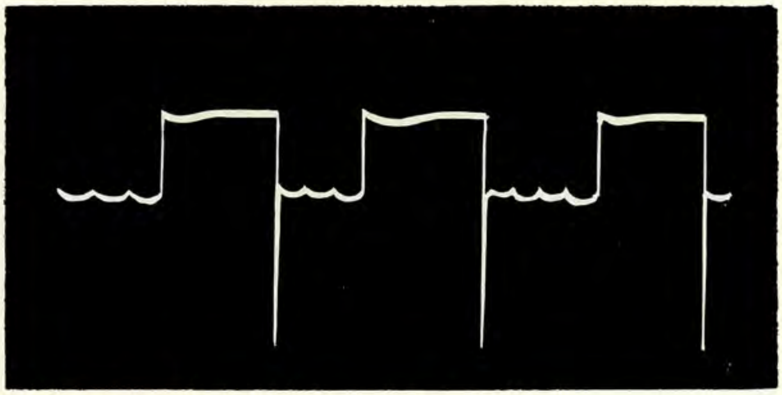
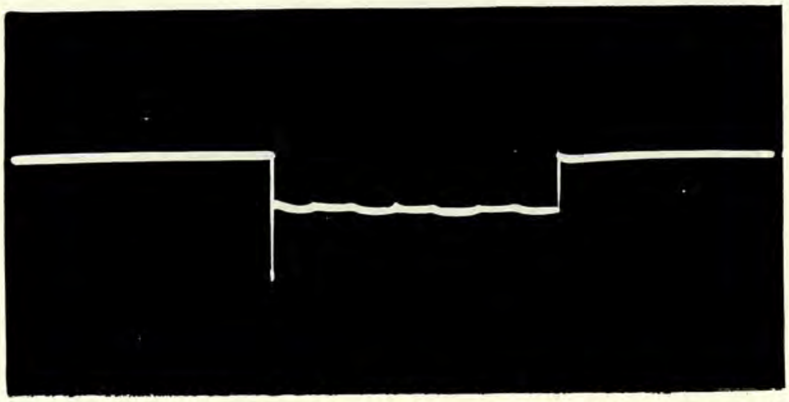


Figure 7–52. Frequency Divider, Counter 3, 4 Stage Output Waveform



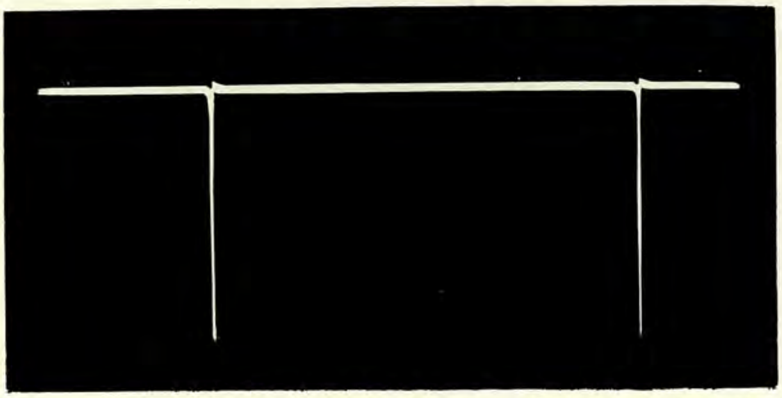
EXTERNAL test point: V216 pin 7

GAIN settings: 55 HI

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for HIGH rate; use probe.

Figure 7–53. Frequency Divider, Counter 3, 8 Stage Output Waveform



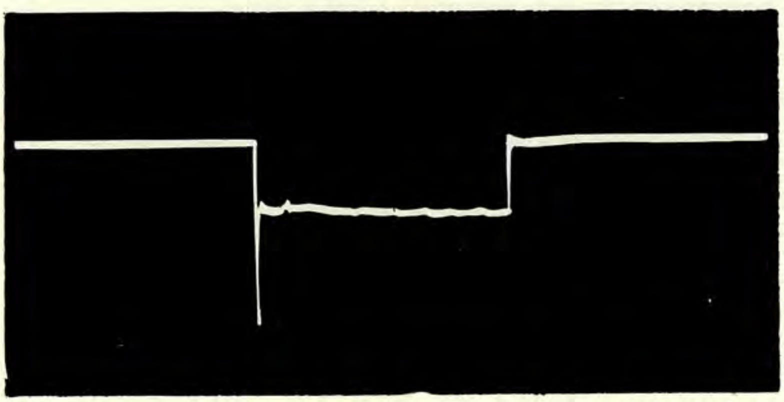
EXTERNAL test point: V217 pin 7

GAIN settings: 50 HI

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for HIGH rate; use probe.

Figure 7–54. Frequency Divider, Counter 3, 16 Stage Output Waveform



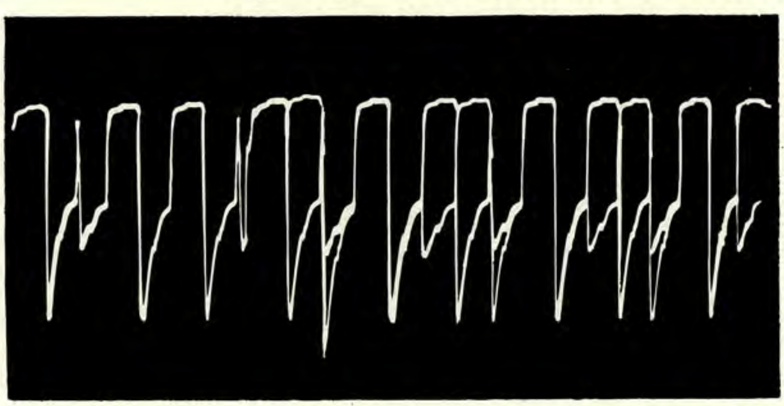
EXTERNAL test point: V217 pin 7

GAIN settings: 50 HI

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for SLOW rate; use probe.

Figure 7–55. Frequency Divider, Counter 3, 16 Stage Output Waveform



EXTERNAL test point: V204 pin 7

GAIN settings: 54 HI

SWEEP SPEED: 600 #2

Notes: Waveform shown for slow right, odd rate, drift. Refer to paragraph 3*d*(2) for delay adjustment. Use probe.

Figure 7–56. Frequency Divider, Counter 1, 2 Stage Output Waveform, Drift

EXTERNAL test point: V206 pin 7

GAIN settings: 54 HI

SWEEP SPEED: 600 #2

Notes: Waveform shown for slow right, odd rate, drift. Refer to paragraph 3*d*(2) for delay adjustment. Use probe.

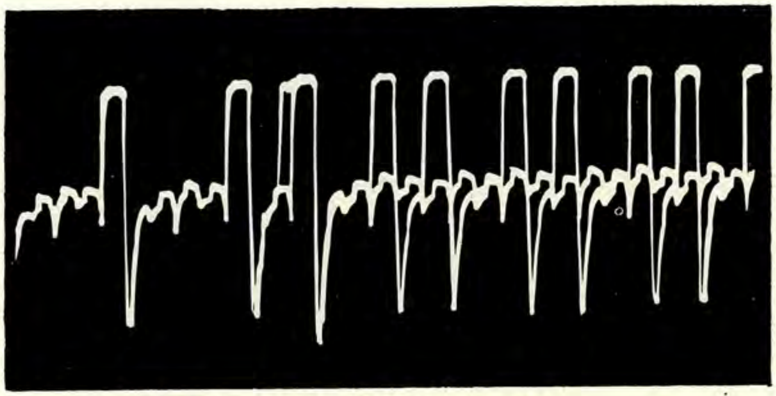


Figure 7–57. Frequency Divider, Counter 1, 8 Stage Output Waveform, Drift

EXTERNAL test point: V204 pin 7

GAIN settings: 54 HI

SWEEP SPEED: 600 #2

Notes: Waveform shown for slow left, odd rate, drift. Refer to paragraph 3*d*(2) for delay adjustment. Use probe.

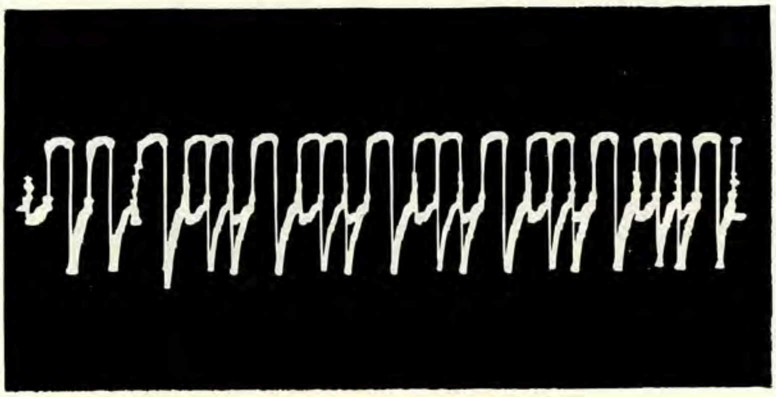


Figure 7–58. Frequency Divider, Counter 1, 2 Stage Output Waveform, Drift

EXTERNAL test point: V206 pin 7

GAIN settings: 54 HI

SWEEP SPEED: 600 #2

Notes: Waveform shown for slow left, odd rate, drift. Refer to paragraph 3*d*(2) for delay adjustment. Use probe.

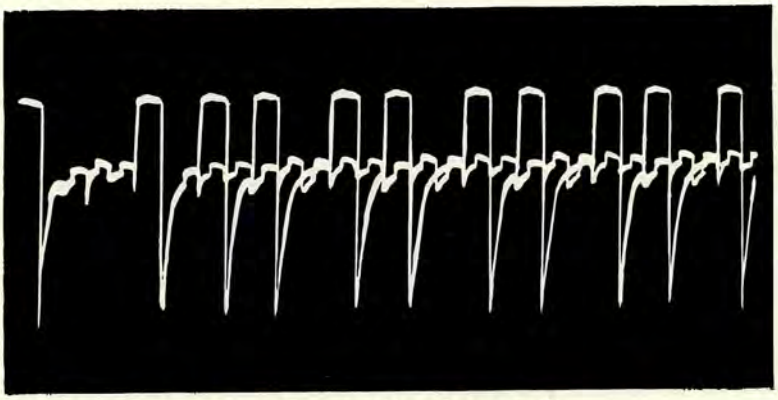


Figure 7–59. Frequency Divider, Counter 1, 8 Stage Output Waveform, Drift

EXTERNAL test point: V204 pin 7

GAIN settings: 54 HI

SWEEP SPEED: 600 #2

Notes: Waveform shown for slow right, even rate, drift. Refer to paragraph 3*d*(2) for delay adjustment. Use probe.

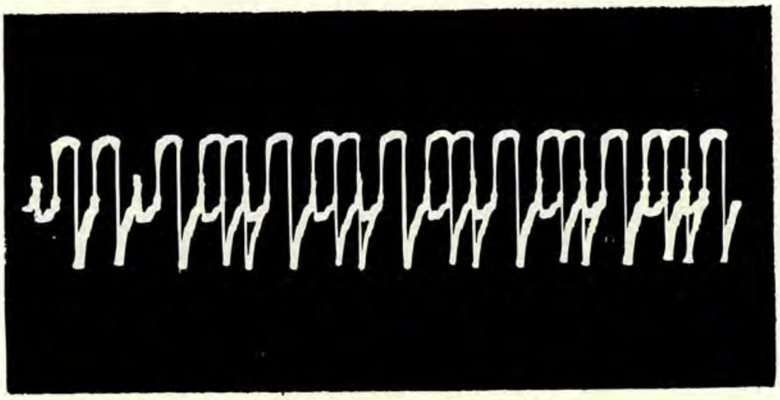
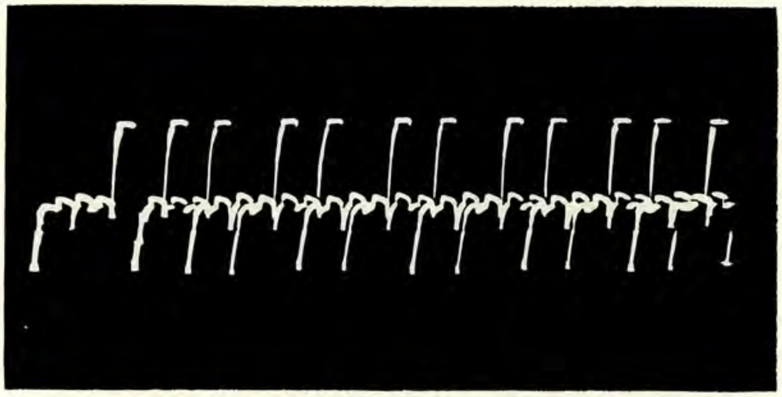


Figure 7–60. Frequency Divider, Counter 1, 2 Stage Output Waveform, Drift



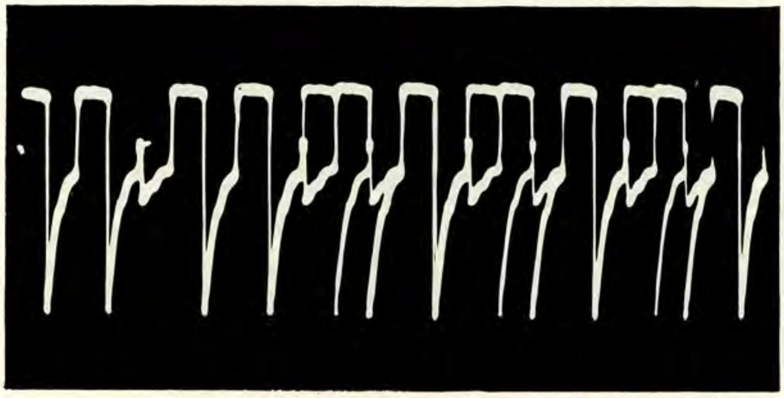
EXTERNAL test point: V206 pin 7

GAIN settings: 54 HI

SWEEP SPEED: 600 #2

Notes: Waveform shown for slow right, even rate, drift. Refer to paragraph 3*d*(2) for delay adjustment. Use probe.

Figure 7–61. Frequency Divider, Counter 1, 8 Stage Output Waveform, Drift



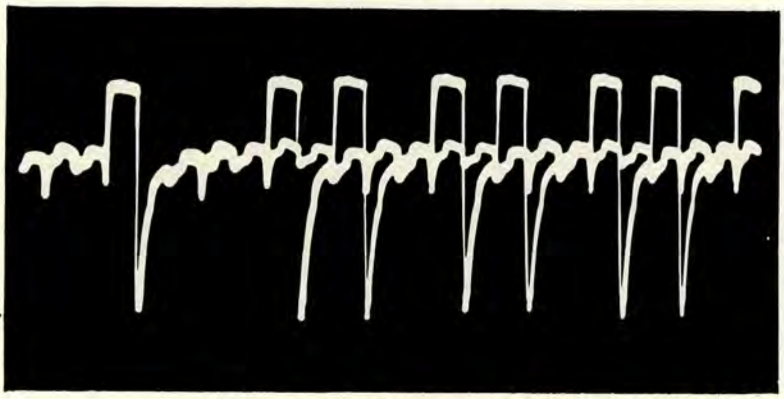
EXTERNAL test point: V204 pin 7

GAIN settings: 54 HI

SWEEP SPEED: 600 #2

Notes: Waveform shown for slow left, even rate, drift. Refer to paragraph 3*d*(2) for delay adjustment. Use probe.

Figure 7–62. Frequency Divider, Counter 1, 2 Stage Output Waveform, Drift



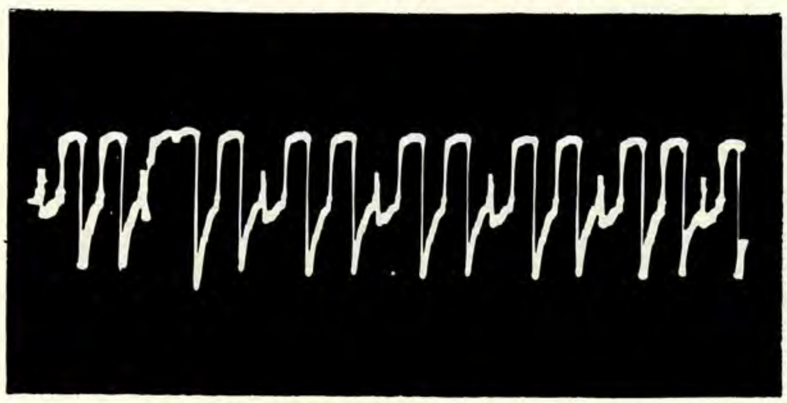
EXTERNAL test point: V206 pin 7

GAIN settings: 54 HI

SWEEP SPEED: 600 #2

Notes: Waveform shown for slow left, even rate, drift. Refer to paragraph 3*d*(2) for delay adjustment. Use probe.

Figure 7–63. Frequency Divider, Counter 1, 8 Stage Output Waveform, Drift



EXTERNAL test point: V204 pin 7

GAIN settings: 54 HI

SWEEP SPEED: 600 #2

Notes: Waveform shown for fast right, odd rate, drift. Refer to paragraph 3*d*(2) for delay adjustment. Use probe.

Figure 7–64. Frequency Divider, Counter 1, 2 Stage Output Waveform, Drift

EXTERNAL test point: V206 pin 7

GAIN settings: 54 HI

SWEEP SPEED: 400 #2

Notes: Waveform shown for fast right, odd rate, drift. Refer to paragraph 3*d*(2) for delay adjustment. Use probe.

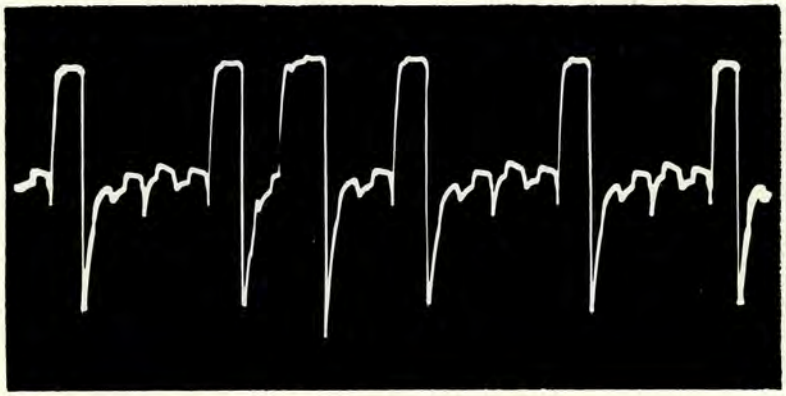


Figure 7–65. Frequency Divider, Counter 1, 8 Stage Output Waveform, Drift

EXTERNAL test point: V204 pin 7

GAIN settings: 54 HI

SWEEP SPEED: 600 #2

Notes: Waveform shown for fast left, odd rate, drift. Refer to paragraph 3*d*(2) for delay adjustment. Use probe.

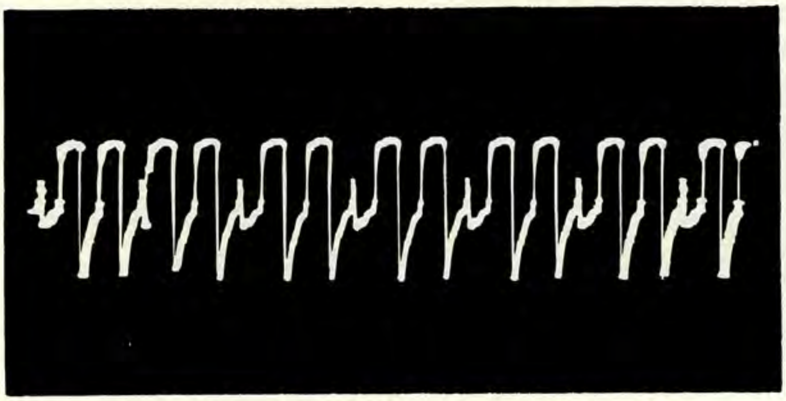


Figure 7–66. Frequency Divider, Counter 1, 2 Stage Output Waveform, Drift

EXTERNAL test point: V206 pin 7

GAIN settings: 54 HI

SWEEP SPEED: 600 #2

Notes: Waveform shown for fast left, odd rate, drift. Refer to paragraph 3*d*(2) for delay adjustment. Use probe.

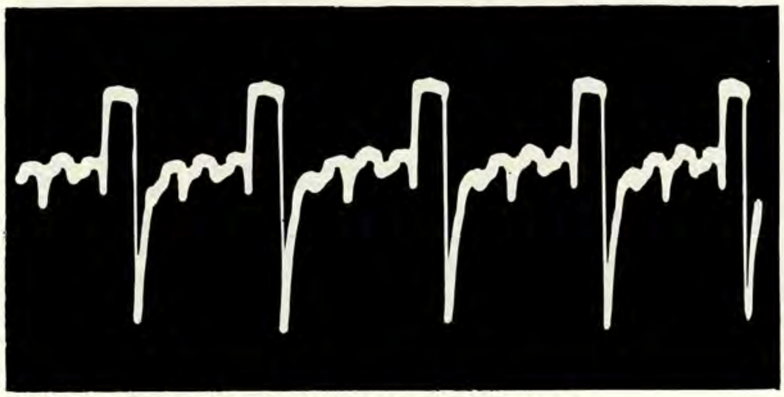


Figure 7–67. Frequency Divider, Counter 1, 8 Stage Output Waveform, Drift

EXTERNAL test point: V204 pin 7

GAIN settings: 54 HI

SWEEP SPEED: 600 #2

Notes: Waveform shown for fast right, even rate, drift. Refer to paragraph 3*d*(2) for delay adjustment. Use probe.

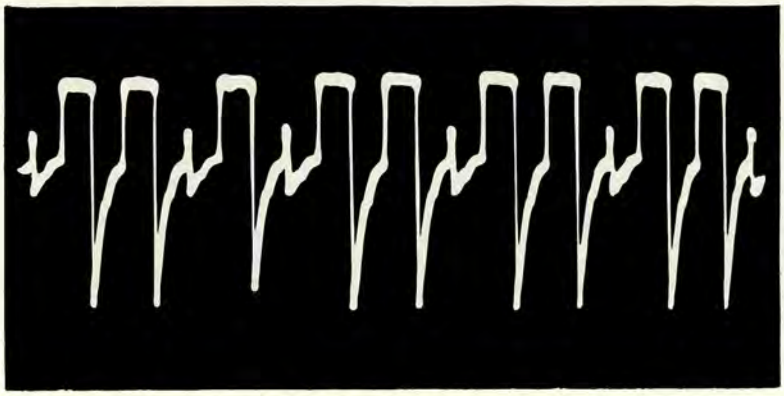
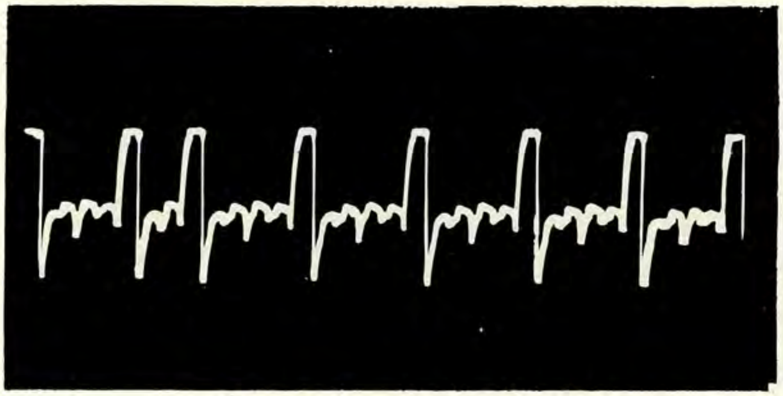


Figure 7–68. Frequency Divider, Counter 1, 2 Stage Output Waveform, Drift



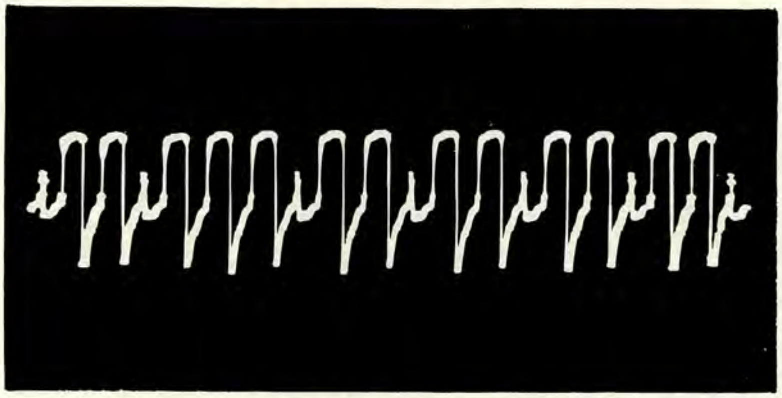
EXTERNAL test point: V206 pin 7

GAIN settings: 54 HI

SWEEP SPEED: 600 #2

Notes: Waveform shown for fast right, even rate, drift. Refer to paragraph 3*d*(2) for delay adjustment. Use probe.

Figure 7–69. Frequency Divider, Counter 1, 8 Stage Output Waveform, Drift



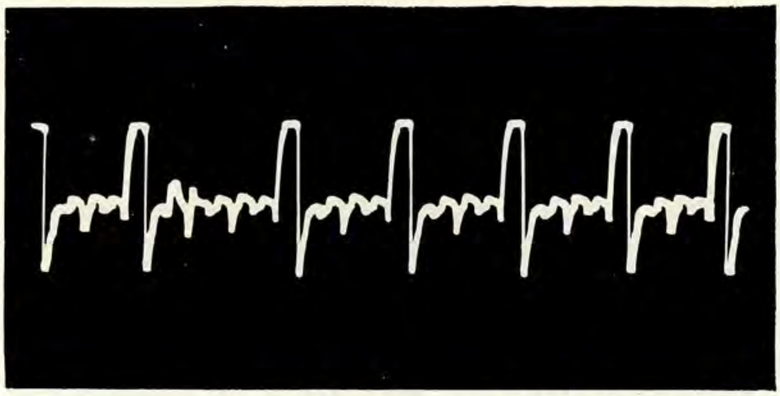
EXTERNAL test point: V204 pin 7

GAIN settings: 54 HI

SWEEP SPEED: 600 #2

Notes: Waveform shown for fast left, even rate, drift. Refer to paragraph 3*d*(2) for delay adjustment. Use probe.

Figure 7–70. Frequency Divider, Counter 1, 2 Stage Output Waveform, Drift



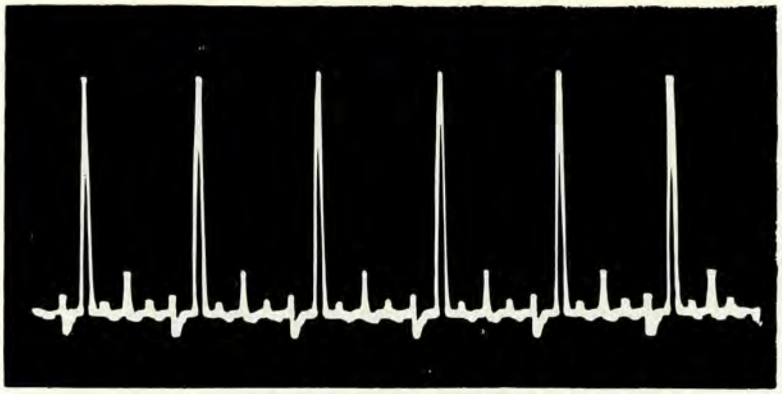
EXTERNAL test point: V206 pin 7

GAIN settings: 54 HI

SWEEP SPEED: 600 #2

Notes: Waveform shown for fast left, even rate, drift. Refer to paragraph 3*d*(2) for delay adjustment. Use probe.

Figure 7–71. Frequency Divider, Counter 1, 8 Stage Output Waveform, Drift



EXTERNAL test point: V207 pin 1

GAIN settings: 45 LO

SWEEP SPEED: 600 #2

Notes:

Figure 7–72. Frequency Divider, 100-μs Blocking Oscillator Driver Plate Waveform

EXTERNAL test point: V207 pin 6
GAIN settings: 50 LO
SWEEP SPEED: 600 #2
Notes:

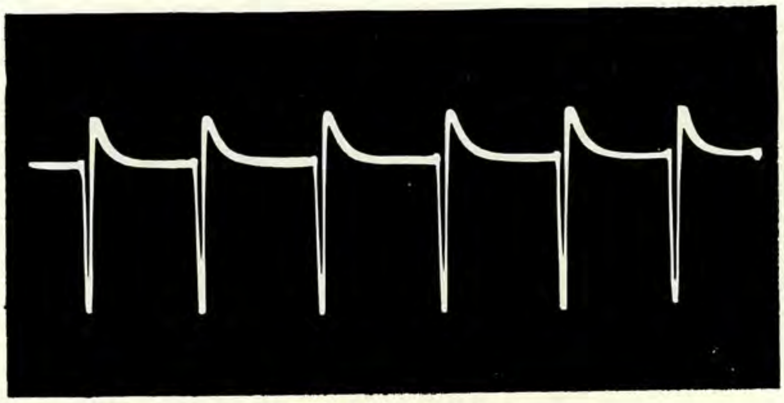


Figure 7–73. Frequency Divider, 100-μs Blocking Oscillator Plate Waveform

EXTERNAL test point: V212 pin 1
GAIN settings: 45 LO
SWEEP SPEED: 5,000 #1
Notes:

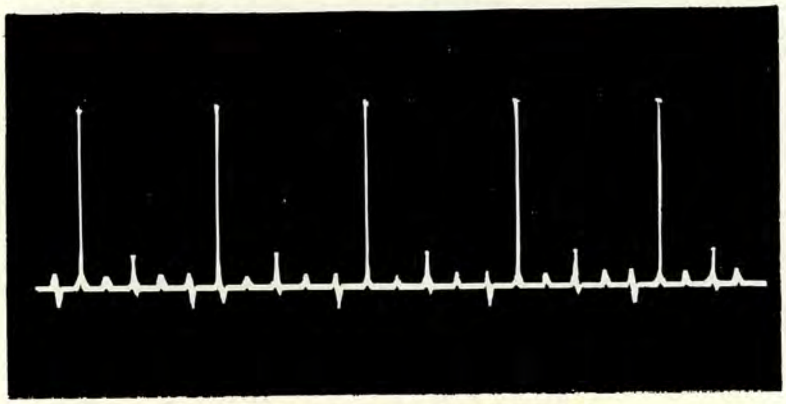


Figure 7–74. Frequency Divider, 1,000-μs Blocking Oscillator Driver Plate Waveform

EXTERNAL test point: V212 pin 6
GAIN settings: 48 LO
SWEEP SPEED: 5,000 #1
Notes:

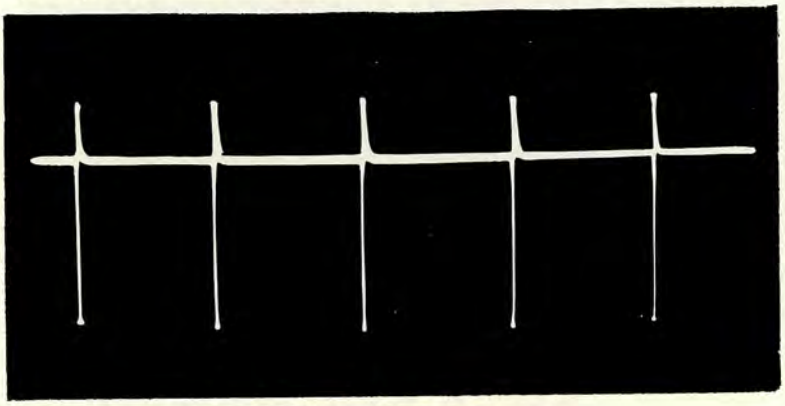


Figure 7–75. Frequency Divider, 1,000-μs Blocking Oscillator Plate Waveform

EXTERNAL test point: V218 pin 1
GAIN settings: 40 LO
SWEEP SPEED: 200 #3
Notes: Refer to paragraph 3*d*(2) for delay adjustment.

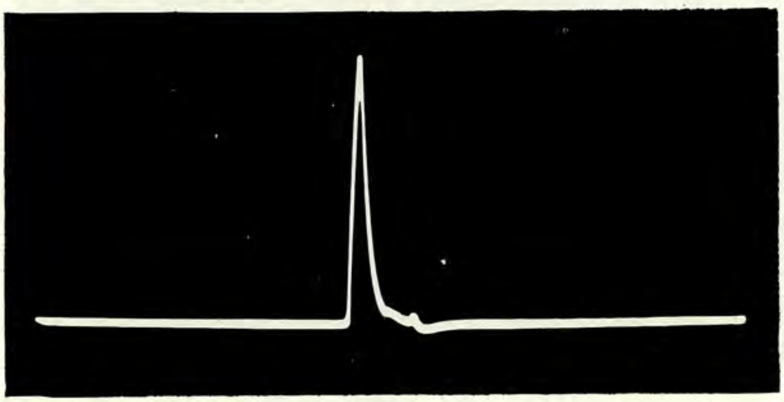
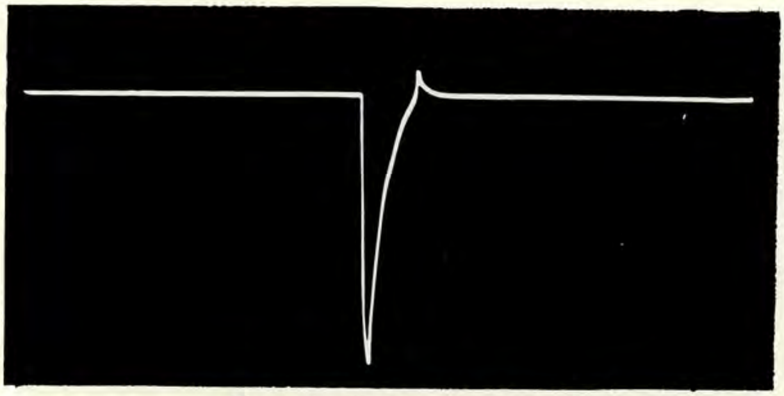


Figure 7–76. Frequency Divider, Preset Input Amplifier Plate Waveform



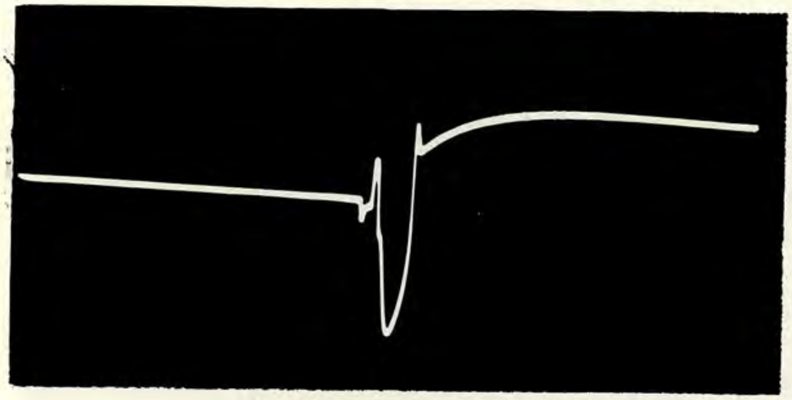
EXTERNAL test point: V218 pin 6

GAIN settings: 42 LO

SWEEP SPEED: 200 #3

Notes: Refer to paragraph 3*d*(2) for delay adjustment.

Figure 7–77. Frequency Divider, Preset Output Amplifier Plate Waveform



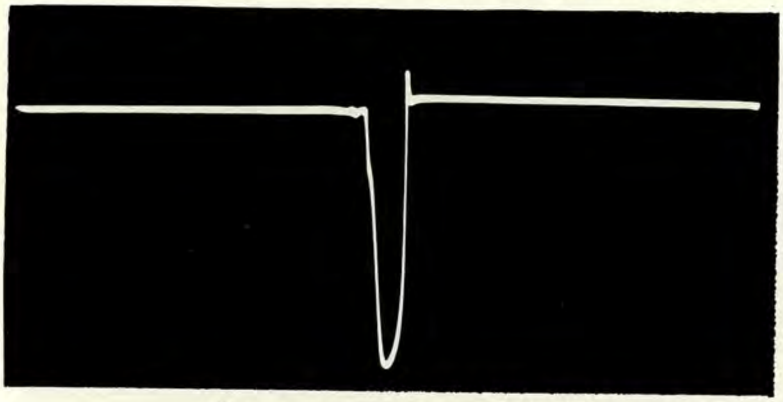
EXTERNAL test point: V219 pin 3

GAIN settings: 40 LO

SWEEP SPEED: 200 #3

Notes: Refer to paragraph 3*d*(2) for delay adjustment.

Figure 7–78. Frequency Divider, Preset Delay Diode Cathode Waveform



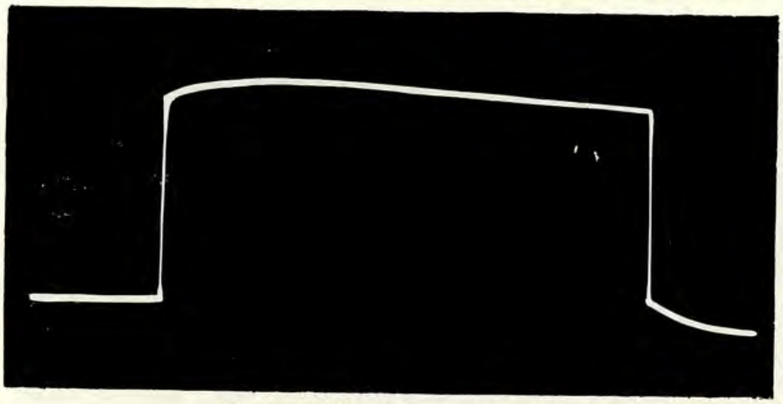
EXTERNAL test point: V219 pin 6

GAIN settings: 40 LO

SWEEP SPEED: 200 #3

Notes: Refer to paragraph 3*d*(2) for delay adjustment.

Figure 7–79. Frequency Divider, Preset Blocking Oscillator Plate Waveform



EXTERNAL test point: V220 pin 1

GAIN settings: 44 LO

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for HIGH rate.

Figure 7–80. Frequency Divider, Square Wave Generator Plate Waveform

EXTERNAL test point: V221 pin 1
GAIN settings: 44 LO
SWEEP SPEED: 25,000 #1
Notes: Waveform shown for HIGH rate.

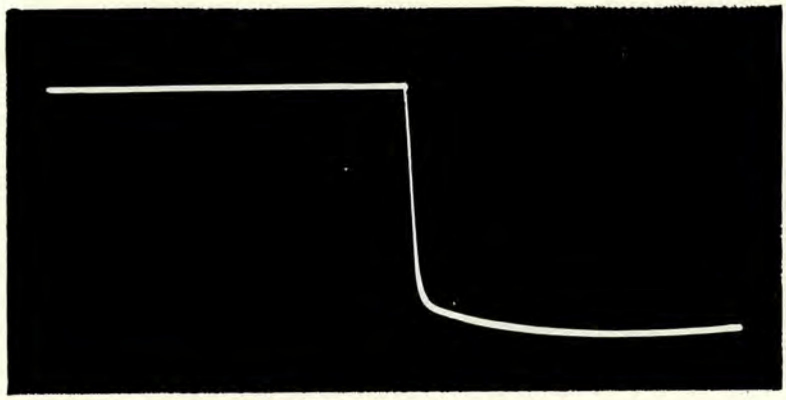


Figure 7–81. Frequency Divider, Square Wave Amplifier Plate Waveform

EXTERNAL test point: V233 pin 2
GAIN settings: 45 LO
SWEEP SPEED: 25,000 #1
Notes:

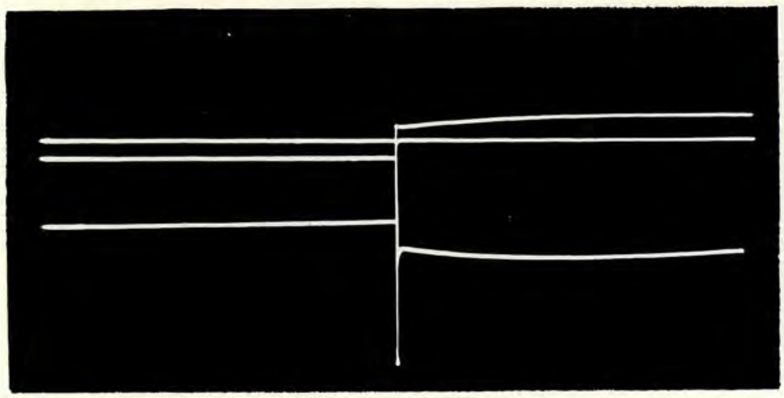


Figure 7–82. Frequency Divider, Left-Right Divider 1 Stage Output Waveform

EXTERNAL test point: V234 pin 2
GAIN settings: 45 LO
SWEEP SPEED: 25,000 #1
Notes:

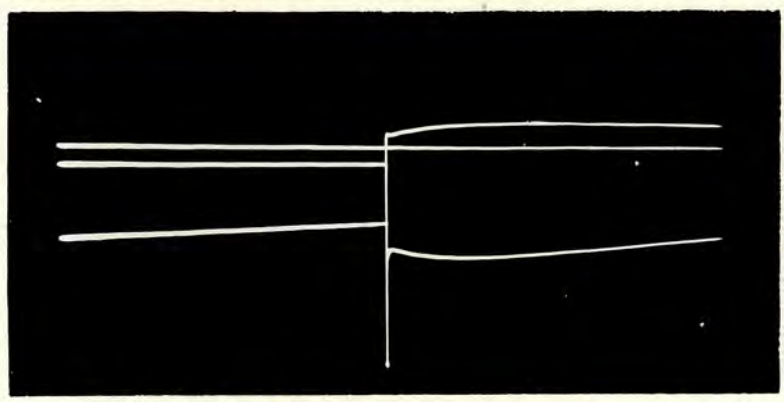


Figure 7–83. Frequency Divider, Left-Right Divider 2 Stage Output Waveform

EXTERNAL test point: V230 pin 8
GAIN settings: 43 LO
SWEEP SPEED: 200 #3
Notes: Refer to paragraph 3*d*(2) for delay adjustment.

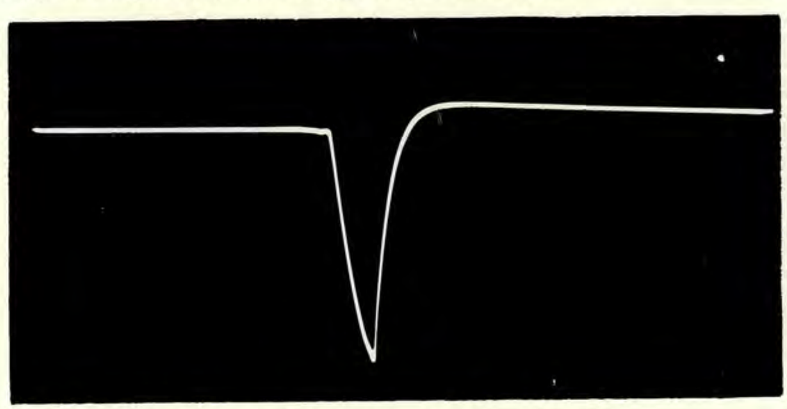
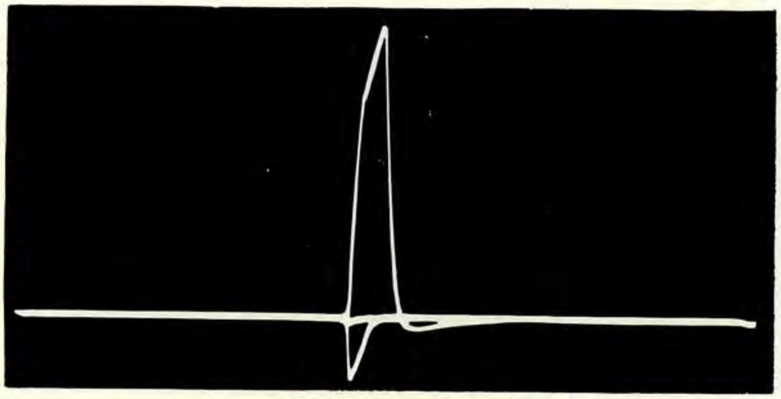


Figure 7–84. Frequency Divider, Fast Left-Right Follower Cathode Waveform



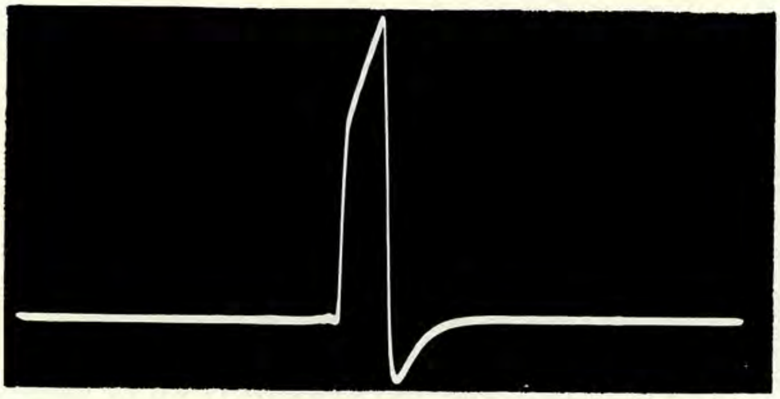
EXTERNAL test point: V228 pin 6

GAIN settings: 48 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for slow drift. Refer to paragraph 3*d*(2) for delay adjustment.

Figure 7–85. Frequency Divider, Left-Right Input Amplifier Plate Waveform



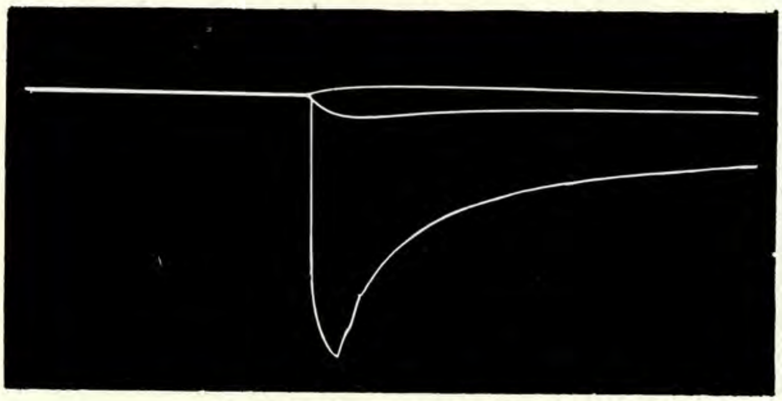
EXTERNAL test point: V228 pin 6

GAIN settings: 48 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for fast drift. Refer to paragraph 3*d*(2) for delay adjustment.

Figure 7–86. Frequency Divider, Left-Right Input Amplifier Plate Waveform



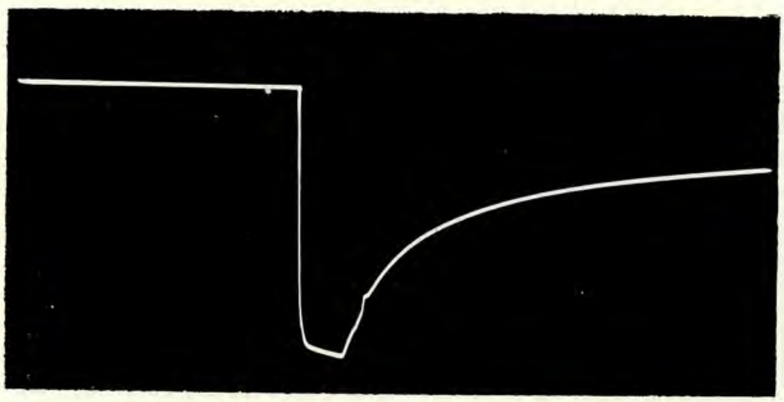
EXTERNAL test point: V228 pin 1

GAIN settings: 40 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for slow drift. Refer to paragraph 3*d*(2) for delay adjustment.

Figure 7–87. Frequency Divider, Left-Right Output Amplifier Plate Waveform



EXTERNAL test point: V228 pin 1

GAIN settings: 40 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for fast drift. Refer to paragraph 3*d*(2) for delay adjustment.

Figure 7–88. Frequency Divider, Left-Right Output Amplifier Plate Waveform

EXTERNAL test point: V229 pin 3

GAIN settings: 60 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for fast left drift. Refer to paragraph 3*d*(2) for delay adjustment.

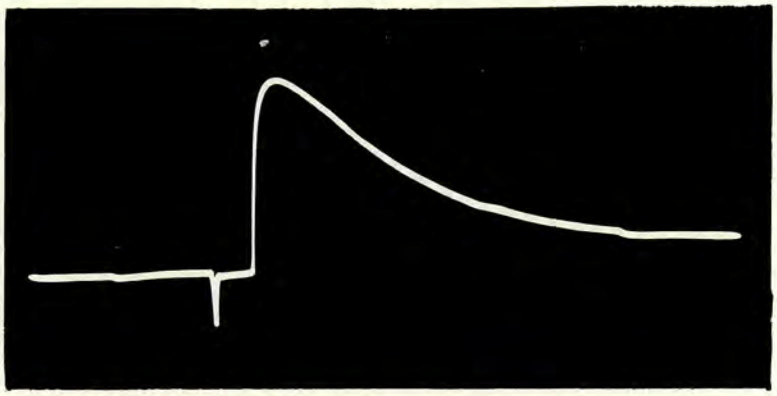


Figure 7–89. Frequency Divider, Left-Right Delay Diode Cathode Waveform

EXTERNAL test point: V229 pin 6

GAIN settings: 37 HI

SWEEP SPEED: 200 #3

Notes: Waveform shown for fast right drift. Refer to paragraph 3*d*(2) for delay adjustment; use probe.

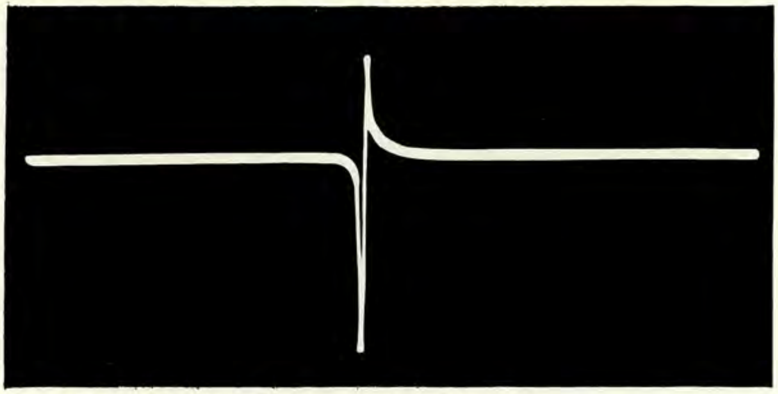


Figure 7–90. Frequency Divider, Right Blocking Oscillator Plate Waveform

EXTERNAL test point: V230 pin 1

GAIN settings: 40 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for fast left drift. Refer to paragraph 3*d*(2) for delay adjustment.

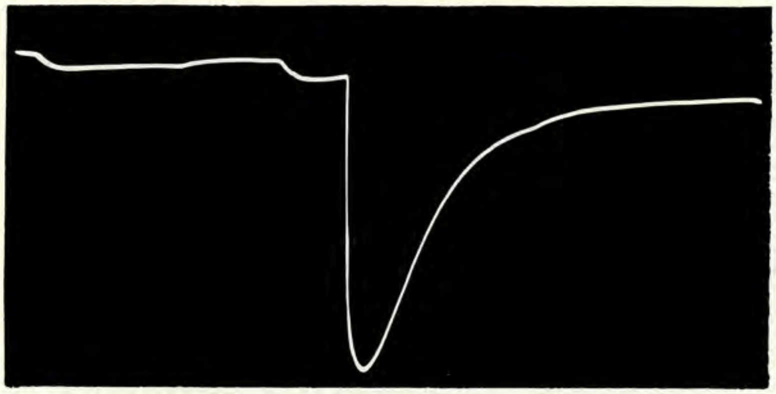


Figure 7–91. Frequency Divider, Left Amplifier Plate Waveform

EXTERNAL test point: V222 pin 1

GAIN settings: 48 HI

SWEEP SPEED: 20 #4

Notes: Use probe. Waveform shows detuning effect caused by probe loading.

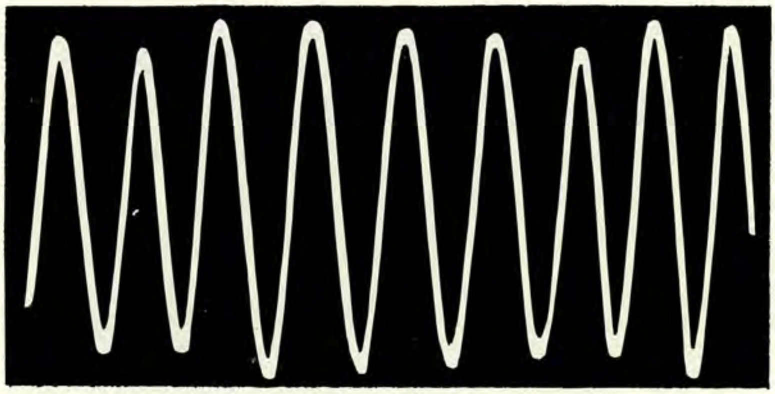
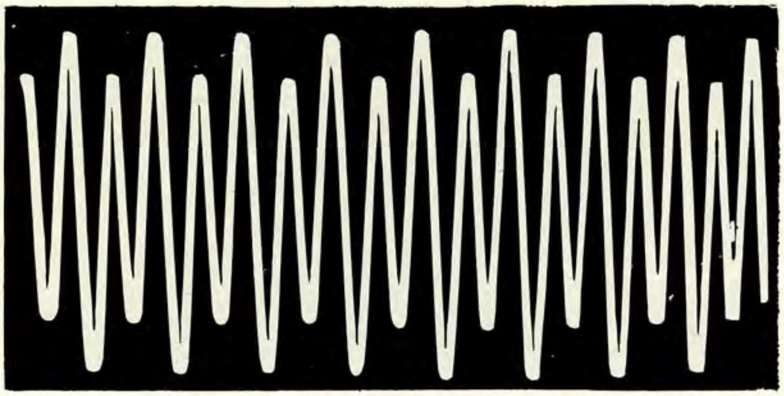


Figure 7–92. Frequency Divider, 500-kc Multiplier Plate Waveform



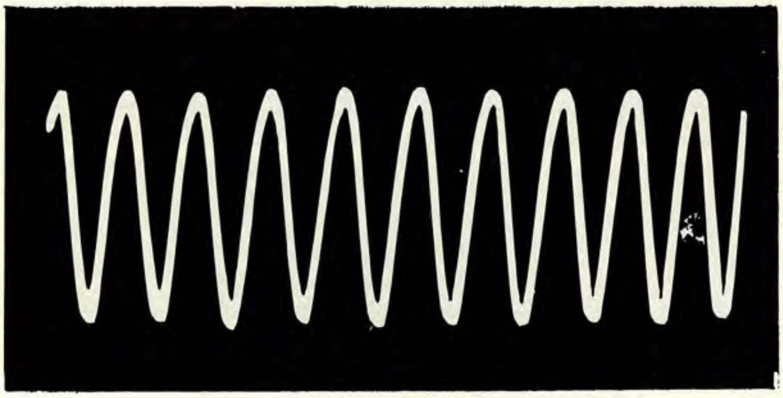
EXTERNAL test point: V222 pin 6

GAIN settings: 55 HI

SWEEP SPEED: 20 #4

Notes: Use probe. Waveform shows detuning effect caused by probe loading.

Figure 7–93. Frequency Divider, 1-mc Multiplier Plate Waveform



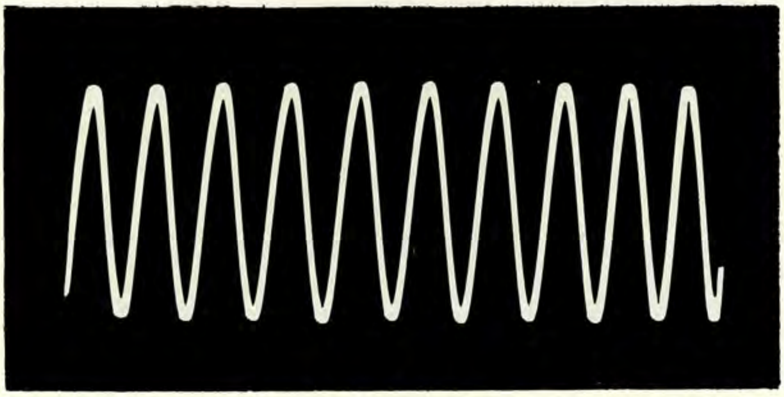
EXTERNAL test point: V223 pin 5

GAIN settings: 100 HI

SWEEP SPEED: 10 #4

Notes: Use probe.

Figure 7–94. Frequency Divider, 1-mc Clipper Plate Waveform



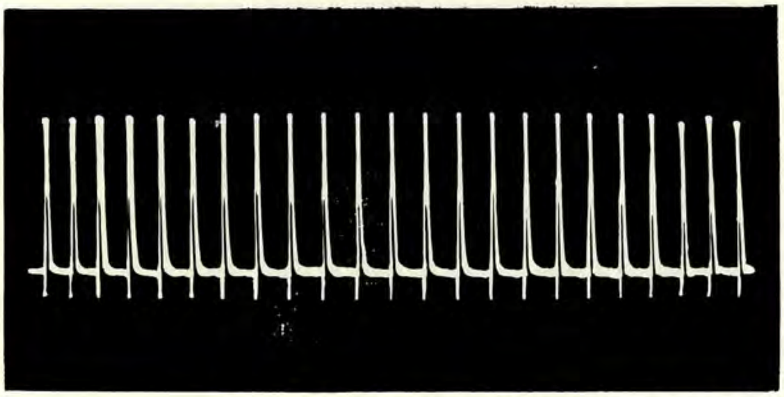
EXTERNAL test point: V235 pin 5

GAIN settings: 65 HI

SWEEP SPEED: 10 #4

Notes:

Figure 7–95. Frequency Divider, 1's Marker Follower Cathode Waveform



EXTERNAL test point: V224 pin 1

GAIN settings: 30 HI

SWEEP SPEED: 24,000 #1

Notes: SLOW SCOPE MARKERS switch S206 On.

Figure 7–96. Frequency Divider, Slow Scope Marker Amplifier Plate Waveform

EXTERNAL test point: V225 pin 6

GAIN settings: 42 LO

SWEEP SPEED: 24,000 #1

Notes: SLOW SCOPE MARKERS switch S206 On.

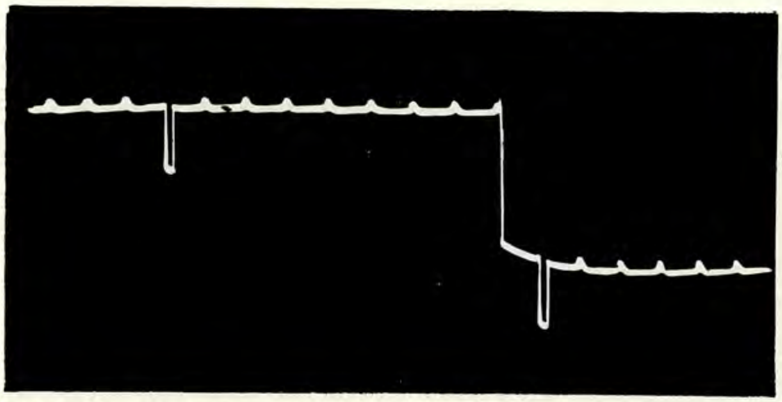


Figure 7–97. Frequency Divider, Slow Trace Separation Plate Waveform

EXTERNAL test point: V225 pin 3

GAIN settings: 75 LO

SWEEP SPEED: 24,000 #1

Notes: SLOW SCOPE MARKERS switch S206 On.

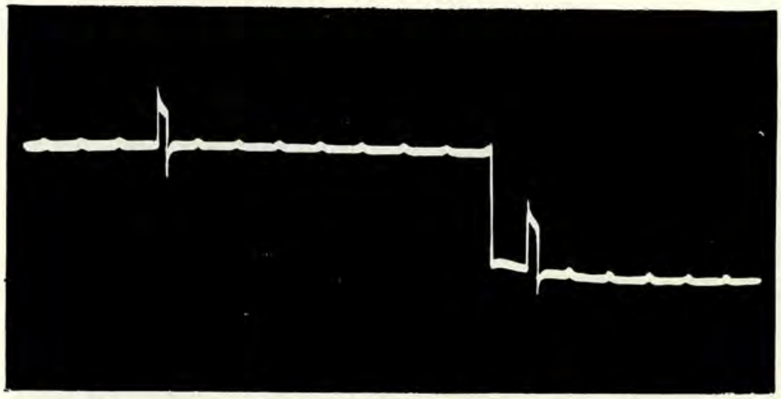


Figure 7–98. Frequency Divider, Slow Trace Separation and Marker Mixer Cathode Waveform

EXTERNAL test point: V224 pin 6

GAIN settings: 40 LO

SWEEP SPEED: 24,000 #1

Notes: Waveform shown for HIGH rate.

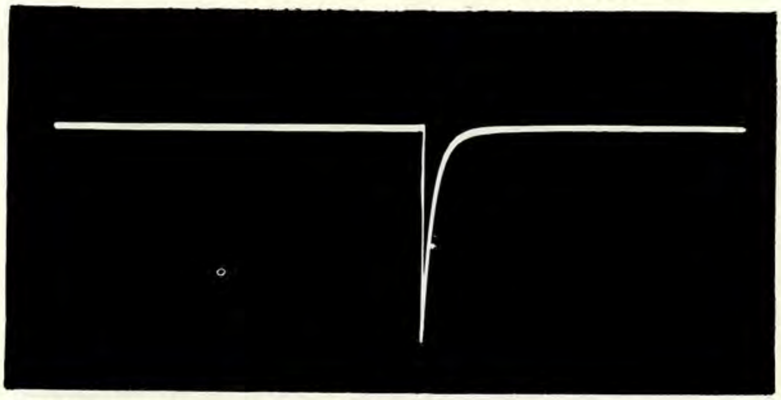


Figure 7–99. Frequency Divider, Isolation Diode Plate Waveform

EXTERNAL test point: V226 pin 5

GAIN settings: 40 LO

SWEEP SPEED: 24,000 #1

Notes: Waveform shown for HIGH rate.

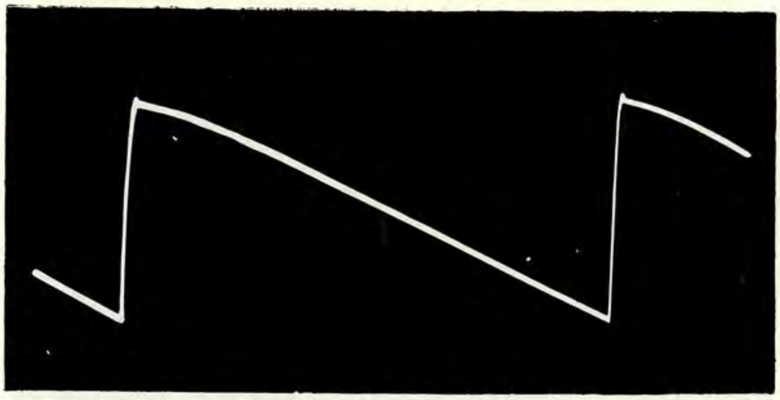
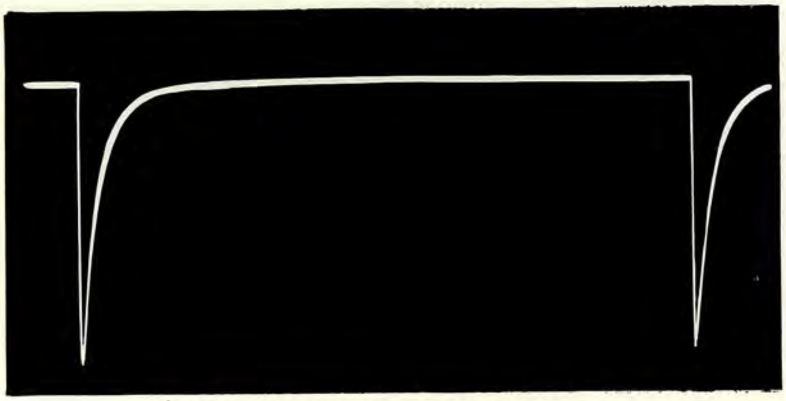
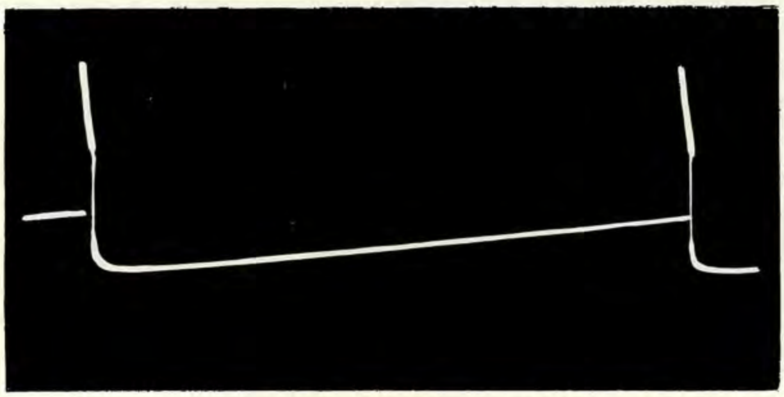


Figure 7–100. Frequency Divider, Slow Sweep Generator Plate Waveform



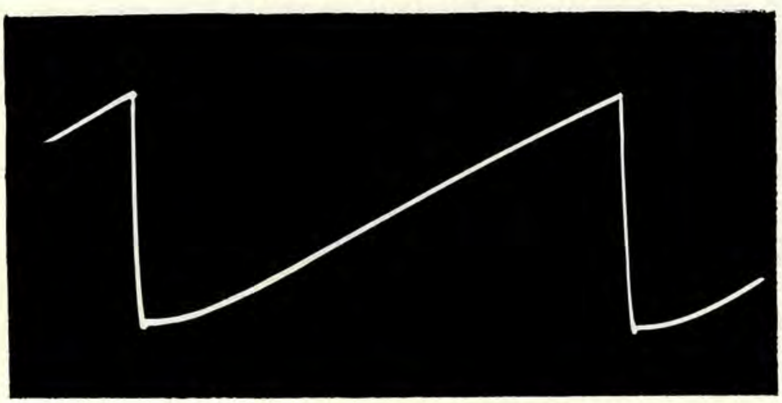
EXTERNAL test point: V226 pin 2
GAIN settings: 40 LO
SWEEP SPEED: 25,000 #1
Notes: Waveform shown for HIGH rate.

Figure 7–101. Frequency Divider, Slow Sweep Generator Suppressor Waveform



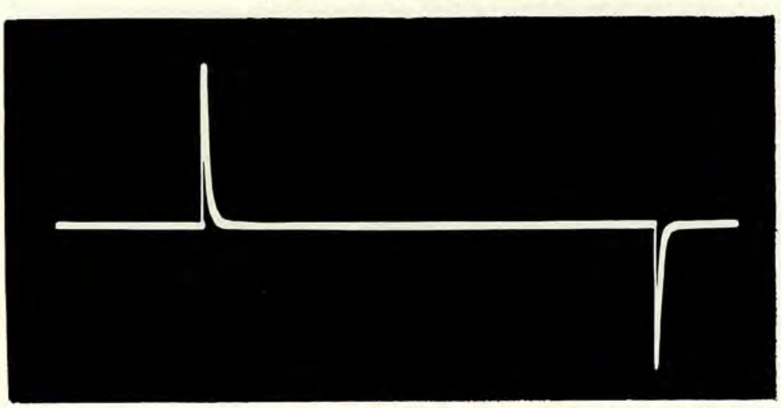
EXTERNAL test point: V226 pin 1
GAIN settings: 75 LO
SWEEP SPEED: 25,000 #1
Notes: Waveform shown for HIGH rate.

Figure 7–102. Frequency Divider, Slow Sweep Generator Grid Waveform



EXTERNAL test point: V227 pin 5
GAIN settings: 40 LO
SWEEP SPEED: 24,000 #1
Notes: Waveform shown for HIGH rate.

Figure 7–103. Frequency Divider, Paraphase Amplifier Plate Waveform



EXTERNAL test point: V501 pin 2
GAIN settings: 55 LO
SWEEP SPEED: 25,000 #1
Notes:

Figure 7–104. Time Delay Unit, A1000 Clipper Grid Waveform

EXTERNAL test point: V502 pin 5
GAIN settings: 60 HI
SWEEP SPEED: 20,000 #1
Notes: A delay = 8,000 μs; use probe.

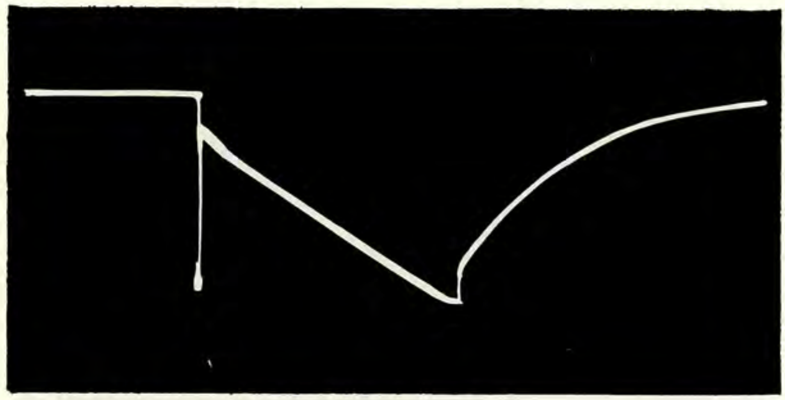


Figure 7–105. Time Delay Unit, A1000 Phantastron Plate Waveform

EXTERNAL test point: V502 pin 1
GAIN settings: 38 HI
SWEEP SPEED: 20,000 #1
Notes: A delay = 8,000 μs.

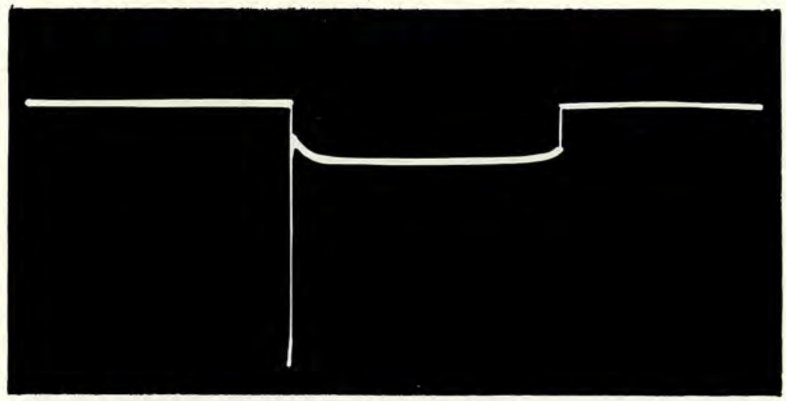


Figure 7–106. Time Delay Unit, A1000 Phantastron Grid Waveform

EXTERNAL test point: V502 pin 6
GAIN settings: 45 LO
SWEEP SPEED: 20,000 #1
Notes: A delay = 8,000 μs.

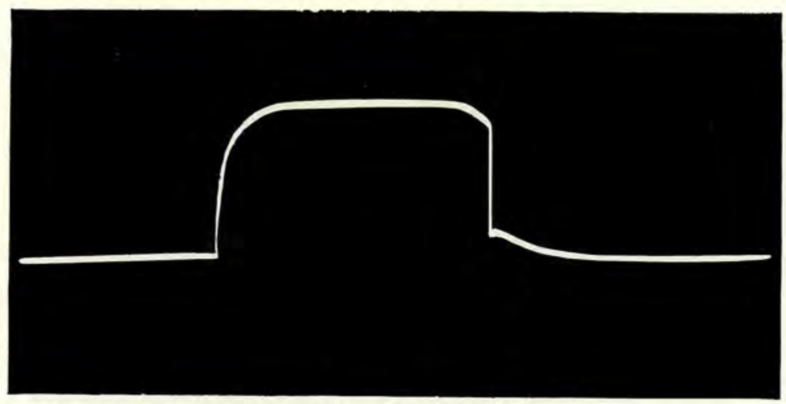


Figure 7–107. Time Delay Unit, A1000 Phantastron Screen Waveform

EXTERNAL test point: V502 pin 7
GAIN settings: 50 LO
SWEEP SPEED: 20,000 #1
Notes: A delay = 8,000 μs.

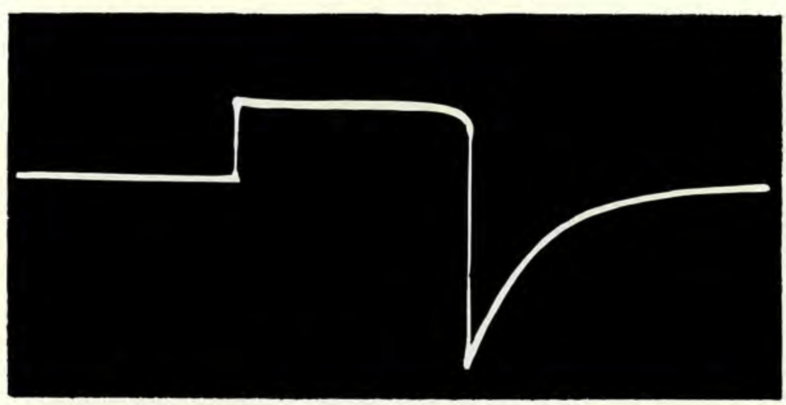
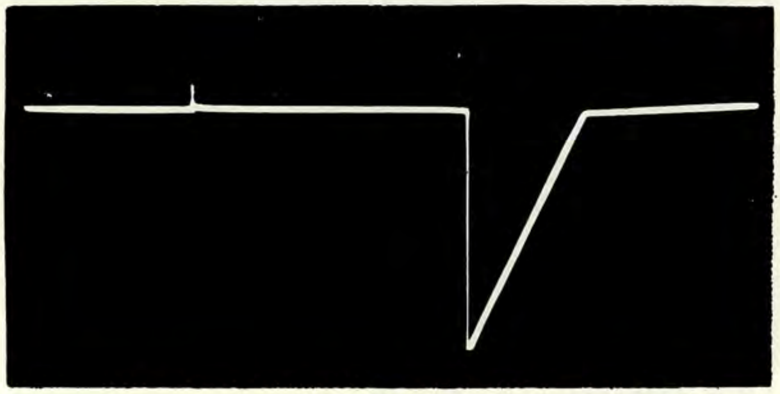
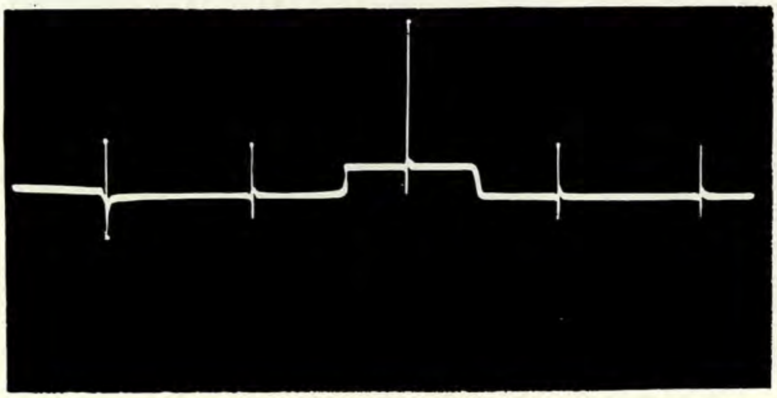


Figure 7–108. Time Delay Unit, A1000 Phantastron Suppressor Waveform



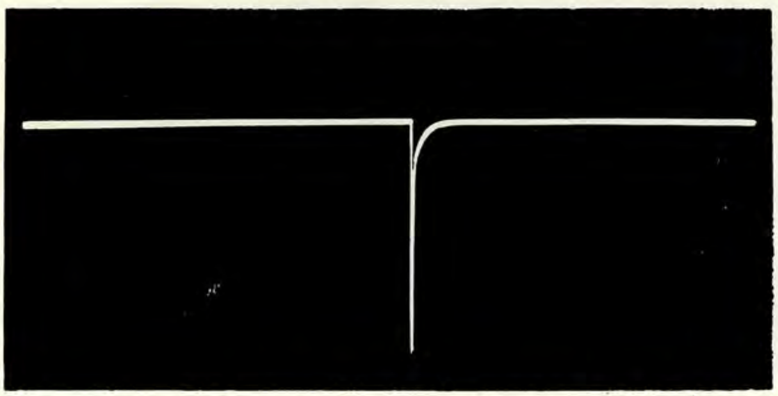
EXTERNAL test point: V503 pin 2
GAIN settings: 50 LO
SWEEP SPEED: 5,000 #1
Notes: A delay = 2,000 μs.

Figure 7–109. Time Delay Unit, A1000 Push-up Gate Grid Waveform



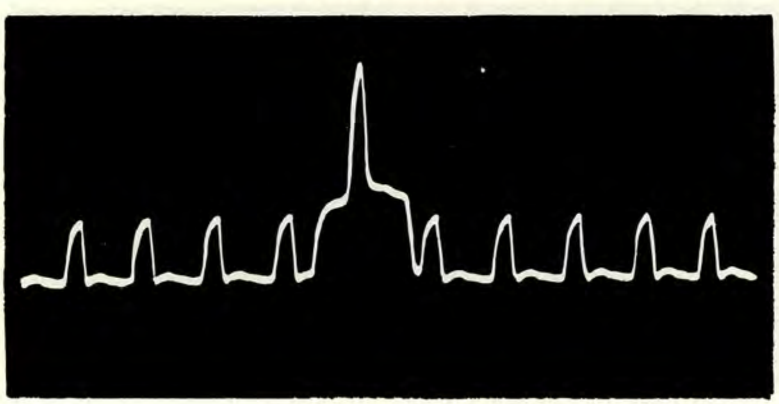
EXTERNAL test point: V503 pin 1
GAIN settings: 44 LO
SWEEP SPEED: 5,000 #1
Notes: A delay = 2,000 μs.

Figure 7–110. Time Delay Unit, A1000 Push-up Plate Waveform



EXTERNAL test point: V505 pin 1
GAIN settings: 40 LO
SWEEP SPEED: 5,000 #1
Notes:

Figure 7–111. Time Delay Unit, A1000 Clipper Plate Waveform



EXTERNAL test point: V504 pin 1
GAIN settings: 42 HI
SWEEP SPEED: 100 #3
Notes:

Figure 7–112. Time Delay Unit, A10 Push-up Plate Waveform

EXTERNAL test point: V501 pin 7
GAIN settings: 48 LO
SWEEP SPEED: 25,000 #1
Notes:

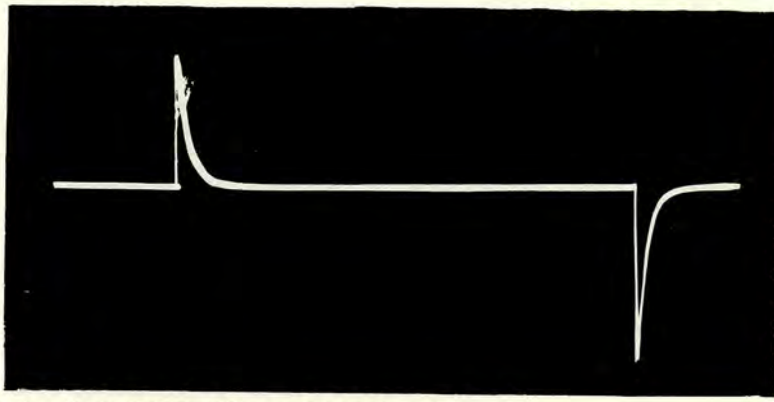


Figure 7–113. Time Delay Unit, B1000 Clipper Grid Waveform

EXTERNAL test point: V508 pin 5
GAIN settings: 60 LO
SWEEP SPEED: 10,000 #1
Notes: B1000 delay = 5,000 μs; use probe.

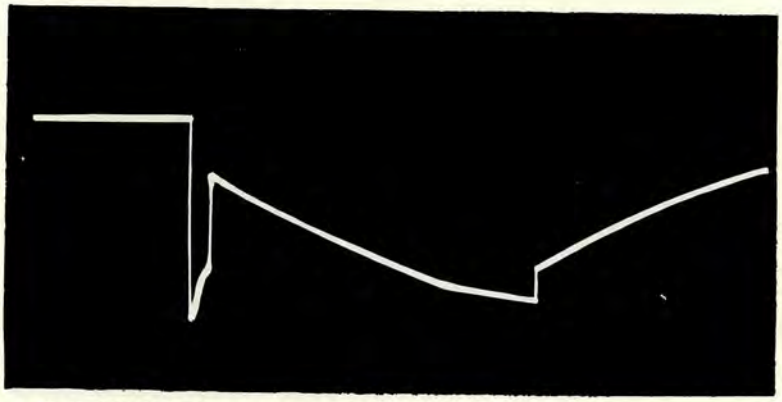


Figure 7–114. Time Delay Unit, B1000 Phantastron Plate Waveform

EXTERNAL test point: V508 pin 7
GAIN settings: 50 HI
SWEEP SPEED: 10,000 #1
Notes: B1000 delay = 5,000 μs; use probe.

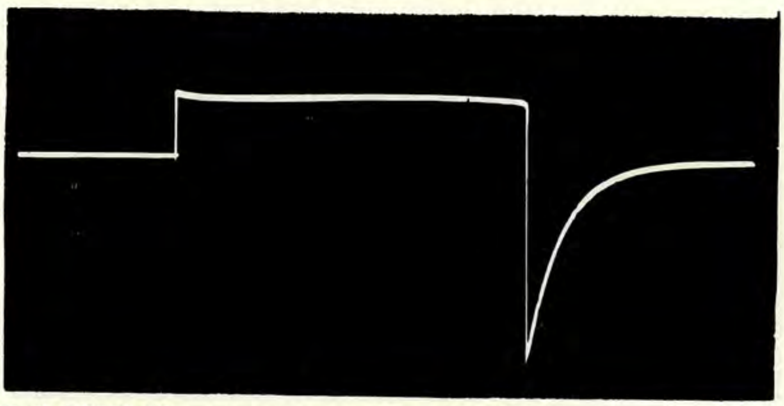


Figure 7–115. Time Delay Unit, B1000 Phantastron Suppressor Waveform

EXTERNAL test point: V509 pin 1
GAIN settings: 45 HI
SWEEP SPEED: 10,000 #1
Notes: B1000 delay = 5,000 μs; use probe.

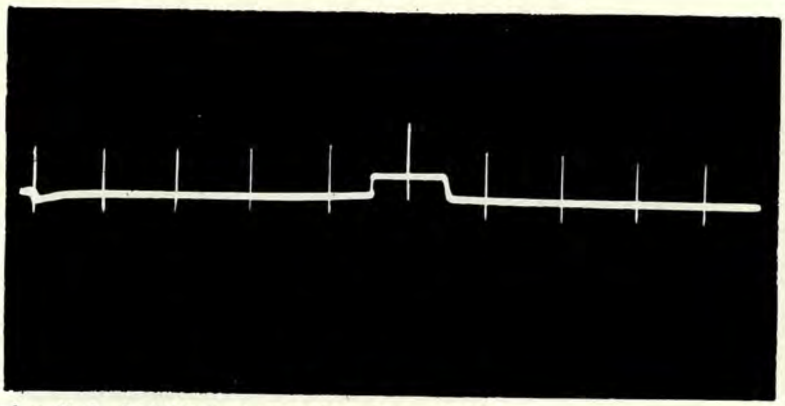
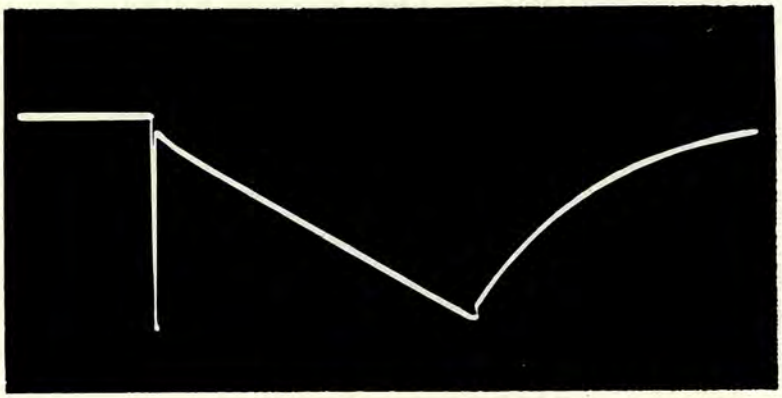
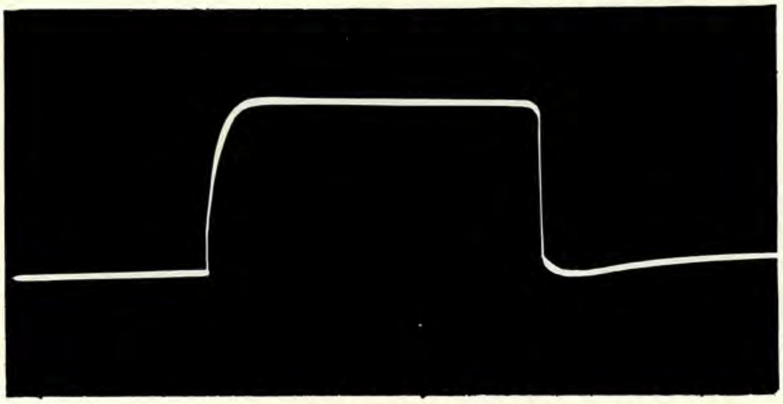


Figure 7–116. Time Delay Unit, B1000 Push-up Plate Waveform



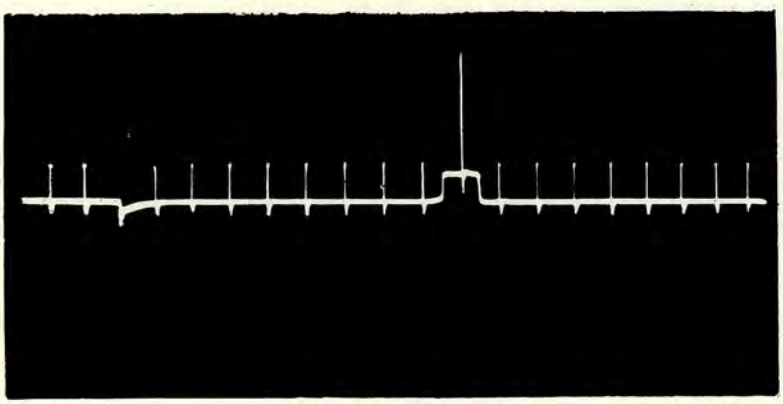
EXTERNAL test point: V511 pin 5
GAIN settings: 55 HI
SWEEP SPEED: 2,000 #2
Notes: B100 delay = 900μs; use probe.

Figure 7–117. Time Delay Unit, B100 Phantastron Plate Waveform



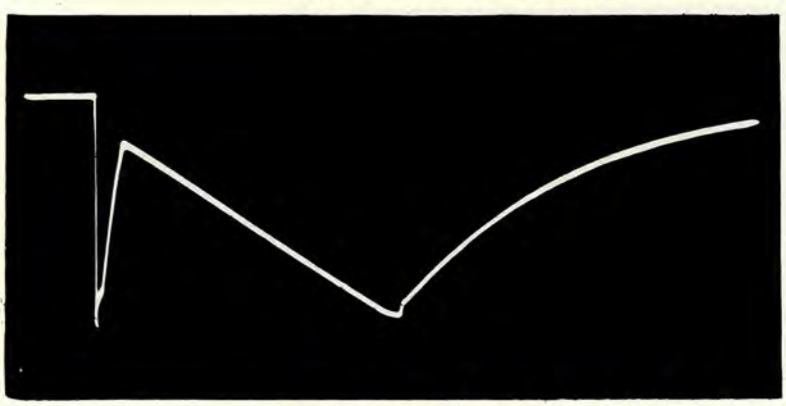
EXTERNAL test point: V511 pin 6
GAIN settings: 50 HI
SWEEP SPEED: 2,000 #2
Notes: B100 delay = 900μs; use probe.

Figure 7–118. Time Delay Unit, B100 Phantastron Screen Waveform



EXTERNAL test point: V512 pin 1
GAIN settings: 42 HI
SWEEP SPEED: 2,000 #2
Notes: B100 delay = 900μs; use probe.

Figure 7–119. Time Delay Unit, B100 Push-up Plate Waveform



EXTERNAL test point: V513 pin 5
GAIN settings: 55 LO
SWEEP SPEED: 200 #3
Notes: B10 delay = 80 μs.

Figure 7–120. Time Delay Unit, B10 Phantastron Plate Waveform

EXTERNAL test point: V513 pin 7
GAIN settings: 35 HI
SWEEP SPEED: 200 #3
Notes: B10 delay = 80 μs.

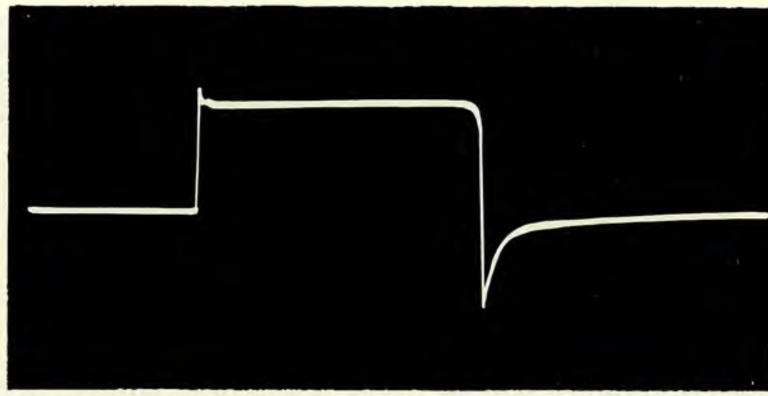


Figure 7–121. Time Delay Unit, B10 Phantastron Suppressor Waveform

EXTERNAL test point: V514 pin 1
GAIN settings: 30 HI
SWEEP SPEED: 200 #3
Notes: B10 delay = 80 μs.

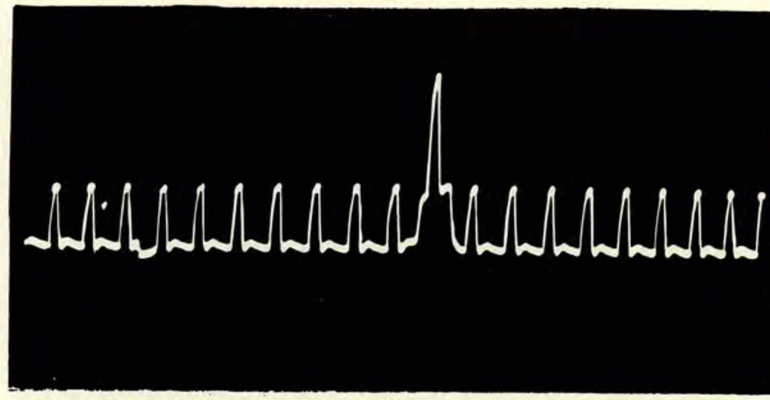


Figure 7–122. Time Delay Unit, B10 Push-up Plate Waveform

EXTERNAL test point: V516 pin 5
GAIN settings: 50 LO
SWEEP SPEED: 100 #3
Notes: B-continuous delay = 15 μs.

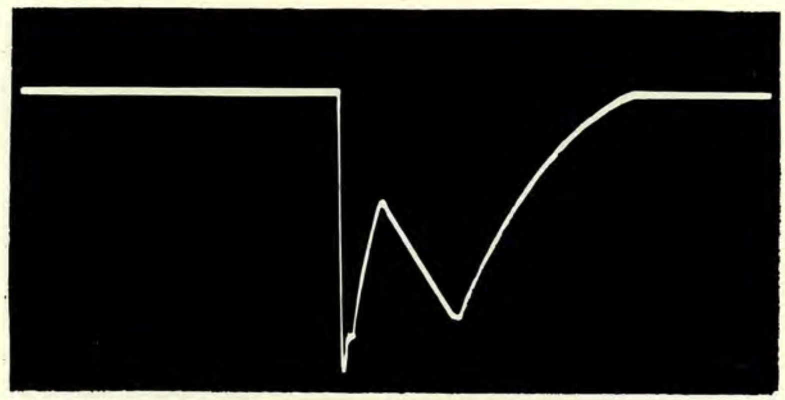


Figure 7–123. Time Delay Unit, B-Continuous Phantastron Plate Waveform

EXTERNAL test point: V519 pin 6
GAIN settings: 45 LO
SWEEP SPEED: 100 #3
Notes: B-continuous delay = 15 μs.

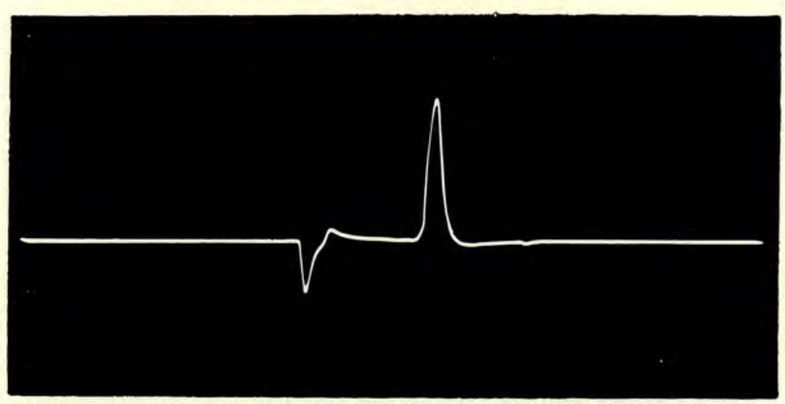
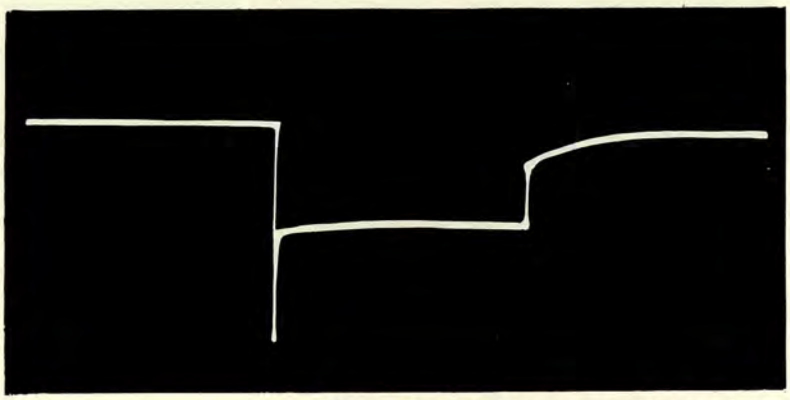


Figure 7–124. Time Delay Unit, B-Continuous Inverter Plate Waveform



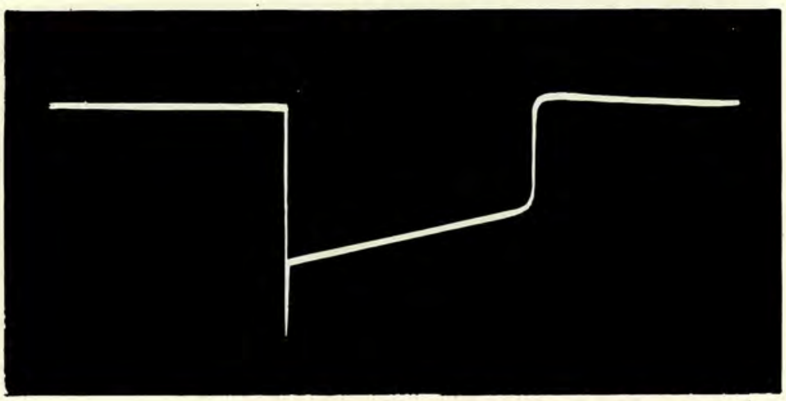
EXTERNAL test point: V507 pin 1

GAIN settings: 35 HI

SWEEP SPEED: 1,500 #2

Notes: Use probe.

Figure 7–125. Time Delay Unit, Pulse Inverter Plate Waveform



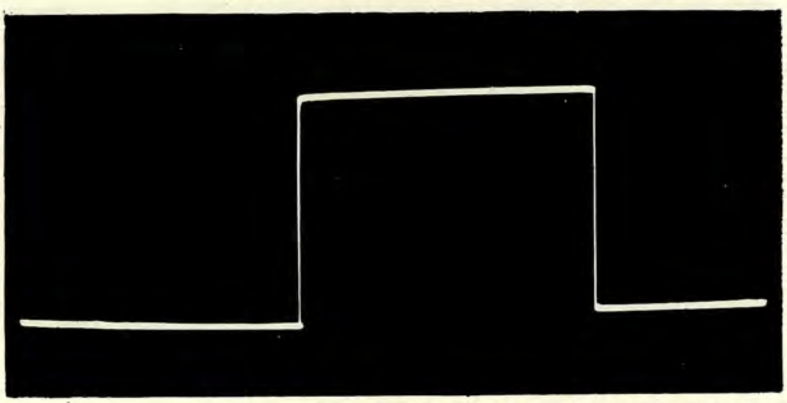
EXTERNAL test point: V506 pin 7

GAIN settings: 35 HI

SWEEP SPEED: 1,500 #2

Notes:

Figure 7–126. Time Delay Unit, Blanking Pulse Generator Output Grid Waveform



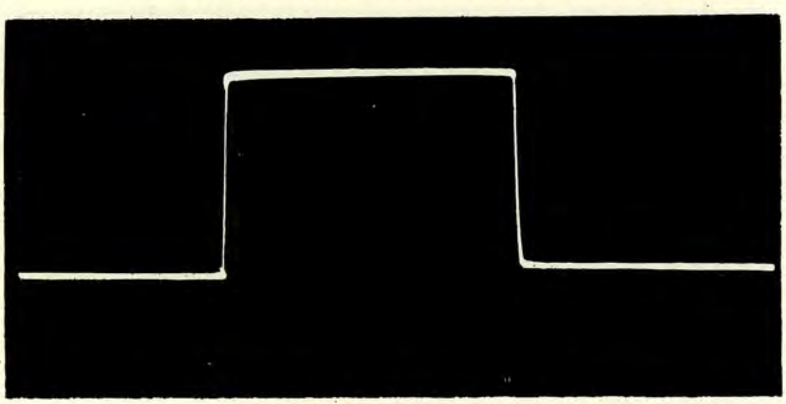
EXTERNAL test point: V506 pin 6

GAIN settings: 25 HI

SWEEP SPEED: 1,500 #2

Notes:

Figure 7–127. Time Delay Unit, Blanking Pulse Generator Output Plate Waveform



EXTERNAL test point: V507 pin 8

GAIN settings: 25 HI

SWEEP SPEED: 1,500 #2

Notes: Timer must be connected to switchgear to provide load and d-c return for cathode.

Figure 7–128. Time Delay Unit, Blanking Output Follower Cathode Waveform

EXTERNAL test point: V527 pin 6
GAIN settings: 60 LO
SWEEP SPEED: 100 #3
Notes:

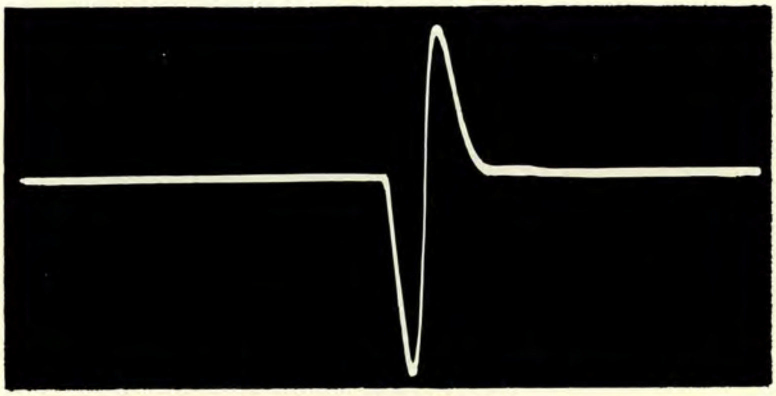


Figure 7–129. Time Delay Unit, Scope Trigger Generator Plate Waveform

EXTERNAL test point: V518 pin 1
GAIN settings: 50 LO
SWEEP SPEED: 100 #3
Notes:

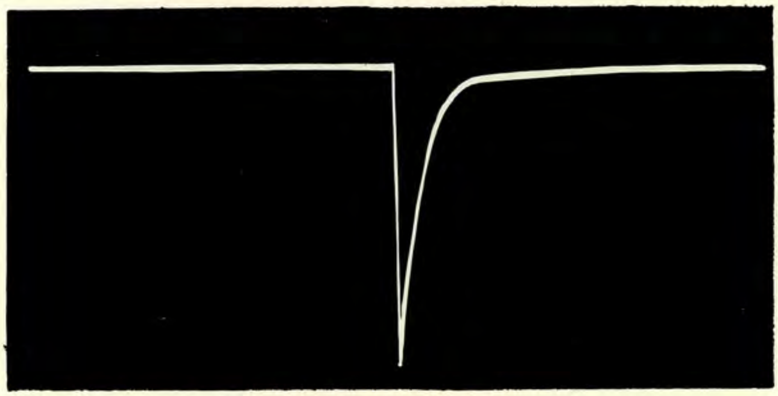


Figure 7–130. Time Delay Unit, Trigger Clipper Plate Waveform

EXTERNAL test point: V518 pin 6
GAIN settings: 45 LO
SWEEP SPEED: 100 #3
Notes:

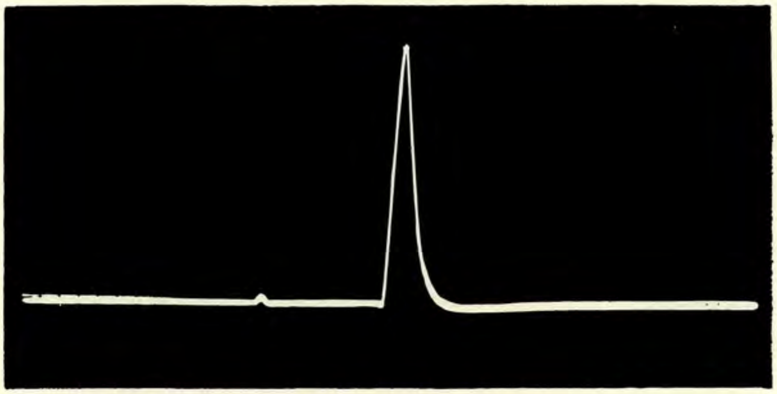


Figure 7–131. Time Delay Unit, Trigger Limiter Plate Waveform

EXTERNAL test point: V520 pin 6
GAIN settings: 40 LO
SWEEP SPEED: 25,000 #1
Notes:

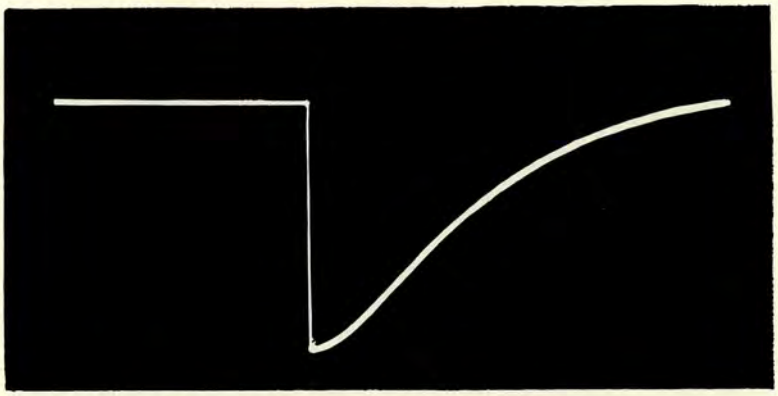
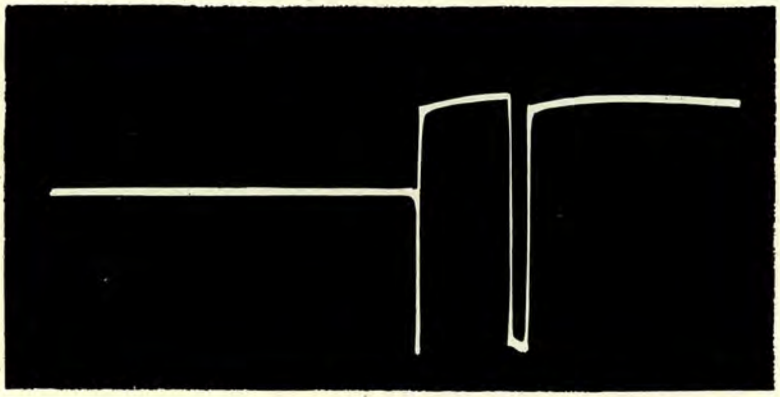


Figure 7–132. Time Delay Unit, Transmitter Trigger Generator Plate Waveform



EXTERNAL test point: V1201 pin 1

GAIN settings: 42 LO

SWEEP SPEED: 25,000 #1

Notes: Waveform shown with AMPLITUDE BALANCE switch S1203 IN.

Figure 7–133. Receiver, Electronic Switch Grid Waveform

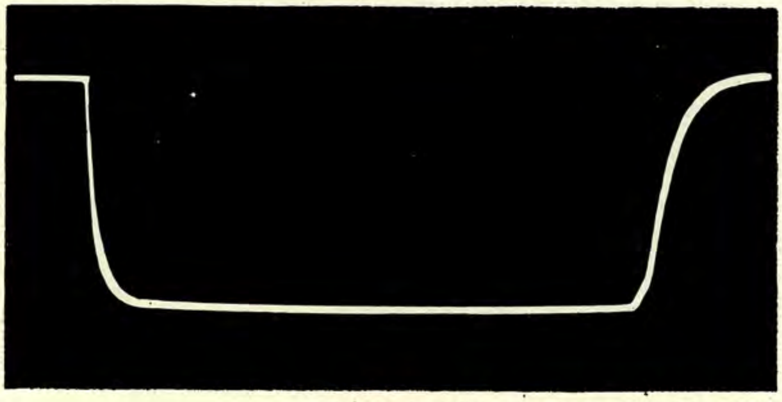
EXTERNAL test point: V1201 pin 1

GAIN settings: 44 LO

SWEEP SPEED: 750 #2

Notes: Waveform shown with AMPLITUDE BALANCE switch S1203 OUT.

Figure 7–134. Receiver, Electronic Switch Grid Waveform



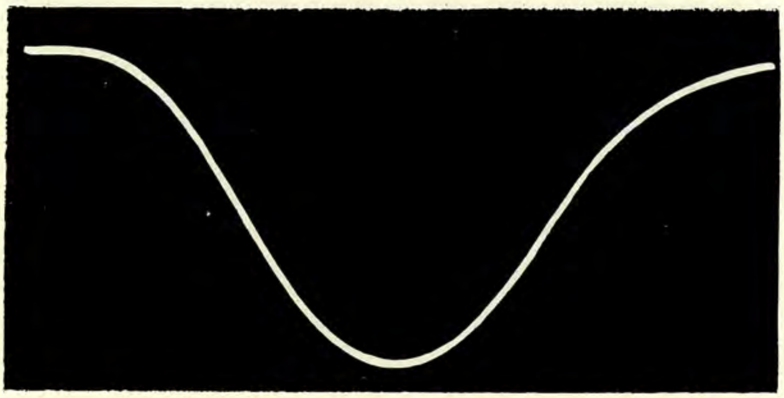
EXTERNAL test point: V1210 pin 1

GAIN settings: 40 LO

SWEEP SPEED: 750 #2

Notes: Waveform shown with AMPLITUDE BALANCE switch S1203 OUT.

Figure 7–135. Receiver, Blanking Driver Plate Waveform



EXTERNAL test point: V1209 pin 2

GAIN settings: 60 LO

SWEEP SPEED: 100 #3

Notes: Waveform shown for normal adjustment of receiver gain controls.

Figure 7–136. Receiver, Video Detector Plate Waveform

EXTERNAL test point: V1216 pin 8

GAIN settings: 58 LO

SWEEP SPEED: 100 #3

Notes: Waveform shown for normal adjustment of receiver gain controls.

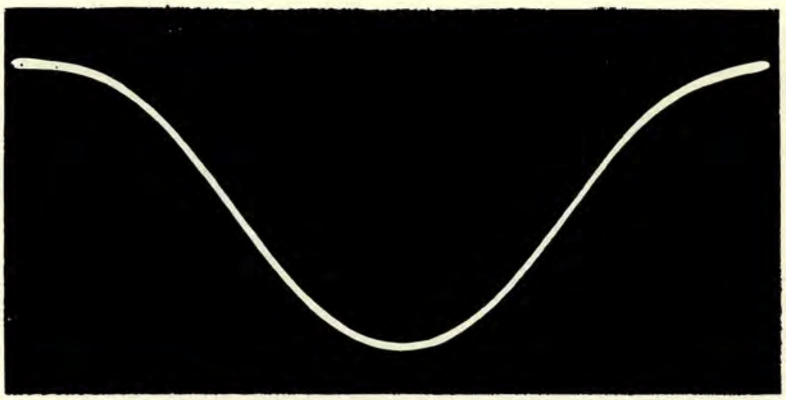


Figure 7–137. Receiver, Video Follower Cathode Waveform

EXTERNAL test point: V1216 pin 3

GAIN settings: 64 HI

SWEEP SPEED: 100 #3

Notes: Waveform shown for normal adjustment of receiver gain controls.

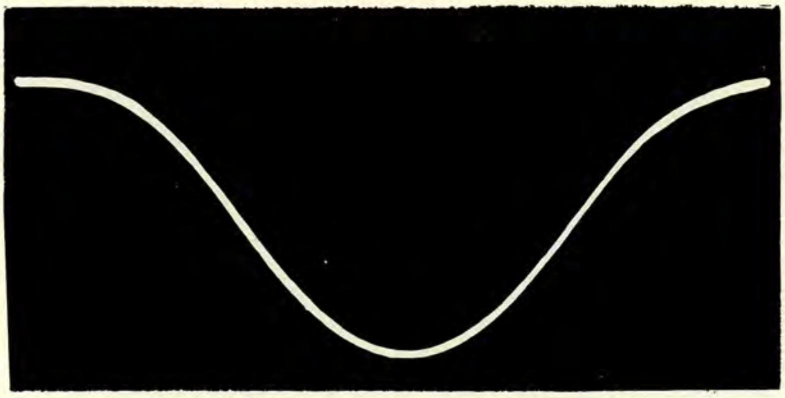


Figure 7–138. Receiver, 1st Differentiator Driver Follower Cathode Waveform

EXTERNAL test point: V1212 pin 1

GAIN settings: 80 HI

SWEEP SPEED: 200 #3

Notes: Waveform shown for normal adjustment of receiver gain controls.

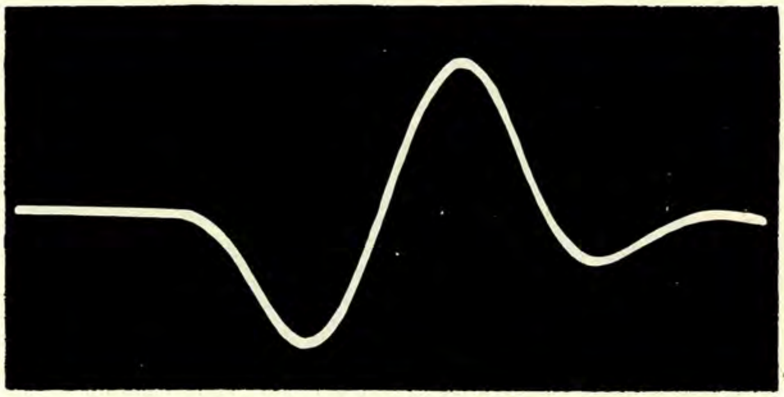


Figure 7–139. Receiver, 1st Differentiator Grid Waveform

EXTERNAL test point: V1212 pin 5

GAIN settings: 45 HI

SWEEP SPEED: 200 #3

Notes: Waveform shown for normal adjustment of receiver gain controls.

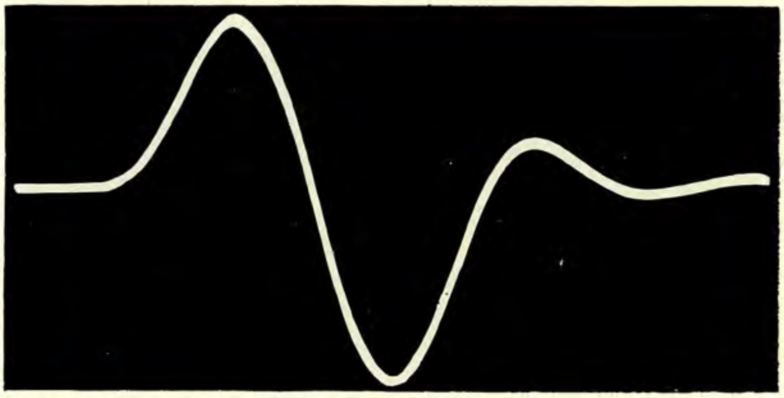
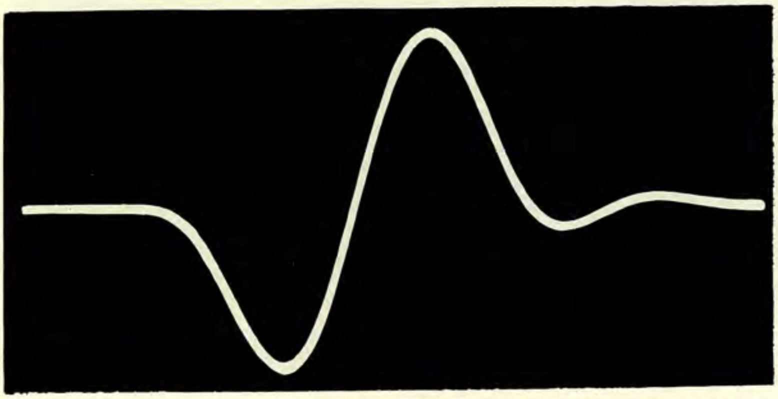


Figure 7–140. Receiver, 1st Differentiator Plate Waveform



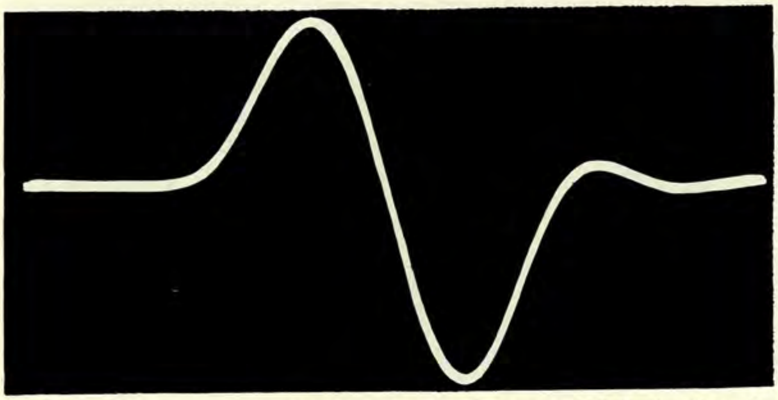
EXTERNAL test point: V1211 pin 6

GAIN settings: 48 HI

SWEEP SPEED: 200 #3

Notes: Waveform shown for normal adjustment of receiver gain controls.

Figure 7–141. Receiver, 1st Inverter Plate Waveform



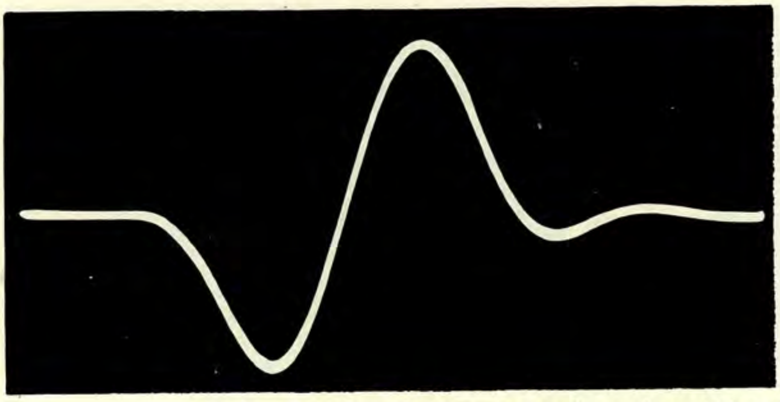
EXTERNAL test point: V1213 pin 1

GAIN settings: 38 HI

SWEEP SPEED: 200 #3

Notes: Waveform shown for normal adjustment of receiver gain controls.

Figure 7–142. Receiver, 1st Derivative Amplifier Plate Waveform



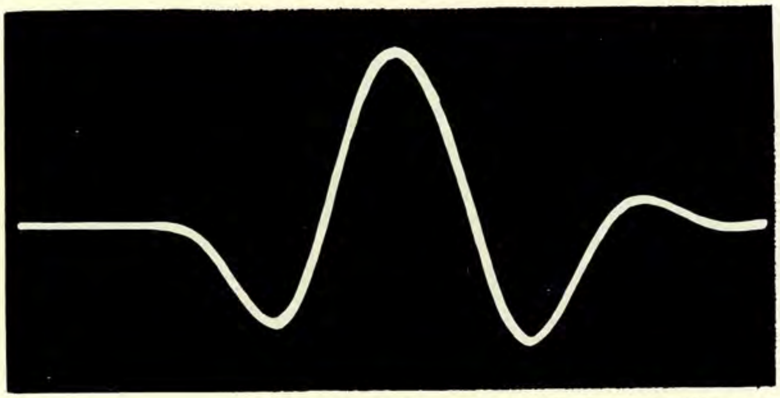
EXTERNAL test point: V1214 pin 3

GAIN settings: 50 HI

SWEEP SPEED: 200 #3

Notes: Waveform shown for normal adjustment of receiver gain controls.

Figure 7–143. Receiver, 2nd Differentiator Driver Follower Cathode Waveform



EXTERNAL test point: V1215 pin 1

GAIN settings: 85 HI

SWEEP SPEED: 200 #3

Notes: Waveform shown for normal adjustment of receiver gain controls.

Figure 7–144. Receiver, 2nd Differentiator Grid Waveform

EXTERNAL test point: V1215 pin 5

GAIN settings: 45 HI

SWEEP SPEED: 200 #3

Notes: Waveform shown for normal adjustment of receiver gain controls.

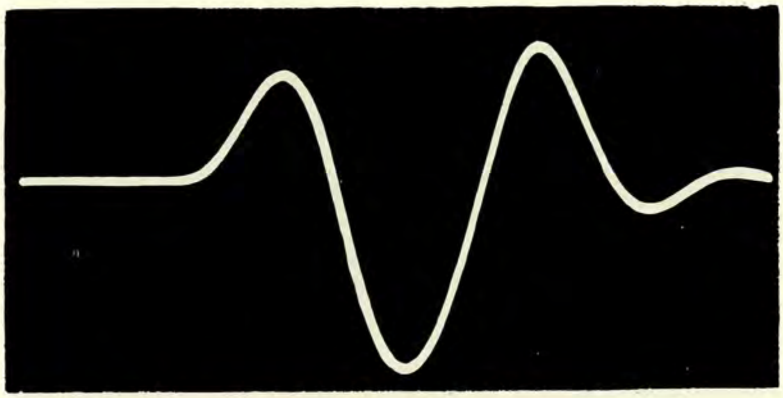


Figure 7–145. Receiver, 2nd Differentiator Plate Waveform

EXTERNAL test point: V1214 pin 8

GAIN settings: 48 HI

SWEEP SPEED: 200 #3

Notes: Waveform shown for normal adjustment of receiver gain controls.

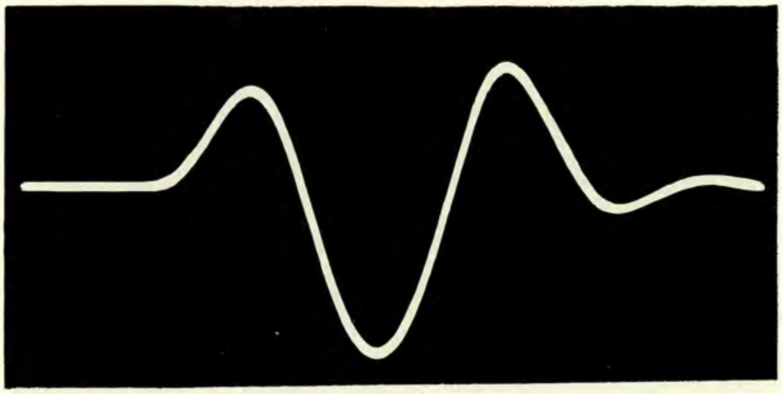


Figure 7–146. Receiver, 2nd Derivative Follower Cathode Waveform

EXTERNAL test point: V802 pin 5

GAIN settings: 48 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for 120-μs sweep delay.

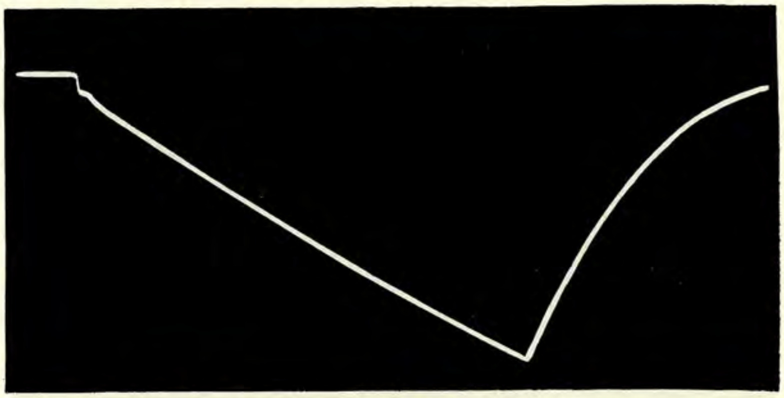


Figure 7–147. Synchronization Indicator, Video Delay Phantastron Plate Waveform

EXTERNAL test point: V802 pin 7

GAIN settings: 62 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for 120-μs sweep delay.

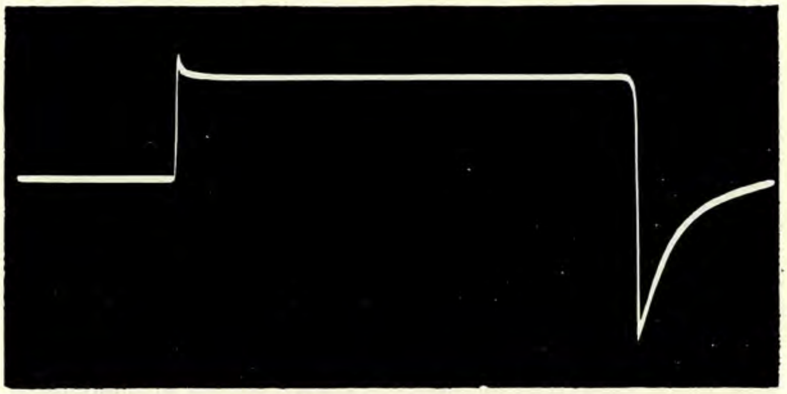
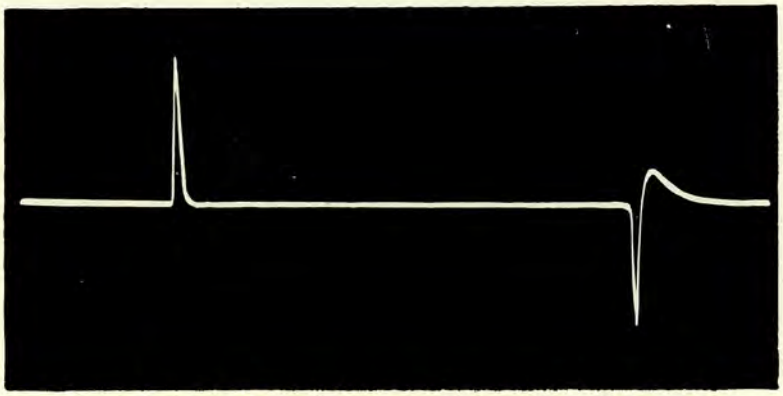


Figure 7–148. Synchronization Indicator, Video Delay Phantastron Suppressor Waveform



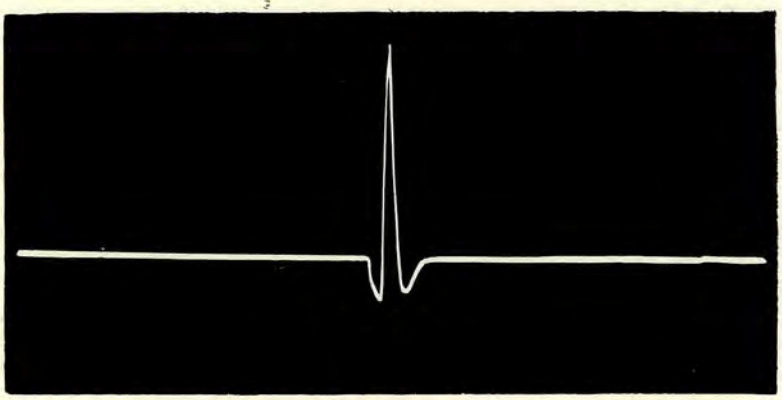
EXTERNAL test point: V803 pin 8

GAIN settings: 90 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for 120-μs sweep delay.

Figure 7–149. Synchronization Indicator, Video Sweep Input Follower Cathode Waveform



EXTERNAL test point: V803 pin 8

GAIN settings: 58 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for undelayed trigger.

Figure 7–150. Synchronization Indicator, Video Sweep Input Follower Cathode Waveform

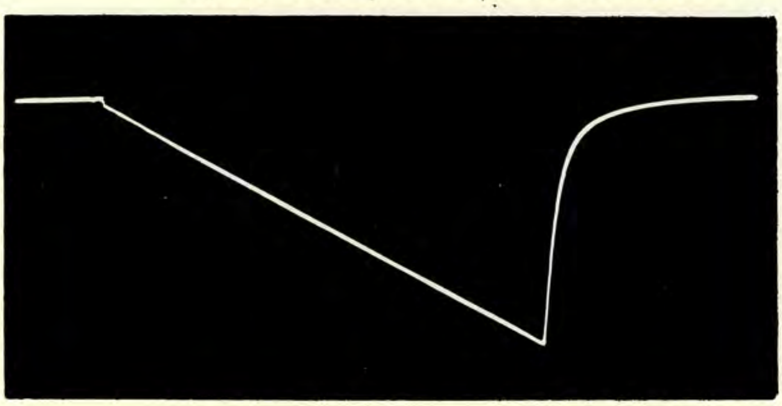
EXTERNAL test point: V804 pin 1

GAIN settings: 45 HI

SWEEP SPEED: 1,000 #2

Notes: Waveform shown for 700-μs sweep speed.

Figure 7–151. Synchronization Indicator, Video Sweep Generator Grid Waveform



EXTERNAL test point: V804 pin 5

GAIN settings: 38 LO

SWEEP SPEED: 1,000 #2

Notes: Waveform shown for 700-μs sweep speed.

Figure 7–152. Synchronization Indicator, Video Sweep Generator Plate Waveform

EXTERNAL test point: V804 pin 2

GAIN settings: 42 LO

SWEEP SPEED: 1,000 #2

Notes: Waveform shown for 700-μs sweep speed.

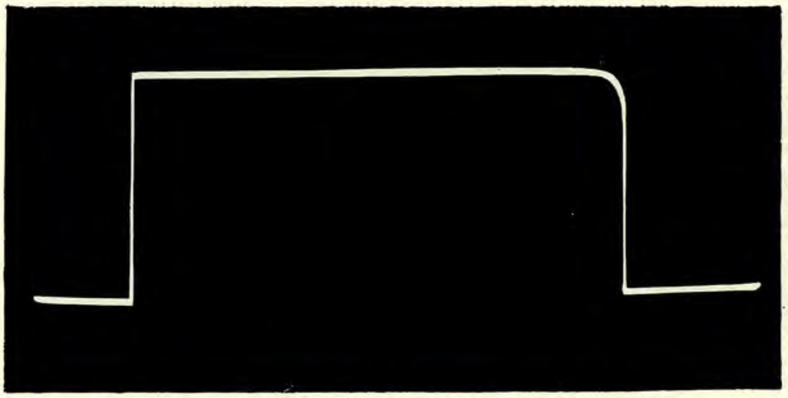


Figure 7–153. Synchronization Indicator, Video Sweep Generator Suppressor Waveform

EXTERNAL test point: V806 pin 5

GAIN settings: 40 HI

SWEEP SPEED: 1,000 #2

Notes: Use probe. Waveform shown for 700-μs sweep speed.

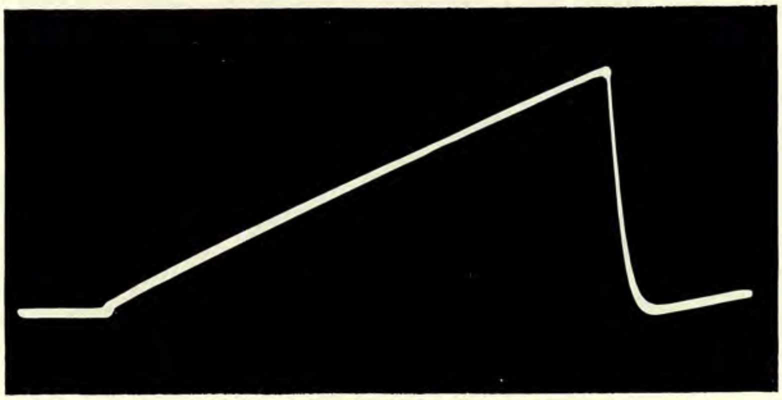


Figure 7–154. Synchronization Indicator, Video Sweep Paraphase Amplifier Plate Waveform

EXTERNAL test point: V807 pin 8

GAIN settings: 52 LO

SWEEP SPEED: 1,000 #2

Notes: Waveform shown for 700-μs. sweep speed.

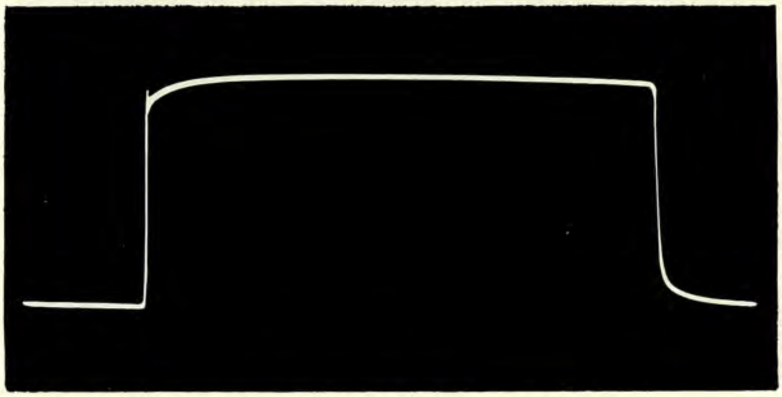


Figure 7–155. Synchronization Indicator, Pedestal Follower Cathode Waveform

EXTERNAL test point: V811 pin 6

GAIN settings: 62 LO

SWEEP SPEED: 500 #3

Notes:

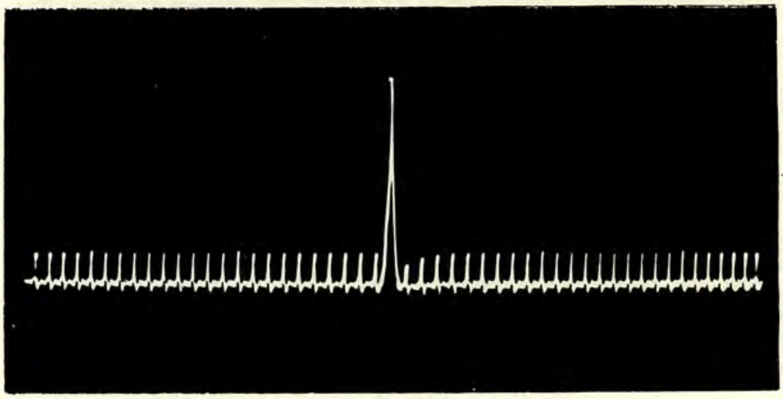
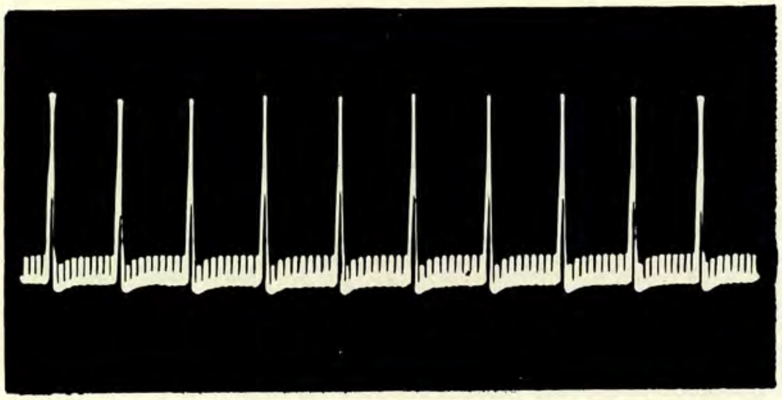
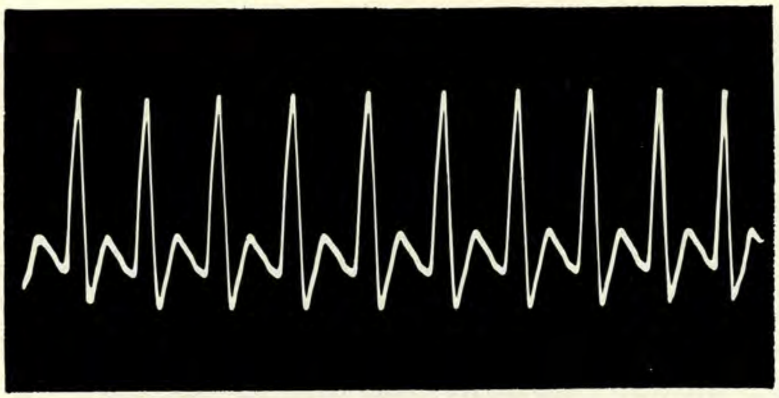


Figure 7–156. Synchronization Indicator, 1000's Amplifier Plate Waveform



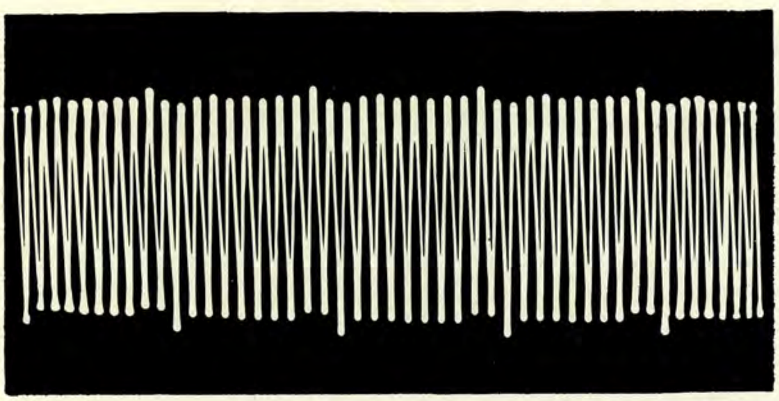
EXTERNAL test point: V826 pin 1
GAIN settings: 68 LO
SWEEP SPEED: 1,000 #2
Notes:

Figure 7–157. Synchronization Indicator, 100's Amplifier Plate Waveform



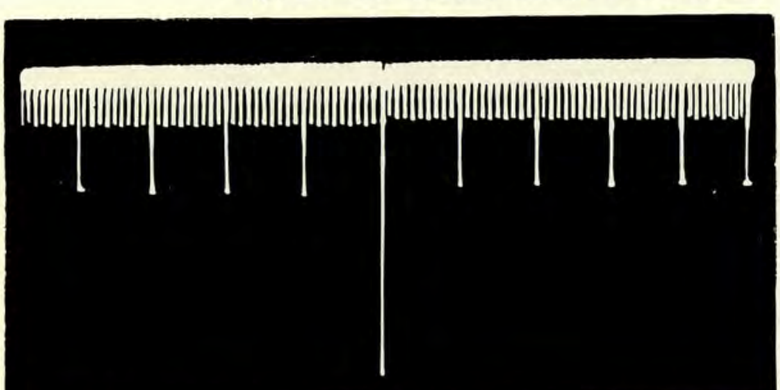
EXTERNAL test point: V811 pin 1
GAIN settings: 52 LO
SWEEP SPEED: 100 #3
Notes:

Figure 7–158. Synchronization Indicator, 10's Amplifier Plate Waveform



EXTERNAL test point: V812 pin 1
GAIN settings: 50 HI
SWEEP SPEED: 50 #4
Notes:

Figure 7–159. Synchronization Indicator, 1's Amplifier Plate Waveform



EXTERNAL test point: V814 pin 1
GAIN settings: 35 HI
SWEEP SPEED: 1,000 #2
Notes:

Figure 7–160. Synchronization Indicator, Marker Mixer Plate Waveform

EXTERNAL test point: V812 pin 6

GAIN settings: Direct

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for one-inch separation of VIDEO SCOPE traces.

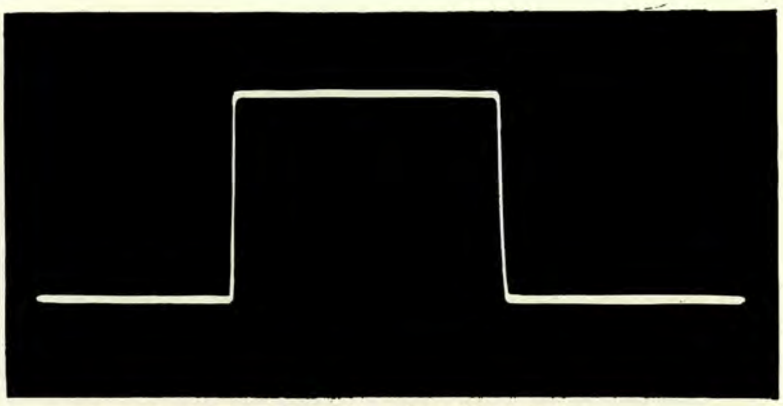


Figure 7–161. Synchronization Indicator, Square Wave Amplifier Plate Waveform

EXTERNAL test point: V824 pin 1

GAIN settings: 38 HI

SWEEP SPEED: 100 #3

Notes:

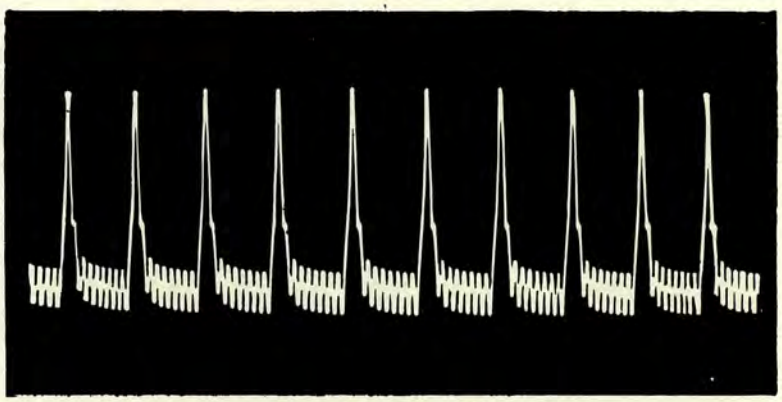


Figure 7–162. Synchronization Indicator, R-F Sweep 10's Amplifier Plate Waveform

EXTERNAL test point: V824 pin 6

GAIN settings: 38 HI

SWEEP SPEED: 100 #3

Notes:

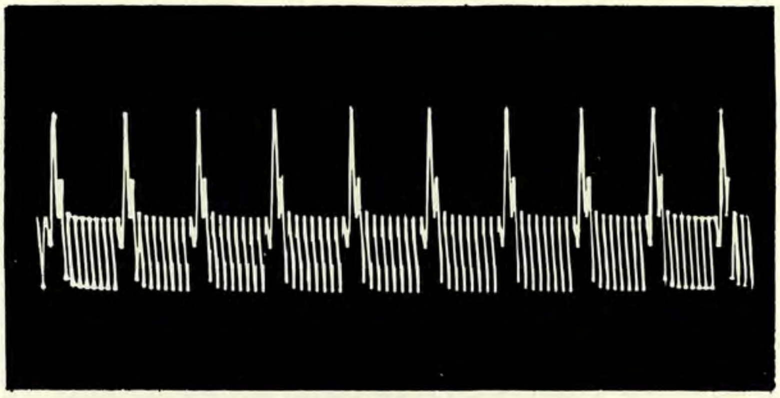


Figure 7–163. Synchronization Indicator, 1's Amplifier Plate Waveform

EXTERNAL test point: V813 pin 1

GAIN settings: 35 HI

SWEEP SPEED: 100 #3

Notes:

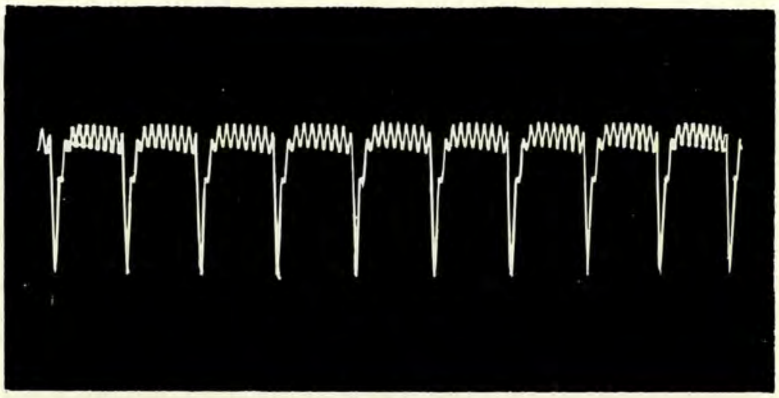
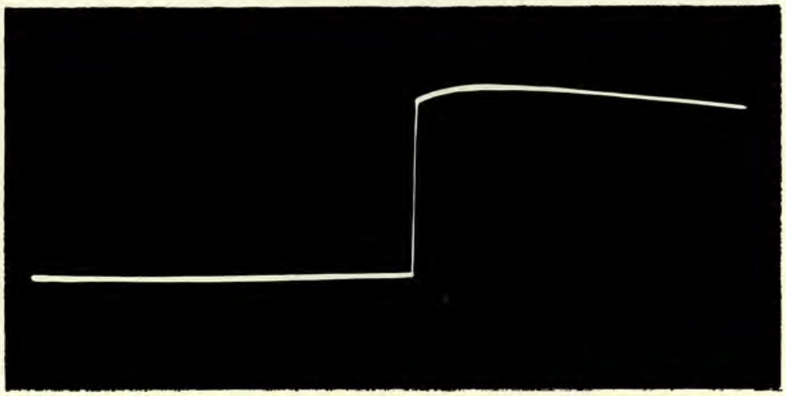


Figure 7–164. Synchronization Indicator, Marker Clipper Plate Waveform



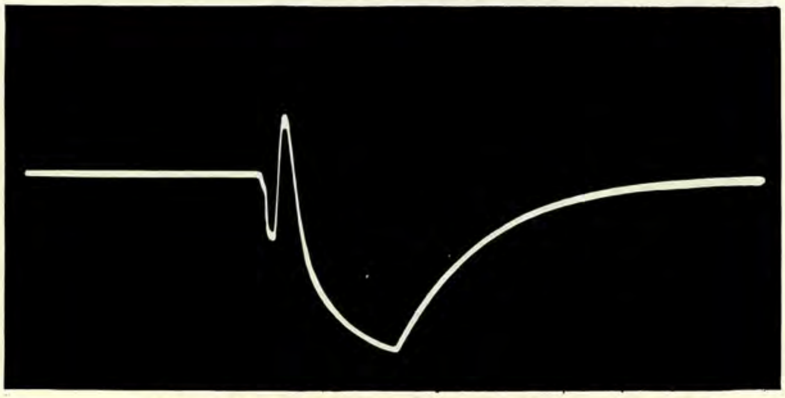
EXTERNAL test point: V813 pin 6

GAIN settings: Direct

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for one-inch separation of RF SCOPE traces.

Figure 7–165. Synchronization Indicator, Square Wave Amplifier Plate Waveform



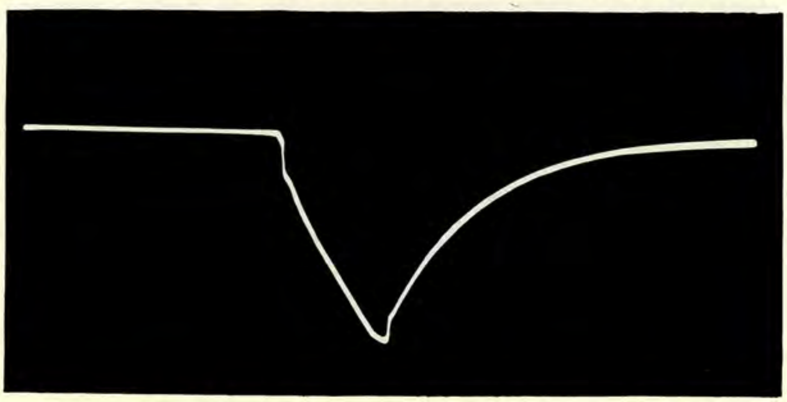
EXTERNAL test point: V816 pin 1

GAIN settings: 62 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for 50-μs sweep delay.

Figure 7–166. Synchronization Indicator, R-F Sweep Delay Clamp Cathode Waveform



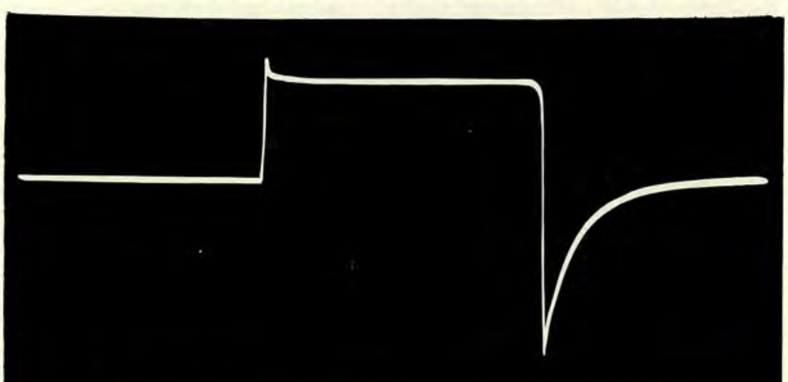
EXTERNAL test point: V817 pin 5

GAIN settings: 60 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for 50-μs sweep delay.

Figure 7–167. Synchronization Indicator, R-F Sweep Delay Phantastron Plate Waveform



EXTERNAL test point: V817 pin 7

GAIN settings: 48 LO

SWEEP SPEED: 100 #3

Notes: Waveform shown for 50-μs sweep delay.

Figure 7–168. Synchronization Indicator, R-F Sweep Delay Phantastron Suppressor Waveform

EXTERNAL test point: V818 pin 8

GAIN settings: 70 LO

SWEEP SPEED: 100 #3

Notes: Waveform shown for 50-μs sweep delay.

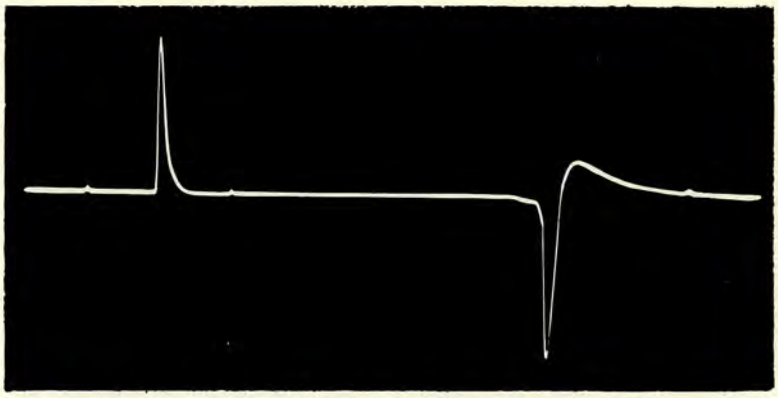


Figure 7–169. Synchronization Indicator, Sweep Delay Output Follower Cathode Waveform

EXTERNAL test point: V819 pin 5

GAIN settings: 35 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for 100-μs sweep speed.

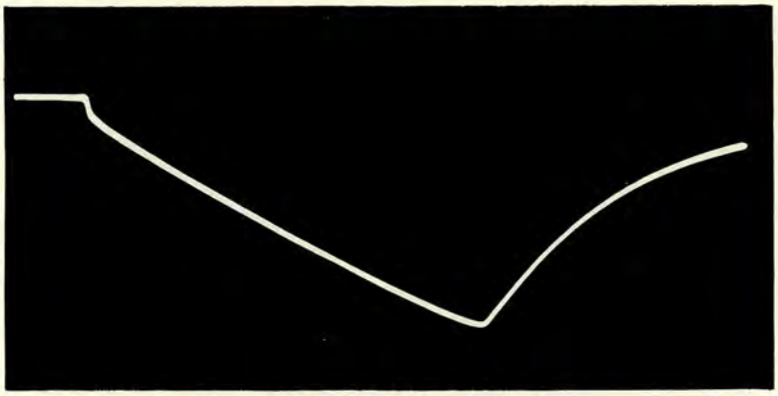


Figure 7–170. Synchronization Indicator, R-F Sweep Generator Plate Waveform

EXTERNAL test point: V819 pin 2

GAIN settings: 40 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for 100-μs sweep speed.

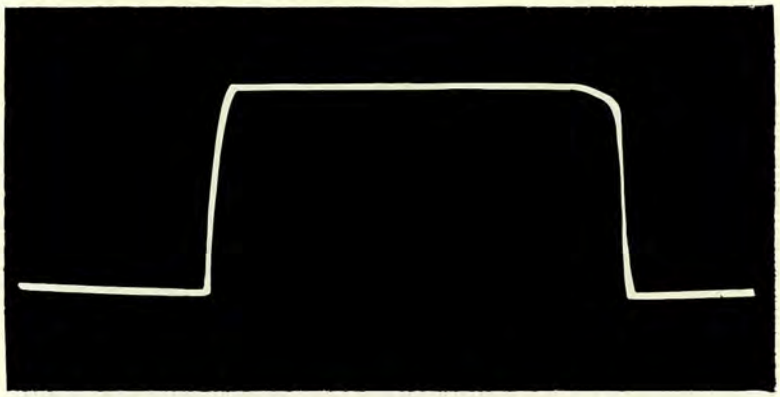


Figure 7–171. Synchronization Indicator, R-F Sweep Generator Suppressor Waveform

EXTERNAL test point: V827 pin 3

GAIN settings: 52 LO

SWEEP SPEED: 500 #3

Notes: Waveform shown for 100-μs sweep speed.

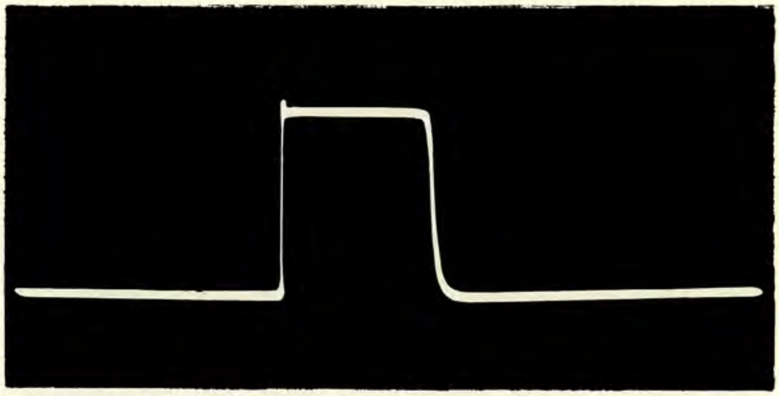
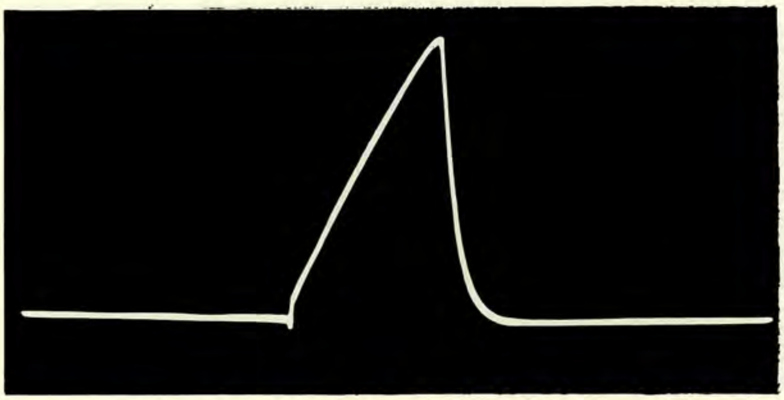


Figure 7-172. Synchronization Indicator, R-F Intensity Follower Cathode Waveform



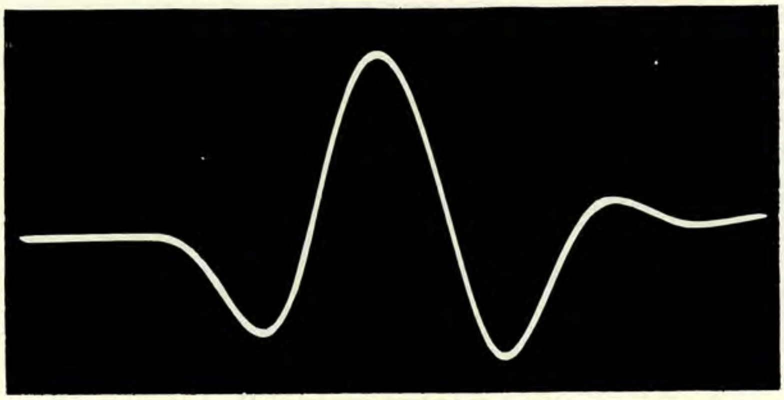
EXTERNAL test point: V810 pin 5

GAIN settings: 40 LO

SWEEP SPEED: 500 #3

Notes: Use probe. Waveform shown for 100-μs sweep speed.

Figure 7–173. Synchronization Indicator, R-F Sweep Paraphase Amplifier Plate Waveform



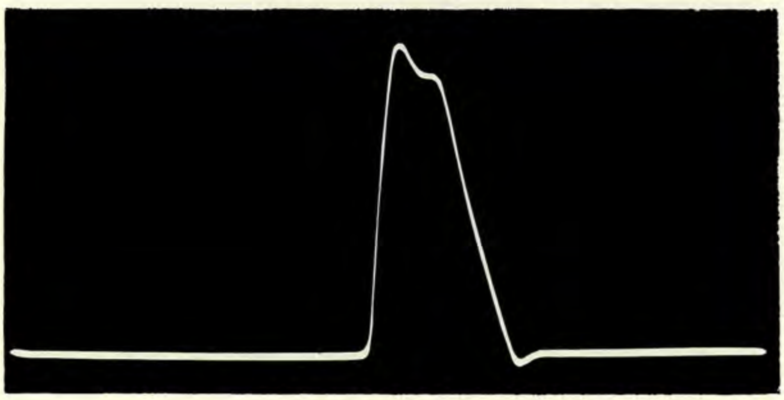
EXTERNAL test point: V1501 pin 1

GAIN settings: 80 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for normal signal level.

Figure 7–174. Electrical Synchronizer, Input Amplifier Plate Waveform



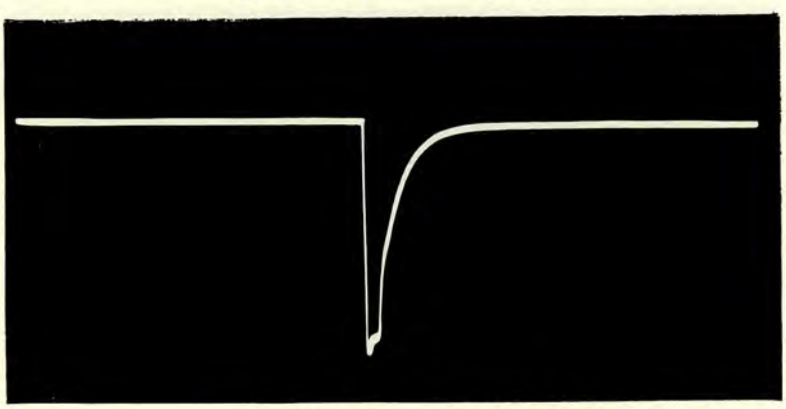
EXTERNAL test point: V1502 pin 1

GAIN settings: 35 HI

SWEEP SPEED: 25 #4

Notes:

Figure 7–175. Electrical Synchronizer, Remote Mixer Gate Grid Waveform



EXTERNAL test point: V1502 pin 5

GAIN settings: 40 HI

SWEEP SPEED: 100 #3

Notes: Waveform shown for zero error or no signal.

Figure 7–176. Electrical Synchronizer, Remote Mixer Plate Waveform

EXTERNAL test point: V1504 pin 1

GAIN settings: 35 HI

SWEEP SPEED: 25 #4

Notes:

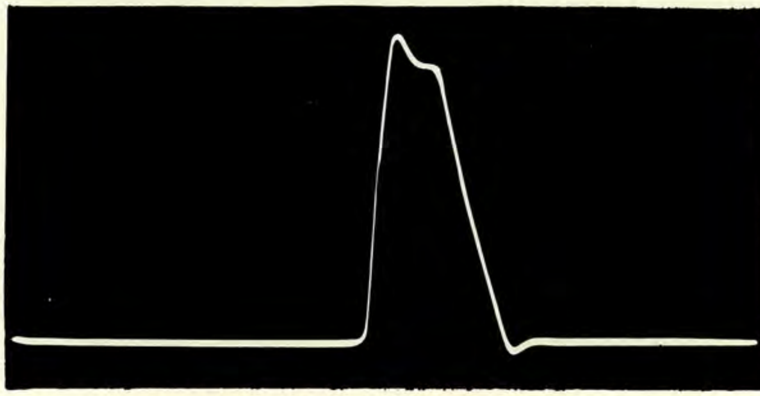


Figure 7–177. Electrical Synchronizer, Local Mixer Gate Grid Waveform

EXTERNAL test point: V1504 pin 5

GAIN settings: 100 HI

SWEEP SPEED: 100 #3

Notes: Waveform shown for zero error or no signal.

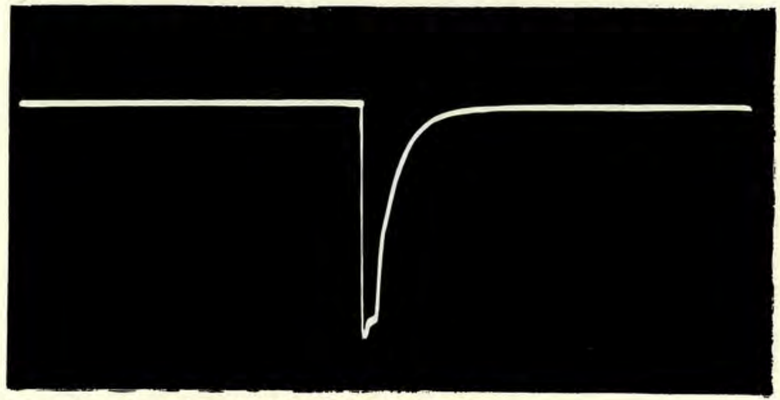


Figure 7–178. Electrical Synchronizer, Local Mixer Plate Waveform

EXTERNAL test point: V1505 pin 2

GAIN settings: 100 HI

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for zero error or no signal.

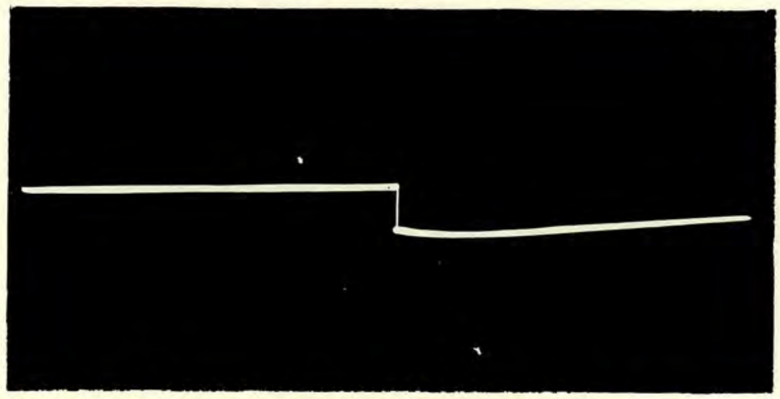


Figure 7–179. Electrical Synchronizer, Remote Sync Charging Diode Plate Waveform

EXTERNAL test point: V1505 pin 2

GAIN settings: 100 HI

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for signal cross-over ahead of gate.

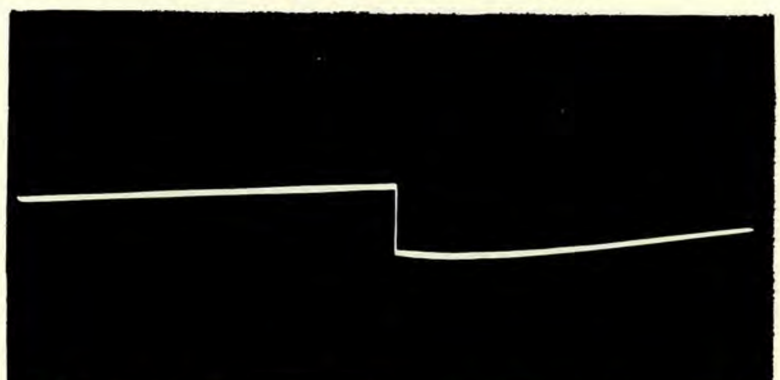
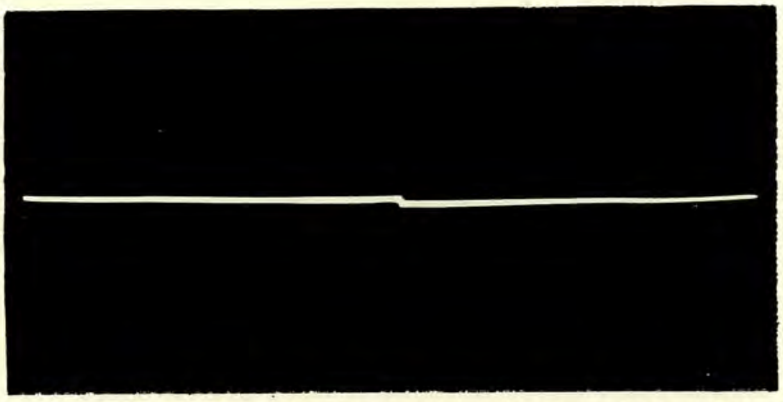


Figure 7–180. Electrical Synchronizer, Remote Sync Charging Diode Plate Waveform



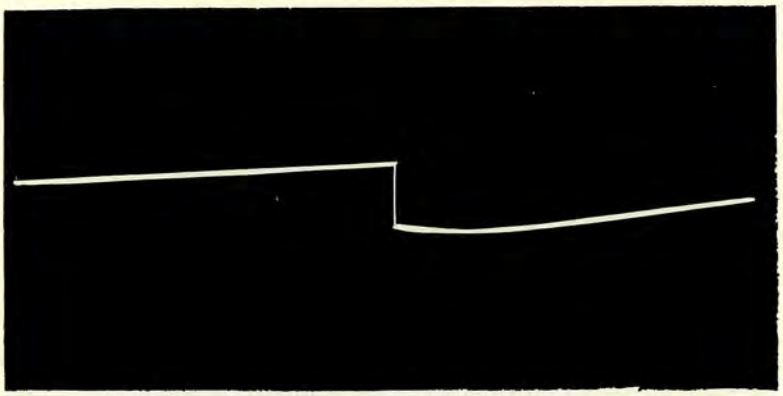
EXTERNAL test point: V1505 pin 2

GAIN settings: 100 HI

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for crossover beyond gate.

Figure 7–181. Electrical Synchronizer, Remote Sync Charging Diode Plate Waveform



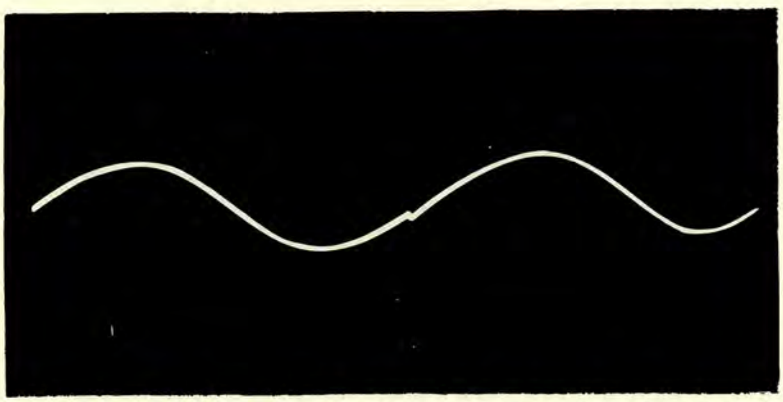
EXTERNAL test point: V1505 pin 7

GAIN settings: 100 HI

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for zero error or no signal.

Figure 7–182. Electrical Synchronizer, Local Sync Charging Diode Plate Waveform



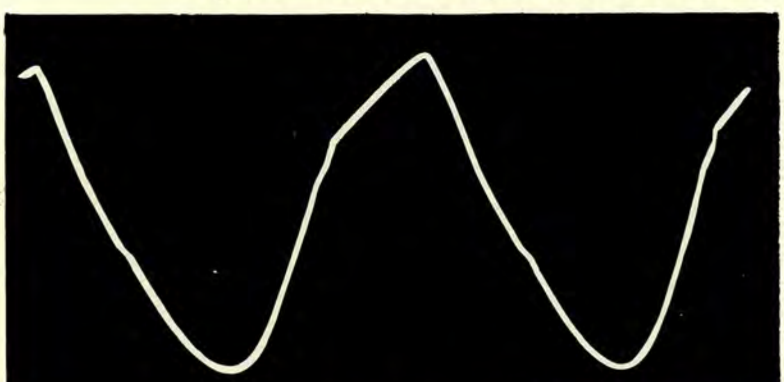
EXTERNAL test point: V1506 pin 1

GAIN settings: 35 HI

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for zero error or no signal; pattern will remain stationary only at some SLOW rates.

Figure 7–183. Electrical Synchronizer, A-C Error Generator Local Plate Waveform



EXTERNAL test point: V1506 pin 1

GAIN settings: 35 HI

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for large error; pattern will remain stationary only at some SLOW rates. Distortion of sine wave will vary with degree of error.

Figure 7–184. Electrical Synchronizer, A-C Error Generator Local Plate Waveform

EXTERNAL test point: V1507 pin 7

GAIN settings: 45 HI

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for zero error or no signal; pattern will remain stationary only at some SLOW rates.

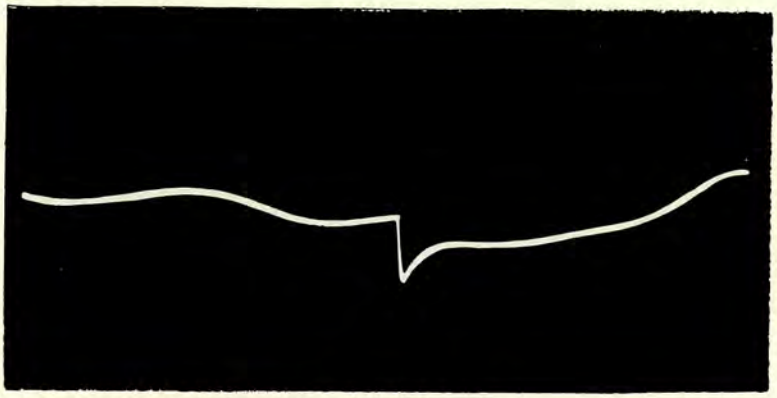


Figure 7–185. Electrical Synchronizer, A-C Amplifier Grid Waveform

EXTERNAL test point: V1507 pin 7

GAIN settings: 35 HI

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for large error; pattern will remain stationary only at some SLOW rates.

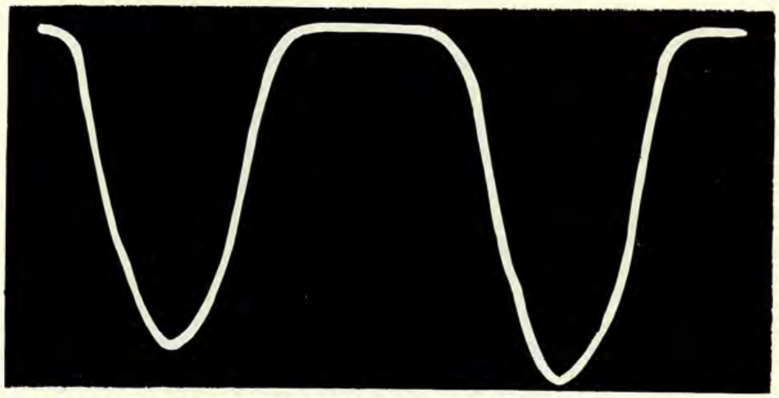


Figure 7–186. Electrical Synchronizer, A-C Amplifier Grid Waveform

EXTERNAL test point: V1507 pin 6

GAIN settings: 35 HI

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for zero error or no signal; pattern will remain stationary only at some SLOW rates.

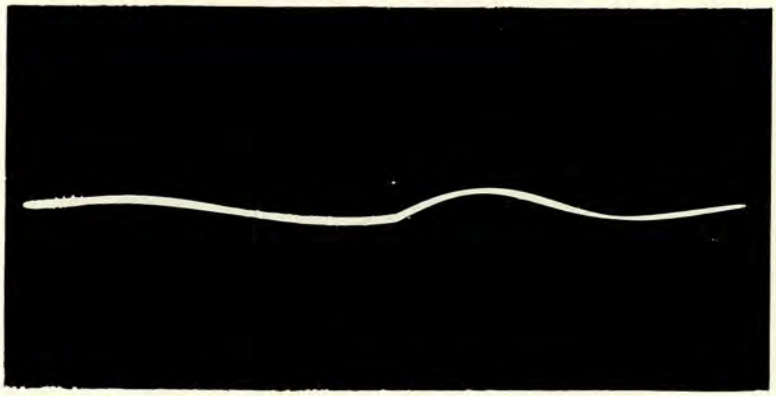


Figure 7–187. Electrical Synchronizer, A-C Amplifier Plate Waveform

EXTERNAL test point: V1507 pin 6

GAIN settings: 35 HI

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for large error; pattern will remain stationary only at some SLOW rates.

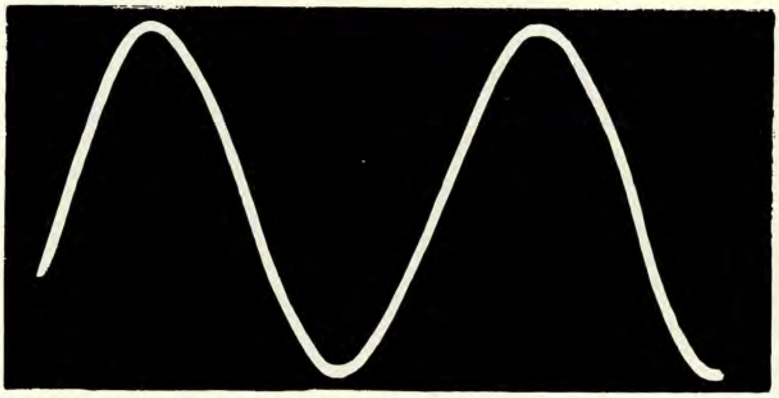
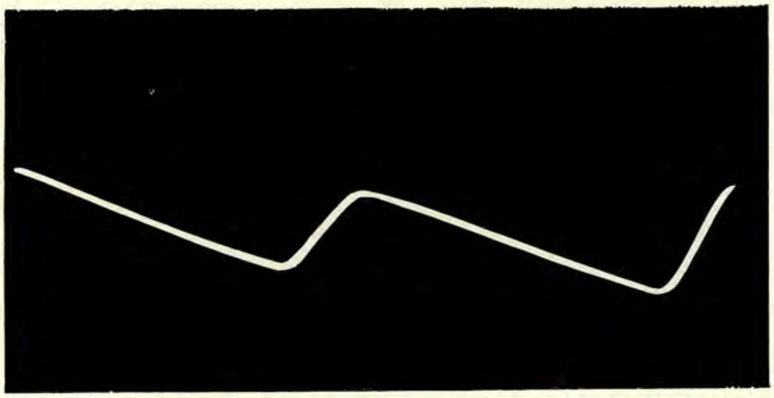


Figure 7–188. Electrical Synchronizer, A-C Amplifier Plate Waveform



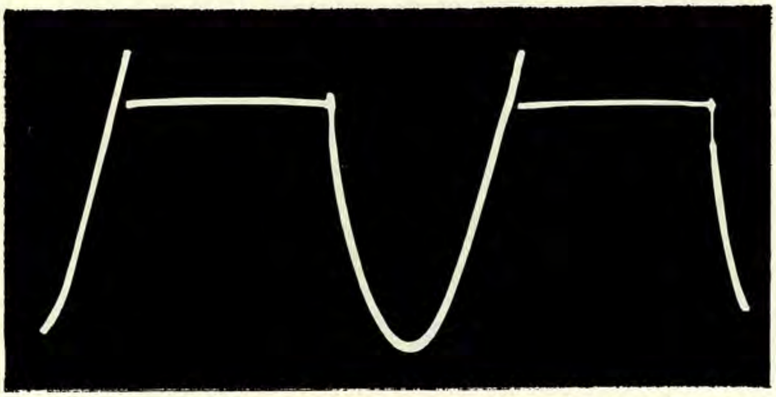
EXTERNAL test point: V1508 pin 8

GAIN settings: 100 HI

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for large error; pattern will remain stationary only at some SLOW rates. Circuit not used at a master station.

Figure 7–189. Electrical Synchronizer, A-C Rectifier Cathode Waveform



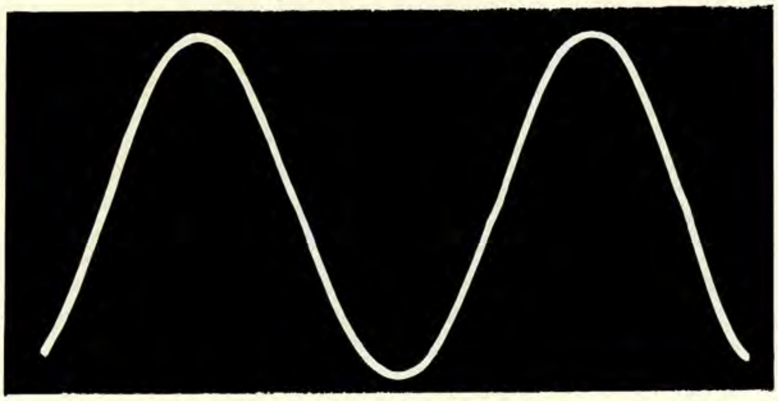
EXTERNAL test point: V1509 pin 6

GAIN settings: 32 LO

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for *alarm on* condition; pattern will remain stationary only at some SLOW rates.

Figure 7–190. Electrical Synchronizer, Sync Error Thyratron Plate Waveform



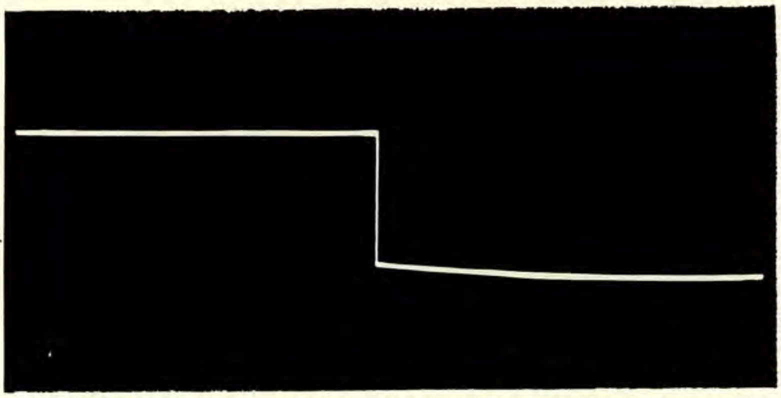
EXTERNAL test point: V1509 pin 6

GAIN settings: 32 LO

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for *alarm off* condition; pattern will remain stationary only at some SLOW rates.

Figure 7–191. Electrical Synchronizer, Sync Error Thyratron Plate Waveform



EXTERNAL test point: V1521 pin 6

GAIN settings: 44 LO

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for master operation with a delay of 60 μs for both gates.

Figure 7–192. Electrical Synchronizer, Square Wave Amplifier Plate Waveform

EXTERNAL test point: V1521 pin 1

GAIN settings: 44 LO

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for master operation with a delay of 60 μs for both gates.

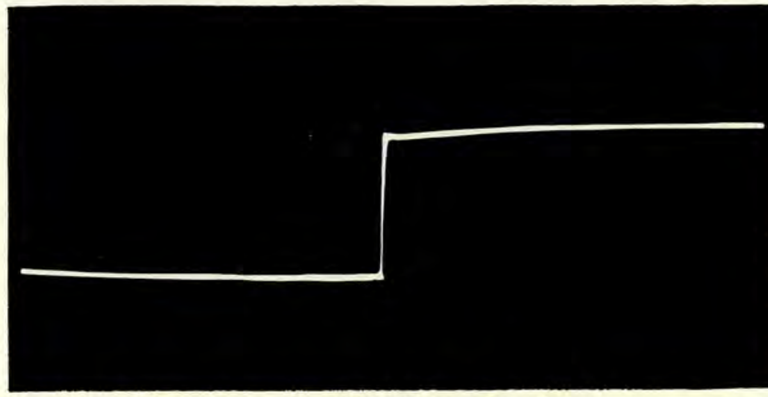


Figure 7–193. Electrical Synchronizer, Square Wave Amplifier Plate Waveform

EXTERNAL test point: V1520 pin 1

GAIN settings: 80 LO

SWEEP SPEED: 8,000 #1

Notes: Waveform shown for master operation with a delay of 60 μs for both gates. (Zero error.)

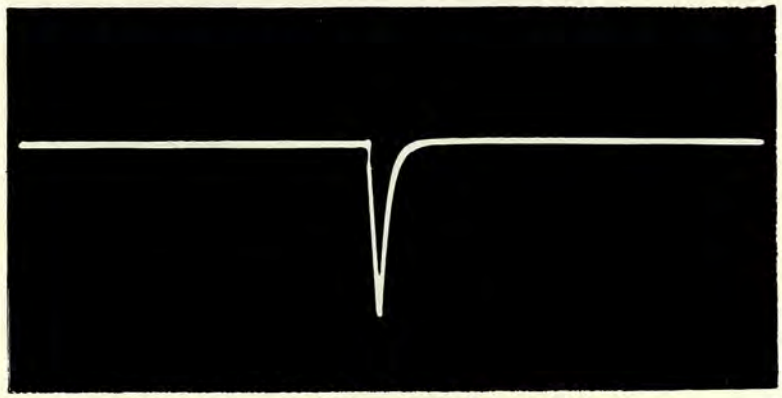


Figure 7–194. Electrical Synchronizer, Square Wave Diode Cathode Waveform

EXTERNAL test point: V1520 pin 1

GAIN settings: 80 LO

SWEEP SPEED: 8,000 #1

Notes: Waveform shown for master operation with a gate delay of 60 μs for local gate and 57 μs for remote gate. (3-μs error.)

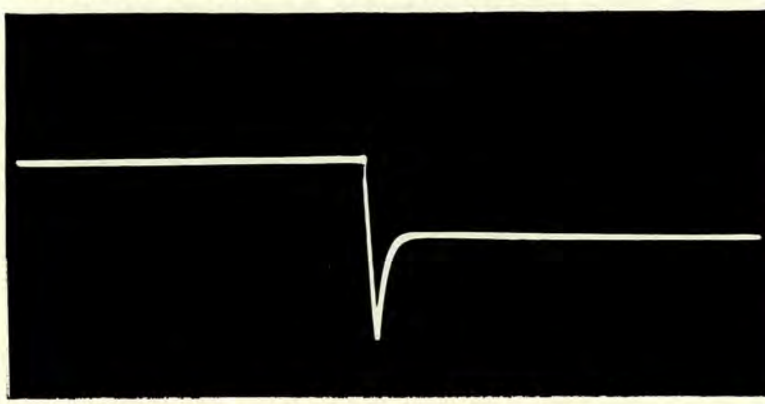


Figure 7–195. Electrical Synchronizer, Square Wave Diode Cathode Waveform

EXTERNAL test point: V1518 pin 8

GAIN settings: 80 LO

SWEEP SPEED: 8,000 #1

Notes: Waveform shown for a gate delay of 60 μs for local gate and 57 μs for remote gate. (3-μs error.) Circuit used only at a master station.

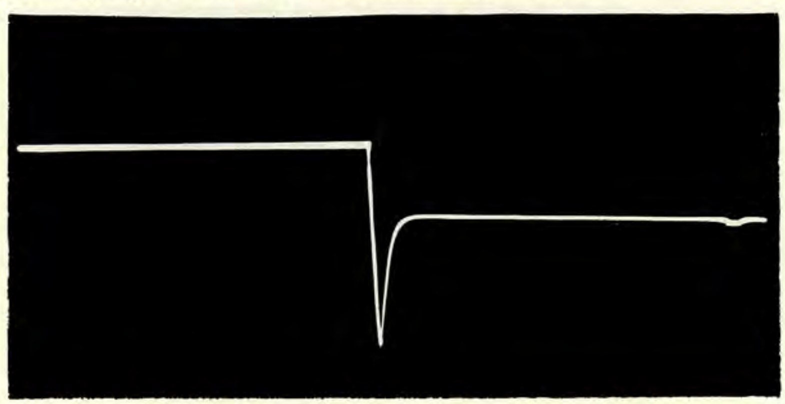
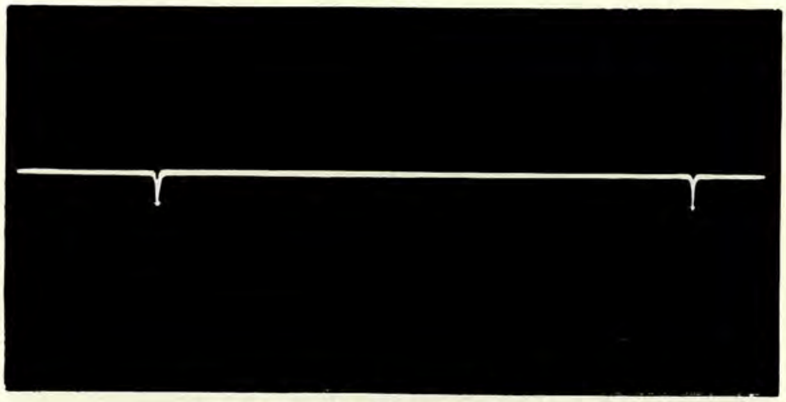


Figure 7–196. Electrical Synchronizer, Delay Follower Cathode Waveform



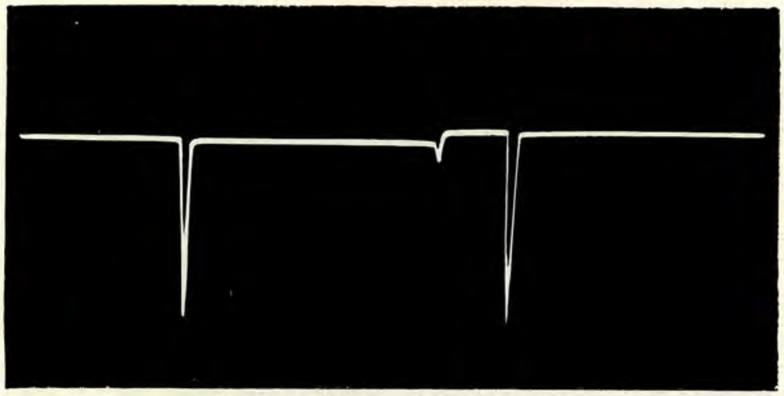
EXTERNAL test point: V1518 pin 3

GAIN settings: 52 LO

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for slave operation.

Figure 7–197. Electrical Synchronizer, Delay Trigger Diode Cathode Waveform



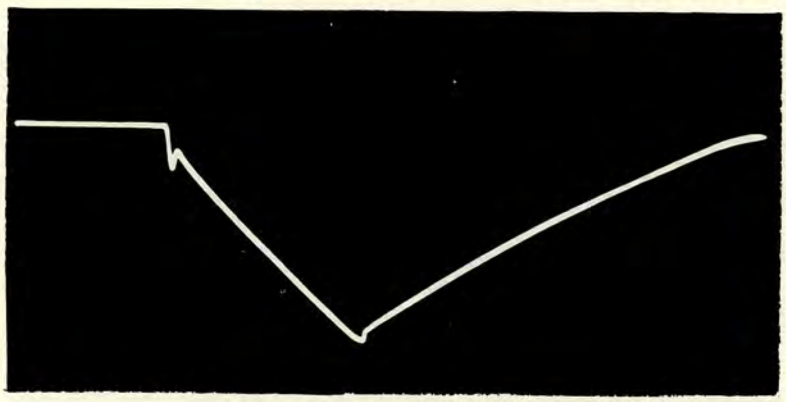
EXTERNAL test point: V1517 pin 5

GAIN settings: 55 LO

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for master operation with a gate delay of 60 μs for local gate and 57 μs for remote gate. (3-μs error.)

Figure 7–198. Electrical Synchronizer, Delay Phantastron Plate Waveform



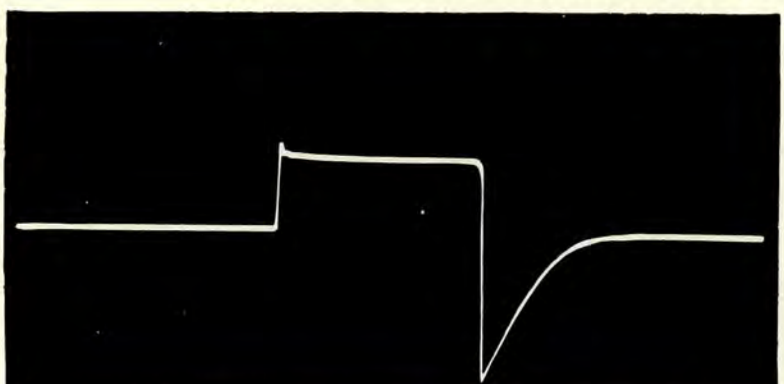
EXTERNAL test point: V1517 pin 5

GAIN settings: 55 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for slave operation with a gate delay of 60 μs.

Figure 7–199. Electrical Synchronizer, Delay Phantastron Plate Waveform



EXTERNAL test point: V1517 pin 7

GAIN settings: 55 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for a gate delay of 60 μs.

Figure 7–200. Electrical Synchronizer, Delay Phantastron Suppressor Waveform

EXTERNAL test point: V1517 pin 6

GAIN settings: 50 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for a gate delay of 60 μs.

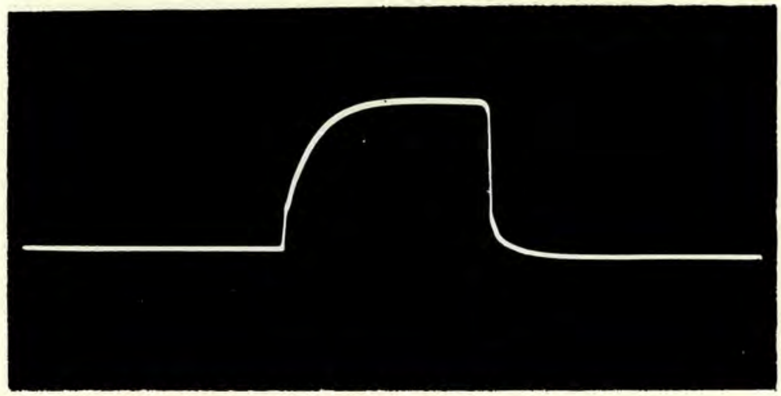


Figure 7–201. Electrical Synchronizer, Delay Phantastron Screen Waveform

EXTERNAL test point: V1525 pin 6

GAIN settings: 52 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for a gate delay of 60 μs.

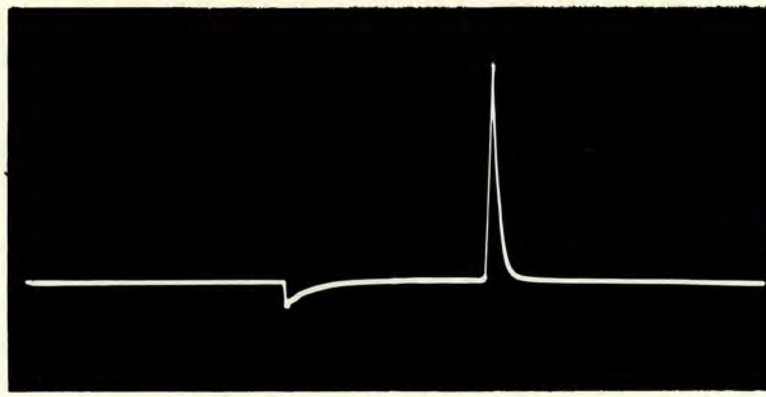


Figure 7–202. Electrical Synchronizer Gate Generator Plate Waveform

EXTERNAL test point: V1525 pin 3

GAIN settings: 50 LO

SWEEP SPEED: 200 #3

Notes: Waveform shown for a gate delay of 60 μs.

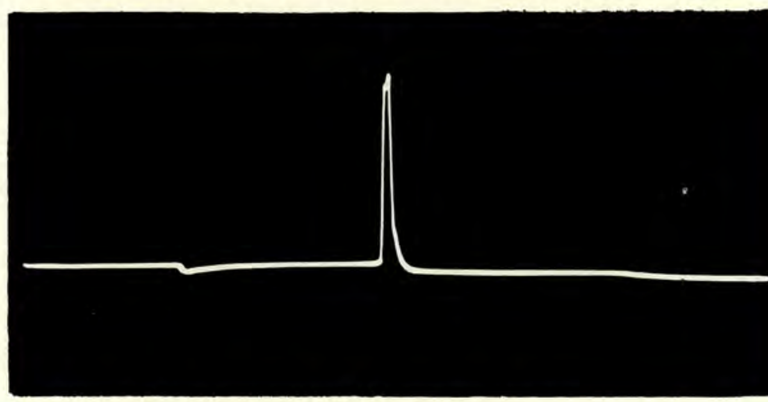


Figure 7–203. Electrical Synchronizer, Gate Follower Cathode Waveform

EXTERNAL test point: V1519 pin 2

GAIN settings: 50 LO

SWEEP SPEED: 200 #3

Notes:

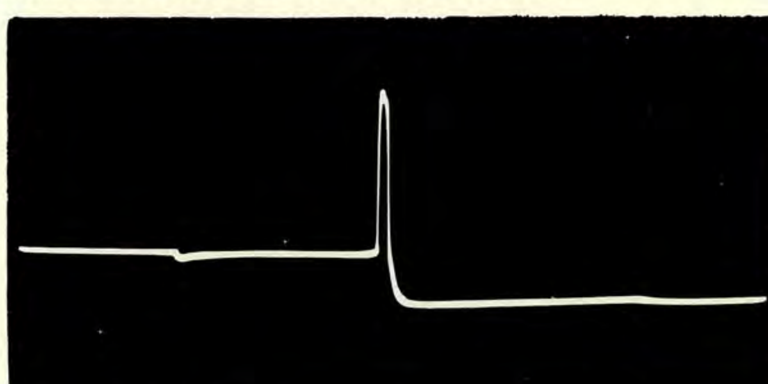
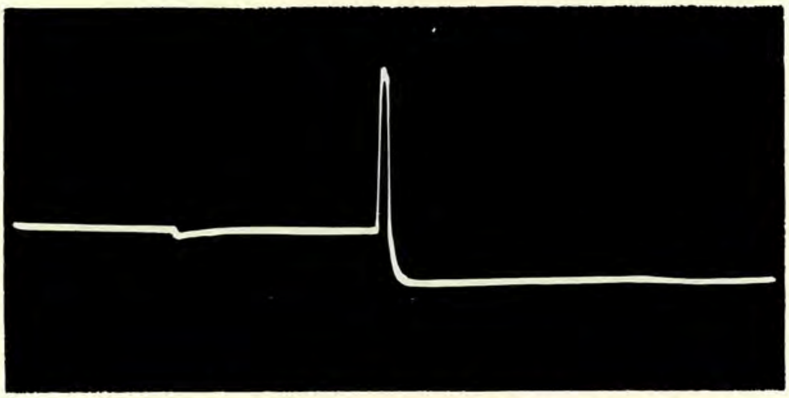
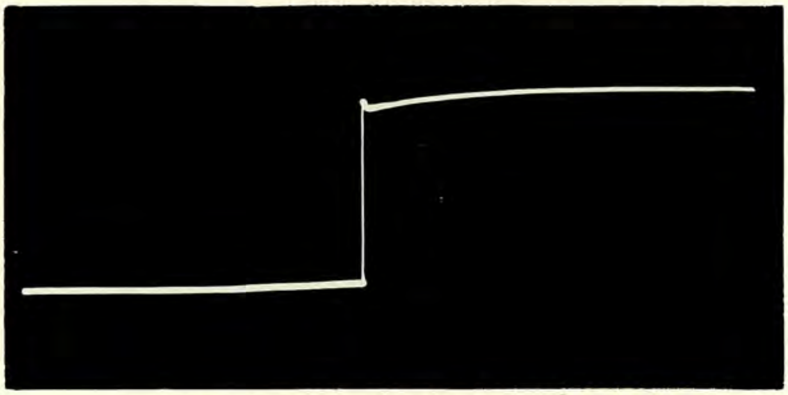


Figure 7–204. Electrical Synchronizer, Remote Gate Separator Plate Waveform



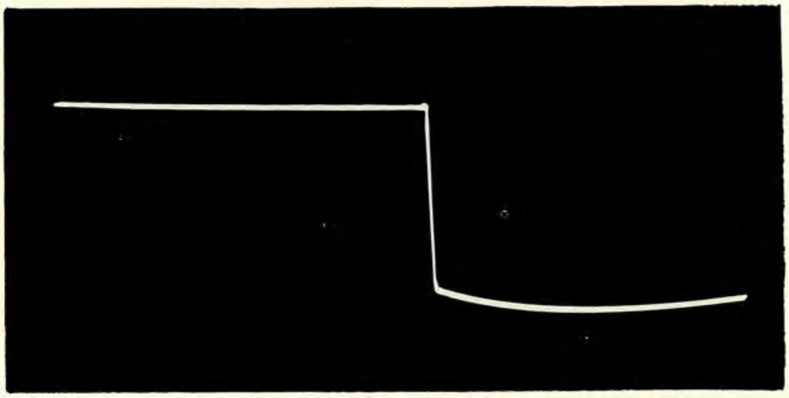
EXTERNAL test point: V1519 pin 7
GAIN settings: 50 LO
SWEEP SPEED: 200 #3
Notes:

Figure 7–205. Electrical Synchronizer, Local Gate Separator Plate Waveform



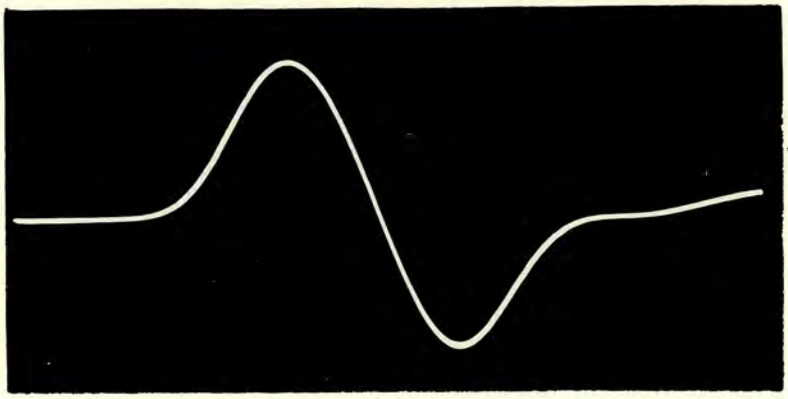
EXTERNAL test point: V1522 pin 7
GAIN settings: 50 LO
SWEEP SPEED: 25,000 #1
Notes:

Figure 7–206. Electrical Synchronizer, Square Wave Amplifier Grid Waveform



EXTERNAL test point: V1522 pin 2
GAIN settings: 50 LO
SWEEP SPEED: 25,000 #1
Notes:

Figure 7–207. Electrical Synchronizer, Square Wave Amplifier Grid Waveform



EXTERNAL test point: V1511 pin 2
GAIN settings: 58 HI
SWEEP SPEED: 200 #3
Notes:

Figure 7–208. Electrical Synchronizer, 1st Derivative Clipper Grid Waveform

EXTERNAL test point: V1511 pin 7
GAIN settings: 55 LO
SWEEP SPEED: 200 #3
Notes:

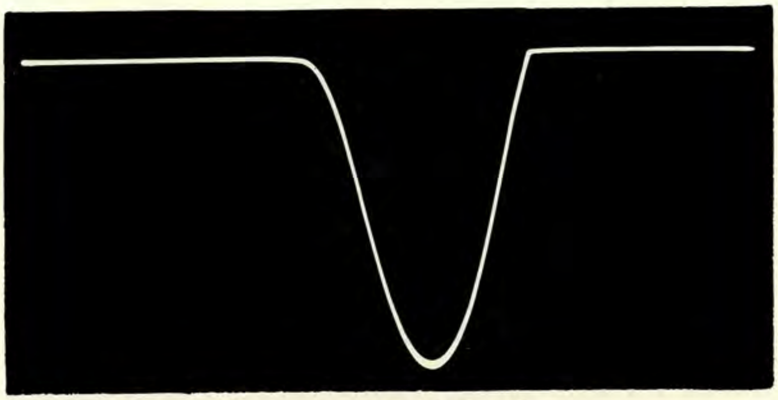


Figure 7–209. Electrical Synchronizer, 1st Derivative Limiter Grid Waveform

EXTERNAL test point: V1511 pin 6
GAIN settings: 45 LO
SWEEP SPEED: 200 #3
Notes:

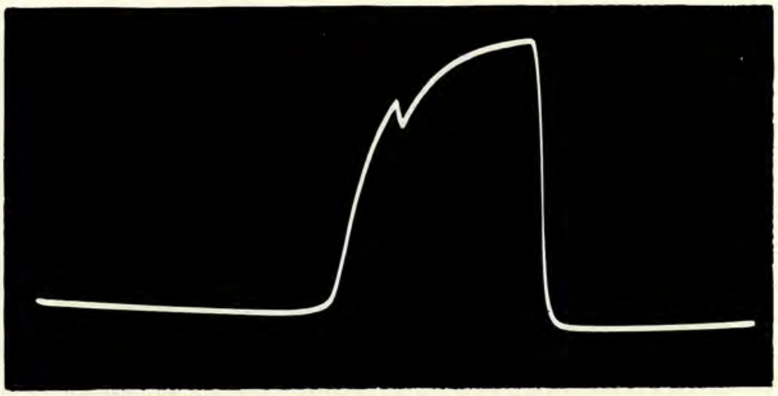


Figure 7–210. Electrical Synchronizer, 1st Derivative Limiter Plate Waveform

EXTERNAL test point: V1512 pin 1
GAIN settings: 40 HI
SWEEP SPEED: 200 #3
Notes: Waveform shown for *alarm off* condition, no error.

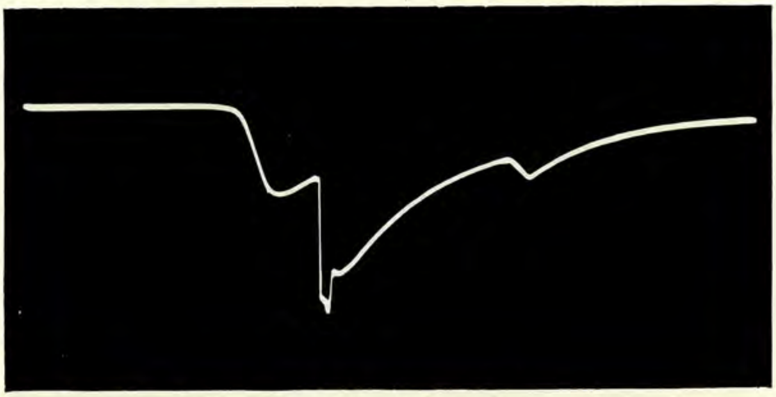


Figure 7–211. Electrical Synchronizer, Alarm Mixer Plate Waveform

EXTERNAL test point: V1512 pin 1
GAIN settings: 40 HI
SWEEP SPEED: 200 #3
Notes: Waveform shown for *alarm on* condition.

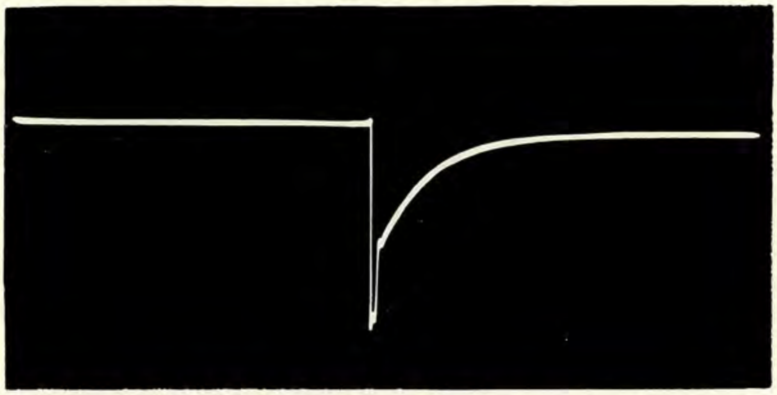
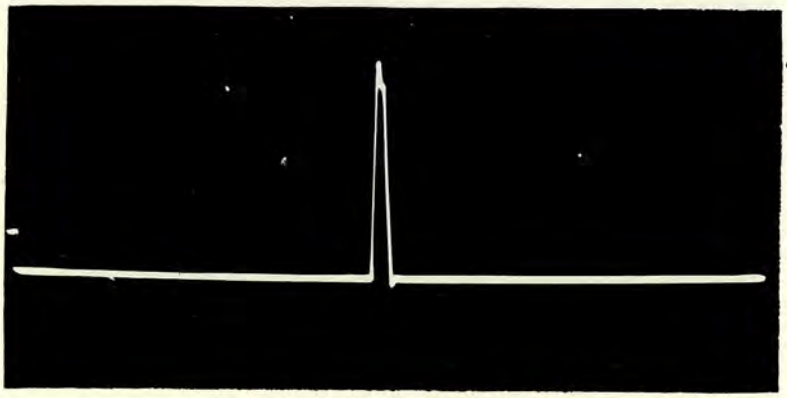


Figure 7–212. Electrical Synchronizer, Alarm Mixer Plate Waveform



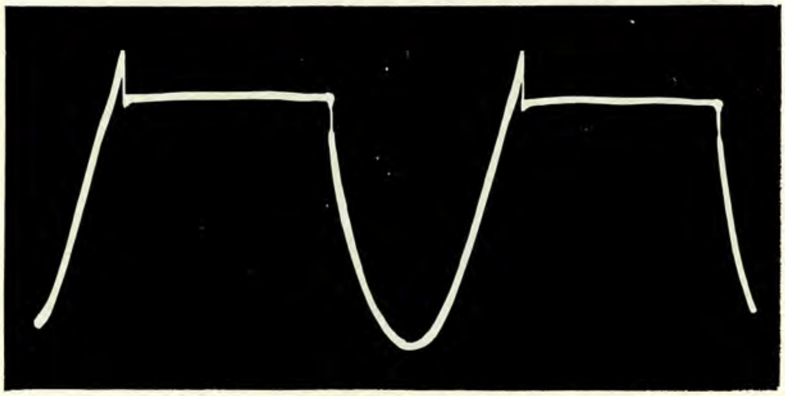
EXTERNAL test point: V1512 pin 7

GAIN settings: 35 HI

SWEEP SPEED: 200 #3

Notes:

Figure 7–213. Electrical Synchronizer, Alarm Mixer Gate Grid Waveform



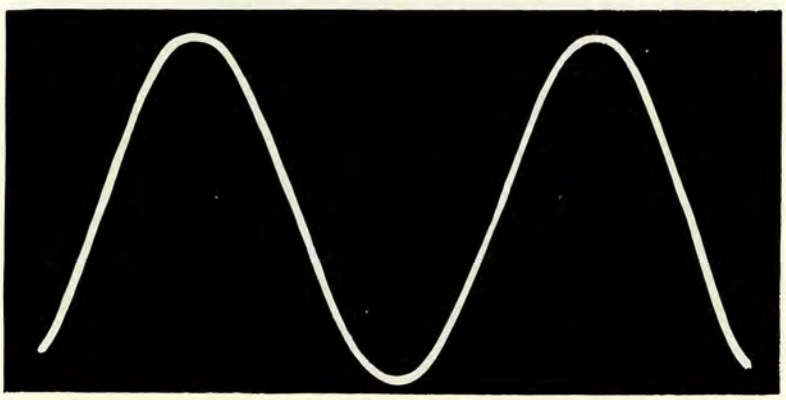
EXTERNAL test point: V1514 pin 6

GAIN settings: 32 LO

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for *alarm on* condition; pattern will remain stationary only at some SLOW rates.

Figure 7–214. Electrical Synchronizer, Off Sync Thyratron Plate Waveform



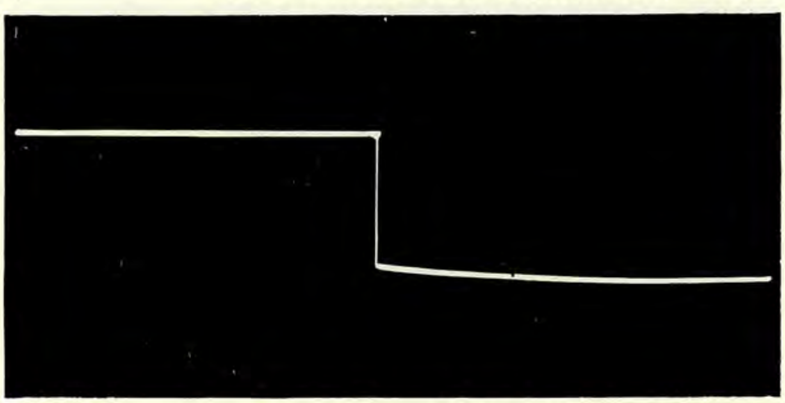
EXTERNAL test point: V1514 pin 6

GAIN settings: 32 LO

SWEEP SPEED: 25,000 #1

Notes: Waveform shown for *alarm off* condition; pattern will remain stationary only at some SLOW rates.

Figure 7–215. Electrical Synchronizer, Off Sync Thyratron Plate Waveform



EXTERNAL test point: V1721 pin 3

GAIN settings: 50 LO

SWEEP SPEED: 10,000 #1

Notes:

Figure 7–216. Test Scope, Square Wave Follower Cathode Waveform

EXTERNAL test point: V1701 pin 1

GAIN settings: 40 LO

SWEEP SPEED: 10,000 #1

Notes: S1701 on SQUARE WAVE ϕ 1 position.

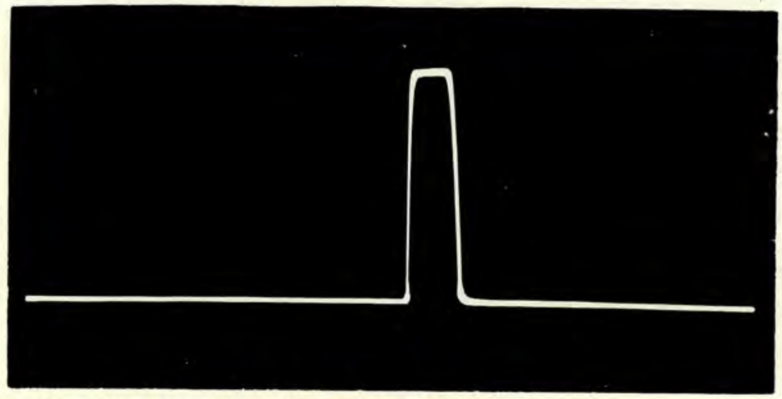


Figure 7–217. Test Scope, Negative Sync Amplifier Plate Waveform

EXTERNAL test point: V1701 pin 6

GAIN settings: 40 LO

SWEEP SPEED: 10,000 #1

Notes: S1701 on SQUARE WAVE ϕ 1 position. 1,000 μs STEP DELAY control will change waveform.

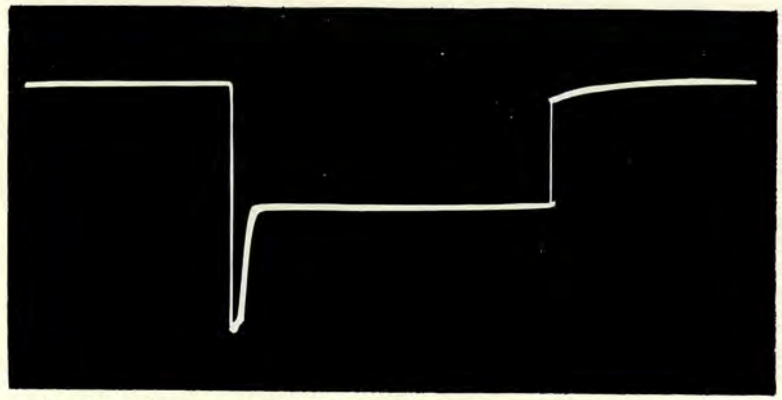


Figure 7–218. Test Scope, Positive Sync Amplifier Plate Waveform

EXTERNAL test point: V1702 pin 6

GAIN settings: 40 LO

SWEEP SPEED: 20,000 #1

Notes: 1,000 μs STEP DELAY control will change waveform.

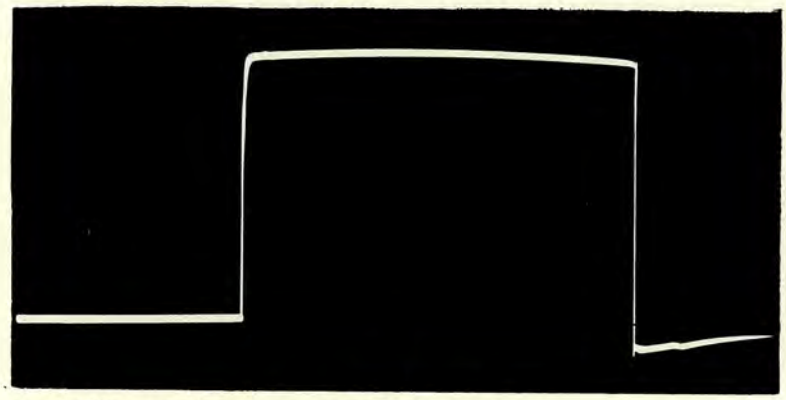


Figure 7–219. Test Scope, 1,000-μs Delay Output Plate Waveform

EXTERNAL test point: V1703 pin 1

GAIN settings: 50 LO

SWEEP SPEED: 20,000 #1

Notes:

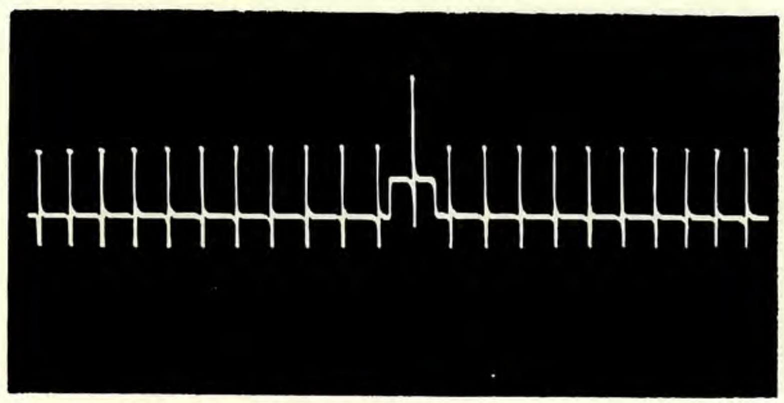
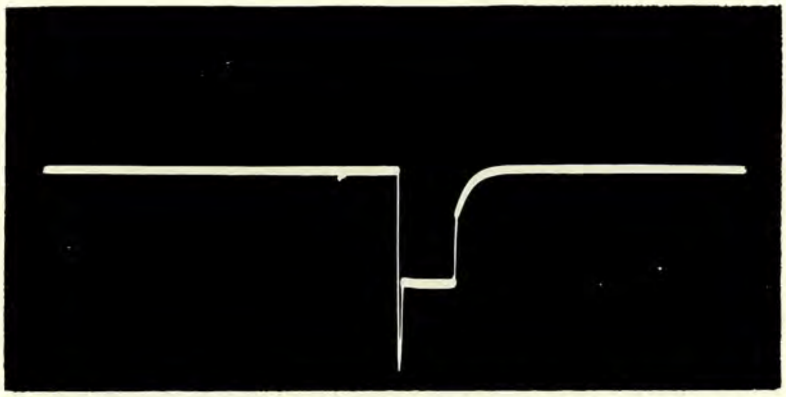


Figure 7–220. Test Scope, 1000's Push-up Plate Waveform



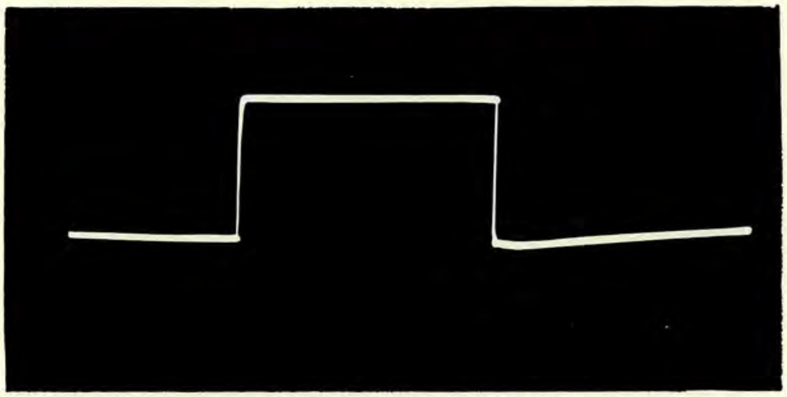
EXTERNAL test point: V1704 pin 1

GAIN settings: 30 LO

SWEEP SPEED: 24,000 #1

Notes: 100 μs STEP DELAY control will change waveform.

Figure 7–221. Test Scope, 1000's Clipper Plate Waveform



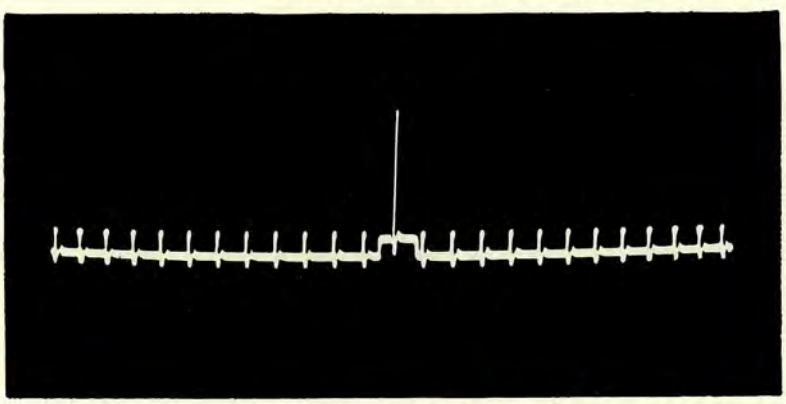
EXTERNAL test point: V1705 pin 6

GAIN settings: 40 LO

SWEEP SPEED: 2,000 #2

Notes: 100 μs STEP DELAY control will change waveform.

Figure 7–222. Test Scope, 100-μs Delay Output Plate Waveform



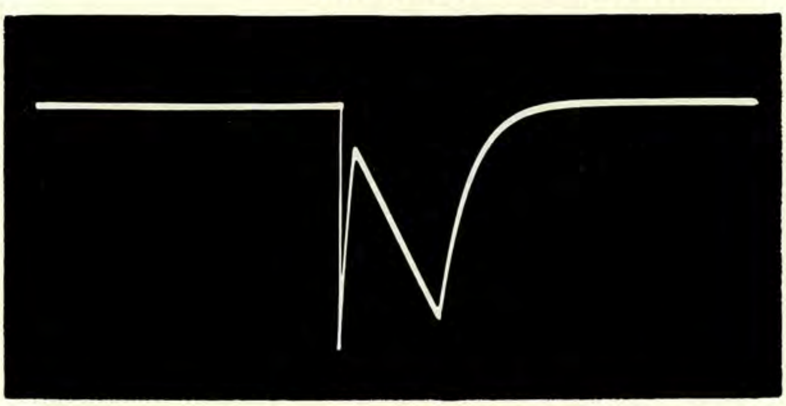
EXTERNAL test point: V1706 pin 1

GAIN settings: 50 LO

SWEEP SPEED: 2,400 #2

Notes:

Figure 7–223. Test Scope, 100's Push-up Plate Waveform



EXTERNAL test point: V1704 pin 6

GAIN settings: 35 LO

SWEEP SPEED: 500 #3

Notes: CONTINUOUS DELAY control will change waveform.

Figure 7–224. Test Scope, 100's Clipper Plate Waveform

EXTERNAL test point: V1708 pin 5

GAIN settings: 35 LO

SWEEP SPEED: 500 #3

Notes: CONTINUOUS DELAY control will change waveform.

Figure 7–225. Test Scope, Continuous Delay Phantastron Plate Waveform

EXTERNAL test point: V1708 pin 6

GAIN settings: 40 LO

SWEEP SPEED: 500 #3

Notes: CONTINUOUS DELAY control will change waveform.

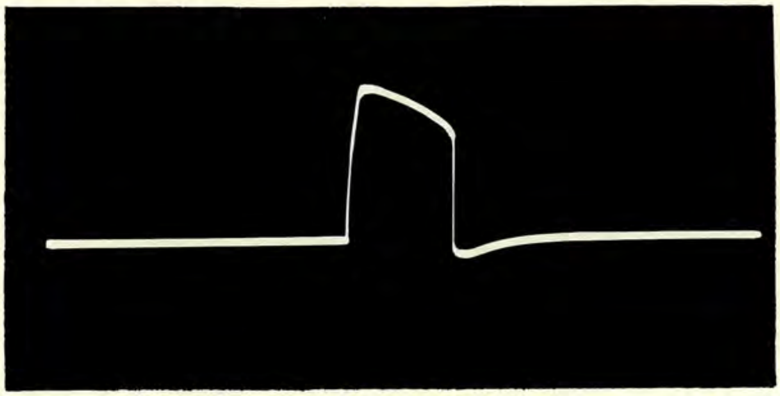


Figure 7–226. Test Scope, Continuous Delay Phantastron Screen Waveform

EXTERNAL test point: V1708 pin 7

GAIN settings: 60 LO

SWEEP SPEED: 500 #3

Notes: CONTINUOUS DELAY control will change waveform.

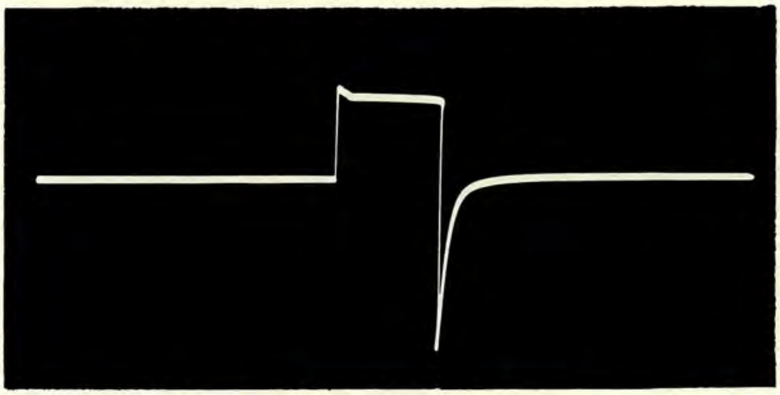


Figure 7–227. Test Scope, Continuous Delay Phantastron Suppressor Waveform

EXTERNAL test point: V1707 pin 8

GAIN settings: 55 LO

SWEEP SPEED: 500 #3

Notes: S1701 on SQUARE WAVE φ 1 position.

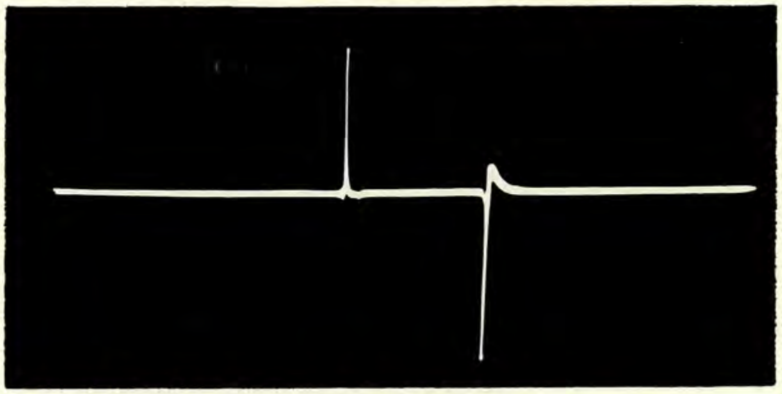
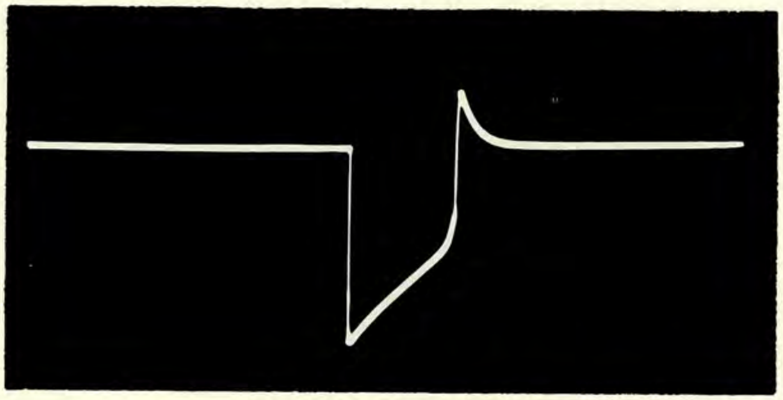


Figure 7–228. Test Scope, Sync Trigger Follower Cathode Waveform



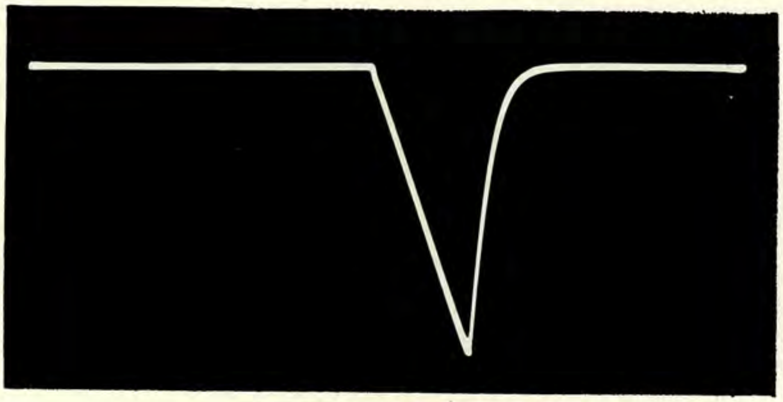
EXTERNAL test point: V1717 pin 1

GAIN settings: 45 LO

SWEEP SPEED: 500 #3

Notes: Waveform shown for 100-μs sweep speed.

Figure 7–229. Test Scope, Sweep Generator Grid Waveform



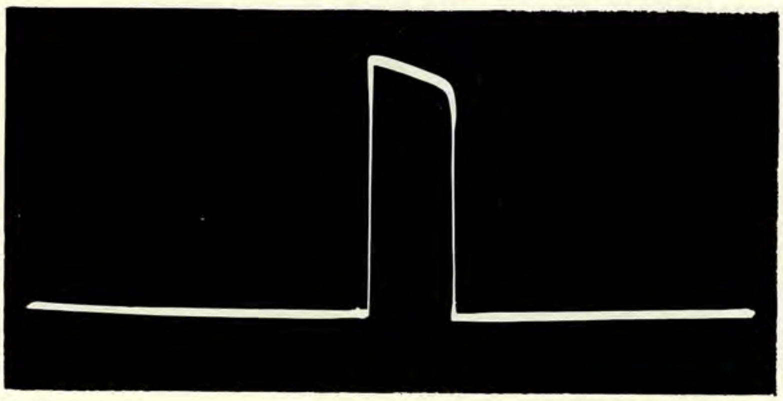
EXTERNAL test point: V1717 pin 5

GAIN settings: 50 LO

SWEEP SPEED: 500 #3

Notes: Use probe. Waveform shown for 100-μs sweep speed.

Figure 7–230. Test Scope, Sweep Generator Plate Waveform



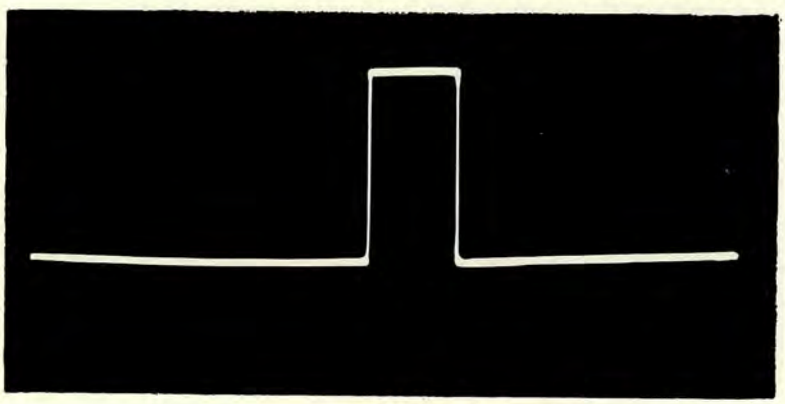
EXTERNAL test point: V1716 pin 1

GAIN settings: 30 LO

SWEEP SPEED: 750 #2

Notes: Use probe. Waveform shown for 100-μs sweep speed.

Figure 7–231. Test Scope, Clamp Cathode Waveform



EXTERNAL test point: V1716 pin 2

GAIN settings: 30 LO

SWEEP SPEED: 750 #2

Notes: Waveform shown for 100-μs sweep speed.

Figure 7–232. Test Scope, Clamp Plate Waveform

EXTERNAL test point: V1718 pin 5

GAIN settings: 38 LO

SWEEP SPEED: 750 #2

Notes: Waveform shown for 100-μs sweep speed.

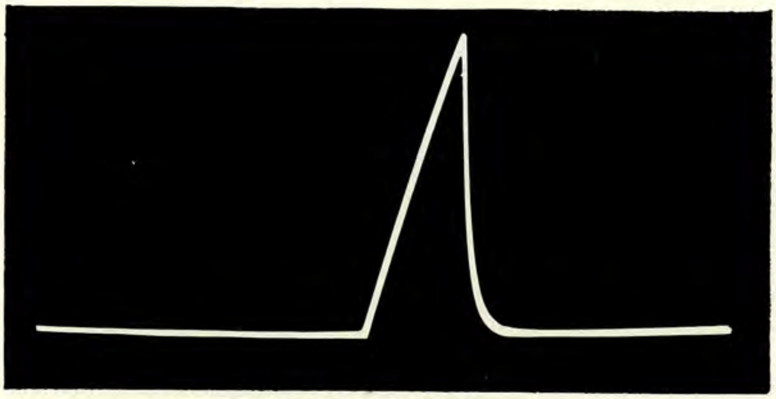


Figure 7–233. Test Scope, Paraphase Amplifier Plate Waveform

EXTERNAL test point: V1722 pin 3

GAIN settings: 40 LO

SWEEP SPEED: 1,000 #2

Notes: Waveform shown for 100-μs sweep speed.

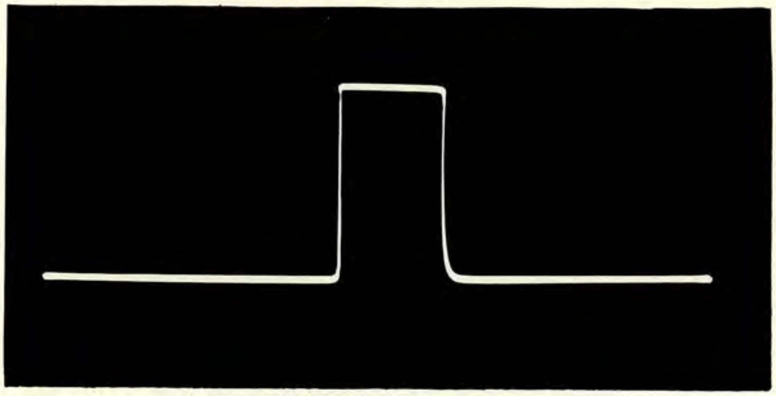


Figure 7–234. Test Scope, Intensifier Follower Cathode Waveform

TEST SIGNAL switch: V1710 pin 1

GAIN settings: 40 LO

SWEEP SPEED: 5,000 #1

Notes: S1703 on 1,000 μs MARKERS position.

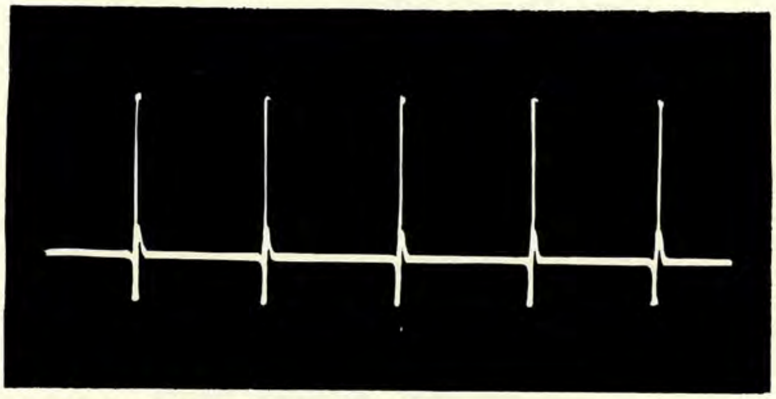


Figure 7–235. Test Scope, Marker Mixer Plate Waveform

EXTERNAL test point: V1710 pin 6

GAIN settings: 40 LO

SWEEP SPEED: 5,000 #1

Notes: S1703 on 1,000 μs MARKERS position.

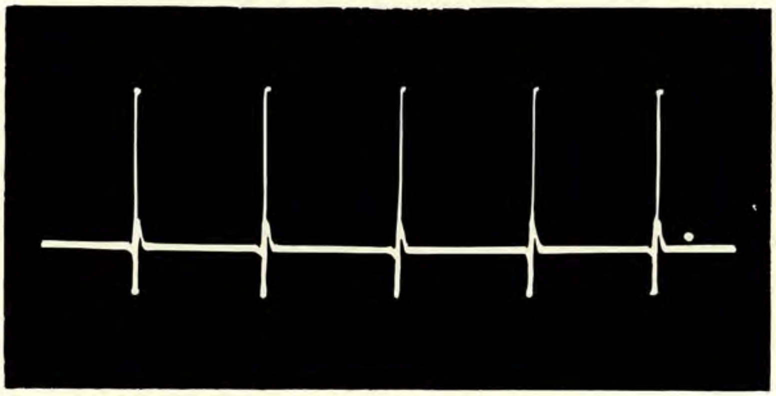
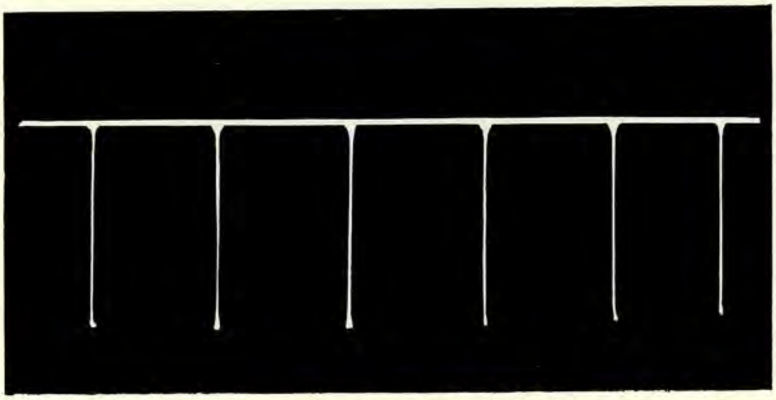


Figure 7–236. Test Scope, 1's Amplifier Plate Waveform



EXTERNAL test point: V1711 pin 1

GAIN settings: 30 LO

SWEEP SPEED: 5,000 #1

Notes: S1703 on 1,000 μs MARKERS position.

Figure 7–237. Test Scope, Marker Amplifier Plate Waveform

(3) TUBE CHARACTERISTICS CHART.—The tube characteristics chart, table 7–14, provides catalog data for each of the tube types employed in the timer. This data may be found useful when testing tubes in a tube tester which does not list specific control settings for the tubes shown. The emission test, shown in the last two columns, may be used as a rough check of tube performance with very simple equipment. The test shows the amount of emission current (I_S) the tube should pass when the grids of the tube are connected to the plate, in diode fashion, the required filament voltage is applied, and the specified test voltage is applied between plate and cathode.

Note

ALL TUBES OF A GIVEN TYPE SUPPLIED WITH THE EQUIPMENT SHALL BE CONSUMED PRIOR TO EMPLOYMENT OF TUBES FROM GENERAL STOCK.

(4) SOCKET VOLTAGES AND RESISTANCES.—The following general notes apply to the tube socket voltage and resistance charts, tables 7–15 through 7–26.

All readings were made with a multimeter similar to Army Type IS–189 (Simpson Model 260) using a sensitivity of 20,000 ohms/volt except where otherwise indicated.

All voltage readings were taken on the lowest meter scale possible except where specifically noted. Such specific scale information follows the voltage reading in this manner: "45 V (250 V sc.)".

All voltage and resistance measurements in columns 4 and 5 were made from the listed pins to ground. Each pin potential in column 4, unless preceded by a minus sign, is positive with respect to ground.

Voltage readings are not given where the measurement from pin to ground would exceed 1,000 volts. NEVER MEASURE POTENTIALS IN EXCESS OF 1,000 VOLTS BY MEANS OF FLEXIBLE TEST LEADS OR PROBES.

Certain resistances were too high for accurate measurement using the 20,000 ohms/volt instrument and were therefore measured with an appropriate VTVM.

The timer was set at "HIGH-O" rate for all measurements.

Certain voltage or resistance readings in columns 4 or 5 will vary when specific controls are operated. Descriptions of the factors which influence these readings are listed in column 6.

The readings for frequency divider binary counter stages are given for normal operation. For some stages the normal operation reading is followed by additional data taken with no input signal and with the tube removed. To disconnect the input signal move the TEST COUNT INSERT switch away from the OFF (CIRCUIT NORMAL) position. When measuring voltages of binary stages use care to insure that the stages do not reverse *on off* states because of transients set up as the meter lead is applied or removed.

All readings are typical measurements and in most cases deviations up to ±20 percent may be considered normal.

Every reasonable effort has been made to insure complete and accurate information; however, discrepancies may arise. The reason for any such discrepancy may usually be determined by comparison of the equipment with the schematic drawings.

(Text continued on page 7–123)

TABLE 7–14. TUBE CHARACTERISTICS

TUBE TYPE	FILAMENT VOLTAGE (V)	FILAMENT CURRENT (A)	PLATE VOLTAGE (V)	GRID BIAS (V)	SCREEN VOLTAGE (V)	PLATE CURRENT (MA)	SCREEN CURRENT (MA)	A-C PLATE RESISTANCE (OHMS)	VOLTAGE AMPLIFICATION FACTOR (MU)	TRANSCONDUCTANCE (MICROMHOS)		EMISSION	
										NORMAL	MINIMUM	I_s (MA)	TEST VOLT
OA2	0		150[1]			30[2]							
OB2	0		108[3]			30[2]							
2D21W	6.3	0.6	400	−3.7		16		2,000					
2X2A	2.5	1.75	200			42							
3RP1	6.3	0.6	[4]										
5CP1A	6.3	0.6	[5]	−60[6]									
5RP2A	5	2		[7]									
5R4WGY	5	2	750			250						225	75
5Y3WGTA	5	2	350			125						120	75
6AC7, 6AC7W	6.3	0.45	300	−2	150	10	2.5	1 meg		9,000	7,000	40	10
6AG7	6.3	0.65	300	−3	150	30	8	130,000		14,000	9,200	180	20
6AS7G	6.3	2.5	250			125		280	2.1	7,500	5,800	75	10
6AU6	6.3	0.3	150	−1	125	7.6	3	1.5 meg	36	4,450	4,150	60	20

1 Maximum d-c starting voltage is 185.
2 Maximum current.
3 Maximum d-c starting voltage is 133.
4 For anode No. 2 voltage of 2,000, maximum grid No. 1 voltage for visual cutoff is −135. Deflection factors for DJ_1 and DJ_2 are 146–198 v DC/in; for DJ_3 and DJ_4 they are 104–140 v DC/in.
5 Anode voltages are $A^1 = 575$, $A^2 = 2000$ and $A^3 = 4000$.
6 Cutoff grid voltage.
7 For an anode No. 2 voltage of 2,000, anode No. 1 voltage for focus is 362 to 695; grid No. 1 voltage for visual cutoff is −30 to −90; deflection factors of DJ_1 and DJ_2 are 102 to 154 v DC/in and for DJ_3 and DJ_4 are 97 to 145 v DC/in.

TABLE 7–14. TUBE CHARACTERISTICS (Cont'd)

TUBE TYPE	FILAMENT VOLTAGE (V)	FILAMENT CURRENT (A)	PLATE VOLTAGE (V)	GRID BIAS (V)	SCREEN VOLTAGE (V)	PLATE CURRENT (MA)	SCREEN CURRENT (MA)	A-C PLATE RESISTANCE (OHMS)	VOLTAGE AMPLIFICATION FACTOR (MU)	TRANSCONDUCTANCE (MICROMHOS)		EMISSION	
										NORMAL	MINIMUM	I_s (MA)	TEST VOLT
6CL6	6.3	0.65	250	−3	150	30	7	150,000		11,000			
6V6GT/G	6.3	0.45	250	−12.5	250	45	4.5	50,000		4,100	3,700	100	30
6Y6G	6.3	1.25	200	−14	135	61	2.2	18,300		7,100	5,800	180	30
12AT7	6.3	0.3	250	−2		10		10,000	55	5,500	4,000	50	10
5651	0	—	87[8]	—	—	3.5	—	——	—	——	——	—	—
5654	6.3	0.175	150	−2	140	7.5	2.5	420,000		5,000	3,750		
5725	6.3	0.175	120	−2	120	5.2	5	150,000		4,000	2,500	75	10
5726	6.3	0.3	165			9						40	10
5749	6.3	0.3	250	−1.5	100	11	4.2	750,000		4,400	3,600	60	20
5814	6.3	0.3	250	−8.5		11.8		7,000	17	3,100	2,200	70	30
5933	6.3	0.9	500	−45	250	100	6	3,000				300	50
6005	6.3	0.45	250	−125	250	45	4.5	52,000		4,100	3,000		

[8] Maximum d-c starting voltage is 115.

TABLE 7-15. SOCKET VOLTAGES AND RESISTANCES FOR RADIO FREQUENCY OSCILLATOR TYPE O-202/FPN-30

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V1401 (6AC7) Octal	1	Shell	0	0	
	2	Heater	0	0	
	3	Suppressor	0	0	
	4	Grid	0	37	
	5	Cathode	2	1k	
	6	Screen	77	108k	
	7	Heater	6.3ac	0	
	8	Plate	90	24k	
V1402 (6AC7) Octal	1	Shell	0	0	
	2	Heater	0	0	
	3	Suppressor	1.75	220	
	4	Grid	0	105k	
	5	Cathode	1.75	220	
	6	Screen	124	2k	
	7	Heater	6.3ac	0	
	8	Plate	124	2k	
V1403 (6AC7) Octal	1	Shell	0	0	
	2	Heater	0	0	
	3	Suppressor	1.95	240	
	4	Grid	0	18k	
	5	Cathode	1.95	240	
	6	Screen	130	1.18k	
	7	Heater	6.3ac	0	
	8	Plate	130	1.2k	
V1404 (6AC7) Octal	1	Shell	0	0	
	2	Heater	0	0	
	3	Suppressor	1.5	1.3k	
	4	Grid	0	58	
	5	Cathode	1.5	1.3k	
	6	Screen	20	270k	
	7	Heater	6.3ac	0	
	8	Plate	58	105k	
V1405 (6V6) Octal	1	—	—	—	The range of voltage given for pin 5 is for a stabilized oven temperature. This voltage may be considerably greater if the oven is cold.
	2	Heater	0	0	
	3	Plate	112	2.2	
	4	Screen	116	1.9	
	5	Grid	0 to −2	500	
	6	—	—	—	
	7	Heater	6.3ac	0	
	8	Cathode	3	210	

TABLE 7-16. SOCKET VOLTAGES AND RESISTANCES FOR SYNCHRONIZATION CONTROL TYPE C-1238/FPN-30

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V101 (5814) Noval	1	Plate A	150	4.8k	
	2	Grid A	0	1 meg	
	3	Cathode A	1.6	130	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	150	4.8k	
	7	Grid B	0	1 meg	
	8	Cathode B	1.6	130	
	9	Heater ct	6.3ac	0	

TABLE 7–16. SOCKET VOLTAGES AND RESISTANCES FOR SYNCHRONIZATION CONTROL TYPE C–1238/FPN–30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V102 (5814) Noval	1	Plate A	0 to 150	0 to 70k	All V102 readings taken with power switch on electrical synchronizer turned OFF. Voltages on plate A, grid A and cathode A depend on setting of R157. Plate A resistance to ground depends on setting of R157.
	2	Grid A	+0.25 to −1	1 meg	
	3	Cathode A	10 to 0	3k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	100	105k	
	7	Grid B	0	250k	
	8	Cathode B	5	3.3k	
	9	Heater ct	6.3ac	0	
V103 (5814) Noval	1	Plate A	60	50k	Resistance of grid A to ground is 1.9k with S101 on MASTER and 1.7k with S101 on SLAVE. Voltage on grid B is −26 with S101 on MASTER and −8.4 with S101 on SLAVE.
	2	Grid A	0	1.9k, 17k	
	3	Cathode A	2.6	1k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	93	50k	
	7	Grid B	−26, −8.4	1 meg	
	8	Cathode B	1	1k	
	9	Heater ct	6.3ac	0	
V104 (5814) Noval	1	Plate A	148	4.7k	
	2	Grid A	−17	1 meg	
	3	Cathode A	5	1.5k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	150	4.7k	
	7	Grid B	−5	1 meg	
	8	Cathode B	5	1.5k	
	9	Heater ct	6.3ac	0	
V105 (5814) Noval	1	Plate A	265	16k	
	2	Grid A	10 (50v sc)	1 meg	
	3	Cathode A	48	1.6k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	300	4.7k	
	7	Grid B	20 (50v sc)	1 meg	
	8	Cathode B	125	23k	
	9	Heater ct	6.3ac	0	
V106 (5814) Noval	1	Plate A	NC	NC	
	2	Grid A	NC	NC	
	3	Cathode A	NC	NC	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	150	4.6k	
	7	Grid B	0	1 meg	
	8	Cathode B	8	10k	
	9	Heater ct	6.3ac	0	
V107 (6005)	1	Grid 1	0	NC	In measuring V107 the power switch on the electrical synchronizer was turned off. Resistance of grid 1 to ground depends on setting of S104.
	2	Cathode	11	270	
	3	Heater	0	0	
	4	Heater	6.3ac	0	
	5	Plate	250	6k	
	6	Screen Grid	250	6k	
	7	Grid 1	0	470k, 1k	

TABLE 7–17. SOCKET VOLTAGES AND RESISTANCES FOR FREQUENCY DIVIDER TYPE CV–274/FPN–30*

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V202 (5814) Noval	1	Plate A	150	4.7k	Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	10v (50v sc)	1.1 meg	
	3	Cathode A	120	100k	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	208	13k	
	7	Grid B	−30	170k	
	8	Cathode B	0.1	5.0	
	9	Heater ct	75	50k	
V203 (5814) Noval	1	Plate A	219	22k	Resistances to ground from cathodes A and B depend on setting of R282. Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	150	33k	
	3	Cathode A	166	3k to 5.6k	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	218	23k	
	7	Grid B	152	26k	
	8	Cathode B	166	3k to 5.6k	
	9	Heater ct	75	50k	
V203 (5814) Noval SIGNAL INPUT REMOVED AND STAGE ON	1	Plate A	260		Refer to introductory notes regarding special care required for this measurement.
	2	Grid A	148		
	3	Cathode A	166		
	4	Heater	75		
	5	Heater	75		
	6	Plate B	200		
	7	Grid B	166		
	8	Cathode B	166		
	9	Heater ct	75		
V203 (5814) Noval SIGNAL INPUT REMOVED AND STAGE OFF	1	Plate A	200		Refer to introductory notes regarding special care required for this measurement.
	2	Grid A	166		
	3	Cathode A	166		
	4	Heater	75		
	5	Heater	75		
	6	Plate B	260		
	7	Grid B	153		
	8	Cathode B	166		
	9	Heater ct	75		
V203 (5814) Noval SIGNAL INPUT REMOVED AND TUBE REMOVED	1	Plate A	265		
	2	Grid A	180		
	3	Cathode A	158		
	4	Heater	75		
	5	Heater	75		
	6	Plate B	265		
	7	Grid B	178		
	8	Cathode B	158		
	9	Heater ct	75		
V204 (5814) Noval	1	Plate A	206	22k	Resistances from cathodes A and B to ground depend on setting of R282. Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	147	26k	
	3	Cathode A	160	1.2k to 4.3k	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	214	23k	
	7	Grid B	143	31k	
	8	Cathode B	160	1.2k to 4.3k	
	9	Heater ct	75	50k	

* All checks made using "High Zero Rate".

TABLE 7-17. SOCKET VOLTAGES AND RESISTANCES FOR FREQUENCY DIVIDER TYPE CV-274/FPN-30* (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V204	1	Plate A	260		Refer to introductory notes regarding special care required for this measurement.
(5814)	2	Grid A	146		
Noval	3	Cathode A	160		
SIGNAL	4	Heater	75		
INPUT	5	Heater	75		
REMOVED	6	Plate B	189		
AND STAGE	7	Grid B	160		
ON	8	Cathode B	160		
	9	Heater ct	75		
V204	1	Plate A	191		Refer to introductory notes regarding special care required for this measurement.
(5814)	2	Grid A	160		
Noval	3	Cathode A	160		
SIGNAL	4	Heater	75		
INPUT	5	Heater	75		
REMOVED	6	Plate B	260		
AND STAGE	7	Grid B	145		
OFF	8	Cathode B	160		
	9	Heater ct	75		
V204	1	Plate A	268		
(5814)	2	Grid A	182		
Noval	3	Cathode A	160		
SIGNAL	4	Heater	75		
INPUT	5	Heater	75		
REMOVED	6	Plate B	265		
AND TUBE	7	Grid B	186		
REMOVED	8	Cathode B	160		
	9	Heater ct	75		
V205 (5814) Noval	1	Plate A	208	23k	Resistances from cathodes A and B to ground depend on setting of R282. Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	148	30k	
	3	Cathode A	160	1.2k to 4.3k	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	219	23k	
	7	Grid B	145	35k	
	8	Cathode B	160	1.2k to 4.3k	
	9	Heater ct	75	50k	
V206 (5814) Noval	1	Plate A	192	22k	Resistances from cathodes A and B to ground depend on setting of R282. Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	144	34k	
	3	Cathode A	160	1.2k to 4.3k	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	219	22k	
	7	Grid B	138	34k	
	8	Cathode B	160	1.2k to 4.3k	
	9	Heater ct	75	50k	
V206	1	Plate A	260		Refer to introductory notes regarding special care required for this measurement.
(5814)	2	Grid A	148		
Noval	3	Cathode A	160		
SIGNAL	4	Heater	75		
INPUT	5	Heater	75		
REMOVED	6	Plate B	197		
AND STAGE	7	Grid B	160		
ON	8	Cathode B	160		
	9	Heater ct	75		

* All checks made using "High Zero Rate".

TABLE 7–17. SOCKET VOLTAGES AND RESISTANCES FOR FREQUENCY DIVIDER TYPE CV–274/FPN–30* (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V206	1	Plate A	196		Refer to introductory notes regarding special care required for this measurement.
(5814)	2	Grid A	160		
Noval	3	Cathode A	160		
SIGNAL	4	Heater	75		
INPUT	5	Heater	75		
REMOVED	6	Plate B	260		
AND STAGE	7	Grid B	143		
OFF	8	Cathode B	160		
	9	Heater ct	75		
V206	1	Plate A	265		
(5814)	2	Grid A	178		
Noval	3	Cathode A	160		
SIGNAL	4	Heater	75		
INPUT	5	Heater	75		
REMOVED	6	Plate B	265		
AND TUBE	7	Grid B	177		
REMOVED	8	Cathode B	160		
	9	Heater ct	75		
	1	Plate A	42	39k	Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	—.3 (2.5v sc)	1.1 meg	
	3	Cathode A	0	0	
V207	4	Heater	75	50k	
(5814)	5	Heater	75	50k	
Noval	6	Plate B	147	4.7k	
	7	Grid B	—26	70k	
	8	Cathode B	0	0	
	9	Heater ct	75	50k	
	1	Plate A	218	22k	Resistances from cathodes A and B to ground depend on setting of R282. Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	139	34k	
	3	Cathode A	160	1.2k to 4.3k	
V208	4	Heater	75	50k	
(5814)	5	Heater	75	50k	
Noval	6	Plate B	182	23k	
	7	Grid B	156	32k	
	8	Cathode B	160	1.2k to 4.3k	
	9	Heater ct	75	50k	
	1	Plate A	210	22k	Resistances from cathodes A and B to ground depend on setting of R282. Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	150	34k	
	3	Cathode A	160	1.2k to 4.3k	
V209	4	Heater	75	50k	
(5814)	5	Heater	75	50k	
Noval	6	Plate B	223	22k	
	7	Grid B	146	32k	
	8	Cathode B	160	1.2k to 4.3k	
	9	Heater ct	75	50k	
V209	1	Plate A	260		Refer to introductory notes regarding special care required for this measurement.
(5814)	2	Grid A	147		
Noval	3	Cathode A	160		
SIGNAL	4	Heater	75		
INPUT	5	Heater	75		
REMOVED	6	Plate B	191		
AND STAGE	7	Grid B	160		
ON	8	Cathode B	160		
	9	Heater ct	75		

* All checks made using "High Zero Rate".

TABLE 7-17. SOCKET VOLTAGES AND RESISTANCES FOR FREQUENCY DIVIDER TYPE CV-274/FPN-30* (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V209	1	Plate A	190		Refer to introductory notes regarding special care required for this measurement.
(5814)	2	Grid A	146		
Noval	3	Cathode A	160		
SIGNAL	4	Heater	75		
INPUT	5	Heater	75		
REMOVED	6	Plate B	260		
AND STAGE	7	Grid B	146		
OFF	8	Cathode B	160		
	9	Heater ct	75		
V209	1	Plate A	265		
(5814)	2	Grid A	188		
Noval	3	Cathode A	160		
SIGNAL	4	Heater	75		
INPUT	5	Heater	75		
REMOVED	6	Plate B	265		
AND TUBE	7	Grid B	184		
REMOVED	8	Cathode B	160		
	9	Heater ct	75		
	1	Plate A	209	22k	Resistances from cathodes A and B to ground depend on setting of R282. Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	149	34k	
	3	Cathode A	160	1.2k to 4.3k	
V210	4	Heater	75	50k	
(5814)	5	Heater	75	50k	
Noval	6	Plate B	224	23k	
	7	Grid B	146	32k	
	8	Cathode B	160	1.2k to 4.3k	
	9	Heater ct	75	50k	
	1	Plate A	188	22k	Resistances from cathodes A and B to ground depend on setting of R282. Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	132	32k	
	3	Cathode A	160	1.2k to 4.3k	
V211	4	Heater	75	50k	
(5814)	5	Heater	75	50k	
Noval	6	Plate B	240	23k	
	7	Grid B	143	29k	
	8	Cathode B	160	1.2k to 4.3k	
	9	Heater ct	75	50k	
	1	Plate A	38	38k	Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	−.25 (2.5v sc)	1.1 meg	
	3	Cathode A	0	0	
V212	4	Heater	75	50k	
(5814)	5	Heater	75	50k	
Noval	6	Plate B	147	5k	
	7	Grid B	−21	70k	
	8	Cathode B	0	0	
	9	Heater ct	75	50k	
	1	Plate A	218	40k	Resistances from cathodes A and B to ground depend on setting of R282. Voltage from either heater connection to heater ct is 6.3 ac.
	2	Grid A	146	49k	
	3	Cathode A	160	1.2k to 4.3k	
V213	4	Heater	75	50k	
(5814)	5	Heater	75	50k	
Noval	6	Plate B	214	39k	
	7	Grid B	147	57k	
	8	Cathode B	160	1.2k to 4.3k	
	9	Heater ct	75	50k	

* All checks made using "High Zero Rate".

TABLE 7-17. SOCKET VOLTAGES AND RESISTANCES FOR FREQUENCY DIVIDER TYPE CV-274/FPN-30* (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V214 (5814) Noval	1	Plate A	220	39k	Resistances from cathodes A and B to ground depend on setting of R282. Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	151	60k	
	3	Cathode A	160	1.2k to 4.3k	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	219	40k	
	7	Grid B	152	56k	
	8	Cathode B	160	1.2k to 4.3k	
	9	Heater ct			
V214 (5814) INPUT SIGNAL REMOVED AND STAGE ON	1	Plate A	265		Refer to introductory notes regarding special care required for this measurement.
	2	Grid A	143		
	3	Cathode A	160		
	4	Heater	75		
	5	Heater	75		
	6	Plate B	185		
	7	Grid B	160		
	8	Cathode B	160		
	9	Heater ct	75		
V214 (5814) Noval INPUT SIGNAL REMOVED AND STAGE OFF	1	Plate A	182		Refer to introductory notes regarding special care required for this measurement.
	2	Grid A	160		
	3	Cathode A	160		
	4	Heater	75		
	5	Heater	75		
	6	Plate B	265		
	7	Grid B	142		
	8	Cathode B	160		
	9	Heater ct	75		
V214 (5814) Noval INPUT SIGNAL REMOVED AND TUBE REMOVED	1	Plate A	270		
	2	Grid A	185		
	3	Cathode A	160		
	4	Heater	75		
	5	Heater	75		
	6	Plate B	270		
	7	Grid B	180		
	8	Cathode B	160		
	9	Heater ct	75		
V215 (5814) Noval	1	Plate A	221	39k	Resistances from cathodes A and B to ground depend on setting of R282. Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	152	58k	
	3	Cathode A	160	1.2k to 4.3k	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	220	40k	
	7	Grid B	153	54k	
	8	Cathode B	160	1.2k to 4.3k	
	9	Heater ct	75	0	
V216 (5814) Noval	1	Plate A	222	39k	Resistances from cathodes A and B to ground depend on setting of R282. Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	151	54k	
	3	Cathode A	160	1.2k to 4.3k	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	218	40k	
	7	Grid B	153	54k	
	8	Cathode B	160	1.2k to 4.3k	
	9	Heater ct	75	50k	

* All checks made using "High Zero Rate".

TABLE 7–17. SOCKET VOLTAGES AND RESISTANCES FOR FREQUENCY DIVIDER TYPE CV–274/FPN–30* (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V217 (5814) Noval	1	Plate A	258	40k	Resistances from cathodes A and B to ground depend on setting of R282. Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	144	50k	
	3	Cathode A	160	1.2k to 4.3k	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	184	39k	
	7	Grid B	160	57k	
	8	Cathode B	160	1.2k to 4.3k	
	9	Heater ct	75	50k	
V218 (5814) Noval	1	Plate A	23	118k	Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	0.55	520k	
	3	Cathode A	0	0	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	300	18k	
	7	Grid B	−20	500k	
	8	Cathode B	0	0	
	9	Heater ct	75	50k	
V219 (5814) Noval	1	Plate A	0	0	Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	0	0	
	3	Cathode A	7.2 (10v sc)	220k	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	300	4.7k	
	7	Grid B	−22	170k	
	8	Cathode B	0	0	
	9	Heater ct	75	50k	
V220 (5814) Noval	1	Plate A	218	39k	Resistances from cathodes A and B to ground depend on setting of R282. Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	152	66k	
	3	Cathode A	160	1.2k to 4.3k	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	219	40k	
	7	Grid B	151	66k	
	8	Cathode B	160	1.2k to 4.3k	
	9	Heater ct	75	50k	
V221 (5814) Noval	1	Plate A	110	17k	Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	−1.9 (2.5v sc)	1.7 meg	
	3	Cathode A	0	0	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	110	17k	
	7	Grid B	−1.9 (2.5v sc)	1.7 meg	
	8	Cathode B	0	0	
	9	Heater ct	75	50k	
V222 (12AT7) Noval	1	Plate A	144	8k	Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	−21 (50v sc)	440k	
	3	Cathode A	0	0	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	144	8k	
	7	Grid B	−1.2 (2.5v sc)	430k	
	8	Cathode B	0	0	
	9	Heater ct	75	50k	

* All checks made using "High Zero Rate".

TABLE 7–17. SOCKET VOLTAGES AND RESISTANCES FOR FREQUENCY DIVIDER TYPE CV–274/FPN–30* (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V223 (6AU6) Noval	1	Grid 1	−0.4(2.5v sc)	450k	
	2	Suppressor Grid	0	0	
	3	Heater	75	50k	
	4	Heater	75	50k	
	5	Plate	120	18k	
	6	Screen Grid	147	6k	
	7	Cathode	0	0	
V224 (5814) Noval	1	Plate A	26, 143	235k	Voltage from plate A to ground is 26 with S206 OFF and 143 with it ON. Voltage from cathode A to ground is 0 with S206 OFF and 12 with it ON. Resistance from cathode A to ground is 0 with S206 ON and infinite with S206 OFF.
	2	Grid A	−0.55	1.1 meg	
	3	Cathode A	0, 12	0, inf	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	−0.4(2.5v sc)	1.1 meg	
	7	Grid B	−0.4(2.5v sc)	1.1 meg	
	8	Cathode B	0.3(2.5v sc)	1.1 meg	
	9	Heater ct	75	50k	
V225 (5814) Noval	1	Plate A	200 to 212	52k	Voltage from plate A to ground depends on setting of R264. Resistance of grid A to ground depends on setting of R264. Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	0	0 to 1 meg	
	3	Cathode A	12	12k	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	207	52k	
	7	Grid B	0	2.5 meg	
	8	Cathode B	12	12k	
	9	Heater ct	75	50k	
V226 (6AU6) 7–pin	1	Grid 1	−0.35(2.5v sc)	1 meg to 1.1 meg	Voltage from plate to ground depends on setting of R275. Voltage from screen grid to ground depends on setting of R255 and R275. Voltage between heater connections (pins 3 and 4) is 6.3 ac. Resistance from grid 1 to ground depends on setting of R254.
	2	Suppressor Grid	−0.4(2.5v sc)	1 meg	
	3	Heater	75	50k	
	4	Heater	75	50k	
	5	Plate	285 to 104	64k	
	6	Screen Grid	105 to 143	17k	
	7	Cathode	0	0	
V227 (6AU6) 7–pin	1	Grid 1	0 to −0.35	1 meg to 1.1 meg	Voltage and resistance from grid 1 to ground depend on setting of R255. Voltages from plate and screen grid to ground depend on setting of R255 and R275. Voltage between heater connections (pin 3 and 4) is 6.3 ac.
	2	Suppressor Grid	0	0	
	3	Heater	75	50k	
	4	Heater	75	50k	
	5	Plate	300 to 125	67k	
	6	Screen Grid	105 to 143	17k	
	7	Cathode	0	0	
V228 (5814) Noval	1	Plate A	300	500k	Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	−5(10v sc)	1 meg	
	3	Cathode A	0	0	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	19	130k	
	7	Grid B	0	1 meg	
	8	Cathode B	0	0	
	9	Heater ct	75	50k	

* All checks made using "High Zero Rate".

TABLE 7–17. SOCKET VOLTAGES AND RESISTANCES FOR FREQUENCY DIVIDER TYPE CV–274/FPN–30* (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V229 (5814) Noval	1	Plate A	0	0	Voltages from grid B and plate B to ground were read with K201 operating. Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	0	0	
	3	Cathode A	0	290k	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	300	6k	
	7	Grid B	−5 (10v sc)	670k	
	8	Cathode B	0	inf	
	9	Heater ct	75	50k	
V230 (12AT7) Noval	1	Plate A	300, 15	110	Voltage from plate A to ground is normally 300 and becomes 15 with S204 depressed. Voltage from grid A to ground measured with K201 operated. Voltage from cathode A to ground measured with K202 operated. Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac.
	2	Grid A	−5	500k	
	3	Cathode A	0	inf	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	300	6k	
	7	Grid B	0.4 (2.5v sc)	1 meg	
	8	Cathode B	137	100k	
	9	Heater ct	75	50k	
V231 (5726) 7–pin	1	Cathode B	150	67k	Voltage between heater connections (pins 3 and 4) is 6.3 ac.
	2	Plate A	300	4.7k	
	3	Heater	75	50k	
	4	Heater	75	50k	
	5	Cathode A	300	4.7k	
	6	Internal Shield	NC	NC	
	7	Plate B	150	170k	
V232 (2D21W) 7–pin	1	Grid 1	−15, 0	53k	Voltage from grid 1 to ground is −15 normally and 0 with S204 operated. Voltage from plate to ground is 300 normally and 15 when S204 operated. Voltage between heater connections (pins 3 and 4) is 6.3 ac.
	2	Cathode	0	100	
	3	Heater	75	50k	
	4	Heater	75	50k	
	5	Grid 2	NC	NC	
	6	Plate	300, 15	540k	
	7	Grid 2	0	100	
V233 (5814) Noval	1	Plate A	208	39k	Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac. Resistances from cathodes A and B to ground depend on setting of R282.
	2	Grid A	155	64k	
	3	Cathode A	160	1.2k to 4.3k	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	235	39k	
	7	Grid B	149	65	
	8	Cathode B	160	1.2k to 4.3k	
	9	Heater ct	75	50k	
V234 (5814) Noval	1	Plate A	208	39k	Voltage from either heater connection (pin 4 or 5) to heater ct is 6.3 ac. Resistances from cathodes A and B to ground depend on setting of R282.
	2	Grid A	155	65k	
	3	Cathode A	160	1.2k to 4.3k	
	4	Heater	75	50k	
	5	Heater	75	50k	
	6	Plate B	235	39k	
	7	Grid B	148	63k	
	8	Cathode B	160	1.2k to 4.3k	
	9	Heater ct	75	50k	

* All checks made using "High Zero Rate".

TABLE 7–17. SOCKET VOLTAGES AND RESISTANCES FOR FREQUENCY DIVIDER TYPE CV–274/FPN–30* (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V235 (6AG7) Octal	1	Shell	NC	NC	Voltage between heater connections (pins 2 and 7) is 6.3 ac.
	2	Heater	75	50k	
	3	Interlead Shield	NC	NC	
	4	Grid 1	14	100k	
	5	Cathode	24	1.1k	
	6	Screen Grid	148	5k	
	7	Heater	75	50k	
	8	Plate	148	5k	

* All checks made using "High Zero Rate".

TABLE 7–18. SOCKET VOLTAGES AND RESISTANCES FOR TIME DELAY TYPE TD–92/FPN–30

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V501 (5814) Noval	1	Plate A	147 to 95	55k	Voltage from plate A to ground depends on setting of R609 and R502. Voltage from plate B to ground depends on setting of R610 and, with S504 at NORMAL, on setting of R532.
	2	Grid A	−25 (250v sc)	1 meg	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	102 to 147	55k	
	7	Grid B	−25 (250v sc)	1 meg	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V502 (5725) 7-pin	1	Grid 1	−1.3	1 meg	Voltages to ground from plate, screen, grid and suppressor grid depend on setting of R609 and R502. Screen and suppressor resistance to ground depends on setting of R609.
	2	Cathode	0	0	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	95 to 147	55k	
	6	Screen Grid	42 to 83	22k to 24k	
	7	Suppressor Grid	−3 to −17	14k to 30k	
V503 (5814) Noval	1	Plate A	18.5 to 20	50k	Voltages to ground from plate A, grid A and plate B depends on setting of R511.
	2	Grid A	−0.7 to −0.9	2.2 meg	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	18.5 to 20	50k	
	7	Grid B	−0.35	1 meg	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V504 (12AT7) Noval	1	Plate A	70	16k	
	2	Grid A	0.4	520k	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	70	16k	
	7	Grid B	−0.2	1 meg	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V505 (5814) Noval	1	Plate A	145	115k	Voltages and resistances from plate B and grid B to ground depend on setting of R609.
	2	Grid A	−2 (10v sc)	5 meg	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	−3 to −17	14k to 30k	
	7	Grid B	−3 to −17	14k to 30k	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	

TABLE 7–18. SOCKET VOLTAGES AND RESISTANCES FOR TIME DELAY TYPE TD–92/FPN–30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V506 (5814) Noval	1	Plate A	300	52k	Voltage and resistance of grid A to ground depend on setting of R529. Voltage of plate B to ground depends on setting of R529.
	2	Grid A	0 to 15	0 to 25k	
	3	Cathode A	46	4.7k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	117 to 120	26k	
	7	Grid B	48	1 meg	
	8	Cathode B	46	4.7k	
	9	Heater ct	6.3 ac	0	
V507 (5814) Noval	1	Plate A	300	52k	Voltage and resistance of cathode B to ground were measured when the timer was connected to switch gear as an operating timer.
	2	Grid A	−7.5	1 meg	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	300	4.5k	
	7	Grid B	−4	2.2 meg	
	8	Cathode B	72	15k	
	9	Heater ct	6.3 ac	0	
V508 (5725) 7-pin	1	Grid 1	−0.8	1 meg	Plate, screen and suppressor voltages to ground depend on setting of R610. Plate and screen voltages to ground also depend on the setting of R532 if S504 is at NORMAL. Screen and suppressor resistances to ground depend on the setting of R610.
	2	Cathode	0	0	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	96 to 147	56k	
	6	Screen Grid	40 to 8	23k to 25k	
	7	Suppressor Grid	−2 to 17	25k to 32k	
V509 (5814) Noval	1	Plate A	16.5 to 19	53k	Voltages of plate A, plate B, and grid B to ground depend on the setting of R545.
	2	Grid A	−0.2	1 meg	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	16.5 to 19	53k	
	7	Grid B	−0.2 to −0.5	1 meg	
	8	Cathode B	0	0	
	9	Heater	6.3 ac	0	
V510 (5814) Noval	1	Plate A	135 to 146	56k	Voltage from plate A to ground depends on setting of R629. Voltages and resistances from plate B and grid B to ground depend on setting of R610.
	2	Grid A	−0.8(2.5v sc)	5 meg	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	−2 to −17	15k to 32k	
	7	Grid B	−2 to −17	15k to 32k	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V511 (5725) 7-pin	1	Grid 1	0 to 0.15	500k	Voltages from grid 1, plate, screen and suppressor to ground depend on the setting of R629 and with S504 at NORMAL on the setting of R561. Resistances from the screen and suppressor grids to ground depend on the setting of R629.
	2	Cathode	0	0	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	135 to 146	56k	
	6	Screen Grid	34 to 75	22k to 24k	
	7	Suppressor Grid	−2 to −14	15k to 29k	

TABLE 7–18. SOCKET VOLTAGES AND RESISTANCES FOR TIME DELAY TYPE TD–92/FPN–30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V512 (5814) Noval	1 2 3 4 5 6 7 8 9	Plate A Grid A Cathode A Heater Heater Plate B Grid B Cathode B Heater ct	14.5 to 17 −0.4 to −0.7 0 0 0 14.5 to 17 −0.35 0 6.3 ac	52k 1 meg to 1.1 meg 0 0 0 52k 1 meg 0 0	Voltages from plate A, grid A and plate B to ground depend on setting of R557. Resistance from grid A to ground depends on R557.
V513 (5725) 7-pin	1 2 3 4 5 6 7	Grid 1 Cathode Heater Heater Plate Screen Grid Suppressor Grid	−1.5 to −0.75 0 0 6.3 ac 80 to 146 38 to 74 0 to −13	540k 0 0 0 56k 22k to 24k 15k to 28k	Voltages from grid 1, plate, screen and suppressor to ground depend on setting of R630. Voltages from plate, screen and suppressor to ground, with S504 at NORMAL, depend on setting of R581. Resistances from screen and suppressor to ground depend on setting of R630.
V514 (12AT7) Noval	1 2 3 4 5 6 7 8 9	Plate A Grid A Cathode A Heater Heater Plate B Grid B Cathode B Heater ct	73 to 78 0.2 to 0.45 0 0 0 73 to 78 −0.70 0 6.3 ac	16k 1 meg to 1.1 meg 0 0 0 16k 1 meg 0 0	Voltages from plate A, grid A and plate B to ground depend on setting of R574. Resistance from grid A to ground depends on setting of R574.
V515 (5814) Noval	1 2 3 4 5 6 7 8 9	Plate A Grid A Cathode A Heater Heater Plate B Grid B Cathode B Heater ct	105 to 140 −8.4 0 0 0 0 to −13 0 to −13 0 6.3 ac	56k 1 meg 0 0 0 15k to 28k 15k to 28k 0 0	Voltage from plate A to ground depends on setting of R631. Voltages from plate B and grid B to ground depend on setting of R630 and, when S304 is at NORMAL, on the setting of R581. Resistances of plate B and grid B to ground depend on the setting of R630.
V516 (5725) 7-pin	1 2 3 4 5 6 7	Grid 1 Cathode Heater Heater Plate Screen Grid Suppressor Grid	+0.45 to −1.25 0 0 6.3 ac 107 to 140 70 to 34 +11 to −14	540k 0 0 0 56k 22k to 24k 15k to 28k	Voltages from grid 1, plate, screen and suppressor to ground depend on setting of R631. Resistances from screen and suppressor to ground depend on setting of R631.

TABLE 7–18. SOCKET VOLTAGES AND RESISTANCES FOR TIME DELAY TYPE TD–92/FPN–30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V517 (5814) Noval	1	Plate A	148	4.9k	
	2	Grid A	−5.2	1 meg	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	148	4.9k	
	7	Grid B	−6.9	1 meg	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V518 (5814) Noval	1	Plate A	147	30k	
	2	Grid A	−15	1 meg	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	33	42k	
	7	Grid B	0.1	1 meg	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V519 (5814) Noval	1	Plate A	+11 to −4	15k to 28k	Voltages and resistances of plate A and grid A to ground depend on the setting of R631.
	2	Grid A	+11 to −4	15k to 28k	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	75	16k	
	7	Grid B	0.6	47k	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V520 (2D21W) 7-pin	1	Grid 1	−14.5 (5v sc)	1.2 meg	Resistances of cathode and grid 2 to ground were measured with plug disconnected from J510.
	2	Cathode	0	47	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Grid 2	NC	NC	
	6	Plate	95	510k	
	7	Grid 2	0	47	
V521 (5726) 7-pin	1	Cathode B	95 to 147	55k	Voltages from cathode A and cathode B to ground depend on setting of R609. Voltages and resistances of plate A and plate B to ground depend on setting of R502. Voltage from cathode A to ground depends on setting of R502.
	2	Plate A	72 to 147	5k to 28k	
	3	Heater	0	0	
	4	Heater	6.3ac	0	
	5	Cathode A	110 to 147	55k	
	6	Internal Shield	NC	NC	
	7	Plate B	72 to 147	5k to 28k	
V522 (5726) 7-pin	1	Cathode B	96 to 147	55k	Voltages from cathode A, plate A, cathode B and plate B to ground (also plates A and B resistance) depend on setting of R532 when S504 is at NORMAL. Voltage from cathodes A and B to ground depend on setting of R610.
	2	Plate A	77 to 148	5k to 28k	
	3	Heater	0	0	
	4	Heater	6.3ac	0	
	5	Cathode A	96 to 147	55k	
	6	Internal Shield	NC	NC	
	7	Plate B	77 to 148	5k to 28k	

TABLE 7–18. SOCKET VOLTAGES AND RESISTANCES FOR TIME DELAY TYPE TD–92/FPN–30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V523 (5726) 7-pin	1 2 3 4 5 6 7	Cathode B Plate A Heater Heater Cathode A Internal Shield Plate B	135 to 146 73 to 148 0 6.3ac 13.5 to 14.6 NC 73 to 148	56k 5k to 28k 0 0 56k NC 5k to 28k	Voltage from cathodes A and B to ground depend on setting of R629. Voltage and resistance from plates A and B to ground depend, when S504 is at NORMAL, on the setting of R561.
V524 (5726) 7-pin	1 2 3 4 5 6 7	Cathode B Plate A Heater Heater Cathode A Internal Shield Plate B	80 to 146 73 to 148 0 6.3ac 80 to 146 NC 73 to 148	56k 5k to 28k 0 0 56k NC 5k to 28k	Voltage from cathodes A and B to ground depends on setting of R630. Voltages from cathode A, plate A, cathode B and plate B to ground depend on setting of R581 when S504 is at NORMAL position. Resistance from plates A and B to ground depends, when S504 is at NORMAL, on setting of R581.
V525 (5726) 7-pin	1 2 3 4 5 6 7	Cathode B Plate A Heater Heater Cathode A Internal Shield Plate B	107 to 140 107 to 140 0 6.3ac 140 NC 68 to 118	56k 56k 0 0 15k NC 132k to 147k	Voltages from cathode B and plate A to ground depend on the setting of R631. Voltage and resistance from plate B to ground depend on setting of R601.
V526 (5814) Noval	1 2 3 4 5 6 7 8 9	Plate A Grid A Cathode A Heater Heater Plate B Grid B Cathode B Heater ct	80 to 146 —15 (50v sc) 0 0 0 —2 to —14 —2 to —14 0 6.3ac	56k 1 meg 0 0 0 15k to 29k 15k to 29k 0 0	Voltage from plate A to ground with S504 at NORMAL depends on setting of R629 and R630. Voltages from plate B and cathode B to ground depend, with S504 at NORMAL, on setting of R561 and R629. Resistances from plate B and cathode B to ground depend on setting of R629.
V527 (5814) Noval	1 2 3 4 5 6 7 8 9	Plate A Grid A Cathode A Heater Heater Plate B Grid B Cathode B Heater ct	150 0 to 5.4 8 to 15.5 0 0 148 —15 (50v sc) 0 6.3ac	4.9k 80k to 100k 100k 0 0 5k 52k 0 0	Voltage from grid A and cathode A to ground depend on setting of S503. Resistance from grid A to ground depends on setting of S503.

TABLE 7–18. SOCKET VOLTAGES AND RESISTANCES FOR TIME DELAY TYPE TD–92/FPN–30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V528 (5726) 7-pin	1	Cathode B	0	0	
	2	Plate A	—15 (50v sc)	1 meg	
	3	Heater	0	0	
	4	Heater	6.3ac	0	
	5	Cathode A	0	0	
	6	Internal Shield	NC	NC	
	7	Plate B	—15 (50v sc)	1 meg	

TABLE 7–19. SOCKET VOLTAGES AND RESISTANCES FOR RADIO RECEIVER TYPE R–564/FPN–30

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V1201 (5749) 7-pin	1	Grid 1	—2 to —28	1 meg	Voltage from grid 1 to ground depends on position of S1203 and the setting of R1303. Value is —2 with S1203 out. Voltages from suppressor, plate, screen and cathode to ground also measured as above. The values with S1203 out are in order: 19, 143, 106 and 19. Resistances from plate and screen to ground are infinite with S1201 out.
	2	Suppressor Grid	2 to 19	820	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	143 to 147	5.5k to inf	
	6	Screen Grid	106 to 126	40k to inf	
	7	Cathode	2 to 19	820	
V1202 (5749) 7-pin	1	Grid 1	0 to —26	42k to 51k	Voltage and resistance from grid 1 to ground depend on setting of R1228 and R1229. Voltages from plate, screen and cathode to ground depend on setting of R1228 and R1229.
	2	Suppressor Grid	0	0	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	117 to 144	6.4k	
	6	Screen	78 to 106	7k	
	7	Cathode	0.45 to 0	33	
V1203 (5749) 7-pin	1	Grid 1	0 to —26	42k to 52k	Voltages from grid 1, plate, screen and cathode to ground depend on setting of R1228 and R1229. Resistance from grid 1 to ground depends on setting of R1228 and R1229.
	2	Suppressor Grid	0	0	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	118 to 145	6.4k	
	6	Screen Grid	80 to 106	7.2k	
	7	Cathode	0.50 to 0	33	
V1204 (5749) 7-pin	1	Grid 1	0 to —26	33k to 42k	Voltages from grid 1, plate, screen and cathode to ground depend on setting of R1228 and R1229. Resistance from grid 1 to ground depends on setting of R1228 and R1229.
	2	Suppressor Grid	0	0	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	120 to 145	6.3k	
	6	Screen Grid	80 to 106	7k	
	7	Cathode	0.45 to 0	33	

TABLE 7–19. SOCKET VOLTAGES AND RESISTANCES FOR RADIO RECEIVER TYPE R–564/FPN–30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V1205 (5749) 7-pin	1	Grid 1	0 to −26	31k to 42k	Voltages from grid 1, plate, screen and cathode to ground depend on setting of R1228 and R1229. Resistance from grid 1 to ground depends on setting of R1228 and R1229.
	2	Suppressor Grid	0	0	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	118 to 142	6.4k	
	6	Screen Grid	88 to 108	6.9k	
	7	Cathode	0 to 0.4	33	
V1206 (5654) 7-pin	1	Grid 1	0	3.3k	
	2	Cathode	2.4	330	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	131	6.2k	
	6	Screen Grid	120	22k	
	7	Cathode	2.4	330	
V1207 (6005) 7-pin	1	Grid 1	0	4.7	
	2	Cathode	5.8	220	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	143	4.5k	
	6	Screen Grid	143	5k	
	7	Grid 1	0	4.7k	
V1208 (6CL6) Noval	1	Cathode	3.4 to 4	150	Voltages from cathode, grid 1 and suppressor to ground depend on setting of R1228 and R1229.
	2	Grid 1	0 to −6.3	10k	
	3	Screen Grid	143	4.5k	
	4	Heater	0	0	
	5	Heater	6.3 ac	0	
	6	Plate	143	4.5k	
	7	Suppressor Grid	3.4 to 4	150	
	8	Screen Grid	143	4.5k	
	9	Grid 1	0 to −6.3	10k	
V1209 (5726) 7-pin	1	Cathode B	0	3.5	Voltages from plates A and B to ground were measured with gain controls at minimum (CCW).
	2	Plate A	0	47k	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Cathode A	0	3.5	
	6	Internal Shield	NC	NC	
	7	Plate B	0	47k	
V1210 (5814) Noval	1	Plate A	95	28k	Voltage from grid A to ground depends on position of S1203 and the setting of R1303. This voltage is −2 with S1203 out.
	2	Grid A	−2 to −7	700k	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	95	28k	
	7	Grid B	0	220k	
	8	Cathode B	36	9.5k	
	9	Heater ct	6.3 ac	0	

TABLE 7-19. SOCKET VOLTAGES AND RESISTANCES FOR RADIO RECEIVER TYPE R-564/FPN-30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V1211 (5814) Noval	1	Plate A	0 to −30	0 to −13k	All readings for triode section A taken with S1202 closed. Resistance of cathode A to ground becomes infinity. Voltages and resistances from plate A and grid A to ground depend on setting of R1289. Voltage from cathode A to ground depends on setting of R1289, R1229, and R1228. Readings for section B measured with gain controls at minimum (CCW).
	2	Grid A	0 to −30	0 to −13k	
	3	Cathode A	0 to 3	49k or inf	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	117	15k	
	7	Grid B	0.35 (2.5v sc)	1 meg	
	8	Cathode B	31	11k	
	9	Heater ct	6.3 ac	0	
V1212 (5654) 7-pin	1	Grid 1	0	1 meg	
	2	Suppressor Grid	3	2.2k	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	72	75k	
	6	Screen Grid	92	170k	
	7	Cathode	3	2.2k	
V1213 (5814) Noval	1	Plate A	104	16k	Voltages from plate B and grid B to ground depend on setting of R1228 and R1229.
	2	Grid A	0	1 meg	
	3	Cathode A	3.3	820	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	−2 to −28	1 meg	
	7	Grid B	−2 to −28	1 meg	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V1214 (5814) Noval	1	Plate A	145	4.5k	
	2	Grid A	0.45 (2.5v sc)	1 meg	
	3	Cathode A	61	23k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	145	4.5k	
	7	Grid B	0.48 (2.5v sc)	1 meg	
	8	Cathode B	58	51k	
	9	Heater ct	6.3 ac	0	
V1215 (5654) 7-pin	1	Grid 1	0	1 meg	
	2	Suppressor Grid	2.8	2.2k	
	3	Heater	0	0	
	4	Heater	0	0	
	5	Plate	83	75k	
	6	Screen Grid	92	155k	
	7	Cathode	2.8	2.2k	
V1216 (5814) Noval	1	Plate A	145	4.5k	Readings of section B taken with no headphones in jack J1209.
	2	Grid A	0.4 (2.5v sc)	1 meg	
	3	Cathode A	62	10k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	145	4.5k	
	7	Grid B	0.5 (2.5v sc)	1 meg	
	8	Cathode B	104	47k	
	9	Heater ct	6.3 ac		

TABLE 7–20. SOCKET VOLTAGES AND RESISTANCES FOR SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V801 (5726) 7-pin	1	Cathode B	140	95k	Voltage and resistance from plate A to ground depends on setting of R804. Voltage from cathode A and plate B to ground depends on setting of R959.
	2	Plate A	65 to 137	12k to 28k	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Cathode A	140 to 136	55k	
	6	Internal Shield	NC	NC	
	7	Plate B	140 to 136	55k	
V802 (5725) 7-pin	1	Grid 1	0	530k	Voltages from plate, screen grid and suppressor grid to ground depend on setting of R959. Resistances from screen grid and suppressor grid to ground depend on setting of R959.
	2	Cathode	0	0	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	140 to 136	55k	
	6	Screen Grid	38 to 52	21k to 23k	
	7	Suppressor Grid	−5 to −13.5	14k to 28k	
V803 (5814) Noval	1	Plate A	−5 to −13.5	14k to 28k	Voltages and resistances from plate A and grid A to ground depend on setting of R959.
	2	Grid A	−5 to −13.5	14k to 28k	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	150	4.8k	
	7	Grid B	0	10k	
	8	Cathode B	6	2.7k	
	9	Heater ct	6.3 ac	0	
V804 (6AU6) 7-pin	1	Grid 1	−0.6 to 0.6	650k to 800k	Voltages from grid 1 and suppressor grid to ground depend on setting of R813. Voltages from plate and screen grid to ground depend on setting of R813 and R824. Resistance from grid 1 to ground depends on setting of R813. Resistances from plate to ground depends on setting of R824.
	2	Suppressor Grid	−93 to −100	1 meg	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	152 to 290	48k to 78k	
	6	Screen Grid	56 to 88	54k	
	7	Cathode	0	0	
V805 (5726) 7-pin	1	Cathode B	−93 to −100	1 meg	Voltages from cathode B and plate A to ground depend on setting of R813.
	2	Plate A	−93 to −100	1 meg	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Cathode A	0	0	
	6	Internal Shield	NC	NC	
	7	Plate B	−104	7k	
V806 (6AU6) 7-pin	1	Grid 1	0 to −1.5	1 meg	Voltage from grid 1 to ground depends on setting of R836. Voltage from plate to ground depends on setting of R836 and R824. Resistance from plate to ground depends on setting of R824.
	2	Suppressor Grid	0	0	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	8 to 300	47k to 76k	
	6	Screen Grid	147	4.8k	
	7	Cathode	0	0	

TABLE 7–20. SOCKET VOLTAGES AND RESISTANCES FOR SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V807 (5814) Noval	1	Plate A	−0.6 to 0.6	650k to 800k	Voltages from plate A, grid A, grid B and cathode B to ground depend on setting of R813. Resistances from plate A and grid A to ground depend on setting of R813.
	2	Grid A	−0.6 to 0.6	650k to 800k	
	3	Cathode A	1.2	470k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	150	4.8k	
	7	Grid B	−93 to −100	1 meg	
	8	Cathode B	−24 to −28	28k	
	9	Heater ct	6.3 ac	0	
V808 (5814) Noval	1	Plate A	20	245k	Resistance from grid B to ground depends on setting of R846.
	2	Grid A	0	68k	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	118	220k	
	7	Grid B	0	0 to 90k	
	8	Cathode B	6.5	6.8k	
	9	Heater ct	6.3 ac	0	
V809 (5933) 5-pin	1	Heater	0	0	
	2	Screen Grid	260	200k	
	3	Grid 1	0	470k	
	4	Cathode	25	1.6k	
	5	Heater	6.3 ac	0	
	Cap	Plate	585	500k	
V810 (6AU6) 7-pin	1	Grid 1	0 to −0.5	1 meg	Voltage from grid 1 to ground depends on setting of R945. Voltage from plate to ground depends on setting of R929 and R945. Resistance from plate to ground depends on setting of R929.
	2	Suppressor Grid	0	0	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	5 to 300	51k to 76k	
	6	Screen Grid	150	4.8k	
	7	Cathode	0	0	
V811 (5814) Noval	1	Plate A	37	52k	
	2	Grid A	−1.6	36k	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	0.6	210k	
	7	Grid B	−0.6	1 meg	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V812 (5814) Noval	1	Plate A	87	16k	Voltages from plate B and grid B to ground depend on setting of R852.
	2	Grid A	−0.6	1 meg	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	164 to 300	100k	
	7	Grid B	−28 to −56	1 meg	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	

TABLE 7–20. SOCKET VOLTAGES AND RESISTANCES FOR SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V813 (5814) Noval	1	Plate A	141 to 146	6k	Voltages from plate A and grid A to ground depend on setting of R966. Voltages from plate B to grid B to ground depend on setting of R898. Resistance from grid A to ground depends on setting of R966.
	2	Grid A	−7 to 37	110k to 172k	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	300 to 165	105k	
	7	Grid B	−11 to −22	2.2 meg	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V814 (5814) Noval	1	Plate A	137 to 147	7.2k	Voltages from plate A and B to ground depend on setting of R967 and R876. Voltage from grid A to ground depends on setting of R967. Voltage from grid B to ground depends on setting of R876.
	2	Grid A	−7 to −23	1 meg	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	137 to 147	7.2k	
	7	Grid B	−24 to −51	1.1 meg	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V815 (6AG7) Octal	1	Shell	0	0	
	2	Heater	0	0	
	3	Interlead Shield	0	0	
	4	Grid 1	0	100k	
	5	Cathode	2.9	100	
	6	Screen Grid	148	4.8k	
	7	Heater	6.3 ac	0	
	8	Plate	300	4.6k	
V816 (5726) 7-pin	1	Cathode B	140	95k	Voltage and resistance from plate A to ground depend on setting of R918. Voltages from cathode A and plate B to ground depend on setting of R960.
	2	Plate A	67 to 138	13k to 31k	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Cathode A	117 to 140	55k	
	6	Internal Shield	0	inf	
	7	Plate B	117 to 140	55k	
V817 (5715) 7-pin	1	Grid 1	0.5	500k	Voltages and resistances from screen grid and suppressor grid to ground depend on setting of R960. Voltages from plate to ground depends on setting of R960.
	2	Cathode	0	0	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	117 to 140	55k	
	6	Screen Grid	34 to 47	21k to 23k	
	7	Suppressor Grid	−6 to −14	16k to 28k	
V818 (5814) Noval	1	Plate A	−0.35 to 0.25	600k to 700k	Voltages and resistances from plate A to grid A to ground depend on setting of R926.
	2	Grid A	−0.35 to 0.25	600k to 700k	
	3	Cathode A	0.35	470k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	150	4.8k	
	7	Grid B	0	10k	
	8	Cathode B	6.6	2.7k	
	9	Heater ct	6.3 ac	0	

TABLE 7–20. SOCKET VOLTAGES AND RESISTANCES FOR SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V819 (6AU6) 7-pin	1	Grid 1	–0.35 to 0.25	640k to 760k	Voltage and resistance from grid 1 to ground depends on setting of R926. Voltage from suppressor grid to ground depends on setting of R926 and R929. Voltage from plate to ground depends on setting of R929.
	2	Suppressor Grid	–85 to –100	1.1 meg	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	156 to 280	700k	
	6	Screen Grid	70	55k	
	7	Cathode	0	0	
V820 (5726) 7-pin	1	Cathode B	0	0	Voltages from cathode A and plate B to ground depend on setting of R926 and R929.
	2	Plate A	–105	5.8k	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Cathode A	–85 to 100	1.1 meg	
	6	Internal Shield	NC	NC	
	7	Plate B	–85 to –100	1.1 meg	
V821 (3RP1A) 11-pin	1	Heater		950k	Voltages are greater than 1,000 v and not to be checked by portable meter. Negative 1,800 v checked by meter in Power supply Type PP–959. Assume that 2,100 v is present if –1,800 v is present. Resistance from anode 1 to ground depends on R845. Resistance from Deflecting Electr. DJ_3 to ground depends on R950.
	2	Grid 1		—	
	3	Cathode 1		950k	
	4	Anode 1		1.2 meg to 1.5 meg	
	5	NC		—	
	6	Deflecting Electr. DJ_3		1.1 meg to 1.2 meg	
	7	Deflect. Electr. DJ_4		1.2 meg	
	8	Anode 2, Grid 2		110k	
	9	Deflecting Electr. DJ_2		63k	
	10	Deflect. Electr. DJ_1		67k	
	11			—	
	12	Heater		1 meg	
V822 (5CP1A) Diheptal 12-pin	1	Heater		950k	Voltages are greater than 1,000 v and not to be checked by portable meter. Negative 1,800 v checked by meter in Power Supply Type PP–959–FPN–30. Assume that 2,100 v is present if –1,800 v is present. Resistance from grid 1 to ground depends on setting of R879. Resistance from anode 1 to ground depends on setting of R882. Resistance from anode 2 to ground depends on setting of R839. Resistance from Deflecting Electr. DJ_1 to ground depends on setting of R824. Resistance from anode 3 is measured with a VTVM.
	2	Cathode		1 meg	
	3	Grid 1		2 meg	
	4	NC	NC	NC	
	5	Anode 1		1.1 meg to 1.5 meg	
	7	Deflecting Electr. DJ_3		2.5 meg	
	8	Deflecting Electr. DJ_4		2.5 meg	
	9	Anode 2		6k to 103k	
	10	Deflecting Electr. DJ_2		57k	
	11	Deflecting Electr. DJ_1		47k to 76k	
	14	Heater		1 meg	
	Cap	Anode 3		25 meg	

TABLE 7–20. SOCKET VOLTAGES AND RESISTANCES FOR SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V823 (5RP2A) Cathode Ray Tube—Refer to Fig. 7–238 (on page 7–134) for terminal connections	1	Heater		950k	Voltages are greater than 1,000 v and not to be checked by portable meter. Negative 1,800 v is checked by meter in Power Supply Type PP–959. Assume that 2,100 v is present if −1,800 v is present. If 8,000 v is missing, r-f scope trace will be very dim and sweep will be too long. Resistance from grid 1 to ground depends on setting of R907. Resistances from anodes 3b, 3c, and 3d to ground are checked using a VTVM.
	2	Cathode		950k	
	3	Grid 1		1.9 meg to 2 meg	
	4	NC	NC	NC	
	5	Anode 1		950k	
	14	Heater		950k	
	Bulb Caps				
	E	Anode 3a		95k	
	F	Anode 3b		25 meg	
	G	Anode 3c		50 meg	
	H	Anode 3d		75 meg	
	Neck Caps				
		Deflecting Electr. DJ_2		2.5 meg	
		Deflecting Electr. DJ_1		2.2 meg	
	A2	Anode 2		95k	
		Deflecting Electr. DJ_3		650k	
		Deflecting Electr. DJ_4		52k	
V824 (12AT7) Noval	1	Plate A	60	22k	Resistance from grid A to ground has either value noted depending on polarity of test meter leads.
	2	Grid A	−0.25	4.4k, 7.5k	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	70	17k	
	7	Grid B	0	470k	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V826 (5814) Noval	1	Plate A	0.2 to −1.4	230k to 470k	Voltage and resistance to ground from plate A depends on setting of R868.
	2	Grid A	−0.65	100k	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	NC	NC	
	7	Grid B	NC	NC	
	8	Cathode B	NC	NC	
	9	Heater ct	6.3 ac	0	
V827 (5814) Noval	1	Plate A	150	4.8k	Voltages from grid A and cathode A to ground depend on setting of R929 and R926. Voltages and resistances from plate B and grid B to ground depend on setting of R960.
	2	Grid A	−85 to −100	1.1meg	
	3	Cathode A	48 to 50	23k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	−6 to −14	17k to 28k	
	7	Grid B	−6 to −14	17k to 28k	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	

TABLE 7–21. SOCKET VOLTAGES AND RESISTANCES FOR ELECTRICAL SYNCHRONIZER TYPE SN–117/FPN–30

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V1501 (5814) Noval	1	Plate A	70	52k	Voltage from grid A to ground depends on setting of R1501.
	2	Grid A	0	0 to 10k	
	3	Cathode A	2.0	1.5k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	NC	NC	
	7	Grid B	NC	NC	
	8	Cathode B	NC	NC	
	9	Heater ct	6.3 ac	0	
V1502 (5725) 7–pin	1	Grid 1	−30	56k	Voltage from suppressor grid to ground depends on setting of R1515 and is read using 2.5v sc.
	2	Cathode	0	0	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	150	27k	
	6	Screen Grid	150	3.6k	
	7	Suppressor Grid	0 to −0.5	1 meg	
V1503 (5726) 7–pin	1	Cathode B	−30	56k	
	2	Plate A	−30	56k	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Cathode A	0	0	
	6	Internal Shield	NC	NC	
	7	Plate B	−30	900	
V1504 (5725) 7–pin	1	Grid 1	−30	56k	Voltage from suppressor grid to ground depends on setting of R1522 and is read using 2.5v sc.
	2	Cathode	0	0	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	150	27k	
	6	Screen Grid	150	3.6k	
	7	Suppressor Grid	0 to −0.5	1 meg	
V1505 (5726) 7–pin	1	Cathode B	0	500k	
	2	Plate A	−1.25	10 meg	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Cathode A	0	500k	
	6	Internal Shield	NC	NC	
	7	Plate B	−1.25	10 meg	
V1506 (5814) Noval	1	Plate A	61 to 66	28k	Voltage from plate A to ground depends on setting of R1522. Voltage from cathode A or B to ground depends on meter polarity since a small d-c component (approx 0.1 v dc) affects reading according to reversal of meter leads. Voltage from plate B to ground depends on setting of R1515.
	2	Grid A	−1.25	10 meg	
	3	Cathode A	0.75 to 0.9 ac	21	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	61 to 67	28k	
	7	Grid B	−1.25	10 meg	
	8	Cathode B	0.75 to 0.9 ac	21	
	9	Heater ct	6.3 ac	0	

TABLE 7–21. SOCKET VOLTAGES AND RESISTANCES FOR ELECTRICAL SYNCHRONIZER TYPE SN–117/FPN–30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V1507 (12AT7) Noval	1	Plate A	NC	NC	Voltages from plate B and cathode B to ground depend on setting of R1522 and R1515.
	2	Grid A	NC	NC	
	3	Cathode A	NC	NC	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	77 to 95	108k	
	7	Grid B	0	470k	
	8	Cathode B	1.6 to 2.1	3.3k	
	9	Heater ct	6.3 ac	0	
V1508 (5814) Noval	1	Plate A	150	3.7k	Voltage from cathode A to ground depends on setting of R1522 and R1515.
	2	Grid A	0	1 meg	
	3	Cathode A	9 to 10.5	10k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	0	580	
	7	Grid B	0	580	
	8	Cathode B	0	1 meg	
	9	Heater ct	6.3 ac	0	
V1509 (2D21W) 7-pin MASTER OPERATION	1	Grid 1	6	700k, 1.1 meg	Voltages and resistances from cathode and grid 2 to ground depend on setting of R1534. Resistance of grid 1 to ground is 700k with phase dial at ±4 and 1.1 meg with phase dial at 0. Voltage from plate to ground is 32 to 0 with unfired tube (SYNC ERROR light off) and −78 with tube fired (250 v sc). Resistance from plate to ground depends on setting of R1534.
	2	Cathode	9 to 30	22k to 62k	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Grid 2	NC	NC	
	6	Plate	32 to 0, −78	27k to 66k	
	7	Grid 2	9 to 30	22k to 62k	
V1509 (2D21W) 7-pin SLAVE OPERATION	1	Grid 1	0, 15 to 32	110k	Voltage from grid 1 to ground is 0 with S108 in the synchronization control unit not operated. It is 15 to 32 volts with S108 operated, depending on setting of R1534. Voltage from plate to ground is 32 to 0 with tube unfired (SYNC ERROR light off) and −78 with tube fired (250 v sc). Voltages and resistances from cathode and grid 2 to ground depend on setting of R1534. Resistance from plate to ground depends on setting of R1534.
	2	Cathode	9 to 30	22k to 62k	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Grid 2	NC	NC	
	6	Plate	32 to 0, −78	27k to 66k	
	7	Grid 2	9 to 30	22k to 62k	

TABLE 7-21. SOCKET VOLTAGES AND RESISTANCES FOR ELECTRICAL SYNCHRONIZER TYPE SN-117/FPN-30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V1510 (5814) Noval	1	Plate A	65, 87	1 meg	Voltage from plate A to ground is 65 with S1504 on OPERATE, and 87 with S1504 on ADJUST. Voltage from grid A to ground is −5.2 with S1504 on OPERATE, and −1.25 on ADJUST. Resistance from grid A to ground is 18k with S1504 on OPERATE and 10 meg on ADJUST.
	2	Grid A	−5.2, −1.25	18k, 10 meg	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	150	3.7k	
	7	Grid B	0	220k	
	8	Cathode B	9.2	22k	
	9	Heater ct	6.3 ac	0	
V1511 (5814) Noval	1	Plate A	106	220k	
	2	Grid A	−0.4 (2.5v sc)	1.3 meg	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	12	100k	
	7	Grid B	0.3	1 meg	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V1512 (5814) Noval	1	Plate A	147	100k	
	2	Grid A	0	1 meg	
	3	Cathode A	12	10 meg	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	12	10 meg	
	7	Grid B	−30	56k	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V1513 (5814) Noval	1	Plate A	−0.4(2.5v sc)	10 meg	
	2	Grid A	−0.4(2.5v sc)	10 meg	
	3	Cathode A	0	1 meg	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	28 to 39	620k	
	7	Grid B	−0.4(2.5v sc)	10 meg	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V1514 (2D21W) 7-pin	1	Grid 1	0 to 44	100k to 140k	Voltages from grid 1, cathode and grid 2 to ground depend on setting of R1555. Resistance from grid 1 to ground depends on setting of R1555. Plate voltage to ground varies from 50 to 0 with SYNC ERROR light on according to setting of R1555. The variation is 0 to 30 with SYNC ERROR light off.
	2	Cathode	28 to 39	620k	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Grid 2	NC	NC	
	6	Plate	−50 to 30	620k	
	7	Grid 2	28 to 39	620k	

TABLE 7–21. SOCKET VOLTAGES AND RESISTANCES FOR ELECTRICAL SYNCHRONIZER TYPE SN–117/FPN–30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V1515 (5814) Noval	1	Plate A	NC	NC	Voltages and resistances from plate B and grid B to ground depend on setting of R1592.
	2	Grid A	NC	NC	
	3	Cathode A	NC	NC	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	−18 to −4	10k to 26k	
	7	Grid B	−18 to −4	10k to 26k	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V1516 (5726) 7–pin MASTER OPERATION	1	Cathode B	32 to 123	47k	Voltages from cathode B, cathode A and plate B to ground depend on setting of R1544, R1551, R1565, R1517 and R138 (latter is in synchronization control unit).
	2	Plate A	29	21k	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Cathode A	32 to 123	480k	
	6	Internal Shield	NC	NC	
	7	Plate B	32 to 123	480k	
V1516 (5726) 7–pin SLAVE OPERATION	1	Cathode B	32 to 123	14k to 22k	Voltages from cathode B, cathode A and plate B to ground depend on setting of R1544 and R1351. Resistance from cathode B to ground depends on setting of R1544.
	2	Plate A	29	21k	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Cathode A	32 to 123	480k	
	6	Internal Shield	NC	NC	
	7	Plate B	32 to 123	480k	
V1517 (5725) 7–pin MASTER OPERATION	1	Grid 1	−1.5 to 0.25	500k	Voltages and resistances from screen grid and suppressor grid to ground depend on setting of R1592. Voltage from grid 1 to ground depends on setting of R1592.
	2	Cathode	0	0	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	32 to 123	470k	
	6	Screen Grid	34 to 53	19k to 21k	
	7	Suppressor Grid	−6 to −18	10k to 26k	
V1517 (5725) 7–pin SLAVE OPERATION	1	Grid 1	−1.5 to 0.25	500k	Voltages and resistances from screen grid and suppressor grid to ground depend on setting of R1592. Voltage from grid 1 to ground depends on setting of R1592.
	2	Cathode	0	0	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	32 to 123	470k	
	6	Screen Grid	34 to 53	19k to 21k	
	7	Suppressor Grid	−4 to −18	10k to 26k	
V1518 (5814) Noval MASTER OPERATION	1	Plate A	32 to 123	470k	Voltages from plate A, grid A, cathode A, grid B and cathode B to ground depend on setting of R1544, R1551, R1565, R1517 and R138 (latter is in sync control unit).
	2	Grid A	32 to 123	470k	
	3	Cathode A	31 to 123	1.5 meg	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	150	3.7k	
	7	Grid B	23 to 126	2.2 meg	
	8	Cathode B	32 to 123	47k	
	9	Heater ct	6.3 ac	0	

TABLE 7–21. SOCKET VOLTAGES AND RESISTANCES FOR ELECTRICAL SYNCHRONIZER TYPE SN–117/FPN–30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V1518 (5814) Noval SLAVE OPERATION	1	Plate A	32 to 123	470k	Voltage to ground from plate A, grid A and cathode A depends on setting of R1544 and R1551.
	2	Grid A	32 to 123	470k	
	3	Cathode A	32 to 123	1.5 meg	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	150	3.7k	
	7	Grid B	0	2.2 meg	
	8	Cathode B	72	47k	
	9	Heater ct	6.3 ac	0	
V1519 (5726) 7–pin	1	Cathode B	−30	56k	
	2	Plate A	−68	470k	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Cathode A	−30	56k	
	6	Internal Shield	NC	NC	
	7	Plate B	−68	470k	
V1520 (5726) 7–pin MASTER OPERATION	1	Cathode B	23 to 126	2.2 meg	This tube is used only for master operation. Voltage from cathodes A and B to ground depends on setting of R1544, R1551, R1565, R1517 and R138 (latter is in sync control unit). Voltage from plates A and B to ground depends on setting of R1544 and R1551. Resistance from plate B to ground depends on setting of R1565.
	2	Plate A	−6 to 50	110k to 115k	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Cathode A	23 to 126	2.2 meg	
	6	Internal Shield	NC	NC	
	7	Plate B	−6 to 50	125k to 115k	
V1520 (5726) 7–pin SLAVE OPERATION	1	Cathode B	0	2.2 meg	This tube is used only for master operation. Resistance from plate B to ground depends on setting of R1565.
	2	Plate A	−15	inf	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Cathode A	0	2.2 meg	
	6	Internal Shield	NC	NC	
	7	Plate B	−16	125k to 115k	
V1521 (5814) Noval MASTER OPERATION	1	Plate A	−6 to 51	110k to 115k	This tube is used only for master operation. Voltage from plates A and B to ground depend on setting of R1544, R1551, R1565, R1517 and R138. (Latter is in sync control unit.) Resistance of plate A to ground depends on setting of R1544 and R1551. Resistance from plate B to ground depends on setting of R1565.
	2	Grid A	−39	1.1 meg	
	3	Cathode A	−30	900	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	−6 to 50	115k to 125k	
	7	Grid B	−38	1.1 meg	
	8	Cathode B	−30	900	
	9	Heater ct	6.3 ac	0	

TABLE 7-21. SOCKET VOLTAGES AND RESISTANCES FOR ELECTRICAL SYNCHRONIZER TYPE SN-117/FPN-30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V1521 (5814) Noval SLAVE OPERATION	1	Plate A	−15	inf	Resistance from plate B to ground depends on setting of R1565.
	2	Grid A	−39	1.1 meg	
	3	Cathode A	−30	900	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	−16	115k to 125k	
	7	Grid B	−38	1.1 meg	
	8	Cathode B	−30	900	
	9	Heater ct	6.3 ac	0	
V1522 (5814) Noval	1	Plate A	−68	470k	
	2	Grid A	−121	1.1 meg	
	3	Cathode A	−104	12k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	−68	470k	
	7	Grid B	−121	1.1 meg	
	8	Cathode B	−104	12k	
	9	Heater ct	6.3 ac	0	
V1523 (5726) 7-pin	1	Cathode B	−30	56k	
	2	Plate A	−30	56k	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Cathode A	0	0	
	6	Internal Shield	NC	NC	
	7.	Plate B	−30	900	
V1524 (not used)					
V1525 (12AT7) Noval	1	Plate A	150	3.7k	
	2	Grid A	−15	1 meg	
	3	Cathode A	−26	11k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	−85	100k	
	7	Grid B	−104	470k	
	8	Cathode B	−104	6k	
	9	Heater ct	6.3 ac	0	
V1526 (5814) Noval	1	Plate A	150	3.7k	Voltages from grid B and cathode B to ground depend on setting of R1538. Voltage from grid A to ground is 65 with S1504 on OPERATE, and 87 with S1504 on ADJUST. Voltage from cathode A to ground depends on setting of R1538 and S1504. Resistance from grid B to ground depends on setting of R1538.
	2	Grid A	65, 87	1 meg	
	3	Cathode A	48 to 85	14k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	150	3.7k	
	7	Grid B	56 to 80	150k to 160k	
	8	Cathode B	62 to 84	14k	
	9	Heater ct	6.3 ac	0	

TABLE 7–22. SOCKET VOLTAGES AND RESISTANCES FOR TEST OSCILLOSCOPE TYPE OS–39/FPN–30

TUBE	PIN	ELEMENT	VOLTAGE* (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V1701 (5814) Noval	1	Plate A	25	100k	
	2	Grid A	−0.9	10 meg	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	124	50k	
	7	Grid B	−1 (2.5v sc)	1.2 meg	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V1702 (5814) Noval	1	Plate A	90 to 145	50k	Voltages from plates A and B, grids A and B and cathodes A and B to ground depend on the setting of R1707. Resistance from grid A to ground depends on setting of R1707.
	2	Grid A	5 to 21	2.7k to 10k	
	3	Cathode A	21 to 32	15k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	75 to 127	39k	
	7	Grid B	32 to 23	550k	
	8	Cathode B	21 to 32	15k	
	9	Heater ct	6.3 ac	0	
V1703 (5814) Noval	1	Plate A	14 to 17	50k	Voltage from plates A and B to ground depends on setting of R1713. Voltage and resistance from grid A to ground depend on setting of R1713.
	2	Grid A	0 to −0.8	1 meg to 1.2 meg	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	14 to 17	50k	
	7	Grid B	−0.4	1 meg	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V1704 (5814) Noval	1	Plate A	147	50k	
	2	Grid A	−3.5	4.7 meg	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	146	66k	
	7	Grid B	−5	1 meg	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V1705 (5814) Noval	1	Plate A	147	50k	Voltage and resistance from grid A to ground depend on setting of R1720. Voltage from plate B to ground depends on setting of R1720.
	2	Grid A	12 to 23	12k to 20k	
	3	Cathode A	38	15k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	65 to 70	39k	
	7	Grid B	36	1 meg	
	8	Cathode B	38	15k	
	9	Heater ct	6.3 ac	0	
V1706 (5814) Noval	1	Plate A	54 to 64	60k	Voltage from plates A and B to ground depends on setting of R1729. Voltage and resistance from grid A to ground depends on setting of R1729.
	2	Grid A	0 to 0.6	1 meg to 1.1 meg	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	54 to 64	60k	
	7	Grid B	0.3	1 meg	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	

* All voltages were measured with R1558 turned to 0 and the timer on HIGH 0 rate.

TABLE 7–22. SOCKET VOLTAGES AND RESISTANCES FOR TEST OSCILLOSCOPE TYPE OS–39/FPN–30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V1707 (5814) Noval	1	Plate A	−5 to −15	14k to 30k	Voltages and resistances from plate A and grid A to ground depend on setting of R1752. Voltages from grid B and cathode B to ground were measured with S1701 at "ϕ 1".
	2	Grid A	−5 to −15	14k to 30k	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	300	6k	
	7	Grid B	0	10k	
	8	Cathode B	0	10k	
	9	Heater ct	6.3 ac	0	
V1708 (5725) 7-pin	1	Grid 1	0.3	540k	Voltages from plate, screen and suppressor to ground depend on setting of R1752. Resistances from screen and suppressor to ground depend on setting of R1752. First voltage readings for plate and screen were for normal operation. Free running begins when voltages reach the second readings.
	2	Cathode	0	0	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	145, 100	66k	
	6	Screen Grid	33, 65	28k to 32k	
	7	Suppressor Grid	−3 to −15	14k to 30k	
V1709 (5CP1A) Diheptal 12-pin	1	Heater		1 meg	Voltages are greater than 1,000 v and not to be checked by portable meter. Negative 1,800 v checked by meter in Power Supply Type PP–959/FPN–30. Assume that 2,100 v is present if −1,800 v is present. Resistance from anode 2 to ground depends on setting of R1779.
	2	Cathode		1 meg	
	3	Grid 1		2.8 meg	
	4	—		—	
	5	Anode 1		1 meg	
		—		—	
	7	Deflecting Electr. DJ_3		2.2 meg	
	8	Deflecting Electr. DJ_4		2.2 meg	
	9	Anode 2		6k to 140k	
	10	Deflecting Electr. DJ_2		85k	
	11	Deflecting Electr. DJ_1		65k	
	12	—		—	
	14	Heater		1 meg	
	Cap	Anode 3		10 meg	
V1710 (12AT7) Noval	1	Plate A	45	20k	Voltage from plate B to ground depends on setting of S1703.
	2	Grid A	0.3	480k	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	62 to 68	15k	
	7	Grid B	0.45	450k	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	
V1711 (12AT7) Noval	1	Plate A	248	13k	Voltage and resistance from grid A to ground depend on setting of R1541.
	2	Grid A	−8 to −27	108k to 140k	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	138	29k	
	7	Grid B	0.1 (2.5v sc)	1 meg	
	8	Cathode B	8	7k	
	9	Heater ct	6.3 ac	0	

* All voltages were measured with R1558 turned to 0 and the timer on HIGH 0 rate.

TABLE 7–22. SOCKET VOLTAGES AND RESISTANCES TEST OSCILLOSCOPE TYPE OS–39/FPN–30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE* (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V1712 (5814) Noval	1	Plate A	150	4k	Resistance from grid A to ground is 0 with S1704 on DIRECT and 1 meg with S1704 on HIGH or LOW.
	2	Grid A	0.4(2.5v sc)	0, 1 meg	
	3	Cathode A	37	11k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	NC	NC	
	7	Grid B	NC	NC	
	8	Cathode B	NC	NC	
	9	Heater ct	6.3 ac	0	
V1713 (6AU6) 7-pin	1	Grid 1	0	0 to 25k	Resistance from grid 1 to ground depends on setting of R1758.
	2	Suppressor Grid	0	0	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	120	26k	
	6	Screen Grid	150	22k	
	7	Cathode	2	220	
V1714 (6AC7W) Octal	1	Shell	0	0	
	2	Heater	0	0	
	3	Suppressor Grid	0	0	
	4	Grid 1	0	280k	
	5	Cathode	1.8	180	
	6	Screen Grid	148	3.5k	
	7	Heater	6.3 ac	0	
	8	Plate	245	13k	
V1715 (6AC7W) Octal	1	Shell	0	0	
	2	Heater	0	0	
	3	Suppressor Grid	0	0	
	4	Grid 1	0	280k	
	5	Cathode	1.8	180	
	6	Screen Grid	148	3.5k	
	7	Heater	6.3 ac	0	
	8	Plate	246	1.3k	
V1716 (5726) 7-pin	1	Cathode B	−77	1 meg	Voltage from plate A to ground depends on setting of R1790 and S1706.
	2	Plate A	−10 to −90	1 meg	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Cathode A	0	0	
	6	Internal Shield	—	inf	
	7	Plate B	−104	7k	
V1717 (6AU6) 7-pin	1	Grid 1	0 to −4.5	500k to 550k	Voltages from grid 1, suppressor grid, plate and screen grid to ground depend on setting of R1790 and S1706. Resistance from grid 1 to ground depends on setting of R1790.
	2	Suppressor Grid	−10 to −90	1 meg	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	180 to 265	65k	
	6	Screen Grid	180 to 62	39k	
	7	Cathode	0	0	
V1718 (6AU6) 7-pin	1	Grid 1	8 to −104	7k to 70k	Voltages from grid 1, suppressor grid, plate, screen grid and cathode to ground depend on setting of R1795 and R1806. Resistance from grid 1 to ground depends on setting of R1795 and R1806.
	2	Suppressor Grid	50 to 300	85k	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Plate	300 to 50	85k	
	6	Screen Grid	50 to 300	85k	
	7	Cathode	0 to 8	22k	

* All voltages were measured with R1558 turned to 0 and the timer on HIGH 0 rate.

TABLE 7–22. SOCKET VOLTAGES AND RESISTANCES FOR TEST OSCILLOSCOPE TYPE OS–39/FPN–30 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE* (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V1719 (5726) 7-pin	1	Cathode B	145, 100	65k	Voltages and resistances from plates A and B to ground depend on setting of R1736. Voltage from cathode A and B to ground depends on the setting of R1752. These cathodes operate normally at 145v, and free running starts at 100v.
	2	Plate A	70 to 137	3k to 33k	
	3	Heater	0	0	
	4	Heater	6.3 ac	0	
	5	Cathode A	145, 100	65k	
	6	Internal Shield	——	inf	
	7	Plate B	70 to 137	23k to 33k	
V1720 (5726) 7-pin	1	Cathode B		2.8 meg	Resistance from plates A and B to ground depends on setting of R1781. CAUTION: All elements of this tube are connected to the —1,800-volt supply. See General Notes preceding table as regards measurements where values exceed 1,000 volts.
	2	Plate A		1 meg to 1.3 meg	
	3	Heater		1 meg	
	4	Heater		1 meg	
	5	Cathode A		2.8 meg	
	6	Internal Shield		inf	
	7	Plate B		1 meg to 1.3 meg	
V1721 (5814) Noval	1	Plate A	150	4k	Voltages and resistances from grid B and plate B to ground depend on the setting of R1790. Voltage from cathode B to ground depends on setting of R1790.
	2	Grid A	0	2.2 meg	
	3	Cathode A	20	100k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	0 to —4.5	500k to 550k	
	7	Grid B	0 to —4.5	500k to 550k	
	8	Cathode B	0.3 to 1	47k	
	9	Heater ct	6.3 ac	0	
V1722 (5814) Noval	1	Plate A	150	4k	Voltages from grid A and cathode A to ground depend on setting of R1790 and S1706.
	2	Grid A	—45 to 90	1 meg	
	3	Cathode A	—28 to 0	22k	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	NC	NC	
	7	Grid B	NC	NC	
	8	Cathode B	NC	NC	
	9	Heater ct	6.3 ac	0	

* All voltages were measured with R1558 turned to 0 and the timer on HIGH 0 rate.

TABLE 7-23. SOCKET VOLTAGES AND RESISTANCES FOR POWER SUPPLY TYPE PP-959

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V2001 (5R4WGY) Octal	1	NC	NC	NC	Voltage between filament pins is 5v ac.
	2	Filament	310	950k	
	4	Plate A	380ac	20	
	6	Plate B	380ac	20	
	8	Filament	310	950k	
V2002 (5R4WGY) Octal	1	NC	NC	NC	Voltage between filament pins is 5v ac.
	2	Filament	310	950k	
	4	Plate A	380ac	20	
	6	Plate B	380ac	20	
	8	Filament	310	950k	
V2003 (6AS7G) Octal	1	Grid A	34 to 195	2 meg	Voltages from grid A, plate A, cathode A, grid B, plate B and cathode B to ground depend on setting of R2022. Resistance from cathodes A and B to ground was measured with stand-by load connected.
	2	Plate A	300 to 255	950k	
	3	Cathode A	119 to 205	1.05k	
	4	Grid B	34 to 195	2 meg	
	5	Plate B	300 to 255	950k	
	6	Cathode B	119 to 205	1.05k	
	7	Heater	0	0	
	8	Heater	6.3 ac	0	
V2004 (6AS7G)	1	Grid A	34 to 195	2 meg	Voltages from grid A, plate A, cathode A, grid B, plate B and cathode B to ground depend on setting of R2022. Resistance from cathodes A and B to ground was measured with stand-by load connected.
	2	Plate A	300 to 255	950k	
	3	Cathode A	119 to 205	1.05k	
	4	Grid B	34 to 195	2 meg	
	5	Plate B	300 to 255	950k	
	6	Cathode B	119 to 205	1.05k	
	7	Heater	0	0	
	8	Heater	6.3ac	0	
V2005		Not used			
V2006 (12AT7) Noval	1	Plate A	13.5 to 63	inf	Voltages from plates A and B, grids A and B and cathode B to ground depend on setting of R2022. Resistance from grid A to ground depends on setting of R2022.
	2	Grid A	−2 to 0	97k to 105k	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	30 to 194	1.8 meg	
	7	Grid B	13 to 57	108k	
	8	Cathode B	13.5 to 63	inf	
	9	Heater ct	6.3ac	0	
V2007 (5814) Noval	1	Plate A	20 to 97	200k	Voltages from plates A and B and cathodes A and grid B to ground depend on setting of R2022. Voltages from plates A and B, grids A and B and cathode A to ground depend on setting of R2033. Resistance from grid B to ground depends on setting of R2033.
	2	Grid A	13 to 24	61k	
	3	Cathode A	37 to 15	inf	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	37 to 15	inf	
	7	Grid B	−15 to 0	32k to 49k	
	8	Cathode B	0	0	
	9	Heater ct	6.3 ac	0	

TABLE 7–23. SOCKET VOLTAGES AND RESISTANCES FOR POWER SUPPLY TYPE PP–959 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V2008 (6Y6G) Octal	1	NC	NC	NC	Voltages from plate, screen grid, grid 1 and cathode to ground depend on setting of R2022. Voltages from grid 1 and cathode to ground depend on setting of R2033.
	2	Heater	0	0	
	3	Plate	118 to 205	4.7k	
	4	Screen Grid	118 to 205	4.7k	
	5	Grid 1	−42 to −84	600k	
	7	Heater	6.3ac	0	
	8	Cathode	−25 to −39	8.5k	
V2009 (5651) 7-pin	1	Anode	0	0	
	2	Cathode	−85	46k	
	3	NC	ic	ic	
	4	Cathode	−85	46k	
	5	Anode	0	0	
	6	NC	ic	ic	
	7	Cathode	−85	46k	
V2010 (OB2) 7-pin	1	Anode	0	0	
	2	Cathode	−104	5.8k	
	3	NC	ic	ic	
	4	Cathode	−104	5.8k	
	5	Anode	0	0	
	6	NC	ic	ic	
	7	Cathode	−104	5.8k	
V2011 (5Y3WGT) Octal 5-pin	1	NC	NC	NC	Voltages from plates to ground were measured with meter on OUTPUT scale.
	2	Filament	0	0	
	4	Plate A	260ac	24k	
	6	Plate B	260ac	24k	
	8	Filament	5ac		
V2012 (OA2) 7-pin	1	Anode	0	0	
	2	Cathode	−150	28k	
	3	NC	ic	ic	
	4	Cathode	−150	28k	
	5	Anode	0	0	
	6	NC	ic	ic	
	7	Cathode	−150	28k	

TABLE 7–24. SOCKET VOLTAGES AND RESISTANCES FOR POWER SUPPLY PP–958

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V1901 (5R4WGY) Octal	1	NC	NC	NC	Voltage between filament pins was 5 volts ac. Voltages from filament pins to ground depend on setting of R1922.
	2	Filament	400 to 420	1 meg	
	4	Plate A	520 ac	38	
	6	Plate B	520 ac	38	
	8	Filament	400 to 420	1 meg	
V1902 (5R4WGY) Octal	1	NC	NC	NC	Voltage across filament pins was 5 volts ac. Voltage from filament pins to ground depends on setting of R1922.
	2	Filament	400 to 420	1 meg	
	4	Plate A	520 ac	38	
	6	Plate B	520 ac	38	
	8	Filament	400 to 420	1 meg	
V1903 (6AS7G) Octal	1	Grid A	205 to 430	1.7 meg	Voltage from each of the 8 pins to ground depends on setting of R1922. Voltage across filament pins is 6.3v ac.
	2	Plate A	370 to 395	1 meg	
	3	Cathode A	260 to 345	4.5k	
	4	Grid B	205 to 340	1.7 meg	
	5	Plate B	370 to 395	1 meg	
	6	Cathode B	260 to 345	4.5k	
	7	Heater	78 to 120	160k	
	8	Heater	78 to 120	160k	
V1904 (6AS7G) Octal	1	Grid A	205 to 340	1.7 meg	Voltage from each of the 8 pins to ground depends on the setting of R1922. Voltage across filament pins is 6.3v ac.
	2	Plate A	370 to 395	1 meg	
	3	Cathode A	260 to 345	4.5k	
	4	Grid B	205 to 340	1.7 meg	
	5	Plate B	370 to 395	1 meg	
	6	Cathode B	260 to 345	4.5k	
	7	Heater	78 to 120	160k	
	8	Heater	78 to 120	160k	
V1905 (6AS7G) Octal	1	Grid A	205 to 340	1.7 meg	Voltage from each of the 8 pins to ground depends on the setting of R1922. Voltage across filament pins is 6.3v ac.
	2	Plate A	370 to 395	1 meg	
	3	Cathode A	260 to 345	4.5k	
	4	Grid B	205 to 340	1.7 meg	
	5	Plate B	370 to 395	1 meg	
	6	Cathode B	260 to 345	4.5k	
	7	Heater	78 to 120	160k	
	8	Heater	78 to 120	160k	
V1906 (12AT7) Noval	1	Plate A	205 to 340	1.8 meg	Voltage from each pin (except pin 8) to ground depends on setting of R1922. Voltage across filament pins is 6.3v ac. Resistance from grid B to ground depends on setting of R1922.
	2	Grid A	107 to 140	65k	
	3	Cathode A	108 to 145	inf	
	4	Heater	78 to 120	160k	
	5	Heater	78 to 120	160k	
	6	Plate B	108 to 145	inf	
	7	Grid B	83 to 85	50k to 60k	
	8	Cathode B	0	94k	
	9	Heater ct	78 to 120	160k	
V1907 (5651) 7-pin	1	Anode	87	94k	
	2	Cathode	0	0	
	3	—	ic	ic	
	4	Cathode	0	0	
	5	Anode	87	94k	
	6	—	ic	ic	
	7	Cathode	0	0	

TABLE 7-24. SOCKET VOLTAGES AND RESISTANCES POWER SUPPLY PP-958 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V1908 (6005) 7-pin	1 2 3 4 5 6 7	Grid 1 Cathode Heater Heater Plate Screen Grid Grid 1	100 to 145 111 to 145 78 to 120 78 to 120 260 to 345 260 to 345 —	470k 60k 160k 160k 4.5k 4.5k —	Voltages from grid 1, each heater pin, plate and screen grid to ground depend on the setting of R1922. Voltage from grid 1 and cathode to ground depend on the setting of R1933. Voltage across filament pins is 6.3 ac.
V1909 (6AU6) 7-pin	1 2 3 4 5 6 7	Grid 1 Suppressor Grid Heater Heater Plate Screen Grid Cathode	83 84 78 to 120 78 to 120 99 to 145 111 to 145 84	35k to 46k 86k 160k 160k 470k 60k 86k	Voltages to ground from each heater pin plate and screen grid depend on setting of R1922. Voltage from screen grid to ground also depends on setting of R1933. Voltage across filament pins is 6.3 ac. Resistance from grid 1 to ground depends on setting of R1933.
V1910 (5651) 7-pin	1 2 3 4 5 6 7	Anode Cathode — Cathode Anode — Cathode	85 0 ic 0 85 ic 0	86k 0 ic 0 86k ic 0	

TABLE 7-25. SOCKET VOLTAGES AND RESISTANCES FOR POWER SUPPLY TYPE PP-957

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V2101 (2X2A) 4-pin	1 2 3 4 Cap	Heater NC NC Heater, Cathode Plate		25 meg NC NC 25 meg 4.2k	Voltages to ground exceed 1,000 and are therefore not listed. The −1,800v is checked by meter in PP-959. Resistances checked by vtvm (heater to gnd).
V2102 (2X2A) 4-pin	1 2 3 4 Cap	Heater NC NC Heater, Cathode Plate		4.2k NC NC 4.2k 1.4 meg	Voltages to ground exceed 1,000 and are therefore not listed. The −1,800 is checked by meter in PP-959.
V2103 (5R4WGY) Octal	1 2 4 6 8	NC Filament Plate 2 Plate 1 Filament	NC 315 to 335 400 to 395 400 to 395 315 to 335	NC 1 meg 26 26 1 meg	Voltage readings taken with the input line voltage at 115v ac. Voltages to ground depend on setting of R2122. Voltage between filament pins was 5v ac.

TABLE 7-25. SOCKET VOLTAGES AND RESISTANCES FOR POWER SUPPLY TYPE PP-957 (Cont'd)

TUBE	PIN	ELEMENT	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V2104 (5R4WGY) Octal	1	NC	NC	NC	Voltage readings taken with input line voltage at 115v ac. Voltages to ground depend on setting of R2122. Voltage between filament pins was 5v ac.
	2	Filament	315 to 335	1 meg	
	4	Plate 2	400 to 395	26	
	6	Plate 1	400 to 395	26	
	8	Filament	315 to 335	1 meg	
V2105		Not used			
V2106 (6AS7G) Octal	1	Grid B	172 to 32	2 meg	Voltage between heater pins was 6.3v ac. All voltage readings taken with input line voltage at 115v ac. Voltages to ground depend on setting of R2122.
	2	Plate B	290 to 330	1 meg	
	3	Cathode B	130 to 206	3.7k	
	4	Grid A	172 to 32	2 meg	
	5	Plate A	290 to 330	1 meg	
	6	Cathode A	130 to 206	3.7k	
	7	Heater	NC	0	
	8	Heater	NC	0	
V2107 (6AS7G) Octal	1	Grid A	172 to 32	2 meg	Voltage between heater pins was 6.3v ac. All voltage readings were taken with input line voltage at 115v ac. Voltages to ground depend on setting of R2122.
	2	Plate A	290 to 330	1 meg	
	3	Cathode A	130 to 206	3.7k	
	4	Grid B	172 to 32	2 meg	
	5	Plate B	290 to 330	1 meg	
	6	Cathode B	130 to 206	3.7k	
	7	Heater	NC	0	
	8	Heater	NC	0	
V2108 (12AT7) Noval	1	Plate A	55 to 14	inf	All voltages measured with line voltages at 115v ac.
	2	Grid A	−1.4 to 0	215k to 245k	
	3	Cathode A	0	0	
	4	Heater	0	0	
	5	Heater	0	0	
	6	Plate B	31 to 172	2 meg	
	7	Grid B	14 to 55	200k	
	8	Cathode B	14 to 54	inf	
	9	Heater ct	6.3 ac	0	
V2109 (5651) 7-pin	1	Anode	0	0	
	2	Cathode	84	390k	
	3	NC	ic	ic	
	4	Cathode	84	390k	
	5	Anode	0	0	
	6	NC	ic	ic	
	7	Cathode	84	390k	

TABLE 7-26. SOCKET VOLTAGES AND RESISTANCES FOR VOLTAGE REGULATOR TYPE CN-235/FPN-30[1, 3]

TUBE	PIN	ELEMENT	VOLTAGE[2] (VOLTS)	RESISTANCE (OHMS)	FACTORS WHICH INFLUENCE READINGS
V2301 (2D21) 7-pin	1	Grid 1	0	100k	Resistance from either heater connection to pin 2 depends on setting of R2303.
	2	Cathode	0	0	
	3	Heater	0	0 to 3.5k	
	4	Heater	4	0 to 3.5k	
	5	Grid 2	0	0	
	6	Plate	105	4.7k	
	7	Grid 2	0	0	
V2302 (2D21) 7-pin	1	Grid 1	0	100k	Resistance from either heater connection to pin 2 depends on setting of R2303.
	2	Cathode	0	0	
	3	Heater	0	0 to 3.5k	
	4	Heater	4	0 to 3.5k	
	5	Grid 2	0	0	
	6	Plate	105	4.7k	
	7	Grid 2	0	0	

1Pin 2 is reference point for all voltage and resistance measurements.
2All voltage readings are 60 cps ac. Voltage measurements were taken with 115v ac, 60 cps INPUT; output was adjusted to 115v ac.
3SENSITIVITY control set for normal operation.

(5) COIL WINDING DATA CHART. — The coil winding data chart, table 7-27, provides information which may be required to repair a coil or transformer in the field. Field repair should be attempted only in an emergency when a spare part is not available. Such a repair may be effected by removing the old wire and interlayer insulation from the original transformer core and replacing it with the specified wire and insulation equivalent to the original. For hermetically sealed transformers this requires that the transformer case be opened, by unsoldering the bottom cover, and all potting compound be melted and poured out. The original potting compound, or an equivalent compound, may be used to moistureproof the transformer after rewinding.

For most listings the *wire size* column also indicates the type of insulation used on the wire. The abbreviation SF means single formvar coated wire, HF means heavy formvar coated wire, EC means enamel covered wire, DCC means double cotton covered wire, SSE means single silk enamel-covered wire, DSC means double silk covered wire, DNE means double nylon covered enamel wire, and SNE means single nylon covered enamel wire.

The letters S and F, on the coil schematics, respectively indicate the start and finish of each winding.

(Text continued on page 7-134)

TABLE 7–27. WINDING DATA

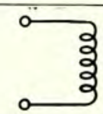
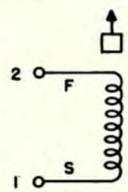
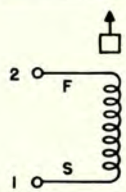
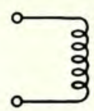
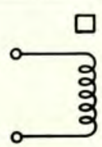
CIRCUIT SYMBOL	FTR DWG OR MFR'S TYPE NUMBER	SCHEMATIC DIAGRAM	WIND-ING	WIRE SIZE	TURNS	TURNS PER LAYER	WINDING LENGTH (INCHES)	D-C RESISTANCE (OHMS)	IN-DUCTANCE	IMPEDANCE RATIO	HIPOT RMS VOLTS	REMARKS
L101	A1023700-1		Single universal	38SSE	1,000		½	81	6.7 mh			
L102	VI-C17 UTC		Single	40	8,000 (approx)			1,820	13 hy (See re-marks)		500	Inductance is variable over the range +85% to —45%.
L103	A1015224-1		Single pie uni-versal	30SSE	405			7.8	2,100 to 3,000 mh			
L1201, L1202, L1206, L1207, L1209, L1211, L1213, L1217, L1221, L1222, L1225	A1022054-2		4 pie universal	36SNE	920			44	2.5 mh			
L1203, L1223, L1224	A1017809-1		Layer 1 Layer 2 Layer 3	26DSE	37 34 31			0.665	144 μh			Wind coil clockwise, closewound. Treat with Q Max. Inductance is minimum acceptable val-ue with core at maximum inductance position.

TABLE 7–27. WINDING DATA (Cont'd)

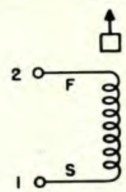
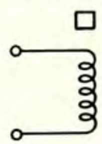
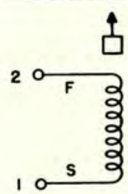
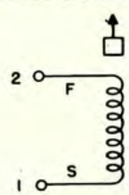
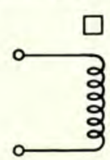
CIRCUIT SYMBOL	FTR DWG OR MFR'S TYPE NUMBER	SCHEMATIC DIAGRAM	WIND-ING	WIRE SIZE	TURNS	TURNS PER LAYER	WINDING LENGTH (INCHES)	D-C RESISTANCE (OHMS)	IN-DUCTANCE	IMPEDANCE RATIO	HIPOT RMS VOLTS	REMARKS
L1204, L1205	A1016720-1		Single layer	10/40 SSE Litz	53	53		0.78	17.8 to 58.8 μh			Wind coil clockwise, closewound.
L1208	A1017807-1		Layer 1 Layer 2 Layer 3	22EC	30 27 24			0.216	82 μh (See remarks)			Wind coil clockwise, closewound. Treat with Q Max. Inductance is minimum acceptable value with core at maximum inductance position.
L1212	A1017180-1		3 pie universal	34SSE	207			6.64	550 μh (See remarks)			Wind coil clockwise, closewound. Treat with Q Max. Inductance is minimum acceptable value with core at maximum inductance position.
L1214, L1215	A1017780-2		3 pie universal	34SSE	177			5.57	416 μh (See remarks)			Wind coil clockwise, closewound. Treat with Q Max. Inductance is minimum acceptable value with core at maximum inductance position.
L1218	A1017777-1		Layer 1 Layer 2 Layer 3	20EC	22 20 18			0.1	58.9 μh (See remarks)			Wind coil clockwise, closewound. Treat with Q Max. Inductance is minimum acceptable value with core at maximum inductance position.

TABLE 7–27. WINDING DATA (Cont'd)

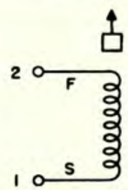
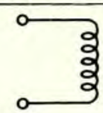
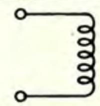
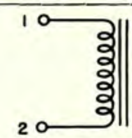
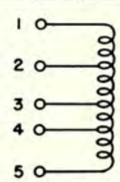
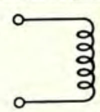
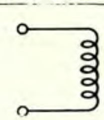
CIRCUIT SYMBOL	FTR DWG OR MFR'S TYPE NUMBER	SCHEMATIC DIAGRAM	WIND-ING	WIRE SIZE	TURNS	TURNS PER LAYER	WINDING LENGTH (INCHES)	D-C RESISTANCE (OHMS)	IN-DUCTANCE	IMPEDANCE RATIO	HIPOT RMS VOLTS	REMARKS
L1219	A1016957-1		Single layer	38SNE	50	50		4.02	46.6, µh (See re-marks)			Wind coil clockwise, closewound. Treat with Q Max. Inductance is minimum acceptable value with core at maximum inductance position.
L1220	A1022055-2		4 pie universal	36SNE	920			44	2.5 mh			
L1401, L1403			Univer-sal	34EC	1,025		⅜	70	15 mh			
L1402, L1404			Multi-layer	36	6,000			1,100	80 hy			
L1405			Multi-layer	7/34EC	216 tapped at 105, 47, and 38			1.35	(See re-marks)			Taps / 100kc Resistance (ohms) / Inductance (µh): 1-2 0.90 145; 1-3 1.5 290; 1-4 2.0 435; 1-5 2.45 580
L1701	A1013328-2		3 pie universal	32SSE	270			6.1	425 µh			
L1702, L1703, L1704	A1013328-3		Single pie uni-versal	32SSE	495			12.5	1,650 µh			

TABLE 7-27. WINDING DATA (Cont'd)

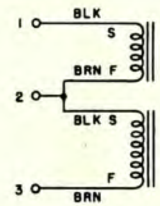
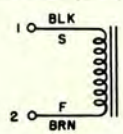
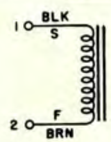
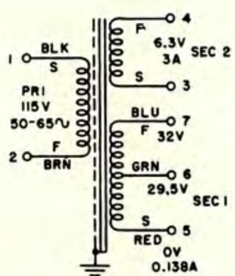
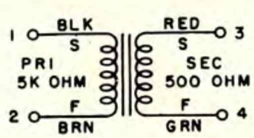
CIRCUIT SYMBOL	FTR DWG OR MFR'S TYPE NUMBER	SCHEMATIC DIAGRAM	WIND-ING	WIRE SIZE	TURNS	TURNS PER LAYER	WINDING LENGTH (INCHES)	D-C RESISTANCE (OHMS)	IN-DUCTANCE	IMPEDANCE RATIO	HIPOT RMS VOLTS	REMARKS
L1901, L2001, L2101	A1010915 FT2611		Each section	25SF	1,500	75	1 9/16	38	5 hy			Each of two sections wound separately and mounted in common can; wired as a tapped choke. Inductance measured with 15 rms volts (100 to 130 cps) and 0.4d-c amperes applied to coil.
L1902	A1011449 FT1605		Single	35SF	2,480	82	9/16	300	10 hy			Inductance measured with 15 rms volts (100 to 130 cps) and 0.4 d-c amperes applied to coil.
L2002	A1010862 FT2605		Single	30SF	2,860	106	1 1/4	144	10 hy			Inductance measured with 18 rms volts (100 to 130 cps) and 0.1 d-c amperes applied to coil.
T101	A1011223 FT2613		Pri Shield Sec 1 Sec 2	29SF 0.0014 copper 27SF 20SF	546 1 164 tapped at 153 34 x 2 (bifilar)	80 60 14	1 1/16 1 1/16 1 1/16 1 1/16	19 4.1 0.1			1,000 500 500	Bifilar secondary #2 winding consists of two parallel strands of #20 wire. Winding is made by having core turn 34 times.
T102	A1011224 FT2637		Pri Sec	36SF 32SF	3,990 1,513	173 110	1 1/16 1 1/16	670 124		2.83: 1	1,500 1,500	

TABLE 7–27. WINDING DATA (Cont'd)

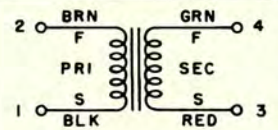
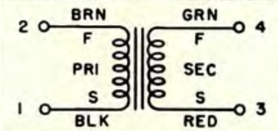
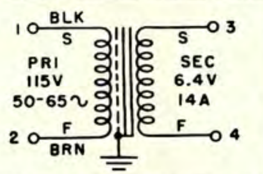
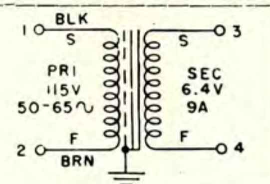
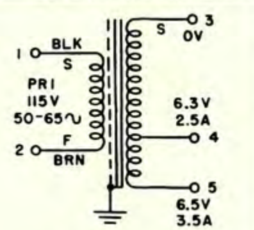
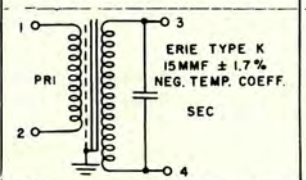
CIRCUIT SYMBOL	FTR DWG OR MFR'S TYPE NUMBER	SCHEMATIC DIAGRAM	WIND-ING	WIRE SIZE	TURNS	TURNS PER LAYER	WINDING LENGTH (INCHES)	D-C RESISTANCE (OHMS)	IN-DUCTANCE	IMPEDANCE RATIO	HIPOT RMS VOLTS	REMARKS
T 201, T 206, T 502	A1011861 FT2642		Pri Sec	34HF 34HF	90 90	30 30	11/32 11/32	2.8 3.6		1: 1	500 500	
T202, T203, T204	A1011862 FT2643		Pri Sec	39HF 39HF	200 200	68 68	5/16 5/16	18 24		1: 1	500 500	
T205, T1903	A1010865 FT2608		Pri Shield Sec	20SF 0.0014 copper 13SF	331 1 19.5 x2 (bifilar)	49 10	1 3/4 1 3/4 1 3/4	1.97 0.0015			1,000 1,000	Bifilar secondary winding consists of two parallel strands of #13 wire. Winding is made by having core turn 19.5 times.
T501, T801, T1701	A1010866 FT2609		Pri Shield Sec	24SF 0.0014 copper 12HF	354 1 21	60 11	1 13/32 1 13/32 1	4.9 0.024			1,000 500	
T1201	A1010867 FT2610		Pri Shield Sec	25SF 0.0014 copper 14SF	600 1 37 tapped at 36	67 19	1 13/32 1 13/32 1 3/8	8.45 0.052			1,000 500	
T1401, T1402	WE Type KS-9472		Pri Sec	40EC stranded 40EC stranded	18 650			0.6 48	0.02 mh 0.25 mh			

TABLE 7–27. WINDING DATA (Cont'd)

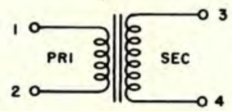
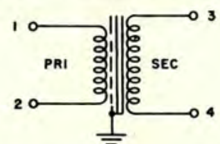
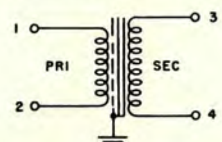
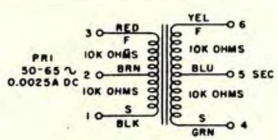
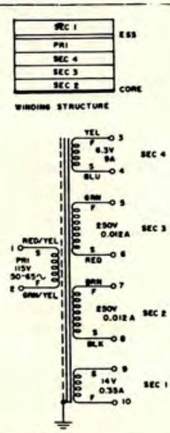
CIRCUIT SYMBOL	FTR DWG OR MFR'S TYPE NUMBER	SCHEMATIC DIAGRAM	WIND-ING	WIRE SIZE	TURNS	TURNS PER LAYER	WINDING LENGTH (INCHES)	D-C RESISTANCE (OHMS)	IN-DUCTANCE	IMPEDANCE RATIO	HIPOT RMS VOLTS	REMARKS
T1403	WE Type KS-9489		Pri	36EC	400			35	0.3 hy			
				36EC	700			78	0.9 hy			
T1404	WE Type D-168816		Pri	23	90			0.75	2.5 mh			
			Sec	28	2,210			60	1.5 hy			
T1405	WE Type KS-9467		Pri	31	760			32	0.7 hy			
			Sec	35	2,000			276	3.0 hy			
T1501	A1011448 FT2614		Pri	37SF	3,180 tapped at 1,590	159	7/8	550		1:	500	
			Sec	37SF	3,180 tapped at 1,590	159	7/8	685		1	500	
T1502	A1011222 FT2612		Sec 2	36SF	1,019	316	1 15/16	233			700	Windings are applied in order given in column 4, with secondary #2 closest to core. Bifilar secondary #1 winding consists of two parallel strands of #15 wire. Winding is made by having core turn 28 times.
			Sec 3	36SF	1,019	316	1 15/16	247			700	
			Sec 4	25SF	61	61	1 17/16	1.25			500	
			Shield	0.0014 copper	1		1 15/16					
			Pri	22SF	469	67	1 15/16	5.24			1,000	
			Sec 1	15SF	28x2 (bifilar)	14	1 15/16	0.036			500	

TABLE 7–27. WINDING DATA (Cont'd)

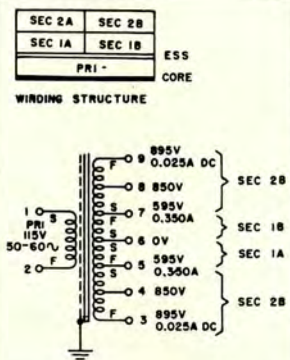
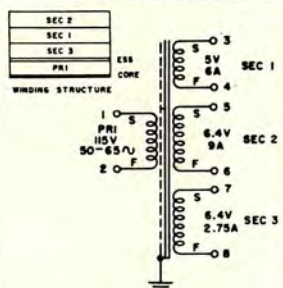
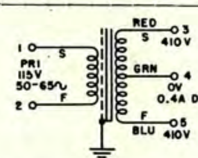
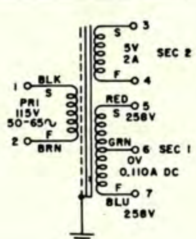
CIRCUIT SYMBOL	FTR DWG OR MFR'S TYPE NUMBER	SCHEMATIC DIAGRAM	WINDING	WIRE SIZE	TURNS	TURNS PER LAYER	WINDING LENGTH (INCHES)	D-C RESISTANCE (OHMS)	INDUCTANCE	IMPEDANCE RATIO	HIPOT RMS VOLTS	REMARKS
T1901	A1011451 FT2617		Pri	17SF	172	44	2¼	0.68			1,000	
			Shield	0.0014	1		2¼					
			Sec 1A	26SF	922	44	13/16	37.2			3,000	
			Sec 1B	26SF	922	44	13/16	37.2			3,000	
			Sec 2A	30HF	460 tapped at 389	60	¾	54.5			3,000	
			Sec 2B	30HF	460 tapped at 389	60	¾	54.5			3,000	
T1902, T2002, T2104	A1010863 FT2606		Pri	20SF	258	43	1 9/16	1.66			1,000	Bifilar secondary windings consist of two parallel strands of wire. Windings are made by having core turn the listed number (15 or 12) of times.
			Shield	0.0014 copper	1		1 9/16					
			Sec 1	20SF	15x2 (bifilar)	15	1 3/32	0.058			500	
			Sec 2	18SF	12x2 (bifilar)	12	1 3/32	0.030			2,100	
			Sec 3	13 Square DCC	15	15	1 11/32	0.021			800	
T2001, T2103	A1010864 FT2607		Pri	18SF	170	43	1 15/16	0.834			1,000	
			Shield	0.002 copper	1		1 15/16					
			Sec	25SF	1,240	93	1 15/16	39			2,000	
T2003	A1010861 FT2604		Pri	25SF	408	68	1 13/32	6.5			1,000	
			Shield	0.0014 copper	1		1 13/32					
			Sec 1	32SF	1,930 tapped at 143	143	1⅜	193			2,500	
			Sec 2	18SF	19	19	55/64	0.1			500	

TABLE 7–27. WINDING DATA (Cont'd)

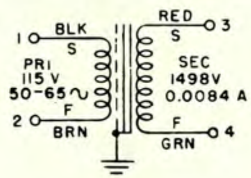
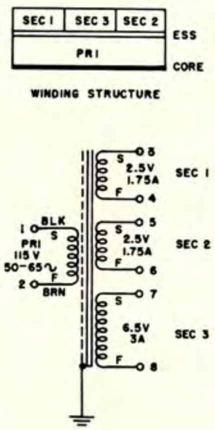
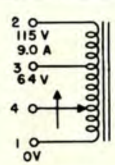
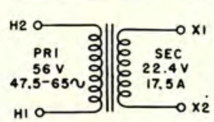
CIRCUIT SYMBOL	FTR DWG OR MFR'S TYPE NUMBER	SCHEMATIC DIAGRAM	WIND-ING	WIRE SIZE	TURNS	TURNS PER LAYER	WINDING LENGTH (INCHES)	D-C RESISTANCE (OHMS)	IN-DUCTANCE	IMPEDANCE RATIO	HIPOT RMS VOLTS	REMARKS
T2101	A1011869 FT2625		Pri	29SF	742	106	1 13/32	27			1,000	
			Shield	0.0014 copper	1		1 13/32					
			Sec	38SF	10,300	252	1 1/4	4,900			1,000	
T2102	A1011450 FT2616		Pri	28SF	534	108	1 19/32	15.2			1,000	
			Shield	0.0014	1		1 19/32					
			Sec 1	21SF	13.5	4	5/32	0.1			4,500	
			Sec 2	21SF	13.5	4	5/32	0.1			4,500	
			Sec 3	20SF	35	12	7/16	0.2			3,800 to case, 8,000 to sec 1 & 2	
T2301	C1040953		Single layer torroid	14HF	159 tapped at 97	159		0.42			1,500	This autotransformer has one fixed and one movable tap.
T2302	C1040954		Pri	11 Sq DCC	111			0.11			1,500	
			Sec	7 Sq DCC	45			0.023			1,500	

TABLE 7–27. WINDING DATA (Cont'd)

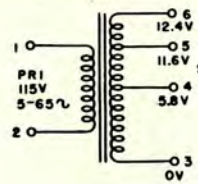
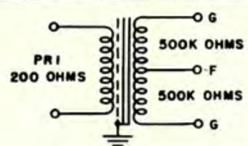
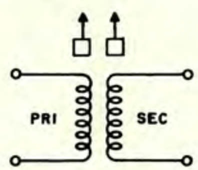
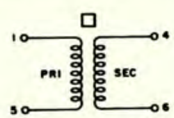
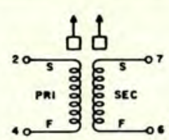
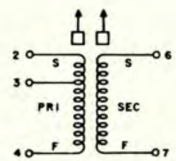
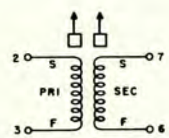
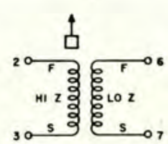
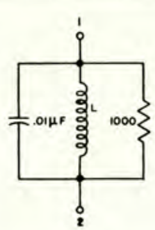
CIRCUIT SYMBOL	FTR DWG OR MFR'S TYPE NUMBER	SCHEMATIC DIAGRAM	WIND-ING	WIRE SIZE	TURNS	TURNS PER LAYER	WINDING LENGTH LENGTH	D-C RESISTANCE (OHMS)	IN-DUCTANCE	IMPEDANCE RATIO	HIPOT RMS VOLTS	REMARKS
T2303	UNT Type M1566		Pri Sec	25SF 17SF	589 65 tapped at 63 and 31.5			8.8 0.22			1,500	
T2304	UNT type M1565		Pri Sec	35SF 44SF	225 15,750 center tapped			7.1 11,250		200: 500,000	1,500 500,000	
Z201, Z202	A1017122-1 A1017122-2		Pri universal wound Sec uni- versal wound	7/41 DSC Litz 7/41 DSC Litz	162 162			5.6 5.6	410 to 580 μh 370 to 560 μh	1: 1		Although the windings for Z201 and Z202 are the same, the two coils are tuned to different frequencies by using different capacitance values.
Z801	A1017122-3		Pri universal wound Sec universal wound	30 30	66 66			1.2 1.2	125 μh 125 μh	1: 1		
Z1201, Z1207	A1024187-1 (1,750 kc) A1024187-2 (1,800 kc) A1024187-3 (1,850 kc) A1024187-4 (1,900 kc) A1024187-5 (1,950 kc)		Pri Sec	30SSE 34SSE	67 90	67 90		1.1 3.6	26.7 μh 54 μh			Wind coils clockwise, closewound. Separate the starts of the windings by 0.065 (±0.003) inch. Treat coils with Q max. Inductance of coils connected series aiding—87.2 μh; series bucking—74.2 μh. After assembling coil tune to frequency and seal in dry nitrogen.

TABLE 7–27. WINDING DATA (Cont'd)

CIRCUIT SYMBOL	FTR DWG OR MFR'S TYPE NUMBER	SCHEMATIC DIAGRAM	WIND-ING	WIRE SIZE	TURNS	TURNS PER LAYER	WINDING LENGTH (INCHES)	D-C RESISTANCE (OHMS)	IN-DUCTANCE	IMPEDANCE RATIO	HIPOT RMS VOLTS	REMARKS
Z1202	A1024195-1 (1,750 kc) A1024195-2 (1,800 kc) A1024195-3 (1,850 kc) A1024195-4 (1,900 kc) A1024195-5 (1,950 kc)		Pri Sec	30DSC 30DSC	63 tapped at 9 63	63 63		1.1 1.1	24.8 μh 24.8 μh	5 5		Wind coils clockwise, closewound. Separate the starts of the windings by 0.3 (±0.003) inch. Treat coils with Q Max. Inductance of coils connected series aiding—51.4 μh; series bucking—48.0 μh. After assembling coil tune to frequency and seal in dry nitrogen.
Z1203, Z1204	A1024197-1 (1,750 kc) A1024197-2 (1,800 kc) A1024197-3 (1,850 kc) A1024197-4 (1,900 kc) A1024197-5 (1,950 kc)		Pri Sec	28DNE 28DNE	43 43	43 43		0.5 0.5	12.5 μh 12.5 μh			Wind coils clockwise, closewound. Separate the starts of the windings by 0.3 (±0.003) inch. Treat coils with Q Max. Inductance of coils connected series aiding—25.95 μh: series bucking—24.05 μh. After assembling coil tune to frequency and seal in dry nitrogen.
Z1205, Z1206	A1024199-1 (1,750 kc) A1024199-2 (1,800 kc) A1024199-3 (1,850 kc) A1024199-4 (1,900 kc) A1024199-5 (1,950 kc)		Hi Z Lo Z	28DNE 28DNE	46 21	46 21		0.52 0.29	13.3 μh 4.7 μh			Wind coils clockwise, closewound. Interwind the first four turns of the low Z winding and the last four turns of the high Z winding. To do this make the spindle rotate 63 times for the total of 67 turns of the coil. Treat coils with Q Max.
Z1401	WE Type D-168856		Layer	34	175			1.25	0.25 μh			

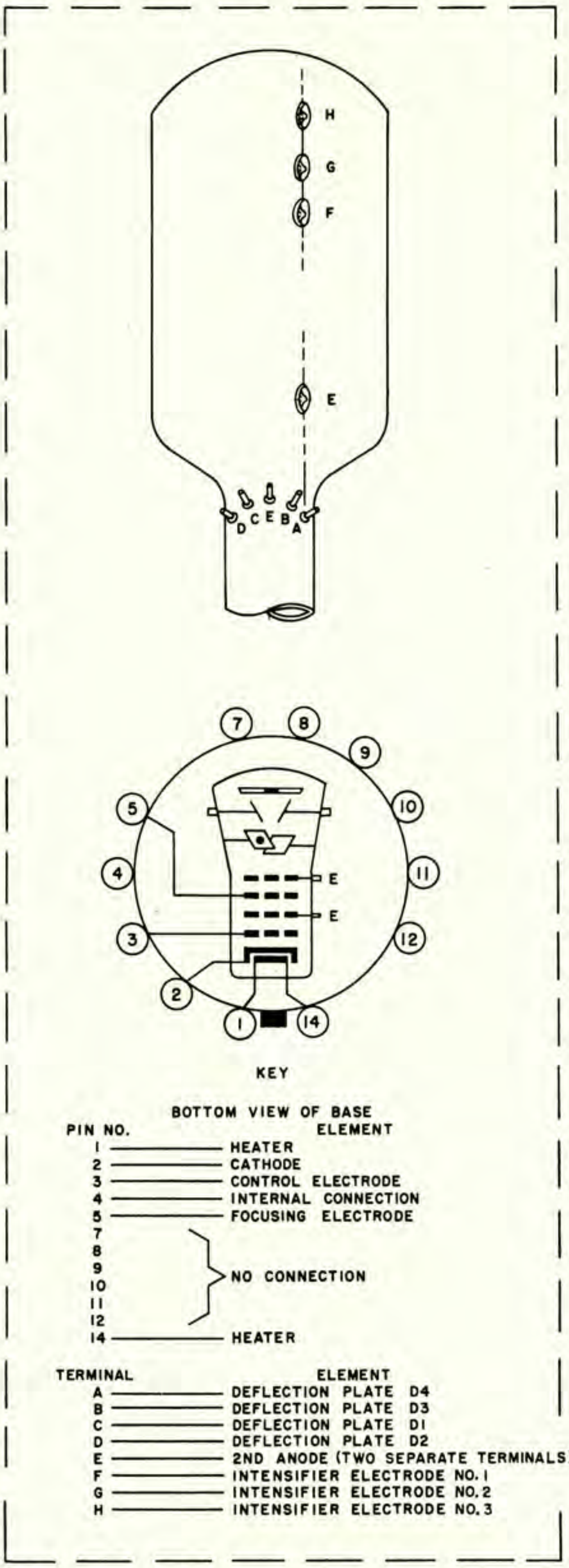


Figure 7–238. Terminal Connections for 5RP2A Cathode-Ray Tube

4. ADJUSTMENT OF FACTORY-SET CONTROLS.

The timer is equipped with a large number of controls and adjustments which were properly set at the factory and hence were not described in Section 3. Many of these controls should not require further adjustment unless the controls themselves, or associated components, are replaced. Other controls may require periodic servicing as noted in Section 6. All controls and adjustments not previously described are described below.

a. RADIO FREQUENCY OSCILLATOR TYPE O-202/FPN-30.—The only factory adjustments which might require change are variable capacitors C1401 and C1407. IN NO CASE SHOULD THE ADJUSTMENT OF VARIABLE CAPACITORS C1401 or C1407 BE CHANGED EXCEPT WHEN TRANSFORMER T1401 OR T1402 IS REPLACED. If an attempt is made to change the adjustment of these capacitors while the circuit is oscillating, a mistuned condition will probably result. This is because mistuning causes a higher output but less stability.

(1) TUNING TRANSFORMER T1402.

Step 1. Remove the oven cable leads from terminals 10 to 14 inclusive on terminal board TB1402. Remove the feedback by disconnecting the brown wire from network Z1401 at terminal 2 of transformer T1402 and connect this wire to terminal 1 of T1402.

Step 2. Connect a 10,000-ohm resistor similar to R1406 across terminals 3 and 4 of transformer T1401 to reduce the gain sufficiently to eliminate hand capacity effects when adjusting capacitor C1407. Connect a 100-kc signal source to terminals 12 and 13 of TB1402. This signal source may either be an audio generator (such as the Hewlett-Packard 200–C) or the oscillator from a stand-by timer (if available). If an audio generator is used, the frequency must be adjusted to 100 kc $\pm$5 cycles. If the oscillator of a stand-by timer is used, means must be provided to attenuate the 15-volt 100-kc output to about 210 microvolts. A 1-megohm resistor and a 100-ohm potentiometer should be connected as shown in figure 7–239 for this purpose. Connect a 135-ohm resistor similar to R1405 to terminals 10 and 11 of TB1402.

Step 3. Set the METER SWITCH to the OSC OUT position. Adjust the amplitude of the 100-kc signal to obtain approximate midscale deflection of the oscillator panel meter. Make this adjustment at the beginning of the tuning procedure and adjust the amplitude during the tuning procedure, if required, to maintain approximate midscale deflection.

Step 4. Loosen the locknut for capacitor C1407 and adjust C1407 to obtain maximum meter deflection. Upon completion of the adjustment, tighten the locking nut and restore the circuit to normal condition.

(2) TUNING TRANSFORMER T1401.

Step 1. Remove the oven cable leads from terminals 10 to 14 inclusive of terminal board TB1402. Connect a 100-kc signal source to terminals 12 and

13 of TB1402. This signal source must have an internal impedance of at least 1,000 ohms; if necessary place a 1,000-ohm resistor in series with the signal source to obtain the required source impedance. The signal source may be either an audio generator (such as the Hewlett-Packard 200–C) or the oscillator from a stand-by timer (if available). If an audio generator is used, the frequency must be 100 kc ±5 cycles. If the oscillator of a stand-by timer is used, means must be provided to attenuate the 15-volt 100-kc output to about 60 microvolts. A 22,000-ohm resistor and a 100-ohm potentiometer should be connected as shown in figure 7–239 for this purpose. Connect a 135-ohm resistor similar to R1405 to terminals 10 and 11 of TB1402.

Step 2. Set the METER SWITCH to the OSC OUT position. Adjust the amplitude of the 100-kc signal to obtain approximate midscale deflection of the oscillator panel meter. Make this adjustment at the beginning of the tuning procedure and adjust the amplitude during the tuning procedure, if required, to maintain approximate midscale deflection.

Step 3. Loosen the locknut for capacitor C1401 and adjust C1401 to obtain maximum meter deflection. Upon completion of the adjustment tighten the locknut and restore the circuit to normal condition.

(3) COARSE HEATER OPERATING TEMPERATURE.—As described in Section 2, paragraph 4 *a* (5), the operating temperature of the coarse heater may be varied over a range of somewhat less than 3° through the action of an auxiliary heater arrangement on the thermoswitch. The check for the need for this adjustment is given in table 7–2, symptom 2*a* and symptom 2*b*. To make the adjustment proceed as follows:

Step 1. Remove the three screws holding the phenol fiber plug in the end plate of the oven. Pull out the plug and gasket, taking care that the discs of heat insulating material remain in place.

Step 2. Adjust the shaft of potentiometer R1422, exposed by the operation in step 1, by means of a small screwdriver. Clockwise rotation of the shaft decreases the coarse heater temperature and increases the reading of the oscillator panel meter when the METER SWITCH is in the HEATER position. Counterclockwise rotation increases temperature and decreases the meter reading. In the middle range of the meter scale a 20° rotation of the shaft produces a change in meter reading of about 10. Toward either end of the meter scale a somewhat greater shaft rotation is required to produce the same change in meter reading. Adjust the potentiometer to obtain a meter reading between 80 and 120. These limits are narrower than actually required for normal operation but should be used to allow for any future change. Adjustment of R1422 will not affect the meter reading immediately; consequently, replace the plug and wait a few hours until the fine heater is observed to stabilize. If the heater stabilizes with the meter reading outside the prescribed

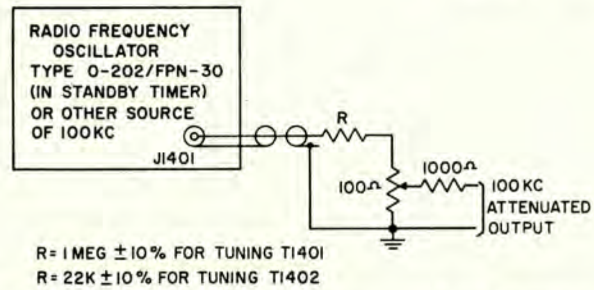


Figure 7–239. Connection Diagram for Obtaining 100-kc Test Signal

limits, repeat the adjustment. If it is found impossible to bring the reading within the limits of 60 to 140, replace the thermoswitch in accordance with instructions of paragraph 5 *b* (3).

Step 3. Upon completion of the adjustment replace the plug and gasket and replace the three screws.

b. SYNCHRONIZATION CONTROL TYPE C–1238/FPN–30.—Mechanical and electrical adjustments of the sync control unit which might require change are described below.

(1) ALIGNMENT OF PHASE DIAL, POTENTIOMETER, AND STOP.—The PHASE dial and the recorder drive potentiometer must be correctly aligned, with respect to each other, for proper operation of the recording system. In addition, at a master station only, the mechanical stop must be properly positioned with respect to the PHASE dial and the potentiometer to insure operation about the center of the potentiometer resistance element and thus prevent the arm from going off either end of the winding. If any symptom of misalignment is detected perform either (*a*) or (*b*) below.

(*a*) ALIGNMENT FOR USE AT A MASTER STATION.

Step 1. Turn the timer MAIN POWER switch OFF. Remove the cover plate (held by slide fasteners) from the phase and frequency components housing which is located in the right center of the sync control unit chassis. Remove the long protective cover which is located immediately behind the front panel and is secured by two cam-lock fasteners. Turn the MAIN POWER switch back ON.

Step 2. Connect the spare recording ammeter to the timer which is to be adjusted by plugging the test cable furnished into EXTERNAL RECORDER jack J105 on the sync control unit front panel. (A procedure for making this connection is given in Section 3, paragraph 29 *e* (2).)

Step 3. Rotate the PHASE dial and observe the reading of the PHASE dial obtained as the stop is encountered at both ends of the dial rotation. (The reading at each extreme will be approximately 4.8

microseconds.) If equal readings (within 0.05 microsecond) are not obtained loosen the setscrews holding the dial to the shaft, reposition the dial as required, tighten the setscrews, and observe the readings again. Repeat as necessary.

Step 4. Loosen the locking nut on the mechanical stop screw and withdraw (counterclockwise rotation) the screw until it clears the stop. Observe the center pen of the recording ammeter as the PHASE dial is slowly rotated in a counterclockwise direction toward the ±5-microsecond mark. The pen should move slowly to the right. Slightly before the ±5-microsecond mark is reached, the recorder should suddenly jump to the zero line on the chart. Record the PHASE dial reading at the point where this occurs. As rotation is continued, the recorder pen should remain on the zero line until a point of rotation where the pen suddenly jumps to the extreme left of the chart (i.e., a large negative deflection). Record this second point. Further counterclockwise rotation of the PHASE dial should make the pen travel slowly to the right. If the two points recorded in this step are not equally centered about the ±5-microsecond mark (within 0.05 microsecond), then set the PHASE dial on the ±5-microsecond mark, loosen the coupling between the autosyn and the potentiometer, and position the potentiometer shaft with the fingers as required to center the area of potentiometer rotation where the recorder pen rests on zero. Leaving the potentiometer shaft in the center of this zero reading position, make sure that the PHASE dial is still on the ±5-microsecond mark and tighten the coupling. Repeat the check and adjustment as necessary until the two readings of the PHASE dial are within 0.05 microsecond of each other.

Step 5. Turn the mechanical stop screw clockwise until it just touches the stop as the PHASE dial is rocked back and forth past the ±5-microsecond mark. With the PHASE dial on 0 turn the stop screw clockwise three full turns and tighten the locking nut. This completes the adjustment at a master station. Turn the MAIN POWER switch OFF. Replace the two cover plates and disconnect the spare recording ammeter. Turn the MAIN POWER switch ON.

(*b*) ALIGNMENT FOR USE AT A SLAVE STATION.

Step 1. Turn the MAIN POWER switch OFF. Remove the cover plate (held by slide fasteners) from the phase and frequency components housing which is located in the right center of the sync control unit chassis. Turn the MAIN POWER switch back ON.

Step 2. Connect the spare recording ammeter to the timer which is to be adjusted by plugging the test cable furnished into EXTERNAL RECORDER jack J105 on the sync control unit front panel. (A procedure for making this connection is given in Section 3, paragraph 28 *b* (2).)

Step 3. Observe the center pen of the recording ammeter as the PHASE dial is slowly rotated in a counterclockwise direction toward the ±5-microsecond mark. The pen should move slowly to the right. Slightly before the ±5-microsecond mark is reached, the recorder should suddenly jump to the zero line on the chart. Record the PHASE dial reading at the point where this occurs. As rotation is continued, the recorder pen should remain on the zero line until a point of rotation where the pen suddenly jumps to the extreme left of the chart (i.e., a large negative deflection). Record this second point. Further counterclockwise rotation of the PHASE dial should make the pen travel slowly to the right. If the two points recorded in this step are not equally centered about the ±5-microsecond mark (within 0.05 microsecond), then set the PHASE dial on the ±5-microsecond mark, loosen the coupling between the autosyn and the potentiometer, and position the potentiometer shaft with the fingers as required to center the area of potentiometer rotation where the recorder pen rests on zero. Leaving the potentiometer shaft in the center of this zero reading position, make sure that the PHASE dial is still on the ±5-microsecond mark and tighten the coupling. Repeat the check and adjustment as necessary until the two readings of the PHASE dial are within 0.05 microsecond of each other. This completes the adjustment at a slave station. Replace the cover plate and disconnect the spare recording ammeter.

(2) ALIGNMENT OF THE FREQUENCY CORRECTOR DIAL, FREQUENCY WARNING CAM, AND FREQUENCY CORRECTOR CAPACITOR. — The FREQUENCY CORRECTOR dial, the frequency warning cam, and capacitor C120 must be properly aligned for the frequency corrector system to operate properly. If misalignment is indicated by improper operation of this system, proceed as follows.

Step 1. Rotate the FREQUENCY CORRECTOR dial alternately in both directions from the 0 mark and observe the FREQUENCY WARNING indicator lamp. Note the dial reading at each of the two points of rotation where the lamp just comes on. If each reading is not between 3-3/4 and 4, loosen the setscrews holding the knob, reposition the knob as required, tighten the setscrews, and recheck. Repeat as necessary. If the knob cannot be centered within the proper limits, microswitch S105 may have to be repositioned. Adjustment of the microswitch is described in paragraph 5 *c* (3), to follow.

Step 2. Turn the timer MAIN POWER switch OFF. Remove the cover plate (held by slide fasteners) from the phase and frequency components housing in the right center of the chassis. Loosen the coupling connecting to C120 and set C120 for maximum capacity (plates fully meshed). Adjust the FREQUENCY CORRECTOR dial to read 4 at the clockwise end (this end reads LOWER OSC DIAL BEFORE RESETTING). With C120 still at maximum capacity, tighten the coupling. This completes the adjustment. Replace the cover. Turn the MAIN POWER switch ON.

(3) ADJUSTMENT OF L103.—100 KC TUNING inductance L103 may require occasional adjustment. The coil tunes broadly and adjustment is not critical.

Step 1. Set the TEST SIGNAL switch on the sync control unit to 100 KC TO FREQ DIV and the test scope SIGNAL SELECTOR switch to SYNC CONTROL. Using a slow sweep speed, set the GAIN SELECTOR switch to HIGH and the SIGNAL GAIN control for some convenient deflection.

Step 2. Use a screwdriver to adjust the tuning slug of L103 for maximum signal amplitude.

c. FREQUENCY DIVIDER TYPE CV–274/FPN–30.—The factory adjustments in this unit consist of adjustments for the 1's marker generator circuit coils (Z201, Z202) and adjustment of the DRIFT ADJUST control. The 1's marker generator adjustments consist of tuning the two coils and phasing the 1's and 10's on the VIDEO SCOPE. Ordinarily the coil-tuning adjustments (steps 1 through 5) will not be required unless one of the transformers, or some associated component, is replaced. The adjustment for proper phasing (steps 6 and 7) may be required from time to time. Need for this adjustment will be visually evident as misalignment of the 1's and 10's on the VIDEO SCOPE.

A special alignment tool, shown in figure 7–240, is supplied with the timer to facilitate these adjustments. One end of this tool is an insulated screwdriver. The other end is a hollow metal tip with a pin running through it. The pin projects beyond the sides of the tool to engage the tuning slot of the upper slug. The insulated screwdriver end may be inserted through the upper tuning slug to engage the tuning slot of the bottom slug. Alternatively, a screwdriver blade, within the hollow tip, may be used to adjust the bottom tuning slug from the underside of the chassis. The choice of tuning the bottom slug from either end is a matter of convenience.

(1) COILS IN THE 1's MARKER CIRCUIT.

Step 1. Apply the test scope low capacity probe to terminal 6 of Z201 (secondary winding output terminal). Set the test scope gain controls for a high signal amplitude and then reduce gain as required to maintain convenient amplitude during the adjustment procedure.

Step 2. Using the special alignment tool described above, adjust the top (primary) tuning adjustment of Z201 for maximum deflection of the test scope signal. (The order of adjustment given in this and following steps must be observed.) Adjust the bottom (secondary) tuning slug for maximum amplitude. The adjustment of Z201 is now tentatively complete; further adjustment, made in the next step, is required because of the capacitive loading of the test probe.

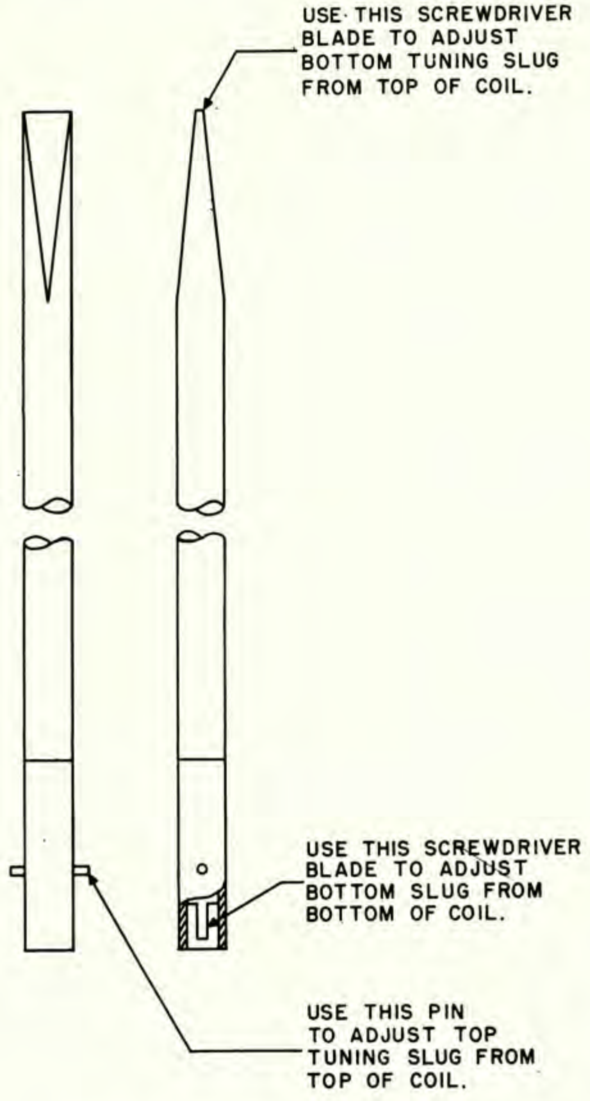


Figure 7–240. Special Alignment Tool

Step 3. Move the probe to terminal 3 of Z202 (secondary winding output terminal) and adjust the test scope gain controls as required for this next adjustment. Again peak the top, then the bottom, tuning adjustment for Z201.

Step 4. Peak the top, then the bottom, tuning adjustment for Z202.

Step 5. Move the probe to the terminal board connection of C323 which is furthest from the chassis. Again tune the top, then the bottom, tuning adjustment for Z202; *this time adjust for minimum signal amplitude.*

Step 6. Turn the VIDEO SCOPE PRESENTATION SWITCH to CAL and the SWEEP SPEED control to the extreme clockwise position, for a fast sweep speed. Separate the traces to simplify observation of some particular group of 10's and 1's.

Step 7. Modify the tuning adjustment of the Z201 secondary bottom screw slightly to obtain maximum amplitude of the 10's. As Z201 is tuned the phase of the 1's will vary with respect to the 10's. This will cause the amplitude of the 10's to change. Adjust the tuning, in the direction giving best results, until the 10's have a maximum amplitude. DO NOT ADJUST ANY BUT THE BOTTOM TUNING ADJUSTMENT FOR Z201. If any other adjustment of Z201 or Z202 is accidentally upset, repeat steps 3, 4, and 5 before continuing with step 6.

(2) DRIFT ADJUST CONTROL ADJUSTMENT.—The DRIFT ADJUST control is provided to vary the shape of the drift pulse, as required to make the added or subtracted drift pulse occur at the proper time. Should the drift circuit provide an incorrect amount of drift, or not operate, in one or more positions of the DRIFT switch, proceed as follows:

Step 1. Adjust the test scope and frequency divider controls to observe the 50-cycle waveform shown in figure 7–8. Be sure to have the test scope SYNC SELECTOR switch in the SQ WAVE ϕ 1 position throughout this procedure.

Step 2. Adjust the SWEEP DELAYS controls to move the 50-cycle pulse to the extreme left edge of the scope. This adjusts the test scope to observe events occurring at the beginning of the A half-cycle, the time when modification of the loran rate, to obtain drift, occurs.

Step 3. Turn the frequency divider TEST SIGNAL switch to 100's and the test scope MARKER SELECTOR switch to 10's and 1's. Adjust the SIGNAL GAIN control to make the 100's about one-half inch high and adjust the MARKER HEIGHT control to make the 10's about one-eighth inch high (just visible). Adjust the sweep speed controls so that a 100 is visible in the middle of the screen.

Step 4. Hold the DRIFT switch (on the synchronization indicator) on SLOW RIGHT and observe the test scope. The 100 should move 40 microseconds (four 10's) to the left. Unlock the DRIFT ADJUST control and adjust to the position where the 100 moves 40 microseconds to the left each time the DRIFT switch is turned from OFF to SLOW RIGHT. Find the positions either side of this setting where the correct motion of the 100 no longer occurs. Put the DRIFT ADJUST control in the center of these two positions and lock the control. Make sure that the 100 moves 40 microseconds to the right for the two positions of left drift and moves 40 microseconds to the left for the two positions of right drift. If correct drift is not obtained in all positions modify the adjustment as required.

d. TIME DELAY TYPE TD–92/FPN–30. — Most of the adjustments for the time delay unit have been described in Section 3; however, the delay bias control adjustment is described here. Delay bias must be made sufficiently negative so that the circuit does not free run, yet not so negative that the range of circuit delay is shortened. Because the adjustment procedure for the A1000, B1000, B100, and B10 controls is identical in each case only the adjustment procedure for the A1000 delay circuit is given. A table, at the end of the procedure, shows which controls to use and what sweep length to use for each delay circuit. Column 1 in this table shows the delay control, column 2 the sweep length, and column 3 the delay bias control. The controls and sweep length for the A1000 adjustment are shown to facilitate comparison. A separate procedure is given for the B continuous bias adjustment.

(1) A1000, B1000, B100, and B10 DELAY BIAS ADJUSTMENTS.

Step 1. Set the A1000 control for maximum delay (full clockwise rotation).

Step 2. Set the TEST SIGNAL switch to A1000 and the SIGNAL SELECTOR switch on the test scope to TIME DELAY. Adjust the test scope controls to position the A1000 push-up gate near the center of the trace, using about a 10,000-microsecond sweep length.

Step 3. Observe the characteristics of the bias adjustment as the A1000 bias control (R507) is slowly rotated (unlock the control) toward the extreme counterclockwise position and then toward the extreme clockwise position. As the control turns counterclockwise, the circuit starts to free run; that is, the push-up gate jumps back and forth as the phantastron triggers itself continuously. As the control is moved clockwise, a point is reached where the gate moves rapidly to the left. This rapid motion is preceded by a much slower motion, which should be ignored.

Step 4. Note the dial reading at which the rapid motion to the left begins. Back the control off two *small* divisions below this point. Tighten the locking nut.

COLUMN 1	COLUMN 2	COLUMN 3
A1000	10,000	R507
B1000	10,000	R610
B100	1,000	R629
B10	100	R630

(2) B CONTINUOUS DELAY BIAS ADJUSTMENT.

Step 1. Set the B DELAY OUTPUT switch to B CONT if it is not already in this position. If at a master station temporarily set the STATION SELECTOR switch to SLAVE. Set the B CONTINUOUS delay control for maximum delay (full clockwise rotation).

Step 2. Set the TEST SIGNAL switch to TRANSMITTER TRIG and the SIGNAL SELECTOR switch on the test scope to TIME DELAY. Adjust the test scope controls to position the transmitter trigger near the center of the trace, using a 100-microsecond sweep length.

Step 3. Observe the characteristics of the bias adjustment as the B CONT BIAS control (R595) is slowly rotated (unlock the control) toward the extreme counterclockwise position and then toward the extreme clockwise position. As the control turns counterclockwise, the circuit starts to free run; that is, multiple transmitter trigger pulses are generated as the phantastron triggers itself continuously. As the control is moved clockwise, a point is reached where the transmitter trigger moves rapidly to the left. This rapid motion is preceded by a much slower motion, which should be ignored.

Step 4. Note the dial reading at which rapid motion to the left begins. Back the control off two *small* divisions below this point. Tighten the locknut, and restore the B DELAY OUTPUT and STATION SELECTOR switches to their original conditions. Restore the B CONTINUOUS delay control setting for a normal B continuous delay.

e. SYNCHRONIZATION INDICATOR TYPE IP–238/FPN–30. — The synchronization indicator contains delay bias adjustments in the delay circuits of the VIDEO SCOPE and the RF SCOPE. The procedure for making these adjustments is similar to that for delay bias adjustments in the time delay unit.

(1) VIDEO SCOPE DELAY BIAS ADJUSTMENT.

Step 1. Set the SWEEP DELAY control to the extreme counterclockwise position (maximum delay) and the SWEEP SPEED control to midposition. Set the PRESENTATION switch to CAL and adjust the TRACE SEPARATION control for a convenient separation to permit observation of the markers on one trace.

Step 2. Observe the characteristics of the bias adjustment as the video BIAS ADJ control (R959) is slowly rotated (unlock the control) toward the extreme counterclockwise position and then toward the extreme clockwise position. As the control turns counterclockwise, the circuit starts to free run; that is, the VIDEO SCOPE trace flickers and is unstable. As the control is moved clockwise a point is reached where the markers move rapidly to the right. This rapid motion is preceded by a much slower motion, which should be ignored.

Step 3. Note the dial reading at which rapid motion to the right begins. Back the control off two *small* divisions below this point. Tighten the locking nut.

(2) RF SCOPE DELAY BIAS ADJUSTMENT.

Step 1. Set the SWEEP DELAY control to the extreme counterclockwise position (maximum delay) and the SWEEP SPEED control to the extreme counterclockwise position (slow sweep speed). Set the PRESENTATION switch to CAL and adjust the trace separation control to a convenient separation to permit observation of the markers on one trace.

Step 2. Observe the characteristics of the bias adjustment as the RF BIAS ADJ control (R960) is slowly rotated (unlock the control) toward the extreme counterclockwise position and then toward the extreme clockwise position. As the control turns counterclockwise, the circuit starts to free run; that is, the RF SCOPE trace flickers and is unstable. As the control is moved clockwise a point is reached where the markers move rapidly to the right. This rapid motion is preceded by a much slower motion, which should be ignored.

Step 3. Note the dial reading at which rapid motion to the right begins. Back the control off two *small* divisions below this point. Tighten the locking nut.

f. RADIO RECEIVER TYPE R–564/FPN–30. — The radio receiver contains a number of broadly tuned circuits which have been factory-adjusted to the center of the operating range of the receiver. These circuits will not normally require readjustment unless the adjusting component, or some associated component, is changed.

(1) CAPACITOR C1298.—Capacitor C1298 (located as shown in figure 7–255) is provided in the local channel to compensate for tube capacities in the remote channel and thus make the local channel input transformer have delay characteristics identical to those of the corresponding transformer in the remote channel. Should C1298 be replaced, or its glyptal sealed adjustment be accidentally disturbed, a sufficiently accurate adjustment will be obtained if the capacitor is set to the angle of the original factory-set capacitor. Figure 7–241 shows an average angle and several identifying features of the rotational position of the rotor and stator.

If a more accurate setting is desired and capacitance measuring equipment is available, the capacitor may be adjusted to 6 mmf before it is wired into the circuit.

After setting C1298, seal the adjustment by painting with glyptal or some similar agent.

(2) FILTER INDUCTORS.—Some of the power filter inductors are provided with powdered iron cores so that a high inductance is afforded. These cores

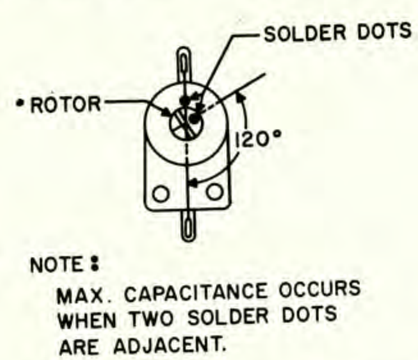


Figure 7–241. Correct Position for C1298 Rotor

are factory-adjusted to the maximum inductance position. Should it be necessary to adjust these cores, position them so that the core-adjusting screw protrudes the distance shown in the following table.

INDUCTOR	DISTANCE SCREW PROTRUDES (INCHES)
L1203	1/2
L1223	1/2
L1224	1/2
L1208	1/4
L1218	3/8

(3) BROAD BAND TUNING ADJUSTMENTS L1212, L1214, L1215.—The broad band tuning adjustments are factory-peaked at 1,850 kc. Because of the broad tuned characteristic of these coils, it is impracticable to tune them in the receiver. Should it be necessary to adjust one of these coils, turn the adjusting screws counterclockwise until the screw is as far out of the coil as it will go. Then turn the screw clockwise in accordance with the following table.

COIL	SLUG POSITION FROM FULL OUT
L1212	4 turns
L1214	6 turns
L1215	2 turns

(4) R-F TRAP RESISTANCE ADJUSTMENTS.

Step 1. Temporarily remove the antenna connection from REMOTE SIGNAL jack J2204 (on the back of the timer cabinet) and feed the output of a signal generator into this jack. Temporarily disconnect the antenna connection to LOCAL SIGNAL jack J2203. Set both r-f trap controls in the extreme counterclockwise position.

Step 2. Tune the signal generator to the same frequency to which the plug-in coils of the receiver are tuned. Set the COARSE RF GAIN control to about 35 on the dial, and adjust the signal generator gain control for some convenient deflection of the RF SCOPE presentation. Refine the frequency setting of the signal generator by varying the frequency slightly as required to obtain maximum signal deflection.

Step 3. Tune RF TRAP NO. 1 to the received signal; this will be indicated by a severe dip in signal amplitude. Advance the COARSE RF GAIN control or the signal generator gain control as necessary to maintain a convenient signal deflection. Refine the trap tuning for minimum output.

Step 4. Remove the snap button covering R1213 (located as shown in figure 5–13) and adjust R1213 for minimum signal amplitude. Readjust the RF TRAP NO. 2 tuning and R1213 as required to obtain minimum output. Replace the snap button.

Step 5. Set RF TRAP NO. 1 in the extreme counterclockwise position. Tune RF TRAP NO. 2 to the received signal, tuning for a minimum output as for RF TRAP NO. 1 in step 3.

Step 6. Remove the snap button covering R1218 (located as shown in figure 5–13) and adjust R1218 for minimum signal amplitude. Readjust the RF TRAP NO. 2 tuning and R1218 as required to obtain minimum output. Replace the snap button, remove the signal generator connections, and restore the normal antenna connections.

g. ELECTRICAL SYNCHRONIZER TYPE SN–117/FPN–30. — The delay bias circuit in the electrical synchronizer is adjusted by a slightly different procedure than that used for the time delay unit.

(1) DELAY BIAS ADJUSTMENT.

Step 1. Set the electrical synchronizer TEST SIGNAL switch to the LOCAL GATE position and the test scope SIGNAL SELECTOR to the ELECT SYNC position. Adjust the test scope controls to place the local gate approximately in the center of the screen, using a 100-microsecond sweep length.

Step 2. Observe the characteristics of the bias adjustment as the DELAY BIAS control (R1592) is slowly rotated (unlock the control) toward the extreme counterclockwise position and then toward the extreme clockwise position. As the control turns counterclockwise, the circuit starts to free run; that is, multiple gate pulses are generated as the phantastron triggers itself continuously. As the control is moved clockwise, a point is reached where the gate moves rapidly to the left. This rapid motion is preceded by a much slower motion, which should be ignored.

Step 3. Note the dial readings for the two points where free running starts and where the gate starts moving rapidly to the left. Set the control midway between these two points. Tighten the locking nut.

h. TEST OSCILLOSCOPE TYPE OS–39/FPN–30.— The test scope gate width and delay bias controls may require occasional adjustment.

(1) GATE WIDTH ADJUSTMENT.

Step 1. Unlock the 1000 GATE WIDTH control (R1713) and rotate it about one-quarter turn counterclockwise. Rotate the 1000 μS STEPS control (R1707) by a small amount in either direction and note that the trace blanks out in between 1,000-microsecond steps of delay change.

Step 2. Rock the 1000 μS STEPS control back and forth over a small range so that the trace appears, disappears, and reappears. At the same time turn the 1000 GATE WIDTH control clockwise. Note that, as the 1000 GATE WIDTH control is turned clockwise, the amount of rotation of the 1000 μS STEPS control, during which the trace blanks out, lessens. When the range over which blanking occurs is practically zero, so that blanking is eliminated, stop turning the 1000

GATE WIDTH CONTROL. Do not advance the control beyond this point or multiple triggering may result. Tighten the locking nut.

Step 3. Unlock the 100 GATE WIDTH control (R1729) and rotate it about one-quarter turn counterclockwise. Rotate the 100 μS STEPS control (R1720) to find the position about which the trace blanks out. Adjust R1729 to eliminate the blanking in the same way as was done in step 2 for the 1,000-microsecond step delay adjustment. Tighten the locking nut.

(2) DELAY BIAS ADJUSTMENT.

Step 1. Set the TEST SIGNAL switch on the time delay unit to TRANS TRIG. Set the test scope SIGNAL SELECTOR switch to TIME DELAY. Adjust the test scope controls to center the transmitter trigger pulse on the trace, using about a 200-microsecond sweep length. Set the CONTINUOUS DELAY control (R1736) to the extreme counterclockwise (maximum delay) position.

Step 2. Observe the characteristics of the bias adjustment as the DELAY BIAS control (R1752) is slowly rotated (unlock the control) toward the extreme counterclockwise position and then toward the extreme clockwise position. As the control turns counterclockwise, a double trace appears and then the circuit starts to free run; that is, multiple transmitter triggers will appear on the screen as the phantastron triggers itself continuously. As the control is moved clockwise, a point is reached where the gate moves rapidly to the right. This rapid motion is preceded by a much slower motion, which should be ignored.

Step 3. Note the dial reading at the point where rapid motion to the right begins. Back the control off one *small* division below this point. Tighten the locking nut.

5. REPAIR TECHNIQUES.

This paragraph describes repair and adjustment procedures which are not immediately obvious by physical inspection. Techniques are given below for each unit of the timer. Photographs of each unit are shown to facilitate location of components.

a. CABINET. — The adjustment procedure for the slide mechanisms and latch mechanisms of the drawer units mounted in the cabinet and the replacement procedures for the cabinet thermostat and blowers are described below.

(1) SLIDE-AND-TILT DRAWER ADJUSTMENTS. — As described in Section 1 all of the major units mounted in Electrical Equipment Cabinet CY–1437/FPN–30 are mounted on slide mechanisms which permit the units to be withdrawn from the cabinet in drawer fashion. Some of the units are also equipped with tilt mechanisms which permit access to the underside of the chassis. Thus there are two different drawer support arrangements used in the cabinet. Each support arrangement has adjustments which permit the drawer unit to be raised or lowered and which permit the front panel of the drawer unit to be tilted slightly so that the panel will be flush with the front plane of the cabinet frame.

The slide mechanisms and the latching arrangements used with all of the drawer units are constructed in the same way. The slides consist of three rails, an *outer rail,* which supports the chassis, a *middle rail,* and an *inner rail,* which is mounted on the inside of the cabinet. The middle rail slides on ball bearings mounted on the inner rail and the outer rail slides on similar bearings mounted on the middle rail. This arrangement permits the drawers to slide completely clear of the cabinet enclosure. A latch mechanism prevents the outer rail from being pulled off the middle rail except when it is desired to take the drawer unit from the cabinet for bench service or replacement. A fixed stop prevents the middle rail from being disengaged from the inner rail.

The panel latching arrangements consist of push-to-operate catch buttons and locking thumbscrews. Adjustments are provided for the catch positions and for alignment of the thumbscrew socket hole plates (mounted on the cabinet frame) with the panel thumbscrews. *This alignment must be adjusted if the panel position is changed.* Adjustments of the panel position (for the two drawer support arrangements), of the catch position, and of the thumbscrew socket hole plate positions, are discussed in the subparagraphs below.

(*a*) SLIDE DRAWER UNITS.—Those drawer units which slide but do not tilt are supported at four points. Each outer rail is secured to a stand-off U bracket at the front and back of each side of the drawer unit. A bolt passes through an elongated hole in the outer rail to hold the rail to each U bracket. By loosening each bolt and manipulating the position of each of the four corners of the drawer unit in succession, it is possible to adjust the position of the drawer panel to fit snugly against the cabinet frame without binding against the panels of adjacent units. Refer to figure 7–242.

To raise or lower the panel of a drawer unit (to prevent binding against an adjacent panel), loosen the holding bolt at the front of each side of the unit, adjust the position as required, and tighten both bolts.

To correct the plane of the panel (to make it fit flush against the cabinet frame), loosen the holding bolt at the rear of each side of the unit, adjust the position as required, and tighten both bolts.

(*b*) SLIDE-AND-TILT DRAWER UNITS. — Those drawer units which slide and tilt are each pivoted near their center of gravity to make tilting easy. The pivot pins rotate in notched vertical plates which are secured to the outer rails. A spring-loaded latch engages the notches in either the normal or the tilted position to hold the unit rigid. The exact horizontal position of each unit is controlled by a stop bar. The ends of the stop bar are fastened to the front

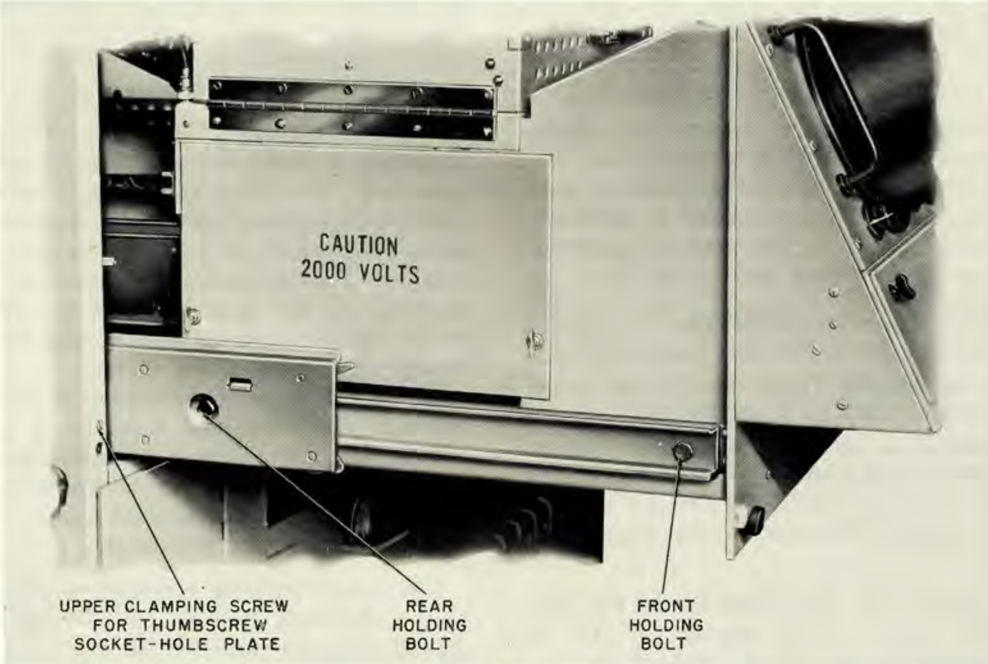


Figure 7–242. Locations of Slide Mechanism Adjustments

ends of the outer rails and the stop bar passes under the unit so that the bottom front of the unit rests against the stop bar. Guide pins in the stop bar pass through locating holes in the bottom lips of the unit to position the unit accurately between the two outer rails. The exact pivot point of each unit is somewhat to the rear of the center of gravity so that the forward portion of the unit rests firmly against the stop bar.

The notched vertical plates and the stop bar are bolted to the outer rails. Elongated holes in the rails permit adjustment of the support positions to permit the drawer panel to fit snugly against the cabinet frame without binding against the panels of adjacent units. Refer to figure 7–243.

To raise or lower the panel of a drawer unit (to prevent binding against an adjacent panel), loosen the small holding bolts at each end of the stop bar, adjust the position of the stop bar as required, and tighten all four bolts.

To correct the plane of the panel (to make it fit flush against the cabinet frame), loosen the locknuts behind the holding bolts which secure each notched vertical plate to each outer rail, loosen the holding bolts, adjust the plate positions as required, and tighten all four bolts and locknuts.

To align the guide pins in the stop bar, first tilt the unit, loosen the nuts which secure these pins to the stop bar, restore the unit to a level position and slide the unit into its latched position in the cabinet; carefully withdraw the unit so as not to change the position of the unit with respect to the stop bar, and tighten the nuts for the alignment pins.

(*c*) ADJUSTING THE THUMBSCREW PLATES.—Whenever a drawer unit panel is raised or lowered, the position of the thumbscrew socket hole plates may have to be changed accordingly to accommodate the new position of the thumbscrews. To adjust the positions of these plates, loosen the clamping screws which hold these plates to the cabinet frame (the lower of the two screws in each plate is covered by the panel of the next lower unit; the screws for the bottom units are exposed), push the drawer back into the cabinet, thread the thumbscrews into the socket hole plates, and tighten the lower clamping screws. (The clamping screws are fitted with nuts, which are accessible by reaching through the opening provided by withdrawing the next lower unit.) Loosen the thumbscrews, pull the drawer unit out, and tighten the upper clamping screws. This completes the adjustment of the thumbscrew plates.

(*d*) ADJUSTING THE PANEL CATCHES.—The panel catches may occasionally require adjustment. If the catches fail to hold, or if the panel can be moved appreciably with the catches engaged, the position of each catch should be changed until satisfactory latching is obtained.

The adjustment is made by loosening screws which hold the catch to the side of the drawer unit and sliding the catch forward or back as required. Once the correct position is obtained, tighten the screws.

(2) THERMOSTAT REPLACEMENT. — The thermostat replacement procedure requires explanation only because of the relative inaccessibility of the thermostat.

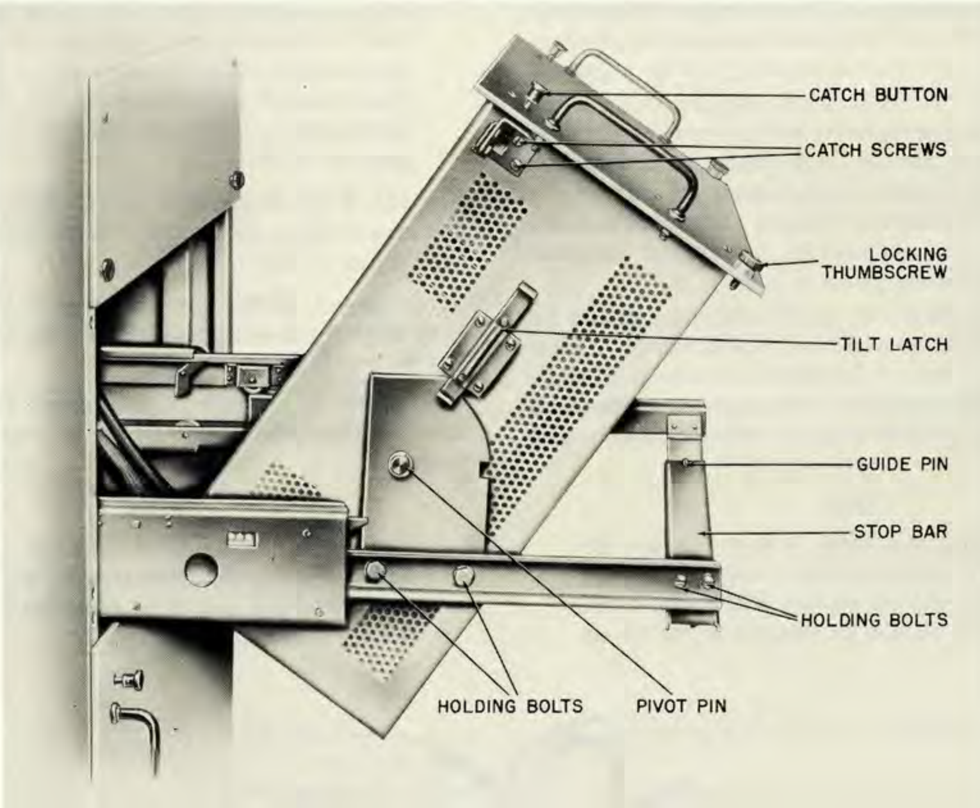


Figure 7–243. Locations of Slide-and-Tilt Mechanism Adjustments

Step 1. Turn the MAIN POWER switch OFF. Unlatch the synchronization indicator unit and withdraw it as far as the slide mechanism will permit.

Step 2. Open the right rear door of the cabinet and observe the location of the thermostat on the side of the center cabinet center position, behind the synchronization indicator unit. Loosen the two terminal screws and remove the thermostat connecting wires.

Step 3. Using an appropriate socket wrench, or pliers, remove the four nuts holding the flanged base of the thermostat to the center partition of the cabinet. Reach behind the center partition and take each screw as the associated nut is removed.

Step 4. Install the replacement thermostat, using the original hardware and replacing the connecting wires on the terminal screws. Close the rear door, restore the synchronization indicator to normal position, and turn the MAIN POWER switch ON.

(3) BLOWER REPLACEMENT.—The replacement procedure for the blowers is obvious and straightforward once some special construction features are known. Each blower is mounted on a rectangular, flanged, duct fitting. The fitting is bolted, by means of its flange, to the rear wall of the cabinet. Two nuts, at the top center of the flange, are welded to the flange to permit easy replacement of the associated bolts. The remaining nuts must be held in place as the associated screws are removed or replaced. To gain access to a blower assembly, withdraw the unit at the top of the cabinet (either the frequency divider or both the time delay unit and the blank panel above the time delay unit). To remove either a blower or a blower motor capacitor, first disconnect the blower wiring from the terminal board at the top of the cabinet, remove the mounting duct, and then separate the blower and/or the capacitor from the duct.

b. RADIO FREQUENCY OSCILLATOR. (*Refer to figure 7–248.*) The oscillator consists of the oven assembly and associated electronic circuitry. The replacement of components in the oven assembly is treated in the paragraphs which immediately follow. Replacement procedures for the rectifiers, and associated resistors, which are in the meter circuit of the electronic circuitry, follow later.

(1) IMPORTANT FOREWORD.—The crystal oven of the radio frequency oscillator contains the most critical components of the oscillator. The construction and assembly are extremely important since the device is made and adjusted to the highest practical standards of precision. The enclosed chamber is hermetically sealed and a small quantity of desiccant is placed inside just before sealing.

It is directed that no repairs be attempted on the oven assembly unless special authorization is given. The end covers of the oven are locked and a wire is passed through the screw heads. The ends of the wire *are sealed with a lead seal. If the seal or the wire is broken, the matter will be viewed seriously by the governing authority and strict accounting will be required!*

It is expected that if a defect appears in an oven, the complete oscillator unit will be returned to the C.O., C.G. Radio Station, Alexandria, Virginia, for repair. The paragraphs which follow are offered for the use of those individuals who are authorized to make repairs or who are interested in the internal construction from an academic point of view.

In normal practice, the entire oscillator should be replaced if it ceases to function satisfactorily. A completely assembled unit is furnished as a spare, in addition to completely assembled ovens and spares for those parts of the unit which can be replaced readily and safely.

Note

If the relative humidity is high (above 80 percent) and an appreciable length of time is consumed in making repairs within the oven, the oscillator should be energized for about four hours before the oven cover is replaced. This will cause any moisture which has accumulated within the oven to be driven off. The presence of moisture within the oven is detrimental to operation and may cause components to fail.

(2) REPLACEMENT OF CABLES.—The heater and crystal cables are replaced in the following manner (see figure 7–244):

Step 1. Break the lead seal at the end of the oven nearest the cables and remove the six fillister-head screws holding the cover.

Step 2. Remove the cover and pile-up of alternate felt discs and metallation discs exposed under the cover.

Note

The two coprene gaskets (marked "gasket" in figure 7–246) are cemented in place on the covers and are not to be removed from them during disassembly operations.

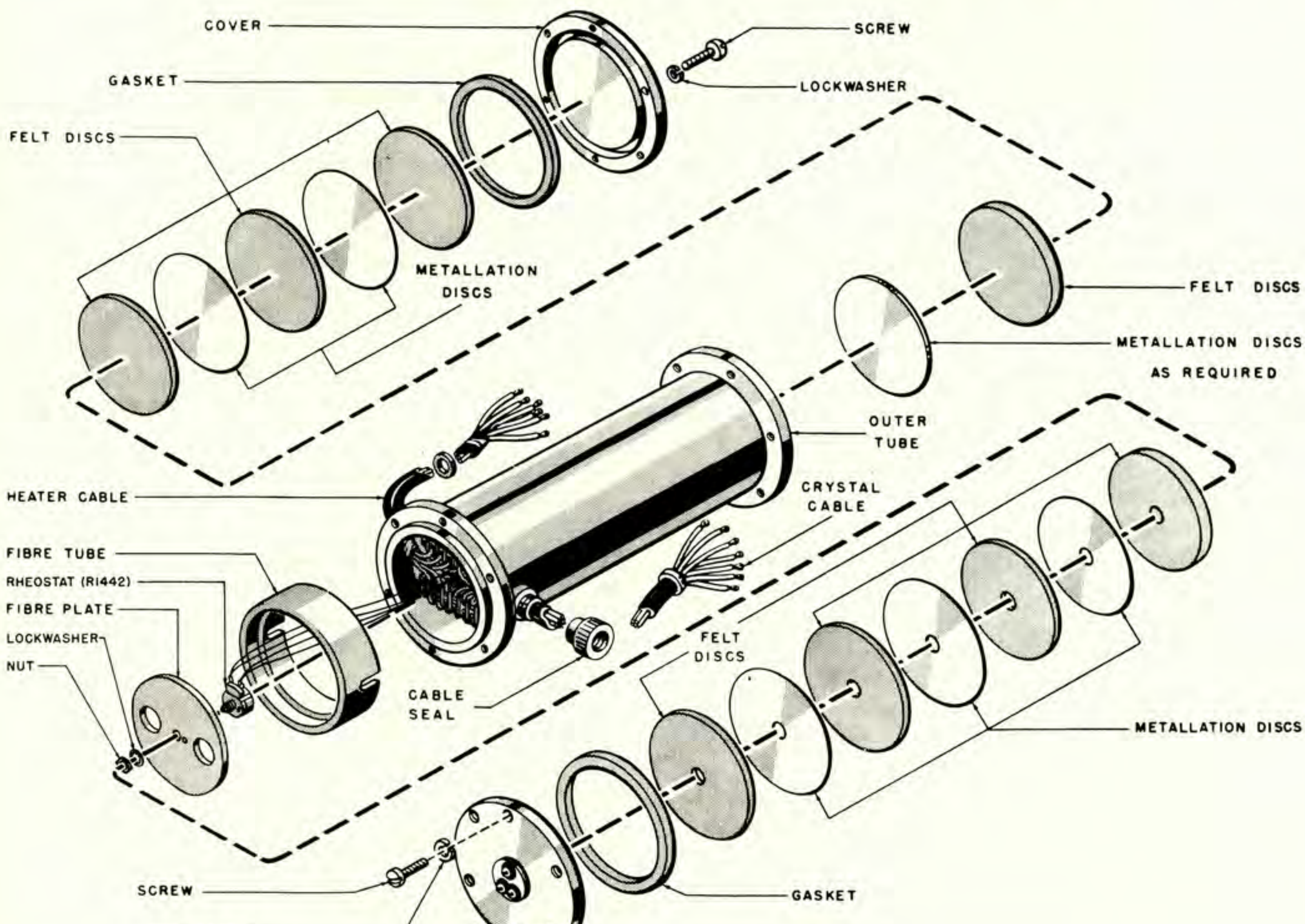


Figure 7–244. Exploded View of Oven Assembly, Showing Construction of the Major Container

Step 3. Remove the fiber plate (lifting by means of the two finger holes provided) and the fiber tube, thus exposing the terminal boards TB1403 and TB1404.

Step 4. Remove the leads of the cable from the inside row of terminals (TB1403 for the heater cable or TB1404 for the crystal cable).

Step 5. Remove the knurled nut and rubber gasket of the cable seal and pull out the cable.

Step 6. Slip the rubber gasket and knurled nut over the replacement cable and push it through the threaded bushing of the cable seal. The cable should be inserted far enough to allow all connections to be made to the terminal board without causing any of the leads to become taut. Care must be taken to insert the proper end of the cable into the oven. The crystal cable has five leads entering the oven and six toward the chassis; the heater cable has eight toward the oven and nine toward the chassis. The extra lead in both cases is the grounding wire of the shield.

Step 7. Connect the leads of the cable to their proper locations on the terminal board as shown in figure 7–245, taking care that a lock washer is in place under the head of each screw replaced on the board. The length of cable inserted into the oven should be adjusted so that there is no strain on any terminal connection.

Step 8. Slip the rubber gasket down against the threaded bushing of the cable seal and then tighten the knurled nut.

Step 9. Replace the fiber tube and fiber plate.

Step 10. Replace the pile-up of felt and metallation discs. The exact sequence of the discs is unimportant, except that the felt. and metallation discs should be alternated.

Step 11. Replace the cover and secure it to the oven by the six fillister-head machine screws, replacing the lock washer under the head of each screw.

(3) REPLACEMENT OF THERMOSWITCH S1403.—The thermoswitch, S1403, is replaced as follows:

Step 1. Remove the cover, felt discs, metallation discs, and fiber plate from the cable end of the oven.

Step 2. Disconnect the four thermoswitch leads. (See figure 7–245.) Other leads or other parts of the oven should not be disturbed.

Step 3. Remove the four screws which hold the thermoswitch in place. These are shown in figure 7–245.

Step 4. Withdraw the thermoswitch; insert the new thermoswitch and replace the mounting screws, taking care to place a lock washer under each screw head.

Step 5. Reconnect the thermoswitch leads. The two black flexible leads go to R1442. Repack and close the end of the oven as described in paragraph 4 *b* (2) preceding, steps 9 to 11. After permitting at least two hours of warm-up, check the operation by observing the reading of the meter with the selector switch in the HEATER position. If the reading is abnormal, readjust R1442, as described in paragraph 4 *a* (3).

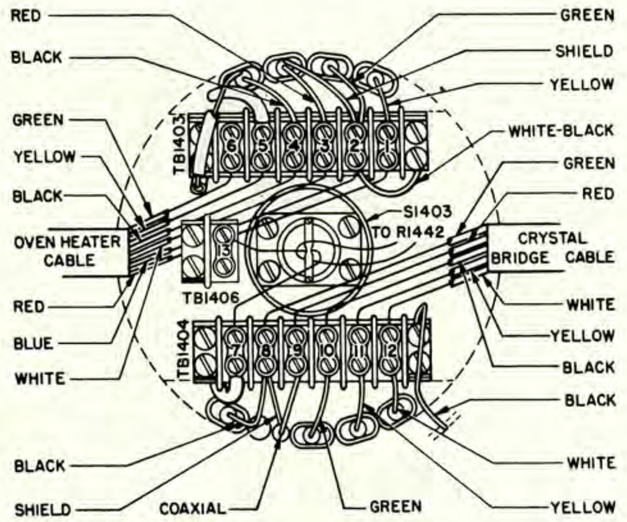


Figure 7–245. Oven Assembly Terminal Board Connections

(4) REMOVING CRYSTAL ASSEMBLY FROM OVEN.—Three replaceable items are mounted on the base of the evacuated crystal unit, with which unit they form the crystal bridge. These items are the two resistors, R1401 and R1402, and a small "ballast" lamp, RV1401. They are shown in the lower right-hand corner of figure 7–246. Before concluding that one of these parts requires replacement, make sure that all possible tests are exhausted. Be certain before opening the oven. Tests should be done by making the necessary external checks of resistance at terminal board TB1402 below the chassis deck of the oscillator. Resistor R1401 is checked between terminals 8 and 10; the resistance should be 2,000 ohms. Resistor R1402 is checked between terminals 9 and 11; the resistance should be in the range of 1 to 10 ohms. The ballast lamp, RV1401, is checked between terminals 8 and 11; the reading should be in the range of 50 to 250 ohms. If the lamp is open, the reading will be about 23,000 ohms.

If the checks at TB1402 indicate a defect, make certain that it is not due to external causes (a short circuit, for example). If it is determined, without question, that the defect is within the oven, make the first tests at terminal board TB1404 in the crystal oven (see figure 7–245), so that the possibility of a defective oven cable will not be overlooked before further disassembly is attempted. To gain access to R1401, R1402, or lamp RV1401, the crystal assembly must be removed as described below. The oscillator should be removed from the cabinet although the oven need not be removed from the chassis.

Step 1. Remove the oven cover at the end away from the oven cables. This one is shown in the upper part of figure 7–244. Remove the pile-up of felt discs and metallation discs. This will expose the end of the coarse heater assembly.

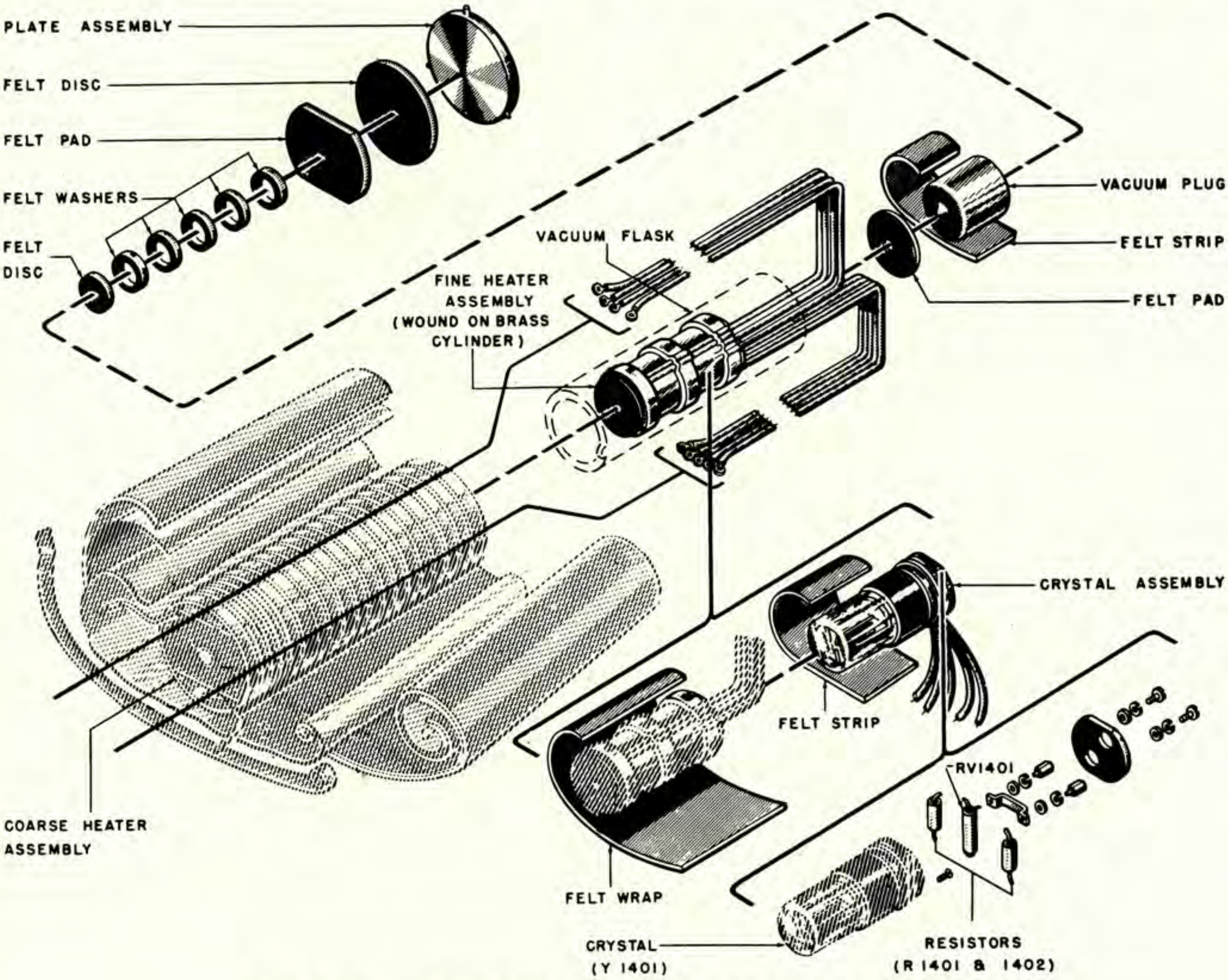


Figure 7–246. Exploded View of Oven Assembly, Showing Construction of Fine Heater and Crystal Assembly

Note

The two coprene gaskets (marked "gasket" in figure 7–244) are cemented in place on the covers and are not to be removed from them during disassembly operations.

Step 2. Refer to figure 7–246. Remove the plate assembly from the end of the coarse heater assembly. This plate assembly is shown in the upper left-hand part of figure 7–246. Withdraw it, using a finger in the center hole (not shown on the drawing) or, if necessary, by prying it out carefully with a screwdriver.

Step 3. Remove the felt disc and felt pad which are next in sequence, thus exposing the end of the vacuum flask and vacuum plug.

Step 4. Remove the vacuum plug (the felt washers and felt disc may be left in the hollow end of the plug) and the felt pad, thus exposing the end of the crystal assembly.

Step 5. Withdraw the crystal assembly from the fine heater assembly (see auxiliary view in figure 7–246), using the fingers only, if possible. It is held only by the friction of the inner felt strip. Finger holes are provided in the filter end plate of the crystal assembly. If the assembly is too tight, use a pair of pliers for pulling but be extremely careful. The vacuum flask and cylindrical brass fine heater assembly remain in place in the oven.

Note

The leads on the crystal assembly are long enough to permit it to be pulled out completely without disconnecting any of the terminals.

Step 6. Refer to the lower right-hand part of figure 7–246, which shows the base of the crystal assembly taken apart.

Step 7. Remove the two screws which hold the fiber end plate in place. This leaves two hexagon spac-

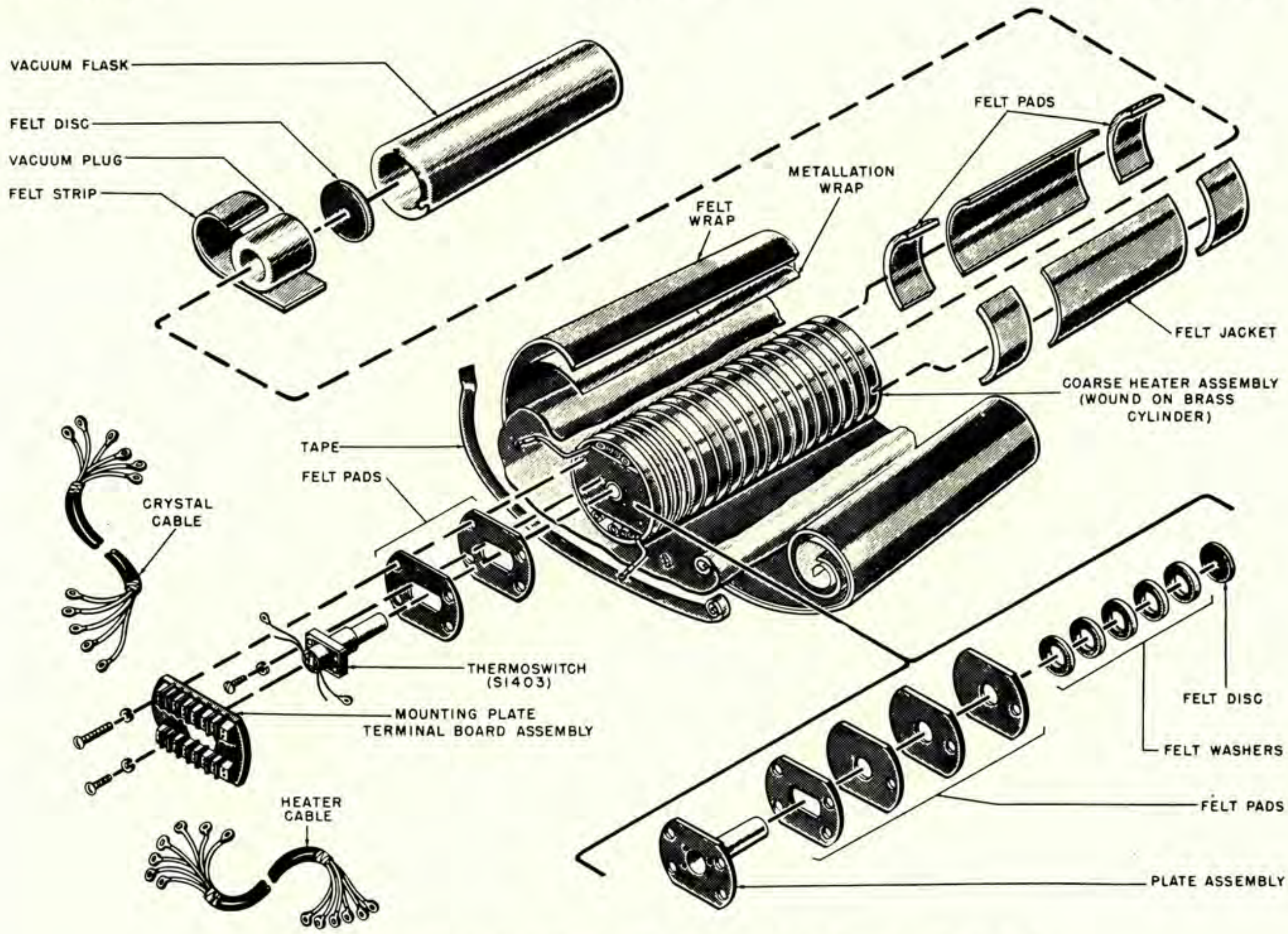


Figure 7–247. Exploded View of Oven Assembly, Showing Exploded View of Coarse Heater and Terminal End

ers exposed. Remove the spacers by turning them counterclockwise with a suitable wrench.

Step. 8 The elements of the crystal bridge, RV1401, R1401, and R1402 are now exposed for repair or replacement.

(5) REPLACEMENT OF LAMP RV1401. Remove the crystal assembly from the oven as explained above, then proceed as follows:

Step 1. Remove the original lamp by unsoldering the leads. Solder short extension wire leads to the new lamp, using a hooked connection so that they will not fall apart if the solder is heated to the liquid state.

Step 2. Slip a length of protective tubing over the entire body of the lamp. The original tubing may be used.

Step 3. Place the lamp in position on the base of the crystal and solder the leads to the original terminals.

(6) REPLACEMENT OF RESISTOR R1401.

Step 1. Remove the crystal assembly from the oven as explained above.

Step 2. The replacement of R1401 involves no special problems. Its value is not critical and it is mounted in an entirely conventional manner. If the resistor is defective, it is replaced without complications.

(7) REPLACEMENT OF RESISTOR R1402.—The replacement of R1402 is a difficult procedure because it must be adjusted accurately to the particular value which provides the desired balance of the bridge. The procedure is complicated by the fact that the oven must be completely assembled and operating when adjustment is made. This requires that the crystal assembly be reinstalled after removal of the resistor, the oven completely reassembled, and the new resistor connected and adjusted externally until it is correct. Then the oven is again taken apart, the resistor added, the oven reassembled, and a final check made.

The procedure follows:

Step 1. Remove the crystal assembly from the oven as described in paragraph 4 *b* (4), above.

Step 2. Remove the defective resistor, R1402.

Step 3. Reassemble the oven without R1402.

Step 4. Adjust the value of the new resistor to about 10 ohms as measured on an ohmmeter.The outer tube of the replacement resistor is not cemented in place to permit access to the resistance element.

Step 5. Connect the resistor temporarily between terminals 9 and 11 of TB1402, below the chassis of the oscillator.

Step 6. Place the oscillator in operation and turn the meter selector switch to the OSC OUT position. Turn the COARSE FREQ. control to position 16. Observe the reading of the meter at the panel of the crystal oscillator.

Step 7. Adjust the value of the new resistor, R1402, so that the panel meter reads between 120 and 150.

Step 8. Allow the oscillator to operate for 24 hours and again observe the meter reading. It should be within 20 units of 120.

Step 9. If the meter reading is not within the specified range, readjust R1402 and again allow 24 hours operation before making the reading. Repeat this as many times as necessary to obtain the correct reading.

Step 10. When R1402 is adjusted properly, reopen the oven, remove R1402 from TB1402, and solder it in place at the base of the crystal unit.

Step 11. Reassemble the oven and again place the oscillator in operation for 24 hours. If the meter reading is still correct, the oven may be opened and the fiber tube cemented to the resistor. If it is not correct, a final adjustment must be made, this time with the resistor in its proper position at the base of the crystal unit.

Note

The description given above takes into account all repairs which may be necessary under normal conditions. Repair work beyond this point is not recommended as a normal practice. The description which follows may be useful for emergency work, for its academic value, or for use where complete overhaul may be necessary for some special reason.

(8) REMOVING THE CRYSTAL ASSEMBLY. —Reference is made to figure 7–246 in the following procedure.

Step 1. After completing the cable removal procedure of paragraph 4 *b* (2), steps 1 through 5, remove the plate assembly from the end of the coarse heater. It is shown in the upper left-hand part of figure 7–246. Withdraw it, using a finger in the center hole (not shown in the sketch) or, if necessary, by prying it out lightly with a screwdriver.

Step 2. Remove the felt disc and felt pad which are next in sequence.

Step 3. Remove the vacuum plug and felt strip around it. The felt washers may be left in the hollow end of the plug.

Step 4. At the opposite end of the oven, disconnect the internal leads from terminal board TB1404 (terminals 8 to 12). (See figure 7–245.)

Step 5. Pull the leads through the terminal tubes, away from the terminal board.

Step 6. Withdraw the crystal assembly and the felt strip which is wrapped around it.

(9) REMOVING THE FINE HEATER ASSEMBLY.

Step 1. Disconnect the leads to terminals 1 to 4 inclusive at terminal board TB1403, figure 7–245.

Step 2. Pull the leads through the terminal tubes, away from the terminal board.

Step 3. Remove the fine heater assembly and its felt wrap from the open end of the oven.

(10) REMOVING AND DISASSEMBLING THE COARSE HEATER.—Reference is made to figure 7–247 in the following procedure.

Step 1. Make certain that the external cables are disconnected from TB1403 and TB1404.

Step 2. Withdraw the coarse heater assembly from the oven at the end opposite to the cable seals.

Step 3. The terminal board end assembly may be removed as a unit simply by removing four small screws around the outside edge of the oven cylinder. The screws are beneath the outside wraps of the oven, and are covered with the tape shown in figure 7–247. The screws engage threads in the edge of the plate assembly shown at the bottom of figure 7–247.

Step 4. If the terminal board end assembly is to be taken apart, disconnect the leads to terminals 5, 6, and 7 of TB1403 and TB1404. Then remove the four screws which pass through the holes in the corners of the plate assembly.

(11) REMOVING THE VACUUM FLASK.—Reference is made to figure 7–247 in the following procedure.

Step 1. Withdraw the vacuum flask from the coarse heater assembly.

Step 2. Remove the two felt jackets and the four felt pads.

Step 3. The vacuum plug, the felt strip around it, and the felt disc may be withdrawn with the flask or may be removed from the terminal board end of the assembly.

(12) REASSEMBLY OF THE CRYSTAL OVEN. —Reassembly of the oven may be carried out in reverse order to that given above. The operation, however, is flexible in that the exact sequence need not be followed. It is possible to place the fine heater assembly in the vacuum flask first, after wrapping it snugly in its felt wrap (figure 7–246); or the crystal assembly may be placed inside the fine heater assembly before or after insertion of the heater into the vacuum flask, or at any later stage of the assembly. If done at this stage of the assembly, the vacuum plugs may be inserted in both ends of the vacuum flask, after first replacing the felt pads underneath each plug and wrapping the plugs with their felt strips.

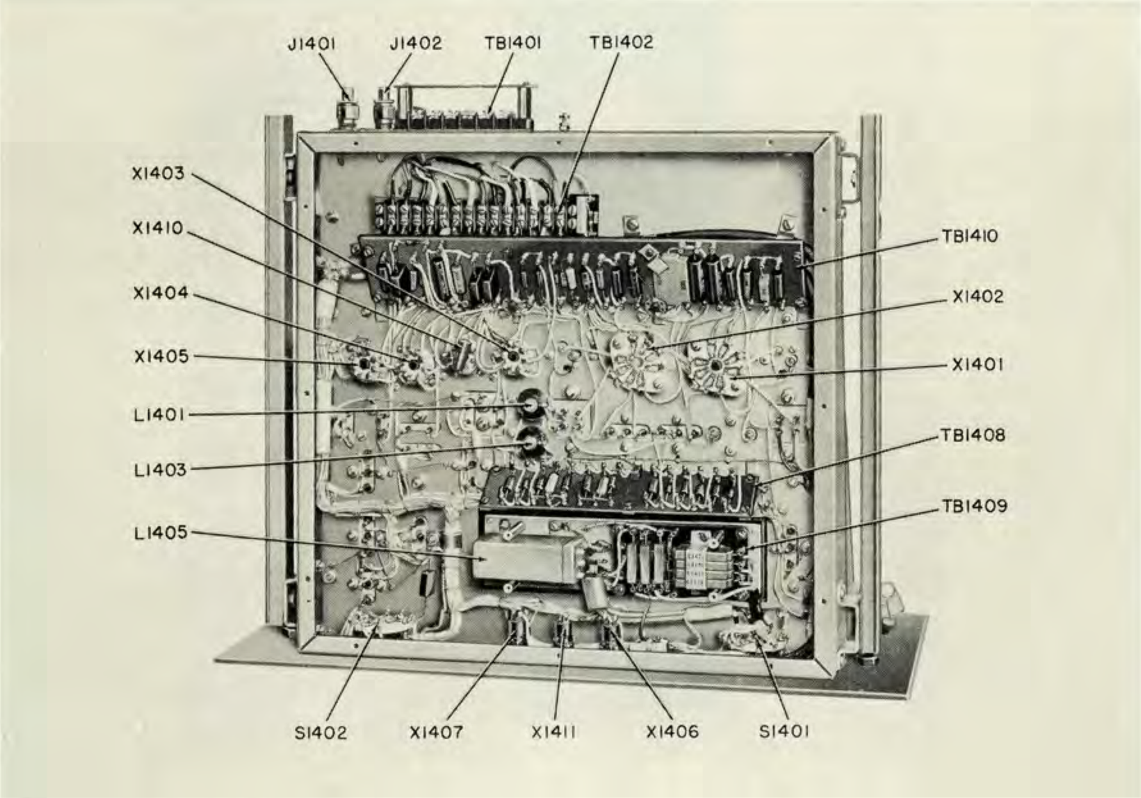


Figure 7–248. Radio Frequency Oscillator Type O-202/FPN-30, Bottom View of Components

The crystal and fine heater leads are run out of the flask in the space between the flask and the plugs and are held firmly by the felt strip surrounding the plug. The small felt discs and felt washers should then be placed inside the vacuum plugs (see figures 7–246 and 7–247), provided they have not been left in position.

The flask is slid into the coarse heater assembly along with two of the surrounding felt pads and the two felt jackets which will be guided and held in position by the terminal tubes; these run the full length inside the coarse heater assembly. When the flask and felts are completely inserted, the remaining two felt pads are pushed into place around the flask.

The flask should be rotated to a position such that the four heater leads emerge from the flask beside the group of four adjacent terminal tubes. The five crystal leads should come out diametrically opposite. All leads should be drawn through their respective terminal tubes.

The entire coarse heater assembly is replaced in the outer housing after first wrapping it snugly in its felt wrap and metallation wrap. The open end of the assembly should be closed with the felt pad, felt disc, and plate assembly (see figure 7–246). The leads should be connected to the terminal boards as shown in figure 7–245.

(13) RECTIFIERS CR1402, CR1403.—If rectifier CR1402 is replaced, it may be necessary to replace resistor R1432. Likewise, if CR1403 is replaced, it may be necessary to replace R1417. The value of each of these resistors depends upon the characteristics of the particular associated rectifier and may be either 750 or 1,000 ohms. The procedure for determining the proper value in each case follows.

To replace CR1402 turn the MAIN POWER switch OFF. Connect an audio test oscillator (such as the Hewlett-Packard 200-C) across terminals 1 and 2 of transformer T1405. Set the frequency to approximately 900 cycles and adjust the output to produce 8 volts across terminals 1 and 2 of T1405. With METER SWITCH S1402 set to the HEATER position, the meter should read between 70 and 130. Change R1432 to either 750 or 1,000 ohms as necessary to meet this requirement.

To replace CR1403 turn the MAIN POWER switch OFF. Connect a test oscillator (such as the Hewlett-Packard 200-C) to jack J1401; leave the normal output of J1401 connected. Set the frequency to 100 kc ±5 cps and adjust the output to 18 volts. With METER SWITCH S1402 set to the AMP OUT position, the meter should read between 70 and 130. Change R1417 to either 750 or 1,000 ohms as necessary to meet this requirement.

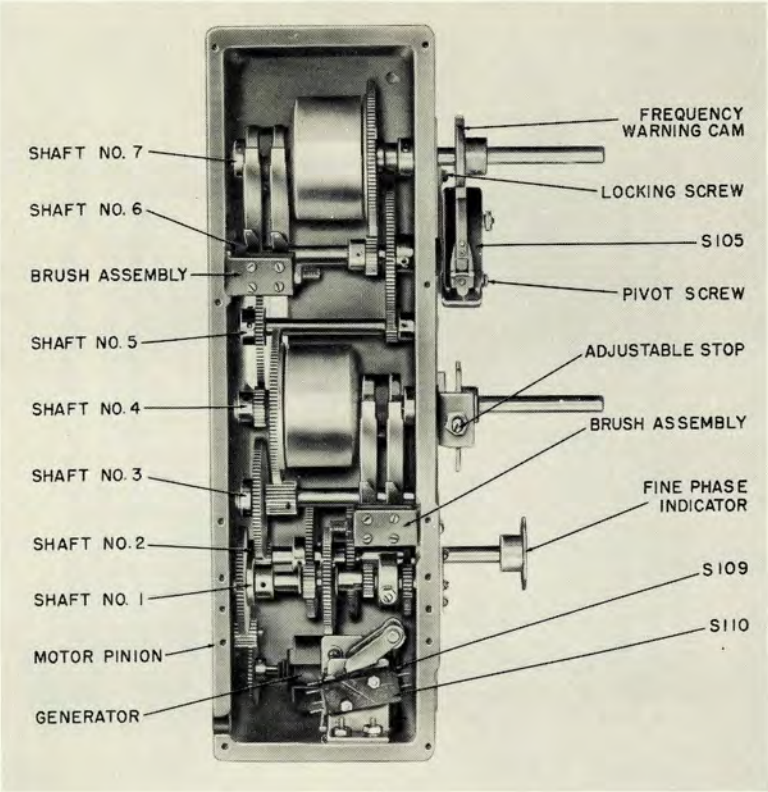


Figure 7–249. Synchronization Control Type C–1238/FPN–30, Top View of Gear Train

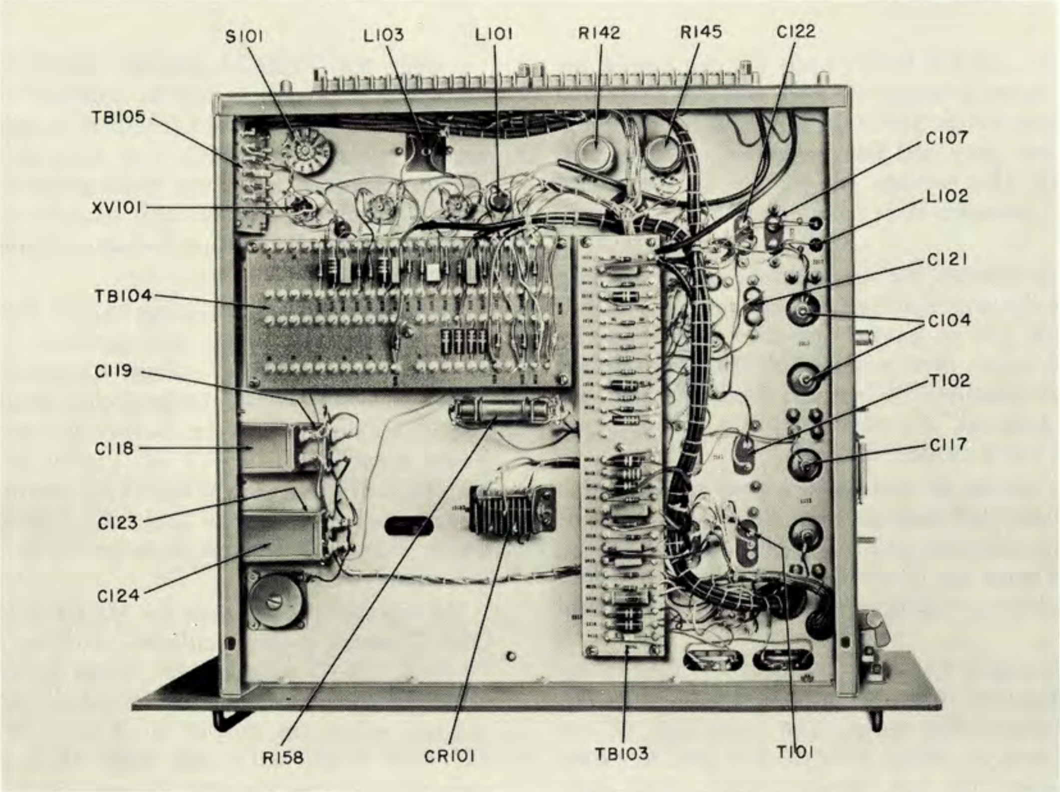


Figure 7–250. Synchronization Control Type C–1238/FPN–30, Bottom View of Components

c. SYNC CONTROL UNIT. (*Refer to figures 7–249, 7–250.*)—The sync control unit includes a gear system which is used to mechanically couple the sync control motor, the phase shift components, and the frequency corrector capacitor. The procedures listed below describe disassembly of the elements of the gear system. For the most part these procedures are obvious upon inspection; however, the procedures for replacement of the phase shifter autosyn (B101) and the precision potentiometer (R138) should be followed carefully to avoid disturbing the factory adjustments for dial shaft alignments.

(1) REMOVAL OF PHASE/FREQUENCY GEAR SYSTEM FROM MAIN CHASSIS.—The motor, gear train, and phase/frequency control components are mounted on a common subassembly which is shock-mounted on the main chassis of the sync control unit. Refer to figure 7–249. To replace components of the gear train, or to adjust the operating range of the frequency warning cam, it is desirable to remove the subassembly from the main chassis. Proceed as follows:

Step 1. Turn off the timer MAIN POWER switch. Pull the sync control unit forward in its slides. Remove the rear cover, which houses the phase/frequency components, by unhooking the slide fasteners and lifting the cover. Remove the two flat covers, on top of the gear train housing, by taking out the roundhead screws. Remove the long protective cover which is located immediately behind the front panel and is secured by two cam-lock fasteners.

Step 2. Disconnect the wiring going to TB103 and TB104 (connections to this terminal board are shown on the wiring diagram, figure 7–290, so that no special identification tagging is required at this point). Remove the coaxial connection from J101. Disconnect the ground strap located at the front of the subassembly by removing a nut located beneath the chassis.

Step 3. Using a multiple spline wrench to loosen the setscrews, remove the knobs of the PHASE and FREQUENCY CORRECTOR dials.

Step 4. Tilt the sync control unit to gain access to the bottom of the chassis. Remove the screws securing TB103 and TB104 (component-mounting boards located under the chassis) and move the boards aside to gain access to the screws holding the phase/frequency subassembly to the main chassis. Remove the four holding screws with their snubbers (large flat washers) and locknuts. Be careful to hold the chassis in place as the last screw is removed to prevent damage to the tubes located behind the subassembly. Unlatch the tilt mechanism and restore the chassis to its flat position.

Step 5. Lift the rear end of the subassembly out first and remove the subassembly from the main chassis, pulling back, away from the front panel, to allow the shafts to clear the panel. Note the large gear projecting through the bottom of the subassembly and take care not to set the subassembly down in such a way that this gear rests on a hard surface.

At the completion of any required work replace the subassembly by reversing the above procedure. Align the elements of the PHASE DIAL shaft and FREQUENCY CORRECTOR shaft in accordance with paragraphs 4 *b* (1) and 4 *b* (2), respectively.

(2) REPLACEMENT OF GEARS OR CLUTCHES IN GEAR TRAIN.—To replace any of the gears or clutches in the gear train it will first be necessary to remove the phase/frequency subassembly from the main chassis as described above in paragraph 5 *c* (1). Gears and clutches are secured to their respective shafts by means of taper pins and setscrews. It will be necessary to drive out all taper pins, loosen all setscrews, and pull the shaft forward through the front bearing hole in order to replace any element mounted on a shaft. The procedure will be obvious upon inspection. Be careful not to exert excessive pressure when driving out taper pins so that shafts will not be bent. In the case of a shaft which carries the clutches, better access will be obtained if the two screws securing the brush assembly to the housing wall are removed and the brush assembly is moved out of the way. Figures 2–55 and 7–249 show the construction of the gear drive assembly and may be useful when replacing parts.

(3) FREQUENCY WARNING LIMIT MICROSWITCH (S105).—The frequency warning limit microswitch is mounted on the front of the gear housing. Any adjustment or replacement of the switch requires the removal of the phase/frequency subassembly from the main chassis as described in paragraph 5 *c* (1) above. To adjust the switch remove the subassembly and proceed as follows:

Step 1. Loosen the pivot screw at the left of the microswitch and the position locking screw at the right end of the microswitch. Position the switch so that the roller rests lightly in the depression of the frequency warning cam. Temporarily tighten the position locking screw.

Step 2. Temporarily replace the FREQUENCY CORRECTOR dial and tighten one setscrew. Fashion a pointer from a piece of stiff wire and position the pointer approximately over the top of the FREQUENCY CORRECTOR dial to provide a reference point. Secure the pointer to the top of the gear housing casting by means of one of the roundhead screws normally used to hold the cover in place.

Step 3. Rock the FREQUENCY CORRECTOR dial back and forth and observe the dial readings at which switch clicks result as the roller moves *out* of the cam depression. Before the microswitch can be properly adjusted the dial must be centered about the pointer so that the switch click occurs at the same reading each side of 0. Loosen the knob setscrew and position the FREQUENCY CORRECTOR dial as required. After tightening the setscrews, observe the two readings at which the switch clicks. If these readings are not between 3-3/4 and 4, loosen the switch position locking screw and change the switch position as required. Move the roller away from the cam to raise the dial readings at which the clicks occur. Conversely, move the roller closer to the cam to lower the dial readings.

After the adjustment has been made tighten the switch pivot and positioning screws, remove the FREQUENCY CORRECTOR dial, and replace the subassembly on the main chassis.

(4) PRECISION POTENTIOMETER (R138).— The axial shaft alignment for R138 must not be disturbed when this component is replaced; therefore, follow the recommended procedure carefully. It is not necessary to remove the phase/frequency subassembly from the main chassis for this replacement.

Step 1. Turn off the timer MAIN POWER switch. Pull the sync control unit forward on its slides. Remove the rear cover, which houses the phase/frequency components, by unhooking the slide fasteners and lifting the cover.

Step 2. Observe the construction of the coupling connecting the phase shifter autosyn to the precision potentiometer. The coupling consists of a grooved disc sandwiched between two hubs mounted on the shafts. The grooves on the disc are lapped with the mating parts on the hubs to assure good sliding action as the shafts rotate. Because each surface is lapped with its mating surface, it is essential that the orientation of the coupling surfaces be maintained when the potentiometer is eventually replaced. Therefore, loosen the setscrew holding the hub to the precision potentiometer shaft, slip the hub back on the shaft, and immediately place a piece of sticky tape on the grooved disc to hold it in position on the remaining hub.

Step 3. Unsolder the wires connected to the terminals of R138. Using an angle screwdriver, remove the three screws holding R138 to the backplate. *Do not loosen the long screws which pass through the hexagonal posts of the frame supporting the backplate* or the shafts may be thrown out of axial alignment. Remove R138.

Step 4. Slip the coupling hub taken from the old potentiometer over the new shaft. Install the new precision potentiometer, making sure that the terminals are on the left side. Replace the three holding screws and tighten the coupling hub in place. Remove the sticky tape immediately before tightening the hub.

Step 5. Resolder the connecting wires, referring to the wiring diagram, figure 7–290, to determine which color-coded wires go to which terminals.

Step 6. Align the precision potentiometer with the PHASE dial as described in paragraph 4 *b* (1). Transfer the sync error cams from the old potentiometer and align the cams as described in Section 3, paragraph 28 *b* (2) or 29 *l*.

(5) PHASE SHIFTER AUTOSYN (B101).—The axial alignments of the phase shifter shaft and of the precision potentiometer shaft must not be disturbed when the phase shifter is replaced; therefore, follow the recommended procedure carefully. It is not necessary to remove the phase/frequency subassembly from the main chassis for this replacement.

Step 1. Turn off the timer MAIN POWER switch. Pull the sync control unit forward on its slides. Remove the rear cover, which houses the phase/frequency components, by unhooking the slide fasteners and lifting the cover.

Step 2. Observe the construction of the couplings connecting the phase shifter autosyn to the precision potentiometer and to the PHASE DIAL shaft. Each coupling consists of a grooved disc clamped between two hubs. The grooves on the disc are lapped with the mating lands on the hubs to assure good sliding action as the shafts rotate. Because each surface is lapped with its mating surface, it is essential that the orientation of the coupling surfaces be maintained when the phase shifter is eventually replaced. Therefore, place a length of sticky tape over the three sections of the forward coupling and then loosen the setscrews holding the forward coupling to the phase shifter. Loosen both setscrews on the rear coupling, slide the coupling back on the precision potentiometer shaft as far as it will go, and tighten the setscrew in the forward hub to secure the coupling to the shaft during the remainder of the procedure. As the coupling is slid back, the reduction bushing used to adapt the diameter of the phase shifter shaft to the coupling hole will be forced out. Set this bushing aside for later use.

Step 3. Unsolder the wires coming from the phase shifter at the terminals to which they connect. Using an angle screwdriver, remove the three small dogs used to clamp the phase shifter to its mounting plate. *Do not loosen the long screws which pass through the hexagonal posts on either side of the mounting plate* or the shafts may be thrown out of axial alignment. Remove the phase shifter.

Step 4. Observe whether the reduction bushing used to adapt the diameter of the phase shifter shaft to the opening in the *forward* coupling remained in the coupling or came out with the old phase shifter. If necessary transfer the bushing to the replacement phase shifter.

Step 5. Replace the new phase shifter, making sure that the group of two leads is at the top and the group of three leads is at the bottom. Replace the dogs removed in step 3, above.

Step 6. Tighten the setscrew securing the forward coupling to the phase shifter shaft, making sure that the reduction bushing is properly located between the rear hub of the forward coupling and the phase shifter shaft.

Step 7. Slip the rear coupling assembly forward, place the reduction bushing, previously set aside in step 2. on the phase shifter shaft, slide the assembly to its proper position, and tighten the setscrews for both hubs. Rotate the PHASE dial to assure that all couplings work properly.

Step 8. Solder the wires of the replacement phase shifter to the appropriate terminals, as designated in the wiring diagram, figure 7-290.

Step 9. Align the precision potentiometer with the PHASE DIAL as described in paragraph 4 *b* (1).

(6) SYNC CONTROL MOTOR (B103).—Replacement of the sync control motor is entirely straightforward. It is not necessary to remove the phase/frequency components subassembly from the main chassis for this operation. The only thing not obvious about the mounting of the motor is that the front projection of the motor housing is a machined surface which accurately mates with a recess in the gear housing casting to align the motor with the gears.

(7) GENERATOR (B102).—The generator is mounted on an angle bracket within the gear housing. Special care is required to align the generator drive gear with the motor pinion to assure minimum gear wear. The procedure which follows describes the steps necessary to get at the relatively inaccessible generator assembly. It is not necessary to remove the phase/frequency subassembly from the main chassis for this operation.

Step 1. Turn off the timer MAIN POWER switch. Pull the sync control unit forward on its slides. Remove the small top cover in the left front of the gear box housing by loosening the four roundhead screws. Remove the long protective cover which is located immediately behind the front panel and is secured by two cam-lock fasteners.

Step 2. Remove the two nuts and bolts holding a switch assembly to the left end of the gear box. Pull the switch assembly up out of the way.

Step 3. Loosen the four bolts holding the generator to the support bracket. Remove the two nuts and bolts holding the generator support bracket to the left end of the gear box. Pull the generator out of the gear box and remove the four bolts holding the generator to the support bracket.

Step 4. Unscrew the leads from the terminals on the front end of the generator. Connect these leads

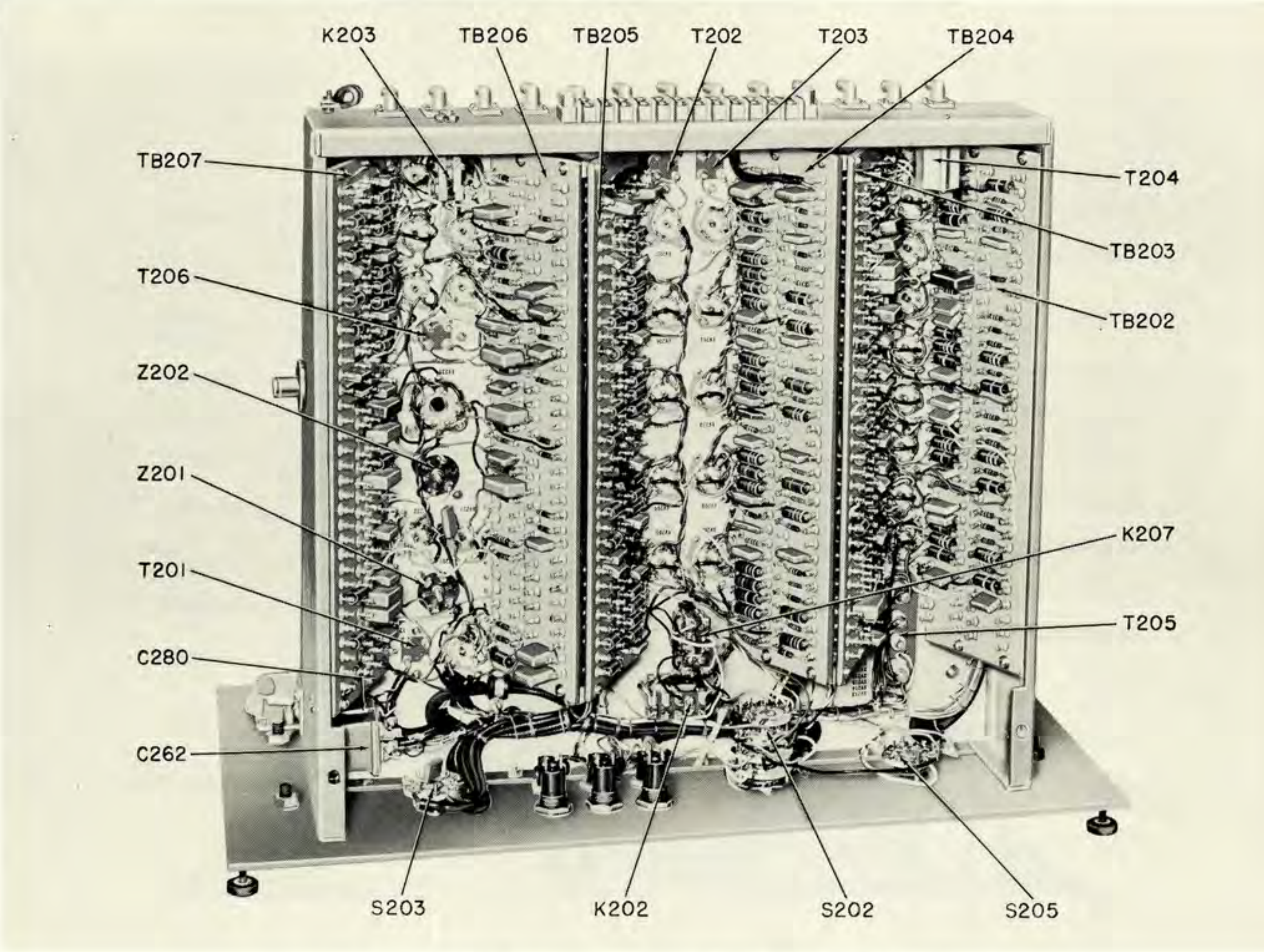


Figure 7-251. Frequency Divider Type CV-274/FPN-30, Bottom View of Components

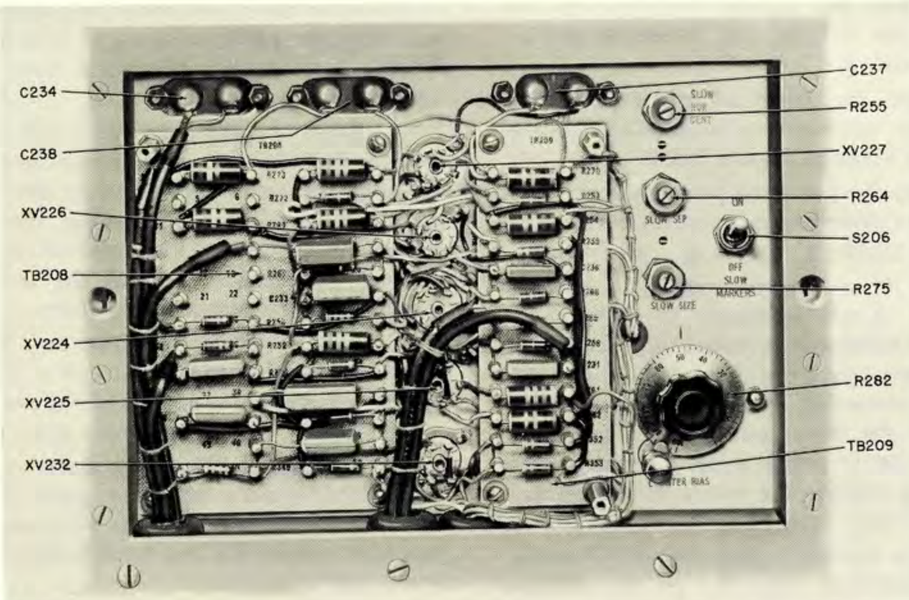


Figure 7-252. Frequency Divider Type CV-274/FPN-30, Close-up of Components Behind SLOW SCOPE CONTROLS Panel

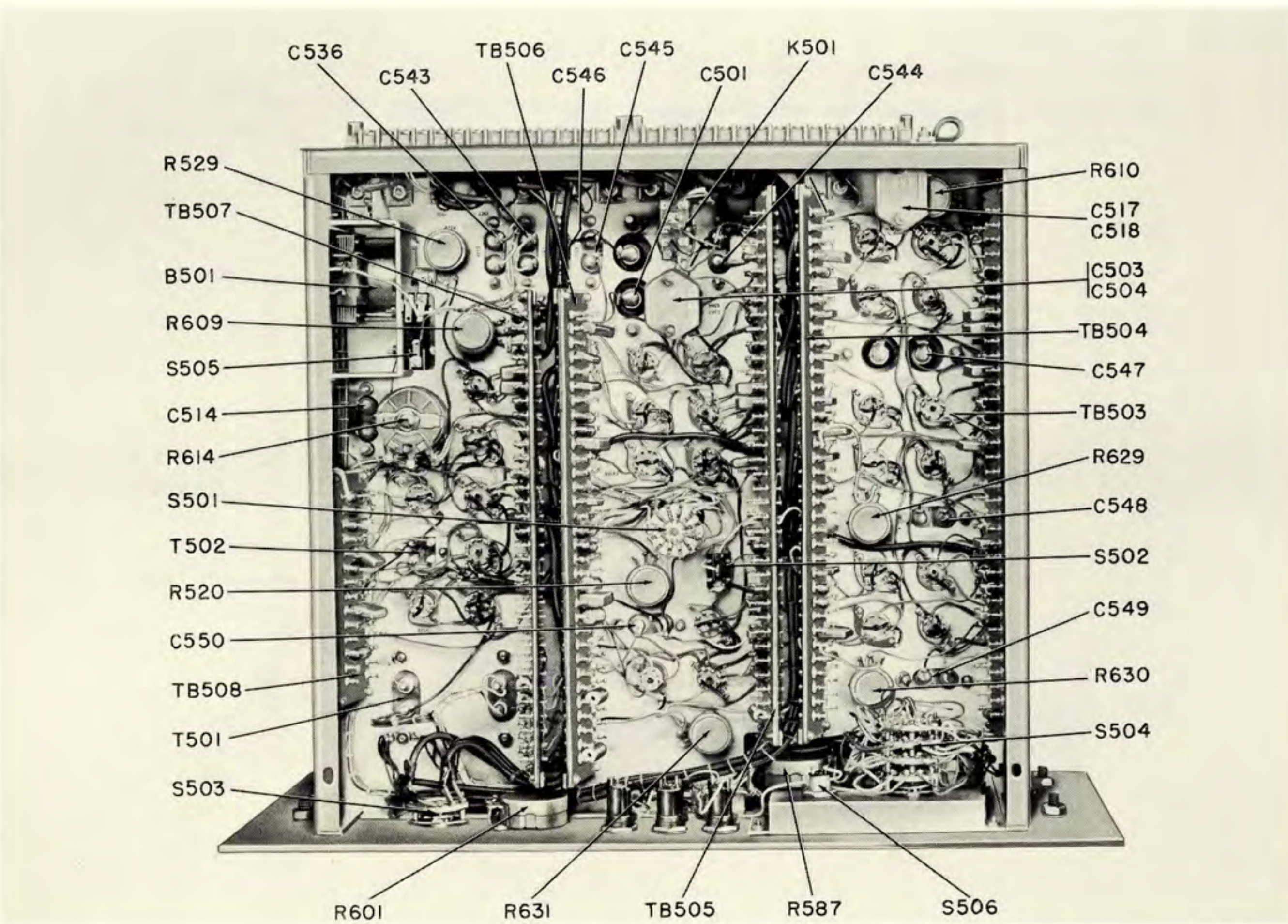


Figure 7-253. Time Delay Type TD-92/FPN-30, Bottom View of Components

to the corresponding terminals on the new generator, observing that the two white-black wires go to the same terminal on the new generator as they did on the old generator.

Step 5. Transfer the gear from the old generator shaft to the new one. Remount the generator support bracket on the new generator, but do not tighten the bolts. Replace the support bracket in the housing.

Step 6. Adjust the position of the generator so that there is just a trace of backlash between the generator gear and the motor pinion, and so that the generator shaft is parallel with the other shafts in the gear housing. Tighten the four generator mounting bolts.

Step 7. Replace the switch assembly making sure to securely tighten the two holding bolts. Turn on the MAIN POWER switch and operate the timer to make the sync control motor operate. Observe that the motor drives the generator smoothly without evidence of gear binding. Turn the MAIN POWER switch off.

Step 8. Replace the small top cover and the long thin cover. Restore the sync control unit to the normal operating position and turn on the MAIN POWER switch to place the timer back in normal operation.

(8) 60-CYCLE TUNING INDUCTOR L102.—The replacement procedure for L102 is straightforward and obvious upon inspection; however, one precaution is required. When installing the new inductor make sure that the coil is turned in such a way that the adjustment hole is accessible through the opening provided in the left wall of the sync control unit chassis. If a new coil is installed, it will be necessary to tune the coil. The tuning procedure is given in Section 3, paragraph 28 *c* for a slave station and 29 *c* for a master station.

d. FREQUENCY DIVIDER.—The repair and replacement procedures for components of the frequency divider are obvious and straightforward. The locations of components are shown in figures 7–251 and 7–252.

e. TIME DELAY UNIT.—The repair and adjustment procedures for components of the time delay unit are obvious and straightforward. The locations of components are shown in figures 7–253 and 7–254.

f. RADIO RECEIVER. (*Refer to figure 7–255.*)—The repair and replacement procedures for the radio receiver are obvious and straightforward. One precaution needs special mention. When disassembling any of the receiver subchassis from the main chassis, note carefully how the subchassis is insulated from the main chassis by means of washers sandwiched between the screw heads and the nuts which secure the subchassis. As described in Section 2, paragraph 4 *e,* chassis Nos. 1 and 3 are each grounded to the main chassis by omitting the insulated washers from one of the screws. The ground connection and insulation arrangement must be preserved when reassembling any of the subchassis to the main chassis.

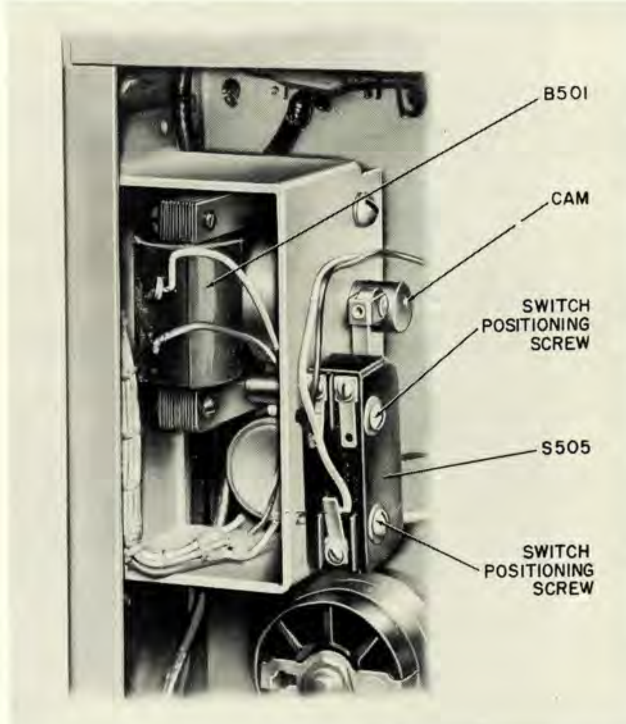


Figure 7–254. Time Delay Type TD–92/FPN–30, Close-up of Blink Motor Assembly

g. SYNCHRONIZATION INDICATOR. (*Refer to figures 7–256 through 7–263.*)—The replacement and adjustment procedures for the mechanical linkage elements of the RF GAIN control are described below. This paragraph also describes the locations of various components hidden within the chassis.

Note

The subchassis of the synchronization indicator may be swung aside (to permit access to the interior of the chassis) if each spring loaded coupling assembly (which links the presentation switch on each chassis to the PRESENTATION control) is pulled apart and if the knurled locking nut in the corner of each subchassis is loosened. When fastening the coupling assemblies back together, make sure that the red line, on each half of each assembly, is aligned with its mating red line.

(1) RF GAIN CONTROL LINKAGE.—The mechanical linkage between the front panel RF GAIN control knob and the gain control capacitor consists of three elements: an upper assembly (box 2) which converts the rotary motion of the knob to a push or pull motion, a flexible cable which is pushed or pulled through a rigid metal conduit, and a lower assembly (box 1) which converts the push or pull motion of the cable to a rotary motion to operate the gain control capacitor. Each box has a grooved wheel which grips the thread-like surface of the flexible cable. A metal

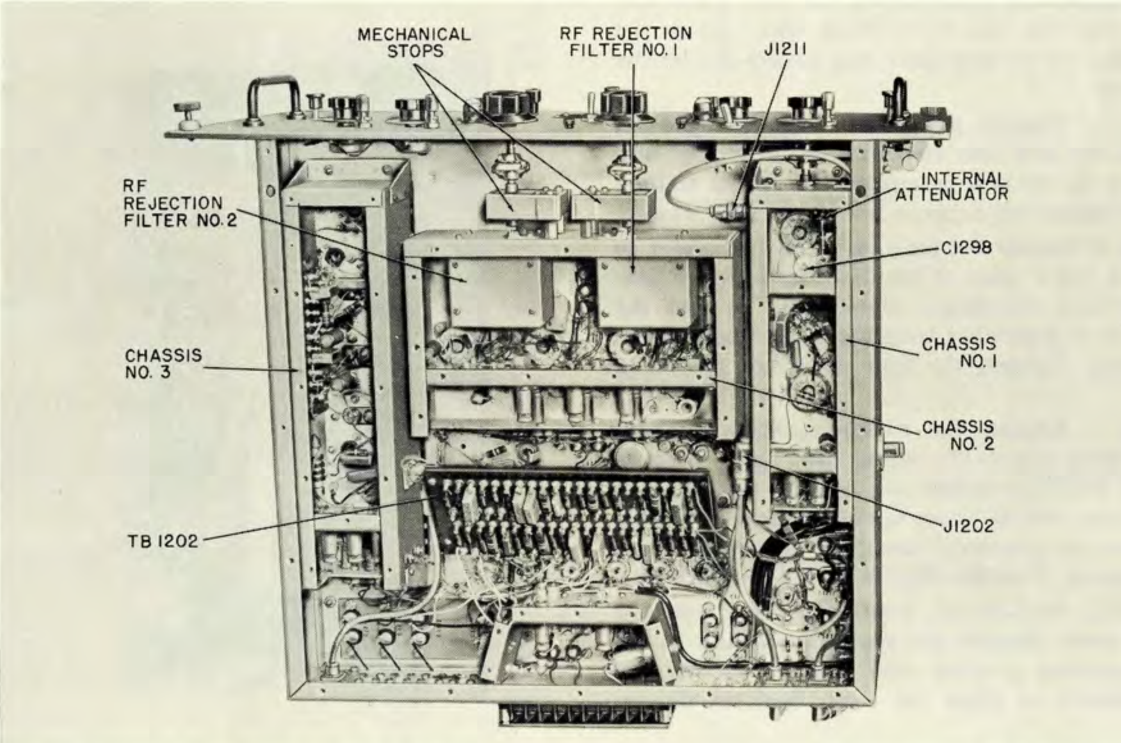


Figure 7–255. Radio Receiver Type R–564/FPN–30, Bottom View of Components

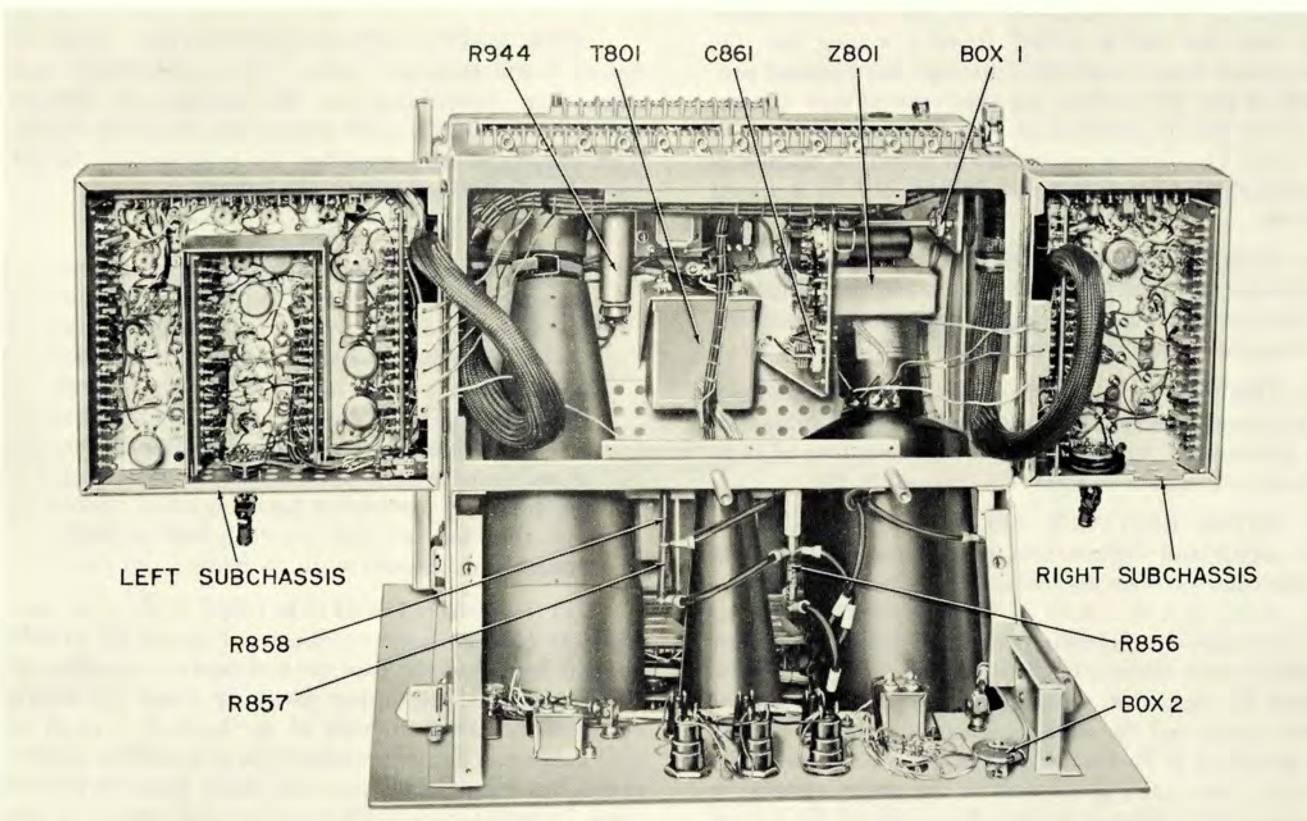


*Figure 7–256. Synchronization Indicator Type IP–238/FPN–30,
Top View of Components*

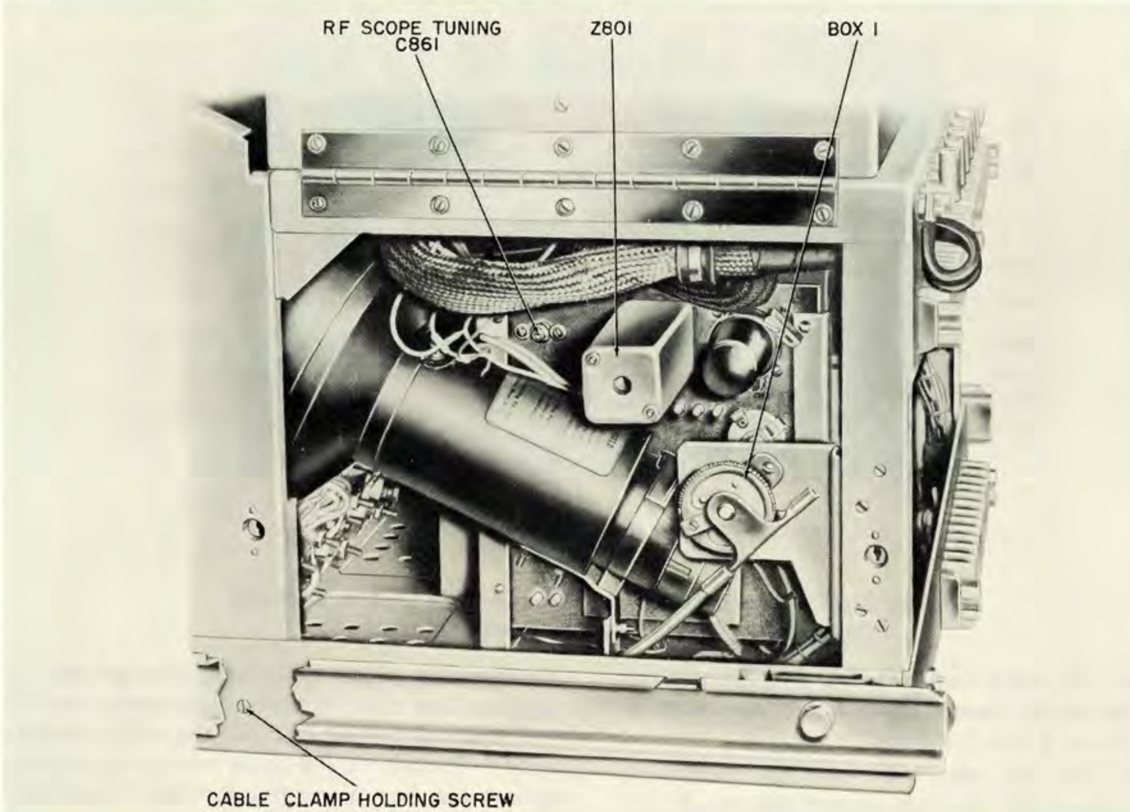


Figure 7-257. Synchronization Indicator Type IP-238/FPN-30, Components Behind Right Side Cover

strip, attached to each wheel, curves around the cable to clamp the ends of the cable to the wheel. This strip, or clamp, projects from the side of the wheel and acts as a stop to limit wheel rotation. The two wheels are so arranged with respect to the cable that the stops permit the capacitor to rotate at least 185° but not more than 200°. If any of the elements of the linkage is disconnected from the linkage, care must be taken, when reassembling the linkage, to restore this arrangement of mechanical stops. Accordingly, the applicable procedures given below must be followed carefully.

(*a*) FLEXIBLE CABLE REPLACEMENT.—To install a new flexible cable in the rigid conduit:

Step 1. Turn the INTERLOCKED POWER switch OFF. Pull the synchronization unit forward on its slides. Remove the two long shield covers located behind the top of the front panel. Remove the panel on the right side of the unit by loosening the two camlock fasteners and pulling the panel out, down, and forward. Loosen the fastenings for the two subchassis, uncouple the linkages to the two control knobs, and swing the subchassis aside. Remove the cover plate from beneath the subchassis location. Remove V815 from its socket.

Step 2. Rotate the RF GAIN control to actuate the linkage; this will facilitate identification of box 1 and box 2. Identify the boxes. Physical locations are shown in figures 7-256 and 7-257. Remove the clamps from the wheels of each box. Be careful to hold the end of the flexible cable down and thus prevent the clamp from being thrown from the unit as each screw is removed.

Step 3. Pull the flexible cable up and out of the conduit through the opening in box 2. Push the new cable into the conduit through the opening in box 2.

Step 4. Loosen the four setscrews on the *solid* coupling between box 1 and the capacitor drive shaft. Slide the coupling over the drive shaft. Remove the two screws holding box 1 to a mounting bracket and pull the box clear of the mounting bracket.

Step 5. Adjust the position of the cable, with respect to box 2, by rotating the cable in the conduit, so that the cable end projects about 3/8 inch beyond the mounting hole for the cable clamp. Wrap the cable around the wheel so that it hugs the groove. Install the clamp on the wheel of box 2.

Step 6. Push box 1 over the new cable and the conduit as far as it will go. Turn the RF GAIN control fully clockwise and make sure that it remains in that position throughout the next step.

Step 7. With box 1 pressed firmly against the conduit, rotate the box around the conduit to make the wheel turn. Rotate the box to adjust the wheel position

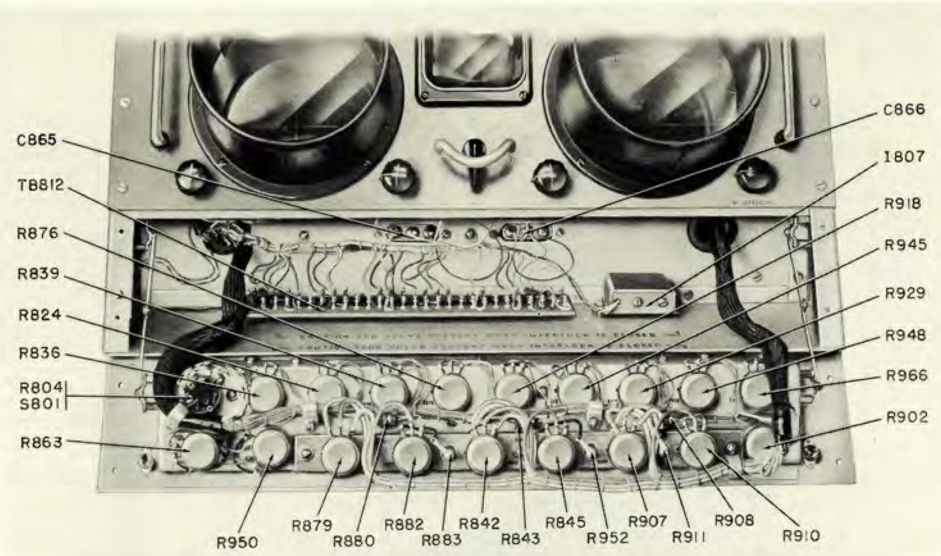


Figure 7–258. Synchronization Indicator Type IP–238/FPN–30, Components Located Behind Lower Hinged Panel

so that, when the box is finally mounted in the original position, the cable clamp mounting screw hole is halfway between 8 and 9 o'clock.

Step 8. Mount the box on the mounting bracket by means of the two screws previously removed. Position the box so that the wheel shaft is in axial alignment with the capacitor drive shaft. Before proceeding, check that the clamp mounting screw is positioned at a point halfway between 8 and 9 o'clock with the RF GAIN control in the extreme clockwise position. (If the screw is not so located, remove box 1 again and repeat steps 7 and 8.) Wrap the cable around the wheel so that it hugs the groove and fasten it in place with the clamp.

Step 9. With the RF GAIN control still fully clockwise, turn the capacitor drive shaft to make the plates of capacitor C864 mesh completely. (Observe the capacitor plates by looking through the top opening provided when the cover plate under the subchassis was removed in step 1.) Slide the solid coupling to the right to just before the point where the coupling binds against the box mounting bracket. Tighten all four screws in the coupling.

Step 10. Rotate the RF GAIN control from the extreme clockwise position to the extreme counterclockwise position; simultaneously, observe that the capacitor plates are driven from the completely meshed position to slightly past the completely unmeshed position. If the plates do not travel through at least 185° of rotation, or if rotation is more than 200°, remove the cable clamp from the wheel of box 1, loosen the screws on the solid coupling, and slide the coupling clear, remove box 1 from the mounting bracket, and repeat steps 7 through 10. In step 7 make the clamp mounting

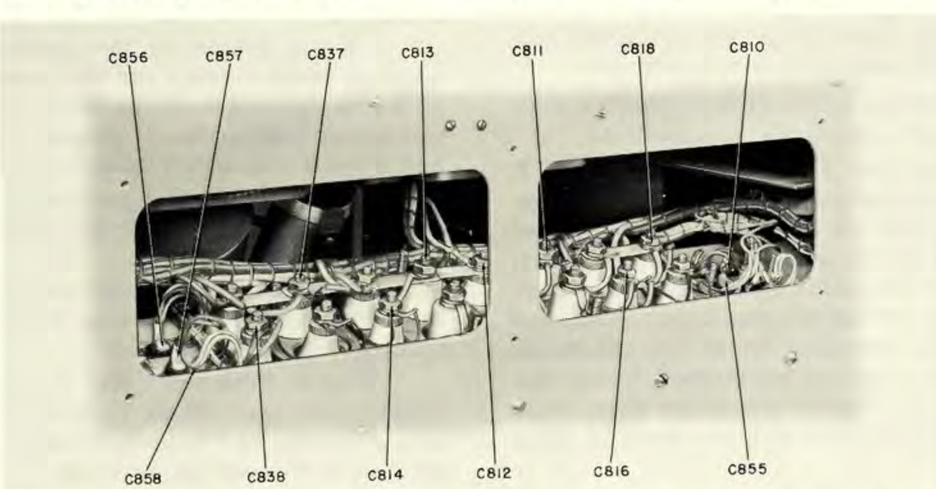


Figure 7–259. Synchronization Indicator Type IP–238/FPN–30, Location of Capacitor Bank Accessible Through Bottom Opening

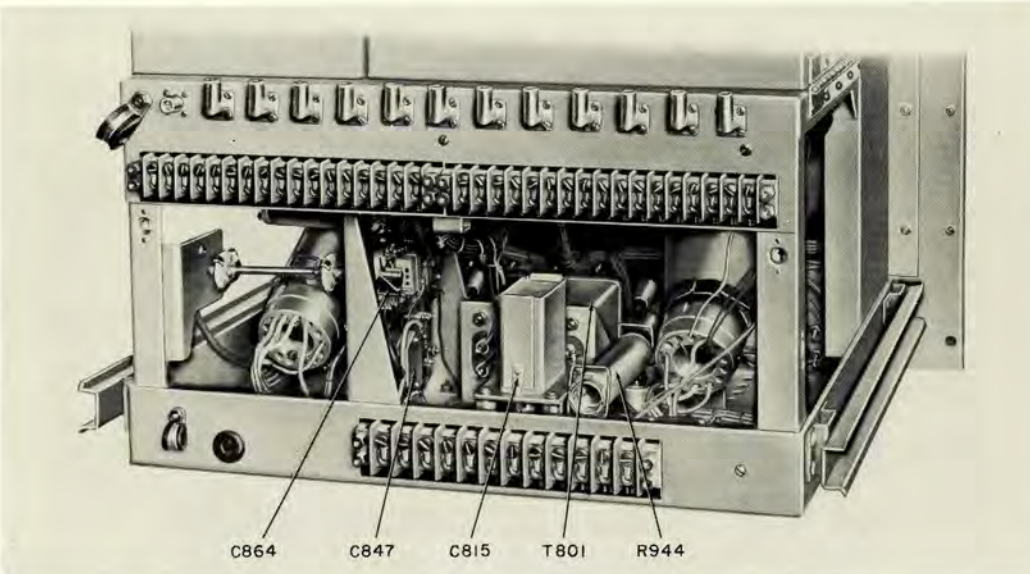


Figure 7–260. Synchronization Indicator Type IP–238–FPN–30, Components Located Behind Rear Cover

screw hole move towards 8 o'clock, if the range was less than 185°, and towards 9 o'clock if the range was more than 200°.

Step 11. Replace V815, restore the large flat cover to the normal position under the subchassis, replace the subchassis, replace the two long covers and the right side cover, restore the unit to normal operating position, and turn on the INTERLOCKED POWER switch. After the unit has warmed up and been adjusted for normal operation, check the operation of the RF GAIN control.

(*b*) BOX 2 REPLACEMENT.

Step 1. Turn the INTERLOCKED POWER switch OFF. Pull the synchronization unit forward on its slides. Remove the two long shield covers located behind the top of the front panel. Remove the panel on the right side of the unit by loosening the two camlock fasteners and pulling the panel out, down, and forward. Loosen the fastenings for the two subchassis, uncouple the linkages to the two control knobs, and swing the subchassis aside. Remove the cover plate from beneath the subchassis location. Remove V815 from its socket.

Step 2. Remove the RF SCOPE cathode-ray tube, as described in Section 5, paragraph 2. Before removing the tube, place a piece of sticky tape on the scope screen to mark a horizontal reference line.

Step 3. Remove the metal shield which surrounded the cathode-ray tube by taking out the two screws at the base of the angle bracket holding the shield to the chassis and the four screws at the front of the shield. Pull the shield forward through the viewing window in the front panel.

Step 4. Rotate the RF GAIN control to actuate the linkage; this will facilitate identification of box 1 and box 2. Identify the boxes. Physical locations are shown in figures 7–256 and 7–257. Remove the clamps from the wheels of each box. Be careful to hold the end of the flexible cable down and thus prevent the clamp from being thrown from the unit as each screw is removed.

Step 5. Remove the RF GAIN control knob. Remove the two screws which were located behind the edges of the knob and which hold box 2 to the panel.

Step 6. Remove the screw holding a cable clamp for the rigid conduit to the chassis. This screw passes through the chassis bottom near the right front corner (as observed from the panel) and is identified in figure 7–257.

Step 7. Work box 2 off the conduit and cable. To do this bend the conduit to the left and to the rear, enough to allow the wheel shaft to clear the opening in the panel, and pull the box up.

Step 8. Remove the clamp from the wheel of the replacement for box 2. Work the replacement box onto the cable and the conduit. Mount the box on the panel by replacing the screws removed in step 5. Replace the knob; position the knob pointer at 9 o'clock with the shaft turned to the extreme counterclockwise position.

Step 9. Replace the screw for the cable clamp holding the rigid conduit to the chassis. Perform steps 4, 5, 6, 7, 8, 9 and 10 of paragraph 5 *g* (1) (*a*), above.

Step 10. Replace the cathode-ray tube shield and the cathode-ray tube. Rotate the tube so that the sticky tape is horizontal. This will assure that the trace will be horizontal. Remove the sticky tape.

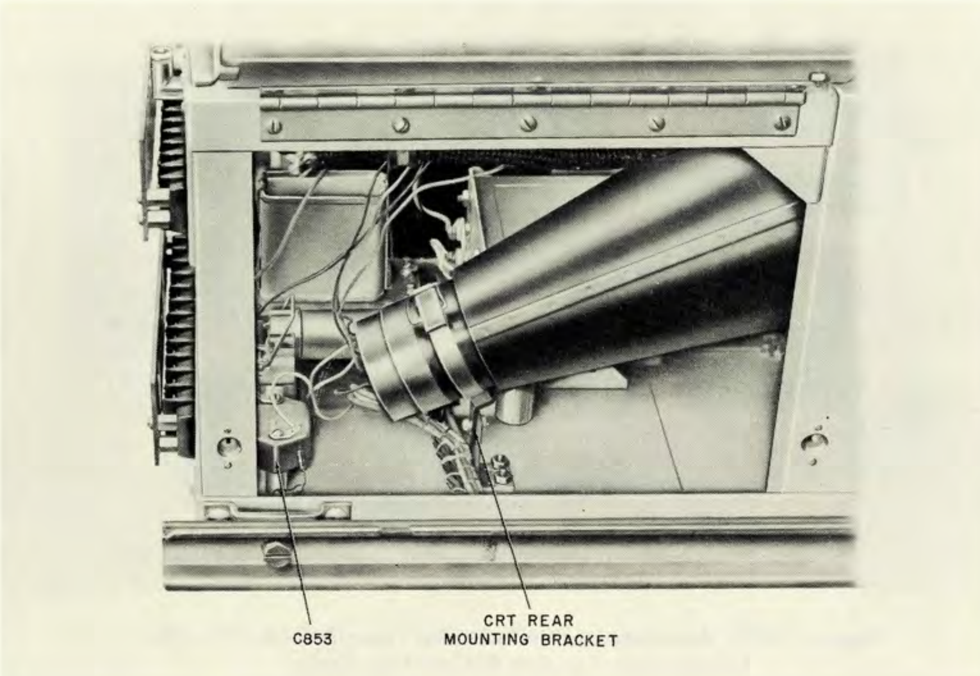


Figure 7-261. Synchronization Indicator Type IP-238/FPN-30, Components Located Behind Left Side Cover

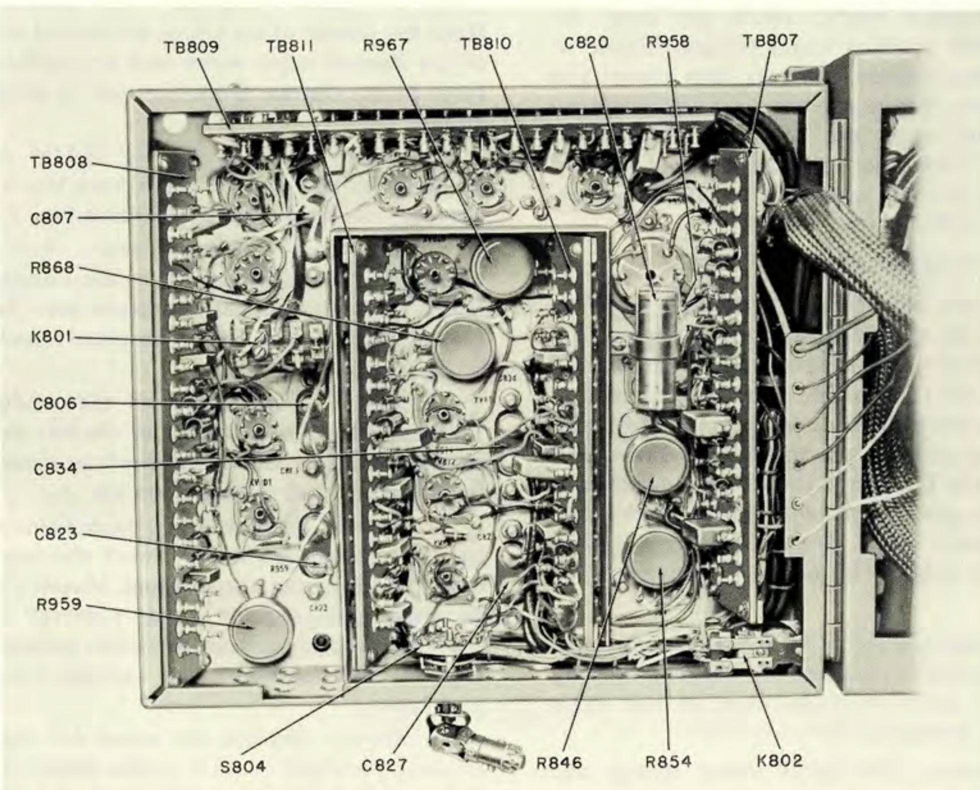


Figure 7-262. Synchronization Indicator Type IP-238/FPN-30, Left Subchassis, Bottom View of Components

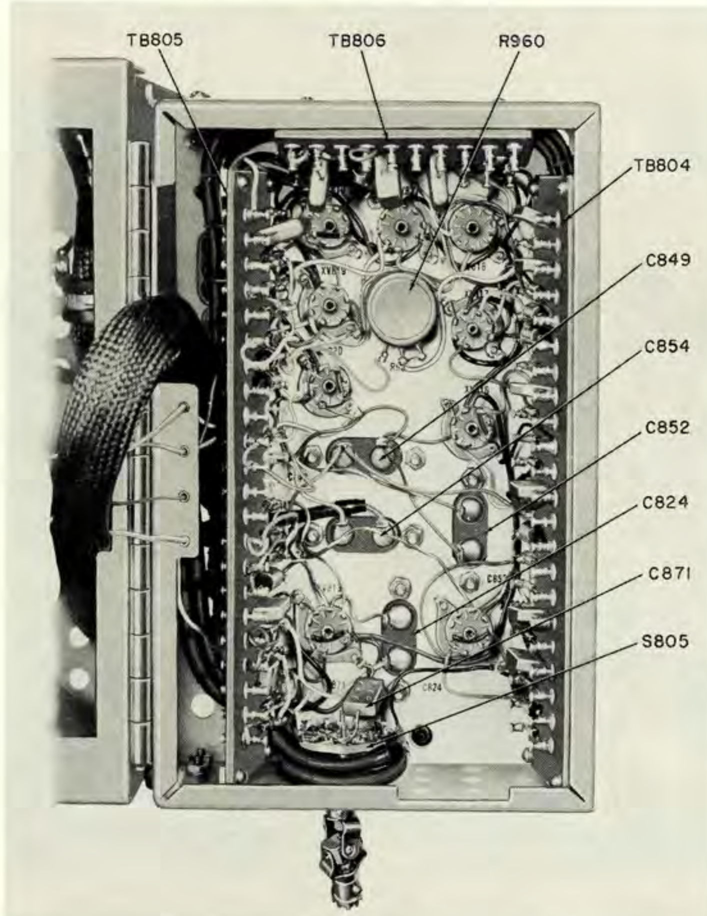


Figure 7–263. Synchronization Indicator Type IP–238/FPN–30, Right Subchassis, Bottom View of Components

Step 11. Replace V815, restore the large flat cover to the normal position under the subchassis, replace the subchassis in their normal positions, replace the two long covers and the right side cover, restore the unit to normal operating position, and turn on the INTERLOCKED POWER switch. After the unit has warmed up and been adjusted for normal operation, check the operation of the RF GAIN control.

(*c*) BOX 1 REPLACEMENT.

Step 1. Turn the INTERLOCKED POWER switch OFF. Pull the synchronization unit forward on its slides. Remove the two long shield covers located behind the top of the front panel. Remove the panel on the right side of the unit by loosening the two cam-lock fasteners and pulling the panel out, down, and forward. Loosen the fastenings for the two subchassis, uncouple the linkages to the two control knobs, and swing the subchassis aside. Remove the cover plate from beneath the subchassis location. Remove V815 from its socket.

Step 2. Rotate the RF GAIN control to actuate the linkage; this will facilitate identification of box 1. Identify the box. The physical location is shown in figure 7–257. Remove the clamp from the wheel of box 1. Be careful to hold the end of the flexible cable down and thus prevent the clamp from being thrown from the unit as the screw is removed.

Step 3. Loosen the four setscrews on the *solid* coupling between box 1 and the capacitor drive shaft. Slide the coupling over the drive shaft. Remove the two screws holding box 1 to a mounting bracket and pull the box clear of the mounting bracket. Work the box off the conduit.

Step 4. Push the replacement for box 1 over the cable and conduit, as far as it will go. Turn the RF GAIN control fully clockwise and make sure that it remains in that position throughout the next step.

Step 5. Perform steps 7, 8, 9, 10, and 11 of paragraph 5 *g* (1) (*a*), above.

(2) HIGH-VOLTAGE BLEEDER RESISTORS.—The mounting arrangement for high-voltage bleeder resistors R857, R858, and R856 is not immediately obvious upon inspection. These resistors are mounted by means of screws or threaded mounting studs, which are threaded into the metal terminals at the resistor ends. Refer to figure 7–256. To replace a resistor, proceed as follows:

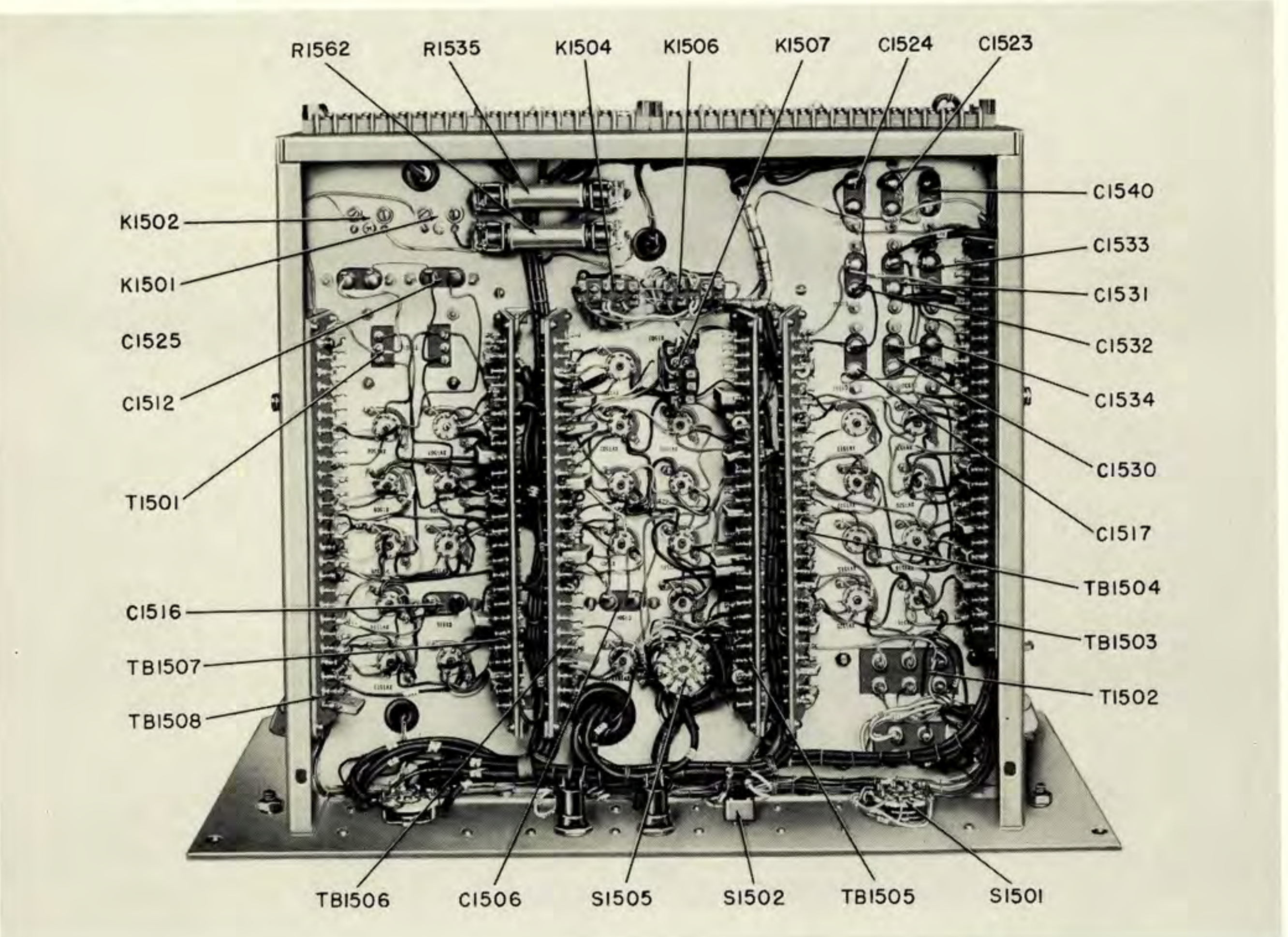


Figure 7–264. Electrical Synchronizer Type SN–117/FPN–30, Bottom View of Components

(*a*) R857.

Step 1. Turn off the INTERLOCKED POWER switch. Pull the synchronization indicator forward on its slides. Remove the two long shield covers located behind the front panel. Discharge the high-voltage capacitors of the 8,000-volt supply associated with high-voltage bleeder resistors R856, R857, and R858 by shorting the terminals of R856 to ground with an insulated screwdriver. Swing the left and right subchassis out of the way and remove the shield cover immediately beneath these chassis.

Step 2. Remove the screw holding the rear end of R857 to the angle bracket which extends across the center of the unit. To do this, reach through the opening, provided by swinging the left subchassis out of the way, with a screwdriver.

Step 3. Thread R857 off the stud which holds R857 to R858.

Step 4. Thread the replacement resistor onto the stud and replace the screw to hold the resistor to the rear end of the bracket.

Step 5. Replace the shield under the subchassis. Restore the subchassis to the normal position, replace the two long shield covers and push the synchronization indicator back into the cabinet. Turn the INTERLOCKED POWER switch ON.

(*b*) R858 OR R856.

Step 1. Turn off the INTERLOCKED POWER switch. Pull the synchronization indicator forward on its slides. Remove the two long shield covers located behind the front panel. Discharge the high-voltage capacitors of the 8,000-volt supply associated with high-voltage bleeder resistors R856, R857, and R858 by shorting the terminals of R856 to ground with an insulated screwdriver. Swing the left and right subchassis out of the way and remove the shield cover immediately beneath these chassis.

Step 2. Remove the screw at the front end of the resistor.

Step 3. Thread the rear end of the resistor off the stud.

Step 4. Install the new resistor, making sure that the connecting wires are replaced at the points to which they originally connected. Replace the screw at the front end of the resistor.

Step 5. Replace the shield under the subchassis. Restore the subchassis to the normal position, replace the two long shield covers, and push the synchronization indicator back into the cabinet. Turn the INTERLOCKED POWER switch ON.

(3) HIDDEN COMPONENTS.—The physical locations of some of the components of the synchronization indicator are obscure because of the unique structural arrangement of the unit. A bank of capacitors, best reached for servicing by removing a cover plate on the bottom of the unit, is shown in figure 7–259. Those components located behind the hinged panel at the bottom front of the unit and the locations of those components will be obvious upon inspection of figure 7–258.

WARNING

Special care must be used with regard to the interlock switch which is located behind the hinged control panel in the front of the synchronization indicator. Opening this panel, and turning on the interlock, energizes a 2,000-volt circuit which is exposed to easy contact by the service technician. If it is desired to work on the low-voltage circuits located behind this panel, be sure to turn off the SCOPE HIGH VOLTAGES switch before turning on the interlock.

h. ELECTRICAL SYNCHRONIZER.—The repair and replacement procedures for components of the electrical synchronizer are straightforward and obvious. The locations of components are shown in figure 7–264.

i. TEST SCOPE.—The repair and replacement procedure for components of the test scope are straightforward and obvious. The locations of components are shown in figure 7–265.

j. POWER SUPPLY TYPE PP–959/FPN–30. (*Refer to figure 7–266.*)—A replacement procedure for the MAIN POWER switch is given below. This switch consists of two identical, separate, circuit breaker sections. Either one or both sections may be replaced at any one time. Each section breaks one side of the power line.

(1) MAIN POWER SWITCH S2001.

Step 1. Turn the 115-volt power off at the switchgear or some other point ahead of the input to

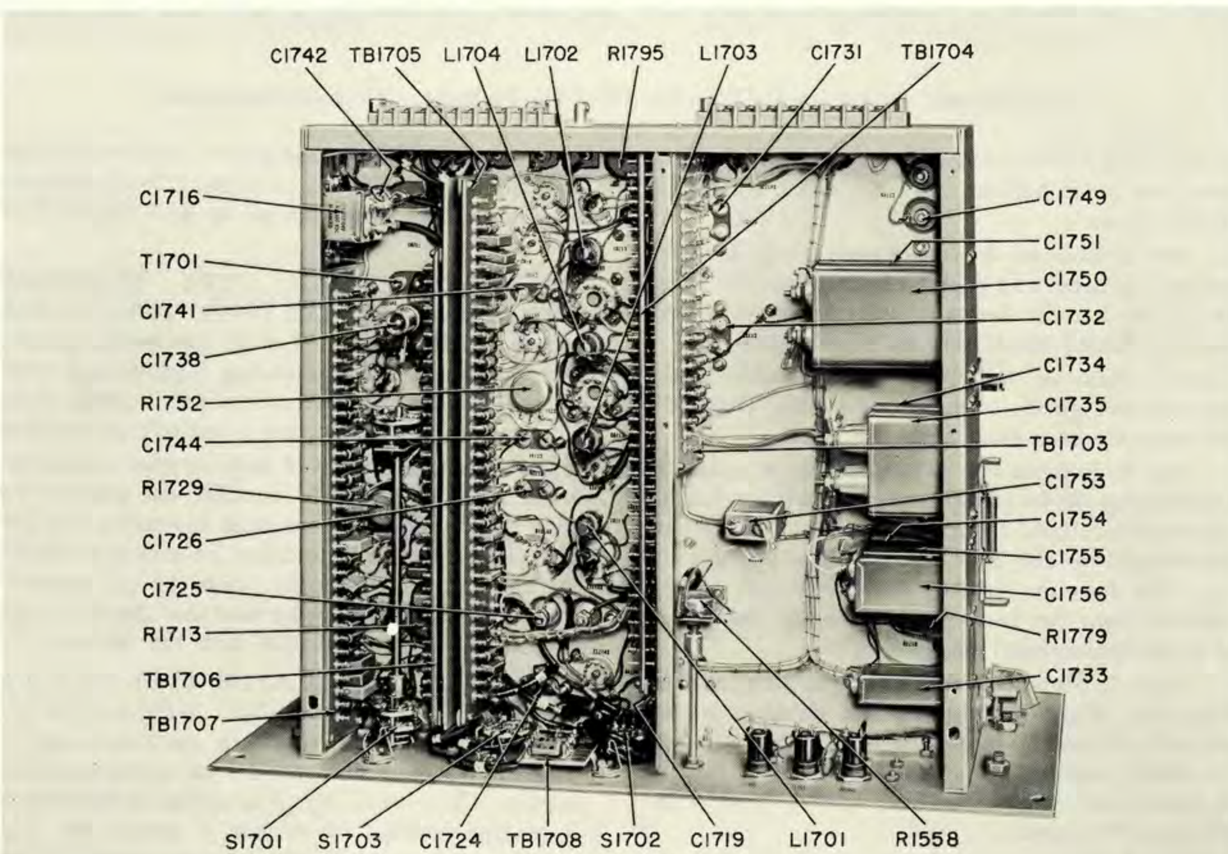


Figure 7–265. Test Oscilloscope Type OS–39/FPN–30, Bottom View of Components

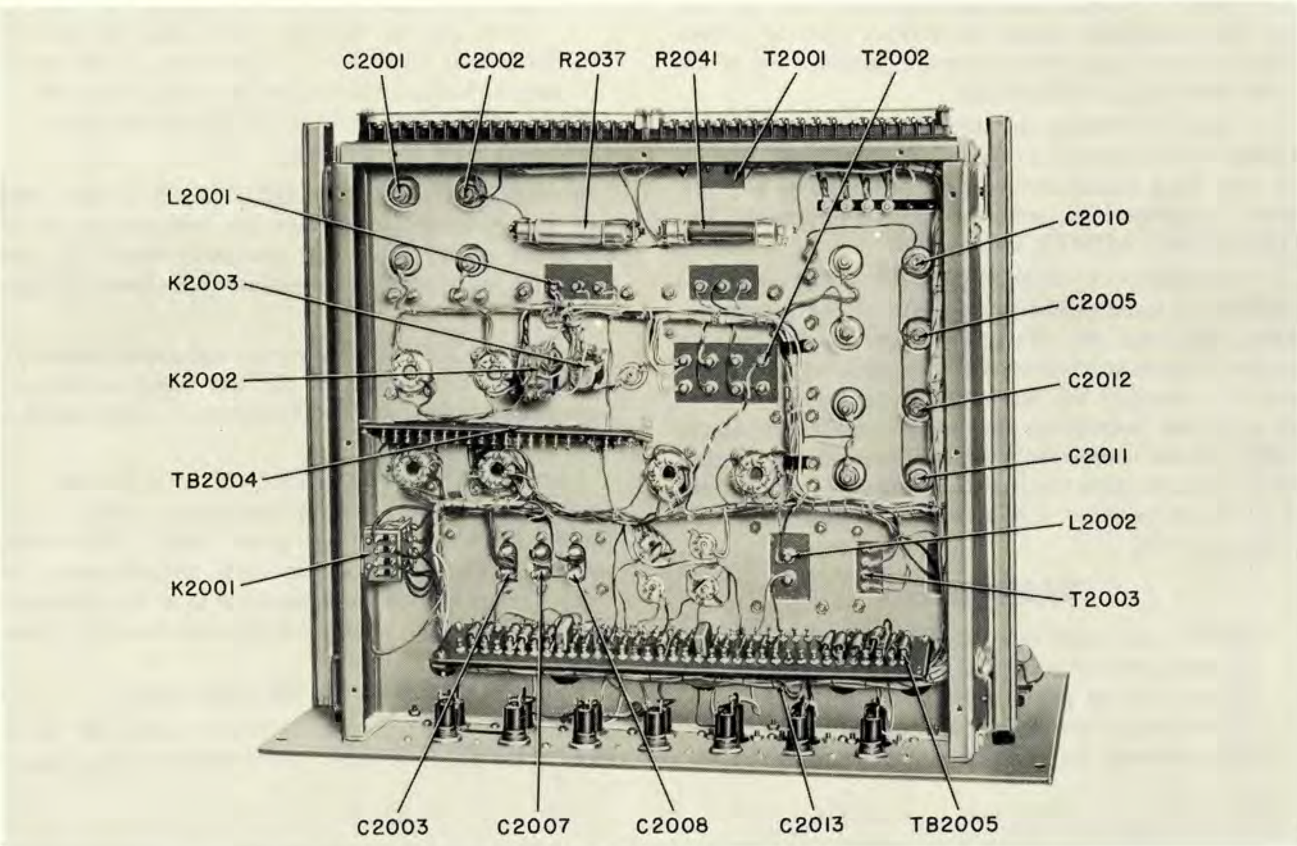


Figure 7–266. Power Supply Type PP–959/FPN–30, Bottom View of Components

the timer. Pull PP–959/FPN–30 forward on its slides. Remove the cover behind the front panel by taking out three screws.

Step 2. Remove the four screws which hold the metering jack panel to a support frame. Pull the panel up and to the left. Set the panel aside so that it is clear of the area behind the MAIN POWER switch.

Step 3. Remove the four screws holding the switch support posts to the front panel. Drop the switch assembly back away from the panel.

Step 4. Replace one switch section at a time to avoid reversing the a-c polarity of timer wiring. Loosen the screws which hold the mounting clips (at the base of the switch) to the back plate which supports the switch. Slip the clips clear of the switch and remove the switch from the back plate. Transfer the switch leads to the replacement switch section.

Step 5. Mount the new switch section in place, position the clips, and tighten the holding screws. When both sections (if two sections are to be replaced) are mounted, position the switch assembly against the front panel, and replace the four screws to hold the assembly to the panel.

Step 6. Restore the metering jack panel to the original position and replace the screws. Replace the cover to its position behind the front panel and replace the three holding screws.

Step 7. Restore the power supply to the normal position in the cabinet, turn the 115-volt power back on, and test the operation of the new MAIN POWER switch.

k. POWER SUPPLY TYPE PP–958/FPN–30, POWER SUPPLY TYPE PP–957/FPN–30. (*Refer to figures 7–267, 7–268.*)—Except for special precautions to be observed when replacing high-voltage rectifiers, or rectifier mounting ferrule clips, in these units, the replacement of components is entirely conventional.

One clip and one end of each rectifier are coded with a red mark. This mark identifies the positive end of each rectifier and the associated mounting clip for that end. When replacing rectifiers be sure to align the red marked end of the rectifier with the red marked clip.

When replacing clips be sure that the clip is aligned so that the sides are parallel with the rectifier.

l. VOLTAGE REGULATOR TYPE CN–235/FPN–30. (*Refer to figures 7–269, 7–270.*)—The voltage regulator consists of two main component groups—a control unit and a motor-driven autotransformer assembly. The control circuit is a plug-in assembly which is readily removed for service. A special test cable assembly is furnished with the regulator to permit operating the control unit when it is removed from the regulator assembly for servicing. Use of this assembly and mechanical servicing of the control circuit are

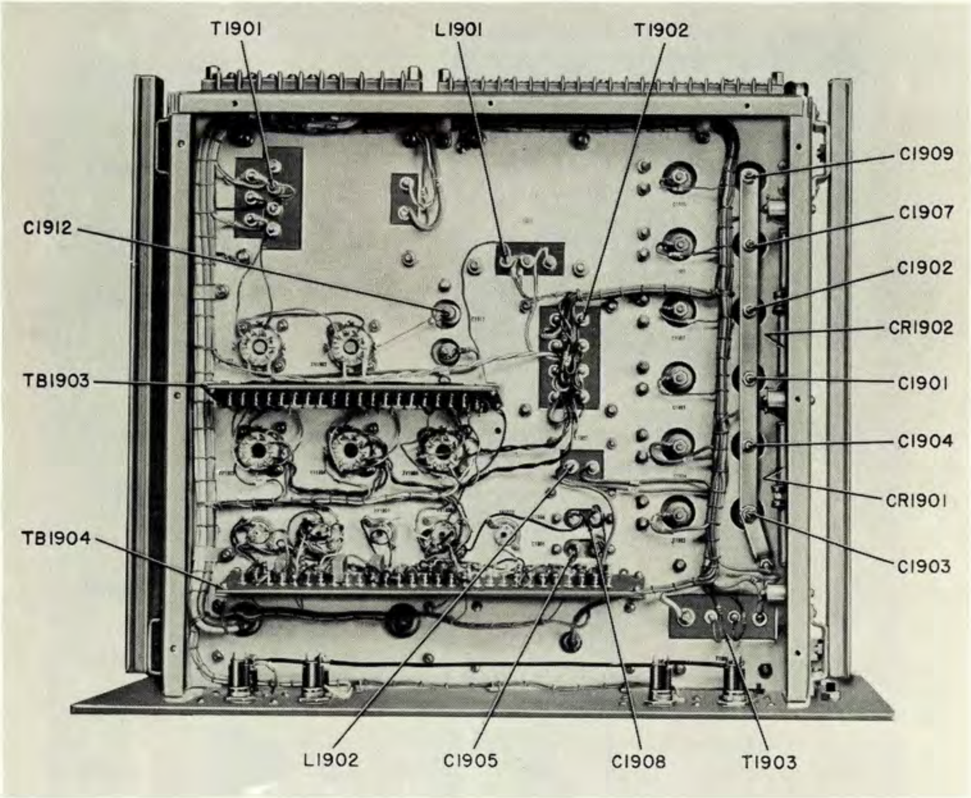


Figure 7–267. Power Supply Type PP–958/FPN–30, Bottom View of Components

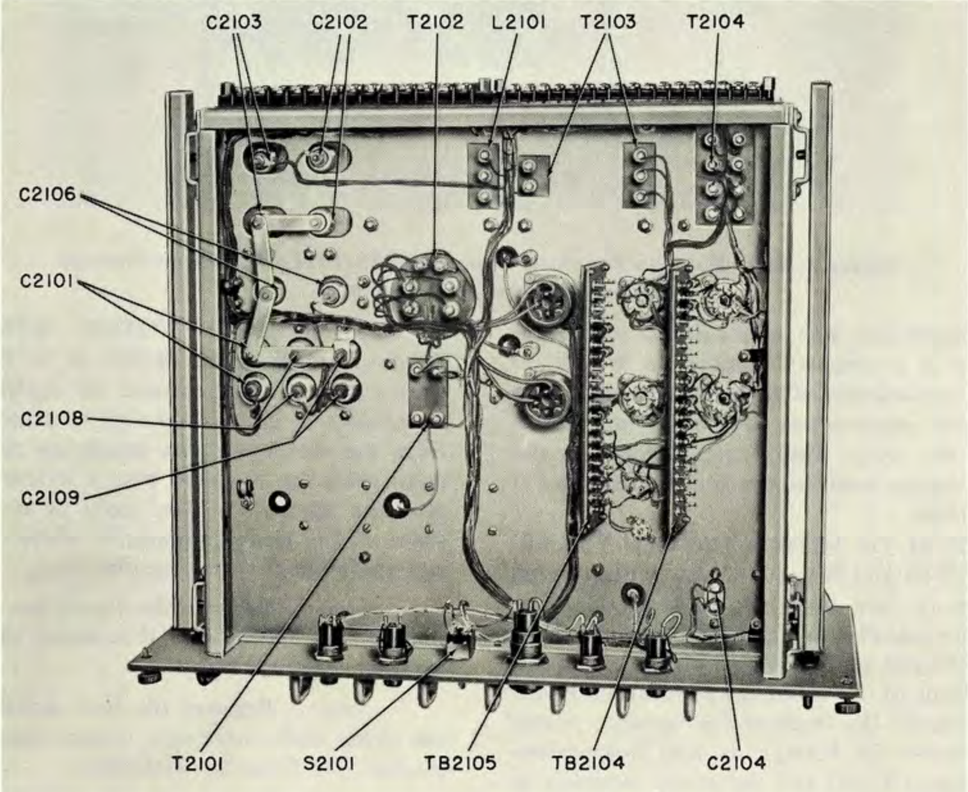


Figure 7–268. Power Supply Type PP–957/FPN–30, Bottom View of Components

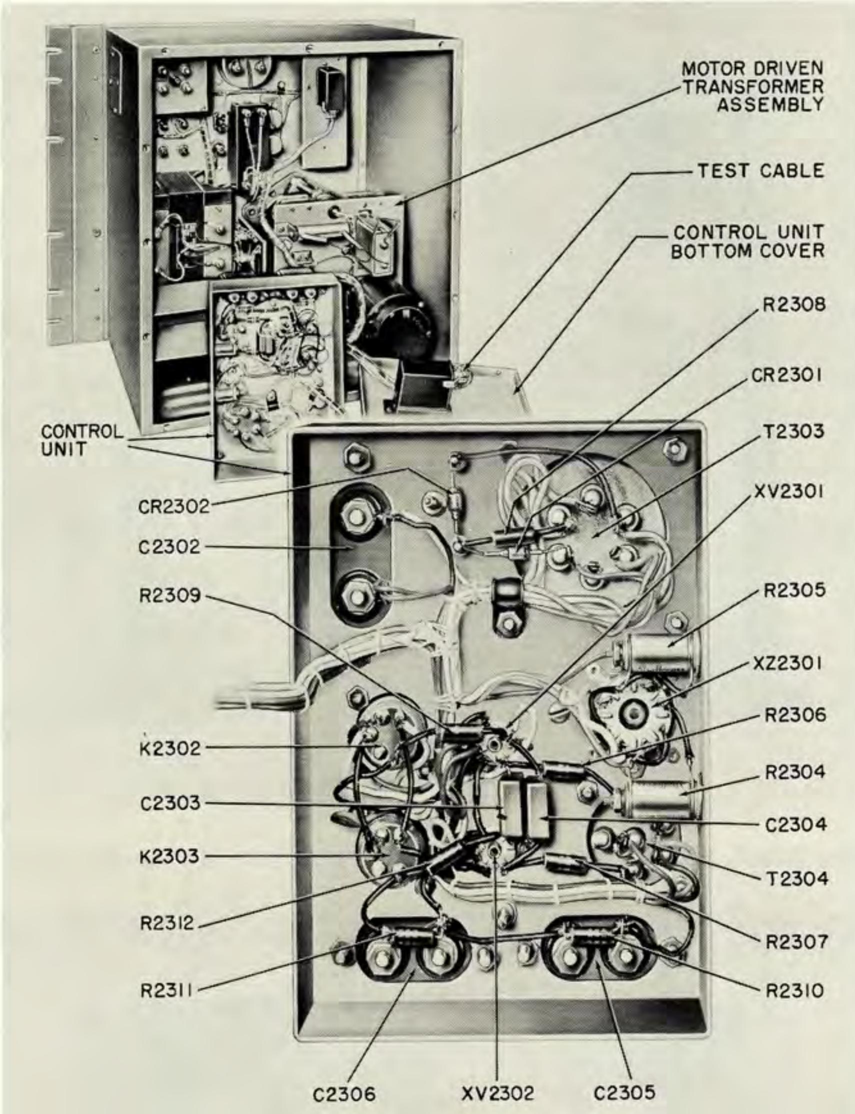


Figure 7–269. Voltage Regulator Type CN–235/FPN–30, Bottom View of Control Chassis Components

obvious upon inspection. The motor-driven autotransformer assembly is a compact mechanism which requires detailed explanation of repair procedures. The explanation covers replacement of the driving motor, replacement of the motor pinion, replacement of the drive gear, and replacement of the brush assembly for the autotransformer.

(1) REMOVAL OF MOTOR-DRIVEN TRANSFORMER ASSEMBLY.—Whenever any replacements are to be made on this assembly, it is necessary to remove the entire assembly to facilitate the procedure. First, turn off 115-volt power, ahead of the regulator, disconnect the leads to the terminals of terminal board TB2302, then remove the leads to the variable power transformer. Remove the bolts, nuts, and lockwashers securing transformer T2301 and the motor assembly to the front panel, then carefully remove the entire assembly.

(2) DRIVING MOTOR REPLACEMENT.—When driving motor B2301 is to be replaced, the pinion gear, O2302, should be replaced at the same time, since it is impracticable to remove the old gear from the motor without damaging the gear. Replacement gears are supplied with a setscrew and a locking pin; the setscrew is used only to secure the gear in place on the shaft temporarily while drilling the gear and shaft for the locking pin.

Step 1. Remove the nameplate from the top of the driving motor and disconnect the leads on the exposed terminal board.

Step 2. Remove the four screws at the base of the motor and remove the motor, mounting plate, and pinion gear from the assembly.

Step 3. Remove the three screws securing the motor to its mounting plate.

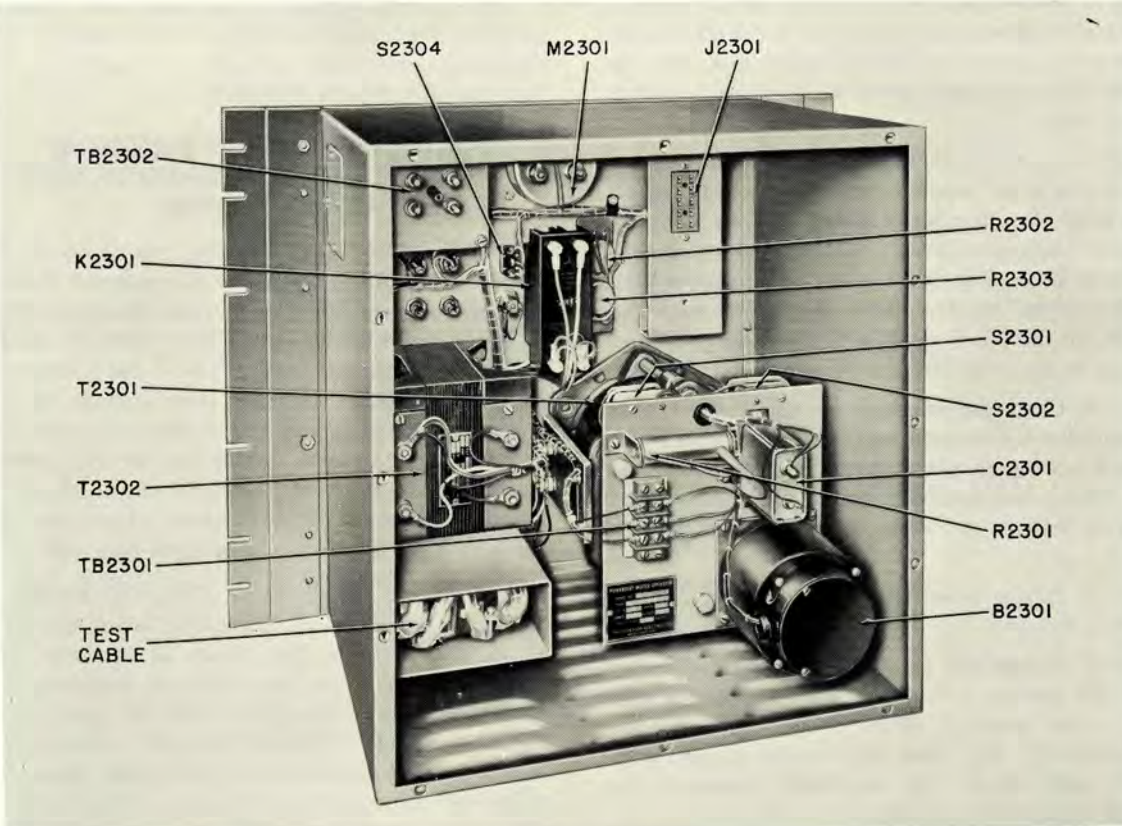


Figure 7–270. Voltage Regulator Type CN–235/FPN–30, Components Mounted Behind Main Panel

Step 4. Place the new pinion gear on the motor shaft as described in steps 3 and 4, paragraph 5 *l* (3) below, and replace the motor using the reverse of the above procedure.

(3) MOTOR PINION REPLACEMENT.—Replace motor pinion gear O2302 as outlined below.

Step 1. Remove the driving motor as described in paragraph 5 *h* (1).

Step 2. Use a gear puller to force the defective pinion gear off the motor shaft, shearing the locking pin in the procedure. Leave the old locking pin in the motor shaft to plug up the old hole.

Step 3. Place the replacement gear on the shaft of the motor at exactly the same distance from the shaft end as the original gear and lock it in place with the setscrew adjacent to one end of the locking pin.

Step 4. Carefully drill through the gear hub and motor shaft at a point 90° from the setscrew, using a size #42 drill. Care must be taken to drill straight through the shaft and not at an angle. Drive in the locking pin and remove the setscrew. Reassemble, using the reverse of the above procedure.

(4) DRIVE GEAR REPLACEMENT.—To replace drive gear O2301, it is necessary to separate the variable power transformer from the rest of the assembly. First remove the three bolts and lockwashers securing the motor mounting plate to the variable power transformer; then carefully lift the upper portion of the assembly from the variable power transformer, being careful not to damage the limit switch actuating levers. This makes the driving gear accessible for replacement; to remove it follow the procedure detailed below.

Step 1. Remove the three flathead screws from the upper surface of the variable power transformer driving gear, noting the position of the limit switch actuating post with respect to the variable power transformer cast frame.

Step 2. Lift the gear from the variable power transformer shaft collar and replace the limit switch actuating post on the replacement gear.

Step 3. Install the replacement gear using the reverse of the above procedure.

(5) BRUSH ASSEMBLY REPLACEMENT.—To replace the brush assembly, the variable power transformer and the motor assembly must be removed from the cabinet as detailed in paragraph 5 *h* (1).

Step 1. Loosen the two screws on each brush clamping spring and carefully lift out the brush assembly. Each brush assembly consists of two brushes, complete with leads. Replace with new brushes and reassemble, using the reverse of the above procedure.

Step 2. As a check for the limit switch actuating cam, maximum rotation in either the clockwise or counterclockwise direction should place the cam on the left side of the variable power transformer, viewing it from the front.

Step 3. After replacing the brushes, push a screwdriver blade or wood wedge under one brush spring to raise the brushes slightly off the commutator surface. Then place a strip of crocus cloth or very fine sandpaper about 1 inch wide and 3-1/2 inches long on the commutator surface under the brush with the smooth side of the cloth against the commutator and the abrasive surface against the brushes.

Step 4. Use some implement to hold the crocus cloth flat against the commutator surface. While holding the cloth tightly in place, remove the wood wedge under the spring and carefully rotate the brush-holder assembly over a short arc. Blow out excess carbon particles.

Step 5. Again raise the brush spring and remove the crocus cloth.

Step 6. Rotate the entire brush assembly many times over the normal full range. This procedure will "work in" the brushes. After "working in", the brushes should fit flat over the entire commutator range, and light should not be visible between the brushes and commutator surface.

6. RECORDING AMMETER.

Corrective maintenance operations on the recording ammeter should be confined to simple, obvious adjustments. The instrument is constructed like a fine watch, and field repair is not recommended unless the technician has had considerable experience in delicate mechanical repair. In any case, field service should only be attempted when it is impracticable to return the instrument to the manufacturer. Normal service adjustments for the pen and inking system are described in Section 4. The measuring element, which actuates the pen, is similar in construction to a conventional D'Arsonval type meter movement, such as that employed in M2001, the d-c panel meter of PP–959/FPN–30. The measuring element is a complete assembly which may be removed from the meter case for service. The assembly may be made accessible for removal by first removing the chart drive assembly, as described below.

The chart drive assembly is secured to the meter case by means of four captive screws. These screws are located at the four corners of the rear of the chart drive frame. To remove the assembly, loosen the four screws (it is not necessary to take them completely out of the frame) and extract the assembly from the case. The complete assembly may then be sent to the factory for service or repair. The factory address of the manufacturer is: The Esterline-Angus Company, Inc., P.O. Box 596, Indianapolis 6, Indiana, U.S.A.

Should field repair of the chart drive assembly be contemplated, refer to figure 7–304, which shows the mechanical assembly and lists the manufacturers' part numbers for replaceable parts.

7. LOCATING TROUBLE IN FREQUENCY DIVIDER COUNTER CIRCUITS WITH TEST COUNT FEATURE.

a. INTRODUCTION.—The frequency divider has a built-in checking feature which permits trouble to be located to a specific stage. This feature is the TEST COUNT INSERT switch, TEST COUNT button, and associated indicator lamps. The binary counter *stages* in the frequency divider form groups of *counters.* Three counters are used in the frequency divider. These are counter 1, counter 2, and counter 3. Counter 1 and counter 2 are four-stage decimal counters and provide a maximum count of 10. Counter 3 is a five-stage counter which can provide a maximum count of 32.

b. USE OF THE TEST COUNT INSERT FEATURE.—The manual test count insert circuit is provided for a convenient check of counter operation. This circuit provides one artificial counting pulse, for each operation of the TEST COUNT push button. By use of the TEST COUNT INSERT switch, this pulse may be inserted into any of the three counter circuits to permit testing of each counter individually. By this means it is possible to check out the operation of each stage of each counter. Indicator lamps and switches used for checking counter operation are located behind the right-hand front panel door designated TEST COUNT on the frequency divider. The indicator lamps are arranged in three vertical rows, one row for each of the three counters. The lamps for counter 1 and counter 2 are numbered 1, 2, 4, and 8. The lamps for counter 3 are numbered 1, 2, 4, 8, and 16. At any time the total count may be obtained by adding together the numbers of the lit lamps. If the TEST COUNT INSERT switch is set to COUNTER-1, and the TEST COUNT button is pressed, one pulse is sent into the first counter. With repeated pressings of the TEST COUNT button, the lamps of counter 1 should show the counter going through a count sequence of 1 to 10 and then repeat. A count of 10 is equivalent to a count of zero as indicated by all the lamps being out. If such a result is not obtained, a circuit defect is indicated. The same procedure applies if the TEST COUNT INSERT switch is set to COUNTER-2, except that count impulses are inserted into counter 2 instead of counter 1. Counter 3 will go through a somewhat different sequence, depending on the basic rate.

If any of the counters do not follow the proper sequence as outlined in detail below, that tube should be suspected which corresponds to the light which first fails to go on or off according to the proper sequence. Replace this tube with one known to be good and recheck the counter. Markings corresponding to the indicator lights are stamped adjacent to each tube on top of the chassis.

If replacing the tube does not remedy the trouble, the technician should investigate the circuit.

c. COUNTER 1 OR 2 CHECK.—To test either of the decimal counters with the manual test circuit, proceed in the following steps:

(1) Set the TEST COUNT INSERT rotary switch to the decimal counter under test (COUNTER-1 or COUNTER-2).

(2) Set the SPECIFIC RATE switch to *zero.*

(3) If any of the lamps are on, they must be turned off before starting the actual test. Do this by operating the TEST COUNT push button until all the lamps go out. Be sure to stop immediately as soon as all the lamps are off, since another button operation will begin turning them on again.

(4) Make the test count check by operating the TEST COUNT button 10 times while observing the lamps after each operation. The lamps should go on and off as shown in table 7–28. A hollow circle indicates a lamp that is on, and a dash a lamp that is off. Note that the total of the numbers associated with the "on" lamps is the count.

d. COUNTER 3 CHECK.—Test count insertion in the third counter is similar to that described for the decimal counters, but the set-up is somewhat different. The results obtained in making the test will vary, depending on the position of the BASIC RATE switch when the test is made. All stages will be checked, in one way or another, if a test sequence is run, regardless of the setting of the BASIC RATE switch. Table 7–29 shows the lamp operation when the BASIC RATE switch is set to SLOW. Since the counter is basically a counter of 32, that number of TEST COUNT switch operations are shown, and a portion of them are left blank to indicate that they are not used. For the SLOW rate, 25 switch operations are indicated. For the other two rates, a lesser number of operations is used. To check the third counter, proceed in the following steps:

(1) Operate the BASIC RATE switch to the desired rate.

(2) Set the TEST COUNT INSERT switch to COUNTER-3.

(3) Operate the push button until all *five lamps of COUNTER-3 are on.* When all the lamps of COUNTER-3 are on, they correspond to an inserted count of 31.

(4) When all the lamps are on, press the TEST COUNT push button once more. If the BASIC RATE switch is set to SLOW, this should result in the 1, 2, and 4 lamps remaining on. This corresponds to a count of seven and indicates that a preset count of seven has taken place and that only 25 more counts will be required to complete the counter cycle.

(5) Proceed with the rest of the check under the assumption that the next button operation is number 8 in table 7–29. With succeeding operations of the TEST COUNT push button, lamp operation should correspond to the table. As noted with the two decimal counters, a hollow circle indicates a lamp that is on and a dash a lamp that is off.

If it is desired to test the counter while switched to the LOW rate, set up the circuit in the same manner described for SLOW. However, when all lamps are on, the next button operation will turn on the 4 and 8 lamps, corresponding to a count of 12. From this point on, proceed with the test, assuming that the next operation is number 13, etc. Refer to table 7–30.

The same procedure holds for the HIGH rate, except that the first operation (after getting all lamps on) will cause the 1 and 16 lamps to go on, indicating a preset count of 17. Proceed with the test count insert, assuming the next button operation to be number 18, etc. Refer to table 7–31.

Note

After making use of the test feature (if the equipment is found normal), always be sure to restore the TEST COUNT INSERT switch to the OFF (CIRCUIT NORMAL)) position, and restore the specific rate switch to its original setting.

TABLE 7–28. TEST COUNT LAMP SEQUENCE FOR COUNTERS 1 AND 2

LAMP NUMBERS	NUMBER OF TIMES "TEST COUNT" SWITCH IS PRESSED									
	1	2	3	4	5	6	7	8	9	10
1	0	—	0	—	0	—	0	—	0	—
2	—	0	0	—	—	0	0	—	—	—
4	—	—	—	0	0	0	0	—	—	—
8	—	—	—	—	—	—	—	0	0	—

TABLE 7-29. TEST COUNT LAMP SEQUENCE FOR COUNTER 3
SLOW BASIC RATE

LAMP NUMBERS	ASSUMED NUMBER OF TIMES "TEST COUNT" SWITCH IS PRESSED																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1							0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	
2							0	—	—	0	0	—	—	0	0	—	—	0	0	—	—	0	0	—	—	0	0	—	—	0	0	
4							0	—	—	—	—	0	0	0	0	—	—	—	—	0	0	0	0	—	—	—	—	0	0	0	0	
8							—	0	0	0	0	0	0	0	0	—	—	—	—	—	—	—	—	0	0	0	0	0	0	0	0	
16							—	—	—	—	—	—	—	—	—	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

TABLE 7-30. TEST COUNT LAMP SEQUENCE FOR COUNTER 3
LOW BASIC RATE

LAMP NUMBERS	ASSUMED NUMBER OF TIMES "TEST COUNT" SWITCH IS PRESSED																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1												—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	
2												—	—	0	0	—	—	0	0	—	—	0	0	—	—	0	0	—	—	0	0	
4												0	0	0	0	—	—	—	—	0	0	0	0	—	—	—	—	0	0	0	0	
8												0	0	0	0	—	—	—	—	—	—	—	—	0	0	0	0	0	0	0	0	
16												—	—	—	—	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

TABLE 7-31. TEST COUNT LAMP SEQUENCE FOR COUNTER 3
HIGH BASIC RATE

LAMP NUMBERS	ASSUMED NUMBER OF TIMES "TEST COUNT" SWITCH IS PRESSED																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1																	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	
2																	—	0	0	—	—	0	0	—	—	0	0	—	—	0	0	
4																	—	—	—	0	0	0	0	—	—	—	—	0	0	0	0	
8																	—	—	—	—	—	—	—	0	0	0	0	0	0	0	0	
16																	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

8. PERFORMANCE CHECK OF RADIO RECEIVER.

The r-f signal levels in the radio receiver are relatively small in amplitude and therefore it has not been possible to provide test scope signal tracing data for the receiver r-f stages. To permit the receiver performance to be checked, procedures are given here for measurement of receiver gain and receiver bandwidth. A rapid gain check provides a very coarse evaluation of receiver performance: point-to-point gain measurements permit an accurate check of over-all receiver gain and also of stage-by-stage gain to isolate an improperly operating stage. The bandwidth measurements provide means for checking the over-all performance of the tuned circuits. Because the tuned circuits are plug-in coil assemblies, a defective tuned coil may best be detected by substituting one coil at a time and checking bandwidth to determine which coils cure any trouble which may be observed.

a. RAPID GAIN CHECK.—This measurement provides a rough measurement of receiver gain and may be used to quickly determine whether failure to receive signals is caused by trouble in the receiver or trouble at some point ahead of the receiver. It consists of removing input connections to the receiver and observing the receiver noise output on the VIDEO SCOPE with the receiver gain controls advanced.

Step 1. Remove the coaxial connections feeding LOCAL SIGNAL INPUT jack J1210 and REMOTE SIGNAL INPUT jack J1201.

Step 2. Advance the FINE RF GAIN control to the extreme clockwise position. If not already set, place the SIGNAL switch, on the VIDEO SCOPE, to the VIDEO position and observe the scope. Advance the COARSE RF GAIN control until the peak-to-peak noise (grass) amplitude is at least three inches. If it is not possible to obtain 3 inches of noise deflections, the receiver gain is not adequate and the procedure of paragraph 3*b,* below, should be used to localize the trouble.

Step 3. At the completion of this check, return the gain controls to their normal positions and restore the coaxial connections to J1201 and J1210.

b. POINT-TO-POINT GAIN MEASUREMENTS. —Point-to-point gain measurement permits the technician to rapidly evaluate the performance of each section of the receiver and therefore locate a defective stage or group of stages. Data is given for the gain of the three subchassis and for the gain of each stage. The method of measurement is to apply signal to the various points of the receiver, adjust the signal level so that the receiver output is 15 volts when the gain control bias is maintained at 4.5 volts, and measure the input signal amplitude. This 4.5-volt bias represents a typical value of bias and must be duplicated if the conditions for which the data was taken are to be duplicated. The signal level required to produce the 15-volt output under these conditions is an indication of the gain of the receiver. Values of input voltage are given for the various signal injection points to be tested by this procedure and values of attenuation, required to reduce a 1-volt signal to these voltages, are also given.

The input jacks of the subchassis are much more accessible than the grids of the various stages. It is therefore suggested that the trouble be isolated to the particular subchassis before attempting to gain access to the tube grids. Thus it will be necessary to disassemble only one subchassis to locate the defective stage.

The input voltages specified for the test procedure given here are for a typical receiver which has considerably higher than the minimum acceptable gain as indicated by the rapid check of paragraph 7*a,* above. If the receiver under test fails the rapid check, the departure from the specified gain figures will be very high and the reason for abnormal performance will be easy to find. The gain through a normal receiver may vary somewhat from the gain through the typical receiver used to obtain the gain figures given here. In view of this, small differences in gain should be ignored; only large differences signify abnormal performance.

Step 1. Disconnect the coaxial connections from REMOTE SIGNAL INPUT jack J1201 and LOCAL SIGNAL INPUT jack J1210. Make sure that both r-f traps are tuned out by turning them to the extreme counterclockwise position.

Step 2. Connect the negative lead of a suitable high resistance voltmeter (Simpson Type 260, Army Type IS–189, or equivalent; or a vtvm) to the arm of COARSE RF GAIN control potentiometer R1228. Connect the positive lead to ground. Using both the COARSE RF GAIN control and the FINE RF GAIN control, adjust for a bias voltage of exactly 4.5 volts (dc), as indicated by the meter. *Leave the gain controls at this position for the remainder of the gain measurement.*

Step 3. Disconnect the coaxial connection from chassis No. 2 into J1206 (on chassis No. 3) and feed an r-f signal (at the nominal operating frequency of the receiver) into J1206. To do this use a suitable signal generator (Type LP, AN/URM–25, General Radio Type 805, Ferris Type 16, or equivalent) and a separate calibrated attenuator capable of reducing the generator output to as little as 65 microvolts. The procedure is based on a generator output of exactly 1 volt and therefore an attenuator capable of inserting up to a 100-decibel loss is required. (The combination of a Daven type RFA–543–50 and RFA–550–50 attenuator, in tandem, will produce 100-db loss, in decade steps, with a resolution to one decibel.) Set the attenuator for an 80-db loss (to provide a load for the signal generator) and adjust the signal generator output for exactly one volt rms (using a suitable vtvm across the attenuator *input* terminals). Change the vtvm to a scale suitable for measuring 15 volts rms and connect the vtvm across RF OUTPUT jack J1208. To do this

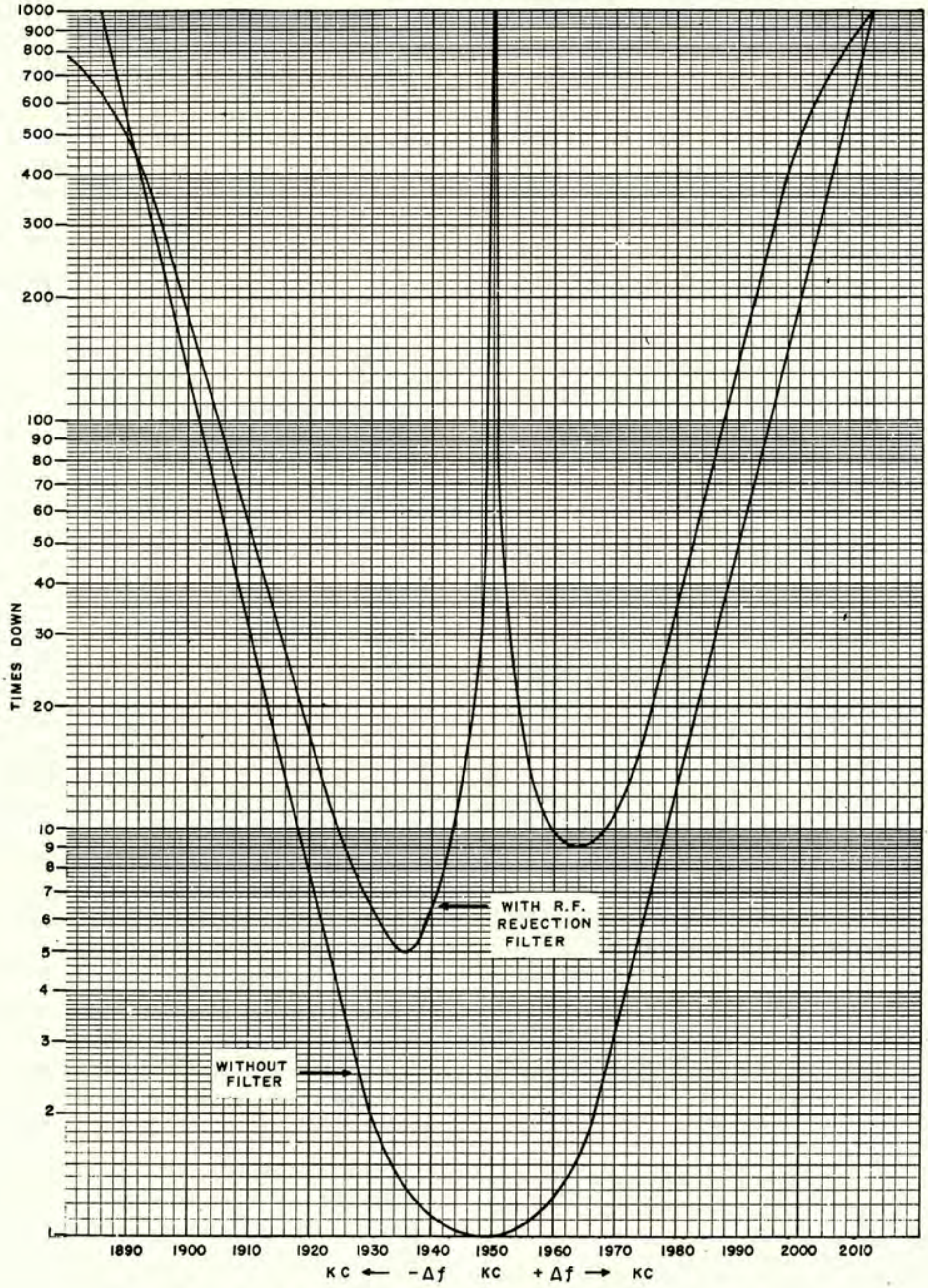


Figure 7–271. Radio Receiver Type R–564/FPN–30, Overall R-F Frequency Response Characteristic

use a T-connector at J1208; do not disconnect the normal connection from J1208 to the RF SCOPE, or the r-f cathode follower (V1205) will be detuned. Adjust the attenuator to make the vtvm read as close to 15 volts as possible. Note the amount of attenuation required to obtain this reading. An attenuation of 55 db below the 1-volt generator output will provide a 1,700-microvolt signal. This signal represents a typical value, for injection into J1206, to obtain 15 volts out. Any lesser attenuation (towards zero db), or larger signal, indicates that the gain is less than the gain over the corresponding portion of a typical receiver.

Step 4. Transfer the r-f feed to J1204 and restore the normal connection for J1206. Adjust the attenuator to make the meter read as close to 15 volts as possible. Note the amount of attenuation required to obtain this reading. An attenuation of 84 db below the 1-volt generator output will provide a 65-microvolt signal. This signal represents a typical value, for injection into J1204, to obtain 15 volts out. Any lesser attenuation (towards zero db), or larger signal, indicates the gain is less than the gain over the corresponding portion of a typical receiver. The difference in

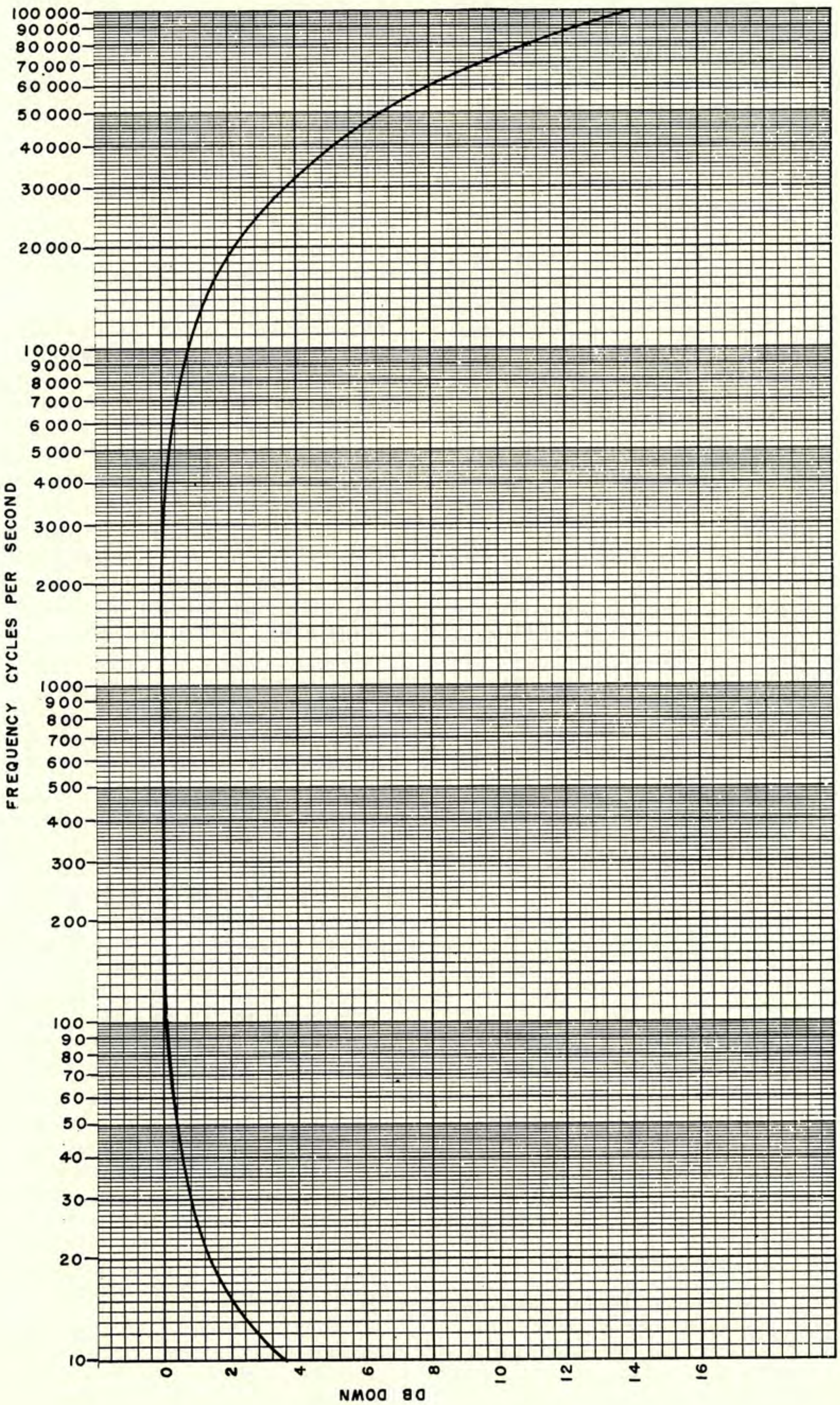


Figure 7–272. Synchronization Indicator Type IP–238/FPN–30, Video Amplifier Frequency Response Characteristic

attenuation values for this and the preceding measurement (84 minus 55 equals 29 db, to use the values for a typical receiver) is the gain for chassis No. 2.

Step 5. Transfer the r-f feed to J1201 and restore the normal connection for J1204. Adjust the attenuator to make the meter read as close to 15 volts as possible. Note the amount of attenuation required to obtain this reading. An attenuation of 81.5 db below the 1-volt generator output will provide an 85-microvolt signal. This signal represents a typical value, for injection into J1201, to obtain 15 volts out. Any lesser attenuation (towards zero db), or larger signal, indicates the gain is less than the gain over a typical receiver. The difference in attenuation values for this and the preceding measurement (84 minus 87 equals 3 db, to use the value for a typical receiver) is the loss for chassis No. 1.

Step 6. Consider the data obtained in steps 3, 4, and 5 above and decide which chassis is causing the trouble. Measure the gain of the stages within that chassis. To do this, remove the shield covers from the subchassis in question and apply the r-f signal to the control grid of each tube. Connect a 0.01-mf capacitor between the output of the r-f attenuator and the tube grid. (Shielded connections must be used up to the capacitor, and the capacitor leads must be as short as possible.) The method of measurement is the same as used in the preceding steps (4.5 volts bias and 15 volts rf out) except as noted in the footnote. The data for a typical receiver is tabulated below:

FEED SIGNAL INTO	DB BELOW 1 VOLT	SIGNAL LEVEL (MICROVOLTS)
V1208 pin 2*	0	1,000,000
V1207 pin 1	4	620,000
V1206 pin 1	29	34,000
V1205 pin 1	35	17,000
V1204 pin 1	48	4,000
V1203 pin 1	57	1,350
V1202 pin 1	64	600
V1201 pin 1	60	1,050

* The VTVM reading for the output of this stage will be 0.95 volt, not 15 volts.

Step 7. When the measurements have been completed, and any necessary repairs made, replace any shield covers removed, disconnect the test equipment, and restore the coaxial connections removed in step 1.

c. BANDWIDTH MEASUREMENT.—The bandwidth measurement permits the technician to evaluate the performance of the tuned circuits of the receiver. Most components which have any significant effect on bandwidth are plug-in assemblies and may be readily checked by substitution. If, upon substituting all plug-in components, the trouble is not cured, measure the resistance of 3,300-ohm resistor R1236, 4,700-ohm resistor R1239, and 10,000-ohm resistor R1242. If any of these untuned r-f amplifier grid resistors do not appear to be within 20 percent of their nominal values, they should be replaced. If the grid resistor values are normal, check the components of each of the two r-f traps. Measure the resistance across the capacitors in the traps to make sure they are not leaky. If the capacitors appear normal, disable the trap by connecting a short piece of wire between the terminals of the tuned coil (L1204 or L1205). If the bandwidth is normal with the trap disabled, replace the coil and both capacitors of the trap.

The bandwidth measurement procedure employs the signal generator and attenuator equipment required for the gain measurements (7*b* above) to feed a reference signal and two attenuated signals into the receiver. The attenuated signals are 6 db and 60 db below the reference signal and are used to determine those frequencies at which receiver gain is 6 db down and 60 db down, respectively.

Step 1. Disconnect the coaxial connections from REMOTE SIGNAL INPUT jack J1201 and LOCAL SIGNAL INPUT jack J1201. Remove blanking driver tube V1210. Make sure both r-f traps are tuned out by turning them to the extreme counterclockwise position.

Step 2. Connect a vtvm across RF OUTPUT jack J1208. To do this use a T-connector at J1208; do not disconnect the normal connection from J1208 to the RF SCOPE, or the r-f cathode follower will be detuned. Set the meter to read 15 volts rms.

Step 3. Feed an r-f signal, at the nominal operating frequency of the receiver, into REMOTE SIGNAL INPUT jack J1201. To do this use a suitable signal generator (Type LP, AN/PRM–25, General Radio Type 805, Ferris Type 16, or equivalent) and a calibrated attenuator capable of reducing a 1-volt generator output by as much as 80 db. (The combination of a Daven Type RFA–543–50 and RFA–550–50 attenuator, in tandem, will produce up to a 100-db loss, in decade steps, with a resolution to 1 db.) With exactly 1 volt into the attenuator (verify by reading with the vtvm) set the attenuator for an 80-db loss.

Step 4. Adjust the r-f gain controls so that the vtvm (connected across J1208) reads exactly 15 volts. The generator frequency must be accurate within 0.5 kc at this point and for the checks to follow. If the accuracy of the generator cannot be depended upon, assume that the receiver is peaked at the nominal frequency and tune the generator for a peak reading of the vtvm. If necessary, readjust the r-f gain controls so that the vtvm reads exactly 15 volts.

Step 5. Remove 6 db from the attenuator setting (total loss of 74 db). Change the signal generator frequency, below the center frequency, until the vtvm again reads 15 volts. Record this frequency as f_1. Raise the generator frequency, past the center frequency, until the vtvm reads 15 volts. Record this frequency as f_2. The bandwidth at 6 db down equals $f_2 - f_1$. This bandwidth should be 35 ±5 kc.

Step 6. Remove an additional 54 db from the attenuator setting (total loss of 20 db). Lower the signal generator frequency, below the center frequency, until the vtvm reads 15 volts. Record this frequency as f_3. Raise the generator frequency until the vtvm again reads 15 volts. Record this frequency as f_1. The bandwidth at 60 db down equals $f_4 - f_3$. This bandwidth should not be over 150 kc.

Step 7. If the bandwidth is not within the required limits, substitute one plug-in tuning assembly at a time and repeat the bandwidth measurement until the cause of trouble is located.

Step 8. When the measurements have been completed, and any necessary repairs made, disconnect the test equipment, replace V1210, and restore the coaxial connections removed in step 1.

9. REDUCING WIDTH OF BLANKING PULSE.

The blanking pulse has been made wider than absolutely necessary in order to minimize the possibility of interference. In some locations, communications signals entering the receiver could heterodyne with radio frequency components of the leading edge of the blanking pulse. If the leading edge of the blanking pulse were coincident with the transmitter trigger, the resulting beat products would distort the leading edge of the loran signal, as presented on the timer oscilloscopes and in the synchronizer, and make synchronization difficult. To eliminate this problem the blanking pulse is triggered somewhat ahead of the transmitter trigger so that any spurious signals cannot coincide with the loran signal.

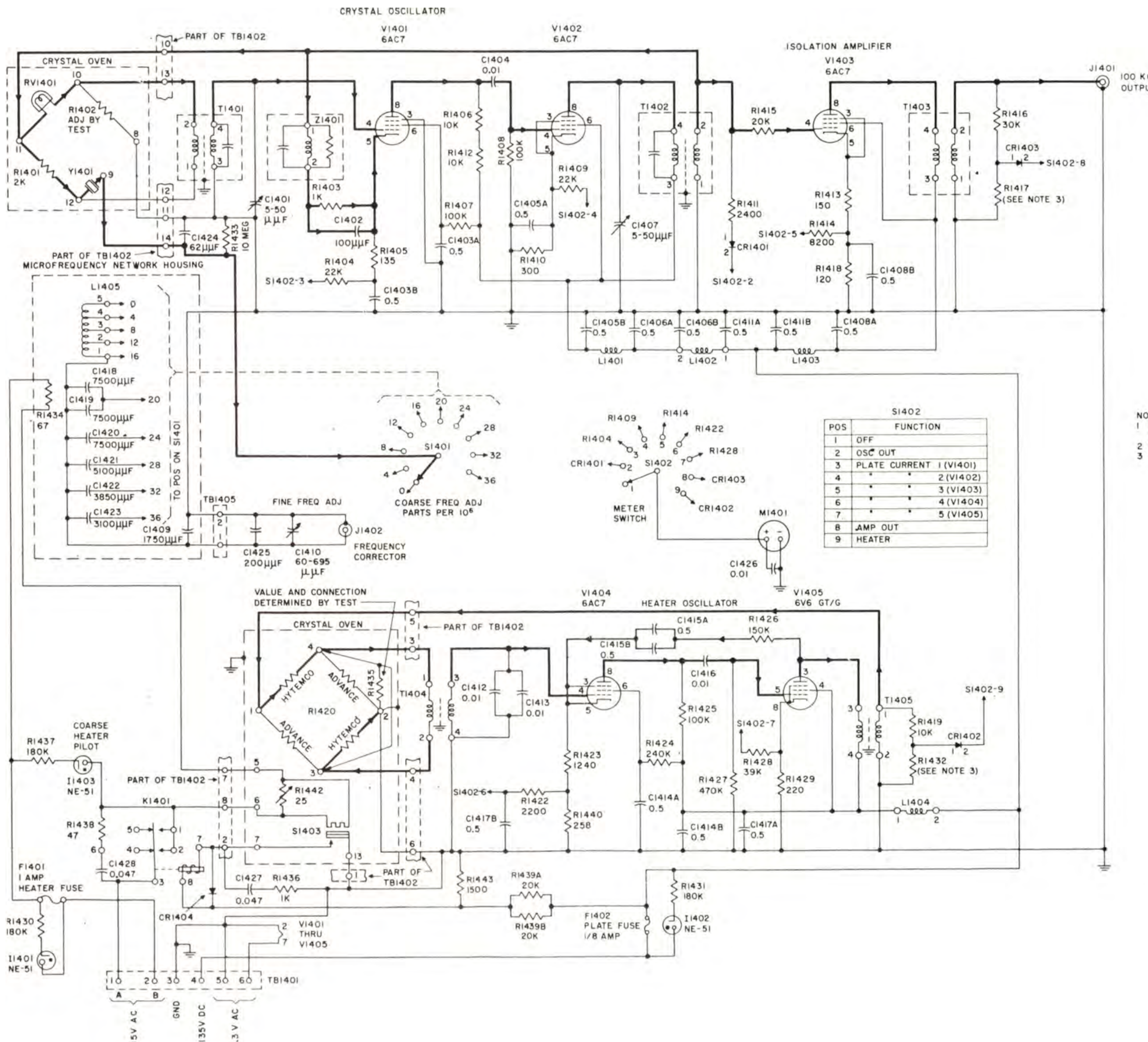
Should local conditions make it desirable to view a signal immediately preceding the transmitter trigger, and provided that there is no likelihood of interference from communications signals on channels near the loran frequency, the following simple modification may be carried out to make the leading edge of the blanking pulse coincide with the transmitter trigger:

Step 1. Remove the connection between pin 2 of V507 and contact 3 of S501–2.

Step 2. Connect a suitable length of wire from pin 2 of V507 to contact 12 of S501–1.

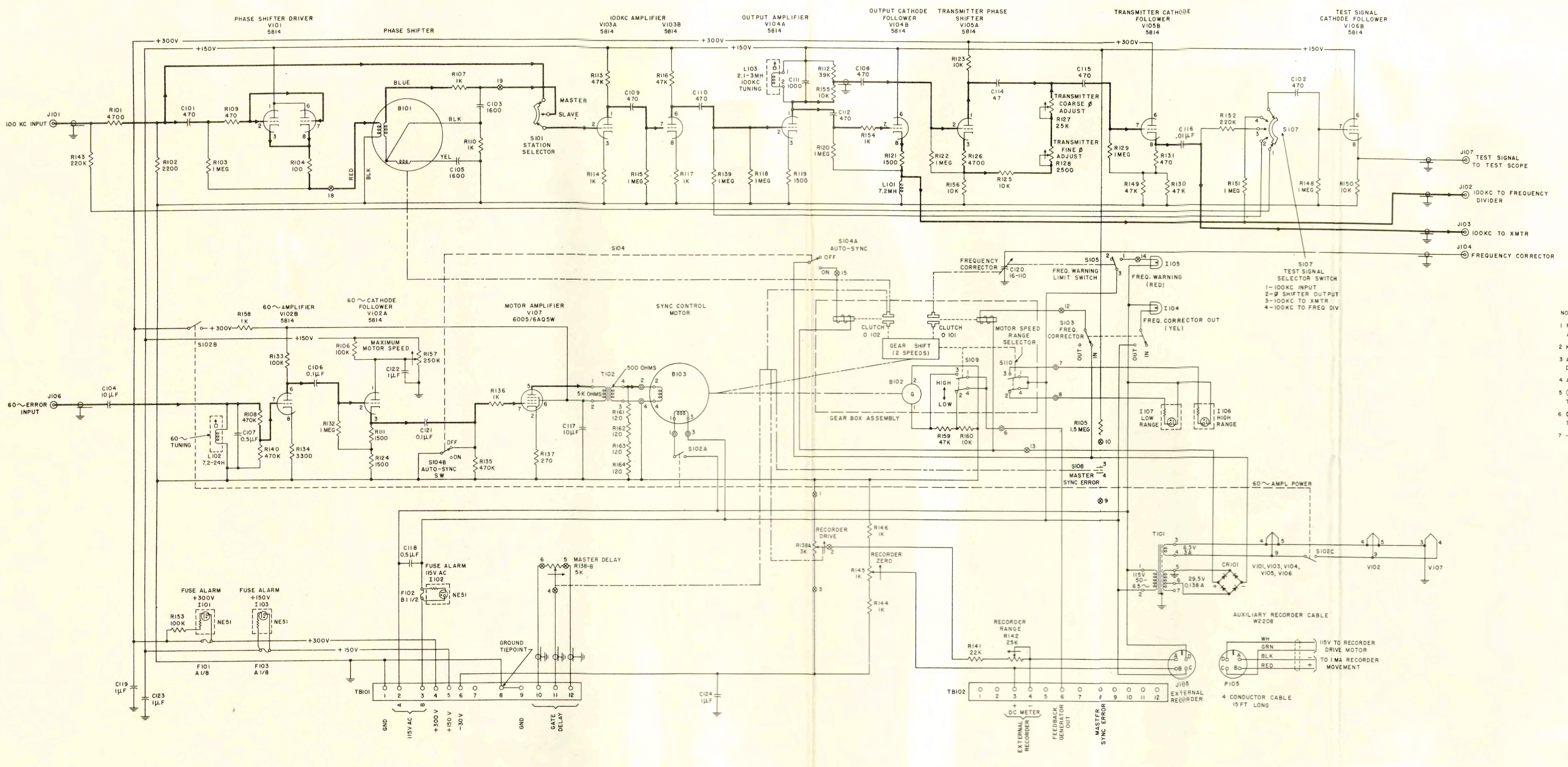
Step 3. Replace C513 with a 2,700-mmf capacitor, such as CM30D272J.

Step 4. Readjust the blanking pulse width, following the procedure of Section 3, paragraph 24*c*.



NOTES:
1 RESISTOR VALUES ARE IN OHMS AND CAPACITOR VALUES ARE IN μF UNLESS OTHERWISE NOTED.
2 K=1000 OHMS.
3 750 OR 1000 OHMS DEPENDING ON TESTS.

Figure 7–273. Radio Frequency Oscillator Type O–202/FPN–30, Schematic Diagram



NOTES:

1 RESISTOR VALUES ARE IN OHMS AND CAPACITOR VALUES ARE IN µµF UNLESS OTHERWISE NOTED.

2 K=1000 OHMS.

3 ARROW ACROSS ARM OF POTENTIOMETER SHOWS DIRECTION OF CW ROTATION FACING SHAFT END.

4 ALL WAFER SWITCHES ARE SHOWN IN EXTREME CCW POSITION

5 ◎-TERMINAL ON TB106, ADJACENT DIGIT SHOWS TERMINAL BOARD CONNECTIONS.

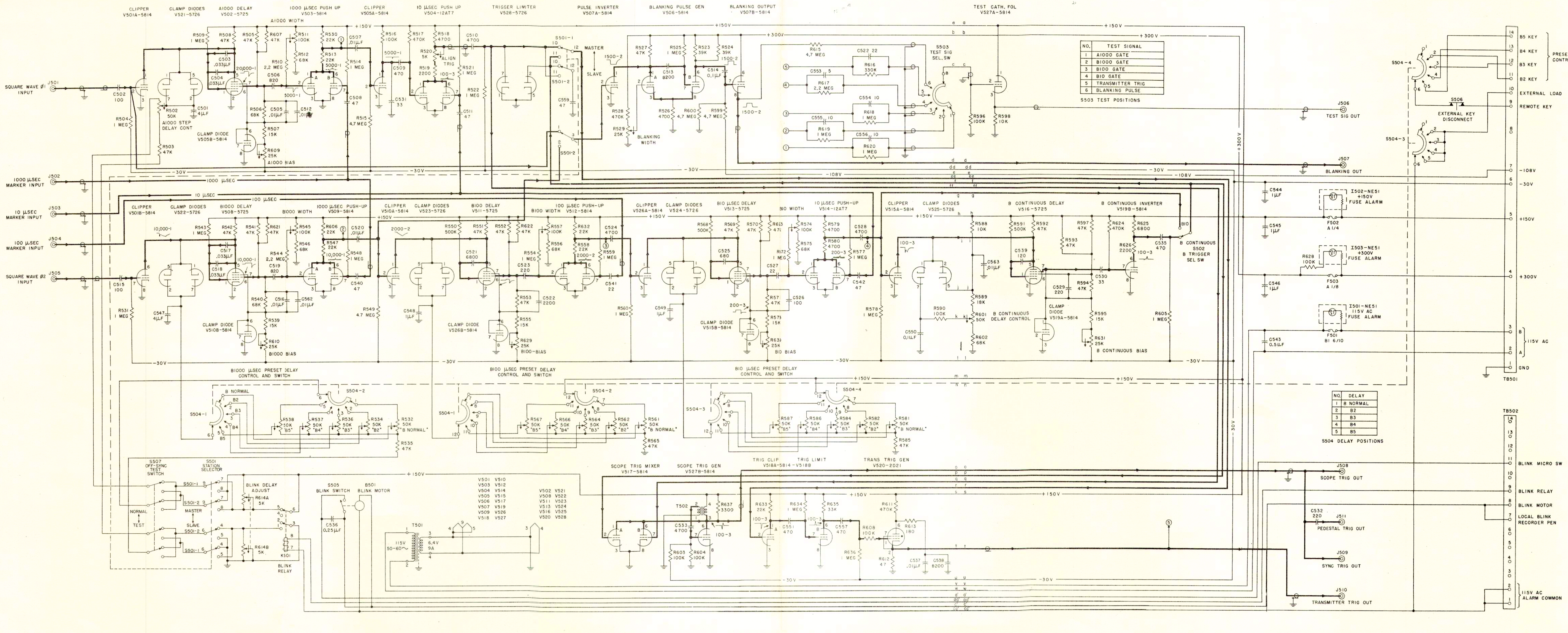
6 ⊗-TERMINAL ON TB107, ADJACENT DIGIT SHOWS TERMINAL BOARD CONNECTIONS.

7 ----------- =MOTOR CONTROLLED MECHANICAL LINKAGES.

Figure 7–274. Synchronization Control Type C–1238/FPN–30, Schematic Diagram

NOTES:
1. RESISTOR VALUES ARE IN OHMS AND CAPACITOR VALUES ARE IN μμF UNLESS OTHERWISE NOTED.
2. K=1000 OHMS.
3. ARROW ACROSS ARM OF POTENTIOMETER SHOWS DIRECTION OF CW ROTATION FACING SHAFT END.
4. ALL WAFER SWITCHES ARE SHOWN IN EXTREME CCW POSITION.
5. THE NUMBER SUCH AS 25,000-1, NEAR EACH WAVEFORM, IS THE SWEEP SPEED (IN MICROSECONDS) AND THE COARSE SWEEP SPEED SWITCH POSITION USED TO OBTAIN THE WAVEFORM.

Figure 7–275. Frequency Divider Type CV–274/FPN–30, Schematic Diagram



NO.	TEST SIGNAL
1	A1000 GATE
2	B1000 GATE
3	B100 GATE
4	B10 GATE
5	TRANSMITTER TRIG
6	BLANKING PULSE

S503 TEST POSITIONS

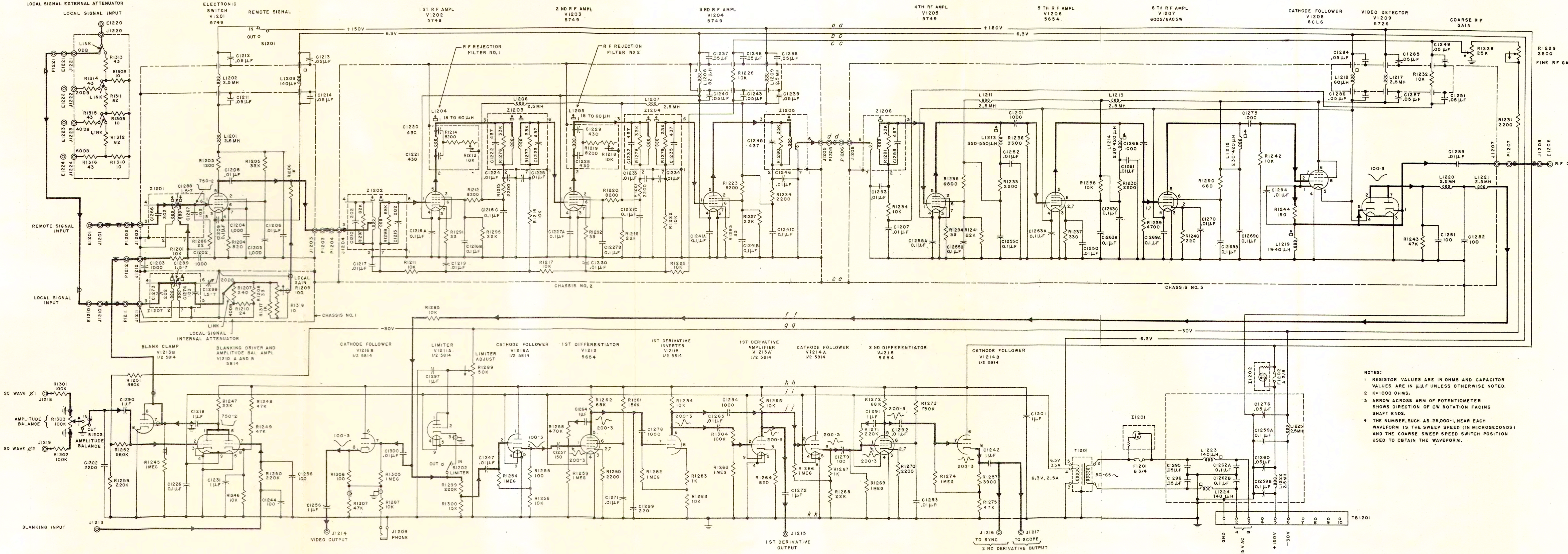
NO.	DELAY
1	B NORMAL
2	B2
3	B3
4	B4
5	B5

S504 DELAY POSITIONS

NOTES:

1. RESISTOR VALUES ARE IN OHMS AND CAPACITOR VALUES ARE IN μμF UNLESS OTHERWISE NOTED.
2. K=1000 OHMS
3. ARROW ACROSS ARM OF POTENTIOMETER SHOWS DIRECTION OF CW ROTATION FACING SHAFT END.
4. ALL WAFER SWITCHES ARE SHOWN IN EXTREME CCW POSITION.
5. CONNECTIONS FROM TEST SIG SEL SW S503 TO SCATTERED POINTS ON SCHEMATIC ARE IDENTIFIED BY A CIRCLED NUMBER THUS: (X)
6. THE NUMBER SUCH AS 25,000–1 NEAR EACH WAVEFORM, IS THE SWEEP SPEED (IN MICROSECONDS) AND THE COARSE SWEEP SPEED SWITCH POSITION USED TO OBTAIN THE WAVEFORM.

Figure 7–276. Time Delay Type TD–92/FPN–30, Schematic Diagram



NOTES:

1. RESISTOR VALUES ARE IN OHMS AND CAPACITOR VALUES ARE IN µµF UNLESS OTHERWISE NOTED.
2. K=1000 OHMS.
3. ARROW ACROSS ARM OF POTENTIOMETER SHOWS DIRECTION OF CW ROTATION FACING SHAFT ENDS.
4. THE NUMBER, SUCH AS 25,000-1, NEAR EACH WAVEFORM IS THE SWEEP SPEED (IN MICROSECONDS) AND THE COARSE SWEEP SPEED SWITCH POSITION USED TO OBTAIN THE WAVEFORM.

Figure 7–277. Radio Receiver Type R–564/FPN–30, Schematic Diagram

NOTES:
1 RESISTOR VALUES ARE IN OHMS AND CAPACITOR VALUES ARE IN µµF UNLESS OTHERWISE NOTED.
2 K=1000 OHMS
3 ARROW ACROSS ARM OF POTENTIOMETER SHOWS DIRECTION OF CW ROTATION FACING SHAFT END.
4 ALL WAFER SWITCHES ARE SHOWN IN EXTREME CCW POSITION.
5 THE NUMBER SUCH AS 25,000-1 NEAR EACH WAVEFORM, IS THE SWEEP SPEED (IN MICROSECONDS) AND THE COARSE SWEEP SPEED SWITCH POSITION USED TO OBTAIN THE WAVEFORM.

Figure 7–278. Synchronization Indicator Type IP–238/FPN–30, Schematic Diagram

ORIGINAL

NOTES:

1- RESISTOR VALUES ARE IN OHMS AND CAPACITOR VALUES ARE IN μμF UNLESS OTHERWISE NOTED
2- K=1000 OHMS
3- ARROW ACROSS ARM OF POTENTIOMETER SHOWS DIRECTION OF CW ROTATION FACING SHAFT END
4- ALL WAFER SWITCHES ARE SHOWN IN EXTREME CCW POSITION
5- CONNECTIONS FROM TEST SIGNAL SELECTOR SWITCH S1503 TO SCATTERED POINTS ON SCHEMATIC ARE IDENTIFIED BY A CIRCLED NUMBER, THUS: (X)
6- THE NUMBER SUCH AS 25,000-1, NEAR EACH WAVEFORM IS THE SWEEP SPEED (IN MICROSECONDS) AND THE COARSE SWEEP-SPEED SWITCH POSITION USED TO OBTAIN THE WAVEFORM

Figure 7–279. Electrical Synchronizer Type SN–117/FPN–30, Schematic Diagram

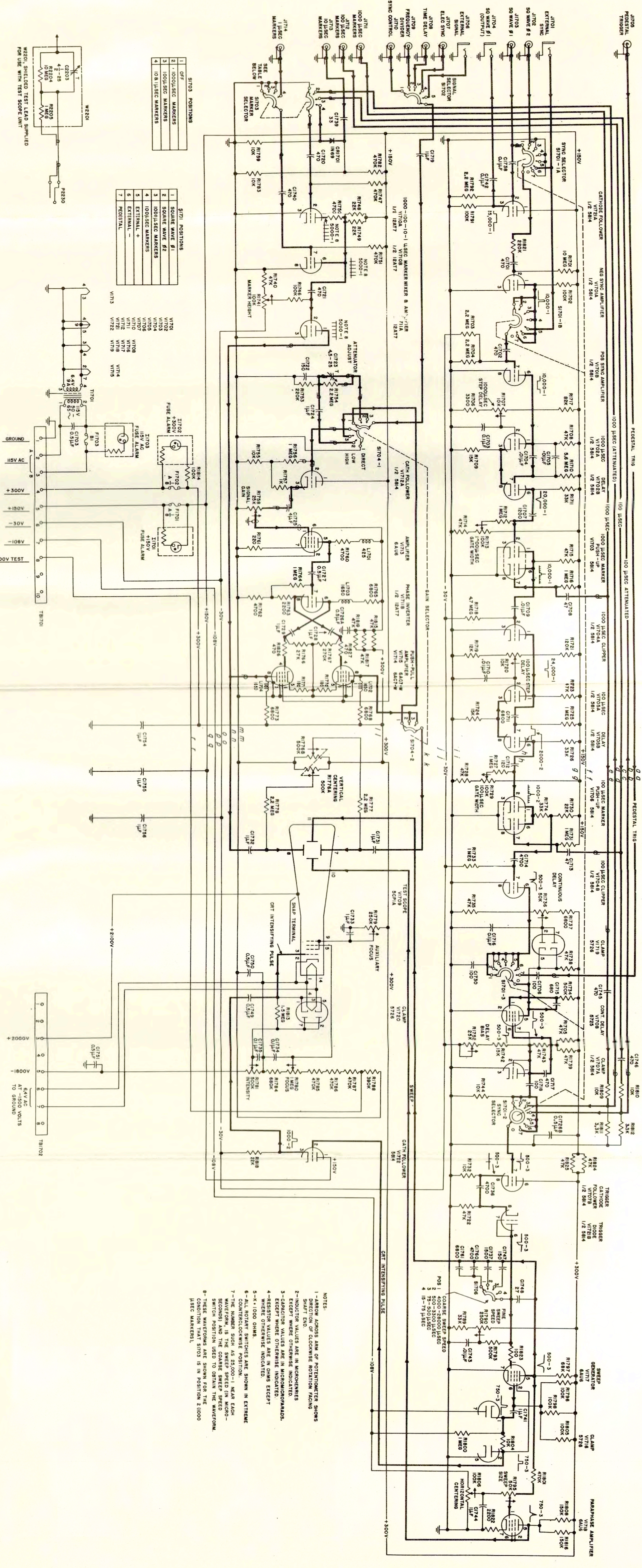


Figure 7–280. Test Oscilloscope Type OS-39/FPN-30, Schematic Diagram

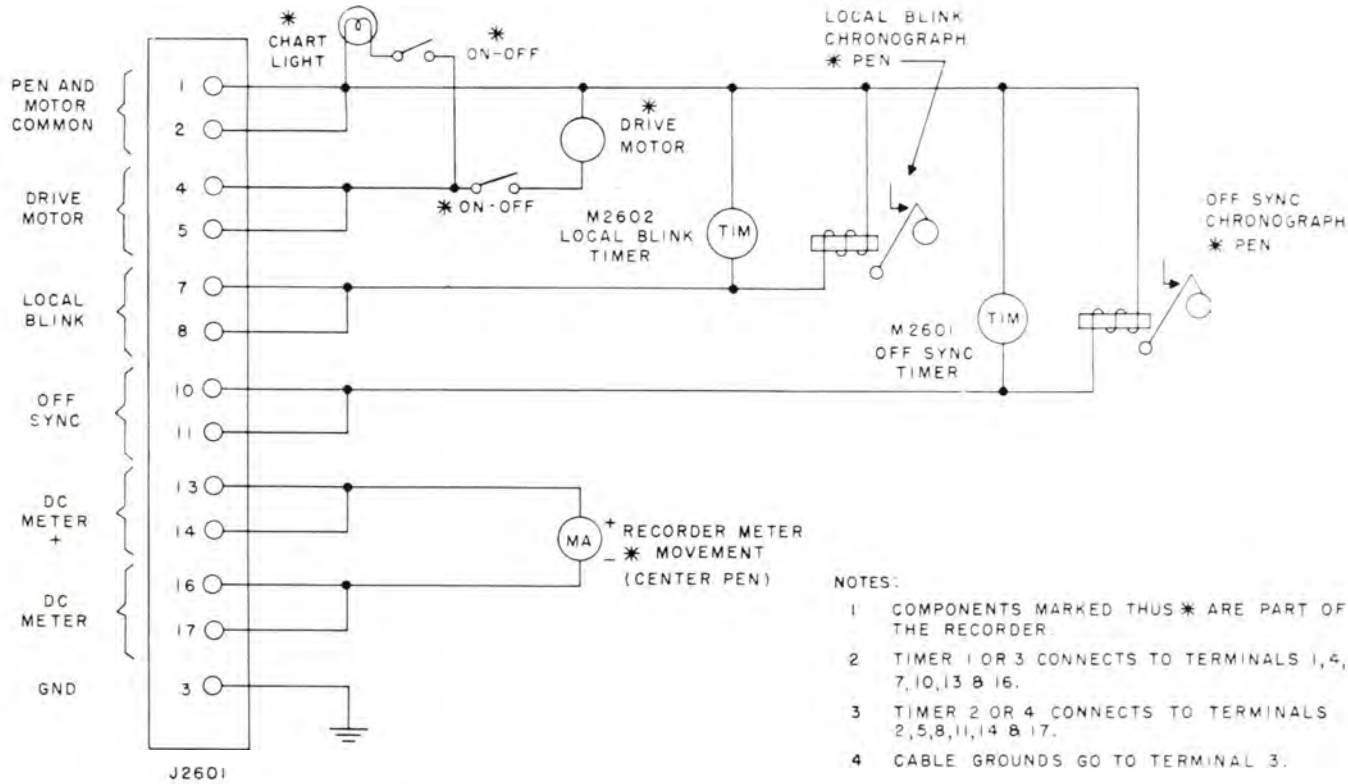
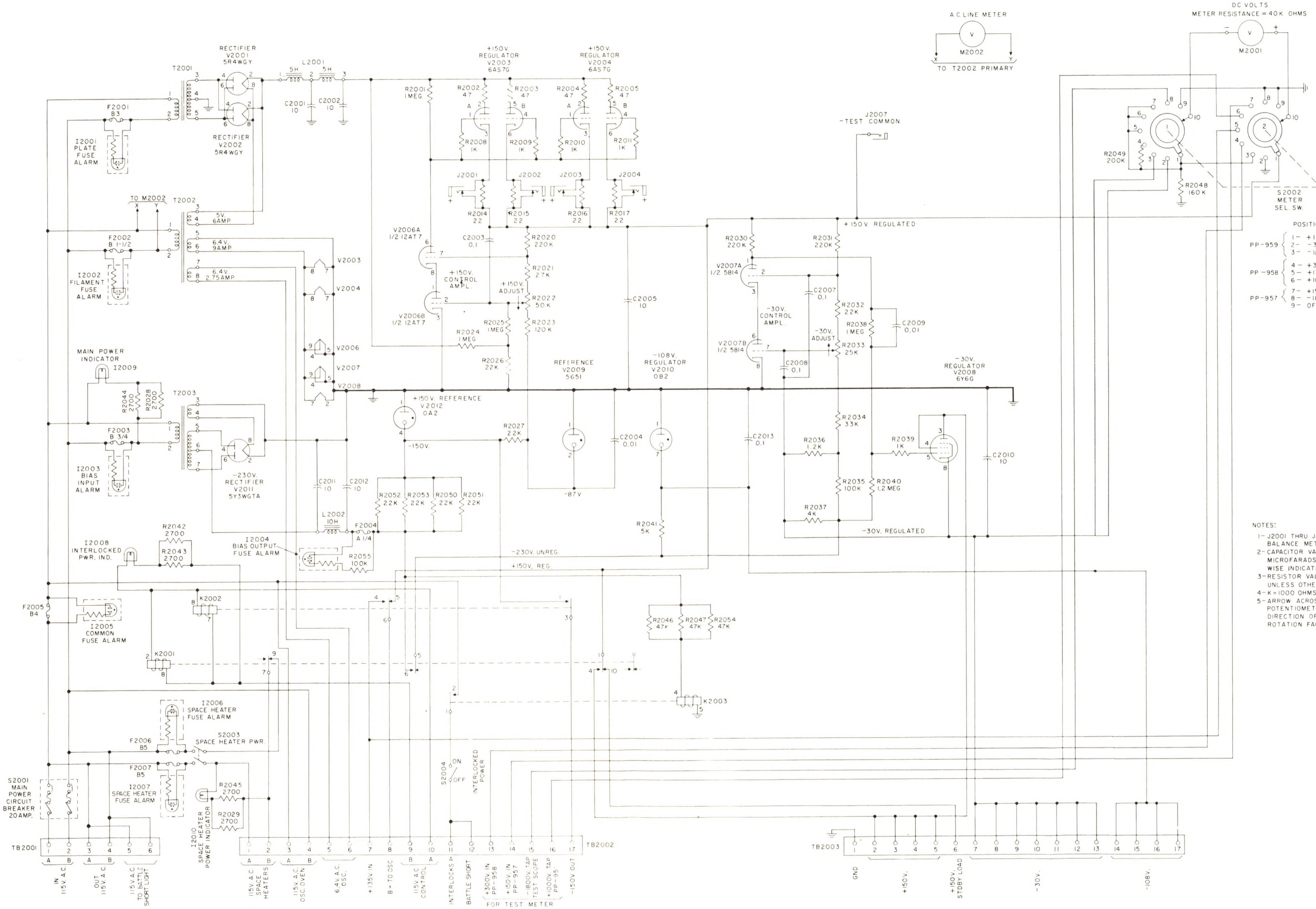


Figure 7–281. Recording Ammeter Type ME–84/FPN–30, Schematic Diagram



POSITIONS ON S2002

PP-959	1- +150V (FS=200V)
	2- -30V (FS=40V)
	3- -108V (FS=200V)
PP-958	4- +300V (FS=400V)
	5- +135V (FS=200V)
	6- +1000V (FS=2000V)
PP-957	7- +150V (FS=200V)
	8- -1800V (FS=4000V)
	9- OFF

NOTES:

1- J2001 THRU J2004 ARE BALANCE METER TEST JACKS.
2- CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE INDICATED.
3- RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE INDICATED.
4- K=1000 OHMS.
5- ARROW ACROSS ARM OF POTENTIOMETER SHOWS DIRECTION OF CLOCKWISE ROTATION FACING SHAFT END.

Figure 7–282. Power Supply Type PP–959/FPN–30, Schematic Diagram

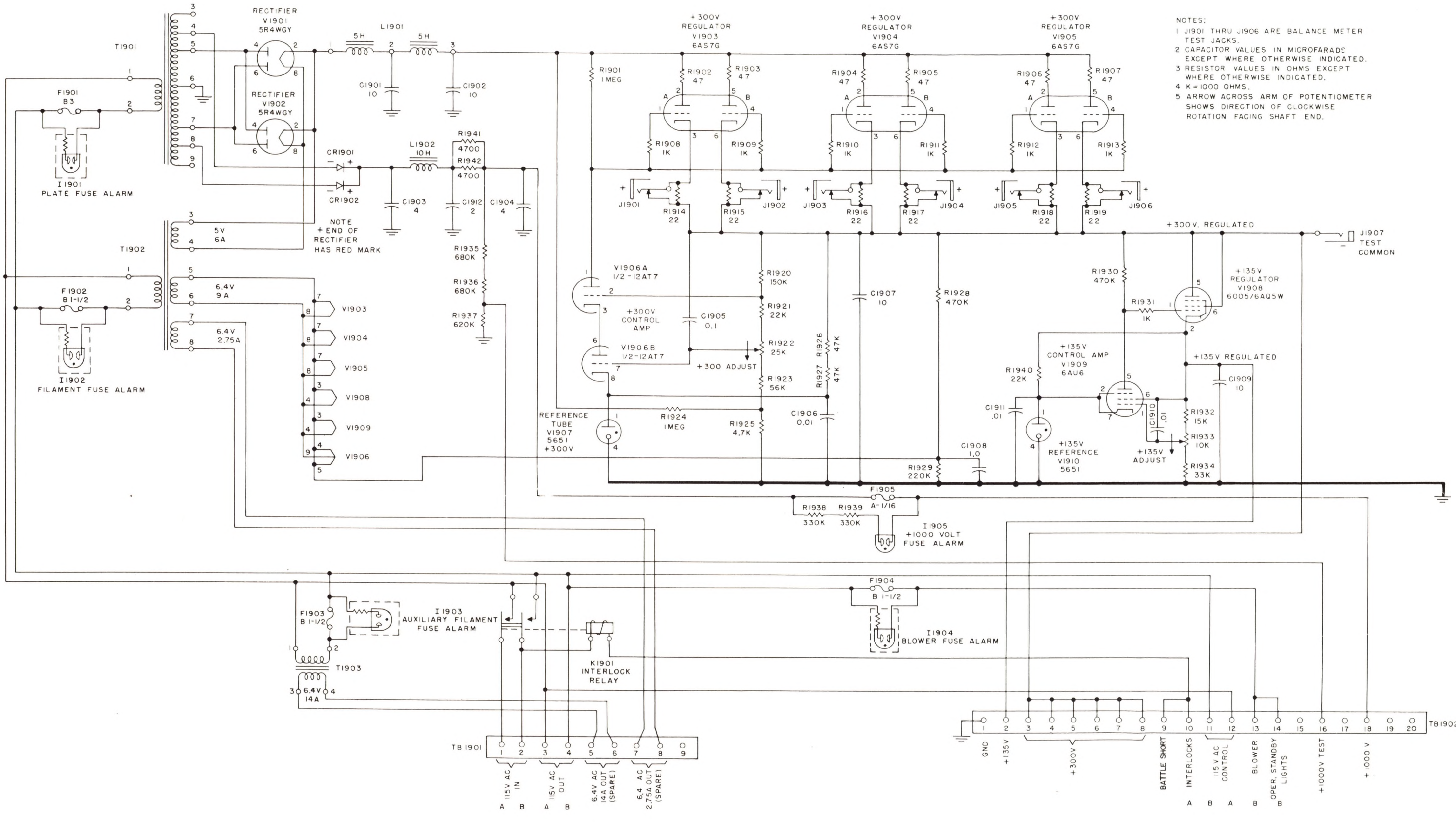
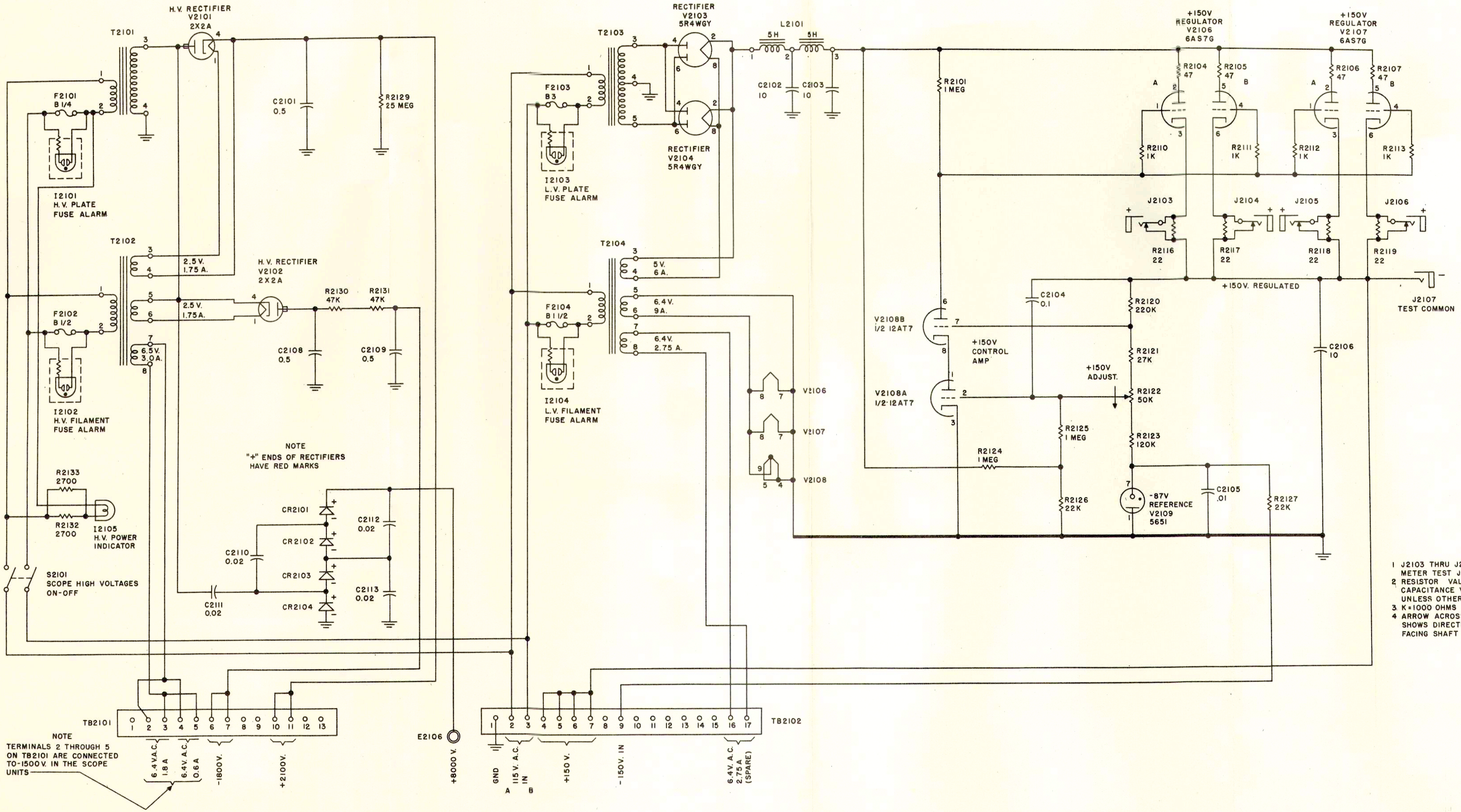


Figure 7–283. Power Supply Type PP–958/FPN–30, Schematic Diagram



NOTES
1 J2103 THRU J2106 ARE BALANCE METER TEST JACKS
2 RESISTOR VALUES ARE IN OHMS AND CAPACITANCE VALUES ARE IN MICROFARADS UNLESS OTHERWISE INDICATED
3 K=1000 OHMS
4 ARROW ACROSS ARM OF POTENTIOMETER SHOWS DIRECTION OF CW ROTATION FACING SHAFT END

Figure 7–284. Power Supply Type PP–957/FPN–30, Schematic Diagram

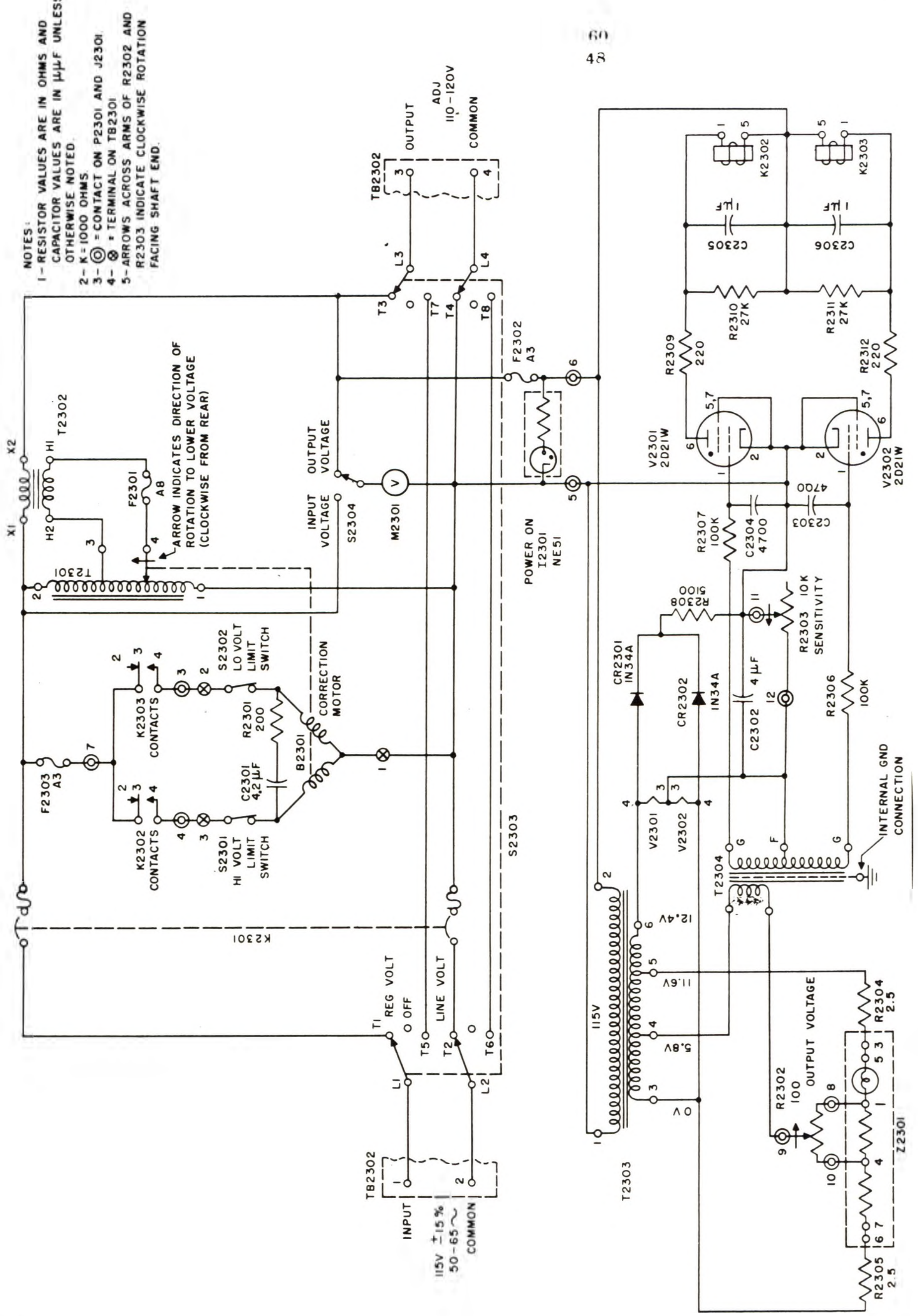


Figure 7-285. Voltage Regulator Type CN-235/FPN-30, Schematic Diagram

Figure 7-286. Electrical Equipment Cabinet CY-1437/FPN-30, Power and Control Connections, Schematic Diagram

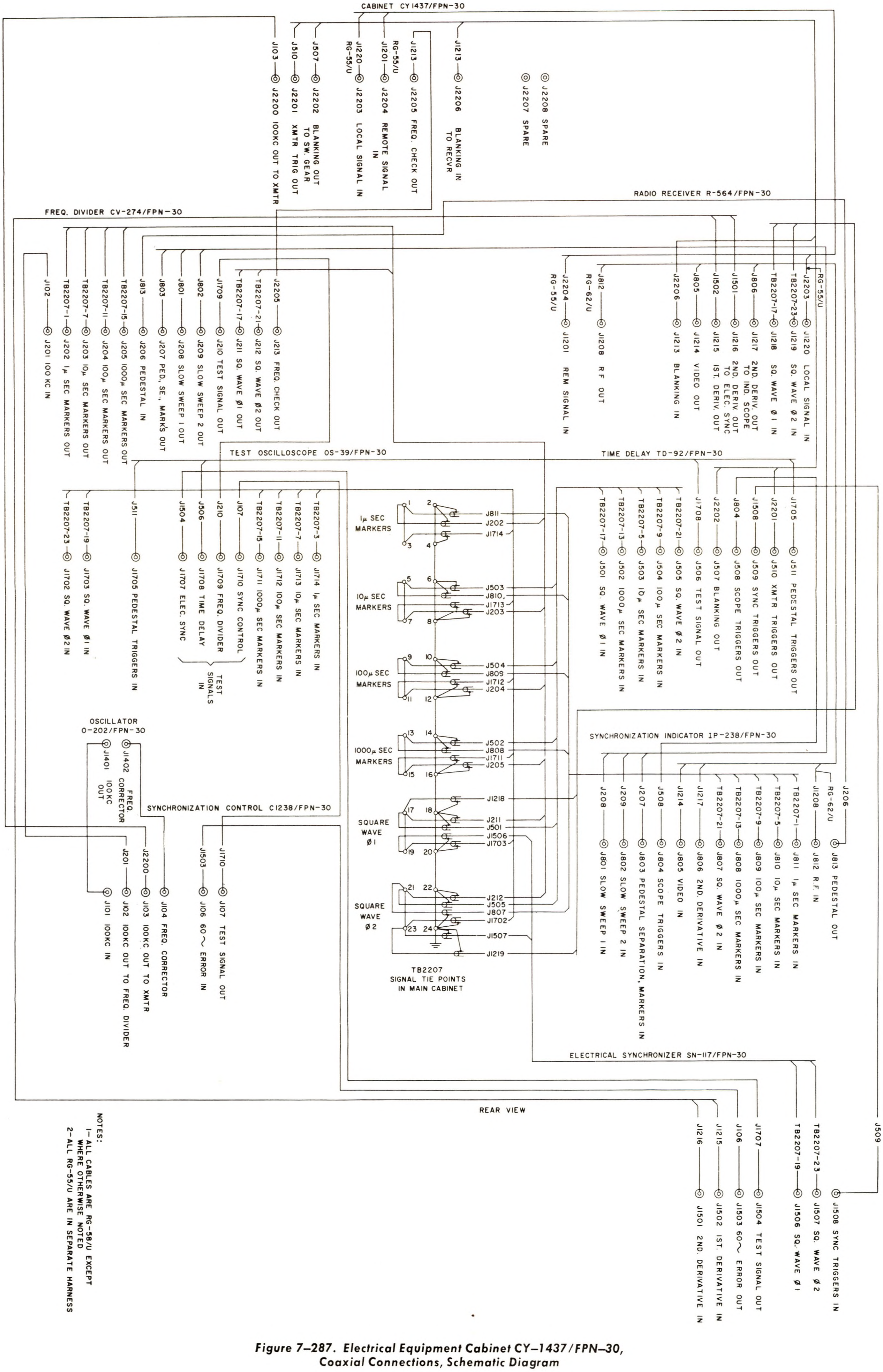


Figure 7–287. Electrical Equipment Cabinet CY–1437/FPN–30, Coaxial Connections, Schematic Diagram

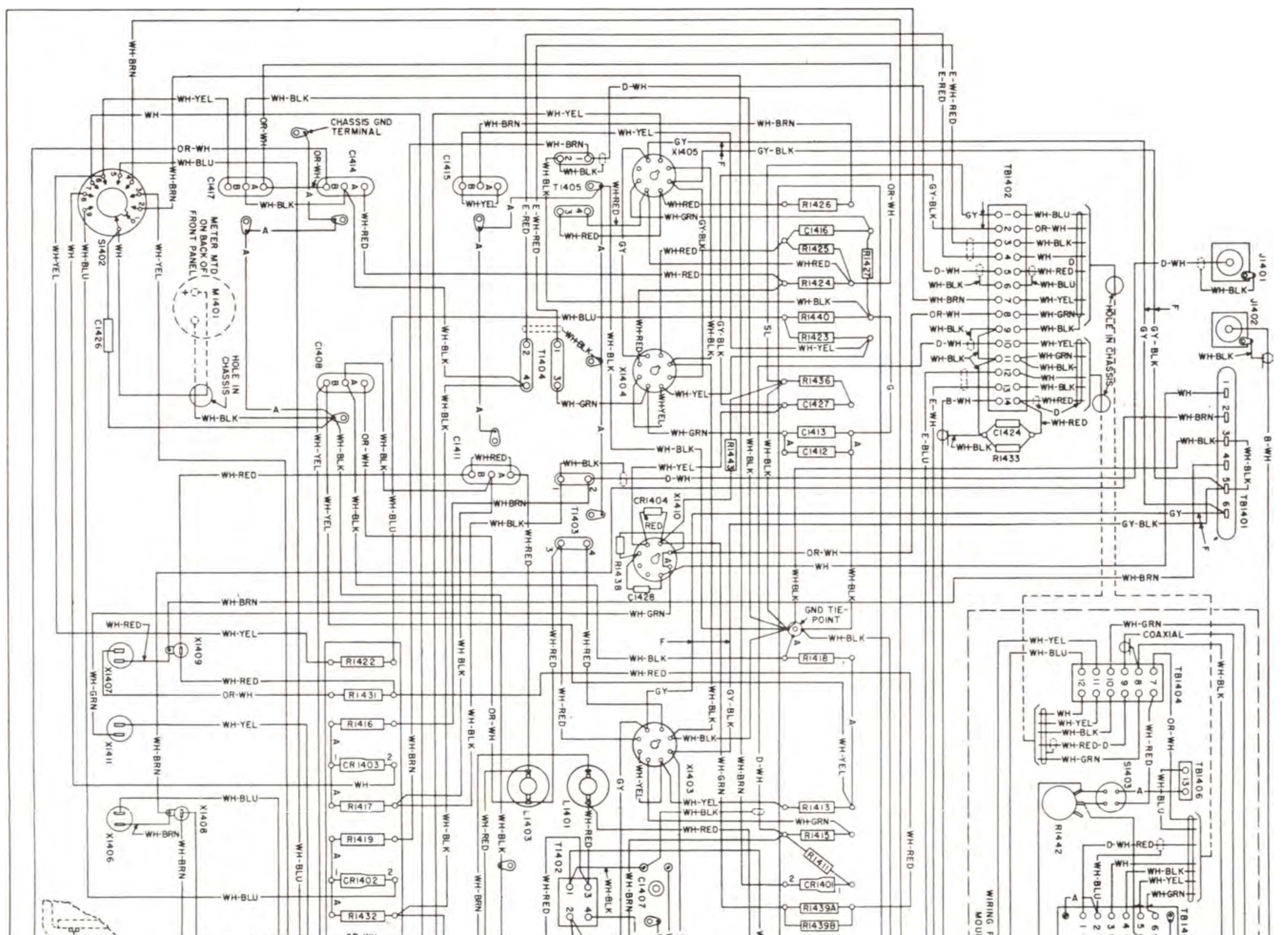
NOTES

1. FUSE VALUES WITH B PREFIX DENOTE A SLOW BLOW FUSE.
2. RESISTOR VALUES ARE IN OHMS AND CAPACITOR VALUES ARE IN MICROFARADS.
3. TITLES OF CIRCUIT GROUPS ARE FOR GENERAL REFERENCE ONLY. ALL CIRCUITS OF A UNIT MAY NOT BE LOCATED IN THE SAME GROUP. THE REFERENCE NUMBER KEY SHOULD BE USED TO DETERMINE WHICH UNIT A CIRCUIT IS IN.

REFERENCE NUMBER KEY

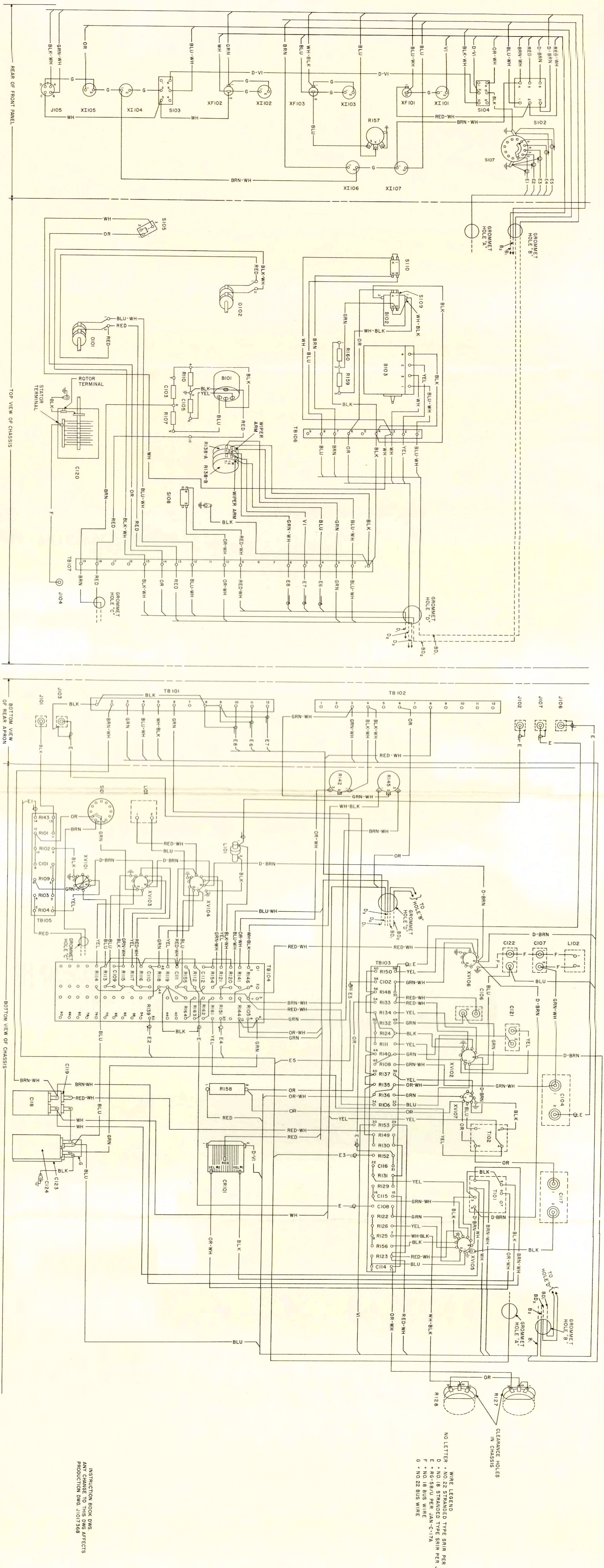
UNIT		REF. NO. GROUP
SYNCHRONIZATION CONTROL	C1238/FPN-30	101 - 199
FREQUENCY DIVIDER	CV-274/FPN-30	201 - 499
TIME DELAY	TD-92/FPN-30	501 - 799
SYNCHRONIZATION INDICATOR	IP-238/FPN-30	801 - 1199
RADIO RECEIVER	R-564/FPN-30	1201 - 1399
RADIO FREQUENCY OSCILLATOR	O-202/FPN-30	1401 - 1499
ELECTRICAL SYNCHRONIZER	SN-117/FPN-30	1501 - 1699
TEST OSCILLOSCOPE	OS-39/FPN-30	1701 - 1899
POWER SUPPLY	PP-958/FPN-30	1901 - 1999
POWER SUPPLY	PP-959/FPN-30	2001 - 2099
POWER SUPPLY	PP-957/FPN-30	2101 - 2199
ELECTRICAL EQUIPMENT CABINET	CY-1437/FPN-30	2201 - 2299
RECORDING AMMETER	ME-84/FPN-30	2601 - 2699

Figure 7–288. Loran Timer Set AN/FPN–30, A-C Power Distribution, Ladder Diagram



WIRE LEGEND
NO LETTER — NO 22 STRANDED SINGLE WIRE
A — NO 18 GA. BUS WIRE
B — COAXIAL CABLE RG 62/U
C — COAXIAL CABLE RG 29/U OR RG 58/U
D — SINGLE SHIELDED WIRE
E — SHIELDED PAIRS
F — NO 22 GA PAIRED WIRES

Figure 7–289. Radio Frequency Oscillator Type O–202/FPN–30, Wiring Diagram



REVISED

Figure 7–290. Synchronization Control Type C–1238/FPN–30, Wiring Diagram

WIRE LEGEND

NO LETTER = NO 22 AWG STRANDED WIRE PER SPEC. JAN-C76,SRIR
D = NO 18 AWG STRANDED WIRE PER SPEC. JAN-C76,SRIR
C = COAXIAL CABLE RG-58/U

INSULATED WIRES ARE COLOR CODED PER STANDARD COLOR CODE AS FOLLOWS:

1 = BROWN	6 = BLUE
2 = RED	7 = VIOLET
3 = ORANGE	8 = GRAY
4 = YELLOW	9 = WHITE
5 = GREEN	0 = BLACK

EXAMPLES: D19 = 18 AWG, BROWN-WHITE

—35 $\frac{69}{}$ = LEAD NO 35, 22 AWG, BLUE-WHITE

NUMBERS IN LEADS ARE REPEATED NEAR BOTH ENDS OF LEADS FOR IDENTIFICATION ONLY

FILAMENT LEADS ARE RUN AS TWISTED PAIRS

JUMPERS ON RESISTOR BOARDS AND COMPONENTS ARE NO 22 AWG SOLID BARE TINNED COPPERWIRE COVERED WITH FIBERGLAS SLEEVING WHERE NECESSARY

COAX SHIELD CONNECTIONS MADE WITH NO 22 AWG SRIR, BLACK WIRE

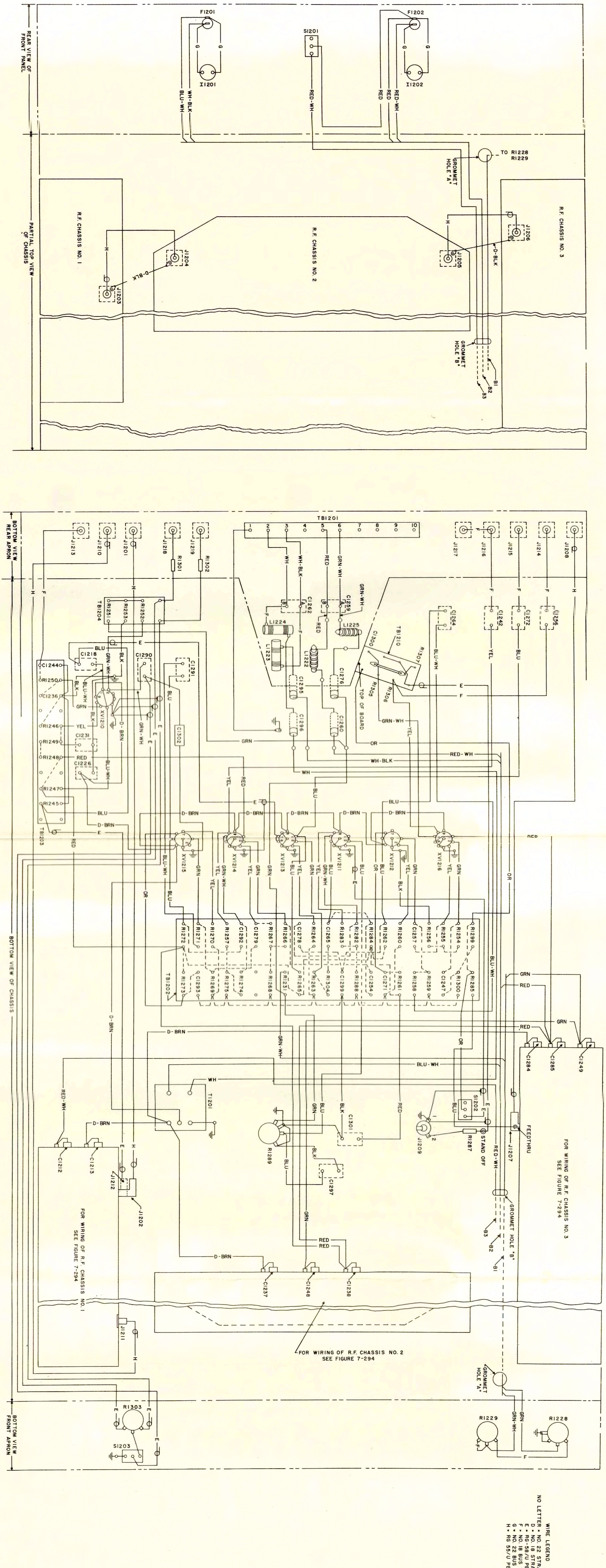
NOTE:

WAFER SWITCHES SHOWN IN EXTREME CCW POSITION

Figure 7–291. Frequency Divider Type CV–274/FPN–30, Wiring Diagram

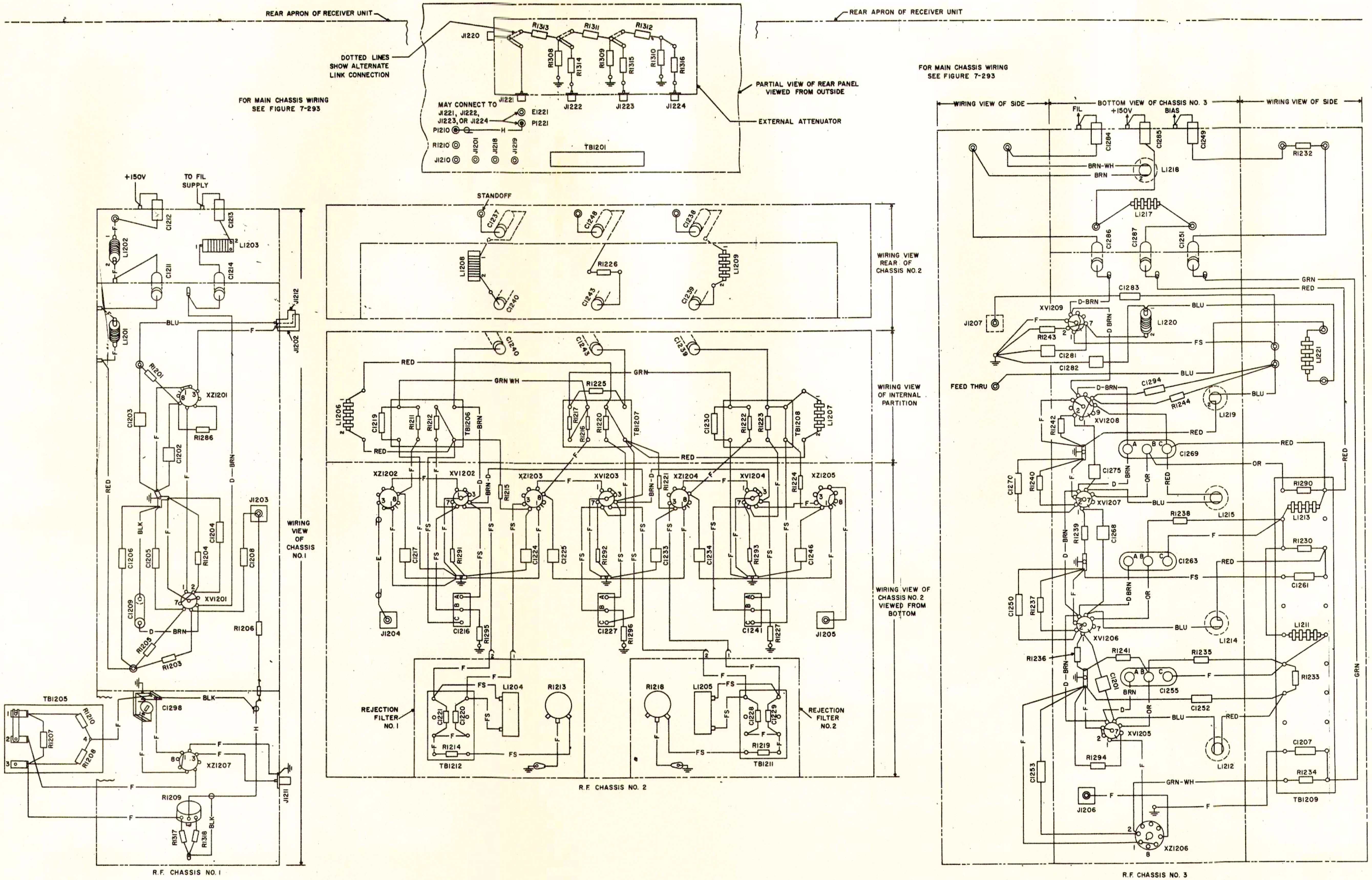
NO LETTER = NO. 22 STRANDED SRIR PER JAN C-76.
D = NO. 18 STRANDED SRIR PER JAN C-76.
E = RG-58/U COAXIAL CABLE PER JAN C-17A
ALL JUMPERS ON REAR OF RESISTOR BOARDS AND ON TUBE SOCKETS ARE WIRED WITH NO. 22 BARE TINNED COPPER WIRE WITH SLEEVING WHERE NECESSARY.

Figure 7–292. Time Delay Type TD–92/FPN–30, Wiring Diagram



WIRE LEGEND
NO LETTER • NO. 22 STRANDED TYPE SRIR
D • NO. 18 STRANDED TYPE SRIR
E • RG-58/U PER JAN-C-17A
F • NO. 18 BUS WIRE WITH SLEEVING WHERE REQ.
G • NO. 22 BUS WIRE WITH SLEEVING WHERE REQ.
H • RG 55/U PER JAN-C-17A

Figure 7–293. Radio Receiver Type R–564/FPN–30, Main Chassis, Wiring Diagram



WIRE LEGEND
NO LETTER – NO. 22 STRANDED TYPE SRIR
D – NO. 18 STRANDED TYPE SRIR
E – RG-58/U PER JAN-C-17A
F – NO. 18 BUS WIRE
FS – NO. 18 BUS WIRE WITH SLEEVING
H – RG-55/U PER JAN-C-17A
ALL JUMPERS AT TUBE SOCKETS AND RESISTOR BOARDS ARE NO. 22 BARE BUS WIRE

ANY CHANGE TO THIS DWG MAY AFFECT PRODUCTION DWG. NO. D1017920, C1040826, D1017921, C1016840, OR C1017919.
INSTRUCTION BOOK DWG.

Figure 7–294. Radio Receiver Type R–564/FPN–30, Subassemblies, Wiring Diagram

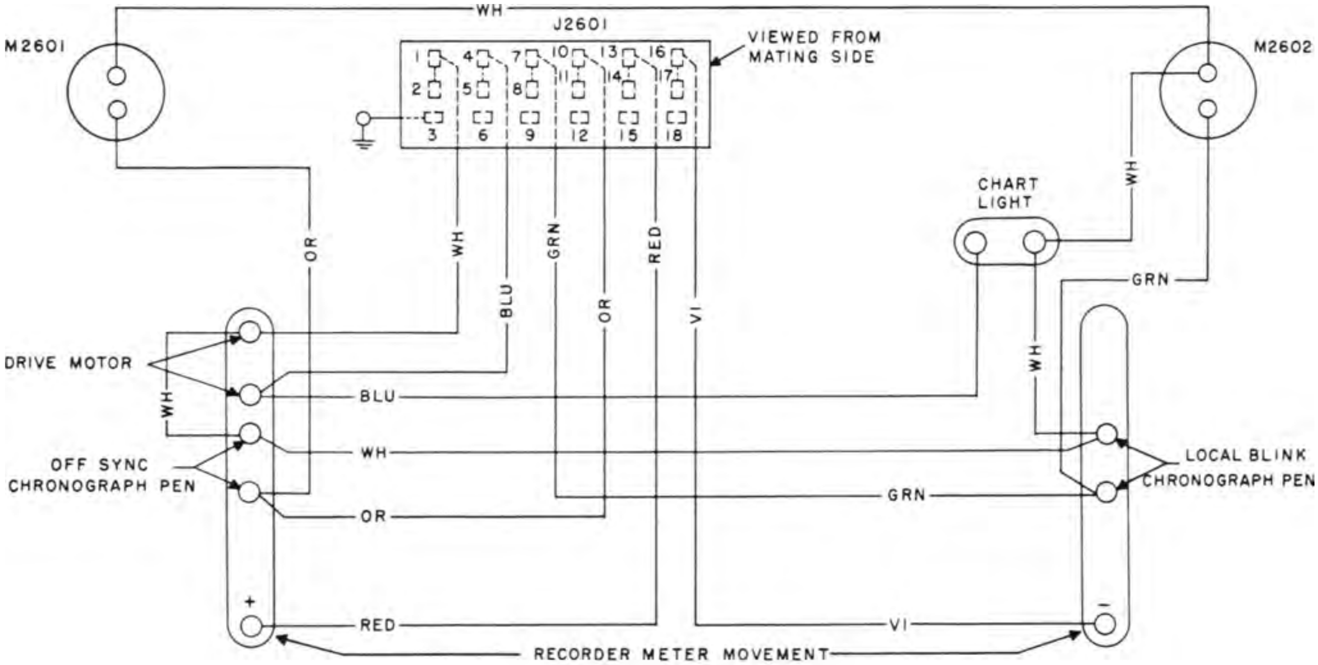
WIRE NO.	FROM COMPONENT	FROM LOCATION	TO COMPONENT	TO LOCATION	WIRE COLOR	WIRE TYPE
1	R804-3		TB812-3		BLU-WH	SRIR
2	R804-2		C823-1		GRN-WH	"
3	R804-1		TB812-1		OR	"
4	R863A-2		R861 STANDOFF		VI	"
5	R863B-2		TB810-28		BLU	"
6	R836-1		TB812-7		OR-WH	"
7	R836-2		TB809-34		GRN-WH	"
8	R950-2		TB815-12		OR	"
9	R824-2		TB809-40		WH	"
10						
11	R839-2		C810-2		OR	"
12	R876-2		TB811-23		GRN	"
13	R876-1		TB812-18		WH	"
14	R918-3		TB812-49		BLU-WH	"
15	R918-2		C849-2		BLU	"
16	R918-1		TB812-47		OR	"
17	R945-2		TB806-2		GRN	"
18	R945-1		TB812-41		WH	"
19	R929-2		TB806-8		RED	"
20						
21	R948-2		C810-1		OR	"
22	R966-3		TB812-53		VI	"
23	R966-2		TB805-35		GRN-WH	"
24	R966-1		TB812-55		WH	"
25	R902A-2		TB805-43		OR	"
26	R902B-2		TB814-5		BLU-WH	"
27	TB812-16		TB807-35		BLU	"
28						
29						
30	T801-2		TB802-2		BLK-WH	SRIR
31	TB802-1		TB802-15		VI	"
32	TB815-17		XV809-2		OR	"
33	C856-2		TB809-6		RED-WH	"
34	R929-1		R948-1		RED-WH	"
35	R898-3		TB812-36		WH	"
36	R898-2		TB805-27		GRN	"
37	R898-1		TB812-34		BLU-WH	"
38	R926-3		TB812-32		OR-WH	"
39	R926-2		TB805-10		WH	"
40	R852-1		TB812-28		VI	"
41	R852-2		TB810-20		GRN	"
42	R852-3		TB812-26		BLU	"
43	R813-2		TB809-19		GRN-WH	"
44	R813-3		TB812-24		WH	"
45	S807-1-11		TB802-12		WH	"
46	S807-2-4		TB802-10		VI	"
47	S807-1-1		TB802-11		BLU	"
48						
49	TB802-2		K802-7		WH-BLK	"
50	TB801-2		T801-1		WH-BLK	"
51	T801-1		C855-2		WH-BLK	"
52	C855-2		S807-2-6		WH-BLK	"
53	S807-2-6		S802-5		WH-BLK	"
54	XI801-1		C855-1		BLK-WH	"
55	C855-1		T801-2		BLK-WH	"
56	C855-2		S801-1		WH-BLK	"
57	XF801-2		TB801-3		WH	"
58	XI804-2		TB801-16		GRN	"
59	S802-1		TB802-15		GRN-WH	"
60	TB802-14		S802-3		VI	"
61	XI805-2		TB801-15		BLU	"
62	S802-4		XI806-2		GRN	"
63	XI806-2		TB802-4		GRN-WH	"
64	S803-1		C870-2		WH-BLK	"
65	S802-8		TB802-3		BLU-WH	SRIR
66	S802-7		I807-1		YEL	"
67	I807-1		TB801-13		YEL	"
68	S808-1		TB802-5		GRN	"
69	S808-2		TB802-6		GRN-WH	"
70	C866B		S801-2		WH	"
71	S806-2		XI804-1		BLK-WH	"
72	I807-2		S806-3		VI	"
73	S801-2		K801-8		WH	"
74	S803-2		K802-8		WH	"
75	TB801-6		TB805-11		YEL	"
76	TB801-6		C858-2		YEL	"
77	C858-2		TB812-8		YEL	"
78	TB812-8		TB809-14		YEL	"
79	R948-1		TB812-13		RED	"
80	R839-1		R950-3		RED-WH	"
81	R839-1		R824-1		RED-WH	"
82	TB812-48		XF802-1		RED	"
83	TB812-2		C857-2		RED	"
84	C857-2		TB815-3		RED	"
85	TB815-3		TB814-17		RED	"
86	TB815-3		TB805-37		RED	"
87	C857-2		TB811-31		RED	"
88	XF802-2		TB801-5		RED-WH	"

WIRE NO.	FROM COMPONENT	FROM LOCATION	TO COMPONENT	TO LOCATION	WIRE COLOR	WIRE TYPE
90	TB810-4		[illegible]		[illegible]	[illegible]
91	TB801-7		[illegible]		[illegible]	[illegible]
92	R948-3		[illegible]		[illegible]	[illegible]
93	TB801-7		[illegible]		[illegible]	[illegible]
94	TB812-25		[illegible]		[illegible]	[illegible]
95	R929-2		[illegible]		[illegible]	[illegible]
96	R839-3		[illegible]		[illegible]	[illegible]
97	R813-1		[illegible]		[illegible]	[illegible]
98	R929-1		[illegible]		[illegible]	[illegible]
99	R824-1		[illegible]		[illegible]	[illegible]
100	C856-2		[illegible]		[illegible]	[illegible]
101	C856-2		[illegible]		[illegible]	[illegible]
102	TB814-21		[illegible]		[illegible]	[illegible]
103	XF803-1		[illegible]		[illegible]	[illegible]
104	XF803-2		[illegible]		[illegible]	[illegible]
105	XI803-2		[illegible]		[illegible]	[illegible]
106	T801-4		[illegible]		[illegible]	[illegible]
107	T801-3		[illegible]		[illegible]	[illegible]
108	TB812-4		[illegible]		[illegible]	[illegible]
109	CHASSIS GND		[illegible]		[illegible]	[illegible]
110	CHASSIS GND		[illegible]		[illegible]	[illegible]
111	J812		[illegible]		[illegible]	[illegible]
112	TB814-7		[illegible]		[illegible]	[illegible]
113	J805		[illegible]		[illegible]	[illegible]
114	J804		[illegible]		[illegible]	[illegible]
115	J804		[illegible]		[illegible]	[illegible]
116	J806		[illegible]		[illegible]	[illegible]
117	J807		[illegible]		[illegible]	[illegible]
118	J807		[illegible]		[illegible]	[illegible]
119	J808		[illegible]		[illegible]	[illegible]
120	J809		[illegible]		[illegible]	[illegible]
121	J810		[illegible]		[illegible]	[illegible]
122	J811		[illegible]		[illegible]	[illegible]
123	J810		[illegible]		[illegible]	[illegible]
124	J811		[illegible]		[illegible]	[illegible]
125	J813		[illegible]		[illegible]	[illegible]
126						
127	T801-4		[illegible]		[illegible]	[illegible]
128	T801-3		[illegible]		[illegible]	[illegible]
129	T801-4		[illegible]		[illegible]	[illegible]
130	T801-3		[illegible]		[illegible]	[illegible]
131						
132	S802-12		[illegible]		[illegible]	[illegible]
133	S802-11		[illegible]		[illegible]	[illegible]
134	S802-2		[illegible]		[illegible]	[illegible]
135						
136	TB809-2		[illegible]		[illegible]	[illegible]
137	TB809-8		[illegible]		[illegible]	[illegible]
138	K801-7		[illegible]		[illegible]	[illegible]
150	J801		[illegible]		[illegible]	[illegible]
151	J802		[illegible]		[illegible]	[illegible]
152	J803		[illegible]		[illegible]	[illegible]
201	TB803-6		[illegible]		[illegible]	[illegible]
202	C838-1		[illegible]		[illegible]	[illegible]
203	C837-1		[illegible]		[illegible]	[illegible]
204	C812-1		[illegible]		[illegible]	[illegible]
205	C816-1		[illegible]		[illegible]	[illegible]
206	C818-1		[illegible]		[illegible]	[illegible]
207	C818-1		[illegible]		[illegible]	[illegible]
208	TB803-7		[illegible]		[illegible]	[illegible]
209	TB803-7		[illegible]		[illegible]	[illegible]
210	TB803-7		[illegible]		[illegible]	[illegible]
211	R879-1		[illegible]		[illegible]	[illegible]
212	XV821-3		[illegible]		[illegible]	[illegible]
213	TB814-1		[illegible]		[illegible]	[illegible]
214	C838-2		[illegible]		[illegible]	[illegible]
215	R879-3		[illegible]		[illegible]	[illegible]
216	R842-3		[illegible]		[illegible]	[illegible]
217	R907-3		[illegible]		[illegible]	[illegible]
218	C811-1		[illegible]		[illegible]	[illegible]
219	R910-2		[illegible]		[illegible]	[illegible]
220	C837-2		[illegible]		[illegible]	[illegible]
221	R879-2		[illegible]		[illegible]	[illegible]
222	R882-2		[illegible]		[illegible]	[illegible]
223	C818-2		[illegible]		[illegible]	[illegible]
224	C813-1		[illegible]		[illegible]	[illegible]
225	R842-2		[illegible]		[illegible]	[illegible]
226	C812-2		[illegible]		[illegible]	[illegible]
227	R845-2		[illegible]		[illegible]	[illegible]
228	C814-2		[illegible]		[illegible]	[illegible]
229	C816-2		[illegible]		[illegible]	[illegible]
230	R944-1		[illegible]		[illegible]	[illegible]
231	V822 ANODE		[illegible]		[illegible]	[illegible]
232	C810-1		[illegible]		[illegible]	[illegible]
233	V823-E(NE[illegible]		[illegible]		[illegible]	[illegible]
234	R907-1		[illegible]		[illegible]	[illegible]
235	XV822-9		[illegible]		[illegible]	[illegible]

Figure 7-295. Synchronization Indicator Type IP-238/FPN-30, Wiring Diagram

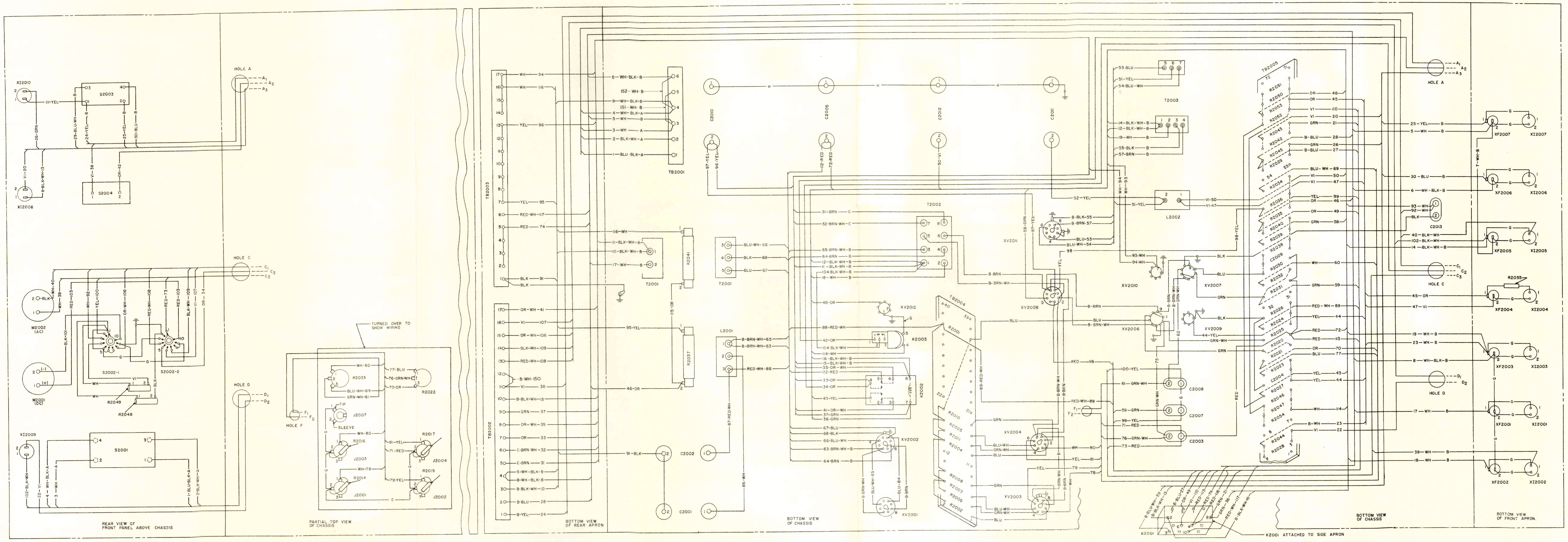
Figure 7-296. Electrical Synchronizer Type SN-117/FPN-30, Wiring Diagram

Figure 7–297. Test Oscilloscope Type OS–39/FPN–30, Wiring Diagram



WIRE LEGEND
ALL CODED WIRING NO.22 TYPE SRIR STRANDED
ALL UNCODED WIRING NO. 22 BUS WIRE

Figure 7–298. Recording Ammeter Type ME–84/FPN–30, Wiring Diagram

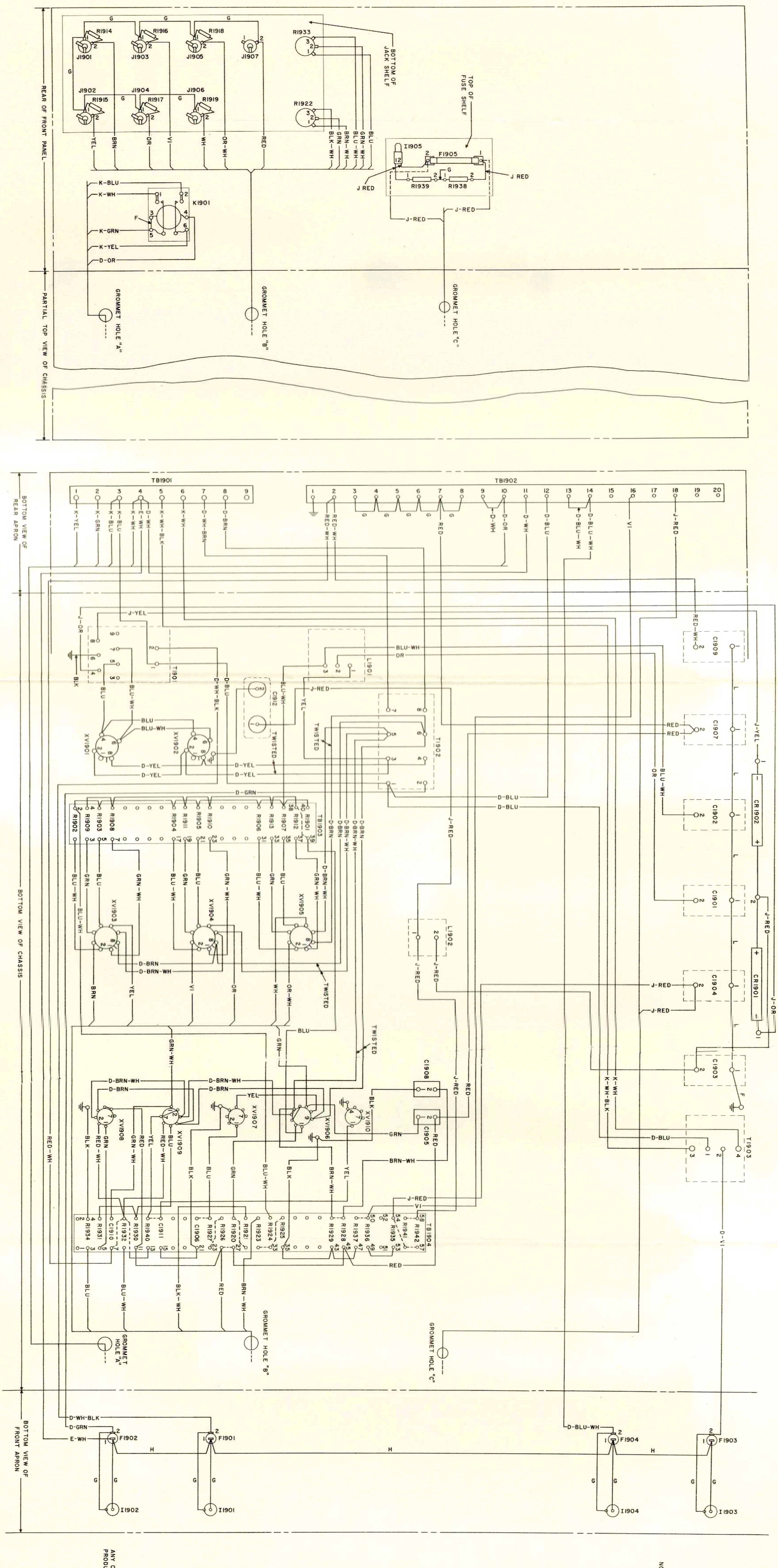


WIRE LEGEND
NO LETTER – NO. 22 WIRE STRANDED PER SRIR
A NO. 10 WIRE STRANDED PER SRIR
B NO. 18 WIRE STRANDED PER SRIR
C NO. 14 WIRE STRANDED PER SRIR
G NO. 22 BUS WITH SLEEVING WHERE NECESSARY.
H 1/2 IN X 1/32 IN COPPER STRIP CAD PL
WIRES ARE IDENTIFIED AT EACH END BY AN ARBITRARY NUMBER.

ANY CHANGE TO THIS DRAWING AFFECTS PRODUCTION DRAWING NO. D1017016

INSTRUCTION BOOK DRAWING

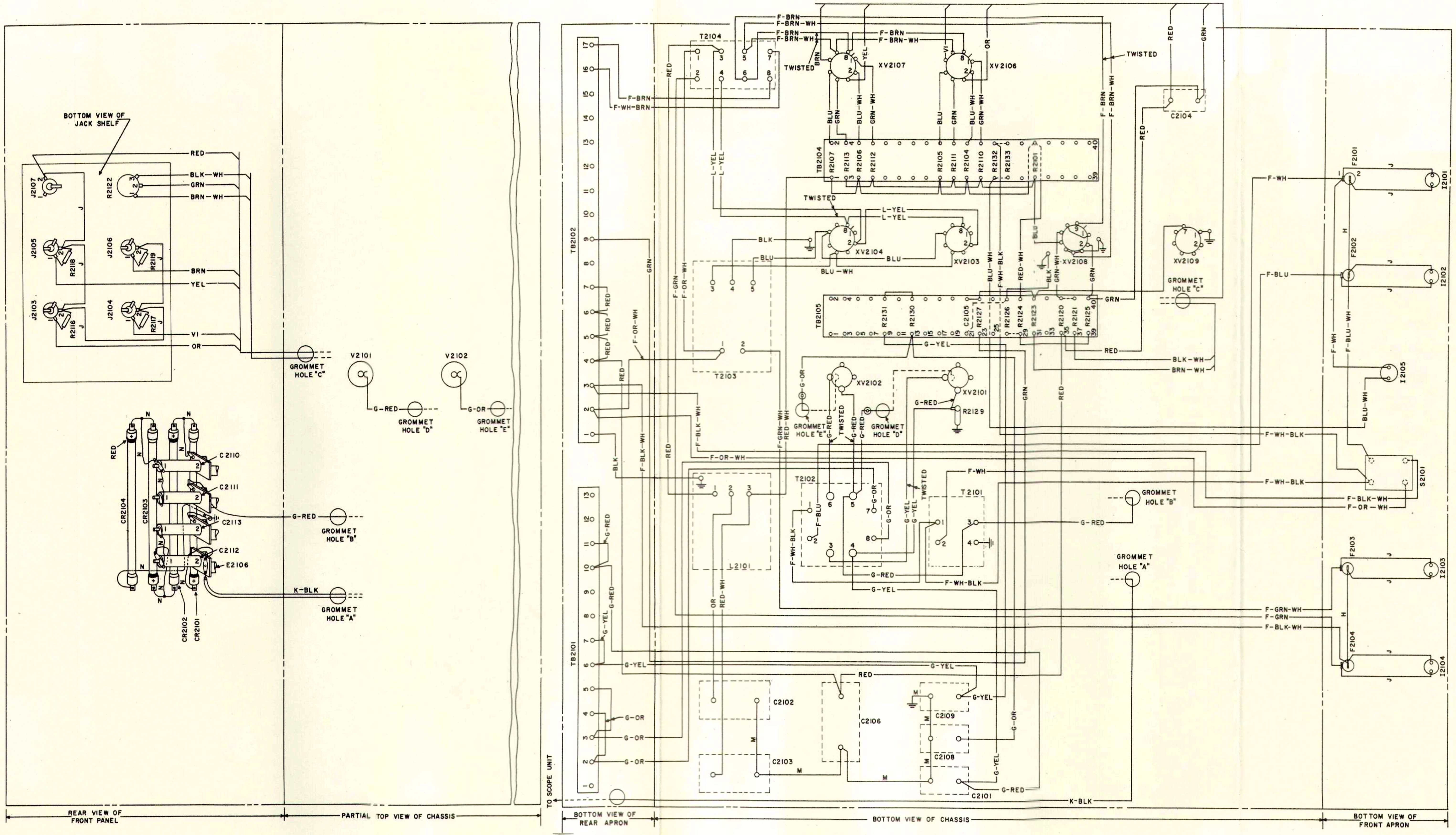
Figure 7–299. Power Supply Type PP–959/FPN–30, Wiring Diagram



ANY CHANGE TO THIS DRAWING AFFECTS PRODUCTION DRAWING

WIRE LEGEND
NO LETTER = NO.22 STRANDED PER SRIR.
D = NO.18 STRANDED PER SRIR.
E = NO.14 STRANDED PER SRIR.
F = NO.18 BUS WIRE
G = NO.22 BUS WIRE
H = NO.14 BUS WIRE
J = NO.18 STRANDED PER SRHV.
K = NO.10 STRANDED PER SRIR.
L = 1/2" X 1/32" COPPER STRIP CAD. PL.

Figure 7–300. Power Supply Type PP–958/FPN–30, Wiring Diagram



WIRE LEGEND

NO LETTER = NO.22 STRANDED PER SRIR.
F = NO.18 STRANDED PER SRIR.
G = NO.18 STRANDED PER SRHV.
H = NO.18 BUS WIRE WITH SLEEVING WHERE NECESSARY.
J = NO.22 BUS WIRE WITH SLEEVING WHERE NECESSARY.
K = H.V. CABLE EX496.
L = NO.14 STRANDED PER SRIR.
M = 1/2" X 1/32" COPPER STRIP CAD PL.
N = BRAIDED TINNED COPPER CABLE ROUND.

ANY CHANGE TO THIS DRAWING AFFECTS PRODUCTION DRAWING J-1017000.

Figure 7–301. Power Supply Type PP–957/FPN–30, Wiring Diagram

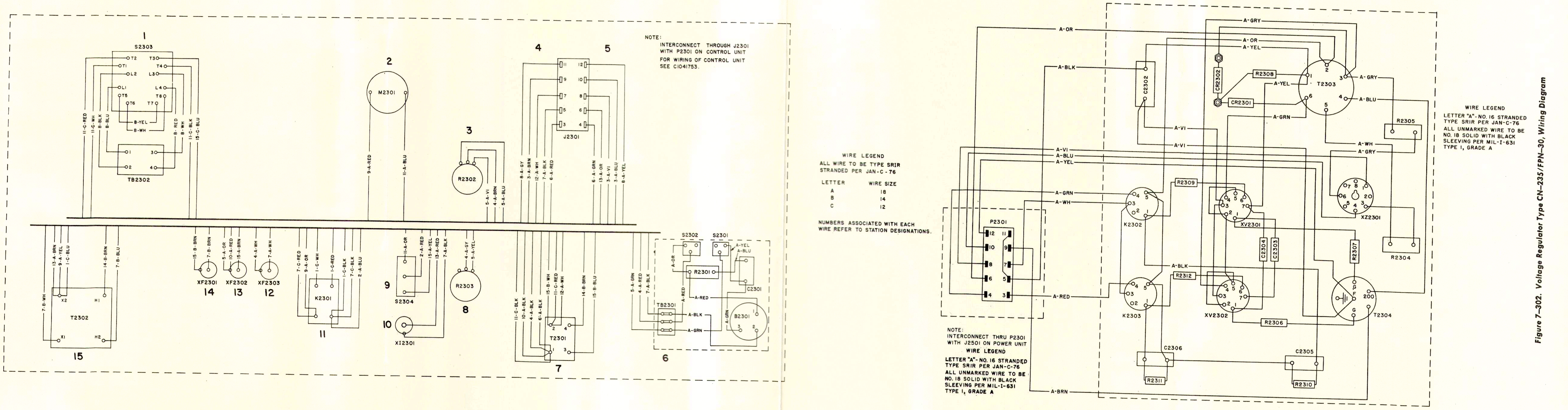


Figure 7–302. Voltage Regulator Type CN–235/FPN–30, Wiring Diagram

Figure 7–303. Electrical Equipment Cabinet Type CY–1437/FPN–30, Power and Control Connections, Wiring Diagram

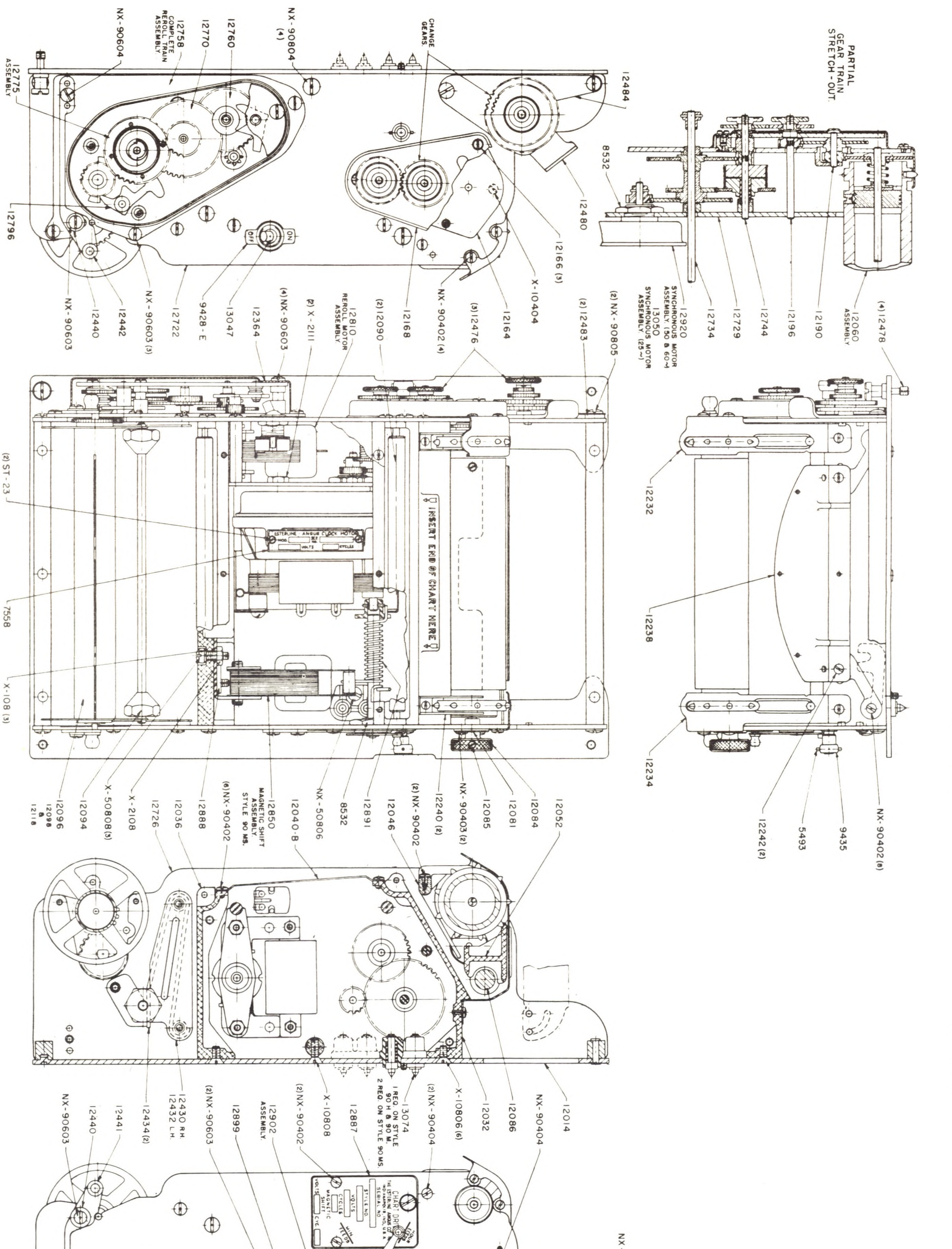


Figure 7–304. Recording Ammeter Type ME–84/FPN–30, Mechanical Assembly of Chart Drive

CG-273-15
(Volume 1)

INSTRUCTION BOOK

for

LORAN TIMER SET
AN/FPN-30

INDEX

ITT *Federal Division*

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

Clifton, New Jersey, U.S.A.

FORMERLY

FEDERAL TELEPHONE AND RADIO COMPANY

TREASURY DEPARTMENT

U.S. COAST GUARD

Contracts: Tcg-38701(CG-20,181-A)
Tcg-39263(CG-27,298-A)
Tcg-40020(CG-35,978-A)
Tcg-41083 (CG-44,327-A)

Approved by C. G. Headquarters:
16 October 1959

Index

Index

TABLE OF SECTIONS

INDEX