STANDARD LORAN
(LORAN-A)

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Treasury Department
United States Coast Guard
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U.S.A.

STANDARD LORAN
(LORAN-A)

(A Long Range Aid to Navigational System)

INTRODUCTION

The Loran system is a modern electronic aid to navigation by means of which navigators on or over the ocean can determine their position accurately and quickly, day or night, and under practically any condition of weather and sea. The name "Loran" was derived from the words "LOng RAnge Navigation," which describe in general terms the system's relative utility when compared to ranges of other electronic navigational aids. The effective range of Loran is as great as 1,400 nautical miles at night and 800 miles during the day. The accuracy obtained is comparable to that which may normally be expected from good celestial observations which require considerable time to make and entail somewhat laborious mathematical computations. Even though such precision is attained, the determination of position by Loran requires but 2 to 3 minutes' time. Loran signals are on the air and available to navigators for 24 hours per day, and cover the major ocean shipping lanes of the world (as shown in figure 1-1). The

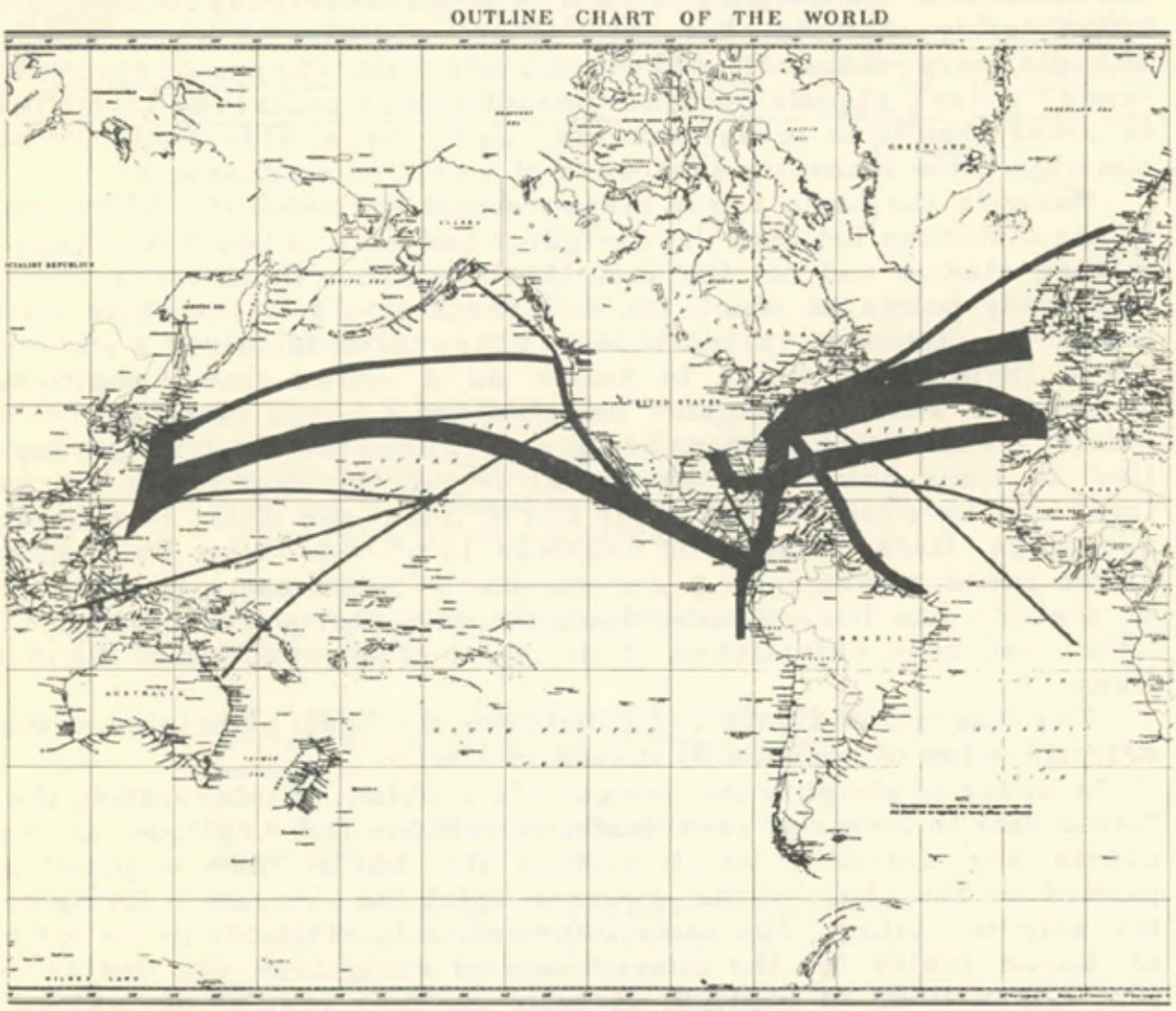


FIGURE 1-1--Major ocean shipping lanes of world.

system is now used extensively by the private maritime users of many nations. All may make free use of it.

PRINCIPLES OF OPERATION

A brief description of Loran operation follows:

1. Radio signals consisting of short pulses are transmitted from a pair of shore-based transmitting stations.
2. These signals are received aboard the ship or plane by a Loran Radio Receiver.
3. The difference in times of arrival of the signals from the two radio stations is measured on a special Loran indicator.
4. This measured time-difference is utilized to determine directly from special tables or charts a line of position on the earth's surface.
5. Two lines of position, determined from two pairs of transmitting stations, are crossed to obtain a Loran fix.

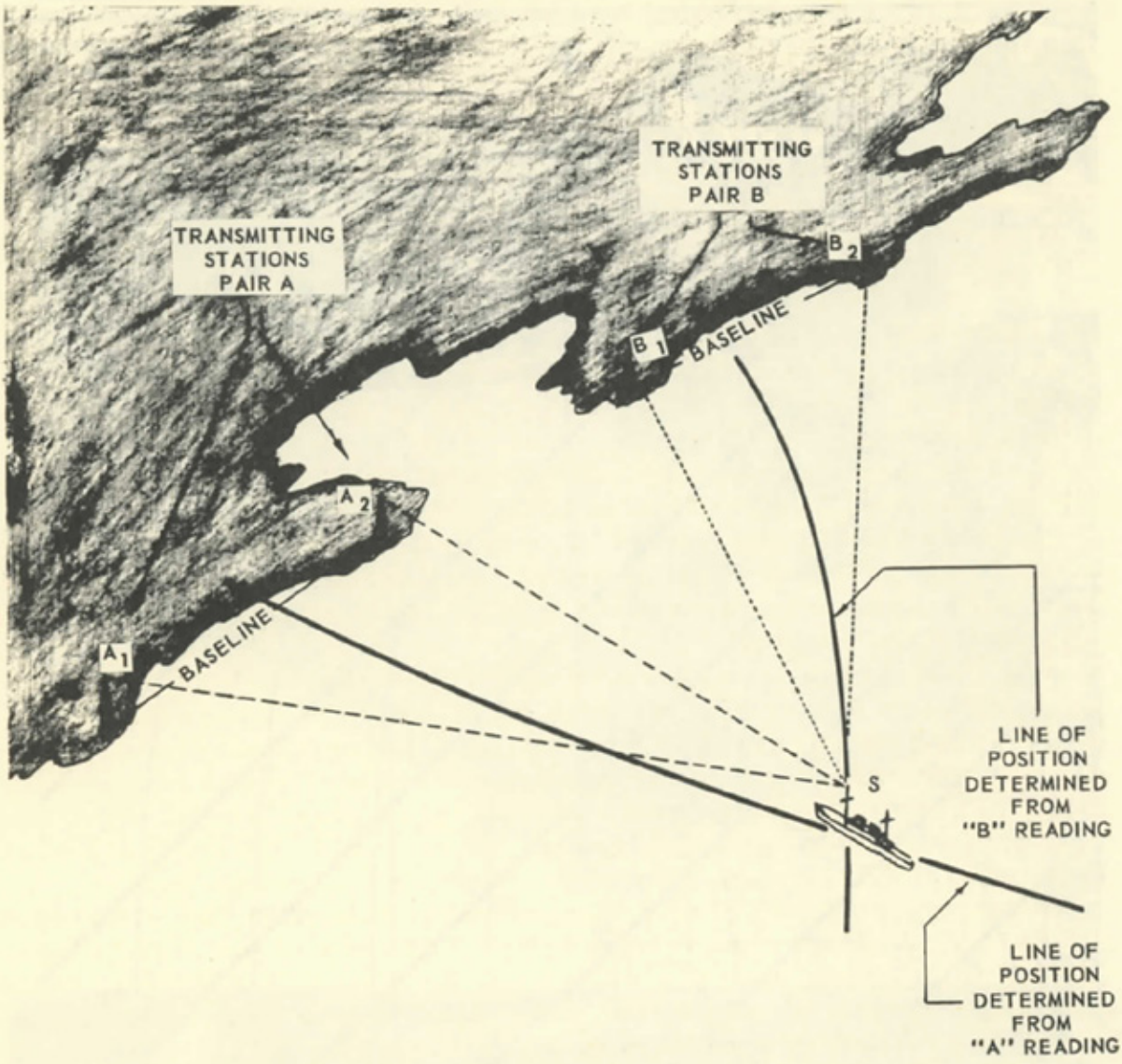
Since radio signals travel at a nearly constant speed, a direct relationship between time of travel and distance traveled exists. Thus, measurement of intervals of time is, in essence, a measurement of distance itself.

The radio signals which are transmitted by Loran stations are not continuous transmissions such as those of everyday commercial broadcasting stations, but are "pulse" signals, or short bursts of radio energy transmitted at regular intervals. The use of specially timed "pulse" signals permits the individual signals to be identified in order that time measurements can be made. This would not be possible if the transmissions were of a continuous character.

Because the basic Loran measurement evaluates the difference in the distances between the navigator and each of two fixed transmitting station and not the individual distances themselves, there are many points at which the difference would be the same even though the distances varied widely. These points fall along a smooth curve (hyperbola) which is known as a Loran line of position. Therefore, when a navigator has obtained a Loran reading from a pair of transmitting stations he has determined that his true position lies at some point on a particular Loran line of position. Loran lines can be crossed with other Loran lines, sun lines, star lines, soundings, Radar ranges or bearings to provide fixes. By making Loran measurements on a second pair of stations, a second line of position has been identified and the navigator's true position or "fix" has been established at the point of intersection of the two lines.

The diagram of figure 1-2 illustrates the basic principles of the determination of position by means of Loran.

In order to simplify the navigator's problem of interpreting the Loran data in terms of coordinates of latitude and longitude, Loran charts are available which picture the Loran lines of position plotted on the chart of the region in which the aircraft is flying or the ship is sailing. The same information is available in the form of Loran tables for the convenience of navigators who desire to plot Loran lines of position directly on their regular navigators' chart. Figure 1-3 shows a typical Loran Chart for the approaches to New York Harbor.



Navigator aboard LORAN equipped ship at "S" establishes "fix" by determining two lines of position, "A" and "B" by LORAN measurements.

Line of position "A" is found by measuring the time difference between signals received from transmitting stations A_1 and A_2 .

Line of position "B" is found by measuring the time difference between signals received from transmitting stations B_1 and B_2 .

The navigators fix is established at the point of intersection of the two lines of position.

The latitude and longitude of the navigators position is determined from the LORAN data by using either the LORAN CHARTS or LORAN TABLES.

FIGURE 1-2.

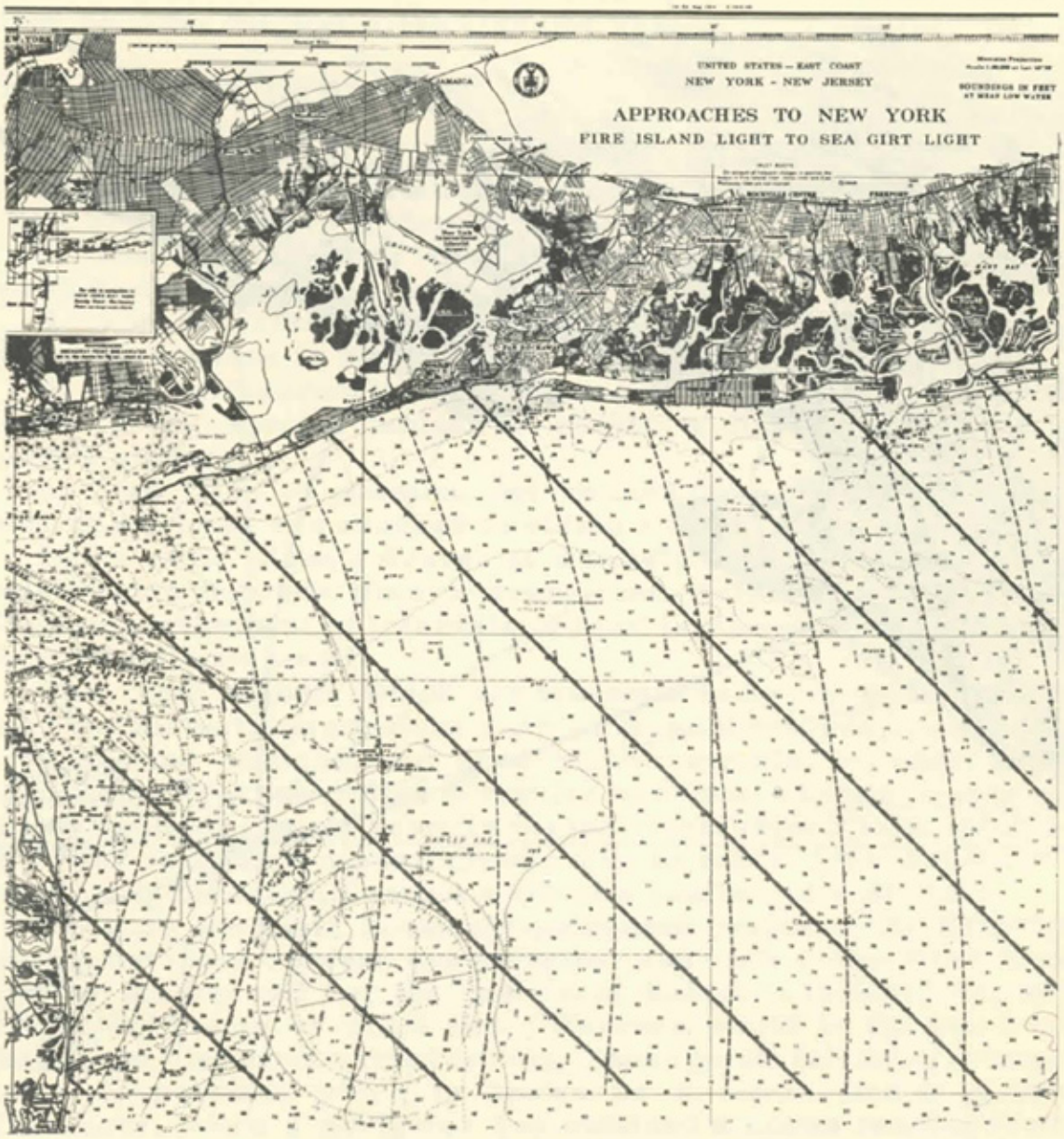


FIGURE 1-3--Typical Loran Chart for the approaches to New York Harbor.

EQUIPMENT USED BY THE NAVIGATOR

The Loran equipment used by the navigator on shipboard or aircraft at sea in the determination of his position is known as a receiver-indicator. The receiver performs the functions of an ordinary radio receiver, but delivers its output to a visual indicator rather than to a loudspeaker, and is designed for the reception of pulsed signals rather than ordinary radio signals. The indicator is essentially an "electronic stop-watch" capable of measuring, in microseconds, the difference in times of arrival of the pulse signals from the two stations of a pair. In the indicator, horizontal traces or lines of light on the screen of a cathode ray oscilloscope form the equivalent of the dial of a watch. A vibrating quartz crystal is the balance wheel, and electrical circuits known as "dividers" or "counters" take the place of gear wheels.

Installation of the receiving equipment is quite simple and can be performed in a few hours' time. Actually, installation merely requires simple mechanical mounting of the equipment to the deck

or bulkhead, erection of an ordinary radio receiving-type vertical antenna, and plugging in the power cord to the local electrical power source.

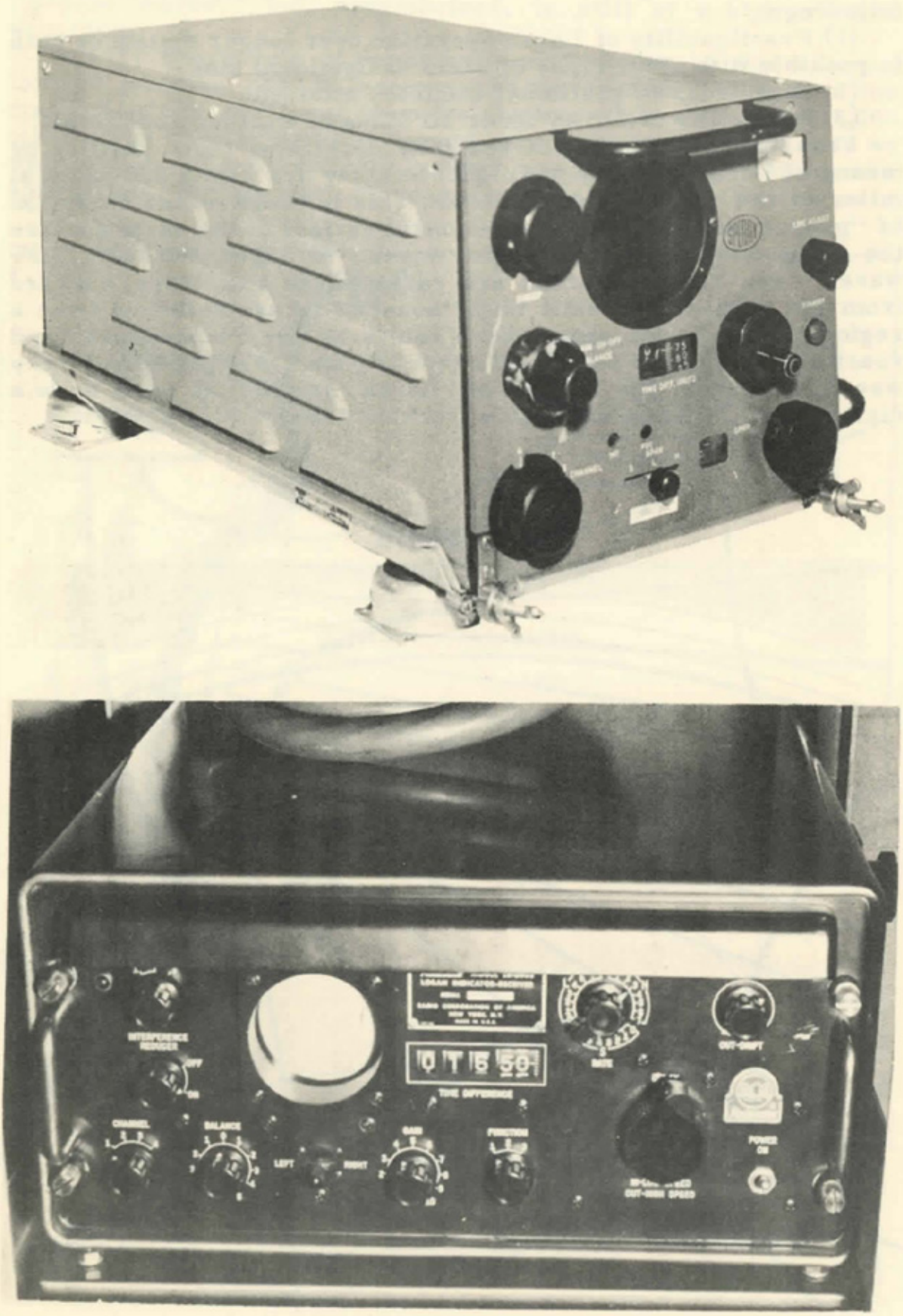


FIGURE 1-4--Typical direct-reading marine Loran receiver-indicator equipment.

OPERATING RANGE AND ACCURACY

Three fundamental characteristics of Loran are of particular importance to navigators using the system. These qualities are the following:

(1) Practicability of Loran operation over longer distances than is possible with older types of radio navigational aids.

(2) High order of positional accuracy attained.

(3) Reliability of Loran under all kinds of weather conditions.

Vessels and aircraft at sea may determine their position by means of Loran both day and night when they are within 800 nautical miles of the transmitting stations. This is based on the reception of "ground waves," which travel on the surface of the earth and are the most stable type of radio waves. At night, however, "sky waves" are received which are radio waves that travel outward from the transmitter until they "bounce" or are reflected from a region of the upper atmosphere known as the "ionosphere" and reach the navigator after reflection (figure 1-5). The use of "sky waves" extends the range of Loran service at night up to a distance of 1,400 nautical miles from the transmitting stations.

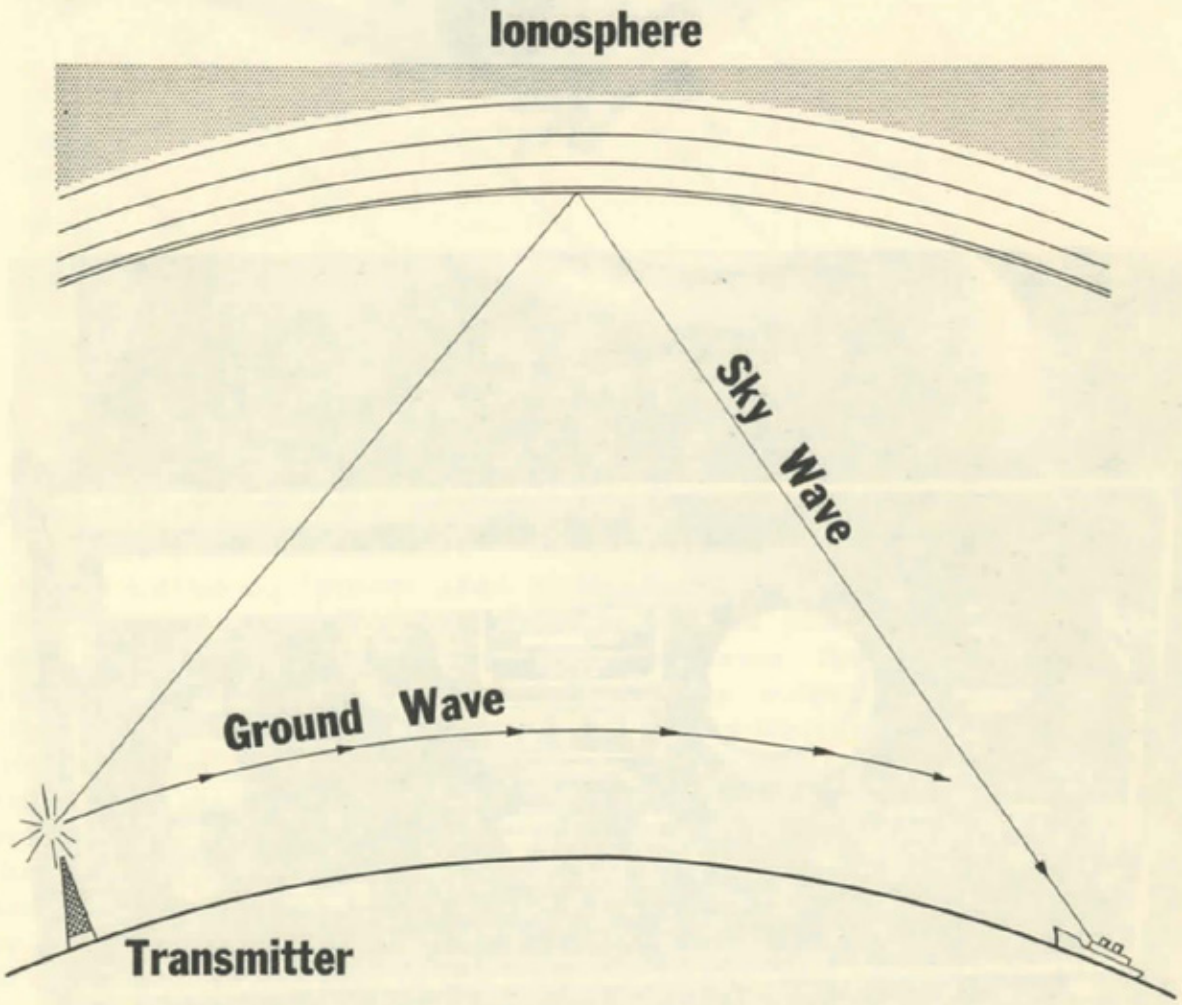


FIGURE 1-5--Ground wave and sky wave paths.

The accuracy of Loran fixes varies depending on the relative position of the navigator and the transmitting stations. Positional data obtained by using "sky waves" Loran signals is somewhat less accurate than the information determined through the use of "ground waves," but, nevertheless, is still of a high order of accuracy.

A very rough rule of thumb has been stated to be that a Loran line of position has an accuracy of better than 1 percent of the distance of the navigator from the stations; thus a navigator 1,000 miles away from the stations would expect the line of position to be well within 10 miles of the proper position. As the stations are approached, the accuracy increases greatly, and along the imaginary

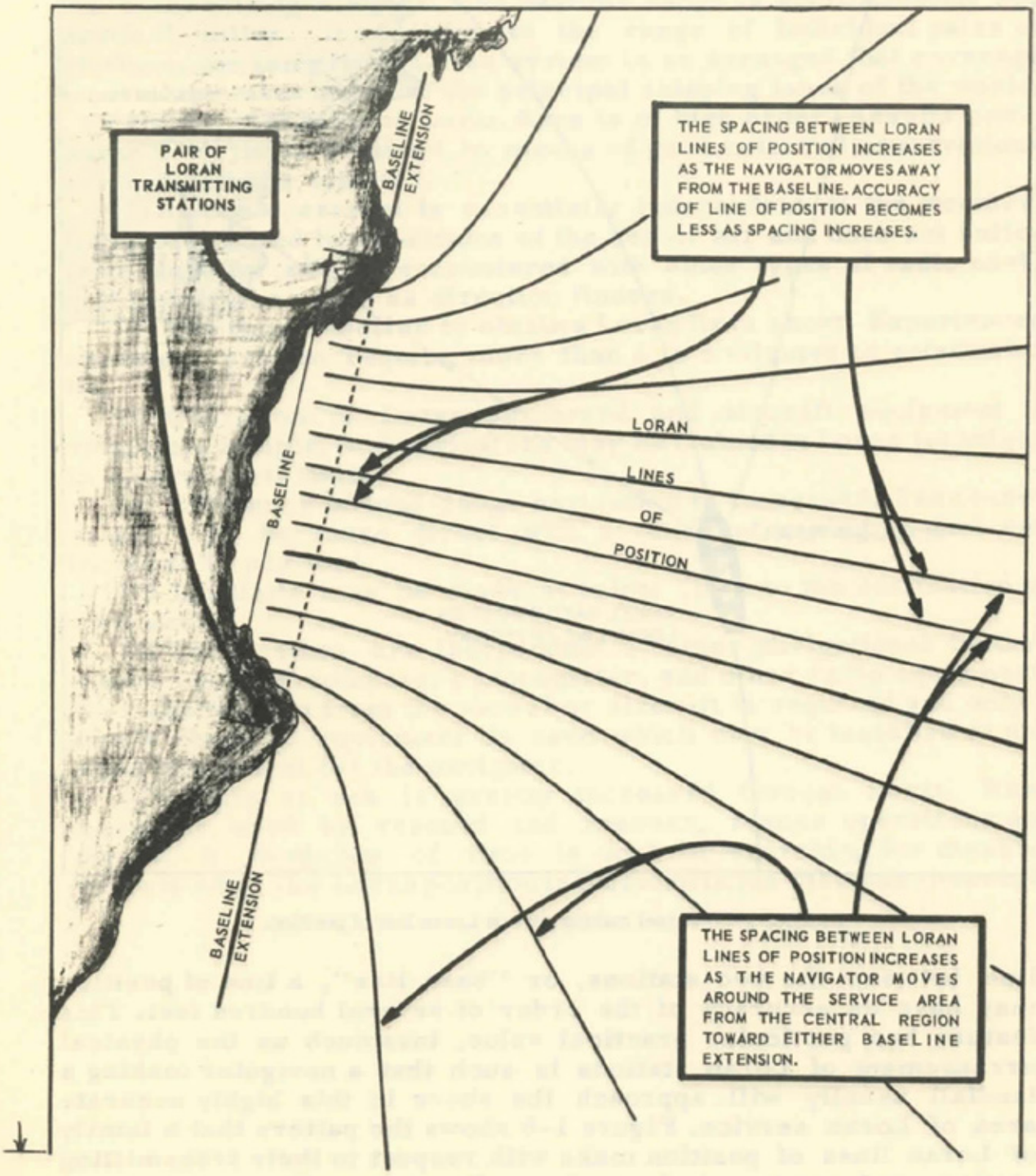


FIGURE 1-6--Loran hyperbolic pattern.

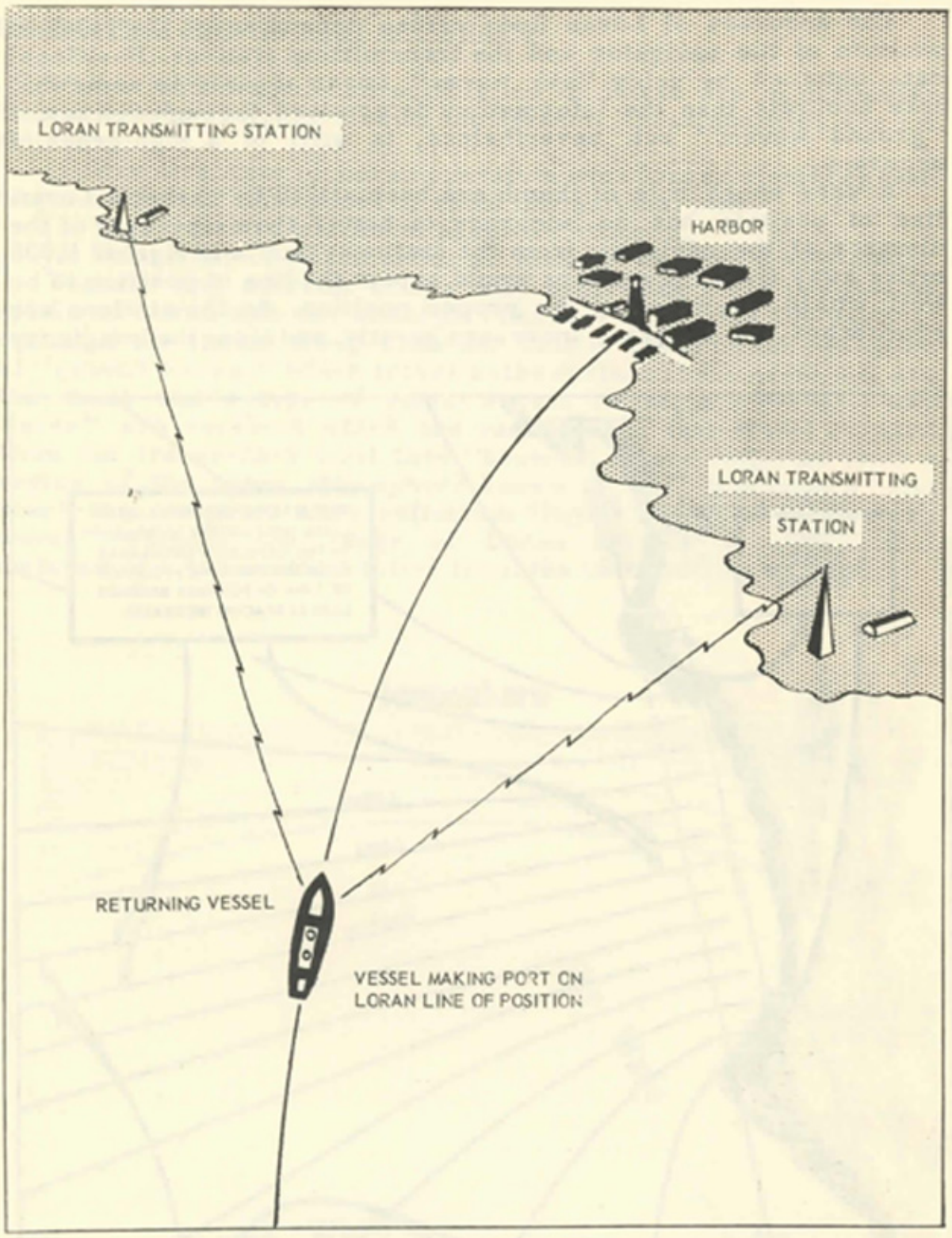


FIGURE 1-7--Vessel making port on Loran line of position.

line between the two stations, or "base line", a line of position may have an accuracy of the order of several hundred feet. This feature has particular practical value, inasmuch as the physical arrangement of Loran stations is such that a navigator making a landfall usually will approach the shore in this highly accurate area of Loran service. Figure 1-6 shows the pattern that a family of Loran lines of position make with respect to their transmitting stations and points out the regions of accuracy. Figure 1-7 shows a vessel approaching a harbor along a line of position.

SUMMARY OF VALUABLE FEATURES OF THE LORAN SYSTEM

The features which make Loran a valuable tool and a highly regarded supplement to the art of navigation are inherent in the technology of the system itself. It is a radio device utilizing the essentially constant speed of travel of radio signals as a basis for operation. This quality is known scientifically to be one of the most stable and unchanging electrical characteristics of radio waves and consequently the Loran system stems from a firm and proven scientific foundation.

The outstanding features of the Loran system may be summarized as follows:

(1) Loran fixes may be obtained readily at long distances from the transmitting stations. The daytime range is approximately 800 nautical miles. In addition to the range of individual pairs of stations, the integrated Loran system is so arranged that coverage is available over many of the principal shipping lanes of the world.

(2) The accuracy of Loran fixes is of high order. Results comparable to those obtained by means of good celestial observations are consistently effected.

(3) Loran operation is essentially independent of the weather. It is not affected by conditions of the sea or air and does not suffer from doubtful effects encountered with older types of radio navigational devices such as direction finders.

(4) The time required to obtain a Loran fix is short. Experienced operators seldom require more than 2 to 3 minutes to establish a fix.

(5) Operation of Loran shipboard and aircraft equipment is relatively simple, and navigators may be trained in Loran technique in a very short time.

(6) Efficiency of long-range navigation is increased. The course sailed may be more direct with a resultant saving in fuel and increase in pay load.

(7) Landfalls may be made at points close to the destination of a vessel.

(8) Loran fixes are independent of other navigational instruments such as compass, chronometer, and other radio equipment. No transmission from the vessel or aircraft is required and only a single item of equipment is used which may be installed at any point convenient for the navigator.

(9) Safety at sea is greatly increased through Loran. When Loran is used by rescued and rescuer, rescue operations are direct. A minimum of time is lost in searching for disabled vessels when the Loran position is included in the distress message.

LORAN TODAY

On 1 July 1958, the following countries were operating LORAN transmitting stations:

Country	Number of Stations
CANADA	6
DENMARK	2
ICELAND	1
UNITED KINGDOM	1
UNITED STATES	50
Total	60

Additional LORAN stations are scheduled for construction during 1958-1961.

Appendixes A through D show the extent of daytime coverage and the results of a Loran use survey conducted during 1955 and 1956.


APPENDIX A
G R E E N L A N D
CAPE ATHOLL, SM 1L8
CAPE CHRISTIAN, DS 1L6, 1L7
NIPISAT, SM 1L1 (DENMARK)
VIK, SS 1L5 (ICELAND)
FAEROES, DM 1L5, 1L6 (DENMARK)
HEBRIDES, SS 1L6 (GREAT BRITAIN)
FREDERICKSDAL, SM 1L4 (DENMARK)
BATTLE HARBOR, DS 1L3, 1L4 (CANADIAN)
BONAVISTA, SM 1L3 (CANADIAN)
FORT AUX BASQUES, SS 1H1 (CANADIAN)
DEMING, DM 1H1, 1H2 (CANADIAN)
BACCARO, DS 1H2, 1H3 (CANADIAN)
NANTUCKET, DM 1H3, 1H4, SS 1H5
SANDY HOOK, SM 1H5
CAPE HATTERAS, DS 1H4, 1H6
VENICE, SS 2H6
BILOXI, SS 2H7
FOLLY IS., DM 1H6, 1H7
HOBE SOUND, SS 1H7
CAPE SAN BLAS, DM 2H6, 2H7
ATLANTIC OCEAN
U N I T E D S T A T E S
C A N A D A
YAKUTAT, DM 1L2, 1L3
SITKA, SS 1L2
KODIAK, SS 1L3
UNIMAK, SS 1L6
SPRING ISLAND, SS 2H5 (CANADIAN)
PT. GRENVILLE, DM 2H4, 2H5
CAPE BLANCO, DS 2H3, 2H4
PT. ARENA, DM 2H2, 2H3
PT. ARGUELLO, SS 2H2
ATTU, SS 1L7
ADAK, DM 1L6, 1L7
MATSUMAE, SS 2H0
NIIGATA, DM 2H0, 2H1
OSHIMA, SS 2H0
MIYAKO JIMA, SM 1L4
SAIPAN, SM 2L3
GUAM, DS 2L2, 2L3
PALAU
ULITHI, DM 2L1, 2L2
TALAMPULAN, DS 1L6, 1L7
KWAJALEIN, SS 1L1
ENIWETOK, DM 1L0, 1L1
WAKE, SS 1L0
FRENCH FRIGATE SHOALS, SM 2L4
KAUAI, DS 2L4, 2L5
MOLOKAI, DM 2L5, 2L4
HAWAII, SS 2L4
NORTH PACIFIC OCEAN
LORAN SYSTEM
1 JULY 1958
APPROXIMATE DAYTIME COVERAGE
PROPOSED ADDITIONAL COVERAGE

APPENDIX B

SUMMARY OF UNITED STATES USERS AND USE OF LORAN

1955--1956 (12 Month Period)

	Known installations	Total installations (estimated)	Reported number of observations (percent total)	Estimated use
Commercial				
U. S. Aircraft	255	275	745,941(17.0%)	1,864,852(16.3)
U. S. Ocean Vessels	288	528	1,489,419(33.7%)	7,447,095(65.0)
U. S. Fishing Vessels	545	1,018		
Number Commercial Users	1,088	1,821		
Total Commercial Use			2,235,360(50.7%)	9,311,947(81.3)
Armed Forces				
U. S. Air Force	----	----	571,392	571,392(5.0)
U. S. Navy	----	----	1,442,265	1,442,265(12.5)
U. S. Coast Guard	116	----	139,354	139,354(1.2)
			2,153,011(50.3)	2,153,011(18.7)

APPENDIX C

LORAN USE SURVEY

	No of replies**	Atlantic Coast	Gulf of Mexico	West Coast	Alaska	Hawaii Islands	Far Pacific	Totals	% of use
Commercial#									
Surface	262	1,313,616	141,490	14,880	6,398	2,405	10,530	1,489,419	33.7%
Air	17	33,415	1,612	250,838	29,768	201,724	228,584	745,941	17.0%
Total 20.3%	279*	1,347,131	143,102	265,718	36,166	204,129	239,114	2,235,360	50.7%
Armed Forces									
Surface***									
Navy	886	822,552	19,163	52,327	27,470	30,503	146,819	1,098,834	25.1%
Coast Guard	111	73,182	10,820	12,373	12,994	3,760	5,730	118,859	2.8%
Total 71.8%	997	895,734	29,983	64,700	40,464	34,263	152,549	1,217,693	27.9%
Air									
U. S. Navy	78	47,690	484	49,816	30,529	48,553	166,359	343,431	7.9%
U. S. Air Force	1	149,078	9,725	100,031	39,154	99,060	174,314	571,392	13.0%
U. S. Coast Guard	17	8,221	2,044	5,330	416	2,367	2,117	20,495	.5%
Total 7.9%	96	204,989	12,253	155,177	70,099	149,980	342,790	935,318	21.4%
Grand Totals	1,372	2,447,854	185,338	485,595	146,729	388,372	734,453	4,388,371	
Percentage		55.7%	4.2%	11.1%	3.3%	8.9%	16.8%		

* 34% requested additional coverage. 72% of the 34% wanted additional coverage in Gulf of Mexico.
** Many of these replies covered more than one user. For instance, the Air Force which conducted and reported its own survey received credit for only one report--similarly, the Navy reports were often consolidated squadron reports covering a number of users.
*** Armed Forces were directed to reply to use survey.
\# Voluntary replies.

APPENDIX D

LORAN SUMMARY OF USE SURVEY SHOWING NUMBER OF KNOWN INSTALLATIONS

	No. letters written	Replies received	No replies (1)-(2)	Installations reported	Number of these previously reported	Number assumed installed by nonreplys $\frac{(3)}{(2)} \times (4)$	Installations planned within 12 months	Installations known not reported	Estimate new installations- $\frac{(3)}{(2)} \times (7)$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Commercial Surface Large	147	83	64	238	82	183	50	----	40
Commercial Surface Fishing	87	29	58	387	0	772	15	158	100
Commercial Aircraft	18	13	5	155	112	57	33	100	13

	Total installations estimated (4)+(6)+(7)+(8)+(9)	Installation percent of companies reporting	Total units involved estimated	Estimated total units with Loran (11) x (12)	Use multiplier factor $\frac{(13)}{(5)}$ & $\frac{(10)}{(5)}$	Known installations	1953 survey comparison	Percent increase
	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Commercial Surface Large	511	48%	1,100	528	5	288	155	86%
Commercial Surface Fishing	1,422	68%	1,500	1,018	5	545	268	103%
Commercial Aircraft	**358 (275)	100%*	350	275	2.5	255	141	81%

* TWA although replying does not have any LORAN Installations but they did not indicate number of aircraft.
** Impractical Figure.

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