CHAPTER 18

Loran System

CONTENTS

Part A. OPERATING INSTRUCTIONS

ILLUSTRATIONS

Part B. MAINTENANCE INSTRUCTIONS

ILLUSTRATIONS

Part A. OPERATING INSTRUCTIONS

18–1 GENERAL

18–1–1 Purpose of This Chapter—

A. Parts 18–1 to 18–4 of this chapter present a nontechnical description of the Loran system of navigation. For specific technical data and maintenance instructions see the manufacturer's instruction book furnished with the equipment.

B. Parts 18–5, and 18–6, consist of operating instructions for loran transmitting stations.

C. Parts 18–10 through 18–18 of this chapter present general engineering information and technical standards for maintenance of the Loran system.

18–1–5 Introduction—

A. 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 750 miles during the day (fig. 18–1). The accuracy obtained is comparable to that which may normally be expected from good celestial observations. Even though such precision is attained, the determination of position by loran requires but 2 to 3 minutes' time.

B. *Lines of position.*—The navigator can think of loran merely as a method of determining lines of position. These loran lines can be crossed with other loran lines, sun lines, star lines, soundings, radar ranges, or bearings to provide fixes. Loran lines are fixed with respect to the earth's surface; their determination is not dependent upon the ship's compass, chronometer, or other mechanical or electronic devices. Loran shipboard equipment requires no special calibration and is not affected by the arrangement or disarrangement of shipboard antennas, cargo booms, ventilators, etc., as in the case of radio direction finders.

C. *Availability.*—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. Developed as a wartime necessity, the system is now at the disposal of private shipping—any nation, any line, all may make free use of it.

18–2 OPERATION

18–2–1 Principles—

A. Loran operates on the following principles:

(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.

B. *Time-distance relationship.*—Since radio signals travel at a constant speed, a direct relationship between time of travel and distance traveled exists. Thus, measurement of intervals of time is, in essence, a measurment of distance itself.

C. *Pulse signals.*—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 "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.

D. *Line of position.*—Because the basic loran measurement evaluates the difference in the distances between the navigator and each of two fixed transmitting stations 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. 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.

E. *Charts and tables.*—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 electeronic lines of position with respect to some convenient chart of the region in which 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.

F. The diagram of figure 18–2 illustrates the basic principles of the determination of position by means of loran.

18–2–5 Equipment Used by the Navigator—

A. *Receiver-indicator.*—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

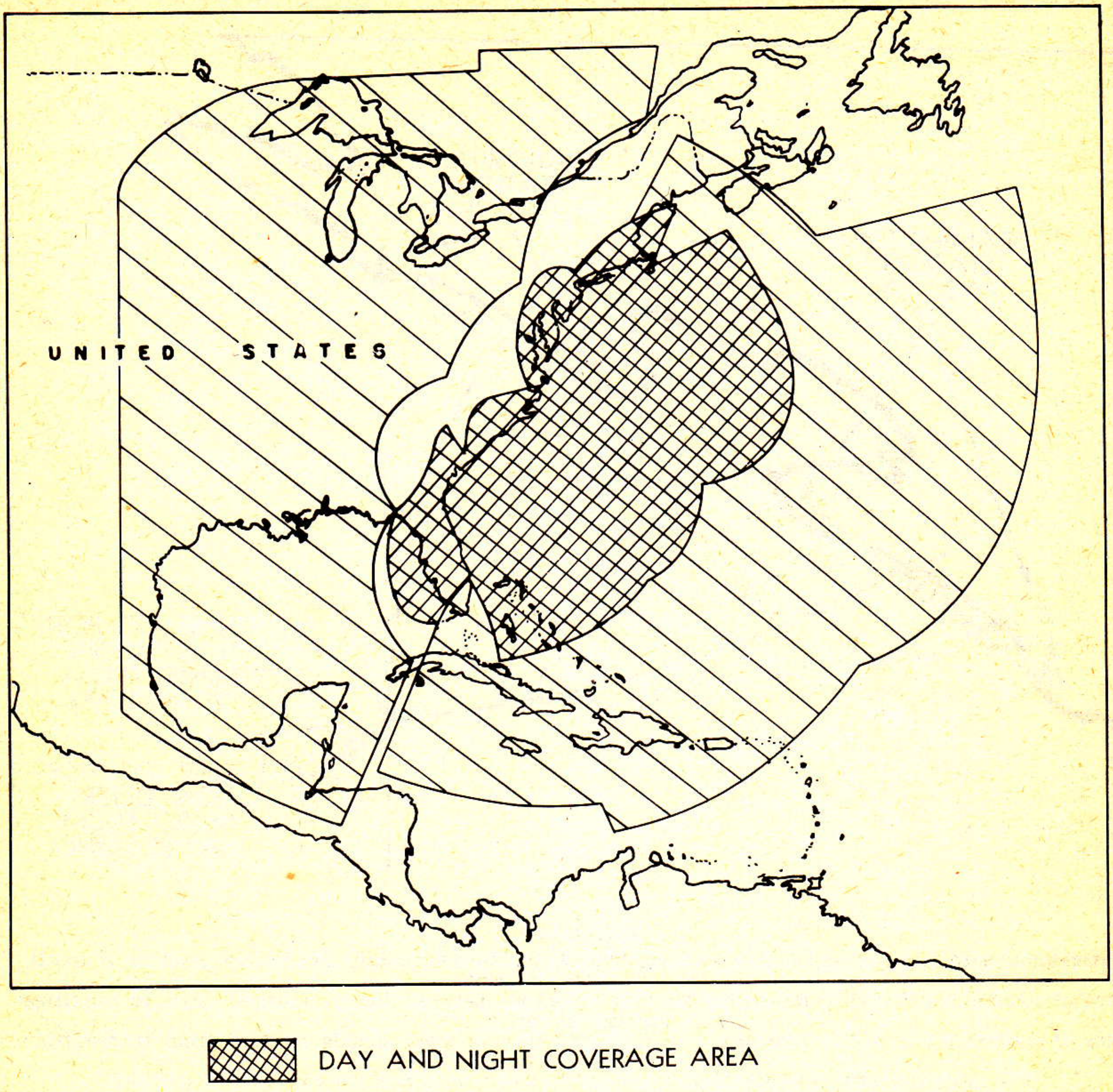

FIGURE 18–1.—Typical day and night loran coverage area.

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.

B. *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.

18–2–10 Range and Accuracy—

A. 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.

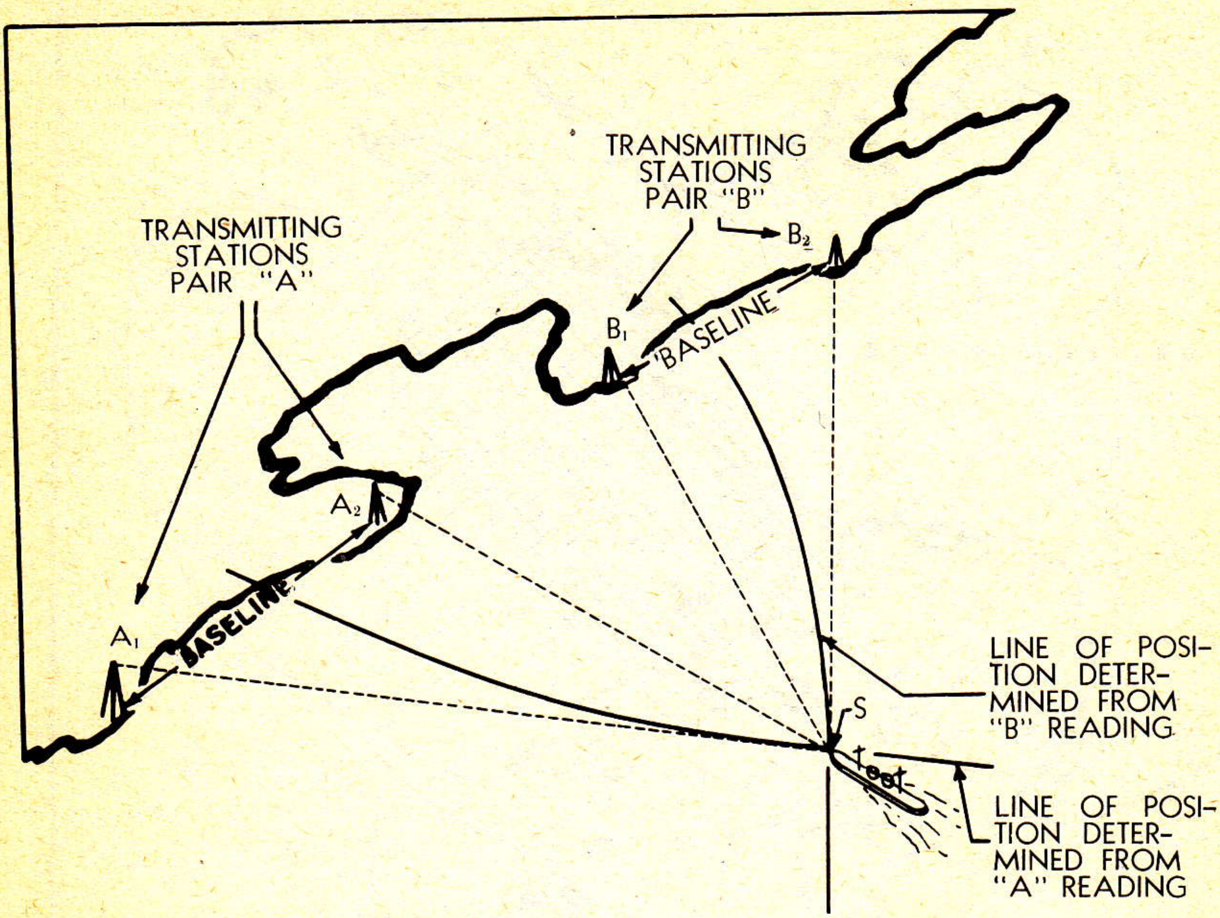

FIGURE 18–2.

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 navigator's fix is established at the point of intersection of the two lines of position.
The latitude and longitude of the navigator's position is determined from the loran data by using either the loran charts or loran tables.

B. *Range.*—Vessels and aircraft at sea may determine their position by means of loran both day and night when they are within 750 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 18–4). 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. However, the 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.

C. *Rapid calculation.*—One of the surprising facts about loran is that in a matter of 2 to 3 minutes' time a navigator at sea can determine his position with an accuracy comparable to that obtained from good celestial observations, which require considerably longer to make and which entail somewhat laborious mathematical computations.

D. *The accuracy* of loran fixes varies considerably, depending on the relative position of the navigator and the transmitting stations, the angle at which the loran lines of position intersect, and several other factors.

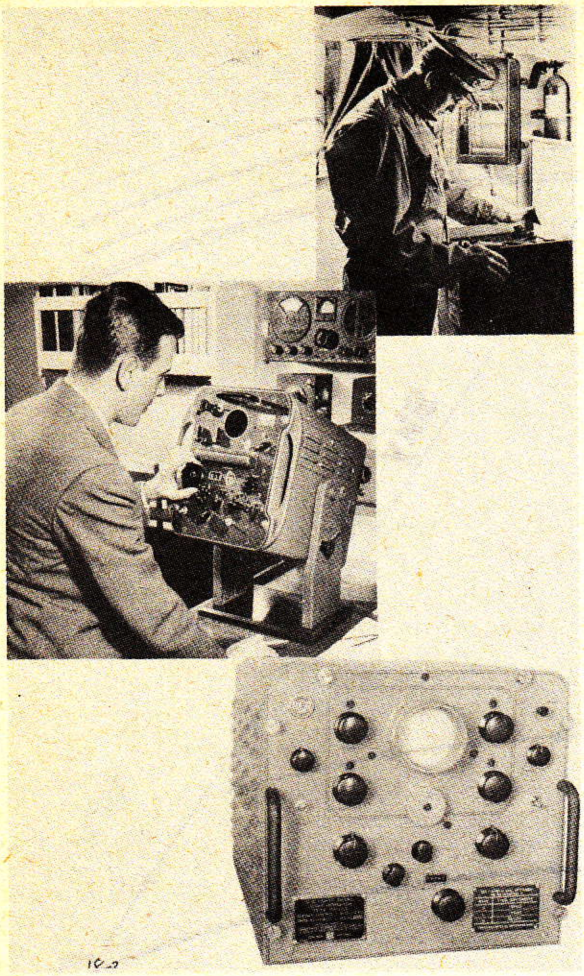

FIGURE 18–3.—Typical direct-reading loran receiver-indicator equipment.

E. A very rough rule of thumb has been stated, 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 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 18–5 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 18–6 shows a vessel approaching a harbor along a line of position.

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F. *Reliability of signals.*—Another important feature of loran to the navigator is the reliability of the signals and the consequent removal of doubt in the navigator's mind as to the dependability of loran fixes. Loran signals can be received under all ordinary conditions of storms, gales, and other severe weather. This is possible because the ordinary electrical interferences that accompany these conditions obscure the loran signal for only a few seconds at a time and the navigator need only wait for a few moments to obtain usable data. For these reasons loran is an especially valuable asset to navigation during bad weather.

18–2–15 Summary of Valuable Features—

A. 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 which makes use of the speed of travel of radio signals as its fundamental principle. This quality is known scientifically to be the most stable and unchanging electrical characteristic of radio waves and consequently the loran system stems from a firm and proven scientific foundation.

B. 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 750 nautical miles. In addition to the range of individual pairs of stations, the integrated loran system is so arranged that coverage is available over most of the major 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 nearly 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, and in case of disaster, rescue operations are direct. A minimum of time is lost in searching for disabled vessels when the loran position is included

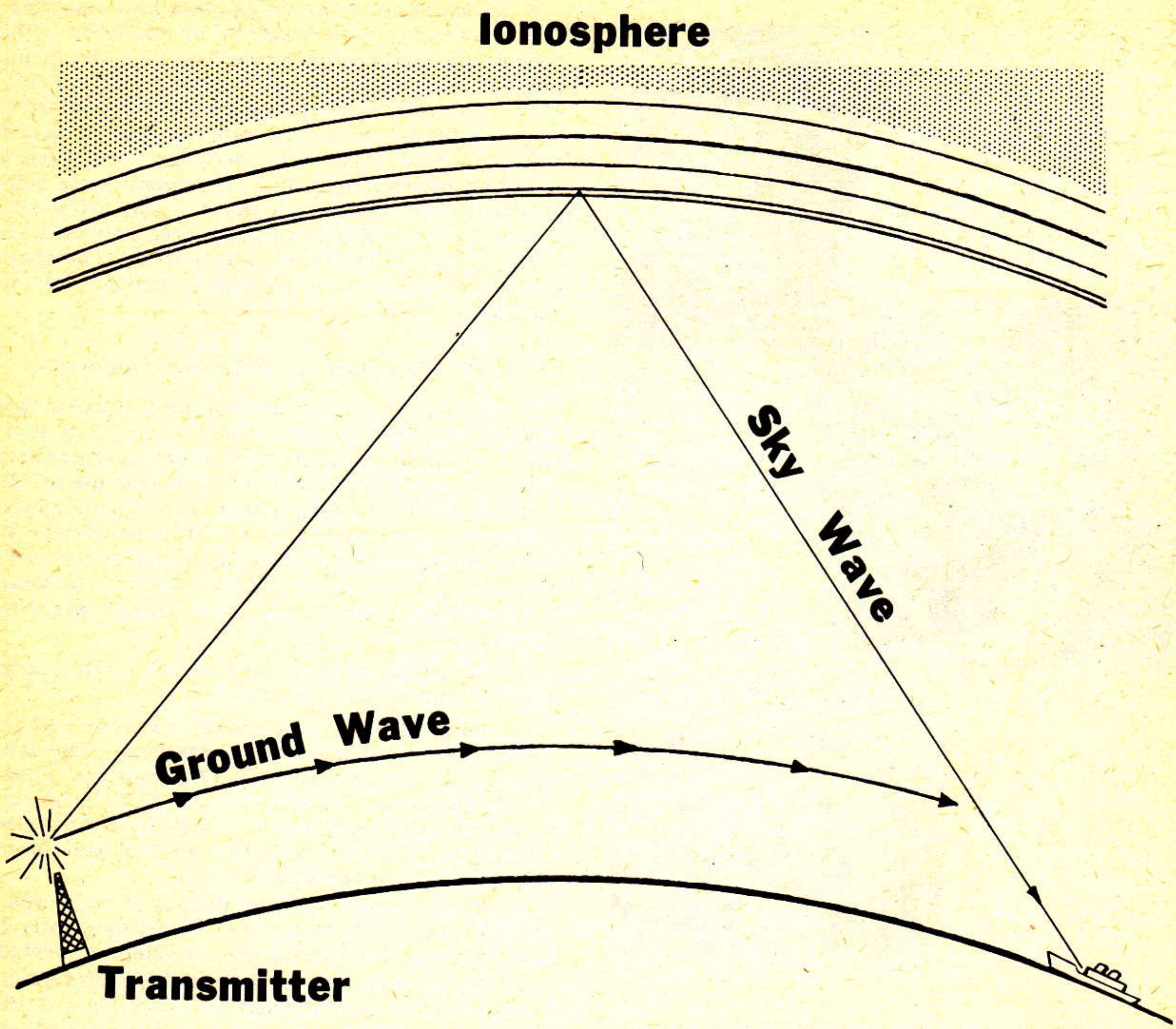


FIGURE 18–4.—Ground wave and sky wave paths.

in the distress message. The increase in safety at sea will probably be reflected in reduced insurance premiums as the application of loran becomes more widespread. This factor alone might easily compensate for the cost of the loran equipment.

C. Loran has already played a prominent role in rescue operations. Distress at sea usually occurs during foul weather when determination of position by celestial observations has been impossible for several days. Under such limitations, the distressed vessel's dead reckoning position may be considerably in error.

D. In the Aleutian area, a distress case occurred which illustrates the value of loran in the saving of life at sea. Surface vessels and aircraft were engaged in search operations for a barge foundering in heavy seas with 8 persons aboard. Positions transmitted by radio from the barge, 24 hours apart, were hundreds of miles different though the craft was not under power. This indicated that she did not have a reasonably correct knowledge of her position, and rescue operations were fruitless. After transmission of the loran-determined position to surface vessels, the distressed craft was located and all hands rescued in a matter of hours before the water-filled barge sank during 70-mile-per-hour winds.

E. Thus loran, through the medium of electronic science, constitutes a fundamental supplement to other methods of navigation, in assisting and protecting lives and property at sea.

18–3 TRANSMISSIONS

18–3–1 Control—

A. *Accuracy of timing.*—Since the value of the loran system is equal only to the accuracy of timing of the signals transmitted, every precaution is taken to safeguard the functioning of the system. This is

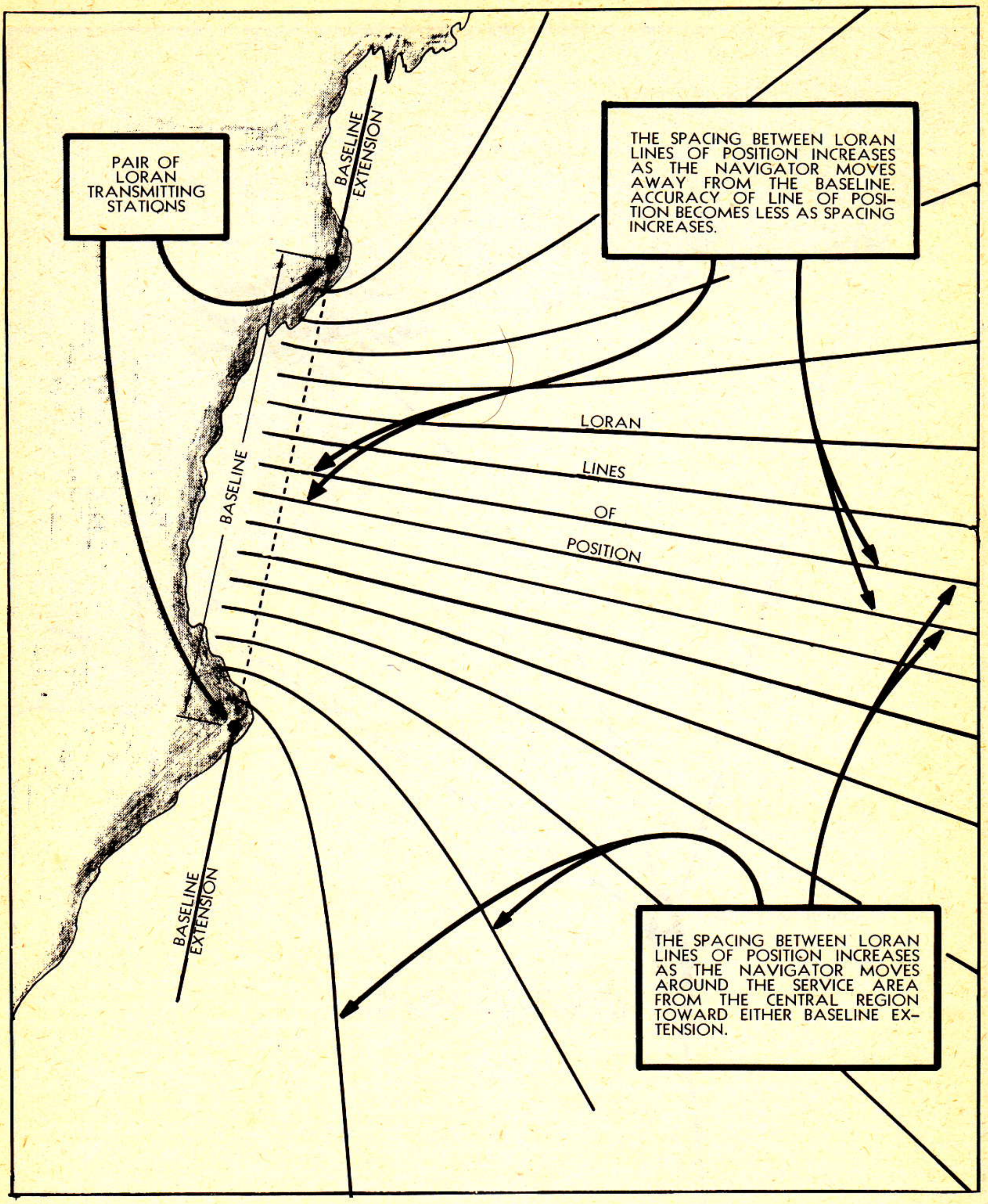


FIGURE 18–5.—Loran hyperbolic pattern.

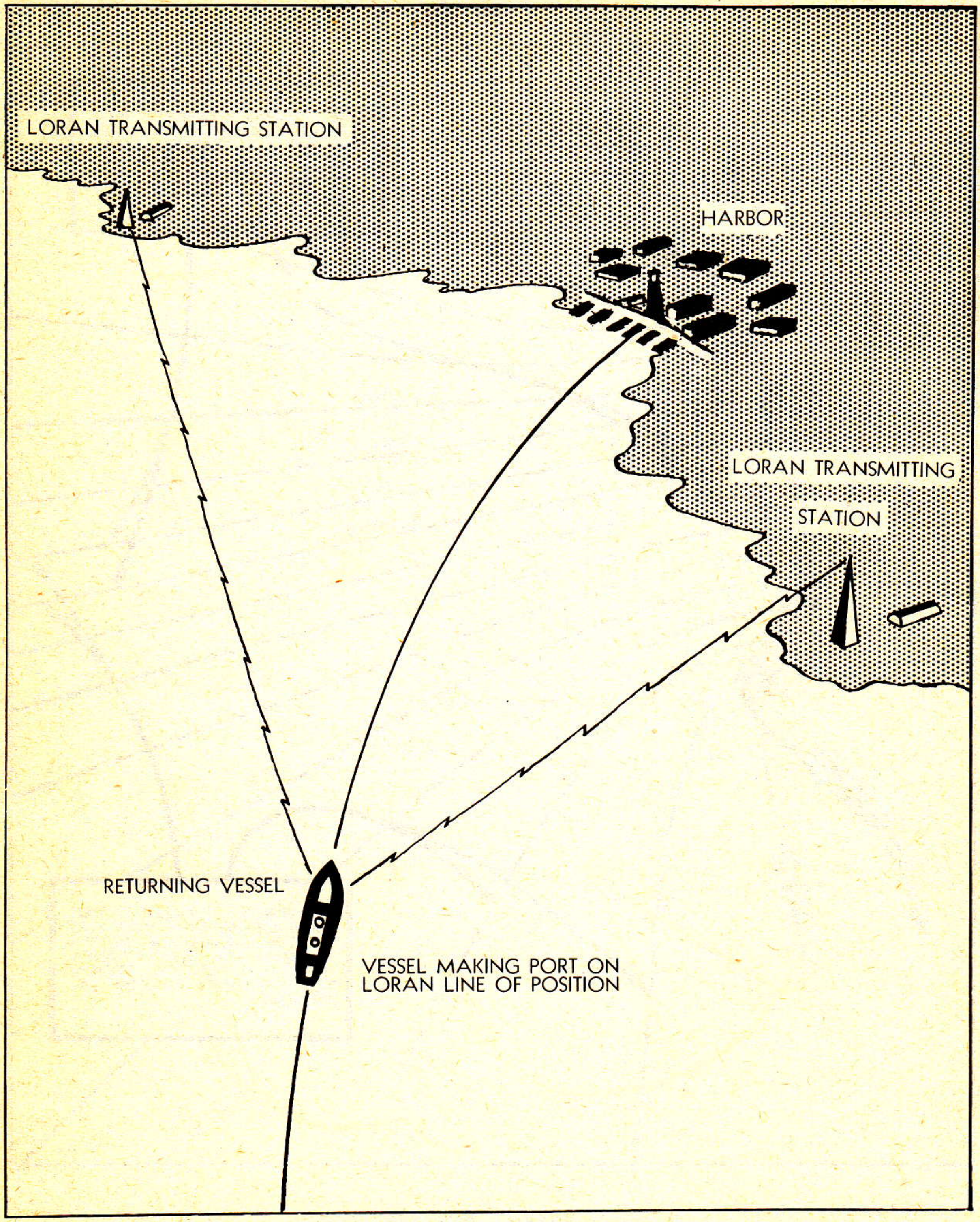
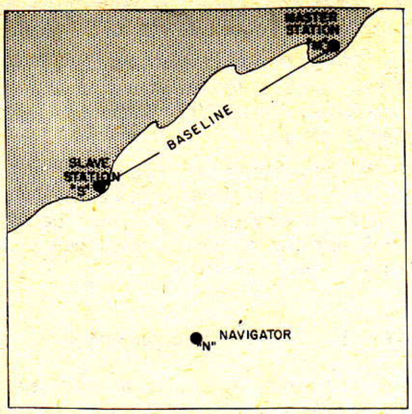
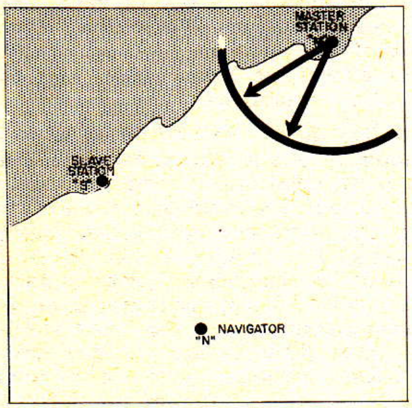


FIGURE 18–6.—Vessel making port on loran line of position.



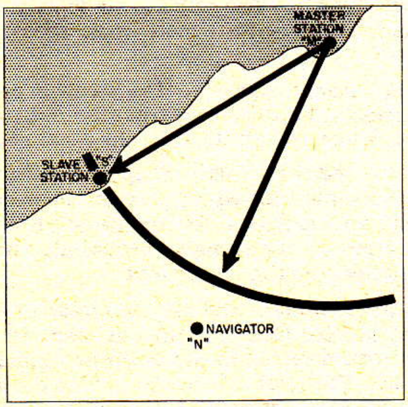
STEP I

NAVIGATOR ABOARD SHIP AT "N" IS WITHIN RANGE OF STATIONS "M" AND "S" AND IS ABOUT TO RECEIVE LORAN SIGNALS.



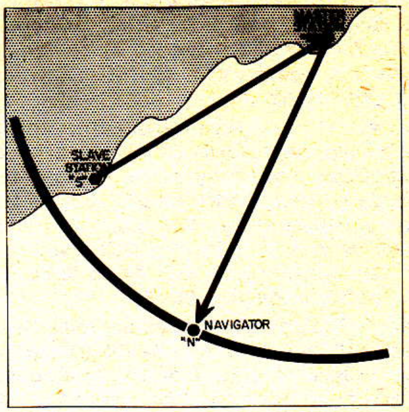
STEP II

LORAN TRANSMISSION CYCLE IS BEGUN BY "MASTER" STATION. PULSE IS RADIATED IN ALL DIRECTIONS AND TRAVELS TOWARD BOTH "SLAVE" STATION AND NAVIGATOR.



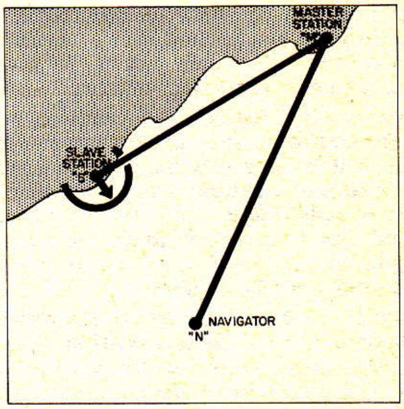
STEP III

PULSE TRANSMITTED BY "MASTER" STATION ARRIVES AT "SLAVE" BUT HAS NOT YET REACHED THE NAVIGATOR.



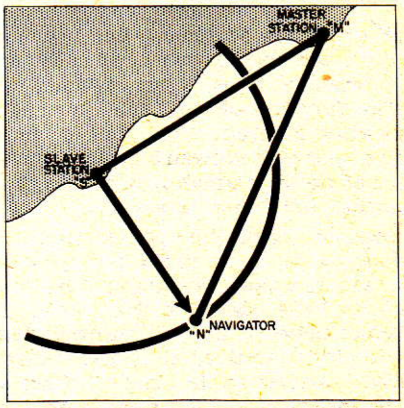
STEP IV

PULSE FROM "MASTER" STATION ARRIVES AT POSITION OF NAVIGATOR. "SLAVE" STATION HAS ALREADY RECEIVED "MASTER" PULSE AND IS WAITING FOR PROPER AMOUNT OF TIME TO ELAPSE BEFORE TRANSMITTING TO ASSURE CORRECT SYNCHRONIZATION WITH "MASTER".



STEP V

AFTER WAITING FOR THE PROPER AMOUNT OF TIME TO ASSURE CORRECT SYNCHRONIZATION, THE "SLAVE" TRANSMITS ITS PULSE. THE NAVIGATOR HAS ALREADY RECEIVED THE PULSE FROM THE "MASTER" STATION.



STEP VI

"SLAVE" PULSE ARRIVES AT NAVIGATORS POSITION. SINCE NAVIGATOR HAS ALREADY RECEIVED THE SIGNAL FROM THE "MASTER" STATION, LORAN READING IS TAKEN BY MEASURING THE TIME ELAPSED BETWEEN THE ARRIVAL OF THE MASTER AND SLAVE PULSES. AFTER BOTH SIGNALS HAVE TRAVELLED THROUGHOUT THEIR EFFECTIVE RANGE, THE CYCLE IS REPEATED.

FIGURE 18-7.—Sequence of operation of loran transmitting stations.

effective to such an extent that the navigator may feel certain that the loran data which he obtains is correct. This fact has been proved by the acid test of completely successful loran operation under the most severe conditions.

B. *Signals monitored.*—The nature of loran transmitting station equipment makes it necessary for the loran transmitting station operator to observe the signals of both stations continuously during transmission. As a consequence, the man on watch at either station of a pair is in a position to "double check" for the existence of any fault that might occur in the signal of either station.

C. *Blinking.*—Loran transmissions can be momentarily at fault due to many possible causes, such as electrical failure of a part of the equipment or operating error in manipulating controls. Even though these troubles may be minor and of relatively short duration, it is essential that the navigator be acquainted with the failure instantly and positively. In order to do this, a blinker device is switched in at either of the two stations. "Blinking" produces a characteristic movement of the transmitted signals, which is easily recognizable and serves to warn the navigator that the signals are not to be used for navigational purposes until the "blinking" ceases.

D. In the event that the failure is sufficiently serious to prevent transmission entirely from one of the paired stations, it would not be possible for the navigator to misinterpret the loran signals, inasmuch as the presence of only one of the expected signals on the air would preclude making any time difference measurements at all from that particular pair. Other pairs would not be affected.

E. Because of the fundamental checks which are vigilantly maintained on the transmitted loran signals, the navigator at sea or in the air is assured that any transmissions which he receives, with the exception of "blinking" signals, are accurate, reliable electronic guideposts marking the lines of positions of this modern long-range navigational aid.

18–3–5 Station Functions—

A. *Master and slave stations.*—Because loran is concerned with the measurement of radio signals from two different sources, loran stations operate in pairs. The function of each station of a loran pair is somewhat different from that of its companion station, and each is given a designation which is descriptive of the role which it performs, namely, "master" station and "slave" station.

B. The "master" starts the cycle of transmission by sending out a pulse of radio energy which is radiated in all directions including that of both the navigator and the "slave" station. After traveling the distance between the two transmitting stations, known as the "baseline," the pulse transmitted by the "master" arrives at the "slave." This signal is received by means of the loran equipment of the "slave" station and the time of its arrival is used by the "slave" as a reference for the transmission of its own signal.

(1) After the "slave" transmits its pulse, the entire cycle is repeated again and again.

(2) Thus the "master" station "sets the pace" and the "slave," by following, completes the loran transmitting cycle. This is shown diagrammatically in figure 18–8.

C. By this simple process, a pair of loran stations send out their guiding signals to the hundreds or thousands of navigators who may be within the area of their service which, in most cases, is well over 1 million square miles!

18–3–10 Station Equipment—

A. In order to send out a succession of reliable loran signals to aid navigators at sea in determining their position, the transmitting station has two fundamental responsibilities. The first of these is the generation of radio pulses of the proper frequency, power, and duration. The second is the timing of these radio pulses at the correct intervals and with the required degree of precision. The three major units of transmitting station equipment are the loran transmitter, the loran timer, and the electronic switching equipment.

B. The *loran transmitter* is a "pulse" type of equipment of a special design developed specifically for loran application. The radio frequency pulses generated by the equipment, while of short duration, contain a great deal of electrical energy and are as powerful as the largest commercial broadcasting station's transmissions. The loran transmitter functions in such a manner that a single pulse of radio energy is sent out each time the transmitter receives an electrical timing impulse. The timing impulse is a "trigger" pulse and serves to "turn on" the transmitter for the duration of the pulse. These "trigger" pulses are generated by loran timing equipment.

C. The *loran timer* is the fundamental unit of equipment on which the accuracy of the loran system depends. The timer is made up of the following basic components which serve the purposes indicated:

(1) *Radio receiver.*—The receiver permits the reception of loran signals from the distant station and also those transmitted by the local station.

(2) *Indicator.*—Based upon the function of the cathode ray tube which permits the operator to "see" electrical impulses, the indicator permits visual inspection of the signals themselves and other basic functions of the equipment.

(3) *Oscillator and timing circuits.*—The complex and precise timing functions stem from a crystal-controlled oscillator of the highest laboratory standards. The timing circuits permit the measurement of the time interval between the signals received and furnish the necessary "trigger" pulses for operating the loran transmitter and similar timing pulses for other secondary station functions.

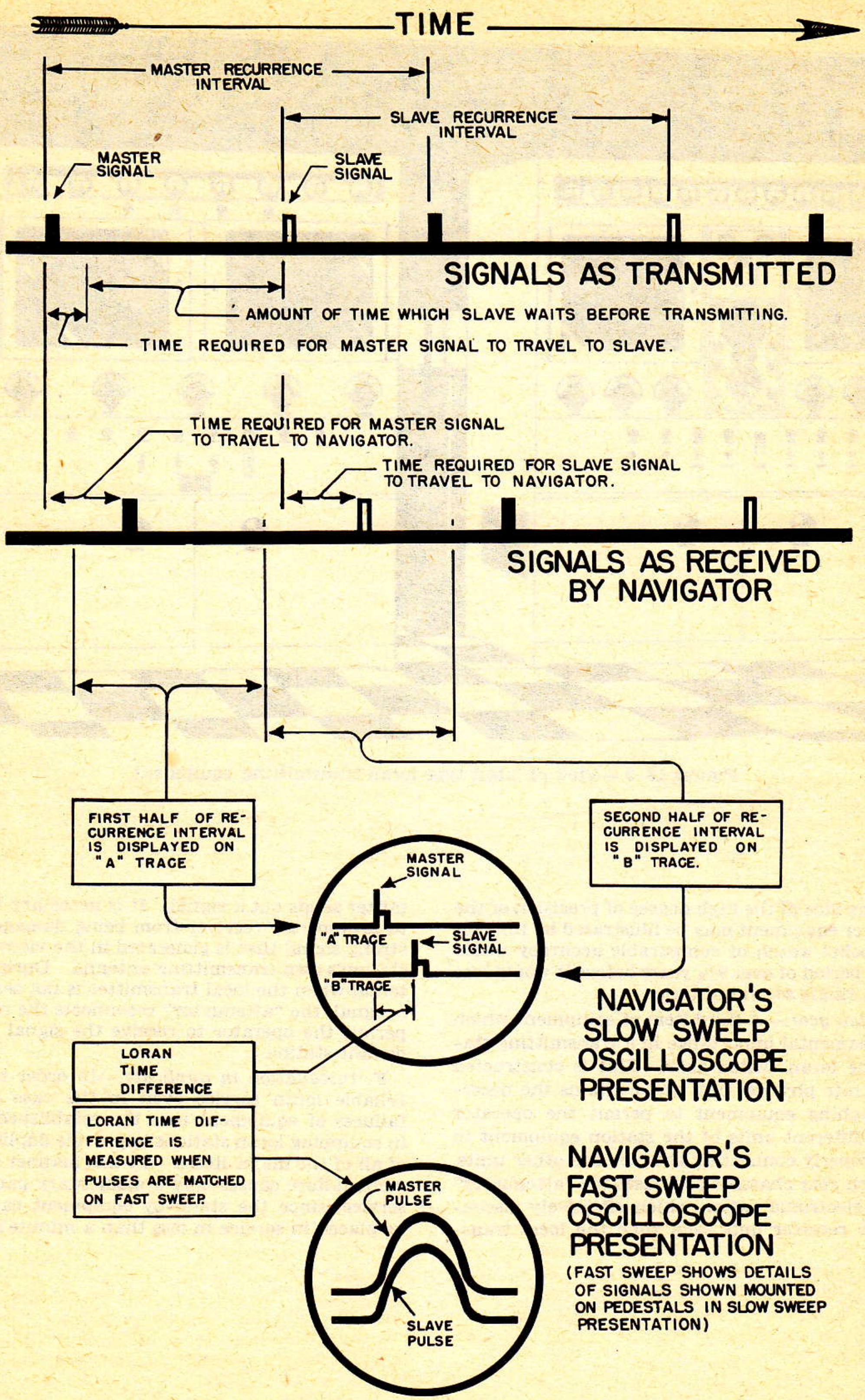


FIGURE 18–8.—Loran timing sequence.

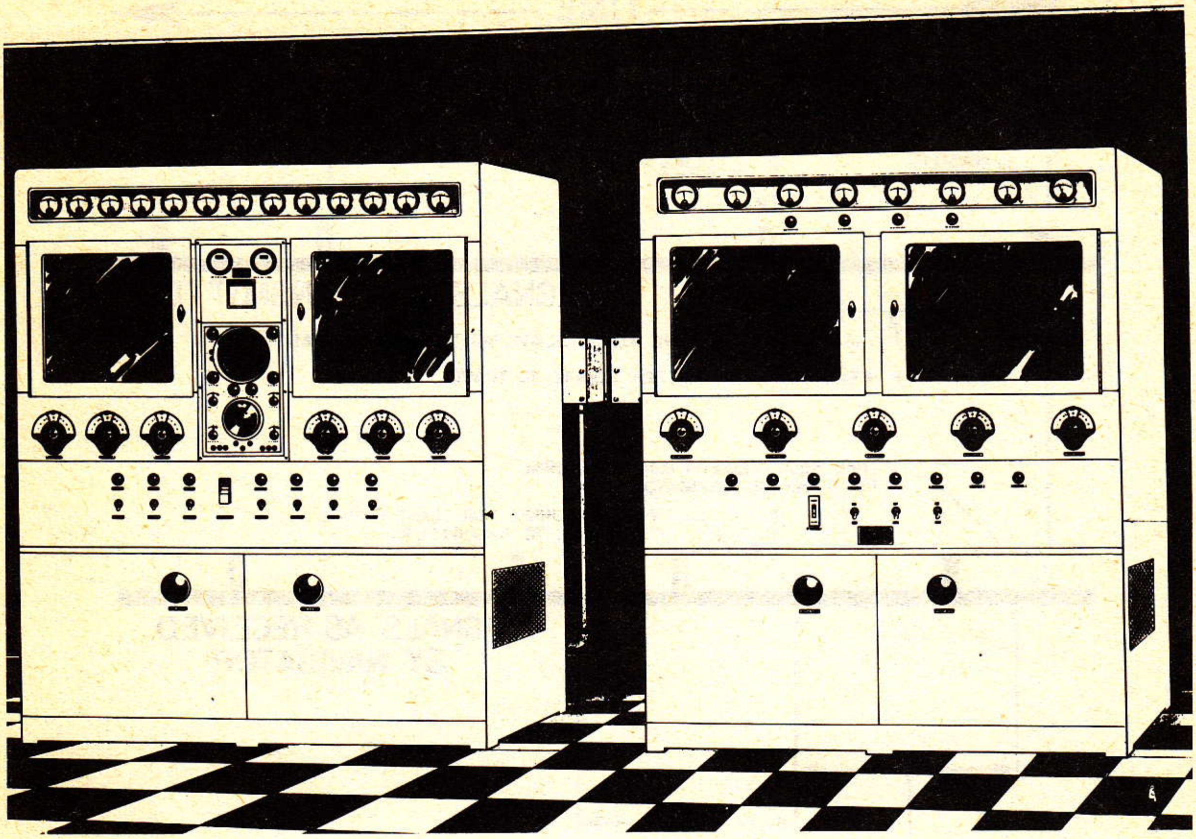


FIGURE 18–9.—View of latest type loran transmitting equipment.

D. Some idea of the high degree of precision of the loran timer equipment may be illustrated by the fact that a pocket watch of comparable accuracy would run for a period of over 9½ years before it would lose or gain a single second of time.

E. *Switch gear.*—A third item of equipment which is of fundamental importance in a transmitting station is the loran switch gear. This is constructed as a separate physical unit and contains the necessary switching equipment to permit the operator to place different units of the station equipment in use by properly connecting them to the other units. The switch gear chassis also houses the "attenuator" unit, an electronic switch which effectively disconnects the receiver unit each time the local transmitter sends out a signal. It is necessary to do this to prevent the receiver from being damaged by the strong signal that is generated in the vicinity of the station's own transmitting antenna. During the interval when the local transmitter is not sending out a signal, the "attenuator" reconnects the receiver to permit the operator to receive the signal from the distant station.

F. *Installation in duplicate.*—In order to provide reliable loran service even in the case of minor failures of equipment it is the established practice in equipping loran stations to provide duplicate units of all of the major items. In this manner an equipment failure causes only a momentary pause in the service, since the stand-by equipment can usually be placed in service in less than a minute's time.

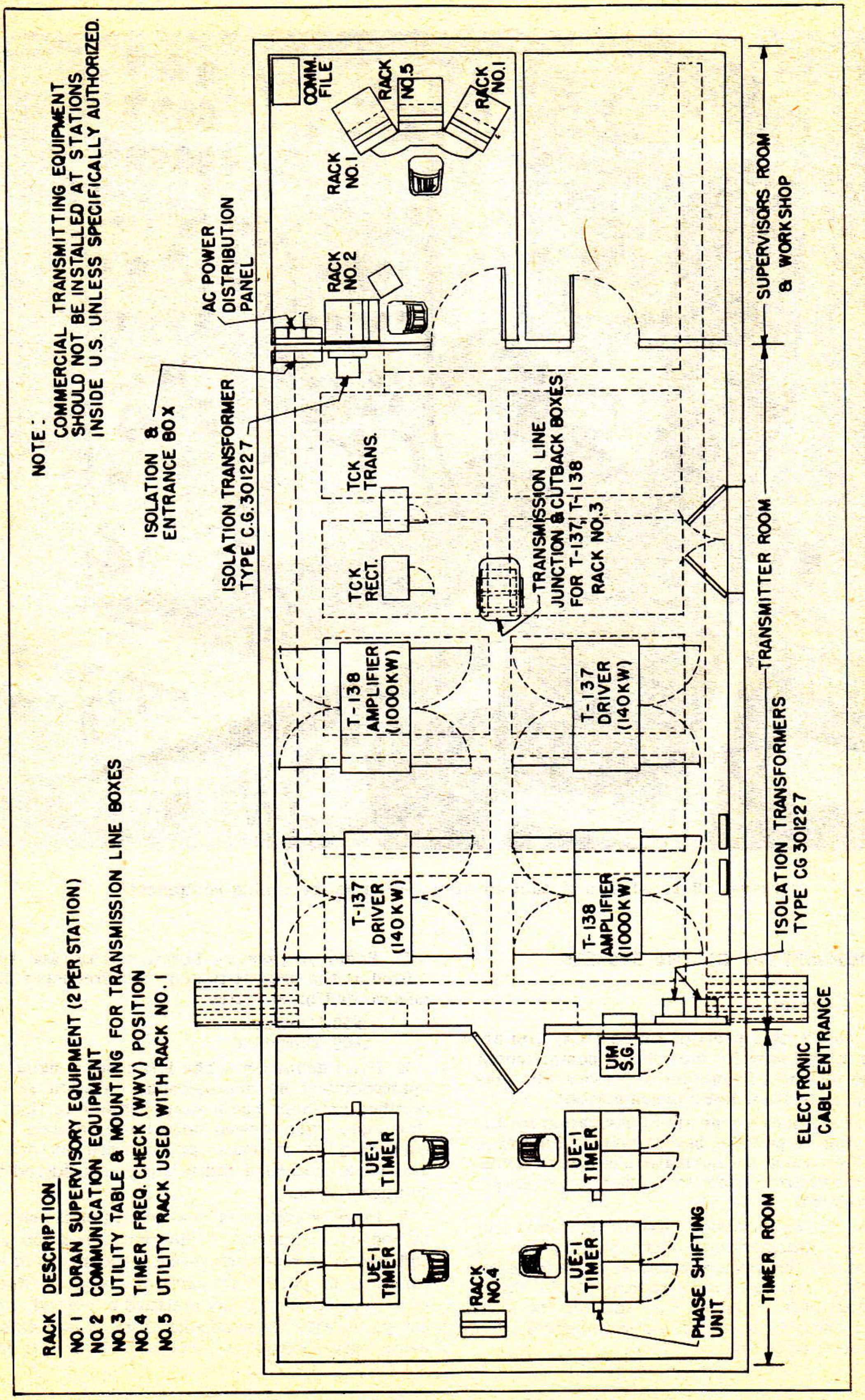


FIGURE 18-10.—Loran equipment building layout.

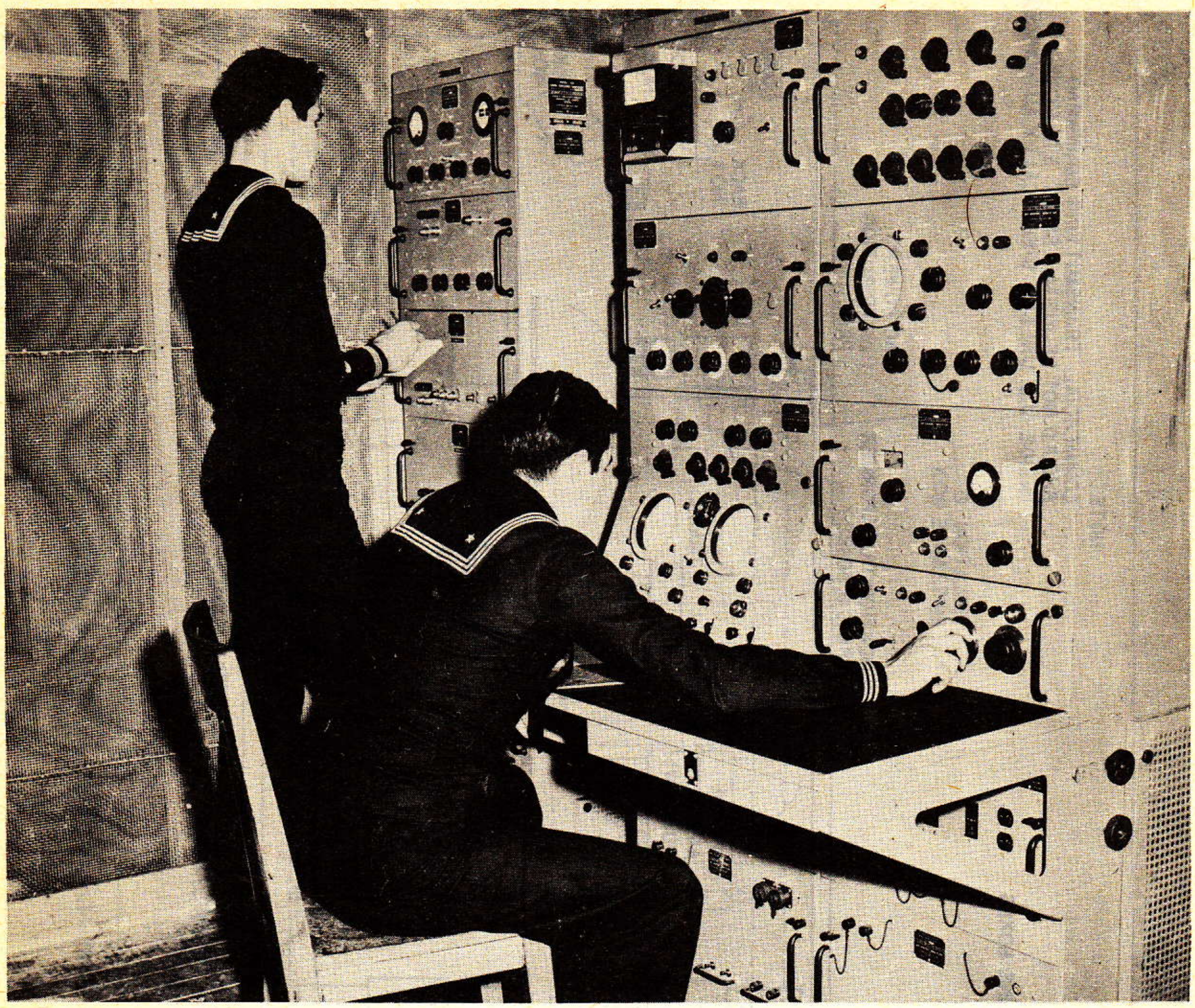


FIGURE 18–11.—Loran station—men on watch at the timing equipment.

18–4 DESCRIPTION OF THE SYSTEM

18–4–1 General—

A. The following aspects of the loran system are described in this part for purposes of completeness, to be used for the information of persons who may have occasion to study loran in some detail.

B. *Loran.*—A long-range aid to navigation for the determination of position, based upon the difference in times of arrival at the navigator's position of radio signals transmitted from two fixed loran transmitting stations.

C. *Type of transmission.*—Loran transmissions are "pulse" transmissions. Very short pulses of radio frequency energy are radiated at periodic intervals which are very long compared to the duration of the pulse. During the interval between successive pulses of a station, no radio signal from that station is on the air.

D. *Radio frequency.*—Loran signals are transmitted at the present time on two frequency channels in the United States:

1950 kilocycles.
1850 kilocycles.

E. *Pulse definition.*—The loran pulse signal is of approximately 80 microseconds duration and the rectified envelope has a shape similar to that of a sine wave when viewed on a loran receiver. It is customary to measure pulse width at one-half amplitude; standard width is thus considered to be 40 microseconds.

F. *Pulse repetition rates.*—Loran pulses are transmitted at a number of different repetition rates. Differences in repetition rate are the means of identification of particular pairs of stations. Specific pulse repetition rates are assigned in several general categories with the particular rates of each category being only slightly at variance with a convenient rate known as the "base rate." Present "base rates" and "specific repetition or recurrence rates" are tabulated under paragraph (G) (1) below.

G. *Loran timing sequences.*—(Loran timing sequences are shown in fig. 18–7.) Master and slave stations are pulsed at exactly the same pulse recurrence rate. The master pulse is transmitted first and, after traveling the distance of the base line, arrives at the slave where it is received and used as a timing reference. After waiting for a predetermined length of time which is necessary to establish correct loran synchronization, the slave station transmits its pulse. The amount of time that the slave waits, or delays, is always fixed at an amount greater than one-half of the recurrence interval plus a coding delay (usually 1000 u/s). As a consequence, the master signal is always transmitted during the first half of the recurrence interval and the slave transmission always occurs during the second half of the interval, regardless of the navigator's position with respect to the stations.

(1) The signals are received and viewed by means of a cathode ray oscilloscope using a time base equal to the recurrence interval, but divided into two equal half-interval traces so placed on the scope by the sweep circuits that two half-traces appear with the first half directly above the second half. Both traces are horizontal in time sweep.

BASE RATE 25 CYCLES (PULSES) PER SECOND

Specific rate designation	Frequency (c. p. s.)	Interval (microseconds)
0	25	40,000
1	$25\frac{1}{16}$	39,900
2	$25\frac{1}{8}$	39,800
3	$25\frac{3}{16}$	39,700
4	$25\frac{1}{4}$	39,600
5	$25\frac{5}{16}$	39,500
6	$25\frac{3}{8}$	39,400
7	$25\frac{7}{16}$	39,300

BASE RATE $33\frac{1}{3}$ CYCLES (PULSES) PER SECOND

Specific rate designation	Frequency (c. p. s.)	Interval (microseconds)
0	$33\frac{1}{3}$	30,000
1	$33\frac{4}{9}$	29,900
2	$33\frac{5}{9}$	29,800
3	$33\frac{2}{3}$	29,700
4	$33\frac{7}{9}$	29,600
5	$33\frac{8}{9}$	29,500
6	34	29,400
7	$34\frac{1}{9}$	29,300

New Loran transmitting station equipment is capable of operation on a base rate of 20 c. p. s. to provide for future expansion of the system without requiring additional radio frequency allocations.

(2) The controls of the receiving instrument are adjusted until the master signal is viewed near the beginning of the upper, or A, trace. The slave signal will appear in its proper place on the lower trace. Measurement of the loran time difference is made by evaluating the horizontal displacement of the slave station with respect to the master in terms of time, microseconds. By this physical arrangement of the traces the half recurrence interval delay which was introduced by the slave is effectually canceled from the measurement. Loran readings thus obtained may be interpreted in conventional coordinates by the use of loran charts or tables. A fast speed time base having a duration of roughly from 100 to 300 microseconds is provided to permit visual examination of the pulse envelope itself which is necessary to establish the precise adjustment required in making a loran reading.

H. *Blinker signal.*—The timers at loran transmitting stations are equipped to perform a function known as blinking. The signal is used to indicate that the transmissions should not be considered reliable during the period of blinking. In general, blinking causes the received pulse to rhythmically swing back and forth as viewed on the slow sweep, and to rhythmically appear and disappear on the fast sweep. In the few exceptions to this method, there is a rhythmic appearance and disappearance on both slow and fast sweeps.

18–4–5 Radio Receiver—

A. *Operating radio frequencies.*—The radio receiver of a loran receiver-indicator is provided with four radio-frequency channels and may be set for operation on any of the frequencies tabulated in the system specification. In operation, receiver tuning is fixed and a four-position switch provides simple means of changing channels. Inasmuch as only two transmitting frequencies are allocated for standard loran, the four-position frequency selector switch, if provided, permits future system flexibility.

B. *Receiver sensivity.*—The receiver has a sensitivity sufficiently high that a signal of approximately 10 microvolts delivered by the antenna to the receiver input will result in full scope deflection of the cathode ray indicator. Receiver and indicator form an integrated unit and are not intended to function separately.

C. *Bandwidth.*—Early designs incorporated a total bandwidth of the order of 80 kilocycles at 6db. down. Current trends are toward considerable reduction, and total bandwidths of 45 kilocycles or less at the same decibel limitation are contemplated.

D. *Differential gain amplifier.*—The receiver incorporates a differential amplifier which operates in synchronism with the incoming signal recurrence frequency to permit amplification of each of the two signals received at different ratios. This feature permits presentation to the cathode ray indicator of signals of equal amplitude. Sufficient range of operation is provided to permit accommodation of incoming signals having a ratio of strengths as high as 1,000 to 1. Earlier equipments had an operating limit of roughly 100 to 1.

18–4–10 Indicator—

A. *Functional purpose.*—The indicator unit contains the necessary circuits to perform all of the timing functions of the equipment with the required precision. It contains the sweep generators and the cathode ray tube for presentation of the signals received.

B. *Master oscillator.*—The basic timing medium of the equipment is a precision, crystal-controlled, master oscillator. The oscillator possesses a high order of short time stability, in the order of a few parts in 10 million. Manual means of adjustment is provided to vary the frequency over a range of more than 200 parts in a million. This adjustment permits cycling the oscillator until the timing of the receiver-indicator is in exact step with the recurring pulses received from the transmitting stations.

C. *Timing markers.*—Through the medium of its timing circuits, the indicator provides a sequence of precise timing markers spaced at convenient intervals to facilitate measurement of time sequences with a basic accuracy in the order of plus or minus 1 microsecond.

D. *Time base.*—The sweep generators provide a slow sweep as outlined in the system specification which covers the entire recurrence interval by means of a divided trace. A fast sweep lasting in the order of 200 microseconds or less is provided and by means of delay controls may be positioned to examine the particular section of the time base at which a signal appears. For convenience in identification and for purposes of triggering and delay measurement, a pedestal or raised rectangular pulse appears on the slow sweep presentation in the portion covered by the fast sweep. Timing arrangements are made to permit the fast sweep generator to fire at a predetermined point on both the upper and lower traces.

E. *Matching pulses.*—To measure loran time differences, the time base is cycled with respect to the transmissions until the master and slave signals appear at convenient points on the upper and lower traces respectively, with adjustment being made such that the fast sweep generator fires precisely in the region of both signals. The signals are examined on the scope operating on fast sweep and a fine adjustment is made until the pulses are superimposed or matched with respect to time. Time-difference measurements are made by means of timing markers, or, in the newer equipments, are read directly from a mechanical counter.

F. *Equipment power requirements.*—Loran receiver-indicators for shipboard installation are designed to operate on 115-volt (nominal), 60-cycle, single phase, alternating current, and require from 200 to 300 watts.

Aircraft equipments are made to operate on voltages of from 80 to 115, single phase, alternating current, and on frequencies from 360 to 2,460 cycles. Equipments require less than 300 watts.

G. *Receiving antenna.*—Receiving antenna installation is simple since only a vertical wire is required. A length of 50 to 60 feet is considered desirable, although satisfactory operation is experienced when physical conditions require considerable decrease in the effective antenna length.

H. *Method of obtaining loran readings.*—Some of the loran receiver-indicator equipment now in use was developed and manufactured during the war. This type of equipment requires that time difference determinations be made by matching master and slave pulses and then, by switching to additional scope selection positions and by reference to a set of markers, counting the divisions and thereby arriving at the reading. Receiver-indicators are now being manufactured and installed which incorporate direct-reading counters; thus, once the pulses are matched, all that is necessary to determine the time difference reading is to refer to a counter device which shows directly the proper numerical reading.

18–5 GENERAL OPERATING INSTRUCTIONS FOR TRANSMITTING STATIONS

18–5–1 General—

A. The instructions contained in parts 18–5 and 18–6 outline in general the administration and operation of loran transmitting stations. The functions of master and slave stations, the duties of personnel, and general information important to the efficient operation and administration of a station are set forth.

B. These instructions are supplemental to, and do not relieve commanding officers or officers-in-charge of loran stations of, any duties or responsibilities imposed on them by law or Coast Guard regulations.

18–5–5 Supervision and Synchronism—

A. Reports are received from both marine and aircraft interests from time to time requesting explanation of inaccurate results obtained at times using loran. Reports of this nature often result in considerable embarrassment to the Coast Guard because, upon analysis of the reported inaccuracy, it must be concluded that the cause of the inaccuracy is in the transmission of loran signals which are out of synchronization, without blinker signal.

B. *Errors due to improper operation.*—It is probable that many inaccuracies reported are due to errors in the equipment operation of the user. Many others, however, are attributable to improper transmitting station operation. It is necessary that all possible effort be exerted toward elimination of errors in loran service caused by improper operation at loran transmitting stations. Errors of this nature must be eliminated, not only to avoid damaging criticism of the Coast Guard but, even more important, to avoid disaster to aircraft or vessels which might be blindly led into danger by faulty loran service.

(1) *The sole purpose of loran transmitting stations* is to transmit reliable signals for use as an aid to marine and air navigation. All other work of the stations must be made secondary to this duty. Transmission of reliable signals requires more than standing proper watches in the signal building. Constant attention must be given to preventative maintenance of the transmitters, timers, and associated equipment as well as antennas and ground systems. Test equipment must be maintained in proper adjustment and spare parts maintained and stowed systematically.

(2) It is not intended to minimize the necessity for maintenance of other station equipment, grounds, and buildings. Nor is it implied that per-

sonnel comfort and welfare and the routine administrative duties of loran station commanding officers should be overlooked. These matters all contribute to the efficient functioning of the station, but they must be considered in their proper place with relation to the primary mission of transmitting reliable loran signals.

C. *The slave station of a rate is responsible for maintaining proper synchronization of the rate.* The master station monitors the rate for accuracy of synchronization and each station acts as a check on the other. Both stations maintain a continuous watch on the rate and by means of the blinker signal must indicate to the users of the system when the rate should not be used due to improper operation. Therefore, if operating personnel are properly standing watch, it is not possible for inaccurate loran service to be provided without the users being advised of this inaccuracy by means of the blinker signal.

D. Unfortunately, however, loran operation is not yet advanced to the point where human shortcomings are completely eliminated. The service not only fails but might provide false navigational information if the personnel at the slave station fail to maintain synchronization and the personnel at the master station fail to keep a check that synchronization is maintained.

E. *Automatic synchronization equipment,* where specifically authorized by Headquarters for operation, is intended to lighten the load of watch personnel. *It is not intended to replace them.* "Auto-Sync" is not a cure-all. It is subject to erratic operation during atmospheric interference and, like all equipment, it can break down. Operating personnel must realize that operation of automatic synchronization equipment does not relieve them of the responsibility of maintaining loran rates in proper synchronization. Use of automatic blink is not authorized. It is imperative that operating personnel maintain a close watch on the automatic synchronization equipment for proper operation and manually blink the loran signal when necessary.

F. Although limited personnel, monotonous watches and isolated duty may be factors not conducive to a high sense of attentiveness to duty, operating personnel must realize that failure to properly perform their duties may very well result in a disaster involving the loss of many lives and valuable property.

G. *Accuracy and reliability.*—All personnel responsible for the proper operation of loran must be continually impressed with the importance of providing accurate and reliable loran service. For the safety of loran users, the emphasis must be shifted to providing good loran service with properly synchronized signals with less thought to logging low blink time and off-air time. In other words, it is far more desirable to provide less "total usable time" if it can be assured that in so doing the service provided is accurate.

H. *Indoctrination programs.*—District and Section Commanders, as well as commanding officers of loran stations, will initiate programs for the indoctrination of subordinate personnel in the importance of providing accurate loran service. This indoctrination should include instruction on how the loran system is used by aircraft and vessels, explanation of how improperly synchronized loran signals can endanger users of the system, and directing attention of personnel to all reports received which favorably or unfavorably comment on the loran service provided.

I. *Investigate all reports.*—All reports of inaccurate service must be thoroughly investigated to determine the cause of the inaccuracy. Normally, checking the loran logs for the period of the inaccuracy is not sufficient, because, obviously, if a rate is out of synchronization without blinking, the operators are unaware of the out of synchronization condition and, therefore, can only log normal operation for the period. Effort should be more toward determination, if automatic synchronization equipment was being used and if in proper adjustment, whether operating personnel were properly standing watch, time of day, and equipment performance. Appropriate action should be taken when erroneous loran service is provided and which is directly chargeable to personnel negligence.

J. The attention of all loran operating and technical personnel shall be directed immediately to the contents of this chapter and periodically hereafter.

K. The following operating and administrative data form may be completed for the specific station concerned and maintained in this manual for reference purposes.

Operating and Administrative Data for Loran

Transmitting Station______________________

Type Station ______________________________
(SS, SM, DS, DM, etc.)

Loran Frequency ____, Basic Recurrence Rate _____,
Specific Recurrence Rate(s) ____________________

Permissible limit of Synchronization from the assigned standard delay using ground wave synchronization (plus or minus) ______________________
(ms)

Auto-Sync Operation Authorized? _______________
(Yes or No)

Authorized Standard Delay or Time Difference:

Rate(s)	*Standard Delay or Time Difference*	*Effective Date*	*Operating Schedule if other than continuous*
____________	____________	____________	____________
____________	____________	____________	____________
____________	____________	____________	____________
____________	____________	____________	____________
____________	____________	____________	____________

Geographic Coordinates:
Latitude: _________ Longitude, _________

Mailing Address: Radio Call Sign:

18–6 SPECIFIC OPERATING INSTRUCTIONS FOR TRANSMITTING STATIONS

18–6–1 General Duties of Commanding Officer

A. *Responsibility*.—It is the responsibility of the Commanding Officer to properly execute all duties of the station, whether performed by himself or his subordinates. This responsibility includes the cleanliness and proper maintenance of all station structures, equipment, machinery, boats, vehicles, tools, etc., including general painting.

B. *Instruction*.—The Commanding Officer shall personally give proper and complete instructions to station personnel in the care and operation of the station and assure himself that all personnel are fully competent to perform the duties of their watch before being permitted to stand such watch.

C. *Inflammables, etc*.—The Commanding Officer shall be particular that all regulations and instructions regarding the storage of inflammables and other dangerous articles, such as ammunition and arms, and precautions against fire, are enforced.

D. *Classified matter*.—The Commanding Officer is responsible for the safekeeping of all secret and confidential publications, documents, instruments, and equipment, and for the proper disposition of them. He shall see that men attached to his unit have ready access to such classified materials as may be necessary for the proper performance of their duties.

E. *Alterations*.—The Commanding Officer shall be responsible for all important evolutions of the station and shall insure that no material alterations in design, structure and/or layout are effected without proper authorization by Headquarters or the District Commander. He shall further insure that authorized modifications are enacted according to prescribed specifications and shall endeavor to complete such innovations in the most efficient and economical manner that conditions permit.

F. *Delegation of authority*.—It should be general practice to entrust the control of the unit to the next senior member of the unit, not only as a mark of confidence and respect, but also as a preparation if consignment of the duties of the Commanding Officer to another is necessitated. However, no person assigned to the unit can demand such recognition as a right.

G. *Log*.—The Commanding Officer shall establish a station log book and shall issue instructions in maintaining it to the extent that it is accurately and properly prepared. The Commanding Officer shall inspect and approve daily the logs prescribed for his unit.

H. *A Watch, Quarter, and Station Bill* shall be posted where it may be easily observed by station personnel. The Commanding Officer shall cause all subordinates to familiarize themselves with its contents and shall conduct frequent drills to make assurance that it is properly interpreted and effected.

I. *A night order book* should be kept in which he should enter any orders or instructions for the guidance of station personnel at night.

J. *Discipline*.—The Commanding Officer shall, if possible, investigate in person all offenses. The investigation shall not be delegated to any other officer. He shall award punishments within the limits of his authority as prescribed by law and Coast Guard regulations.

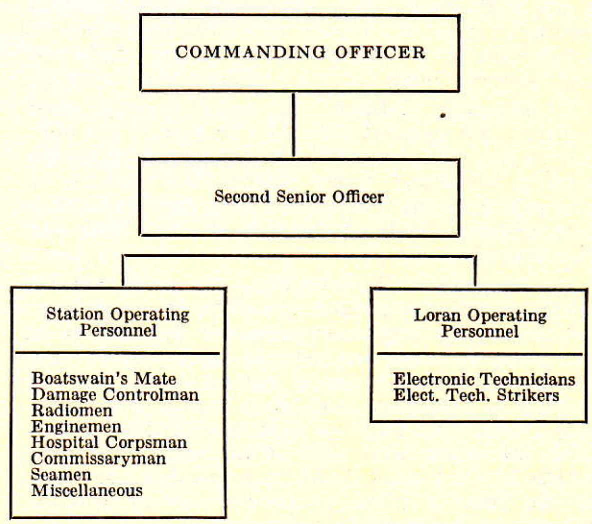
K. *Sanitation*.—The Commanding Officer shall safeguard the health of the personnel attached by careful supervision of the sanitation of his unit and by avoiding unnecessary exposure to disease or unhealthful conditions ashore.

L. *Logistics*.—The Commanding Officer shall maintain and adequate supply of water, fuel, equipment spares, and other essentials, and whenever this supply has diminished to the minimum limits for efficient operation, he shall take appropriate action to replenish the supply as soon as possible.

M. *Liaison*.—The Commanding Officer shall exercise great care that all under his command scrupulously respect the territorial authority of foreign nations in amity with the United States. He shall render every effort to maintain cooperative relations with all civilian and military inhabitants with which he and his unit are associated. Social and business relations should be conducted in a manner becoming to an officer and a gentleman. Local agreements with foreign authorities should be forwarded to Headquarters for information and comment. Under no circumstances shall a Commanding Officer permit activities such that hostile relations or unfriendly agitations are allowed to develop.

18–6–5 Organization—

A. The organization of a Coast Guard loran station will follow the general plan shown below.



B. The following standard personnel allowance has been established for LORAN stations:

(1) Commanding Officer—LT, LTJG, or ENS.

(2) Station Operating Personnel (Non-LORAN Trained):

1–BMC (a)	1–DC2 (d)
1–EN1	1–EN3 (e)
1–CS1 (b)	3–SN (d)
1–HM1 (c)	1–FN (f)

(3) LORAN Operating Personnel (LORAN Trained):

1–ETC (a) or ET1
1–ET2
2–ET3

NOTES:

(*a*) At stations within the continental United States, a commissioned officer is not assigned, and the senior non-commissioned officer assigned acts as Officer-in-Charge. At overseas stations if a BMC is assigned an ETC is not.

(*b*) At stations where personnel are subsisted at other units, the CSI is deleted.

(*c*) At stations where a hospital or doctor can be reached within one hour or less, the HM1 is deleted.

(*d*) At stations where repairs are done by other units, the DC2 is replaced by an additional seaman.

(*e*) At stations using outside electric power, the EN3 is deleted.

(*f*) At stations equipped with LCM's or similar large boats, a BT1 and an additional FN are added.

(*g*) At stations where CW communications are required and installed, a RM2 is added.

18–6–10 Loran Station Functions

A. The function of a loran station is to perform as described in the following paragraphs as efficiently as possible so as to provide accurate and reliable loran service with a minimum of unusable service time.

B. *Master station.*—Transmit steady loran signals with good pulse shapes on the frequency, basic recurrence rate, and specific rate assigned.

(1) Measure the time difference between the transmission of its own pulses and receipt of pulses from its paired slave station.

(2) Blink in accordance with blinking instructions.

C. *Slave station.*—Transmit steady loran signals with good pulse shapes on the frequency, basic recurrence rate and specific rate assigned.

(1) Using the proper coding delay, maintain synchronization with loran signals from its paired master station within the permissible limits.

(2) Blink in accordance with blinking instructions.

18–6–15 Blinking Instructions—

A. *When to blink.*—The blinker signal will be exhibited only when conditions set forth below are found to exist on a particular loran transmission rate and will be exhibited on that rate only as long as these conditions continue to exist:

(1) When the permissible limits of synchronization are exceeded for more than 15 seconds.

(2) When the reception of regular loran ground wave signals at either station is such that synchronization within the permissible limits (SLAVE) or measurement of time difference (MASTER) for the rate being observed is not positively determined.

(3) When the specific rate of the standard signals as transmitted by either station in a pair differs by any amount from the designated specific rate for that pair of stations.

(4) When one station on any assigned rate is off the air.

(5) When the signal transmitted is not standard or is unsatisfactory for operational use.

B. *Blinking procedure.*—The procedure outlined below shall be followed in connection with the exhibition of the blinker signal:

(1) The blinker signal will be exhibited by the first operating station in a pair which observes any faulty signals being transmitted for a period of 15 seconds without correction.

(2) The slave station will promptly "pick up" and continue all blinker signals being initiated by its paired master station.

(3) The master station, if blinking, will cease blinking when its paired slave station on the rate being blinked exhibits its blinker signal.

(4) In the event the master and slave stations on the same rate initiate a blinker signal simultaneously, the master station will cease blinking while the slave station continues the blinker signal until normal operation on the rate is resumed.

(5) A master station observing the blinker signal initiated by its paired slave will acknowledge receipt of the blinker signal by blinking not less than two nor more than five times. Except for this acknowledgment, a master station will not "pick up" and repeat the blinker signal initiated by the slave with which it is paired on the rate in error.

C. *When blinker signal observed.*—Immediately upon exhibiting or observing a blinker signal on a given rate, both stations on that rate will proceed to check all functions in accordance with paragraph 18–12–50 of part B of this chapter and will expedite the correction of any operational defects found.

18–6–20 Conditions Requiring a Report to Higher Authority—

A. A station shall promptly notify the District commander, or his authorized representative through proper channels, for information of the paired station, by the most expedient means of communication available as follows:

(1) When there has existed continuously for 1 hour, or intermittently during the greater part of an hour, any unscheduled impairment of loran service from any cause whatsoever.

(2) When a station is forced to cease transmitting and it is believed that the off-air time will be 1 hour or more.

(3) When loran signals on a designated rate and frequency are definitely observed to be off frequency and/or rate for a period of more than 1 minute without blinking.

(4) When a condition has been corrected that was previously reported by the station or brought to the attention of the station by the district commander or his authorized representative.

18–6–25 Duties of Electronics Personnel—

A. *The Senior Electronics Technician assigned to a station shall:*

(1) Be responsible to the Commanding Officer for the efficient operation, maintenance, and repair of all LORAN and associated electronic equipment.

(2) Insure the proper execution of duties in accordance with existing instructions by all electronic personnel assigned.

(3) Make periodic inspections of the LORAN equipment, antennas, ground systems, spare parts, etc., and report conditions to the Commanding Officer. When the Senior Electronics Technician is assigned as the Officer-in-Charge, these reports do not apply.

(4) Report immediately to the Commanding Officer any condition requiring a report to higher authority.

(5) Inspect all completed LORAN logs and equipment failure reports for compliance with instructions pertaining thereto.

B. *The loran maintenance man shall:*

(1) Maintain all LORAN and associated electronic equipment in proper adjustment and repair, and inspect timers, transmitters, etc., to insure that the Loran equipment is in good operating condition.

(2) Maintain standby equipment in proper adjustment and repair for immediate service, and place standby equipment in service when required.

(3) Immediately notify the Senior Electronics Technician and/or Commanding Officer whenever he feels that he needs assistance in repairing or correcting any equipment failure.

(4) Notify the Senior Electronics Technician and/or Commanding Officer whenever there has existed continuously for 15 minutes, any impairment to LORAN service from any cause whatsoever.

(5) Immediately notify the Senior Electronics Technician and/or Commanding Officer whenever the station is forced to cease transmitting.

(6) As soon as practicable, notify the Senior Electronics Technician and or Commanding Officer whenever defective equipment has been repaired or corrected and is operating normally.

(7) Periodically check quality of LORAN service being rendered by the master and slave stations for the rate rates assigned. This shall be accomplished by use of electronic supervisory equipment when such is installed.

C. The Loran watchstander shall:

(1) Be responsible for the carrying out of the station operational function during the period of his watch.

(2) Maintain a constant watch at the timing and transmitting equipment, making tests and adjustments as necessary to insure proper operation of the equipment.

(3) Maintain standby equipment in proper adjustment for immediate service and place it in operation when necessary.

(4) Immediately notify the LORAN Maintenance Man whenever an equipment failure occurs or whenever an equipment irregularity occurs which he cannot immediately correct.

(5) Notify the LORAN Maintenance Man whenever there has existed continuously for fifteen (15) minutes, or intermittently during the greater part of fifteen (15) minutes, any impairment to LORAN service from any cause whatsoever.

(6) Maintain the LORAN logs in accordance with the instructions pertaining thereto.

18–6–30 Schedule Modifications—

A. Schedule modifications for system maintenance except for emergent reasons will not be inaugurated without authorization from the commander of the cognizant Coast Guard district. Where practicable, request schedule modifications by message to the District Commander or his authorized representative at least 7 days prior to expected date of inauguration of the modified schedule, setting forth reasons for such modification. The request will be reviewed by the District Commander and off-air time authorized if warranted. Headquarters and all interested military commands and civil agencies, will be informed of such authorization.

B. Emergent schedule modification (i. e., schedule modification for which, due to its urgent nature, advance notice in accordance with the time limitation set forth above cannot be given) will be dispatched to the District Commander, with information to appropriate local military commands. Similar notification should be made when normal operation is resumed.

C. All requests or notices of modifications of regular operating schedules, for any reason, will state the loran rate or rates affected and the time periods over which such modifications of schedules will apply. If the time periods are not known, then estimated time-off period, date and time restoration of service should be given. GMT will always be used.

18–6–35 Watches—

A. *Watch schedule.*—The commanding officer shall establish a system of watches for all technical personnel attached to his unit and shall keep a loran watch schedule posted at all times where it is easily observed. No person, while assigned to a watch, shall have any duties other than those required by the watch nor will he be relieved without permission of the commanding officer except as is indicated in the watch schedule. The commanding officer shall see that capable personnel are assigned to the various duties and that alert and efficient watches are stood. Technical personnel will have no nontechnical duties which conflict with their regular watches on loran equipment, but this does not mean that they cannot have other duties, when not on watch, which are not of a technical nature.

B. *Loran maintenance.*—The two Senior Electronics Technicians shall act as LORAN Maintenance Men and perform the general duties outlined in paragraph 18–6–25A (2). One of these men shall be present at all times. Normally, the LORAN Maintenance Man should be assigned as such for a week at a time as a day worker. Every opportunity should be given to the watchstanders to assist the LORAN Maintenance Man so that their professional knowledge and the technical efficiency of the station are advanced.

C. *Loran watchstander.*—All Electronics Technicians and strikers other than the LORAN Maintenance Men will be arranged in watch sections so that at least one man is on watch at all times performing the duties outlined in paragraph 1–5–1 (C). Should circumstances require, the Commanding Officer, at his discretion, may augment the number of watchstanders by utilizing non-electronics personnel provided they have been qualified by the Commanding Officer and can be supervised by the LORAN Maintenance Men. No man should be required to stand more than a total of eight hours watch per day except when circumstances so require.

18–6–45 Security Delays—

A. Standard delays will not be changed nor security delays instituted without specific authority of Coast Guard Headquarters.

B. *Alteration procedure.*—In the event that it becomes necessary to alter the existing standard delays used by slave stations through the introduction of an additional "security delay," all stations will be prepared to take the necessary action to accomplish same when so directed. The Commanding Officer shall see that personnel are informed that the standard delay may at some date be changed for security or operational reasons by an amount called a security delay. He shall have adequate instructions posted such that errors in effecting same will be eliminated. Authorized changes of all delays will be supervised by the Commanding Officer and he will assure himself that the proper delay is being used before leaving the operating room. Reports of such changes will be recorded in the station log. During the absence of the Commanding Officer, the person acting in his stead shall have the responsibility for effecting these changes.

18–6–50 Drills—

A. The Commanding Officer shall schedule, organize, and supervise the execution of fire, resuscitation, signal, and such other drills as may be necessary insofar as conditions will permit. The object of all drills is to perfect the organization as a whole, and the greatest efficiency in this respect is attained when each member of the unit is proficient in his particular duties.

PART B

MAINTENANCE INSTRUCTIONS

18–10 GENERAL MAINTENANCE INSTRUCTIONS FOR LORAN TRANSMITTING STATIONS

A. LORAN, as a precision electronic Aid to Navigation system, must provide air and surface navigators with information which is consistently accurate and always reliable. Only the highest standards of technical knowledge and equipment maintenance will enable the United States Coast Guard to meet fully its responsibility for the successful operation of the LORAN system.

All technical personnel assigned to LORAN transmitting stations shall comply with the following instructions in order that all LORAN and other electronic equipment will be operated, adjusted, and maintained in accordance with the standard practices outlined herein.

Part B of this chapter contains general engineering information pertaining to the various components of the LORAN system of navigation. These instructions present the technical standards for engineering and maintenance of the LORAN electronic, electrical, and associated equipment. To establish maximum reliability, accuracy, and efficiency of operation of this equipment, service personnel must be thoroughly familiar with the standards set forth in the following paragraphs.

18–11 DEPLOYMENT AND UTILIZATION

18–11–1 GENERAL—

The deployment of LORAN transmitting stations is determined by estimating the desired service area, adjusting the area to fit the geographical limitations of the available sites, then readjusting to provide a maximum LORAN coverage.

A. The desired service area is that region in which the LORAN transmissions will be of service to the largest numbers of users. The geographic limitations are suitable LORAN transmitting station sites, logistic convenience, attenuation characteristics in the direction of the service area and the paired station or stations, baseline distance between stations, and the orientation of these baselines.

B. LORAN transmissions are extensively used over heavily traveled ocean routes and other areas by civil and military aircraft. Most U. S. military and several hundred merchant vessels are equipped with LORAN receivers in obtaining "all weather" accurate navigational positions.

18–11–5 TRANSMITTING STATION SITE, ELECTRONIC REQUIREMENTS—

A. The LORAN transmitting station site must provide space for the following structures:

(1) LORAN transmitting antenna and associated ground system.

(2) LORAN receiving antenna(s) and associated ground system(s).

(3) Communications transmitting antenna and associated ground system.

(4) Communications receiving antenna and associated ground system.

(5) LORAN signal building.

(6) Power Building (if provided).

B. Since maximum ground wave coverage is required for optimum utilization of LORAN transmissions, great care is used in selecting a site from those available. Maps and charts are consulted for approximate locations, and aerial photographers of possible sites are examined carefully. Then site survey parties select the most appropriate site on the basis of site selection instructions and service area requirements. The best site has the shortest overland transmission take-off path to the paired station(s) and service area, good ground conductivity, high water table level, and proximity to shore lines. The site should be reasonably level or be leveled, and be cleared of trees and unnecessary obstructions at least over the area used for the LORAN transmitting antenna ground system.

C. The LORAN transmitting antenna ground system is the largest grounding structure in the system. It consists of a 600-foot circular web of conductors which are generally buried just beneath the surface of the ground for protection. Spatial limitations may force omission of some of the ground system area, but 300-foot radials will run from beneath the antenna to as large a part of the area as possible. Buildings should not be erected on the baselines of the system.

18–11–10 BUILDINGS

A maximum of two buildings is required for the technical equipment of a LORAN station: (1) a LORAN signal building which houses the transmitters, amplifiers, timers, switching equipment, communications equipment, etc., and (2) a power building which houses the engine-generators and provides workshop space. In some cases a single building is provided which combines the functions of (1) and (2). The heavy floor loading by transmitters and timers will be adequately supported by concrete floor slab construction designed for 250 pounds per square foot loading with additional isolated foundations for engine-generator units. A Coast Guard LORAN signal building is shown in figures 18–20 and 18–21 which is typical of current design.

In installations using timers and switch gear other than AN/FPN–30 and AN/FPA–2, a shielded room within the LORAN signal building is provided to house and shield the timers and switch gear from the strong signal radiated by the local LORAN transmitting antenna. This room consists of a framework of wood two-by-fours, spaced 16 inches apart, covered and lined outside and inside with ¼" mesh zinc dipped hardware cloth, with all junctions overlapped and soldered together. There are no

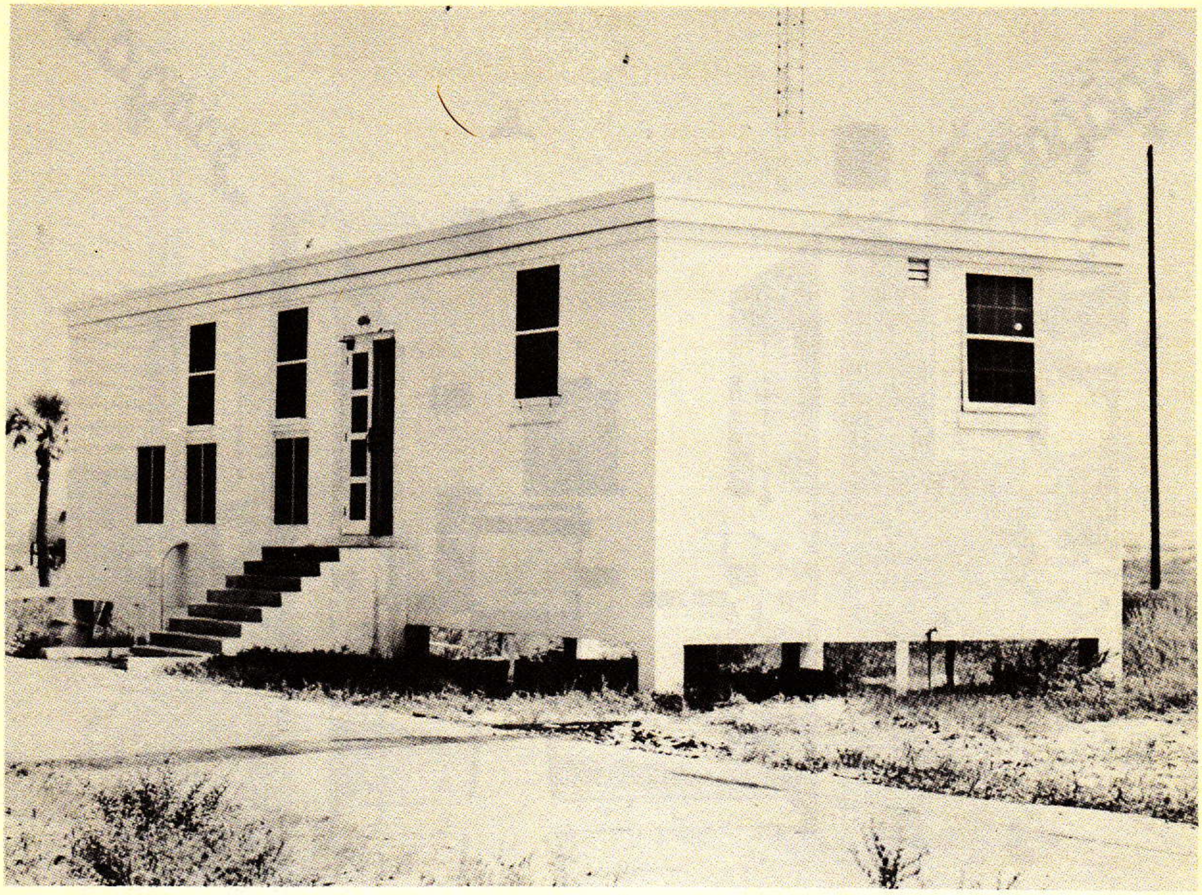


FIGURE 18–20.—Coast Guard LORAN Signal Building.

electrical connections between the inner and outer screens except at the switch gear. Flooring is provided to electrically insulate the equipment in the timer room from the inner screen and to protect the inner screen from damage. A door not less than six feet high and three feet wide is provided. The wire screening, covering both sides of the door, electrically connects the walls of the screened room by means of electrical weatherstripping, copper and brass strip, so that a continuous contact results when the door is closed. Floor covering and filtering or air conditioning to reduce dust are recommended. A typical signal building floor plan is shown in figure 18–10. Two transmitters and four timers are shown, as required for double pulse operation. For single pulse operation only two timers are needed. However, space for four timers is usually provided for system expansion.

18–11–15 EQUIPMENT—

The basic electronic equipment of a LORAN transmitting station consists of three units: the transmitter, the timer, and the switch gear. The transmitters and timers are installed in duplicate; the switch gear provides duplicate and some triplicate independent switching functions. In case of a malfunction, the switch gear provides a means of rapid change over to the standby timer. A timer frequency checking system for using WWV standard frequency transmissions is included in the miscellaneous equipment installed in the timer room.

Supervisory monitoring equipment is provided in duplicate for making independent time difference checks as an auxiliary system using its own antennas. Engine driven generators installed in duplicate provide power for stations where no outside power is available, and standby power for stations using external power sources.

Communications transmitters, receivers and associated antennas are provided those stations which are without other means of communication.

Adequate electronic test equipment is provided at all stations. A complete list of LORAN equipment is given in figure 18–22 with notes explaining contradictory names and nomenclatures.

18–11–20 TRANSMITTING STATION ELECTRONIC LAYOUT—

After the best possible location for a LORAN transmitting antenna has been selected, the other

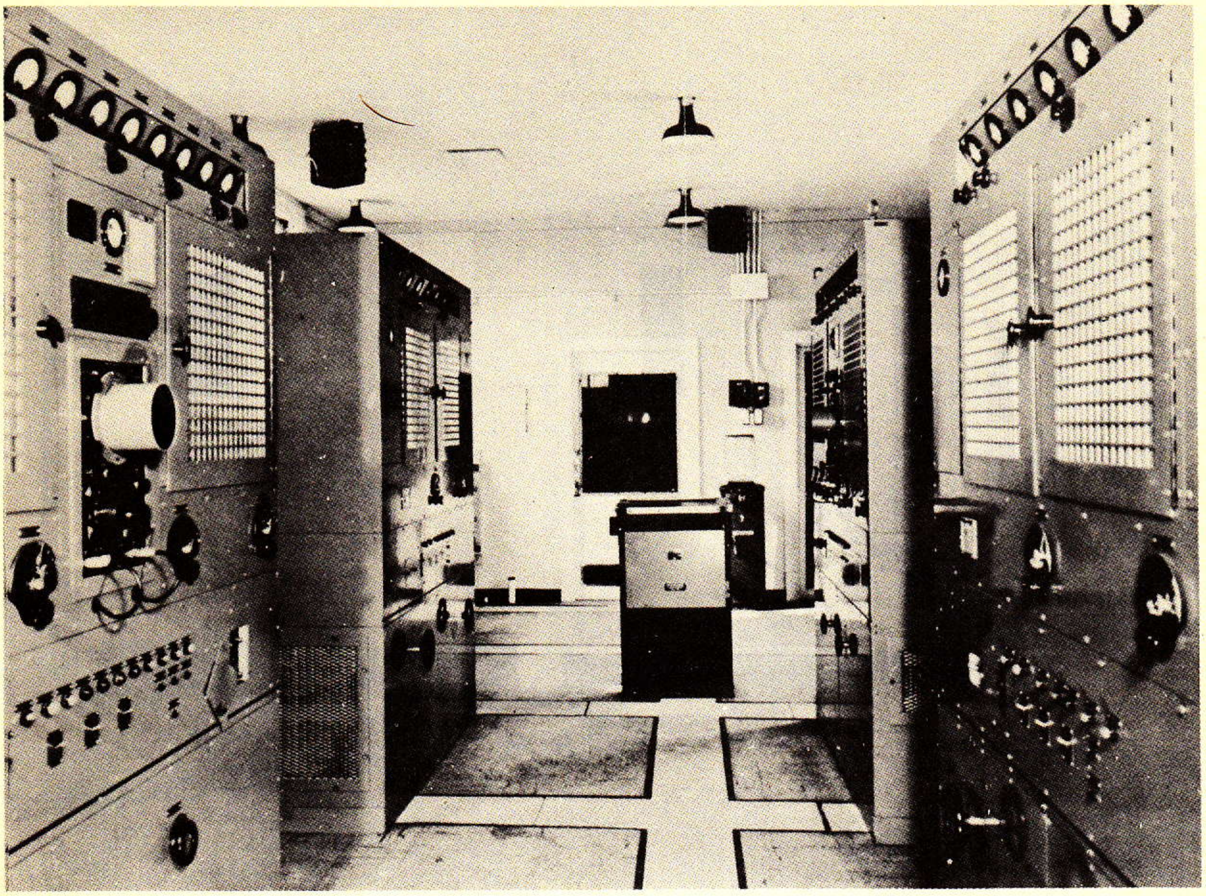


FIGURE 18–21.—Interior of LORAN Signal Building, Transmitter Room.

structures and elements must be located as efficiently as possible. A typical electronic layout is shown in figure 18–23, Electronic Layout. If a tower antenna is used, the signal building should be located at a distance from the tower greater than the height of the tower to avoid possible damage in case the tower should fall. The LORAN romote receiving antenna and its associated ground system shall, if possible, be located on the baseline extension and at least 350 to 500 feet from the transmitting antenna. If the station is double pulsed, the remote receiving antenna shall, if possible, be located on the bisector of the angle formed by the intersection of the baseline extensions and at least 350 to 500 feet from the transmitting antenna. The monitoring antenna should be over 500 feet from the transmitting antenna and as near the baseline extension as possible, without interferring with the LORAN remote receiving antenna(s). The communications transmitting antenna shall be located at the LORAN signal building. The broadband communication antenna should be as far as possible (at least 1,000 feet) from the LORAN transmitting antenna. If a comb receiving antenna is used, it should be located several hundred feet to one side of the transmitting antenna location and orientated toward the remote station. Power supply equipment should be located in accordance with approved plans.

18–11–25 MOBILE STATIONS—

A. Mobile LORAN units are designed to provide immediate LORAN navigational service from advanced base areas. The entire station, as shown in figure 18–24 Mobile Transmitting Equipment, uses standard LORAN communication and power equipment, and is permanently mounted in trailers which are towed into position, electrically interconnected by cables and plugs, and made ready for immediate operation. The transmitters and associated equipment are in one trailer, the timers and their equipment in another trailer separated a few feet, and physically connected by a removable covered passage as shown in figure 18–25.

Only the antennas, ground systems and interconnections have to be set up, thus shortening set up and construction time. Since standard equipment is installed in the trailers, the service supplied by these mobile units is in every way equal to permanent stations.

B. A typical mobile LORAN station consists of the following units:

NAME	NO. REQ.	STANDARD	SUBSTITUTE STANDARD	OBSOLETE
Timer: Single Pulse Double Pulse	2 4	AN/FPN-30, UE-1b	UE-1	UJ, C1
Switch Gear	1	AN/FPA-2, UM (Mod. for T-137/325 series Transmitters)		UM (UNMOD.), C1, UK
Transmitter	2	T-325B/FPN, T-325A/FPN, T-325/FPN, T-137A, T-137		TDP-1
Amplifier	2	AM-701/FPN, T-138A, T-138		
Junction Box, Transmission Line Junction Unit, or Switching Group, RF	1	AN/FPA-3, J-455/FPN, MA-221		
Loran Transmitting Antenna Coupler	1 or 2	CU-277/URT	CG-47368	
Loran Receiving Antenna Coupling Unit	1 or 2	CAQT-47438		
Oscilloscope	2	256 D		OBN (used with TDP-1)
Isolation Transformer	2 1	TF-191/FPN (12.5 kva Timer Room) CG-301227		CG-301227 for timer room use
Communication Transmitter	1 or 2	AN/FRT-23, TCK-6, TCK-4, TDE	as assigned	
Communication Receiver	3 to 5	R115, RBH-2, R100, RAO	as assigned	
Receiver Indicator	2	RD-137, DAS-A		
Discriminator	1	MR-197B		MR-197
Supervisory Rack	2	MR-213		
Timer Frequency Check Rack	2	MR-215		
Communication Rack	1	MR-214		
Mixer Panel	1	(WWV or WWVH)		
Isolation Box	1	MR-204 (Supervisory Room)		
TEST EQUIPMENT				
Oscilloscope	1	(as furnished)		
Wavemeter	1	724 A		
Standard Signal Generator	1	LP series		
Voltohm-milliammeter	1	MM-115A		
Vacuum Tube Voltmeter	1	(as furnished)		
Capacity Analyzer	1	(as furnished)		
Frequency Indicator	1	LM-15		
Tool Test Set	1	AN/USM-3 Kennedy Tool Kit as issued		
Vacuum Tube Tester	1	TV-3A/U		
INTER-COMMUNICATIONS EQUIPMENT				
Sound Powered Intercom-master	5			
Sound Powered Single Station Handsets	7			

FIGURE 18–22.—LORAN Equipment.

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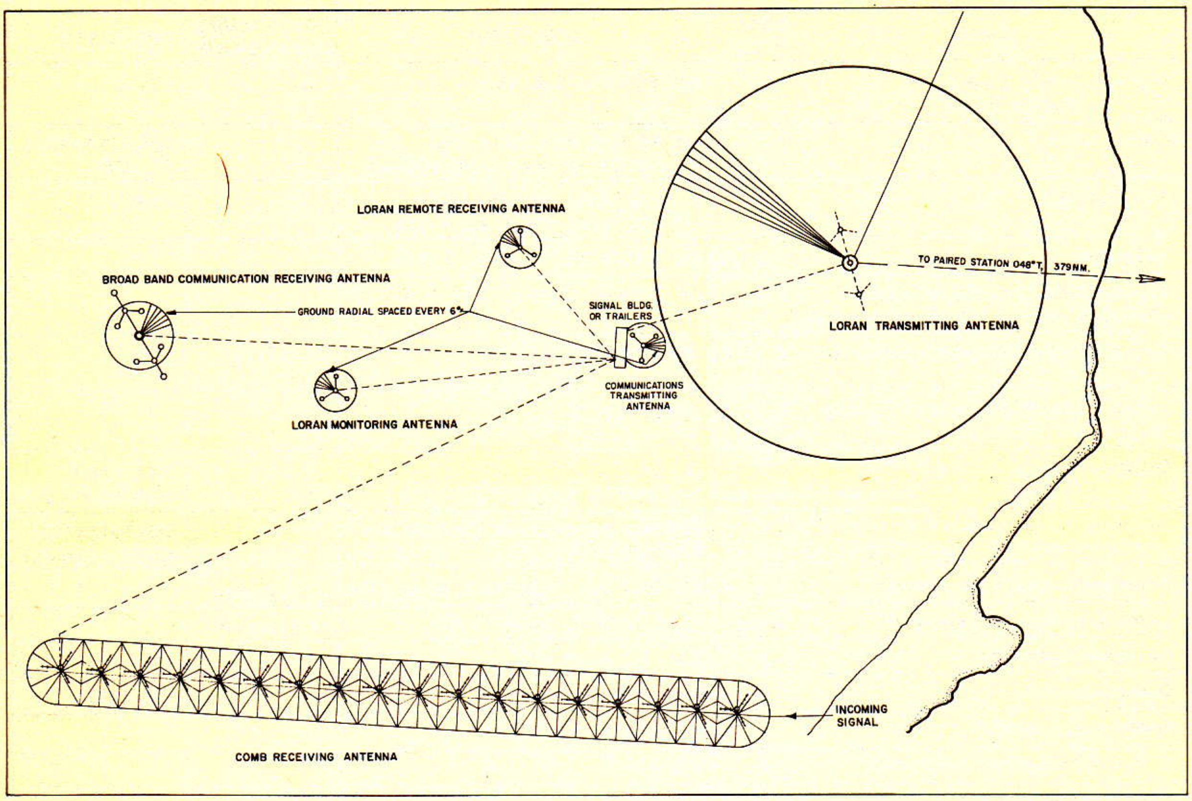


FIGURE 18–23.—Typical LORAN Station Antenna Layout.

(1) One Transmitter Trailer Type V–69/MPN which houses:

- (*a*) Two T–137 or T–325/FPN series transmitters.
- (*b*) One TCK–4 or TCK–6 communication transmitter and its rectifier power unit.
- (*c*) One MA–221 Junction Box.

(2) One Timer Trailer Type V–68/MPN which houses:

- (*a*) Two or four Model UE–1b Timers.
- (*b*) One Model UM Switch Gear (modified).
- (*c*) One communications rack containing two RBH–2 receivers, one R–100 receiver, one WWV mixer panel and one TCK–4 or TCK–6 remote control unit and hand key, auxiliary speakers, clock and a desk.
- (*d*) Power isolation transformers.
- (*e*) Air conditioning and heating equipment.

(3) Two Power Trailers Type V–70/MPN with engine generators, power distribution panels and work shop space.

(4) LORAN transmitting antenna, antenna coupling unit, and ground system.

(5) LORAN receiving antenna, coupling unit, and ground system.

(6) Communications receiving antenna and ground system.

(7) Communications transmitting antenna and ground system.

18–12 TECHNICAL INSTRUCTIONS

18–12–1 GENERAL—

The installation of all major items of electronic equipment is made in accordance with standard plans promulgated by the Commandant (EEE). Deviation from such plans shall not be made unless specifically authorized by the Commandant (EEE) or by cognizant District authority. Subsequent changes in the electronic equipment plant shall be made only when such change has been approved by an Electronics Alteration Request, Form CG–3439. The latter request for alteration is usually initiated by the cognizant District. Installation instructions pertaining to the various models of individual equipment are included in the instruction books for the equipment. The following paragraphs present specific technical instructions which must be followed by LORAN station technicians.

The standard models or types of equipment listed in figure 18–22 are specifically covered by the following technical instructions. For information on other models refer to the applicable instruction books. Two copies of the instruction book are normally supplied with each electronic equipment. Files of instruction books shall be maintained up to date and in agreement with the latest information on changes, revisions, etc., as promulgated by Coast Guard Instruction Book Amendments. The instruc-

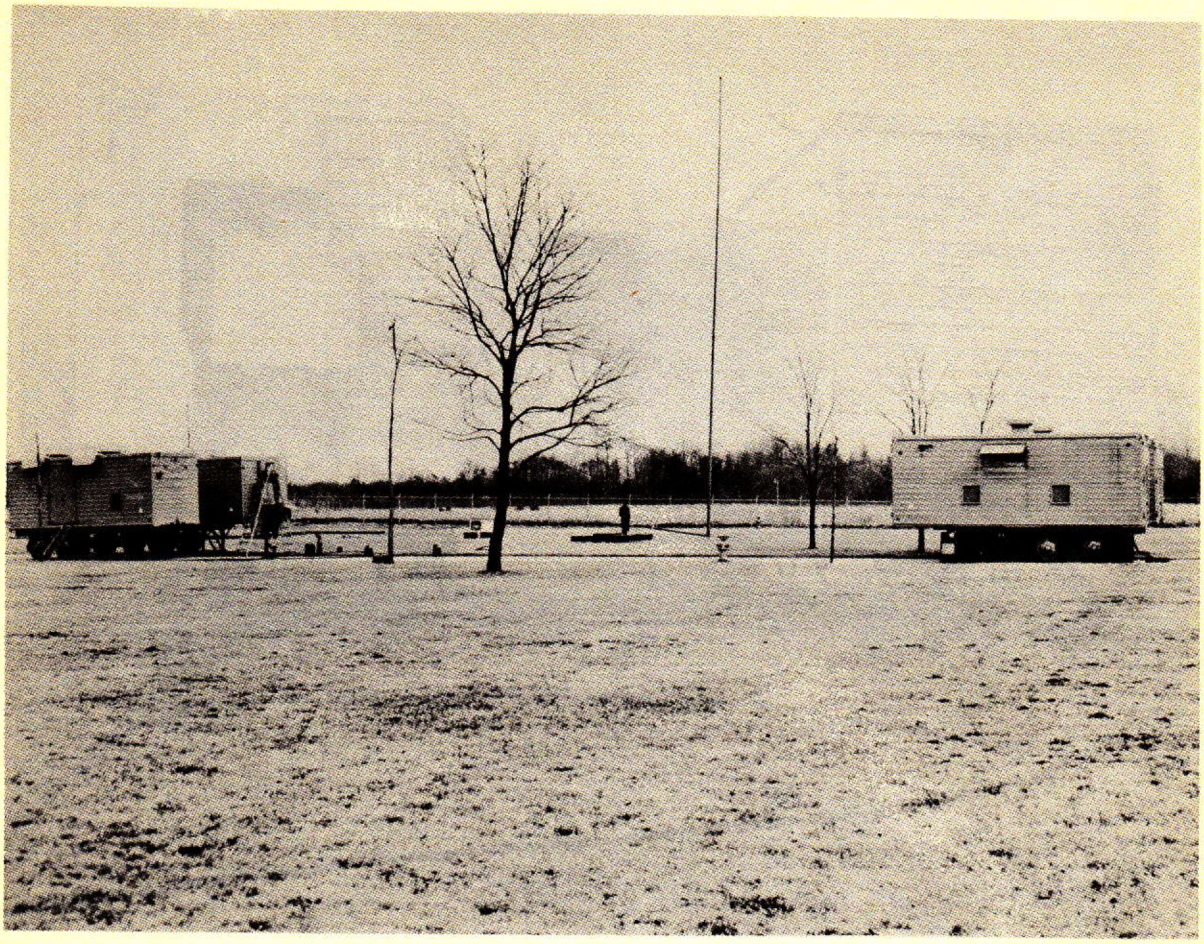


FIGURE 18–24.—Mobile Transmitting Equipment.

tion book is an official document and all contents therein shall be considered as emanating from the Commandant. Attention is invited to the letter of promulgation which establishes the official status of the instruction books. The instruction books furnished with the equipment are a part thereof and shall always accompany the basic equipment.

18–12–5 SAFETY

LORAN equipment employs voltages which are dangerous and may be fatal if contacted. It is, therefore, extremely important that special precautionary measures be understood and observed by all personnel authorized to open or service the equipment. All maintenance work must be performed in a careful and intelligent manner.

In addition to the special safety precautions which are cited in the instruction books for each unit in the LORAN system, some general safety rules are listed below:

(1) Keep away from live circuits. Do not change tubes or make adjustments inside the equipment with the high voltage supply on. Under certain conditions, dangerous potentials will exist in circuits even with the power controls in the OFF position due to charges retained by capacitors. This is especially true with circuits directly associated with cathode ray tubes. Always remove power first and then discharge to ground all circuits before touching them.

(2) Cathode ray tubes must be handled with extreme care. Because of their large size and high degree of evacuation, they are apt to implode violently if cracked or broken. Always wear goggles and gloves (or other approved protective clothing) when handling these tubes. Do not grasp any of the various tubes with the bare hands or contact them with the forearm. They become very hot after prolonged use and can cause painful burns.

(3) Do not depend upon door switches or interlocks for removing voltages from equipment. Remove power first! 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.

(4) Before measuring potentials in excess of 1,000 volts, attach the approved type voltmeter leads while equipment is de-energized. Then, turn power on

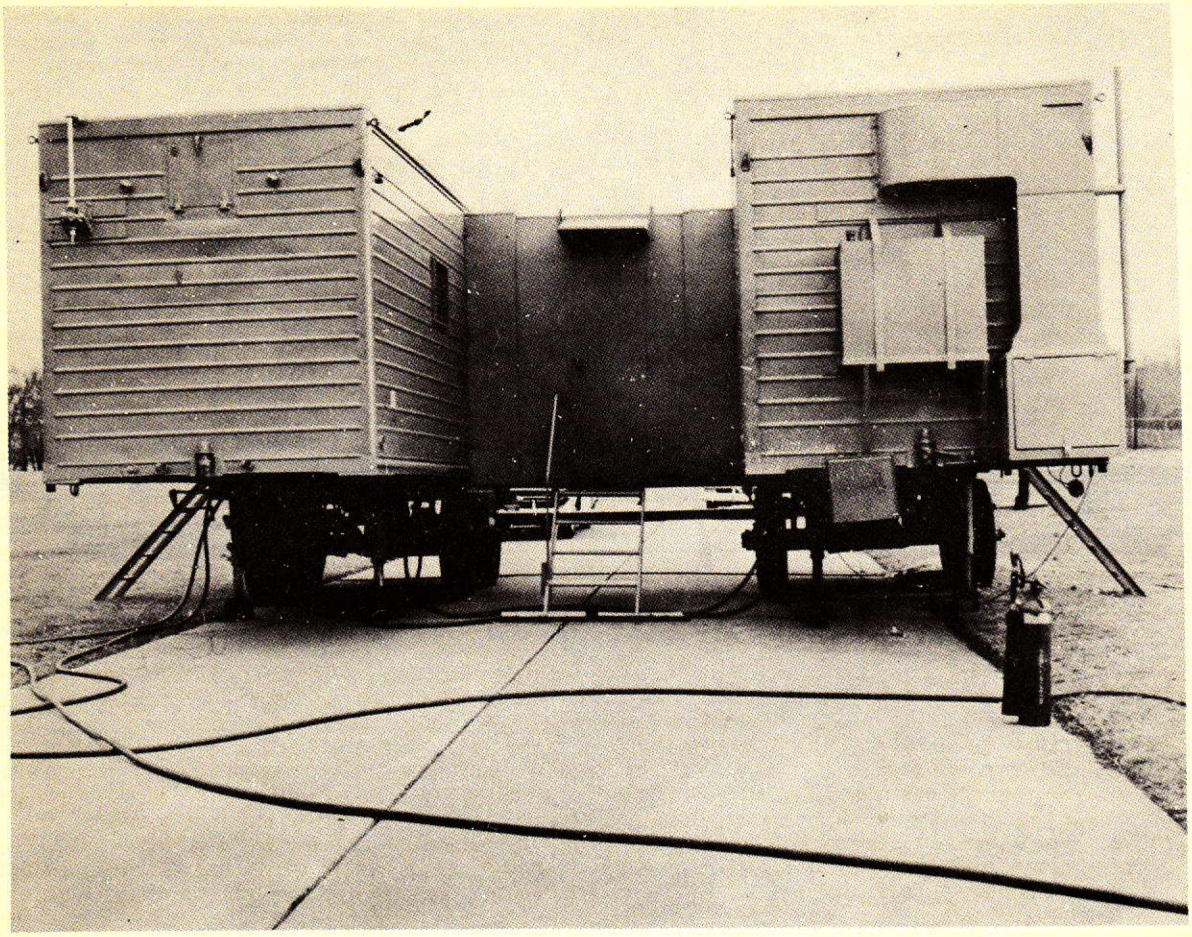


FIGURE 18–25.—Mobile Equipment—Transmitter and Timer Trailers.

and take readings. De-energize again before taking leads off.

(5) Do not remove the protective covers from, or touch the high voltage test jacks of the high voltage power supply at any time that the power is on. Throw the high voltage OFF first, and then remove the cover and connect the test meter for voltage measurements.

(6) Do not service or adjust the equipment alone. Always have the immediate presence or assistance of another person capable of rendering first aid if it be necessary.

18–12–10 PLACING NEW EQUIPMENT IN SERVICE—

A. *General.*—This section deals with the initial testing and operation of new equipment as differentiated from its installation. Timers, transmitters, and switching equipment must be dried out thoroughly before an initial application of power. Either space heaters or portable banks of lamps supplying 200 watts or more shall be utilized.

B. *Procedure.*—

(1) Study the applicable instruction manuals.

(2) Examine all power, ground, and antenna connections for good physical and electrical contacts.

(3 Measure resistances of dummy loads in transmitters, amplifiers, and antenna coupling units.

(4) Accomplish coarse adjustments indicated in the instruction manuals necessary to set up the timers, switching equipment, and transmitters for operation as a master or slave on each LORAN rate (1H2, 1H3, etc.) assigned to the station.

(5) Adjust equipment input voltage in accordance with instruction manuals.

(6) For initial testing and adjustment of Timers, Model UE–1 series:

(*a*) Place the SPACE HEATER toggle switch at the rear of the main power supply chassis to the ON position. Check toggle switch indicator on main power supply panel.

(*b*) Place the CRYSTAL POWER switch in the ON position and lock. This switch is located on the main power supply.

(*c*) Throw the MAIN POWER switch ON.

(*d*) BIAS POWER supply and HIGH VOLTAGE POWER supply should be ON.

(*e*) Allow 24-hour warm-up period.

(*f*) Proceed with timer instructions in accordance with the instruction book.

(7) For initial testing and adjustment of SWITCHING EQUIPMENT, Model UM series:

With Transmitter off:

(*a*) Be sure that the discriminator input cable, the receiving antenna cables, and the attenuator bias cable connections are made properly.

(*b*) Set the input selector switches located at the upper rear of each discriminator unit in the proper single antenna position.

(*c*) Set the power switches in the ON position, and check to see that the power indicator light is on. Observe the fuse failure indicators along with the voltmeter and frequency meter for proper indication.

(*d*) Observe and adjust power supply voltages to correct value.

With transmitter on:

(*e*) Determine whether the antenna termination in the entrance box should be in the ATTENUATED or NON-ATTENUATED position, in accordance with the instruction book.

(*f*) Adjust local signal resistance attenuators (located beneath each discriminator unit) for proper local pulse amplitude range at the Timer.

(*g*) Ascertain the continuity of signal carrying circuits, and operation of discriminator units (specific information for doing this can be found in the Switching Equipment Instruction Book).

(8) For initial testing and adjustment of the TRANSMITTER, Model T–137 or T–325/FPN series.

(*a*) Place the MAIN switch in the OFF position.

(*b*) Place the FILAMENTS switch in the OFF position.

(*c*) Place the LOW VOLT-BIAS switch in the OFF position.

(*d*) Place the HIGH VOLT switch in the OFF position.

(*e*) Place the EXCITER A switch ON.

(*f*) Place the EXCITER B switch ON.

(*g*) Adjust the following controls to the maximum clockwise position: DBLR BIAS control, IPA BIAS control, 2nd IPA BIAS control, PA BIAS control.

(*h*) Adjust the following controls to the extreme counter-clockwise position: FILAMENT VOLTAGE and PLATE VOLTAGE.

(*i*) Place the POWER switch of the OSCILLOCOPE in the OFF position.

(*j*) After closing the MAIN switch, proceed with the adjustments in accordance with the instructions in the appropriate transmitter manual.

(*k*) Switch the transmitter excitation circuit originating in the timer to the proper input in the transmitter.

(*l*) Place transmitter into operation on dummy load, using proper frequency, standard pulse rise time, and standard pulse width.

(*m*) Repeat above procedure with second transmitter.

(*n*) Cut off transmitter HIGH POWER, disconnect dummy load and connect transmitter output to the coaxial transmission line. Place link in the transmission line junction unit to connect operating transmitter to proper antenna coupling unit.

(*o*) Place the operating coupling unit link to dummy load.

(*p*) At the transmission line junction unit, connect the monitoring line from the operating transmitter to the proper antenna coupling unit.

(9) *Antenna Installation.*—The antenna impedance shall be measured with a suitable RF bridge when the antenna is first installed. A typical measuring setup would consist of a General Radio Type 916A RF Bridge, a suitable Signal Generator, and a good communications receiver covering the frequency range of 1500 kc. to 2200 kc. for use as a bridge detector. Connect these equipments as indicated in their appropriate instruction manuals. Sufficient data shall be taken to plot a resistance and reactance versus frequency curve over the range from f−200 kc. to f+200 kc., where f is the assigned LORAN frequency. If the reactance curve approaches zero, the frequency range should be extended so that the curve includes the zero point. Refer to the instruction manual for the proper technique for tuning the antenna coupling unit.

(10) *Receiver Indicator Discriminators.*—The MR–197–B Discriminator is used in conjunction with the LORAN Receiver-Indicator in the supervisor's room and should not be confused with the discriminator (ESU) in the switching unit installed in the timer room. This discriminator makes it possible to attentuate or reduce the local signal at the station where it is located without impairing the strengh of the signal from the remote station. Switching is provided to attentuate the local signal. For operation at a master station, the ATTENUATED TRACE SELECTOR should be in the UPPER position. If the unit is installed at a slave station, the selector should be in the LOWER position.

The attenuation of the local signal is adjustable in three steps by switch SW–3, which is labeled "Near Signal Attenuator Pad."

Initial adjustments of the MR–197–B Receiver Indicator Discriminator involve the following steps.

(*a*) The NEAR SIGNAL ATTENUATOR PAD should be set at POSITION 3.

(*b*) LO REJECT should be set at minimum; HI REJECT at maximum. The RF REJECT FILTER should be placed in a full counter-clockwise position.

(*c*) In the case where the signals cannot be balanced due to a weak local signal, reset NEAR SIGNAL ATTENUATOR PAD switch to position 1 or 2.

(*d*) If the local signal is too large with attenuator pad in position 3 and the BALANCE control on the Receiver Indicator is adjusted for minimum local signal, the 6 db pad in the discriminator antenna input circuit will have to be connected. If the local pulse remains too large after this is done or if the remote signal level is now too low, the receiving antenna will have to be moved farther away from the transmitting antenna.

(*e*) In normal operation with no changes of equipment taking place, the determined setting of the NEAR SIGNAL ATTENUATOR PAD does not need to be changed. The ATTENUATED TRACE SELECTOR can also be left at the position of initial adjustment.

For more detailed instructions refer to manual CG–273–3.

18–12–15 CHANGEOVER PROCEDURES FOR EQUIPMENT—

A. *General.*—In normal station operating procedure two transmitters are used with one transmitter in operation and the other on standby. It is extremely important that the changeover from one transmitter to the other be accomplished in a minimum of time. This applies equally to amplifiers, timers, electronic switching units (ESU) and supplementary equipment. On-air equipment shall remain in service until such equipment requires preventive or corrective maintenance. All equipment on standby shall have filament switches ON at all times.

B. *Manual Changeover.*—The following paragraphs present the procedures to be followed at LORAN station installations where semi-automatic changeover equipument is not installed.

(1) *Transmitters.*—In normal on-air transmitter operation LINK A (in the Power Amplifier component of the transmitters) should be in the LINE position so that the transmission line is connected to the transmitter, the links in the terminal (junction) box are positioned so that the line from the transmitter is connected to the transmission line in use and the monitor line to the transmitter is connected to the monitor line from the coupling unit in use. In normal standby transmitter operation all switches, except the HIGH VOLT and LOW VOLT BIAS, are in their normal ON operation position. LINK A is in line position and is connected through to the dummy load in the standby antenna coupling unit. The standby transmitter shall be operated and tested into its internal dummy load for a minimum of 15 minutes out of each 24-hour period, and into the standby antenna coupling unit dummy load for an additional 15 minutes out of each 24-hour period. Upon completion of test, return LINK A to line position.

The following changeover instructions apply to Models T–137 and T–325/FPN series transmitters:

(*a*) De-energize the on-air transmitter by placing all switches, except MAIN switch, in OFF position. (MAIN switch should not be placed in OFF position for at least three (3) minutes to allow the blower to cool the tubes.)

(*b*) Observe all safety precautions and ground all exposed circuits in the transmission line junction box.

(*c*) Change links in terminal (junction) box so that transmission line and monitor line from the operating antenna coupling unit are both connected to the transmitter to be placed in operation.

(*d*) Place standby unit into operation by turning the HIGH VOLT and LOW VOLT BIAS switches to the ON position.

(2) *Transmitter-Amplifier Combination.*—Under normal station procedure, a LORAN amplifier will be kept in either an operating or standby state. The same set of conditions must also apply to the transmitter which drives the amplifier. A standby state implies that all switches and controls on both the transmitter and amplifier, except the HIGH VOLT and LOW VOLT BIAS switches on the amplifier, are in their normal ON position, and each transmitter output is connected to an amplifier input. Each transmitter-amplifier combination is changed from standby to on-air, and vice versa as a unit.

The following changeover instructions apply to Model T–138 and AM–701/FPN series amplifiers. OBSERVE ALL SAFETY PRECAUTIONS!

(*a*) Place the switch on center rear panel of the standby amplifier in OUTPUT position.

(*b*) De-energize the on-air transmitter and amplifier by placing all amplifier switches, except the MAIN switch, in the OFF position.

(*c*) Ground all exposed circuits with capacitor discharge rods.

(*d*) Change links in the Transmission Line Junction Unit so that the standby transmitter-amplifier combination is connected to the transmission line leading to the Antenna Coupling Unit in use. Connect the standby transmitter to the on-air monitor line.

Under certain conditions it might be necessary to operate either of the station transmitters directly into the antenna system with its amplifier inoperative. This can be accomplished by shorting between the input and output terminals of the amplifier as per instructions in respective amplifier instruction manuals.

(3) *Timers.*—The following discussion applies to the Model UE–1 series Timers only. Whether designated as a master or a slave, the operating status of a timer falls into one of three categories: SHUT–DOWN, STANDBY, and ON-AIR OPERATION. The timers at a station shall not be put on a shutdown status except for the performance of maintenance procedures. Usually, a 24-hour period is needed to allow the CRYSTAL OSCILLATOR to warm up and become stabilized. The balance of the timer units require 15 minutes to reach a stable condition, but it is advisable to extend this period to an hour. When starting from shutdown (after preliminary warm-up period), follow directions as outlined in B(6) of section 18–12–10 in the preceding pages. Since there are some operational differences in placing the master or the slave timer

on standby and then into operation, they will be considered separately.

(4) Placing a master standby timer into on-air operation:

(*a*) The CRYSTAL OSCILLATOR frequency shall be checked and adjusted to 100 kc. (see section 18–12–25 for procedure).

(*b*) Counters shall be checked for correct and stable count.

(*c*) Check two-microsecond markers for coincidence with ten-microsecond markers.

(*d*) Adjust "A" gate until proper marker is in center of pedestal.

(*e*) Set pedestals for assigned standard time difference reading.

(*f*) Put TEST SIGNAL switch on OUTPUT and SIG SEL switch to CU–2 to test timer for trigger pulse.

(*g*) Tune Receiver for maximum signal amplitude.

(*h*) Stop pulse drift by adjusting frequency of on-air timer.

(*i*) Put Fast Scope SPEED switch to FAST NO. 1 speed. (See figure 18–26 Front Panel Synchronization Indicator, Type CG–55144.)

(*j*) Shift pulses so that they appear on their respective pedestals on the Slow Scope. Center pulses in Fast Scope.

(*k*) Adjust Receiver and sweep speed so that pulses are standard.

(*l*) Place timer in operation by throwing the BLANKING switch to the ON position (see figure 18–27 Front Panel Time Delay Sweep Unit, Type CG–35046), and make appropriate changeovers at the switching equipment.

(*m*) Disconnect the BLANKING switch on the timer which has been in previous operation.

(*n*) Check slave synchronization by taking a time difference reading. Set the Test Oscilloscope controls as follows: set SWEEP SPEED to MED.; set SYNC SELECTOR to CU–1; and set SIGNAL SELECTOR to CU–2. Set the Time Delay Sweep Unit TEST SIGNAL switch to A1000.

(*o*) For detailed timer adjustments and auto-alarm adjustments, refer to the applicable instruction book.

(5) Placing a slave timer on standby and into operation:

(*a*) Place AUTO-SYNC in OFF position. This switch should not be turned on until synchronization has been established manually. (See figure 18–28 Front Panel Synchronization Control Unit, Type CG–23417.)

(*b*) The MOTOR and PLATE VOLTAGE switches on the Synchronization Control Unit should be ON.

(*c*) Check operation of counters for correct and stable count by using the TEST COUNT INSERT rotary switch and the push-button TEST COUNT switch, while observing the front panel neon indicator lamps located behind the right-hand front panel door designated COUNTER TEST.

(*d*) Check two-microsecond markers for coincidence with ten-microsecond markers.

(*e*) Set the CODING DELAY, adjusting to assigned value and centering all delay adjustments.

(*f*) Check for timer TRIGGER PULSE.

(*g*) Adjust Receiver to pick up remote and local signal on Slow Scope.

(*h*) Adjust Crystal Oscillator so that drift ceases. Place pulses on respective pedestals and increase sweep speed until pulses appear in center of Fast Scope.

(*i*) Adjust Receiver and sweep speed so that pulses are standard.

(*j*) If the Timer is to be operated on AUTO-SYNC, refer to the appropriate Timer and Synchronizer Instruction Book for detailed information.

(*k*) Place timer into operation by throwing BLANKING switch to ON. Make appropriate changes on the switching equipment. Disconnect BLANKING switch on the Timer which has been in previous operation.

(*l*) Properly locate local and remote pulses on Fast Scope. Even if the timer was adjusted carefully during standby, initial synchronization must be accomplished manually.

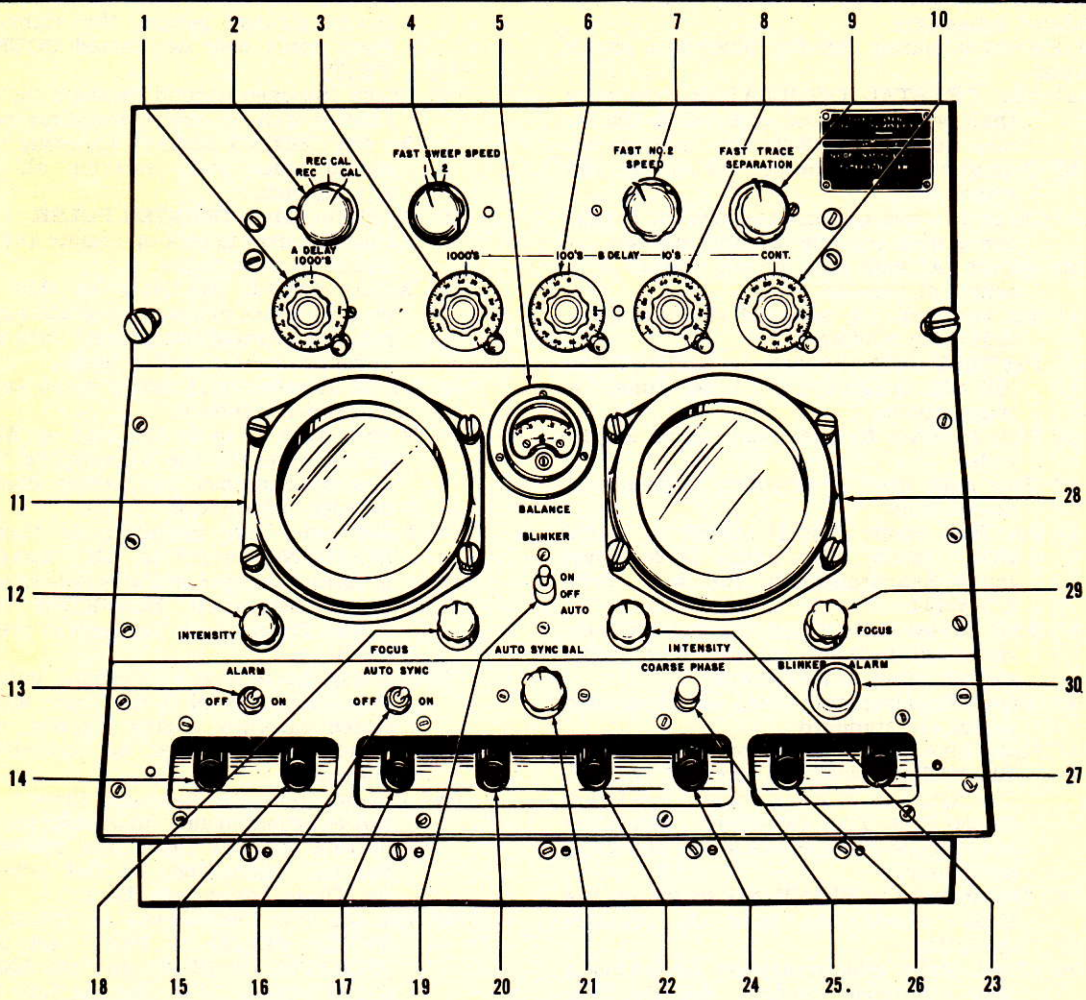
(*m*) Cut off previously operating timer. (This can be accomplished simultaneously with putting the new timer into operation.) For full instructions on this procedure see Timer Instruction Book.

(*n*) Set the Test Oscilloscope as follows: set SWEEP SPEED to FAST; set SYNC SELECTOR to CU–1; and set SIGNAL SELECTOR to CU–2. Set the Time Delay Sweep Unit TEST SIGNAL switch to B10.

(*o*) For detailed timer adjustments and auto-alarm adjustments, refer to applicable instruction book.

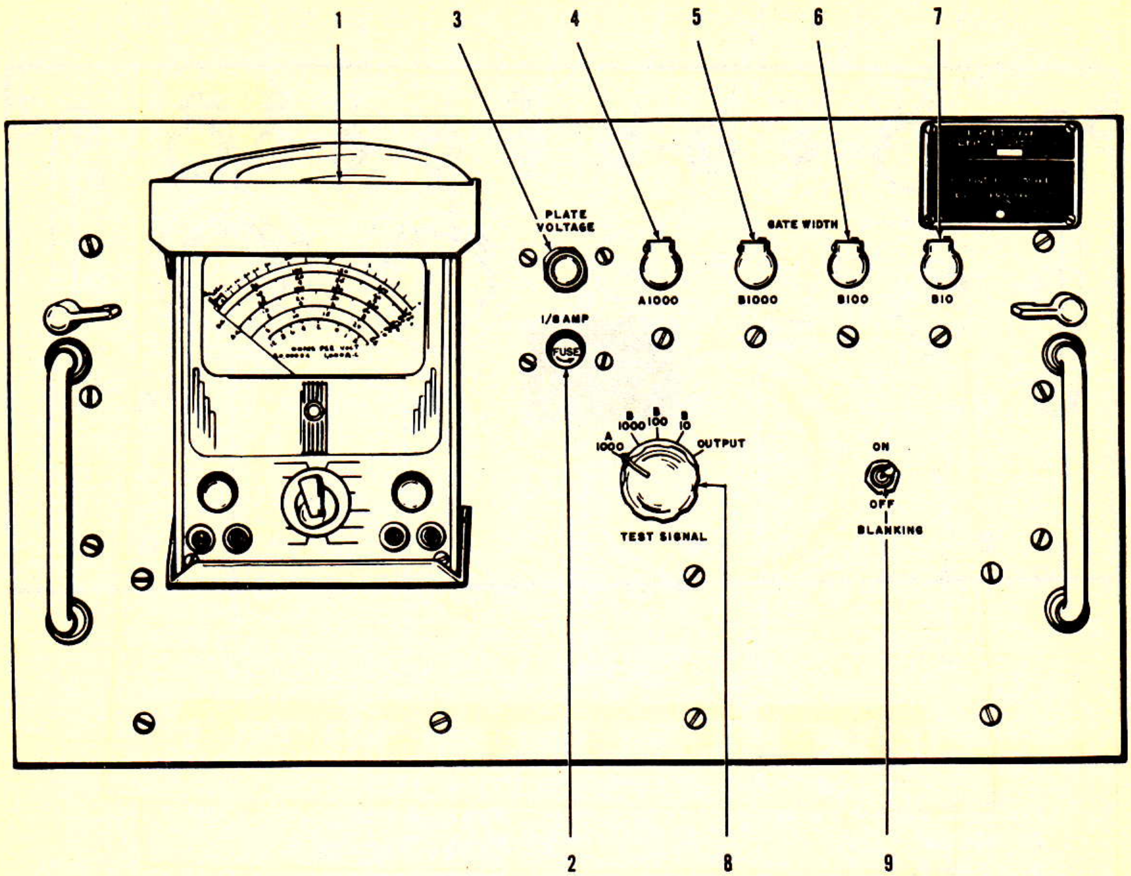
(6) *Isolation Transformers.*—The typical LORAN installation includes two 12.5-kva. type TF–191/FPN, and one 7.5 kva. type CG–301227 isolation transformers located in the transmitter room (see figure 18–29 Isolation Transformers). The power distribution panel, located in the switching equipment in the timer room, is provided so that either or both 12.5-kva. transformers can carry the load of the equipment listed in the screened room and the lighting circuits. The transformer attenuates stray radio frequencies picked up by the power lines in addition to compensating secondary voltage and acting as a stepdown transformer. The 7.5-kva. isolation transformer carries the supervisory room load.

(7) *Antenna Coupling Units.*—In the dual antenna coupling unit installation, each unit has a single run of coaxial cable to serve as a transmission line. Changeover from one coupling unit to the other may be accomplished by following the procedures listed below. Personnel must observe all



1. A-Delay 1000's
2. Rec-Cal
3. B-Delay 1000's
4. Fast Sweep Speed
5. Balance
6. B-Delay 100's
7. Fast No. 2 Speed
8. B-Delay 10's
9. Fast Trace Separation
10. B-Delay Cont.
11. Slow Scope
12. Intensity
13. Alarm
14. H. Center Slow
15. V. Center Slow
16. Auto-Sync
17. Slow Size
18. Focus
19. Blinker
20. Blinker Shift
21. Auto-Sync Bal.
22. Fast No. 1 Speed
23. Intensity
24. Fast Size
25. Coarse Phase
26. H. Center Fast
27. V. Center Fast
28. Fast Scope
29. Focus
30. Blinker Alarm

FIGURE 18–26.—Front Panel Synchronization Indicator, Type CG–55144.



1. Simpson Model 260
2. 1/8 Amp. Fuse
3. Plate Voltage
4. A-1000 Gate Width
5. B-1000 Gate Width
6. B-100 Gate Width
7. B-10 Gate Width
8. Test Signal
9. Blanking

FIGURE 18–27.—Front Panel Time Delay Sweep Unit, Type CG–35046.

safety regulations. Make certain that the transmitter is de-energized before attempting change-over. Normally, couplers are not changed over except in cases of failure.

Procedures inside the signal building:

(*a*) The transmission lines are changed over by switching the line link inside the Transmission Line Junction Box to the operating transmitter.

(*b*) The transmitter monitor line is changed over by shifting the coaxial cable from one receptacle to the other on the Transmission Line Junction Box.

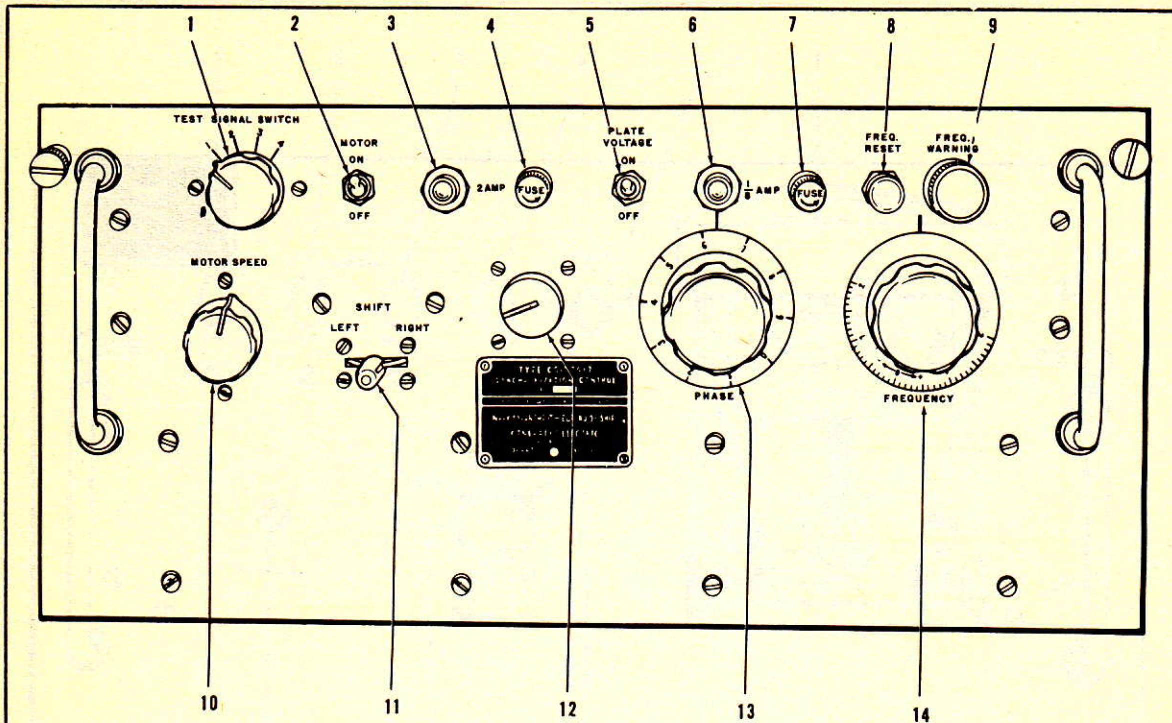
Procedures outside the signal building:

(*c*) Change the link in the on-air antenna coupling unit to dummy load position, and the link in the standby antenna coupling unit to the antenna position.

(*d*) The antenna lead is changed over by switching it from one coupling unit to the other.

18–12–20 PEAK POWER MEASUREMENT—

A. *General.*—The LORAN transmitters, and transmitter-amplifier combinations, when properly adjusted and aligned, are designed to supply approximately 160-kilowatt peak power carrier frequency



1. Test Signal Switch
2. Motor
3. 2 amp.
4. 2 amp. Fuse
5. Plate Voltage
6. 1/8 amp.
7. 1/8 amp. Fuse
8. Freq. Reset
9. Freq. Warning
10. Motor Speed
11. Shift
12. Rotation Indicator
13. Phase
14. Frequency Speed Adj. Phase Adj. 100 kc Level

Figure 18–28.—Front Panel of Synchronization Control Unit, Type CG–23417.

(128-kw. double pulsed) and 1 megawatt peak power carrier frequency (800-kw. double pulsed), respectively, into a 52-ohm resistive load. It is important to keep the peak power carrier frequency output up to its rated value at all times to insure adequate signal strength over the service area. Two methods of computing peak power are described in paragraphs C and D below.

B. *Definition of Peak Power.*—The peak pulse power, carrier frequency, is defined as the power averaged over that carrier frequency cycle which occurs at the maximum of the pulse power. This should not be confused with maximum instantaneous power (peak pulse power), which is twice the peak pulse power, carrier frequency, when the basic carrier is sinusoidal in wave form. The peak pulse power, carrier frequency, hereinafter called peak power, corresponds to the peak power discussed in the instruction manual.

C. *Approximate Formula.*—It can be shown mathematically that, for a standard output pulse ($\cos^2$ envelope and 40 μs pulse width at half amplitude), that peak power can be determined from:

$$P = \frac{1730\ I^2}{PRR} \text{ (kilowatts)}$$

Laboratory tests performed on the T–137 and T–325/FPN transmitters, and on the T–138 ampli-

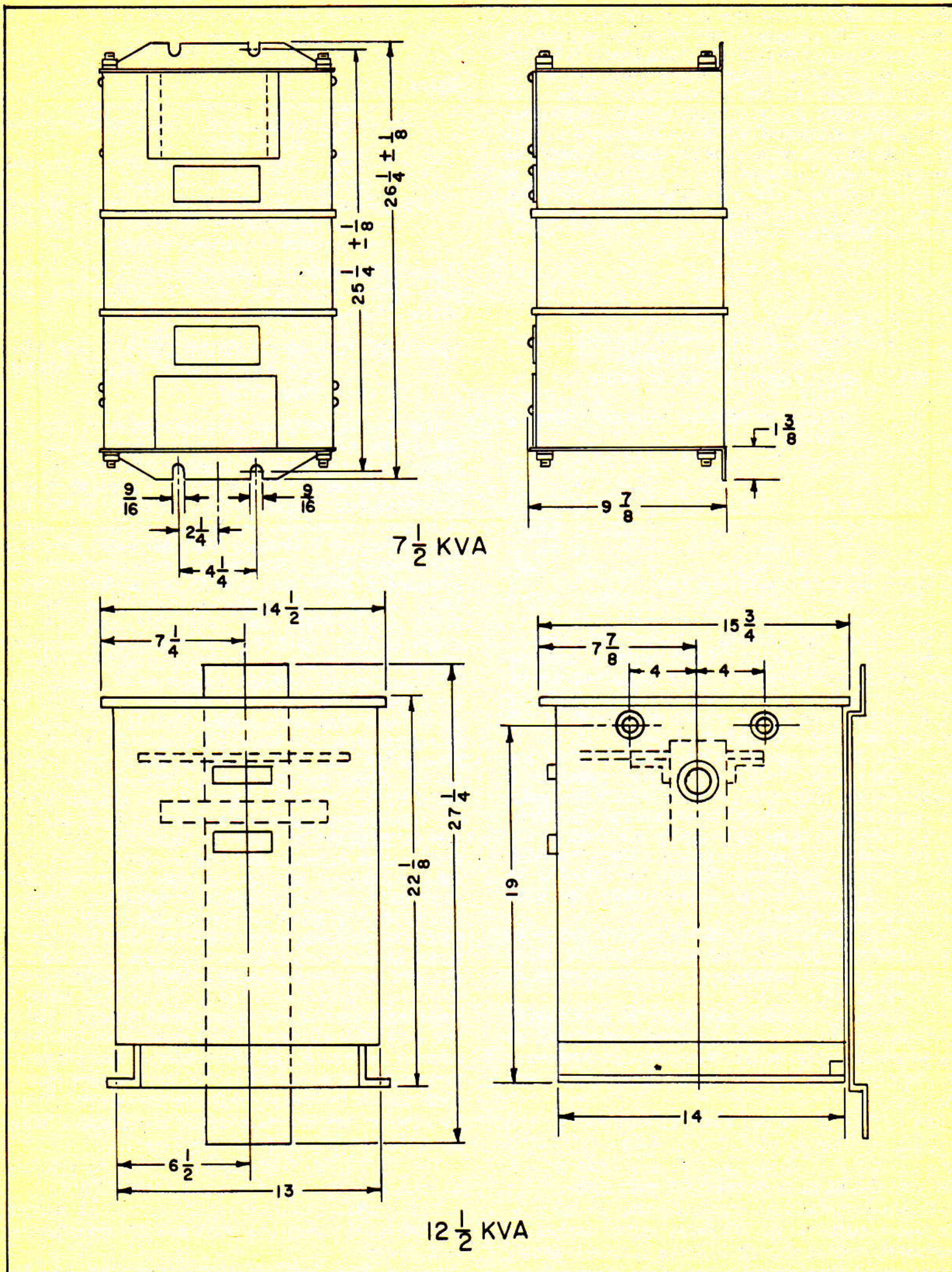


FIGURE 18–29.—Isolation Transformers.

fiers have shown that the exact $\cos^2$ pulse shape is not generally obtained even when the equipment has been adjusted so that the pulse shape is within tolerances. A good average multiplying factor has been determined by the manufacturer which will correct for pulse shape to some extent. When the transmitting equipment is properly adjusted so that the output pulse is within the permissible tolerances (see paragraph 18–12–30 B), and the antenna is properly matched to the transmission line, the peak power output for the system can be determined by using the following formula:

$$P = \frac{KI^2}{PRR}$$

where,

P = peak power in kilowatts.

I = line current (measured at antenna coupling unit) in amperes.

PRR = pulse repetition rate in pulses per second.

and K is determined from the following table.

	K	
	Single pulsed	Double pulsed
Transmitter (T-137 or T-325/FPN)	1,677.8	838.9
Transmitter-Amplifier Combination using T-138 Amplifier	1,587.2	795.6

The link in the antenna coupling unit can be changed to the DUMMY LOAD position and the peak power again computed as described above. This value of peak power, when compared with the actual output peak power, serves as a check on the antenna coupling unit adjustment.

D. *Area Measurement.*—This method takes the pulse shape into consideration and provides a greater degree of accuracy than is obtainable, using the approximate formula given above. However, the antenna still must be properly matched to the transmission line in order to obtain accurate results. The following procedure should be followed to measure the peak power output using the area measurement method:

(1) Place the MONITORED CIRCUIT switch to the ANTENNA position and adjust monitor scope to obtain a steady envelope of the output pulse on the monitor scope screen.

(2) Measure the pulse amplitude (E_n in inches or centimeters), by rotating the sweep delay dial, at 2 μs intervals on the 100 μ range using 150 μs sweep in 25 position; and square each value (E_n^2) thus obtained.

(3) Add all E_n^2 values obtained in step (2) and multiply the sum by 2×10^{-6}, i. e., $A=2\times10^{-6}\times(E_1^2+E_2^2+\text{- - -}+E_{40}^2)$. If the station is double pulsed, this step should be performed for each pulse.

(4) Measure the peak amplitude (E_p) of the voltage pulse envelope in the same units (inches or centimeters) as in step (2). If the station is double pulsed, the peak amplitude should be measured for each pulse.

(5) Compute the peak output power using:

$$P=\frac{[0.52 \times E_p2]I^2}{PRR \times A}\text{(Kilowatts)}$$

where,

P=peak output power in kilowatts.

E_p=peak amplitude of voltage pulse envelope (see step 4 above).

I=line current (measured at the antenna coupling unit) in amperes.

PRR=pulse repetition rate in pulses per second.

A=area proportional to total pulse energy computed as shown in step (3).

If the station is double pulsed, compute (P) for each pulse and average these values to obtain the peak power output.

18–12–25 TIMER CRYSTAL OSCILLATOR FREQUENCY CHECK USING WWV–WWVH—

The crystal oscillator frequency of each timer at the master station shall be checked against and adjusted to agree with a primary standard of frequency, such as the United States Bureau of Standards' Standard Frequency Stations WWV or WWVH, or if more accessible, the British, Italian, or Japanese Standard Frequency Stations MSF, IBF, and JJY, respectively. The present schedules and frequencies of WWV and WWVH are shown in figure 18–30 Standard Frequencies and Time Signals, WWV and WWVH; and MSF, IBF, and JJY are shown in figure 18–31 Data on Frequency Standard Stations, MSF London, IBF Turin, and JJY Tokyo.

Timer crystal oscillator frequency at master stations shall be checked and adjusted to exactly 100 kc at least once each week. This is accomplished by reference to the standard frequency broadcasts from WWV and WWVH on 2.5, 5, 10, or 15 megacycles. Since the 25th, 50th, 100th, or 150th harmonic of the crystal oscillator is beat against WWV, the accuracy at one cycle per second beat rate is 1 part in 2,500,000 to 1 part in 15,000,000. However, zero beat or at worst one beat in several seconds is readily attained, giving the basic timer accuracy required for reliable LORAN transmissions. Routine checks shall be made on the standby timer to avoid confusing navigators who might be using the station signal at that time. The on-air timer shall then be changed over to the standby condition and its crystal oscillator frequency checked. When each timer is installed, a coaxial lead is connected from the 100 kc test jack of that timer to one position of the timer selector switch on the WWV Mixer. By means of this switch, any one of two or four timers can be connected to the mixer for frequency checks. These connections are shown in figure 18–32 Signal Mixer for Timer Oscillator Frequency Check.

The CRYSTAL OSCILLATOR shall be operated at least 24 hours before checking with WWV.

The crystal oscillator shall be checked against and adjusted to zero beat with a WWV transmission as follows:

Step 1: Turn ON the WWV RECEIVER and the TIMER TEST OSCILLOSCOPE.

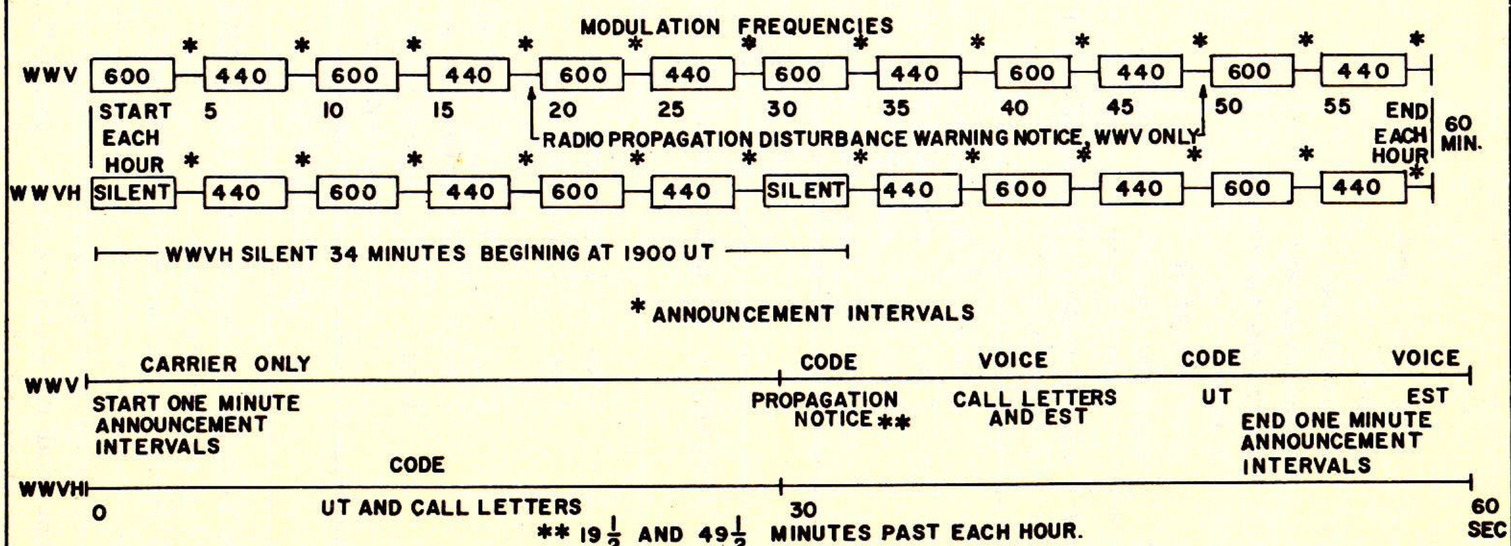
WWV BROADCAST CONTINUOUSLY		
MC	POWER, KW	MODULATIONS, C/S[b]
2.5	0.7	440 OR 600
5	8.0	440 OR 600
10	9.0	440 OR 600
15	9.0	440 OR 600
20	8.5[a]	440 OR 600
25	0.1	440 OR 600

WWVH BROADCAST CONTINUOUSLY		
MC	POWER, KW	MODULATIONS, C/S[b]
5	2.0	440 OR 600
10	2.0	440 OR 600
15	2.0	440 OR 600

(a) 2.0KW, FOR FIRST 4 WORK DAYS AFTER FIRST SUNDAY OF EVEN MONTHS.

(b) TIMER MARKER PULSE - 5 CYCLES OF IKC AT END OF EACH SECOND EXCEPT 59TH OF EACH MINUTE.

NOTE: AMPLITUDE MODULATION, WWV AND WWVH PULSE, 100% TONE, 75%.



NO PULSE IS TRANSMITTED AT THE BEGINING OF THE LAST SECOND OF EACH MINUTE.

FOR ADDITIONAL INFORMATION SEE H.O. 205

FIGURE 18–30.—Standard Frequencies and Time Signals, WWV and WWVH.

MSF LONDON

HOURLY SCHEDULE

Min.		Min.	
0-5	1 kc and 1 pps	30-35	1 kc and 1 pps
5-10	1 pps	35-40	1 pps
10-14	unmodulated	40-44	unmodulated
14-15	announcement	44-45	announcement
15-20	silent no carrier	45-50	1 kc and 1 pps
20-25	1 pps	50-55	1 pps
25-29	unmodulated	55-59	unmodulated
29-30	announcement	59-60	announcement

Frequency	Modulation Frequency	Timer Marker Pulse	Broadcast	Power
2.5 mc	1 kc	5 cycles 1 kc at end of each second except 59th second in each minute	24 hours	500 watts
5.0 mc	1 kc		24 hours	500 watts
10.0 mc	1 kc		24 hours	500 watts

JJY TOKYO

The frequency standard station JJY, Tokyo, Japan operates as follows:

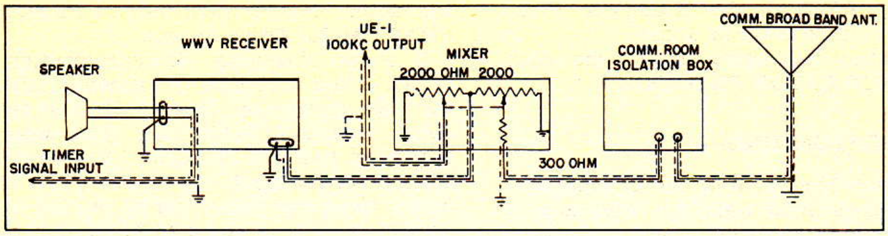
4 mc	1 kc	See note (a)	24 hr. daily	2 kw
8 mc	1 kc	See note (a)	2100 to 1100 daily	2 kw
2.5 mc	1 kc	7 cycles 1.4 kc	Mon. 24 hrs.	1 kw
5.0 mc	1 kc	7 cycles 1.4 kc	Wed. 24 hrs.	1 kw
10 mc	1 kc	7 cycles 1.4 kc at end of each second	Fri. 24 hrs.	1 kw

IBF TURIN (each Tuesday)

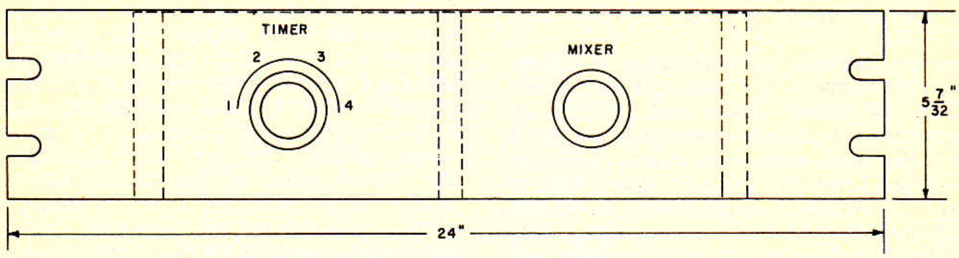
The frequency standard station IBF, Turin, Italy operates each Tuesday for six hours from   to   on 5 megacycles modulated 440 cycles with seconds pulse of 5 cycles of 1 kc.

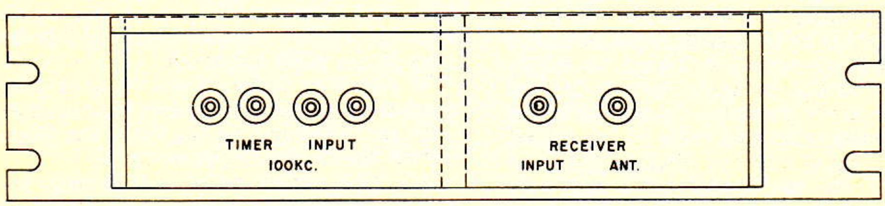
(a) The carrier and modulation frequency are interrupted 20 milliseconds at the end of each second, and 200 ms at the end of each minute. The resumption of the carrier and modulation marks the beginning of each time interval.

FIGURE 18–31.—Data on Frequency Standard Stations MSF London, IBF Turin, and JJY Tokyo.



WWV-UE-I SIGNAL MIXING METHOD





REAR

Figure 18–32.—Signal Mixer for Timer Oscillator Frequency Check.

Step 2: Withdraw the CRYSTAL OSCILLATOR UNIT from the timer housing until the factory markings on the top of the FINE FREQUENCY CAPACITOR shield are seen. These markings give the exact setting at the time of manufacture of the COARSE and FINE frequency controls for exactly 100 kc. Push the CRYSTAL OSCILLATOR UNIT back in the timer housing and secure. This step is necessarily done at timer installation and crystal replacement, but may be omitted at daily checks.

Step 3: Press the FREQUENCY RESET button above the FREQUENCY dial of the timer SYNCHRONIZATION CONTROL UNIT and manually set the dial to zero.

Step 4: Set the COARSE and FINE frequency dials of the timer CRYSTAL OSCILLATOR to the positions recorded on the cover of the FINE FREQUENCY CAPACITOR. This step is usually done only on installation of a timer or replacement of a crystal.

Step 5: Turn the MIXER control on the WWV MIXER PANEL in the direction which produces the loudest signal from the COMMUNICATIONS or WWV ANTENNA and then select the WWV or WWVH signal which is strongest and steadiest on the WWV RECEIVER. With the WWV RECEIVER BEAT FREQUENCY OSCILLATOR (BFO) switch in the OFF position, tune the WWV RECEIVER for maximum WWV signal, turn up the gain until a broad solid trace is seen in the TEST OSCILLOSCOPE. Turn the WWV MIXER PANEL TIMER switch to the timer being checked; then turn the WWV MIXER PANEL MIXER control to the position which produces the strongest beats between the WWV signal and the timer crystal oscillator harmonic frequency. Advance the WWV RECEIVER GAIN until a broad solid pulsating trace is seen on the TEST OSCILLOSCOPE screen. At the next and succeeding periods of no modulation (see figure 18–30), adjust the FINE FREQUENCY control, and if necessary, the COARSE FREQUENCY control until the beat slows to zero, if possible. The exact setting is found by observing the slow pulsation in background noise and scope trace height as the harmonic comes close to zero beat and adjusting to a point where the pulsation disappears or occurs at a very slow rate, i. e., one pulsation in several seconds. The pulsations may be seen and heard even better at times by switching ON the WWV RECEIVER BFO after approximate zero beat is secured and by listening to and watching the rise and fall in intensity (not frequency) of the BFO tone.

Daily TIMER CRYSTAL OSCILLATOR FREQUENCY checks shall be made as above.

The master station will establish and maintain the CRYSTAL OSCILLATOR FREQUENCY.

18–12–30 SYNCHRONIZING—

A. *General.*—Since the value of the LORAN system is primarily dependent upon the accuracy of timing of the signals transmitted, every precaution must be taken by LORAN technical personnel to safeguard the functioning of the system. Therefore, it is important that all technical equipment connected with the system be properly adjusted and maintained.

The timers are designed to retain their precision in spite of varying temperature, humidity, and other conditions. In the Model UE–1b and AN/FPN–30 timers the accuracy is maintained within a few parts in a billion. However, even this slight deviation could build up an error in LORAN reading unless compensated. Therefore, it is necessary to correct constantly at the slave station (synchronizing) for the slight difference which accumulates between the two timers operating together as a slave and master.

The process of keeping the interval of time between master and slave pulse transmission constant within the assigned tolerances is known as SYNCHRONIZING and is the primary operational responsibility of the slave station. Synchronization requires that the pulse repetition rates of the paired stations be exactly equal and the relative phase be properly adjusted. On the Model UE–1 and AN/FPN–30 Timer series, control over both frequency and phase is provided for at the Synchronization Control Unit by the FREQUENCY and PHASE knobs. Rotation of the PHASE control changes the phase angle of the output signal. The electrical phase angle corresponds quite closely to the angular position of the dial. Synchronization is maintained at the slave station by manual or automatic adjustment of the PHASE control. It should be remembered that manual sync accuracy depends on operating personnel, and auto sync accuracy depends on the degree of accuracy originally set in the equipment. Figure 18–28 shows the front panel of the UE–1 Timer Synchronization Control Unit.

A system of gears connects the FREQUENCY control to the fine PHASE control. When the PHASE control is turned, the gear train also turns this FREQUENCY control, though at a much slower rate. The relative directions of the two controls provide compensation in crystal frequency for phase shift errors. The ratio is such that the frequency-correcting follow-up is slow; that is, extended phase correction in one predominant direction is needed to bring about a consequential change in frequency.

A driving motor is also connected into the gear train. The motor may be operated by manual switches or by an automatic synchronizing circuit. Because of the high gear ratios and also because individual operation is sometimes necessary, panel-controlled clutches are provided which permit the PHASE and FREQUENCY dials to be operated manually, either separately or together in their normal gearing arrangement but disconnected from the motor. Figure 18–33 shows a FREQUENCY and PHASE Motor Drive System.

B. *Pulse Matching.*—Synchronization is maintained either manually or automatically by matching (see paragraph 18–4–10 E) the two separate pulses from a LORAN pair. The pulse shapes in any given pair are identical. The standard output pulse shape for the T–137 (T–325/FPN) series transmitter has a rise time from 10 percent to 90 percent amplitude of 21 μs and a width at 50 percent amplitude of 40 μs. The maximum tolerance for both time measurements is ± 1 μs. This approximates a cosine squared waveform. Adjustments are made at the transmitter, in accordance with the instruction book, so that the output pulse is held within the allowable tolerances for standard pulse shapes. The standard output pulse for the LORAN Amplifier Model T–138 or T–138–A excited with a Model T–137 or T–325/FPN series transmitter is the same as described above. However, it is necessary to adjust the output pulse of the transmitter to different values of rise time and width to obtain a standard output pulse from the amplifier. The amplifier input and output pulse shape differences are caused by slight nonlinearity in the amplifier and by the fact that the impedances of the amplifier tuned circuits are not constant over the bandwidth occupied by the pulse spectrum.

If amplifier failure requires that the station be operated on reduced power (transmitter alone) it will be necessary to readjust the transmitter to obtain the standard output pulse.

A typical output pulse as it appears on the monitoring oscilloscope is shown in figure 18–34. The allowable tolerances are also shown in this figure.

Figure 18–35 shows waveforms for the automatic synchronizer. The positive envelope of the output pulse, after being shaped somewhat by the bandwidth of the receiver, appears on the fast oscilloscope of the timer as shown in figure 18–35 (a). It must be remembered that the pulse shape as it appears on the timer oscilloscope is not a direct indication of the output pulse shape of the transmitter, since the bandwidth of the receiver (50 kc.) will effectively attenuate side bands so that even a square wave output pulse would resemble a cosine squared shape on the timer oscilloscope. The leading edges (linear portion from 10 to 90% of peak pulse amplitude) of the pulses on the timer oscilloscope are used when matching two LORAN pulses.

LORAN timing equipments provide the functional means of making precise measurements through a cathode ray tube display of signals and accurate timing pulses generated within the timing equipment. Thus the basic LORAN receiving equipment may be thought of as a calibrated ruler or scale that is used to measure the time interval. The "ruler" itself is highly accurate as the result of inherent features of design and construction. The process of applying the ruler to the problem is subject to several types of errors; it is with this part of measurement that pulse matching techniques are directly pertinent.

(1) *Problems of Ground Wave Pulse Matching.*—The process of matching pulses for purposes of making LORAN measurements at master or maintaining

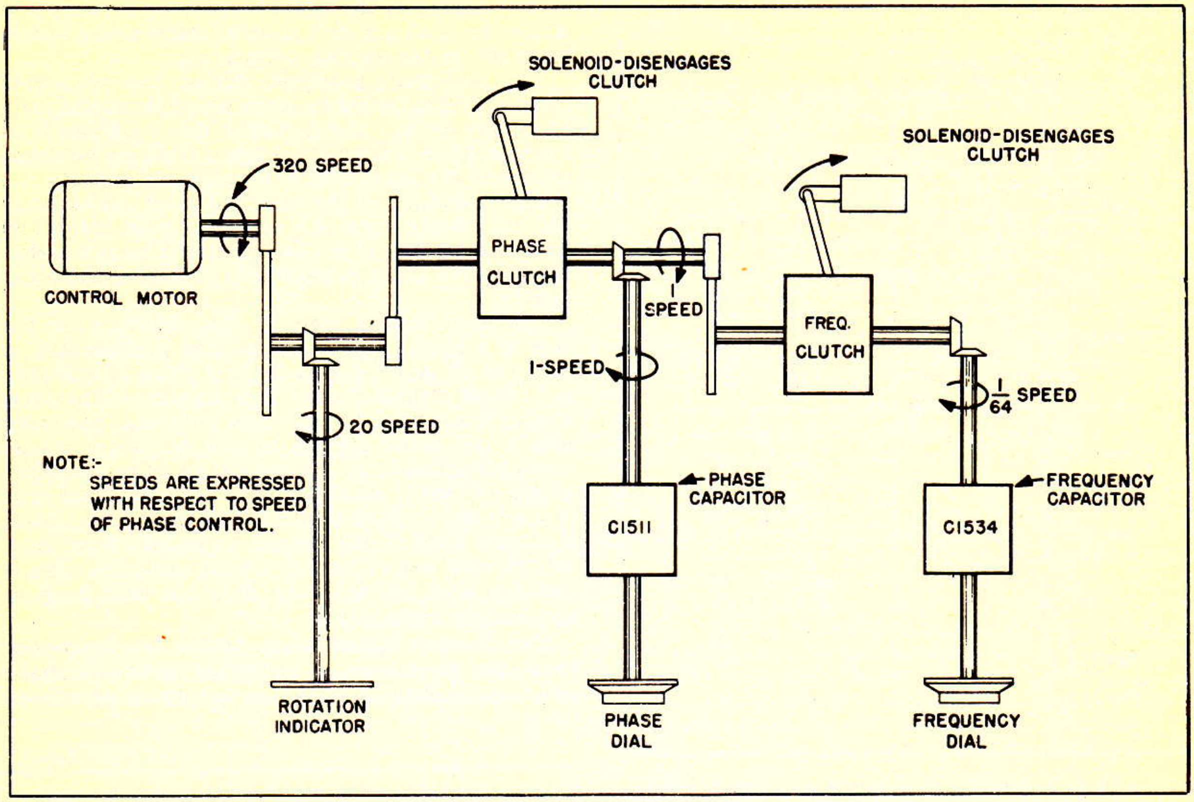


FIGURE 18–33.—Frequency and Phase Motor Drive System.

sync at slave stations is attended by two general types of problems, as follows:

(*a*) Steady state problems, consisting of differences in pulse amplitude and shape which are inherent in either or both signals as displayed and which do not change during the time required to take a reading.

(*b*) Transient problems, consisting of changes taking place in either or both signals during the time normally required to take a reading. Such changes may include variations in pulse amplitude, phase, or shape.

(2) *"Steady State" Matching Techniques.*—The steady state condition is representative of the basic theory of LORAN pulse matching. The displayed signals are constant in shape, amplitude, and phase, and it is only necessary to follow basic procedure in order to make a match.

It is essential to remember that all basic timing in the LORAN system is measured theoretically from the beginning of each pulse. This is done because better electrical control exists at the initial stage than at any other time during the pulse period. However, from a practical standpoint the actual point of the start of a pulse cannot be readily determined since it would normally fall at some point on the straight portion of the trace ahead of any rise in the voltage pulse that would be apparent from visual inspection. As a consequence, pulse matching techniques are in reality a compromise; pulses are matched at convenient points which have been found by experiment to have close correlation with the actual commencement points of the pulses.

As a matter of practical convenience, pulse matching is based upon coincidence of the large smooth portions of the leading edges of the pulses. This method is reliable because a definite correlation exists between the commencement point and the smooth portion of the leading edge of a pulse as long as the pulse amplitude is constant. It follows, therefore, that if the leading edges of two pulses of the same amplitude and shape are coincident, the commencement points of the pulse are also coincident even though the latter cannot actually be identified on the trace.

Changes in pulse amplitude will change the basic correlation, and as a consequence, it is necessary to place a numerical limitation upon the differences in amplitude of pulses which may be matched reliably in this manner. It has been determined empirically that accurate results for timer and synchronizing equipment operation are obtained when the smaller pulse has an amplitude not less than 90% of the larger. This limit will yield results of the order of accuracy of ± 1 μs in the basic measurement.

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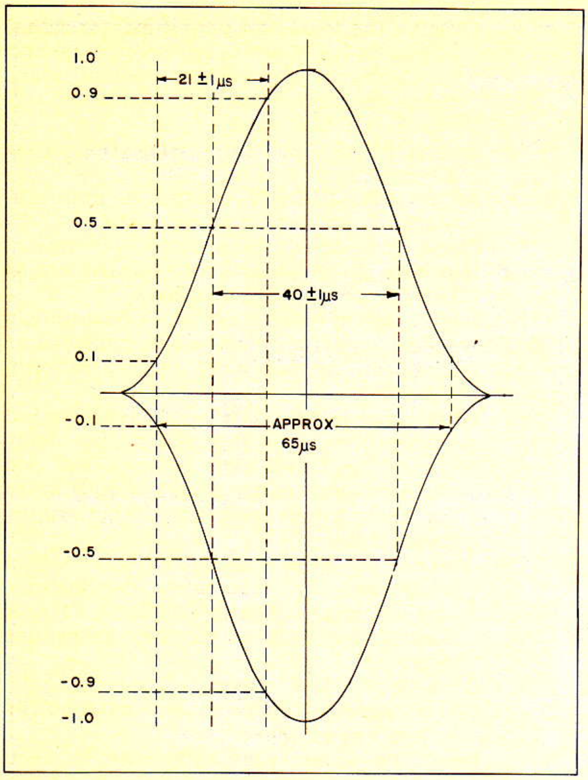


FIGURE 18–34.—Standard Output Pulse of T–137 Type Transmitters as it Appears on the Monitoring Oscilloscope.

Figure 18–36 illustrates the basic considerations regarding pulse matching techniques. Figure 18–37 presents a procedure chart for pulse matching.

In the ideal case the pulses displayed on the LORAN scope would be of similar shape. It would then only be necessary to adjust the receiver controls to produce equal amplitudes after which a delay adjustment would permit perfect matching. The pulses would be superimposed and would be coincident not only along the leading edges but throughout the entire pulse period.

(3) *Transient Effects.*—In addition to the normal problems of pulse matching the LORAN operator is confronted with additional difficulties arising from transient effects which alter the amplitude, shape, or phase of a pulse during the period of time which is required for a LORAN reading to be taken.

The principal problem of this nature is the effect produced at the moment of cross-over in LORAN double pulsed transmissions. At this moment the pulses transmitted are spaced so closely together that the transmitter power supply does not recover capacity sufficiently after the first pulse to deliver full energy to the second. The result of this is a variation of pulse amplitude which is sometimes accompanied by changes in the observed shape or phase of the pulse transmitted. The changes thus brought about may be aggravated by receiving circuits in some instances. However, the significant factor insofar as the LORAN operator is concerned is the fact that a match must be made under conditions which are varying periodically.

The variations produced during the cross-over cycle are repeated in the same sequence during each successive cycle. The period of this variation is 16 seconds when transmitters are pulsed on adjacent rates and the basic rate is 25 cycles per second.

The variations of the observed pulse are dependent principally upon the closeness with respect to time of the pulses of the two rates and upon whether the observed pulse is leading or following the other signal.

The approximate cycle of this variation for the case of a double pulsed transmitter is illustrated in figure 18–38, Approximate Cycle of Pulse Irregularity in LORAN Double-Pulsed Transmission. The cycle shown is intended to represent a general case only and is not to be applied to any particular transmitting station since the cycle may differ considerably at different stations. This is particularly true if one of the stations working with the double pulsed station is itself double pulsing on an additional rate. In this case and in most practical cases the cycle is complex and, consequently, does not lend itself to any simple explanation.

The changes taking place during the cross-over cycle may be changes of amplitude, phase, or shape or a combination of these factors. These conditions

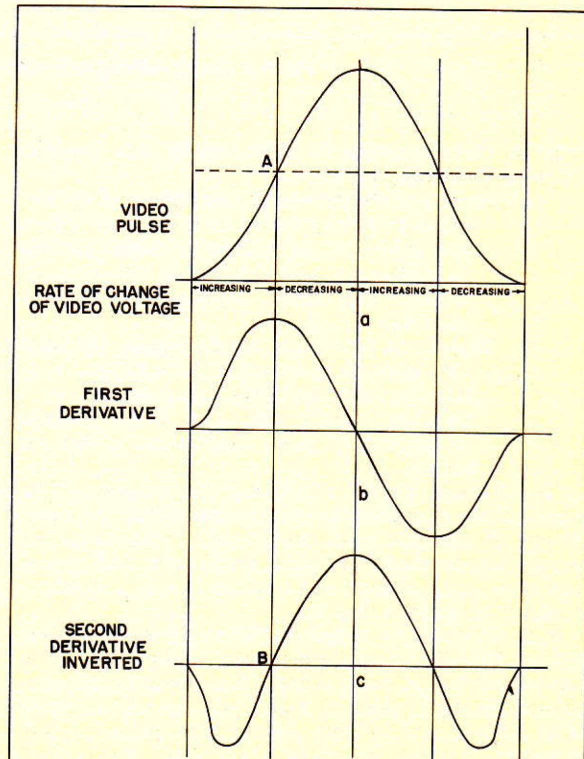


FIGURE 18–35.—Waveforms—Automatic Synchronizer.

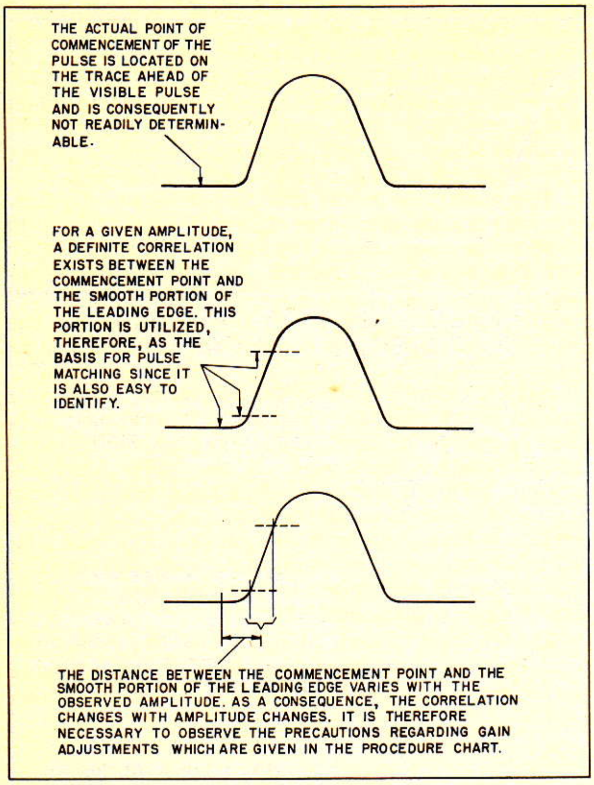


FIGURE 18–36.—Basic Considerations of Pulse Matching.

are illustrated in figure 18–39 Cross-Over Effects in Pulse Matching.

The only rule of thumb which may be applied satisfactorily to the technique of making LORAN measurements under these conditions is as follows:

"Observe the variation of the LORAN pulses carefully through several complete cycles to ascertain the pattern of these variations. Determine the portion of the cycle, during which the pulses appear to be most stable and make adjustments for matching during that period ONLY. The important point is to WAIT throughout the unstable part of the cycle, being careful NOT to make any adjustments during that period. A satisfactory match can probably be made in the course of four or five complete cross-over cycles."

While the appearance of the pulse pairs when properly matched is the same on the timer indicators, the sequence of operation in the pulse matching process is different for the master and slave stations.

(4) *Slave Station Pulse Matching.*—Synchronism is obtained and maintained at the slave station by following the operational steps shown below:

(*a*) Place timer in operation as a slave station with proper pulse repetition rate and proper coding delay, according to the instruction book for timing equipment installed.

(*b*) Observe the local and paired master signal pulses on the slow sweep oscilloscope and by means of the PHASE control, place them on their respective pedestals.

(*c*) Observe the fast sweep.

(*d*) Adjust PHASE control so that the pulses are matched.

(*e*) Adjust FREQUENCY control to maintain a stationary distant signal pulse.

(*f*) Check for correct time delay (coding).

(*g*) Maintain synchronization by adjustment of PHASE control as necessary.

(5) *Master Station Pulse Matching.*—Monitoring of the slave station synchronism is accomplished at the master station by following the operational steps shown below:

(*a*) Place timer in operation as a master station with proper pulse rate and proper delay (twice the travel time between the two stations plus coding delay) according to the instruction book for timing equipment installed.

(*b*) Observe the local and paired slave signal pulses on the slow sweep oscilloscope, and by means of the COARSE PHASE control, place them on their respective pedestals.

(*c*) Observe the fast sweep.

(*d*) Adjust pedestal delay control so that the pulses are matched.

(*e*) Read the actual time difference between transmitted and received pulse and compare with the assigned master STANDARD TIME DIFFERENCE reading (twice the travel time between the two stations plus coded delay).

(6) *Appearance of Signals on the Screen.*—Since ground waves are always used in LORAN station pulse matching, it is important that positive identification of ground wave pulse be obtained on the timer scope. There are inherent differences in the reception of ground and sky waves which may be used to identify them, if the signals are carefully observed. Ground waves are normally steady in amplitude, whereas sky waves are subject to fading. Ground waves, although they may flicker from noise interference, do not split, as do sky waves. Splitting is observed when the pulse breaks into two humps which fade independently.

On the slow sweep the beginning of a series of sky waves can be found by noting that the pulses near the beginning are larger and closer together than the trailing ones. The ground wave and E-layer reflections are often weaker than the following F-layer reflections. Therefore, the gain should always be turned up as far as noise permits to insure that a weak ground wave is not being overlooked.

The first easily visible pulses should be run to the right side of one of the medium fast sweeps; the gain should then be turned up and the balance control swung first one way and then the other, to see if there is a weak ground wave to the left of the first visible pulse. The pulses should be drifted to the right side of the slow sweep first to discover a weak ground wave; then the desired pulses should be aligned approximately and drifted to the left before

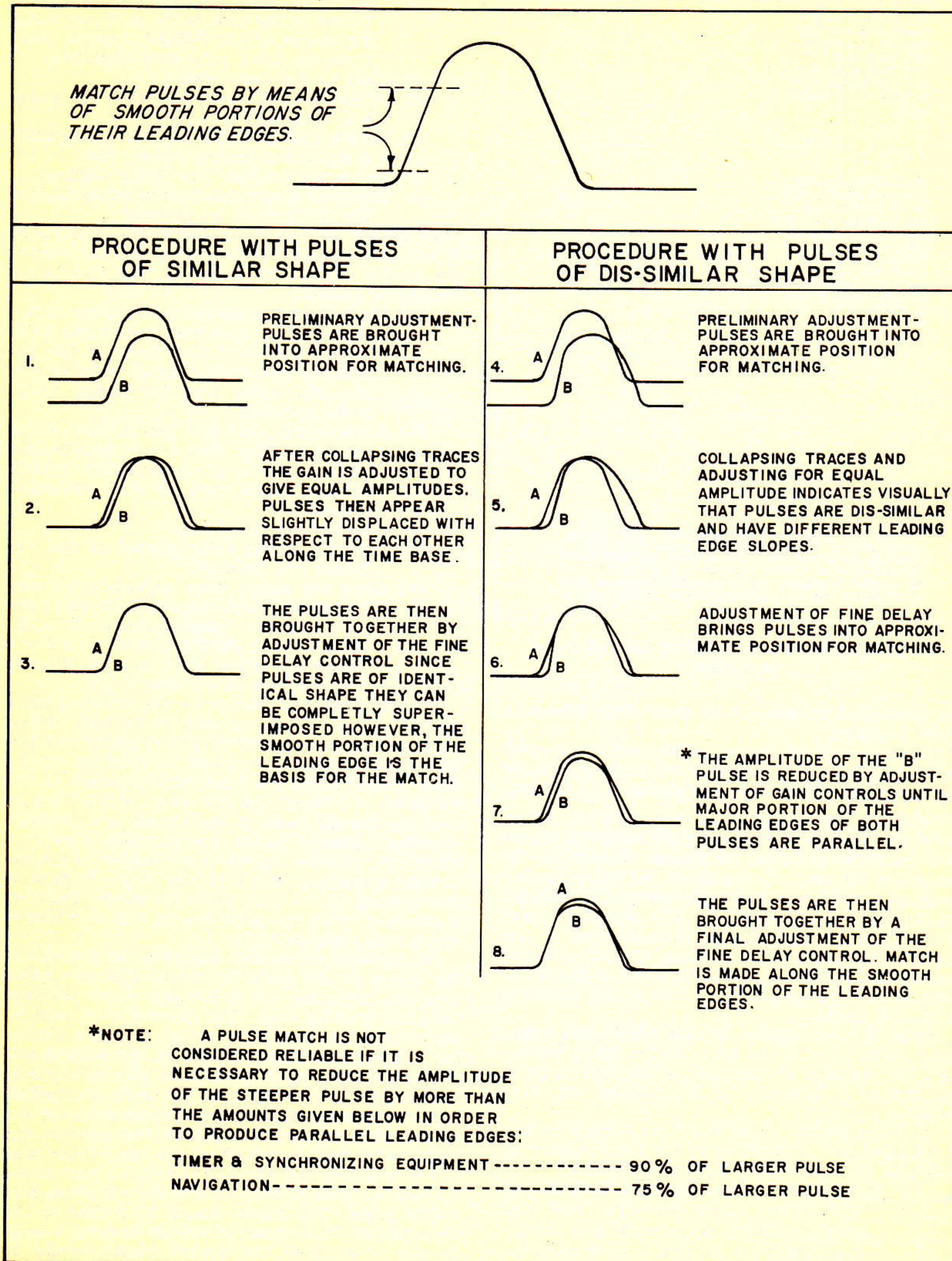
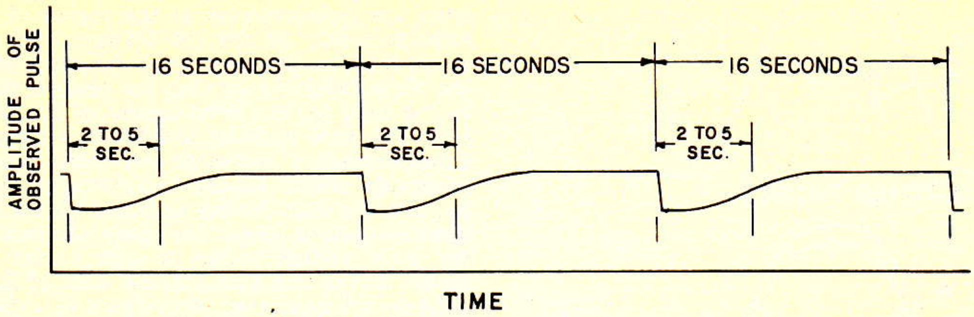
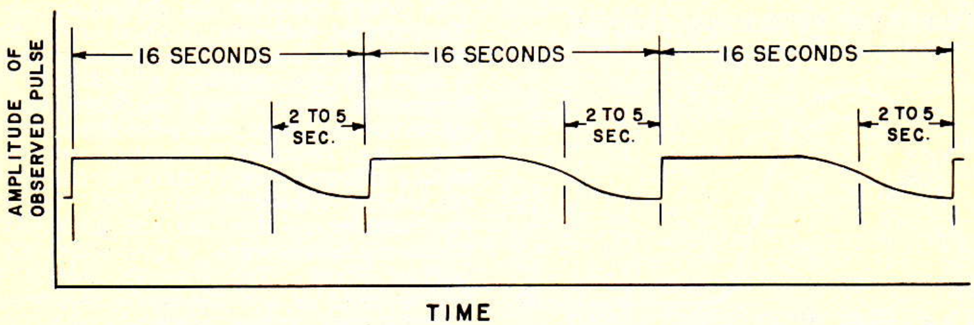


FIGURE 18–37.—Procedure Chart LORAN Pulse Matching Techniques.



CROSSOVER OF OBSERVED PULSE BY A PULSE OF AN ADJACENT HIGHER RATE.
(FOR EXAMPLE O CROSSED BY I.)



CROSSOVER OF OBSERVED PULSE BY A PULSE OF AN ADJACENT LOWER RATE.
(FOR EXAMPLE I CROSSED BY O.)

CHANGES IN PULSE AMPLITUDE AS INDICATED MAY BE ACCOMPANIED BY PHASE SHIFT AND CHANGE OF PULSE SHAPE. IF ANY OF THE TRANSMITTERS INVOLVED ARE DOUBLE-PULSED ON AN ADDITIONAL RATE, THE CYCLES BECOME MORE IRREGULAR THAN THAT ILLUSTRATED.

FIGURE 18–38.—Approximate Cycle of Pulse Irregularity in LORAN Double-Pulsed Transmission.

switching to the fast sweep to continue the measuring process.

Turning up the gain, however, may cause pulses on the lower trace to project through the upper trace, with the consequent possibility of mistaking these for pulses on the upper trace. This error can be avoided by turning the gain down momentarily, in order to make certain which pulses are actually on each trace.

Fading in a pulse which looks steady but which is suspected to be a sky wave may be detected by placing the pulse on the lower pedestal. Then turn to a fast sweep, eliminate noise on the top trace by adjusting the balance, and adjust the gain so that the top of the pulse just touches the top trace. This procedure will provide a reference line to detect fading as soon as it starts.

Confusion in signal identification may exist unless the operator is aware of some of the factors which may cause signals, including ground waves, to change in shape.

Drifting of markers up and down the sides of the pulse as it drifts across the screen, may be confused with splitting. This applies to equipments where markers and signals are on the traces at the same time.

When the gain is turned up high to observe weak signals, strong signals on other recurrence rates will cause the entire trace to pump; this should not be confused with changes in the amplitude of the signal itself.

C. *Manual Synchronizing.*—The facilities for manual synchronization are located in the Synchronization Control Unit. In initial operation the station signals are synchronized at the slave station as described above, under pulse matching. Synchronism is then maintained manually by adjusting the **PHASE** knob. For larger corrections it may be necessary to adjust the **FREQUENCY** control also. In any case the respective clutch must be disengaged, as explained above, to permit manual adjustment. The phase clutch is disengaged when the

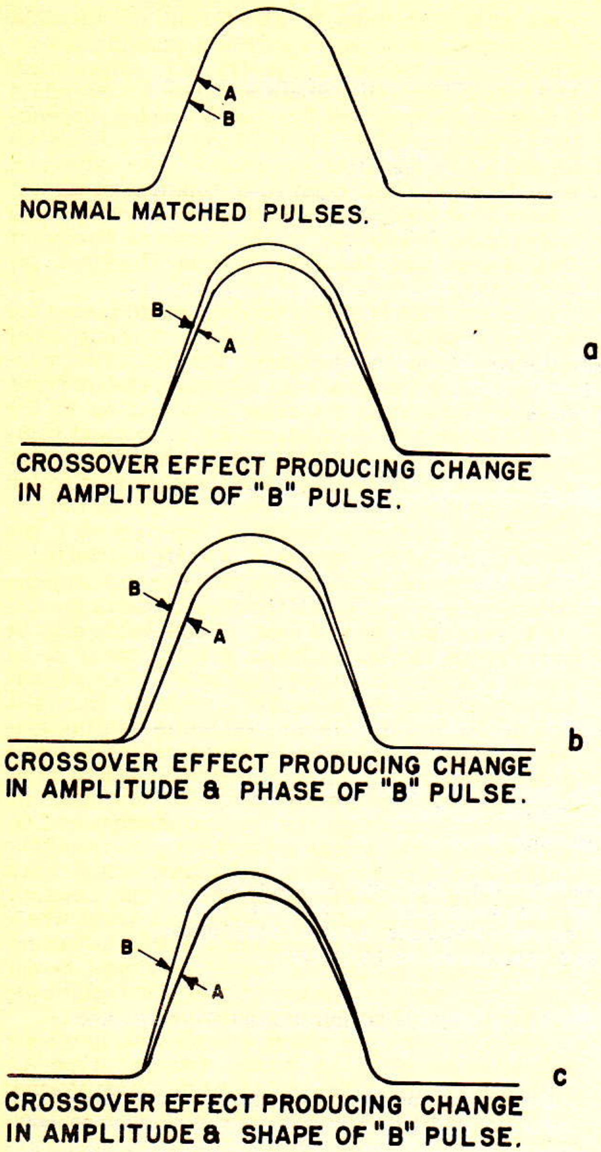


FIGURE 18–39.—Cross-Over Effects in Pulse Matching.

AUTO-SYNC switch is placed in the OFF position. This switch is located on the Synchronization Indicator Panel. The frequency clutch is disengaged when the FREQ. RESET push button is depressed. This push button is located on the Synchronization Control Unit. When the automatic synchronizer is in operation (AUTO-SYNC switch on) the phase may be manually adjusted through the motor drive by manipulating the SHIFT switch which is also located on the Synchronization Control Unit panel. In each case the degree of synchronization is observed on the Synchronization Indicator.

D. *Automatic Synchronizing.*—The automatic synchronizer provides the facilities necessary for automatic pulse matching. The circuits included in this unit generate error voltages whose characteristics are representative of the degree of synchronization error. In the UE–1 Timer both a remote signal from the Receiver and a reference pulse from the Time Delay-Sweep Unit are applied to the unit as the basis for the development of the error voltage. The unit operates the Balance meter at the Synchronization Indicator, an alarm buzzer, the automatic blinker circuit, and furnishes an AC signal to the motor-driving amplifier at the Synchronization Control Unit. The phase and magnitude of the error voltage varies in such a way that the motor drives the fine PHASE and FREQUENCY dials toward zero error. When used at a master station the electrical output signals of the synchronizer are used solely to provide visual and aural indications of synchronization accuracy maintained by the slave.

In initial operation the station signals are first synchronized at the slave station as described above under pulse matching. The automatic synchronizer is then put into operation according to the Timer Instruction Book. There are three models of the automatic synchronizer in general use with the UE–1 Timer, each requiring different procedures and possessing different control dials. These are the Type SN–108/FR Electric Synchronizer, the Automatic Synchronizer and Recorder, and the Type CG–50176 Automatic Synchronizer, a unit of the Model UE–1 LORAN Timer. The type SN–108/FR Electrical Synchronizer or the Automatic Synchronizer and Recorder may replace, physically and functionally, the Type CG–50176 Automatic Synchronizer. No controls are provided at the panel of the Type CG–50176; the few controls affecting its operation are located at other units. The replacement synchronizer units have a number of controls and additional alarm circuits which facilitate operation and provide additional operational safeguards.

For automatic synchronization of a LORAN pair, the method used in the Model UE–1 Timer series is to obtain a precisely delayed reference gating pulse, derived from within the timer, and to compare it with point A of the delayed LORAN pulse received from the remote station. Figure 18–35 (a) shows a typical LORAN pulse signal with the reference point marked A. In the original auto synchronizer and in one of the two alternate methods of operation of the SN–108/FR synchronizer, the method is to use the reference pulse in an electrical gate circuit to sample the amplitude of the received pulse. Thus, the time of sampling (instant of gating) is determined by the occurence time of the reference pulse. Synchronization is correct when the output voltage of the sampling circuit equals a preset reference voltage. The useful information then is in the form of a variable amplitude error voltage, which, in turn, is used to control the speed and direction of a synchronization error-correcting motor. Unfortunately, any change in the amplitude of the received pulse will result in a change in the amplitude of the output voltage and will therefore appear, falsely, as a synchronization error.

The technique for developing the zero error output voltage has been modified in the second mode of operation offered by the SN–108/FR synchronizer to eliminate errors in synchronization due to amplitude variations in the received signal. By passing the received pulse through two consecutive differentiator networks a new waveform, the second derivative, is developed. That part of this new waveform which corresponds approximately to point A on the received pulse is at zero amplitude and is labeled B on figure 18–35 (c). Sampling the second derivative at point B will produce an output voltage which equals a reference voltage corresponding to zero error. Since zero error corresponds to zero amplitude of the second derivative, any change in the amplitude of the received pulse will not cause an apparent error to be detected by the synchronizer. However, nonlinearity of the receiver results in a change in the time position of point B causing some false indication of synchronization error with changes in the received pulse amplitude. Despite this detriment, the SN–108/FR synchronizer is much less responsive to amplitude changes, when operating on the second derivative.

The LORAN Automatic Synchronizer and Recorder replacement unit is functionally similar to the second mode of operation of the SN–108/FR except that inaccuracies, due to amplitude variations in the remote pulse, are eliminated. This is accomplished by utilizing the first zero cross-over point of the second derivative of the detected RF LORAN pulses as the synchronization reference points. These points, corresponding to the point of maximum slope of the closely controlled leading edges of each LORAN pulse envelope, provide fixed reference points permitting basic synchronization techniques similar to those used in manual synchronization and by navigators. Sampling of the second derivative of each detected RF LORAN pulse is provided by synchronization gate sampling circuits. The sampling gates are manually positioned in time coincidence with these reference points for slave operation and for preset of the master automatic monitoring circuits. In addition, for master monitoring, automatic positioning of the remote signal gate around its preset delay is accomplished by motor control of the gate positioning potentiometer. In slave operations, this unit provides a graphic record of periods of operational failure, as well as excitation for an alarm when the remote signal fails or blinks (see 1–4–1). At the master station this unit is employed to automatically monitor and record the time relationship between the reception of two LORAN pulses. The pulse from the master operation also provides excitation for aural and/or visual warning indication when the time relationship is incorrect, or when the remote signal fails or blinks.

The SN–117/FPN–30 Electrical Synchronizer is used in the AN/FPN–30 Timer. This unit is functionally similar to the LORAN Automatic Synchronizer and Recorder replacement unit described above. See paragraph 18–12–45 B for a discussion of the AN/FPN–30 Timer.

18–12–35 ANTENNA SYSTEMS—

A. *General.*—It is imperative that all transmitting and receiving antenna systems installed at LORAN transmitting stations be as efficient as posssible, within the limitations of practical antenna design. Therefore, proper initial installation, adjustment, and future maintenance are mandatory. Standard antennas are designed for specific usages, depending in some cases on geographical location, transmitter power, assigned frequencies, etc. Attention must be paid to the detailed installation of all antennas to assure that each antenna is located and constructed as required by the approved Electronic Layout Plan and Standard Antenna Drawings, for the station.

Once installed LORAN transmitting and receiving antennas must not be relocated without prior authority from the cognizant District. The relocation of such antennas may introduce system error. In some instances, this error is passed on to the user. There are no standards for directional communications receiving antennas; therefore, such antennas shall be designed and installed as directed by the cognizant District. Such arrays shall be installed and located so as not to interfere with the performance of the standard LORAN antennas.

When obstacle lights are installed on the antenna structure, isolation transformers and lightning arrester gaps must be provided. These lights may be mounted on the transmitting antenna tower or on any of the antenna supporting poles. The electrical power must be inductively coupled from the power line into the antenna structure lighting system to isolate the wiring mounted on the antenna poles from ground. Lightning arrester gap must be provided across the transformer to prevent lightning discharges from damaging the transformer or LORAN equipment. Lightning arrester gaps should be adjusted to a point where breakdown occurs when full transmitter power is applied to the antenna. Then, the gaps should be opened to a point where no further breakdown or corona discharge occurs. For maximum protection, special care must be exercised in the installation of the isolation transformer to insure adequate grounding.

When the antenna system and obstacle lights are supported by poles, an Austin Toroidal Type Air Insulated Radio Tower Lighting Transformer (A–2701) is used; A–2701 is also used with 120-foot towers.

B. *LORAN Transmitting Antennas.*—There are two basic types of transmitting antennas employed: the "T" types, and the vertical radiators (towers). The five kinds of standard LORAN transmitting antennas authorized for use at transmitting stations are listed in figure 18–40. Figure 18–41 shows the Standard and Alternate LORAN Transmitting Antennas. Figure 18–42 shows the 300-foot tower.

When higher power outputs are utilized, corona and plume discharge may take place, with a consequent power loss and interference generation. A corona free antenna has been designed using a cage construction (see figure 18–43). However, the system must be carefully installed according to instructions to fully realize the advantages. The isolation transformer used with the 300-foot tower antenna lighting system is an oil insulated transformer of the Austin toroidal type with spaced primary and secondary rings. (See figure 18–44.)

Kind	Use	Dimensions	Power	Nominal Impedance
Tower	Transmitting	120 feet	Medium	1850 kc: 37.5 + j23
				1950 kc: 46 + j48
Tower	Transmitting	300 feet	Medium	1850 kc: 70 - j150
				1950 kc: 55 - j100
Single Wire "T"	Transmitting	90 ft. pole	Medium	1850 kc: 24 - j15
				1950 kc: 27.5 + j16
Single Wire "T"	Transmitting	75 ft. pole	Medium	1850 kc: 19 - j23
				1950 kc: 22 + j10
Cage Wire "T"	Transmitting	90 ft. pole	High	1850 kc:
				1950 kc:

FIGURE 18–40.—Kinds of Antennas Authorized for Use at LORAN Transmitting Stations.

C. *Communications Transmitting Antenna.*—The details of the communications transmitting antenna are given in figure 18–45. This antenna is a slant wire mounted as shown just outside the signal building. Due to transmitter design, this antenna is fed directly from the transmitter in the transmitter room of the signal building. In the event it is necessary to install additional communications transmitting antennas, such antennas shall be installed in accordance with the applicable instruction book for the equipment.

D. *LORAN Receiving Antennas.*—The LORAN remote vertical antenna is the standard receiving antenna for LORAN stations. This antenna is shown in figure 18–46. It consists of a 7-strand #14 AWG phosphor-bronze wire suspended vertically from a cross-arm mounted on top of a 75-foot pole. Such an antenna is quite satisfactory in areas where the noise level is relatively low. However, in regions where man-made or atmospheric noise is high, the signal-to-noise ratio may be too low for reliable reception. In these cases a highly directional comb receiving antenna is employed. The comb antenna is a special type of linear end-fire antenna array, employing vertical elements which are connected and phased by means of nonresonant transmission lines. The antenna signal-to-noise ratio is considerably improved by the narrow directivity pattern of reception. Reliable ground wave LORAN synchronization can be insured in many cases between master and slave stations where ground wave synchronization is impossible with a single vertical antenna. The length of the array is 1,020 feet from the first to the last vertical element. Each array contains 18 elements, at 60-foot intervals. Where installation space is restricted, it may be necessary to install two parallel arrays of elements, each physically separated by one-half wavelength of the receiving frequency. However, the actual number of elements used may vary to suit the space limitations of the particular installation. In addition to the vertical elements, each element has a Loading Unit MR–192 with interconnecting cables. The array is terminated in a Line Terminating Unit, MR–193, with a connecting cable. This comb antenna has replaced the Wave or Beverage antenna which was used on earlier installations. Figure 18–47 shows a typical comb receiving antenna.

E. *LORAN Monitoring Antenna.*—The LORAN monitoring antenna is installed at some LORAN transmitting stations to supply sample slave and master stations signals to the supervisory equipment in the signal building. This system provides for self-monitoring at both master and slave stations. The monitoring antenna is identical to the LORAN remote receiving antenna (see figure 18–46).

F. *Communication Receiving Antenna.*—A broad band communications receiving antenna is installed at the LORAN station to provide for interstation communication and for reception of standard frequency signals from WWV, WWVH, or JJY. Figure 18–48 illustrates such an antenna system. Under adverse conditions or at remote locations, reliable standard signals may not be available with the broad band antenna. In such cases a rhombic receiving antenna may be required.

G. *Antenna Coupling Unit.*—Antenna coupling units are provided at LORAN installations to match the antenna impedance to the 52-ohm coaxial transmission lines, which are used to connect the antenna

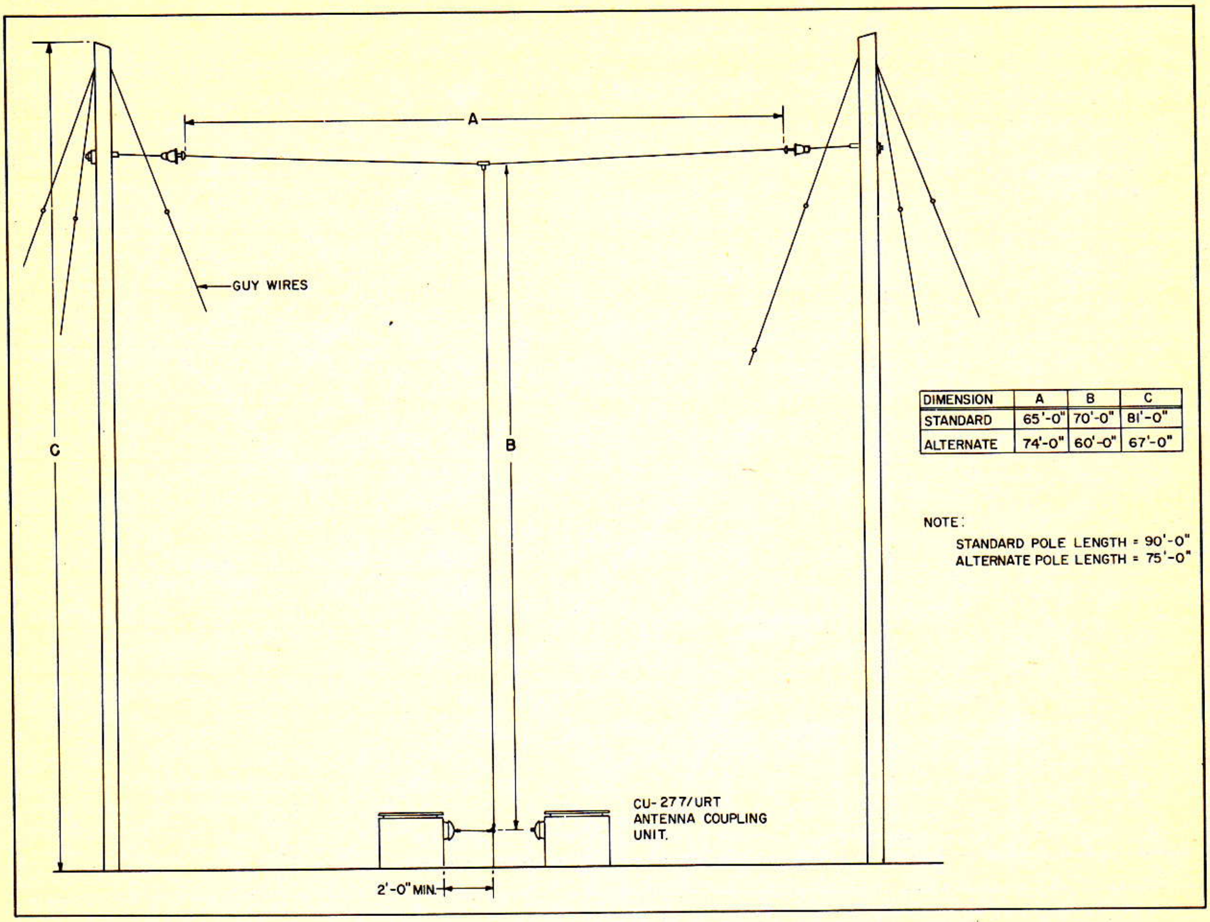


FIGURE 18–41.—Standard and Alternate LORAN Transmitting Antennas.

to the equipment in the signal building. In general, the antenna impedance consists of both reactive and resistive components. The reactive component must be balanced out and the resistive component stepped up or down by the coupling unit so that the input impedance of the antenna coupling unit is 52+j0 ohms.

Each antenna, except for the communications antenna and the comb antenna (when used), is supplied with an antenna coupling unit which is located at the base of the antenna. The standard models in use at the present time are discussed in the following paragraphs:

(1) *Transmitting.*—There are two models of the transmitting antenna coupling unit, the CU-277/URT and the Federal Model. These are used to couple a LORAN transmission line to a LORAN transmitting antenna. Each of these models is suitable for use with either a Model T–137 (or T–325/FPN) series transmitter for 160-kw. peak power output operation, or a Model T–137 (or T–325/FPN) series transmitter and a Model T–138–A (AM–701/FPN) series amplifier combined for megawatt peak power output operation.

There are four transmission lines between the LORAN signal building and the transmitting antenna coupling units at the base of the antenna. One transmission line is attached to each coupler on one end, and each transmitter, through the junction box, on the other end. One transmitter monitoring line is connected to each antenna coupling unit.

(2) *Receiving.*—The antenna coupling assembly Type CAQT–47438 is used to match a vertical wire antenna to a 52-ohm coaxial transmission line so as to provide maximum signal transfer from the antenna to the line, with selectivity compatible with the maximum permissible distortion. This is accomplished by adjusting an inductance in series with the antenna and an inductance in shunt with the transmission line until the input impedance of the coupling unit, with the antenna connected, is 52+j0 ohms at the desired operating frequency.

The Model CAQT–47438 antenna coupling assembly is used with the LORAN remote receiving antenna and with the LORAN monitoring antenna. It is normally mounted on two short cross arms at the base of the antenna pole.

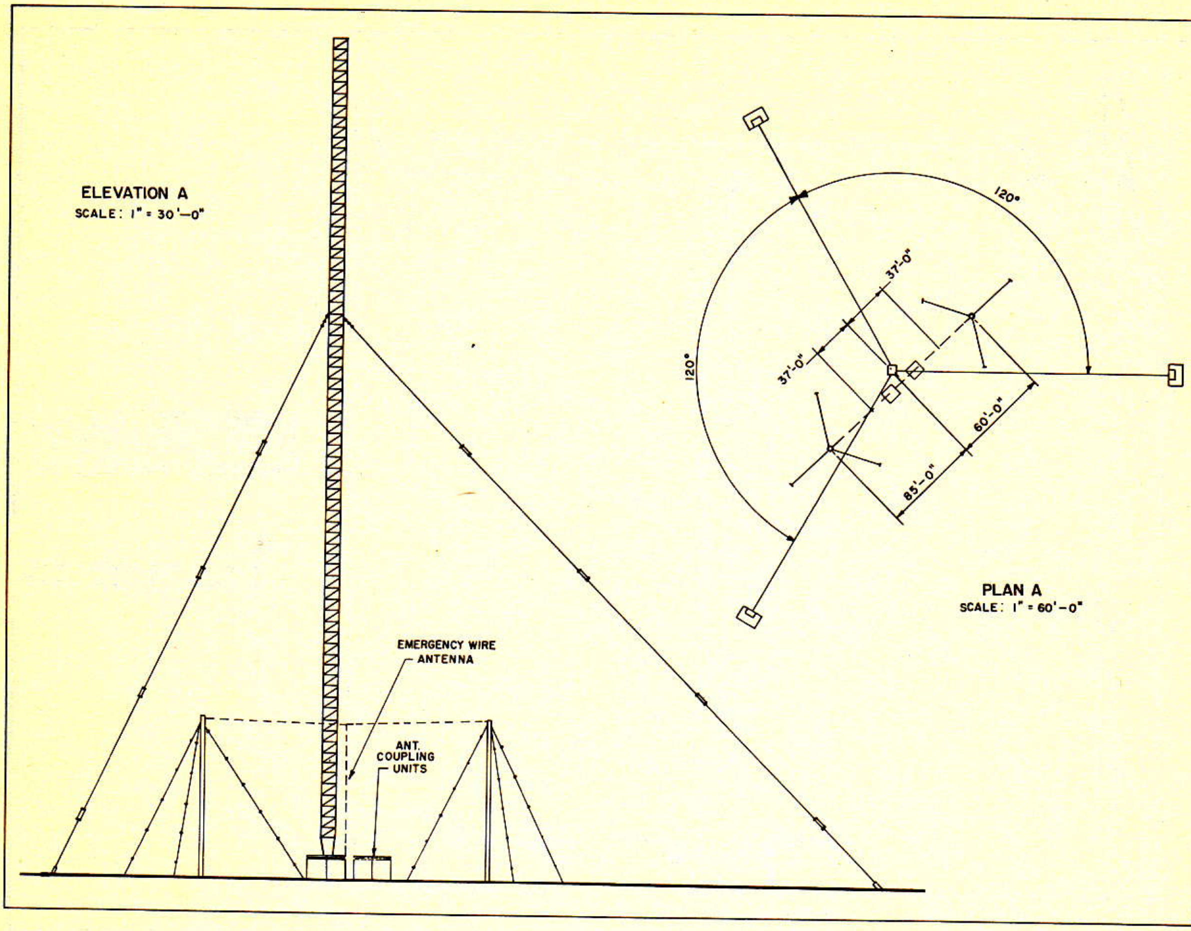


FIGURE 18–42.—LORAN Transmitting Antenna—300-Foot Tower.

H. *Antenna Ground Systems.*—Details of the ground systems employed at LORAN transmitting stations are described in the appropriate drawing for each specific antenna used. A typical antenna ground system layout is shown in figure 18–23. The transmitting and receiving antenna ground system, when installed in accordance with approved instructions, will insure maximum ground conductivity for all types of terrain. However, the efficiency of the ground system tends to decrease with time unless carefully maintained. Therefore, it is extremely important that LORAN station personnel become thoroughly familiar with the proper maintenance of the antenna and its associated ground system.

18–20–40 SOLID DIELECTRIC COAXIAL CABLE INSTALLATION—

The development of solid dielectric coaxial cable filled a need for cables of improved electrical and mechanical properties, provided in most cases greatly increased ease of installation and maintenance, and permitted much wider application. For satisfactory service, however, there are certain important precautions that must be observed during installation and maintenance. These precautions are necessary primarily because of the physical characteristics of the solid-dielectric, polyethylene, a thermosplastic material with a sharp melting point in the vicinity of 225° F. Below this temperature there is some tendency for the plastic to flow under pressure, with a consequent dimensional change (between the inner and outer conductors) which in turn affects the electrical properties.

During installation and maintenance of this cable the following general precautions must be carefully observed:

A. *Avoid hot spots.*—The maximum working temperature of the dielectric at the inner conductor shall not exceed 180° F. In actual practice the average power ratings for given frequencies specified for the cable are such that with the cable operating in a closed space at 105° F., the heat generated by the electrical load should not cause the interior of the dielectric to exceed a temperature of 180° F. In situations where cables must be installed in closed spaces at temperatures above 105° F., the cables should be sized to carry less than rated load. A rough rule to follow is that the ambient temperature of the closed space may be increased 5° F. for each

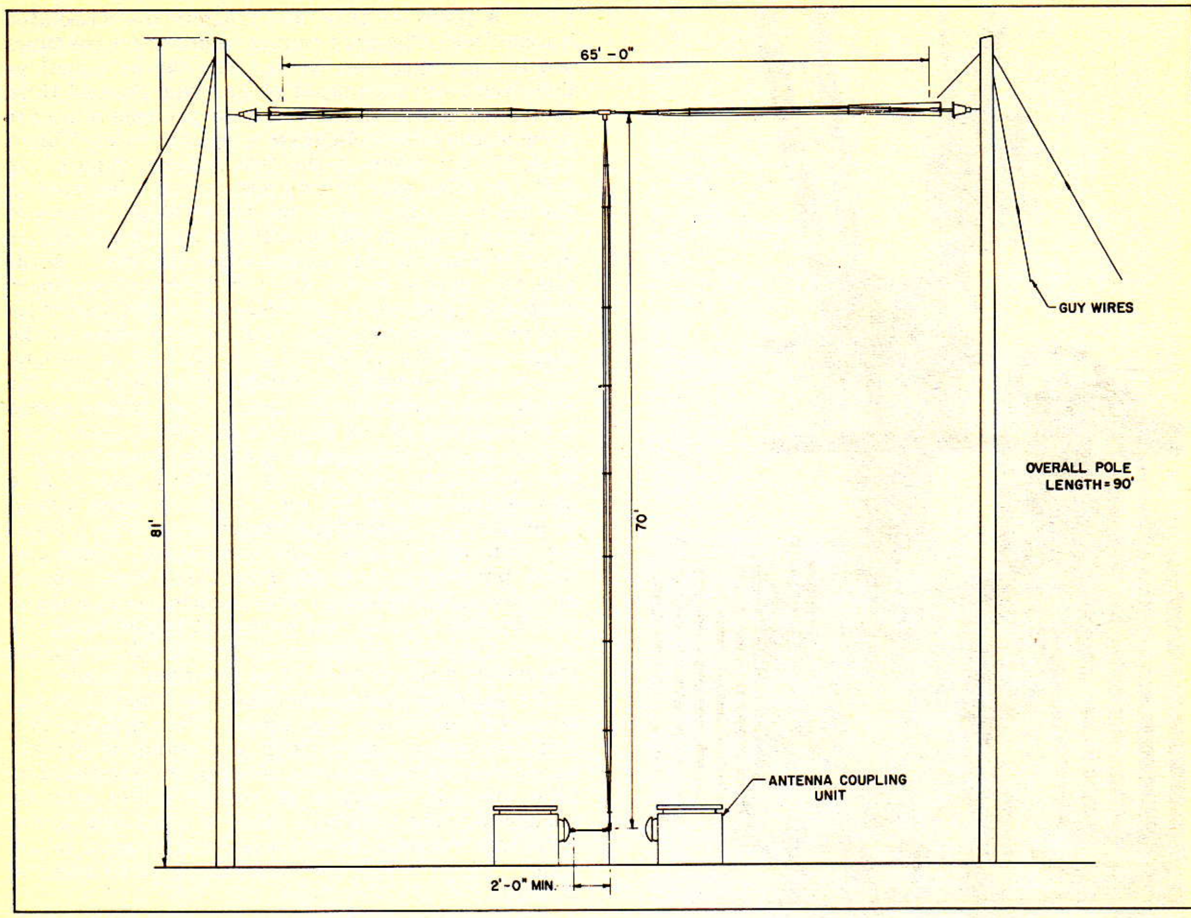


FIGURE 18–43.—LORAN Transmitting Antenna—Cage Construction.

10% increment that the actual load is below the rated load. In case of any uncertainty, the more detailed treatment of this problem presented in the manuals on transmission lines should be consulted.

B. *Avoid sharp bends.*—Bends in coaxial cables shall have as large a radius of curvature as possible. In no case shall the radius of curvature be less than 10 times the diameter of the cable.

C. Extreme care should be used at bulkhead fittings and stuffing tubes to prevent dimensional distortion (squeezing). The special rubber packing available for each size of stuffing tube should be used to insure leak-free seals without distortion of the cable.

D. Prefabricated straps should always be used for securing cables, and under no circumstances should straps ever be formed by hammering around cables.

E. Whenever possible single cables should be run the full required length to avoid splicing. If this is impossible and splicing is necessary, the special procedures prescribed for splicing solid dielectric coaxial cables should be carefully followed.

F. When cable is run between rigidly mounted and flexibly or shock-mounted equipments, sufficient slack should be allowed in the line to permit unrestricted motion of the flexibly mounted equipment.

G. Avoid exposing the cable to points of constant abrasion. Provision should be made at the support points (e. g., by using rubber grommets or wrapping a short length with friction tape) to prevent undue abrasion or deformation because of constant vibration.

H. When coupling rigid coaxial lines to solid dielectric lines, all mating surfaces should be clean and the couplings made up securely to prevent the possibility of arcing.

I. The cable should not be subjected to unnecessary pulling or stretching, and should never be used as a tow cord.

J. Cable runs should be made as short as possible, consistent with good installation practice, since attenuation (power loss) in a line increases with length.

18–12–45 REPLACEMENT EQUIPMENT—

A. *General.*—The LORAN equipment list shown in figure 18–22 includes the AN/FPN–30 Timer, and the AN/FPA–2 Switching Unit replacement equipments for which no instruction manuals are avail-

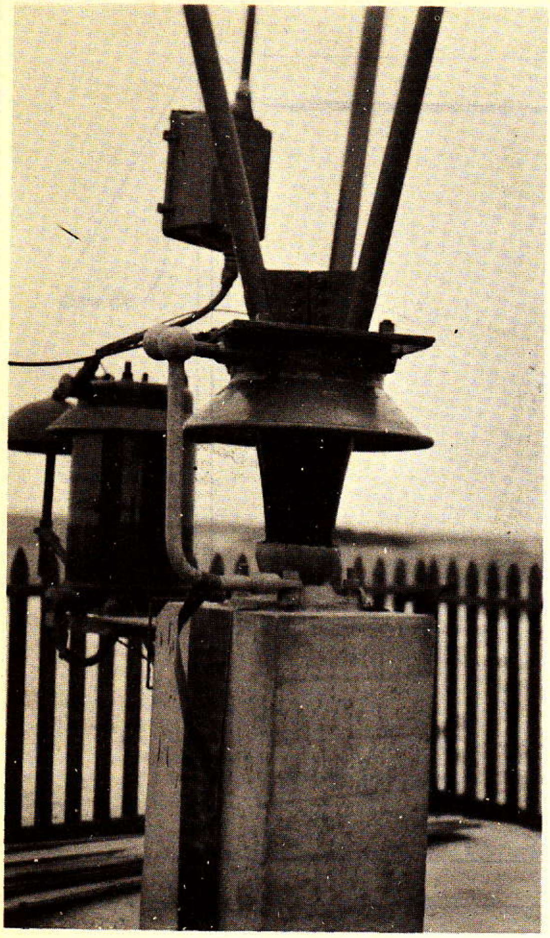


FIGURE 18–44.—Lighting Transformer A–2743 Installation on 300-Foot Tower.

able at the present time. A brief description of these equipments is included in this paragraph to introduce them and provide advance information for the LORAN station technician. The improved design of the replacement equipment will provide greater reliability, accuracy, and stability of operation and facilitate future changeover to semiautomatic and automatic operation with the accompanying reduction in technical personnel required to maintain the LORAN Station Electronic equipment. The replacement equipment has certain design features incorporated that will provide smoother operation, when used in conjunction with the LORAN Monitor Alarm Equipment and the RF Switching Group (AN/FPA–3), than is now possible with the present units.

B. *LORAN Timer Type AN/FPN–30.*—The AN/FPN–30 Timer in controlling the moment of occurrence of the transmitted pulse performs three basic functions: (1) Establish Rate, (2) Establish Reference Delay, and (3) Establish Time Difference.

(1) *Establish Rate.*—The timer generates a signal whose precise recurrence establishes the LORAN rate. A pulse, at this rate, triggers the associated transmitter. The basic timing standard for the timer is a 100-kc. crystal oscillator. The 100-kc. signal, as delivered from the output of the Sync Control Unit, is divided down in frequency to produce a square wave at the desired LORAN repetition rate. This is basically the same as the UE–1 Series Timers. In fact, the same type crystal and crystal oven used in the UE–1 are also used in the AN/FPN–30. However, the divider used in the AN/FPN–30 improves stability and simplifies setting up the repetition rate. Actually two square waves are produced in the timer. Both are identical in all respects except that they are of opposite polarity. The leading edges of the positive half of each square wave 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, each one delayed with respect to each corresponding square wave. 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 pulse. The replacement timer uses delay phantastrons, in the Time Delay Unit, instead of delay multivibrators. This contributes to a much greater stability and thus reduces drift and readjustment. Provision is also made for rapidly changing the coding delay to any one of five preset values.

(2) *Establish Reference Delay.*—A timing interval is established within the timer. This interval is a reference delay and is used as a standard against which the timer difference between the reception of local and the reception of remote pulses may be measured. The reference delay is measured as the difference between the two main delays set up in the timer. These delays are called the A delay and the B delay.

(3) *Establish Time Difference.*—The time difference between local and remote pulses may be controlled by the timer at the slave station. The occurrence time of the slave pulse is adjusted, either manually or automatically, so that the time difference equals the reference delay. An automatic synchronizer (SN–117/FPN–30) 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 (see paragraph 18–12–30) of the two signals. The error voltage thus developed is used to operate a synchronization control motor which changes the phase to correct the error in exactly the same manner as in the UE–1 Timer. Functionally, the SN–117/FPN–30 is similar to the LORAN Automatic Synchronizer and Recorder unit developed at the Coast Guard Electronics Engineering Station, Wildwood, New Jersey, by the Coast Guard.

LORAN personnel familiar with operation of the UE–1 Timer should familiarize themselves with certain new features of the automatic synchronizing system in the AN/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 ap-

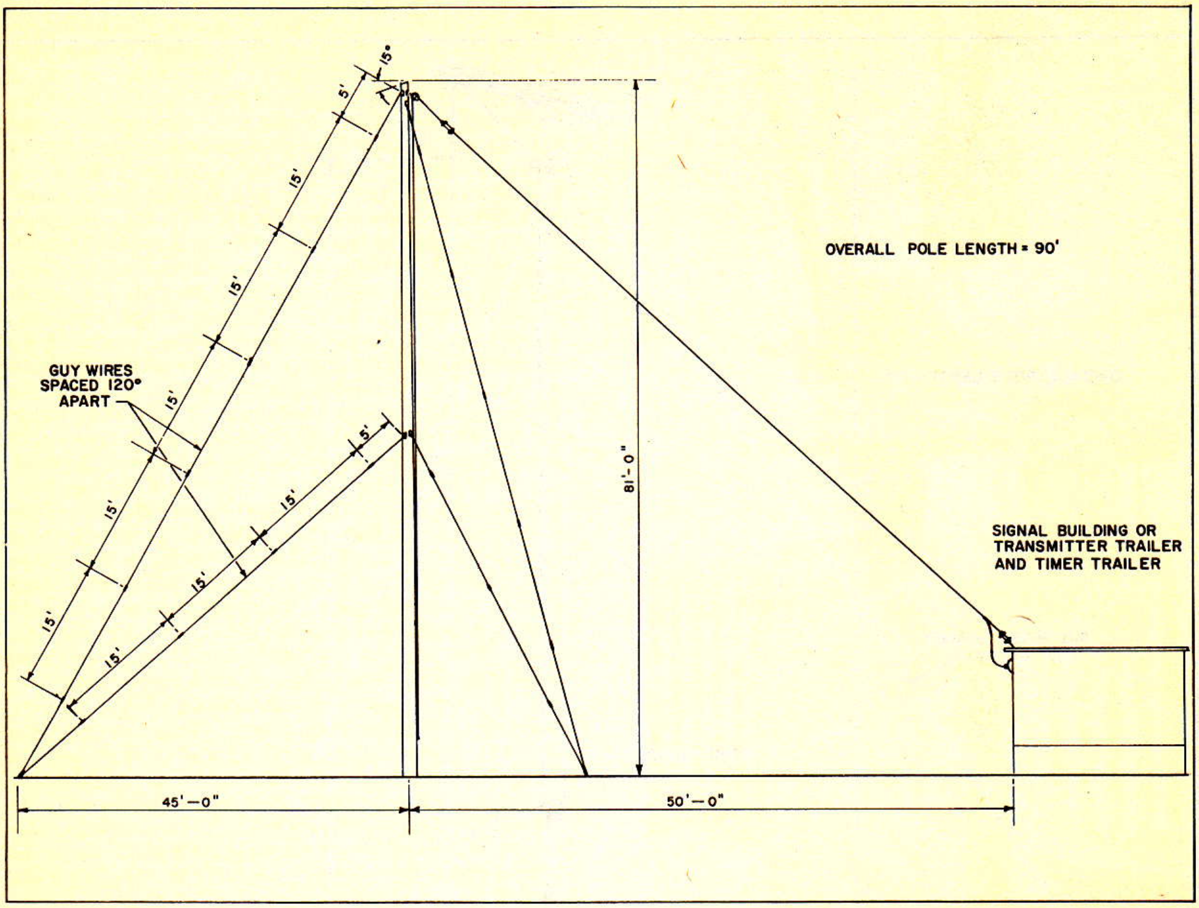


FIGURE 18–45.—Communications Transmitting Antenna.

preciated, however, so that the operator may discard those practices, formed by habit, which prevent derivation of maximum benefit from the new features.

With the AN/FPN–30 Timer, it is not necessary to establish a precise manual match of the received signals, as seen on the fast scope, in order 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 AN/FPN–30 Timer the gate delay circuit is accurately adjusted without reference to the remote signal. Only a coarse visual synchronization adjustment (±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.

(4) *Electrical Synchronizer Type SN–117/FPN–30.*—The electrical synchronizer in the AN/FPN–30 Timer operates using the time difference between the local and remote signals, whereas the UE–1 Timer synchronizer 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 AN/FPN–30 system is that it works directly from the received signals, whereas in the UE–1 system it was 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 the 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 AN/FPN–30 Timer, synchronization error caused by improper adjustment of the gate delay setting is considerably 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 that the signals are of equal amplitude and similar shape).

(5) *Timer Receiver.*—The radio receiver provides means for delivering RF and detected video pulses to the other units of the timer. Primarily, the receiver picks up the local and remote LORAN signals and makes them available for presentation on the

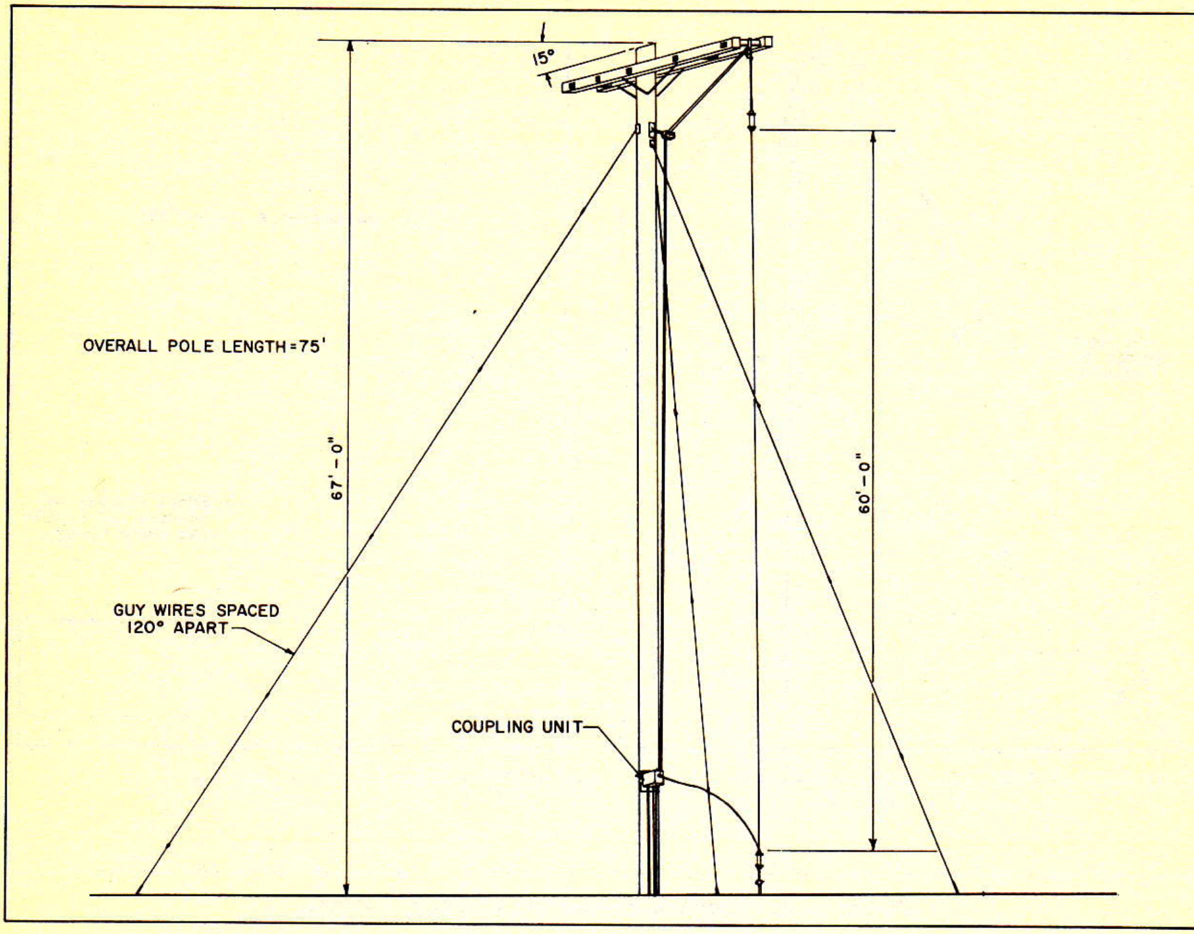


FIGURE 18–46.—LORAN Remote Receiving Antenna.

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 is useful for cycle matching operation. Because the receiver does not employ a local oscillator, the phase relationship between the pulse envelope and the RF carrier is preserved and the individual RF cycles may be used for phase comparison of local and remote signals. The RF cycles provide a more sensitive indication of phase relationships. This indication is useful because the RF 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 available 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. Different signal gains are provided in the two channels so that the amplitudes of the received signals may be equalized.

(6) *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.

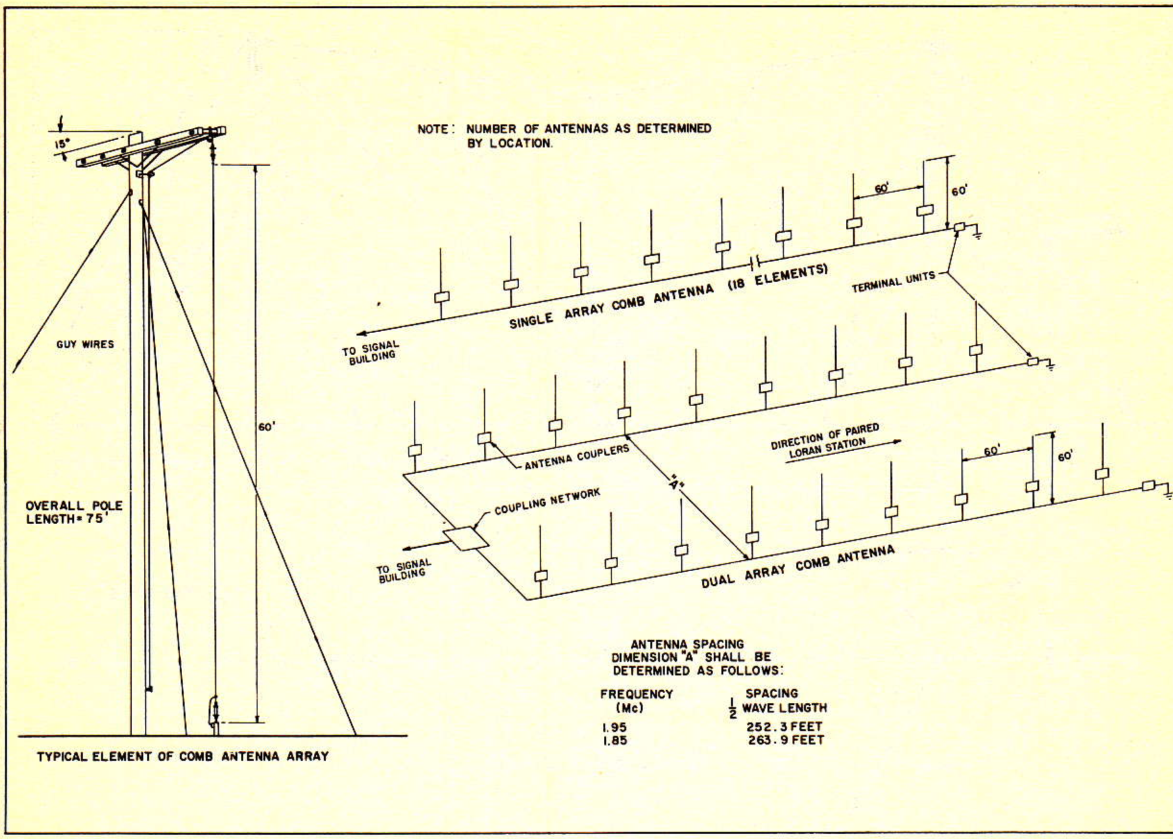


FIGURE 18–47.—Comb Receiving Antenna.

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. A third oscilloscope 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 RF presentation over the video presentation under noisy conditions is freedom from "baseline bounce." Detected noise components change the average DC voltage in the detector output circuit to shift the video baseline up and down with noise. This shift makes the video presentation bounce up and down, making pulse matching difficult. Because the RF presentation is an AC presentation, noise will not shift the baseline. Thus, the envelopes of the signals presented on the RF SCOPE are better suited to pulse matching under noisy reception conditions. Since the RF presentation provides for detailed observation of individual carrier cycles, cycle matching may eventually be used.

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.

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 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. One of these lamps will glow if a synchronization abnormality exists. 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

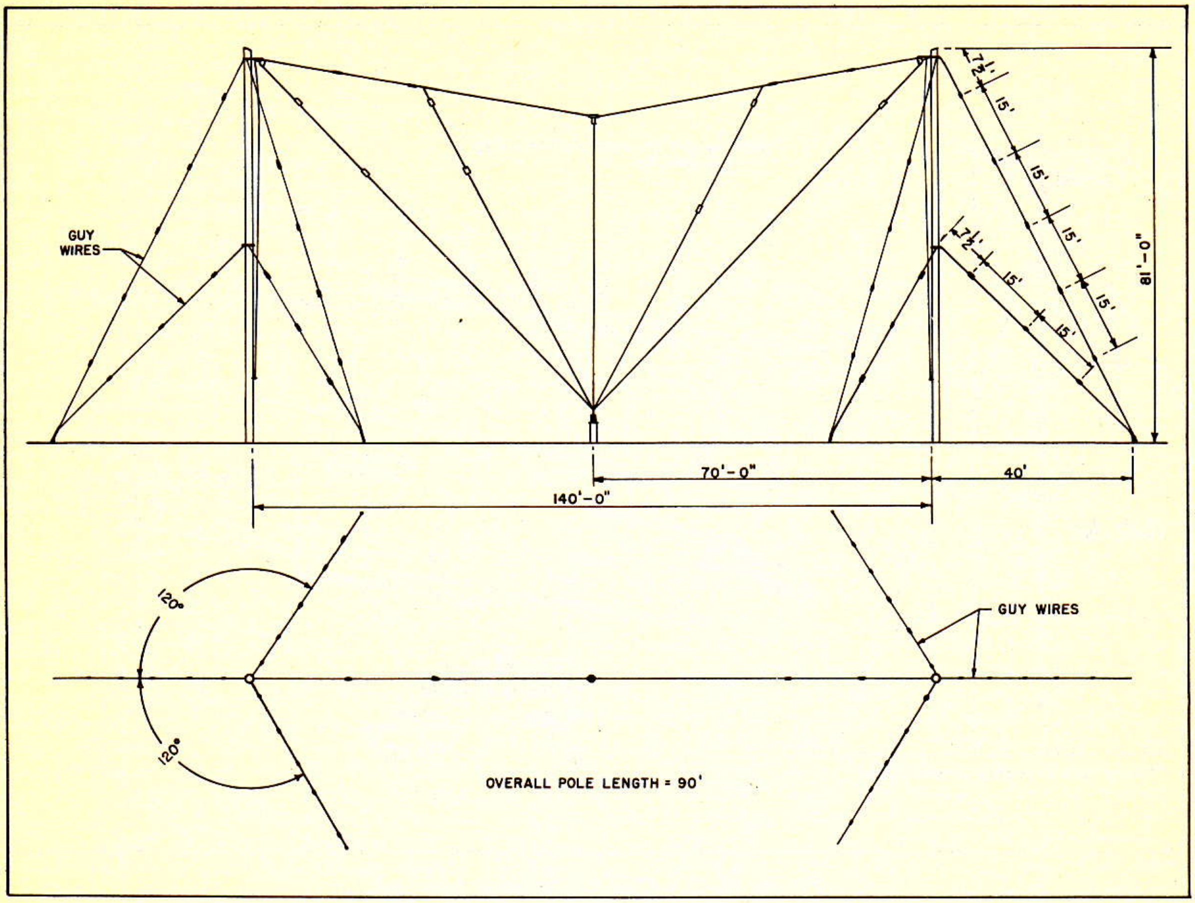


FIGURE 18–48.—Broad Band Communications Receiving Antenna.

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.

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 steps as required. 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.

C. *LORAN Switching Group Type AN/FPA–2.*—The AN/FPA–2 switching group is provided at a LORAN station to (1) permit the selection of a desired combination of connections between the timer and transmitter equipment, (2) separate the local and remote LORAN signals into two channels and reduce the amplitude of the local signal, and (3) attenuate RF leakage and distribute power to the timers and associated equipment. This new switching group will replace the UM switching equipment at LORAN stations where AN/FPN–30 Timers are installed. The design of the replacement switch gear facilitates future changeover to semi-automatic or automatic operation. Better control grouping and more legible control markings will simplify operation and minimize operational errors. The principal features differing from the UM switching equipment are listed below:

(1) The AC voltmeter and frequency meter are now mounted on the power distribution panel to facilitate readings as circuits are changed.

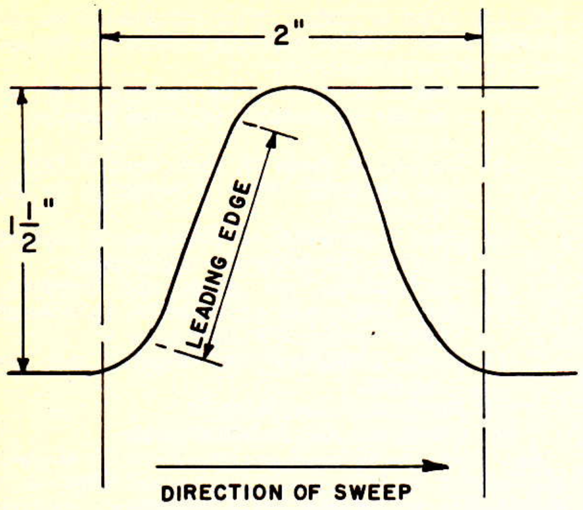


FIGURE 18–49.—Standard Signal as Viewed on LORAN Timer.

(2) In addition to the usual isolation transformers RF line filters have been added to the primary lines entering the LORAN switching group to remove the possibility of the strong local signal finding its way into the timer and switching group. This makes the screened room, so long a feature of LORAN transmitting stations, unnecessary for timer isolation purposes.

(3) Electronic switching units now separate the distant signal from the local signal, partially attenuate the latter, and send each along its proper line to the dual timer receiver inputs, where the local signal is further attenuated and adjusted manually to match the distant signal as then received.

(4) RF impedances are effectively matched throughout this switching equipment. Switches and impedance matching pads provide means for matching 1, 2, or 3 antenna transmission lines to 1, 2, or 3 ESU inputs.

(5) Provision is made for remote control of the transmitter exciter connections from the operating timer(s).

(6) Sealed, pretuned plug-in coils for each LORAN radio frequency are used in the output circuits of the ESU.

18–25–50 ROUTINE OPERATIONAL INSPECTION, ADJUSTMENT, AND IRREGULARITY CORRECTION—

A. *General.*—Routine operational checks of LORAN stations will reveal functional difficulties when the equipment meter readings, oscilloscope patterns, and other indicating devices are not displaying their normal values. Such abnormal readings generally call for corrective maintenance. However, if the indicating devices are not properly adjusted, the difficulty may be in the indicators rather than in the equipment itself. Therefore, routine operational inspections, adjustments, and irregularity corrections must be performed by qualified technicians to insure that all readings present a true picture of the equipment performance.

B. *Timer Signal Standard.*—At all times while maintaining synchronization, signal patterns shall be maintained on fast sweep at a standard of two inches in base width and one and one-half inches in amplitude, as shown in figure 18–49. When matching signals to obtain time difference readings, the leading edge of one standard signal is to be directly superimposed upon the leading edge of the other standard signal, so that both signals appear as one signal.

C. *Signal Focus.*—Personnel are cautioned to use care in adjusting the focus and intensity of oscilloscopes and oscillographs to obtain a clear pattern with fine traces. Cathode-ray tubes that cannot be focused to give a fine trace do not permit sufficient accuracy in signal matching and delay measurement and shall not be used in the LORAN system, except in an emergency when a suitable replacement is not immediately available. The "Intensity" control should be left in that position where the trace is visible and in best focus. Maximum "Intensity" settings on some oscilloscopes may result in foreshortening cathode ray tube life due to "burning" of the screen.

D. *Primary Power Supply.*—Stations using prime movers for power shall change over in accordance with cognizant District instructions. Prior to such changeover, the power unit to be placed in service shall be operated for a period sufficient to assure stable Power Plant operation at proper frequency and voltage.

E. *Transmitters.*—

(1) A transmitter in service shall be inspected at least once every hour to determine that pulse shape and stability are satisfactory, and that meter readings are normal.

(2) Changeover of transmitters shall be accomplished as outlined in paragraph 18–12–15. On-air equipment shall remain in service until such equipment requires preventive or corrective maintenance.

(3) Blinking shall be initiated by the station changing over fifteen seconds before the changeover occurs, cease blinking after changeover is completed and rate synchronization is regained.

(4) A standby transmitter shall be kept in readiness for emergency changeover, except when being serviced, with filament voltage applied and the RF output connected to the transmission line link.

(5) When the transmitter in service develops trouble which cannot be corrected in a period not to exceed two minutes, changeover to the standby transmitter shall be made in accordance with paragraph 18–12–15.

(6) A transmitter taken out of service in emergency shall be serviced as soon as practicable and tested on the dummy load to determine that the trouble has been removed. When normal operation is obtained, it shall be put on standby until the next transmitter changeover.

F. *Timers.*—

(1) Timers in service shall be inspected at Master stations once every fifteen minutes, and at slave stations once every hour, to determine that markers,

406226 O—57——6

focus and time delay or coding delay are correct, and that signal match is satisfactory.

(2) Standby timers shall be inspected at the beginning of the watch and at mid-watch, and except when being serviced, shall be maintained in adjustment for immediate service. The proper coding delay or time difference shall be set up, and the phase shifter adjusted so that master and slave pulses are on their respective pedestals. When the standby timer is not synchronized, the signals will "drift" along the trace, and the blanking pulse of the standby timer will attenuate the remote signal. If the signals show a tendency to "drift" along the trace, the crystal controlled oscillators are not synchonized. At a slave station, the standby timer shall be synchronized with the operating timer. At a master station, both timers should be checked against WWV. If this check cannot be made immediately, the standby timer at a master station shall be synchronized with the operating timer, and the WWV check made as soon as practicable.

(3) Changeover to the standby timer shall ordinarily be made when the on-air timer becomes defective and at such other times as necessary for equipment maintenance. Changeover shall be in accordance with paragraph 18–12–15.

(4) At master stations the crystal frequency of the standby timer on each rate shall be corrected at least once each week by reference to a standard frequency transmission. The timer shall then be put into service *without* adjustment of frequency and the crystal frequency of the timer taken out of service shall be corrected.

(5) The following routine procedure shall be observed every fifteen minutes at a master station and every hour at a slave station. The standby timer shall be used as a constant check on the operating timer.

- (*a*) Check signal focus by adjustment.
- (*b*) Check receiver tuning by tuning to maximum pulse amplitude and, if necessary, rebalance and match signals to standard amplitude.
- (*c*) Inspect all counters.
- (*d*) Inspect gates.
- (*e*) Inspect recurrence rate.
- (*f*) Inspect (by actual reading) total time delay if master, or coding delay if slave, reading major, intermediate, minor markers, and interpolating to obtain the last digit.

(6) Under no circumstances shall any adjustment of the equipment which affects counters or dividers, gates, or time delay circuits, be made except by qualified personnel.

G. *Irregularities.*—Immediately when rate irregularity occurs as indicated by impairment of either signal, by the paired station blinking, or by any condition not permitting normal rate operation or necessitating blinking, the technician shall observe the following procedures:

(1) Determine that blinker instructions are being properly observed.

(2) Localize the trouble insofar as possible, considering the nature of the irregularity.

(3) Make an inspection as indicated below, adjusting equipment as necessary, double checking the time delay or coding delay adjustment on the standby timer, proceed with any or all of the following as circumstances require:

- (*a*) Inspect such items in paragraph F (5) as the irregularity indicates may be in error.
- (*b*) Inspect all items in paragraph F (5), if no particular error is indicated by the irregularity.
- (*c*) Check Attenuator or Electronic Switching Unit in the Switching Equipment.
- (*d*) Check power line voltage and frequency.
- (*e*) Check transmitter adjustments, pulse shape and stability of leading edge.
- (*f*) Check transmitter and coupling unit line current.
- (*g*) Check antenna current.
- (*h*) Check receiving antenna system.

(4) When the cause of the irregularity is located, the trouble shall be corrected immediately, or a changeover to standby made—whichever permits the quickest resumption of normal service.

(5) When timer readings remain within tolerance and a thorough check of all equipment indicates normal operation, it may be assumed that station operation is normal and further equipment inspection should not be necessary. Synchronization is obtained only by the cooperation of both stations comprising a LORAN rate. When the paired station blinks every means possible should be used to determine the fault and to correct the "sync outage" with the minimum of unusuable service time. Under no circumstances should "blink battles" ensue. Remember—difficulties may be encountered at either station, but the Master station has the responsibility for determining when proper synchronization is being maintained.

(6) When any equipment irregularity occurs, a suitable entry shall be made in the "Remarks" column of the log and initialed.

18–13 PREVENTIVE MAINTENANCE

18–13–1 GENERAL—

A. *Definition and Necessity.*—Maintenance can be divided into two categories: preventive and corrective. Corrective maintenance is concerned with the repair of equipment after it has been damaged or becomes inoperative. Preventive maintenace (with which we are dealing in this section) is concerned with the routine, periodic performance of certain mechanical and electrical procedures required to keep the equipment in the best possible condition.

The equipment installed at LORAN transmitting stations is designed to give long, trouble-free service. Nevertheless, preventive maintenance is important because the routine checking and servicing of the equipment will often result in the location of potential sources of trouble. Remedial steps can then be taken before actual component failures occur. By proper maintenance, equipment breakdowns and the resulting discontinuities of service can be practically eliminated. Routine maintenance checks should always be followed by inspection, since the very performance of some procedures, such as cleaning, may inadvertently cause a loose wire or broken connection.

An important factor in any systematic program of preventive maintenance is the keeping of an accurate and complete record of each maintenance operation. This aids in establishing routine, and the records may serve as valuable reference material for future use.

B. *Safety.*—The voltages employed in the LORAN system are dangerous and may be fatal if contacted. It is extremely important that personnel authorized to open and service the equipment understand and observe precautionary measures. All maintenance work must be performed in a careful and intelligent manner. Keep away from live circuits and do not attempt to do any maintenance with the high voltage supply on. Do not depend upon door switches or interlocks for removing voltages from equipment. Remove power first! ! Flexible test leads or probes should not be held when measuring potentials in excess of 1,000 volts. Do not remove the protective covers or touch the high voltage test jacks of the high voltage power supply at any time when the power is on. Do not service the equipment alone; always have the immediate presence or assistance of another person capable of rendering first aid if it should be necessary. Certain precautionary measures should be observed when using carbon tetrachloride as a cleaning agent. Prolonged exposure to the fumes from carbon tetrachloride can have a toxic effect, especially in closed-in areas, such as inside cabinets. Also, the action of "carbon-tet" on rubber tends to make the rubber "spongy" and after prolonged contact may actually dissolve it. When surfaces are cleaned with carbon tetrachloride, be sure to wipe the surface over with a lint-free, dry cloth since this agent leaves a film on the cleaned surface.

C. *Methods.*—The following methods of approach to preventive maintenance are basic to any routine program and may be performed easily and conveniently by a non-technical operator. It should be kept in mind that these procedures are of a general nature and are not intended to supplant the detailed information in the manuals pertinent to each unit of equipment.

(1) Feeling—such as heat of tubes, gear boxes and transformers; mechanical movements such as backlash, freedom of operation, and tightness of connections.

(2) Listening—such as bearing noise, vibration, and arcing.

(3) Seeing—pilot lamps, meters, fuses, tube filaments, cables, wiring, connections, effects of heat and moisture.

(4) Cleaning—wiping, scraping, vacuum cleaning.

(5) Testing and measuring.

(6) Lubricating.

D. *What to Check.*—The importance of setting up and adhering to a systematic and periodic preventive maintenance program has already been stressed. The performance of such techniques as cleaning, inspection, adjustment and lubrication in addition to the keeping of appropriate records can serve to reduce breakdowns and component malfunctions to a minimum. The general information listed below describes some simple checks which should be made, and is not intended to represent a maximum preventive maintenance program. If any situation arises which demands more details and complete information, the appropriate instruction book should be referred to. The exact maintenance schedule and the time interval between the performance of particular procedures will depend upon operating times, and other factors peculiar to any one station. No one schedule should be conceived as being unalterable; the schedule of one station may vary with prevailing conditions.

(1) *Air Filters.*—There are two types of air filters used at LORAN installations—fiber glass and wire mesh. Both types of filters should be cleaned weekly. Remove the filter and take it out of doors, away from the equipment room. Clean, using a vacuum cleaner or blower and then replace. When a filter becomes clogged with dirt to such an extent that the above cleaning is no longer effective, then proceed as follows: In the case of the fiber-glass filter, replace with a new cartridge drawn from spares. In case of the wire mesh filter, clean as above. Then rinse in a hot solution of fresh water and dishwashing compound until free from dirt and grease. Allow to dry, and place in a pan of No. 10 or 20 motor oil. Then drain off surplus oil (about 3 or 4 hours) and replace in the equipment. DO NOT USE GASOLINE OR OTHER SUCH SOLVENTS.

(2) *Blower Fan Blades.*—Clean and dust from the front with a soft cloth. Be careful not to bend the blades out of alignment.

(3) *Blower Motor.*—Disassemble semi-annually; thoroughly clean and dry the grease packed bearings and replace with a good grade of cup grease.

(4) *Cabinets.*—Should be checked for weather-sealing; all nuts, bolts, and screws should be checked, tightened and aligned.

(5) *Cable Connections.*—Should be examined when the interior of the equipment is dusted; check for loose connections, charred or discolored resistors, and dirt or corrosion between points of high potential. If corrosion is so deep that cleaning reduces the size of the pin, replace the connector. Charred resistors should also be replaced.

(6) *Cables, Receptacles, and Plugs.*—Inspect for dirt, corrosion, breaks in insulation, kinks which place cable connections under strain, and improper seating. Clean dirty connections and plugs with a brush dipped in dry cleaning solvent, and dry with a clean cloth. Repair faulty connections.

(7) *Capacitor Cases.*—Inspect for leaks, bulges, and discoloration; if dirty, clean with a dry cloth, or one moistened with dry cleaning solvent if necessary. Replace damaged capacitors.

(8) *Capacitor Terminals.*—Inspect for corrosion and loose connections. (All high-voltage capacitors must be short-circuited with the capacitor-discharge rods provided.) Gaskets on high voltage bushings serving as terminal supports should be inspected for oil leakage. If leaks are detected replace gaskets. Leads should be examined for poor insulation, oil film, cracks, and deterioration, and repaired if necessary.

(9) *Ceiling Mounting Brackets.*—Inspect for tightness of mounting screws and tighten the screws if necessary.

(10) *Ceramic Wafer Switches.*—Make certain that power is OFF. Examine for positive contact and freedom from dust and corrosion. If necessary, clean out dust with a bellows. Check the switch wafers and detent plates for looseness. If the switch wafers are loose, tighten the shaft nut. If detent plate is loose, tighten the two mounting screws.

(11) *Chassis Slides and Tilt Assemblies.*—Check slides for each operation, and tilt mechanisms for free engaging and releasing. If action is poor, clean thoroughly. Check alignment of the panel for signs of sagging.

(12) *Clutches.*—Test for excessive slippage by turning phase and frequency dials with motor off. (NOTE.—The phase and frequency clutches on Master Timers are normally disengaged.) Turning torque on these dials should be in excess of the force needed with the motor in operation.

(13) *Coaxial Cables.*—Inspect for sharp bends near jacks and properly seated cable springs. Right-angle connectors should be examined to see that the contact pin is free from dirt and corrosion, and that the contact springs have good tension when inserted in the jack.

(14) *Controls.*—Check and clean when equipment is dusted externally.

(15) *Discriminator Unit (ESU Spare).*—Check for proper operation by switching to spare timer receiver and examining signal amplitude. Output voltages of regulated power supplies within each of the Discriminator Units should be checked and adjusted.

(16) *Dust Filters.*—See Air Filters.

(17) *External Cables and Connectors.*—Check for deterioration, fraying, cracks, kinks in the cable, and dirty or corroded connections. Clean dirty or corroded connections; replace if necessary. If cracks or fraying cannot be repaired, replace cable.

(18) *Fuses.*—Inspect for evidence of overheating, corrosion, and weak tension of fuse clips. Corrosion and dirt should be removed from fuse clips and caps, and all pitting should be removed by sandpapering or filing to provide a smooth contact surface.

(19) *Ground and Coaxial Connections.*—Check for good contact and freedom from corrosion, dirt, or fungi. This can be accomplished with the internal cleaning of the equipment. The air outlet screen should also be cleaned at this time.

(20) *High Voltage Bushings and Insulators.*—These components are usually highly glazed ceramic material subject to hairline cracks, and the consequent accumulation of dust and moisture. If this accumulation is severe enough, a high-voltage flash-over can result. Insulator bushings should be cleaned and checked for loose connections. Avoid the use of abrasive cleaners. Tighten all loose bushings and insulators. Replace defective units. If a bushing is a mounting for an oil-filled unit, install new gaskets when replacement is made.

(21) *Indicator Lights.*—Check these assemblies for cracked jewels, loose or burned out bulbs, and defective bases, loose mounting screws and corroded or loose connections. Repair or replace defective parts. (Red jewel lights are power indicators and are on when power is being applied to the circuit; white jewel lights are fuse indicators and are on when fuse is opened and should be replaced.)

(22) *Interlocks.*—Check to make certain that the disc will engage when the door is opened ⅛ inch. if the interlock does not make positive contact, insufficient spring tension is indicated. Replace part of interlock which is mounted on the door.

(23) *Line Voltage.*—Should be 115 ± 5 volts and the frequency should be 60 ± 1 cps.

(24) *Lubrication.*—For the proper lubrication techniques applicable to each unit of equipment, refer to the appropriate instruction book.

(25) *Mechanical Inspection.*—Inspect all units of equipment. Check all bolts, nuts, and screws for tightness. Check connections to all components; particularly the link connectors in the transmitter, junction unit, and antenna coupling unit. Examine links for evidence of arcing (sand or file down if necessary). Tighten connections to terminal boards, and inspect all ground leads and clamps.

(26) *Meters.*—Check leads and connections to the meter. Look for loose, dirty, and corroded connections, broken cases or cover-glasses, and loose mounting screws. Clean dirty meter cases with a dry cloth. Clean corroded or dirty connections with a small brush or cloth moistened with dry-cleaning solvent. If necessary use fine sandpaper (#0000). With power off, tap meter case with finger for zero reading. If pointer does not register properly, adjust zero-adjusting screw.

(27) *Motor Maintenance, Lubrication, and Replacement of Bearings.*—Faulty motor operation is usually caused by an accumulation of dirt and other foreign matter on the movable parts, or insufficient lubrication of these parts. Check all bolts for tightness and shock mounts for flexibility. Lubrications and replacement of bearings procedures are given in the pertinent instruction book.

(28) *Relays.*—Both power and telephone type relays should be checked periodically. Turn all power off before removing covers. Then examine relays for pitting, corrosion, and dirty contacts. Check the coils for signs of overheating. Do not employ any cleaning methods which utilize abrasive compounds. Be careful not to bend the contacts and use the proper tools for relay maintenance work as listed in the manuals.

(29) *Resistors.*—Check for cracks, chipping, blistering, discoloration, and other signs of overheating. Inspect leads, clips, and metallic ends of ferrule-type resistors for corrosion, accumulation of dirt, loose connections, and broken strands. Replace damaged resistors. The tension of clips can be increased by pressing them together with the fingers or pliers. Do not attempt to remove resistors which have soldered pigtail connections, except for replacement purposes.

(30) *Rheostats and Potentiometers.*—Examine for mechanical condition. Check assembly and mounting screws, set-screws, and nuts. Examine insulating body for dust, dirt, cracks, or chipped places. Inspect all metallic parts for dirt, dust, and corrosion. Tighten all loose assembly or mounting screws.

(31) *Rotary Ceramic Switches.*—Check for proper contact, pitting and burning. Replace faulty components.

(32) *Solenoids.*—In the Sync Control Unit, solenoids should be adjusted so that they hold in with a minimum of buzzing and release freely. (This check is not necessary on the Phase and frequency solenoid of the Master Timer.)

(33) *Switches.*—Mechanical action should be positive. Check for dirt, dust, and corrosion on exposed elements; clean if necessary. The mounting and connecting screws should be tightened. Check the snap action of toggle switches for positive operation. Wafer type switches should be examined to see that the blade makes positive contact with the leaves. Also check wafer switches for dirt, corrosion and pitting without prying the leaves apart. Clean if necessary. Feel the power switches for signs of heating. A switch which shows indications of heating should be replaced.

(34) *Sync Control Motor.*—Check for cleanliness. Make certain that it responds to its switches and is not sluggish. Wipe off oil deposits that may appear on the motor case. Sluggish motor action may indicate the need for lubrication, brush, or commutator servicing.

(35) *Temperature of Crystal Oscillator.*—Check with the METER switch in HEATER position. Should be 60 to 140 microamperes or midscale. If these limits are exceeded adjust in accordance with applicable instructions.

(36) *Temperature of Cabinet.*—Check cabinet temperature. If temperature within Timer cabinet is higher than 95° F. and blowers are not operating, the screw on the end of the cabinet thermostat should be turned in a clockwise direction to start blowers at lower temperature. However, if the temperature exceeds 95° F. and blowers are operating, check: (*a*) Filters, (*b*) Fan blades, and (*c*) Blower motor speed.

(37) *Temperature of Equipment.*—Equipment should be kept at room temperature or above to avoid condensation. When not in use, equipment should be left on with INTENSITY control turned low.

(38) *Terminals.*—Inspect for dirt, dust, moisture, loose connections, and overheating. Clean if necessary and tighten loose connections. Also check both circuit breakers on the power distribution panel for positive action.

(39) *Terminal Blocks.*—Inspect for cracks, breakage, dirt, and loose connections or mounting screws. Examine connections for mechanical defects. If connections must be loosened to remove dirt and corrosion, make sure that they are replaced properly. Clean dirty terminal blocks with a dry brush; corroded connections with crocus cloth.

(40) *Transformers and Filter Chokes.*—Inspect terminals for dirt, dust, moisture, and loose connections, since these conditions located at high-potential points in the circuit can cause flash-over. Inspect for loose mounting brackets and loose rivets. The presence of insulating compound on the outside of the seams of impregnated transformers indicates overheating. Clean cases of transformers and chokes with a dry cloth. If wires must be removed to perform cleaning or tightening procedure, be sure that they are restored to original positions.

(41) *Tubes and Sockets.*—Inspect tube envelopes for accumulation of dirt and for possible breakaway from the base. Examine caps for dirt, corrosion, and possible break-away. Examine spring clips for corrosion and loss of tension. Check lead wires to caps for exposed or broken strands. Replace when breakaway, cracks, etc., are noted. Test the firmness of tubes in their sockets by pressing them down in their sockets. Do not wiggle or partly withdraw tubes. (NOTE.—Severe burns may result if tubes are touched immediately after shutdown.)

(42) *Variable Inductors.*—Inspect for dust, corrosion and freedom of movement. Clean the coils, if necessary, with a suitable solvent. If binding is noted, the bearings supporting the rotor coil should be lubricated with a drop of light machine oil.

(43) *Variable Transformers.*—Check for exterior dirt or corrosion, loose assemblies, mountings, or terminal screws. Transformer brushes should be examined to determine that contact surfaces are clean and that brushes are the correct width. Brushes worn down to ⅛ inch should be replaced. Insulating strings between the variable transformer wires and the mounting brackets should be inspected for overheating and deterioration.

(44) *Voltage Checks.*—High voltage supply: check on +250, −1800, and +2200. Main power supply: check on +300 and +135. Bias power supply: check on −50 and −105.

18–13–5 CHECK LIST—

A check list for every item of LORAN equipment at the transmitting station shall be prepared by a qualified technician or engineer to assist concerned personnel in the periodic performance of routine preventive maintenance procedures on electronic equipment. The on-air units shall be changed over to standby once a week for the performance of those maintenance procedures pertinent to that period.

A check list for the transmitter is presented in figures 18–50 and 18–51 as a sample format to show the type of information which should be included. In the preparation of a check list the particular needs of each station should be kept in mind so that the list will be most suitable to the schedule of operating times, number of personnel, etc.

In connection with the meter readings to be inserted in figure 18–50, be sure that all meter pointers return to zero with the power off (except the TUBE HOURS meter). If a meter does not return to zero, tap the case lightly. If this does not correct the situation, rotate the zero-adjust screw until the pointer is correctly set.

The following procedures describe the steps entailed in the performance of the daily, weekly, and monthly checks on the transmitter. It should be noted that at the end of each month the three checks will coincide, and should be performed in sequence.

A. *Daily Checks.*—

Step 1: Operate standby transmitter into dummy load and take meter readings on both operating and standby transmitters as shown in figure 18–50 (daily).

TRANSMITTER NO. 1 — TRANSMITTER DAILY CHECK LIST — NOV. 5 1953

DAILY — ENTER ACTUAL METER READINGS

METER DESIGNATION	METER SWITCH SYMBOL	POSITION	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
LOW VOLTAGE M105	S112	DBLR BIAS	198	200	200	201	196	197	197								195	198	198	204	200	200	200								200	203	200
		1ST IPA BIAS	50	50	51	60	49	49	52								48	[illegible]	52	51	50	49	50								48	52	52
		2ND IPA BIAS	355	358	358	360	360	360	362								360	360	365	358	362	360	360								360	362	360
		EXCITER PLATE	300	300	300	295	295	300	300								295	298	301	300	302	300	300								302	302	297
MEDIUM VOLTAGE M103	S111	MOD. PLATE	5.8	5.8	5.6	5.7	5.7	5.8	5.8								6.0	5.9	5.9	5.7	5.8	5.8	5.8								5.7	5.8	5.8
		2ND IPA PLATE	6.7	6.7	6.9	6.9	7.0	6.9	6.9								7.0	7.0	6.8	6.8	6.9	6.7	6.9								6.7	6.9	6.9
PA BIAS M104			2.8	2.9	2.9	3.0	3.0	2.9	3.0								3.0	3.0	3.0	2.9	3.0	3.0	3.0								2.8	3.1	3.1
PA PLATE (VOLTMETER) M102			15.3	15.3	15.4	15.4	15.5	15.5	15.6								15.5	15.6	15.6	15.6	15.6	15.4	15.4								15.5	15.5	15.5
LINE M101	S110	LINE	215	225	[illegible]	240	240	235	235								220	220	230	235	235	240	242								240	230	230
		FIL. PRI.	230	230	[illegible]	[illegible]	228	230	230								228	230	230	232	234	230	230								229	231	231
EXCITER CURRENT M112	S120	V301 CATH	39	38	[illegible]	40	[illegible]	40	41								41	41	40	40	39	40	40								38	38	41
		V302 CATH	55	55	58	[illegible]	[illegible]	57	[illegible]								56	56	58	57	58	57	57								57	58	57
		V303 CATH	48	48	57	50	[illegible]	[illegible]	48								50	51	50	49	48	48	48								47	49	48
		V304 CATH	47	47	49	49	48	[illegible]	[illegible]								48	48	48	49	47	48	47								48	46	48
		V305-V306 CATH	71	71	70	71	71	72	71								71	71	71	68	70	71	70								71	70	70
		V307 CATH	68	67	67	65	65	65	66								67	67	64	66	65	66	65								65	67	65
		V308 CATH	60	60	60	61	61	60	61								60	60	61	60	61	61	61								59	58	60
		V309 CATH	49	49	52	52	51	52	52								53	53	51	51	52	52	51								52	52	51
		GRID CUR-J301	30	30	30	32	32	29	30								31	30	29	30	30	30	31								29	29	31
		GRID CUR-J302	27	27	25	25	26	25	25								26	26	25	25	25	25	25								27	26	25
		GRID CUR-J303	33	33	35	35	36	35	35								33	34	35	36	36	35	35								36	35	36
		GRID CUR-J304	25	25	25	26	25	25	24								26	26	25	26	24	24	25								27	25	25
		GRID CUR-J305	55	54	54	54	52	54	54								53	53	53	54	54	52	53								53	52	52
		GRID CUR-J306	7.0	7.0	6.5	7.0	7.0	7.3	7.0								6.7	6.5	6.8	7.0	7.0	6.8	6.8								7.0	7.0	7.1
		GRID CUR-J309	10	10	10	10	10	10	10								9.8	9.8	9.9	10.1	10	10	10								10	10.1	10
1ST IPA PLATE M110			1.2	1.2	1.15	1.18	1.2	1.2	1.2								1.2	1.3	1.2	1.1	1.1	1.2	1.2								1.1	1.2	1.2
M109 2ND IPA PLATE	S114	V103	50	49	50	50	48	50	51								49	49	50	50	51	50	50								50	48	51
		V104	51	51	50	50	49	50	50								51	52	50	48	49	52	50								50	50	50
		TOTAL	101	100	100	100	97	100	101								100	101	100	98	100	102	100								100	98	101
PA GRID M108			1.6	1.7	1.5	1.5	1.4	1.5	1.5								1.6	1.6	1.7	1.7	1.5	1.5	1.6								1.6	1.7	1.7
PA PLATE (MILLIAMETER) M106	S113	V104	6.0	5.5	6.0	6.0	6.1	6.0	6.0								6.1	5.7	6.0	6.1	6.0	6.0	6.0								5.8	6.1	6.0
		V105	6.0	5.8	5.8	6.1	6.1	6.0	6.0								6.0	6.0	5.9	5.8	6.2	6.1	6.0								6.0	6.1	6.0
		V106	6.0	6	6.0	6.0	5.8	6.0	6.0								5.8	5.8	6.0	5.5	6.0	6.1	6.0								6.1	6.1	6.1
		V107	5.9	6.1	6.0	5.8	6.0	6.0	5.8								6.0	6.1	5.5	6.1	6.0	6.0	6.1								5.8	5.8	5.8
TRANSMISSION LINE M111	S115	TOTAL	23.9	23.4	23.8	23.9	24.0	24	23.8								23.9	23.4	23.6	23.5	24.2	24.2	24.1								23.7	24.1	23.9
		UNSHORT	1.7	1.7	1.8	1.8	1.8	1.8	1.8								1.7	1.7	1.9	1.8	1.9	1.7	1.8								1.8	1.8	1.7
INITIALS OF MAN MAKING CHECK			CM	CM	CM	CM	CM	CM	CM.								CM	CM	CM	CM	CM	CM	CM								L.C.	L.C.	L.C.

SAMPLE

FIGURE 18–50.—Typical Transmitter Daily Check List.

TRANSMITTER WEEKLY AND MONTHLY CHECK LIST
TRANSMITTER NO. 1

NOV. 1953
MONTH

SAMPLE

WEEKLY		WEEK					MONTHLY		
COMPONENT	CHECK POINTS	1	2	3	4	5	COMPONENT	CHECK POINTS	
CAPACITORS	CHECK TERMINALS FOR TIGHTNESS; CLEAN AS NECESSARY	✓	✓	✓	✓	✓	CABLES, PLUGS AND RECEPTACLES	CHECK FOR DIRT, BREAKS IN INSULATION, BENDS, AND PROPER SEATING; CLEANING.	✓
FILTERS	CHECK FIBER GLASS TYPE; CLEAN WIRE MESH TYPE.	✓	✓	✓	✓	✓	INDICATOR LIGHTS	CHECK FOR CRACKED JEWELS, LOOSE BULBS, DEFECTIVE BASES AND LOOSE CONNECTIONS; REPLACE FAULTY COMPONENTS	✓
FUSES	CHECK CAPS FOR SIGNS OF OVERHEATING AND DIRT; CLEAN.	✓	✓	✓	✓	✓	MECHANICAL INSPECTION	CHECK ALL BOLTS, NUTS, AND SCREWS FOR TIGHTNESS; CHECK LINK CONNECTIONS TO TRANSMITTER	✓
HIGH VOLTAGE BUSHINGS AND INSULATORS	CHECK FOR CRACKS, MOISTURE AND DIRT ACCUMULATION; CLEAN.	✓	✓	✓	✓	✓	METERS	CHECK FOR DIRT, LOOSE CONNECTIONS, BROKEN CASES OR COVER GLASSES; CLEAN IF NECESSARY.	✓
OVERALL CLEANING	REMOVE FRONT, SIDE AND BACK PANELS; CLEAN WITH VACUUM CLEANER OR DRY LINT FREE CLOTH.	✓	✓	✓	✓	✓	RELAYS	CHECK FOR PITTING, CORROSION, DIRTY CONTACTS; CHECK COILS FOR SIGNS OF OVERHEATING; BURNISH AND CLEAN.	✓
RHEOSTATS AND POTENTIOMETERS	CHECK INSULATING BODIES FOR DIRT AND CRACKS; METALLIC PARTS FOR DUST AND CORROSION; CLEAN.	✓	✓	✓	✓	✓	SWITCHES	CHECK FOR POSITIVE MECHANICAL ACTION; CHECK EXPOSED ELEMENTS FOR DIRT, DUST, AND CORROSION; CLEAN.	✓
TUBES AND SOCKETS	CHECK ENVELOPES FOR BREAKAWAY FROM BASES; CHECK LEADS, CAPS, WIRES, TENSION CLIPS; CLEAN IF NEEDED	✓	✓	✓	✓	✓	TERMINAL BLOCKS	CHECK FOR CRACKS, DIRT, BREAKAGE, AND LOOSE CONNECTIONS ON MOUNTING SCREWS; CHECK FOR MECHANICAL DEFECTS.	✓
VARIABLE INDUCTORS	CHECK FOR DUST, DIRT, CORROSION, FREEDOM OF MOVEMENT, CLEAN COILS, LUBRICATE ROTOR COIL IF NEEDED.	✓	✓	✓	✓	✓	TRANSFORMERS AND FILTER CHOKES	CHECK TERMINALS FOR DIRT, DUST, MOISTURE, AND LOOSE CONNECTIONS; CHECK SEAMS OF CASES FOR INSULATION LEAKS.	✓
RESISTORS	CHECK FOR CRACKS, DISCOLORATION, ETC.; CHECK LEADS FOR DIRT, DUST, CORROSION AND LOOSE CONNECTIONS; CLEAN.	✓	✓	✓	✓	✓	VARIABLE TRANSFORMERS	CHECK FOR EXTERIOR DIRT, CORROSION, LOOSE ASSEMBLY MOUNTINGS; CHECK BRUSHES FOR PROPER CONTACT WIDTH (1/8")	✓
DATE CHECK MADE		11-7-53	11-14-53	11-21-53	11-28-53	12-1-53	DATE CHECK MADE		12-1-53
INITIALS OF MAN MAKING CHECK		HL	HL	HL	HL	HL	INITIALS OF MAN MAKING CHECK		HL

Figure 18–51.—Typical Transmitter Weekly and Monthly Check List.

Step 2: On standby transmitter, place all transmitter switches, except the **FILAMENT** and **MAIN** switch, in **OFF** position, and check meters for zeroing.

B. *Weekly Checks.*—

Step 1: Change over transmitter (see paragraph 18–12–15, 1 or 2).

Step 2: Perform step 1 under Daily Checks.

Step 3: On standby transmitter place all switches except **MAIN** switch in **OFF** position.

Step 4: Allow 3 minutes for cooling, then place the **MAIN** switch in **OFF** position.

Step 5: Allow sufficient time for complete cooling, then perform checks as shown in figure 18–51 (Weekly).

Step 6: Place **FILAMENT** and **MAIN** switches in **ON** position.

C. *Monthly Checks.*—

Step 1: Perform steps 1, 2, 3, 4, and 5 under Weekly checks.

Step 2: Perform checks as shown in figure 18–51 (Monthly checks).

Step 3: Place **FILAMENT** and **MAIN** switches in **ON** position.

18–13–10 SYSTEM PERFORMANCE STANDARDS—

A qualified technician or engineer shall determine the standards of system performance for each new LORAN transmitting station at the time of installation, and at existing stations as soon as practicable after receipt of these instructions. He will perform the necessary work himself—take the measurements by which he will determine performance standards; prepare the information on a form; and sign the form. System performance standards in general will comprise standard meter readings, dial settings, oscilloscope patterns, and other similar indications. Since these values are determined when the system is functioning at its optimum capabilities, they are representative of good performance, and consequently will serve as an excellent guide for new and untrained station personnel in their task of maintaining continuous uninterrupted LORAN service through proper maintenance. Figures 18–52, 18–53, and 18–54 are typical performance standards charts for the Transmitter, Antenna Coupling Unit, and the Antenna respectively. These equipments are a primary indication of the standards of system performance for any particular station. Nevertheless, the preparation of standard performance charts is not restricted to these three units of equipment. With regard to figures 18–52, 18–53, it should be said that these charts have been prepared for a transmitter at a master station operating at a frequency of 1950 kc. with a basic rate of 33⅓ pps. and single pulse operation (1HO–M). Figure 18–53 is a performance chart prepared for an antenna coupler type CU–277/URT with a matching "T" connected network. It should be noted that the LINE and ANTENNA meter readings are applicable only if an amplifier is not used. Higher meter readings are to be expected if any amplifier is used. Also, the link settings are applicable only if the CU–277/URT type of coupler is used. These readings do not apply to the Federal type coupler. Figure 18–54 is a standard impedance chart of a 300-foot vertical antenna.

18–13–15 PROTECTION OF TEST EQUIPMENT FROM DAMPNESS—

Special precautions are required to protect test equipment from dampness. These precautions are of particular importance to LORAN stations in tropical and damp climates. During periods when the equipment is not in use, the action of absorbed moisture, if not "baked-out," can result in complete equipment failure, or in the lowering of operational efficiency. The insulation of these equipments is particularly susceptible to moisture absorption and its effects. The adherence to routine measures for protection against dampness will reduce equipment failures. Portable light banks capable of dissipating not less than 200 watts should be used in the "baking procedure" or heated lockers may be provided in which to keep test equipment when not in use. The instruction books should be referred to for specific instructions regarding the "baking-out" of any particular equipment.

18–13–20 ELECTRON TUBES—

A. *Tube Replacement and Checking.*—In preventive maintenance, tubes are not to be removed for routine tube tester checks. Tubes are to be replaced on the basis of operational failure or for obvious physical defects, such as cracked bases, separation of envelope from base, etc. In replacing the 2nd IPA tubes in the transmitter, special attention must be paid to the locking device on the tube socket. When replacing PA tubes in the transmitter or amplifier, it should be made certain that the thumb screws on the filament, cathode, and grid connectors are tightened securely; otherwise, burning and pitting of tube pins and eventual destruction of the tube will occur.

Cathode ray tubes must be handled with extreme care since they may implode because of their high degree of evacuation. As a safety measure, goggles and gloves should be worn when handling these tubes. Although most cathode ray tubes are harmless, it is possible that some tubes would utilize phosphors which contain a small amount of beryllium, and it would be impossible to distinguish these tubes from those that do not contain harmful chemicals. Therefore, this type of tube should be disposed of, using the same precautions that are necessary in the disposition of fluorescent lamps. This involves breaking the tubes in a closed container to avoid inhalation of any of the powder, and to avoid the danger from cuts by flying glass. The broken glass should then be disposed of in a safe manner. (See current safety directives covering the disposal of fluorescent lamps.)

Before the external-anode, air-cooled, gas type tubes are replaced, certain steps should be taken to make sure that they are in proper condition. These tubes operate at high voltages, and if the exposed connections are not kept free from dirt and dust, leakage between plate and grid terminals is possible. Use a dry, lint-free cloth to remove dust and dirt from the tubes, making sure to remove all fingerprints from the envelope. Clean and polish tube pins

MODEL T-137

TRANSMITTER PERFORMANCE STANDARDS CHART

SAMPLE

TUNING CONTROL SETTINGS

LETTER	CONTROL DESIGNATION	SETTING
A	DOUBLER PLATE TUNING	69
B	FIRST IPA PLATE TUNING	62
C	SECOND IPA PLATE TUNING	78
D	PA PLATE TUNING	81
E	OUTPUT COUPLING	MAX.
F	OUTPUT TUNING	59
G	NEUTRALIZATION	075
H	PULSE WIDTH ADJ — EXC A	.6
I	PULSE WIDTH ADJ — EXC B	.6
J	PULSE SHAPE ADJ	1.4

STANDARD METER READINGS

METER DESIGNATION	METER SWITCH SYMBOL	METER SWITCH POSITION	READING
LOW VOLTAGE - M105	S112	DBLR BIAS	200
		FIRST IPA BIAS	50
		SECOND IPA BIAS	360
		EXCITER PLATE	300
MEDIUM VOLTAGE - M103	S111	MODULATOR PLATE	5.8
		SECOND IPA PLATE	6.9
PA BIAS			3.0
PA PLATE (VOLTMETER) - M102			15.5
LINE - M101	S110	LINE	214 - 244
		FIL. PRI	230
EXCITER CURRENT - M112	S120	V301 CATHODE	41
		V302 CATHODE	57
		V303 CATHODE	48
		V304 CATHODE	48
		V305 - V306 CATHODE	71
		V307 CATHODE	65
		V308 CATHODE	61
		V309 CATHODE	52
		GRID CURRENT - J301	30
		GRID CURRENT - J302	25
		GRID CURRENT - J303	35
		GRID CURRENT - J304	25
		GRID CURRENT - J305	54
		GRID CURRENT - J306	7
		GRID CURRENT - J307	10
FIRST IPA PLATE - M110			1.2
SECOND IPA PLATE - M109	S114	V103	50
		V104	50
		TOTAL	100
PA GRID - M108			1.5
PA PLATE - M106 (MILLIAMETER)	S113	V104	6
		V105	6
		V106	6
		V107	6
		TOTAL	24
TRANSMISSION LINES - M111	S115	UNSHORT	1.8

PULSE SHAPE AS SEEN ON MONITOR SCOPE WITH MONITORED CIRCUIT SWITCH IN "OUTPUT P.A. POSITION."

PULSE DEFINITION ∿	% OF PEAK AMPLITUDE	MICROSECONDS
RISE TIME	10 TO 90	21
DELAY TIME	90 TO 10	21
PULSE WIDTH	50	40
COMPUTED POWER OUTPUT		163 KW*

*SEE SECTION 2-2-5

FIGURE 18–52.—Typical Transmitter Performance Standards Chart.

MODEL CU-277/URT
ANTENNA COUPLING UNIT PERFORMANCE STANDARDS CHART

CONTROL DESIGNATION		CONTROL SETTING
A-ANTENNA TUNING		320
B-ANTENNA TUNING		0
METER DESIGNATION		METER READINGS-AMPS.
LINE		1.8 AMPS
ANTENNA		1.6 AMPS
LINK DESIGNATION		LINK SETTING-TURNS
L402		10 TURNS
L403		12 TURNS
PULSE SHAPE AS SEEN ON MONITOR SCOPE WITH MONITORED CIRCUIT SWITCH IN "ANT. POSITION"		
PULSE DEFINITION	% OF PEAK AMPLITUDE	MICRO-SECONDS
RISE TIME	10 TO 90	21
DECAY TIME	90 TO 10	21
PULSE WIDTH	50	40

SAMPLE

FIGURE 18–53.—Typical Antenna Coupling Unit Performance Standards Chart CU–277/URT.

to insure proper connection in the socket. Clean grid and plate caps with crocus cloth or #0000 sandpaper. When inserting the tubes in the sockets, care should be exercised not to twist the socket ring unnecessarily, since this may result in the crossing of connecting wires to the socket. After the tube has been cleaned, it should not be handled with the bare hands, but a dry, lint-free cloth should be used when inserting the tube into its socket. Once the tube is in the socket, test for firmness by pressing downward and not by partly withdrawing and moving from side to side. This procedure tends to spread the contacts in the socket and may develop trouble. Make sure tubes are sufficiently cooled down before handling them with the bare hands or reaching into a cabinet for a tube. Severe burns on the hands or forearms may result from contact with the tube envelope.

B. *Rotation and Degassing.*—Transmitter IPA and PA tubes shall be rotated periodically so that no tube remains on the "shelf" for longer than three months without operation in the equipment. The frequency with which this rotation occurs depends upon the number of spares at hand. The standby transmitter is used for degassing. Install the tubes in the usual manner and start the equipment. The initial potential should be 7,500 volts with an increase of 1,000 volts every fifteen minutes. If any arcing is noticed, decrease the potential until no arcing is seen and operate at this potential for at least fifteen minutes before making the next increase. It may be necessary to cut the increments to 500 volts if excessive arcing is noticed. If tubes have not "cleaned up" in about eight hours, it is probable that they cannot be used. Care should be exercised so that tubes are not always taken out of the same transmitter.

WARNING: Transmitter tubes, once operated, have brittle filaments. Suitable storage space should be provided so that tubes are not knocked about, since they will damage easily.

C. *Record of Tube Life.*—A complete and accurate record of the operating hours of each tube installed shall be kept, so that the "tube life" will be realistically reported on the Electronics Failure Report. Include tube type and number, serial number, and time clock readings off the transmitter at the time the tube was installed, or removed. The record on each tube should be current until the tube is surveyed.

18–13–25 TRANSMISSION LINES—

A periodic visual inspection of the transmission lines above the ground should be conducted. Check for proper grounding and bonding. Inspect the clamps to make sure that they are secure. Check the sealing for breaks or leakage. If a transmission line is suspected of being faulty, such as might be indicated by a falling off of the line current in the antenna coupler, measure the insulation resistance of the transmission line with a Megger. If the measurement indicates that the transmission line is at fault, then perform the necessary corrective

STANDARD IMPEDANCE CHART OF 300 FOOT VERTICAL ANTENNA

FREQUENCY-KC	RESISTANCE	REACTANCE
1000	167	+ 180
1275(λ/2)	640	0
1500	250	- 350
1750	70	- 200
1800	60	- 175
1850	51	- 157
1900	44	- 125
1950	39	- 105
2000	37	- 88
2225(3λ/4)	49	0
2500	170	+ 135

SAMPLE

FIGURE 18–54.—Typical Antenna Impedance Chart—300-Foot Vertical Antenna.

maintenance according to the current instructions concerning transmission lines.

18–13–30 ANTENNAS—

A. *Emergency Antennas.*—Once a year the antennas should be interchanged; that is, the transmitting antenna should be taken down and the emergency antenna should be put into operation. The antenna which has been taken down should be completely overhauled and made ready for emergency use. Emergency antennas should be properly coiled for immediate use, but should be kept under cover for protection. If a tower is installed, emergency poles and rigging should be in place.

B. *Inspection and Cleaning.*—Inspect down haul line for fraying, unravelling, chafing, etc. Determine the cause, such as, flapping against poles, rubbing, etc. If the down haul line is old, it should be opened up and the inside should be inspected. When down hauls are used, inspect the antenna periodically for sagging to make sure that the proper antenna position is maintained. This is important because, if the antenna sags, the impedance is changed and, thus, the characteristics of the antenna are changed also.

C. *Comb Antenna.*—The junction unit at the base of the vertical element has a silica gel cartridge which should be inspected periodically. The frequency of this inspection is determined, to a large extent, by the particular climatic condition of the area in which the station is located. If there is a high percentage of moisture content in the air, then the inspection should take place more often than in a dry climate. When the cartridge becomes pink in color, it should be replaced. The removed cartridge should not be disposed of, but should be prepared for re-use. This can be accomplished by heating-out the cartridge slowly in a light bank setup, or in a controlled-heat oven until the normal blue color returns.

The ground, which is attached to the plate under the coupling unit, should be brazed to the plate. Do not rely on the screw connections!

18–13–35 GROUND SYSTEMS—

The ground system should be maintained in the condition in which it was originally installed. Refer to the appropriate drawing for the proper techniques to be employed in making the various connections. If the system is buried, examine the area periodically for evidence of broken wires. If a heavy vehicle has been driven across the area, or if personnel have made footpaths over the area, dig up the system under the road bed and examine it. The portion of the system at the base of the antenna should be dug up periodically and examined for breaks and loose connections. Breaks should be repaired; damaged sections replaced; conductors at joints should be cleaned, wrapped, and soldered or brazed, making sure that there is a good electrical connection. Loose connections should be opened, cleaned, re-wrapped, and soldered or brazed. Where ground systems conductors are connected to plates, connect the conductor through the hole in the plate, solder and wrap connector back on itself. Make sure of good electrical connection to plate. Ground connectors must be wrapped around all rods and soldered or brazed. Be sure that the grounding strips between the antenna coupler units have good electrical connections by brazing or soldering throughout.

18–14 CORRECTIVE MAINTENANCE

18–14–1 GENERAL—

The most difficult part of corrective maintenance generally consists of trouble localization. Except in rare cases, replacement, repair and readjustment are fairly simple one the trouble has been localized. When trouble develops in electronic components, corrective action should be taken as quickly as possible to avoid damaging other components through interaction and to avoid off-air time. Where standby equipment is available, the defective equipment should be shut down and then repaired as soon as is practicable.

The localization of trouble conists of finding the specific defective part that caused malfunctioning. A logical series of observations and tests and a logical process of reasoning will, in almost all cases, locate the exact cause of a malfunction in a LORAN transmitting station.

WARNING: The voltages employed in the LORAN system are dangerous and may be fatal if contacted. It is extremely important that personnel authorized to open and service the equipment understand and observe precautionary measures.

18–14–5 TROUBLE LOCATION—

In tracing trouble the technician should make use of the operating data which has been accumulated in the course of operating the equipment, and the very detailed and specific information in the various instruction manuals under the heading of corrective maintenance.

Some of the specific difficulties that may arise and simple diagnostic procedures for isolating the defective unit are as follows:

A. *Power Failure.*—

(1) *Power Failure in LORAN Signal Building.*—Check main fuses in station AC power distribution panel. Throw a lighting circuit switch to the other bus to see if it is energized. If not, the trouble is in the external power lines. Activate emergency or standby power unit. If still no power, check all power lines for opens, grounds and shorts, and rig emergency lines from standby power units.

(2) *Power Failure in Transmitting Room.*—This is due to fuse or circuit breaker opening. The transmitter and lighting circuits are separately fused.

(3) *Power Failure in Screened Room.*—If failure is general, check fuses on station distribution panel. Listen for transformer hum on isolation transformers, change transformers by means of switch gear, and/or station distribution panel, check fuse at entrance box, remove cover of entrance box at switch gear and check for voltage.

B. *Loss of Synchronization.*—Check signal on the spare timer to ascertain whether local or remote signal is at fault. If the local signal is at fault, change timers.

C. *Loss of Distant Signal Pulse.*—Sudden loss of the distant signal pulse is usually due to a failure in the paired station. If on increasing the receiver gain atmospheric noise (static) or other pulse signals are noted on the screen, the trouble is in the distant station. If not, the trouble must be in the LORAN receiving antenna circuit, the discriminator circuit, the distant signal input circuit of the timer receivers or the connecting coaxial cables. The following steps will localize the trouble:

(1) If the local signal is visible at normal amplitude, the trouble is in the discriminator, the remote receiving input circuit of the timer or the connecting cable.

(2) Check discriminator output to timer receiver switch position. If normal,

(3) Connect discriminator output to spare timer receiver. If the signal appears, the other timer receiver input circuits are defective.

(4) Change discriminators. If signal appears, the other discriminator is at fault.

(5) Disconnect blanking pulse circuit. If local pulse (much distorted) is received trouble is in the distant station, in reduced receiver gain or attenuation due to a defective component in the discriminator.

(6) See if all discriminator tube filaments are operative.

(7) Check discriminator plate voltage.

(8) Check coaxial cable connectors on switching equipment and timer.

(9) Check antenna and antenna coupling unit.

(10) Disconnect outdoor coaxial cable and check for continuity.

(11) Disconnect and check continuity of the coaxial cable from discriminator output to remote signal input of the timer receiver.

D. *Loss of Local Signal Pulse.*—

(1) Check transmitter for proper output. If normal,

(2) The trouble is in the input circuit to the operating timer receiver, in the isolating resistors (pads), in the switch gear or in the connecting cables.

E. *Loss of Both Signal Pulses.*—

(1) If trace is also lost, change timers. If the signal is now normal, the defective timer should be checked in accordance with the instruction book supplied.

(2) If trace is present, change timers. If there is still no signal, check antenna cable connections antenna coupling units, and antenna.

F. *Pulse Jitter.*—

(1) Horizontal jitter in the distant signal is caused by a fault in the distant station. Blink to indicate fault to distant operator.

(2) Horizontal jitter in the local signal is caused by the local transmitter. Check transmitter.

G. *Falling Off of Transmitter Output.*—

(1) If the output decrease is gradual, the transmitter tubes may be at fault.

(2) Check antenna coupling unit.

H. *Arcing.*—This may cause operation of the overload relay, and is generally due to:

(1) Dirty tubes or insulators in high voltage stages.

(2) Impedances not matched between transmitter and transmission line or between transmission line and antenna.

(3) Excessive plate voltage.

(4) Improper tuning of output power stage.

(5) Defective connection in power supply or RF circuit parameters.

18–14–10 CORRECTIVE MEASURES—

A. *General Trouble-Shooting.*—Once the technician has determined which unit in the LORAN system (e. g., timer, transmitter) is not functioning properly (refer to section 18–14–5 Trouble Location). Then his job consists of isolating the cause of the trouble to a particular component part within the unit. When the defective component has been pinpointed, repair or replacement become relatively simple operations. This is true, of course, only if the initially defective component has not, through interaction, damaged other components. It is important, therefore, to correct equipment failures as soon as possible, and to see that standby equipment is always in readiness if needed. In the event that a unit not supplied in duplicate should breakdown, complete shutdown is necessary. Immediate action in the correction of equipment failures as soon as they become evident can reduce trouble-shooting procedures to a series of logical steps, whereas delay may lead to more serious consequences which will require complicated procedures to restore normal operation. The importance of detecting component failure or deterioration at the earliest possible time cannot be overstressed.

It is true that some malfunctions will be simple in nature and their causes indicated by a single well-defined symptom. More often, the fault will have various interacting and complex effects so that symptoms will not be indicative as to the immediate cause. In his attempt to isolate the trouble to some particular component, the technician should make use of the operating data which has been accumulated in the course of operating the equipment. An accurate operating log will be of great value in this respect. In addition, the technician should learn to utilize the various aids to trouble-shooting which are incorporated in the appropriate instruction books, e. g., typical meter readings, test oscillograms, voltage and resistance measurements, tuning charts, sequential trouble-shooting charts, wiring diagrams and schematics.

Vacuum tubes are a primary source of failures in electronic equipment and should be regarded with suspicion whenever performance falls off or a fault occurs. The tube characteristic charts will be of aid to the operator in this respect.

In all his trouble-shooting work the technician should organize his approach so that his procedures constitute a series of logical steps and not random guesses as to what the fault might be.

18–15 ASSOCIATED EQUIPMENT

18–15–1 GENERAL—

The complete LORAN electronic system is comprised of certain units such as timers, amplifiers, transmitters, receivers and switching units, whose operation constitute the basic functions of the LORAN station. Each station is also equipped with varying amounts of associated electronic equipment, which although not directly concerned with primary LORAN operations, is important and necessary to station functions. Intercommunication systems, supervisory equipment, test instruments and communications equipment are good examples of such supporting equipment. The service and maintenance of most of this equipment is carried out, generally, in the same manner prescribed for LORAN gear. Detailed preventive and corrective maintenance procedures are beyond the scope of this section and consequently, are not discussed. The pertinent instruction manuals should be consulted for this information.

18–15–5 COMMUNICATIONS EQUIPMENT—

Communications equipment at the LORAN station may be contained to the extent authorized by the station's electronic allowance lists. Service and maintenance procedures for such equipment will be found in the pertinent manuals.

18–15–10 INTERCOMMUNICATION SYSTEMS—

In order to provide adequate communications among various personnel and between station rooms and buildings, LORAN stations are supplied with sound powered telephone systems for talking purposes, with magneto code ringing for signaling. This type of equipment has been chosen because of its reliability and simplicity of installation and maintenance. The installation and maintenance of this gear shall be in accordance with standards established for such systems, as outlined in Headquarters Drawing No. R–2456.

18–15–15 SUPERVISORY EQUIPMENT—

The supervisory equipment at LORAN stations is independent of the standard LORAN units, and is essentially a duplication of user equipment. When properly used, it can provide an overall visual check for gross inaccuracies in signal transmission. Information concerning the operation and maintenance of this equipment can be found in the pertinent instruction manuals.

18–16 RADIO INTERFERENCE

18–16–1 GENERAL—

Radio interference at a LORAN transmitting station may present a major difficulty, since to maintain proper synchronization, LORAN timer receivers must receive a reliable signal from the paired station at all times. Any interference with these synchronizing signals must be corrected or eliminated as soon as possible. Problems arising from radio interference with, and radio interference by, the LORAN system are discussed below.

18–16–5 SUSCEPTIBILITY TO INTERFERENCE—

A. *General.*—LORAN timer receivers are pulse transmission receivers and must have wide band (50 kc.) tuned circuits to avoid distortion of the received pulse shape. Wide band receivers are inherently more susceptible to interference than narrow band receivers. When interference occurs, the technician should: (1) eliminate the interference by use of wave traps as discussed below; (2) identify the interference source; and (3) report to the officer in charge.

B. Since interference and "splatter" from other transmitters may be received from well outside the pass band of receivers in general, the designers of the LORAN timer receiver has incorporated several special circuits to eliminate or attenuate certain types of radio interference. In the UE–1 Timer, these include intermediate and radio frequency wave traps, tunable from the panel and a special automatic volume control circuit. The methods of use and the adjustments of these circuits to minimize interference are contained in the LORAN timer instruction manual.

C. Even the best commercial broadcast receivers may radiate at the local oscillator frequency, and the less expensive AC-DC types can be major sources of interference to LORAN reception. In at least one case, the LORAN remote station signal was completely obliterated by the signal emanating from a small AC-DC personal receiver. Personal receivers at LORAN stations should be checked and evaluated as producers of interference, and measures should be taken to eliminate any interference with LORAN reception from this source.

D. Broadcast band transmitters near or on the UE–1 Timer receiver intermediate frequency (1100 kc.) may, at times, cause serious interference. Careful and proper alignment of all the receiver circuits and adjustments of the IF rejection trap should remove this interference. The AN/FPN–30 Timer utilizes a tuned RF receiver and, therefore, is not troubled by this type of interference.

18–16–10 GENERATION OF RADIO INTERFERENCE—

A. *General.*—LORAN radio frequency signals consist of short-wave trains of 40 to 50 microseconds in duration, which appear on an oscilloscope screen as pulses with fairly steep leading edges. To produce such pulses requires a large number of radio frequency components, spaced at frequency intervals equal to the recurrence rate on either side of the nominal frequency. Since LORAN transmitters operate at very high peak power levels, these sidebands may be sources of radio interference to receivers tuned to neighboring frequencies, and by means of shock excitation, to almost any frequency. Arcing between ungrounded metallic objects near a LORAN transmitter may cause local interference.

B. The LORAN transmitting antenna coupling unit can, unless properly adjusted, produce an asymmetrical distribution of sideband power which may interfere with other radio services. Careful tuning of the antenna coupling unit, which also acts as a band pass filter, will eliminate this type of interference.

C. A purely local source of interference may be caused by arcing between two poorly grounded metallic objects. It is important that all metallic objects in the vicinity of the transmitter be bonded together and well grounded.

D. Radio receiving installations using modern receivers with noise limiters or noise suppressors are effective in eliminating or reducing pulse type interference. Older receivers can be fitted with noise limiting or noise suppressing circuits. Circuits and constructional details for solutions to such problems are contained in the U. S. Coast Guard publication CG–163–14. This publication has been furnished to all cognizant District offices.

18–17 SPARE PARTS

18–17–1 GENERAL—

The importance of maintaining adequate supplies of spare parts for electronic equipment at LORAN transmitting stations cannot be overemphasized. It is extremely important that replacement parts be available to immediately effect repairs of defective electronic equipment.

18–17–5 INTEGRATED ELECTRONIC MAINTENANCE PARTS SYSTEMS—

Paragraph FA03075 to 03078 inclusive in the Comptroller Manual, Vol. 7, furnish detailed instructions relative to the maintenance of the integrated electronic maintenance parts stowage system. All LORAN transmitting stations were included in the original distribution of Vol. 7 and amendments thereto. Requests for missing copies of this volume or subsequent amendments should be addressed to the Commandant (CHS) via the cognizant District Commander.

Spare parts furnished with each equipment as "parts peculiar" should be maintained in the quantity indicated in the Instruction Book for the equipment involved.

A. *Description of System.*—The average unit with the old system using spare parts boxes devotes considerable space to electronic spare parts. These boxes are, at least in part, usually stowed in rather inaccessible spaces or storerooms. There is, as every technician knows, a great deal of duplication of parts common to more than one equipment in this system of stowage. The integrated system should reduce the spare parts requirements approximately in half and should make the parts carried a great deal more accessible.

This is accomplished by: (1) Segregating by Standard Navy Stock Number (SNSN) all parts which are common (used in two or more equipments); (2) selecting the quantity of each common part as "allowed for stocking" in the Electronic Spare Parts Allowance List; and (3) placing "allowed" parts in boxes, bags, and other convenient containers for later stowage in drawer type cabinets and bins. This raises the question: If all of one part common (for instance, 10 kilohm ½ watt, 10%, carbon resistors) are stowed in one place, will not identification of this part from the instruction book be more difficult? It would be, except for the way the system is set up. The parts in each drawer are identified by stock number, and a list of these stock numbers versus circuit symbols is furnished for each type of equipment. This list is called a Stock Number Identification Table (SNIT). A further question is: How does one know how many of a given part (50 $\mu\mu$f mica capacitor, for instance) the unit should carry? The unit is furnished an Allowance Book which lists all the parts in the various equipments on board by stock number. The quantity of a given part (i. e., the 50 $\mu\mu$f capacitor) allowed is listed opposite each stock number. This, briefly, is a description of the system in its converted form. How it reaches this state of being will be described in the following paragraphs:

B. *Make-Up of the New Allowance.*—The Coast Guard and the Navy have prepared SNITs for practically all electronic equipment used. These SNITs identify each electronic component (class 16 and 17) in a given equipment by SNSNs. The four columns of a SNIT are:

(1) Noun Name: Resistor, capacitor, 6SN7, etc.

(2) Symbol Designation: Same symbols as used in equipment instruction book lists and circuit diagrams. (R–103, C–310, etc.) The tabulation of information is in alphabetical-numerical sequence according to circuit symbol.

(3) Replacement or Preferred Replacement: SNSN.

(4) SNSN Part Originally Installed in Equipment: Columns 3 and 4 in most cases are the same. Where they differ, it is a result of purification of the stock numbers. This results, in general, from using standardized parts. Column 3 contains the stock numbers given in the Allowance List.

A great deal of work is necessary before either the SNITs or Allowance Lists are prepared. The parts lists of the various equipments must be converted to the proper form. The parts are identified by SNSNs and a card is made up for each part for use in an IBM machine. This machine then sorts the cards and prints the SNITs from them. When set up in a different manner, the IBM machine prints the unit's Allowance List from these "decks of cards" for the equipments installed at a unit.

The information in the Allowance List is tabulated in columnar form as follows:

(1) Equipment Model: T–137–A, T–138, UE–1b, etc. Nomenclature—same as used in Form CGHQ–3134. The various equipment models aboard which contain the line-item as listed. (Vertically.)

(2) Tube Type or Component Noun Name: Resistor, capacitor, 6SN7, etc.

(3) Standard Navy Stock Number: Of the line-item concerned.

(4) Number per Equipment: Number of the line item installed in each of the equipment models listed in column 3. Numbers are listed vertically to correspond to the vertical list in column 3.

(5) Number Equipments Installed: Number of each equipment model installed at a unit is listed in column 3. Numbers listed vertically to correspond to columns 3 and 4.

(6) Number in Use: All but the bottom number are the horizontal multiplication of columns 4 and 5. The bottom number is the sum of the products. It is the total sum of the line-item, as described in columns 1 and 2.

(7) Number Allowed: The number of the line-items needed to maintain the Unit's electronic equipment. The determination is based on failure reports submitted by all units. Hence, if allowances are to be kept realistic, Electronic Failure Reports (DD–787) must be submitted every time an equipment requires repair. The "no. allowed" is entered by Headquarters. These allowances are not rigid and may be changed on the recommendation of the Commanding Officer (based on a unit's needs or usage experience); however, such changes must be referred to the Commandant (EEE) via the cognizant District Commander for evaluation and action.

18–17–10 CONVERSION PROCEDURE—PREPARATIONS—

Before Headquarters can make up an Allowance List, the electronic equipment on board the unit for which it is being prepared must be known. This information is obtained from the unit's CGHQ–3134, Record of Electronic Installation. Hence, it is necessary for each unit, as a first step in conversion to make sure this form is corrected and up-to-date. The conversion requires careful preparation, detailed instruction of any non-technical personnel involved, adequate supervision of the parts identification work by a technician and complete revision of the repair parts records at the unit. The knowledge gained of the system and repair parts problems in general will compensate for this effort. Preparations for conversion must include designation of the personnel who are actually to perform the work of identification and of restowing spare parts.

18–18 LORAN STATION RECORDS

18–18–1 GENERAL—

Responsible personnel at all LORAN installations are required to keep various types of electronic engineering records and make certain standard and special reports. The primary purpose of these records is to provide a continuous source of all operational and engineering data. The information on these records is concerned not only with the normal phases of operation, but also with all equipment irregularities as they occur. The records shall be kept on the proper forms, prescribed by Headquarters or cognizant authorities, and are to be maintained in a neat, correct and detailed manner by the responsible personnel.

18–18–5 LORAN TRANSMITTING STATION LOG, FORM CG 2594—

A. *General.*—The LORAN log forms prescribed by Headquarters shall be used to give a clear description of LORAN operation and equipment irregularities. Log entries shall be made in strict compliance with instructions. Each entry shall be complete in itself, and special markings to indicate repetition of an entry shall not be used. Any irregularities of operation should be explained as completely and concisely as possible. When additional space is required to complete an explanation, the following full line or space elsewhere on the sheet may be used. It is the responsibility of the supervisor, when assigned, and technician to see that the logs are properly maintained, and to sign the logs during watches as required.

The log sheets should be numbered consecutively, with a new series of sheet numbers being started on the first of each month. Log entries shall begin on a new sheet daily at 0000 GCT. A new series of sheet numbers shall be started each month. Logs shall be assembled for submission with the lowest sheet number on top, and the highest sheet number on the bottom. Logs for each rate shall be kept entirely separate. Typical Logs for a master and slave stations are shown in figure 18–55 and 18–56, respectively.

At LORAN transmitting stations where special techniques are used to provide semi-automatic or automatic operation, procedures for log keeping shall be as directed by operational directives.

B. *Time Entries.*—Time entries shall be made to the nearest tenth of a minute. In order to maintain correct correlation between log entries of individual stations in the same chain, the time must be kept accurately. Accordingly, the LORAN timer room clock shall be checked against standard time signal transmissions at least once daily, and corrected if necessary. Such correction shall be noted in the LORAN log at the time made.

C. *Signal-Blink Entries.*—Entries in this column should be made by drawing a vertical line through the appropriate data to indicate continuity of signal or blink.

D. *Rate Designation.*—The notation for "Rate" in the transmitting station log forms shall be a combination of the standard rate designation and the letter "M" or "S" for master or slave. For example: 1L3–M where "1" represents the transmitting frequency (1950 kc.), "L" represents a basic rate of 25 pps and "3" represents the specific rate (25 3/16 pps or 39,700 μsec interval), and "M" indicates master station.

E. *"TD" Readings.*—In this column of the transmitting station log form used by the master station, a full delay entry shall be made once every fifteen minutes. After the full reading has been measured from the major, intermediate, and minor marker values, the last digit being the result of interpolation between minor marker values if necessary. Partial readings at other times shall be logged only to the extent actually taken: for example, "– – – 3", "– – 23", or "– 623". At master stations, in addition to the routine readings, a full delay reading shall be taken and entered after each equipment irregularity affecting the "TD."

At the slave station, the coding delay as set on the Timer shall be entered on the first line in this column on each log sheet. The watch supervisor shall enter a new set of readings thereunder for each delay adjustment, and shall initial this entry in the "Remarks" column.

F. *Pulse Shape Entries.*—Only non-standard pulse shapes shall be drawn in the log, using as many lines of the "Remarks" column as necessary for this purpose. The distortion should be indicated and the pulses should be labeled "M" or "S." When the leading edges are not identical, the pulses

TREASURY DEPARTMENT
UNITED STATES COAST GUARD
CG–2594 (Rev. 6–51)

LORAN TRANSMITTING STATION LOG

LOCATION OF UNIT	RATE	STANDARD "TD"	DATE (GREENWICH)	SHEET NO. FOR MONTH
Eniwetok Island	1L Ø-M	5864	3 December 53	7

REMARKS

(1) Clearly state fault and action taken to correct it or to notify authority.
(2) At each change, enter readability (R), atmospherics (X), and interference (W).
(3) Record all WWV frequency and time checks.
(4) Record every change of watch and/or relief. Log shall be properly SIGNED OFF when relieved.
(5) At each change, enter oscillator dial settings. Osc. Dial 16~1845
(6) At each change, enter transmission line current. Line I 2.05A.

TIME GCT	MASTER SIGNAL	MASTER BLINK	SLAVE SIGNAL	SLAVE BLINK	TD READING	OPERATOR	REMARKS
0800					5863	TB	R5~XØ~WØ Oper. Norm. Equip Ckd. Blakely on watch
15					5863	TB	Oper. Norm.
30					5864	TB	Oper. Norm.
45					5864	TB	Oper. Norm.
0900					5864	TB	Oper. Norm. Equip. Ckd.
15					5863	TB	Oper. Norm.
30					5864	TB	Oper. Norm.
45					5864	TB	Oper. Norm.
51.5						TB	M off Air Pwr. Failure
1000						TB	Condition Same
05.5						TB	M on Air S Blk.
05.6					5864	TB	S in Sync. Stpd. Blk.
15					5865	TB	Oper. Norm.
30					5865	TB	Oper. Norm.
45					5865	TB	Oper. Norm.
1100					5864	TB	Oper. Norm. Equip Ckd.
10.8						TB	S out of Sync. M. Blk.
10.9						TB	S ans. Blk. M Stpd.
11.1					5864	TB	Oper Norm
15					5865	TB	Oper Norm WWV time check Retarded Clock 1.1mins.
30					5865	TB	Oper. Norm.
45					5866	TB	Oper. Norm Thomas Blakely off to Rumplik
1200					5865	RR	Oper. Norm. Equip. Ckd.
12.1						RR	Exiter Failure Racing Rate S Blk
15						RR	Condition Same
15.3					5865	RR	Changed Xmtr Mon Rate S stpd Blk Line I 2.1A
30					5864	RR	Oper. Norm.
45					5864	RR	Oper. Norm.
46.5						RR	S off Air M Blk
49.7						RR	S on Air Blk M Stpd Blk
50					5864	RR	Oper. Norm. S stpd Blk
1300					5864	RR	Oper. Norm. Equip. Ckd
15					5864	RR	Oper. Norm.
30					5864	RR	Oper. Norm
45					5864	RR	Oper. Norm.
1400					5864	RR	Oper. Norm. Equip. Ckd
09.3						RR	S Blk No Apparent Reason M Acknowledged
11.9					5865	RR	S Stpd. Blk Oper. Norm.

TOTAL BLINK 9.7

TOTAL OFF AIR 17.2

TOTAL UNUSABLE 23.7

INSTRUCTIONS

(1) Prepare in duplicate, copy to District Office, original to unit files.
(2) Under "RATE" enter standard designation (1LØ, 4H3, etc.) followed by -M or -S.
(3) Make a time entry to the nearest tenth of a minute each time a signal starts, stops, blinks, unblinks, or other change or fault occurs.
(4) Make "Time Delay" entry to the nearest microsecond.
(5) Make an additional routine entry every quarter hour.
(6) Forward on the 10th, 20th, and last day of each month.

EQUIPMENT AND COMPLETED LOG CHECKED BY:

Harry James ET2
WATCH SUPERVISOR

COMPLETED LOG CHECKED AND APPROVED BY:

H. J. Elmore
C.O. OR O-IN-C

U. S. GOVERNMENT PRINTING OFFICE 16—39185-4

FIGURE 18–55.—Typical Master LORAN Transmitting Station Log.

TREASURY DEPARTMENT
UNITED STATES COAST GUARD
CG-2594 (Rev. 6-51)

LORAN TRANSMITTING STATION LOG

LOCATION OF UNIT	RATE	STANDARD "TD"	DATE (GREENWICH)	SHEET NO. FOR MONTH
WAKE ISLAND	1LØ-S	1000	3 DECEMBER 1953	7

REMARKS
(1) Clearly state fault and action taken to correct it or to notify authority.
(2) At each change, enter readability (R), atmospherics (X), and interference (W).
(3) Record all WWV frequency and time checks.
(4) Record every change of watch and/or relief. Log shall be properly SIGNED OFF when relieved.
(5) At each change, enter oscillator dial settings. OSC. DIAL 14-1520
(6) At each change, enter transmission line current. LINE I 1.95A

TIME GCT	MASTER SIGNAL	MASTER BLINK	SLAVE SIGNAL	SLAVE BLINK	TD READING	OPERATOR	REMARKS
0915	│	•	│	•	1000	KR	R4-X1-WØ OPER. NORM. KIRK ROSE ON WATCH
30	│	•	│	•	1000	KR	OPER. NORM. WWV TIME CHECK OK
45	│	•	│	•	1000	KR	OPER. NORM.
50.4	│	•	│	│		KR	M OFF AIR S BLK
1000	•	•	•	│		KR	CONDITION SAME
04.5	│	•	│	•	1000	KR	M ON AIR S IN SYNC STPD BLK EQUIP CKD.
15	│	•	│	•	1000	KR	OPER. NORM.
30	│	•	│	•	1000	KR	OPER. NORM. CHANGED TIMER
45	│	•	│	•	1060	KR	OPER. NORM.
1100	│	•	│	•	1000	KR	OPER. NORM. EQUIP. CKD.
09.7		│	│	•		KR	S JPD. SYNC. M BLK
09.8	│		│	│		KR	S ANS. BLK. M STPD.
10	│	•	│	•	1000	KR	S IN SYNC. STPD BLK OPER. NORM.
15	│	•	│	•	1000	KR	OPER. NORM.
30	│	•	│	•	1000	KR	OPER. NORM.
45	│	•	│	•	1000	KR	OPER. NORM. Kirk Rose OFF TO Dave Hayworth
1200	│	•	│	•	1000	DH	OPER NORM EQUIP CKD.
12.1	│	•	│	│		DH	M RACING RATE S BLK.
15	│	•	•	│		DH	CONDITION SAME
15.3	│	•	│	•	1000	DH	M ON RATE S IN SYNC. STPD. BLK.
30	│	•	│	•	1000	DH	OPER. NORM.
45	│	•	│	•	1000	DH	OPER NORM.
46.5	│	•	│	•		DH	S OFF AIR XMTR FAILURE
49.7	│	•	•	│		DH	S ON AIR BLK.
50	│	•	│	•	1000	DH	S IN SYNC. STPD BLK. LINE I 1.90A.
1300	│	•	│	•	1000	DH	OPER NORM. EQUIP. CKD.
15	│	•	│	•	1000	DH	OPER NORM.
30	│	•	│	•	1000	DH	OPER NORM.
35	│	•	│	•	1000	DH	Hayworth OFF TO Carter
	│	•	│	•	1000	BC	Carter OFF TO Hayworth
45	│	•	│	•	1000	DH	OPER. NORM.
1400	│	•	│	•	1000	DH	OPER NORM.
09.3	│	•	•	│		DH	SEVERE ELECTRICAL STORM RØ-W5-XØ S BLK
11.9	│	•	│	•	1000	DH	R3-W2-XØ S STPD BLK. IN SYNC.
15	│	•	│	•	1000	DH	OPER. NORM.
30	│	•	│	•	1000	DH	OPER. NORM.
45	│	•	│	•	1000	DH	OPER. NORM.
1500	│	•	│	•	1000	DH	OPER NORM.

TOTAL BLINK 20.5

TOTAL OFF AIR 17.3

TOTAL UNUSABLE 23.7

INSTRUCTIONS

(1) Prepare in duplicate, copy to District Office, original to unit files.
(2) Under "RATE" enter standard designation (1LØ, 4H3, etc.) followed by -M or -S.
(3) Make a time entry to the nearest tenth of a minute each time a signal starts, stops, blinks, unblinks, or other change or fault occurs.
(4) Make "Time Delay" entry to the nearest microsecond.
(5) Make an additional routine entry every quarter hour.
(6) Forward on the 10th, 20th, and last day of each month.

EQUIPMENT AND COMPLETED LOG CHECKED BY:
Sam Jones ET1
WATCH SUPERVISOR

COMPLETED LOG CHECKED AND APPROVED BY:
A. M. N. Admiral
C. O. OR O-IN-C

U. S. GOVERNMENT PRINTING OFFICE 16—39185-4

FIGURE 18–56.—Typical Slave LORAN Transmitting Station Log.

406226 O—57——7

VIDEO SIGNAL SCALE	R Readability	X, Natural Atmospherics or W, Interfering Signals
0	Unreadable	None
1	Visible but not usable	Weak or infrequent, not troublesome
2	Occasionally with difficulty	Moderate, sometimes troublesome
3	Usable with some difficulty	Considerable, sometimes preventing accurate use
4	Usable with ease	Strong, usually preventing accurate use
5	Perfectly usable	Very strong, useful reception impossible

FIGURE 18–57.—Relative Conditions of Reception.

should be drawn as they appear superimposed. An indication should be made in the "Remarks" column when the pulse shapes are restored to normal. If the condition continues into a new log sheet period, the distorted pulses should be drawn at the top of the new sheet.

G. *"Remarks" Column Entries.*—The following information shall be entered in the "Remarks" column:

(1) Readability, static, and interference shall be indicated on the first line of each sheet by an RXW entry employing a scale of 0–5; for example, R4–X2–W2. A new entry should be made when any one or more of the conditions change. Figure 18–57 shows a table of relative RXW values and should be used as a guide to assure uniformity of log entries of reception conditions.

(2) The watch supervisor and scopeman when relieved from the watch shall sign the log properly; for example, W. T. Door, ET2 relieved by C. Noble, ET3. Temporary relief at other times shall be indicated clearly.

(3) At transmitting stations, each adjustment of operating timer equipment which affects, or is likely to affect, either the time delay or coding delay, or set of dial readings for the coding delay shall be entered (see paragraph E for master and slave instructions). Such entry shall be initialed by the watch supervisor.

(4) Any changeover to standby equipment, either routine or because of irregularity, shall be noted.

(5) Irregularities shall be described with applicable information from the following categories:

(*a*) Interference-type, frequency, deviation.

(*b*) Pulse condition—use nomenclature in (6) below.

(*c*) "Out of sync"—actual error, or reason reading could not be obtained.

(6) The following nomenclature shall be used to describe pulse condition:

(*a*) Breathing—rhythmic enlarging and contracting of pulse in size or amplitude (indicate which).

(*b*) Blinking—rhythmic off-and-on operation of the pulse.

(*c*) Jittery—entire pulse unstable.

(*d*) Flapping—unstable trailing edge.

(*e*) Fluttering—front or top of pulse unsteady (indicate which).

(*f*) Jumping—signal jumps out of synchronization.

(*g*) Drifting—slow movement of signal in one direction.

(*h*) Shifting—back and forth movement of signal.

(*i*) Searching—movement of signal back and forth when slave station is using phase shift dial to restore synchronization.

(*j*) In sync.—maintaining standard delay.

(*k*) In tol.—standard delay plus or minus two-microseconds, except when tolerance other than two-microseconds is specifically authorized by Headquarters.

H. *Abbreviations.*—The following abbreviations are authorized for use on LORAN Station Logs:

M	—Master.
S	—Slave.
Blk	—Blinking.
Stpd Blk	—Stopped Blinking.
Oper. Norm	—Operation Normal.
Equip. Ckd.	—Equipment Checked.
Pwr. Failure	—Power Failure.
Xmtr	—Transmitter.
Line I	—Transmission Line Current.
Osc. Dial	—Oscillator Dial Settings.
Ans.	—Answered.
R	—Readability of LORAN Signals.
X	—Atmospherics affecting the LORAN Signals.
W	—Man-made interference affecting LORAN Signals.
μs	—microsecond.
sec.	—second.
mins.	—minutes.

I. *Log Inspection.*—The commanding officer shall inspect and verify each log sheet, and shall sign for each day, in ink or pencil. The lower portion of each unsigned log sheet shall be removed.

18–18–10 ELECTRONIC EQUIPMENT HISTORY CARDS, FORM NAVSHIPS 536.—

These cards are used to record all information concerning emergency changes, modifications, failures, irregularities, and any other pertinent data on each unit of electronic equipment. One card should be made out for each equipment unit. These cards shall be transferred with the units when they are removed from a station or ship.

The format of the cards is designed to provide maximum ease in indicating all necessary information concerning a failure or irregularity. The headings of the cards should be typed; the body may be typed or written in ink or indelible pencil. Ordinary pencil results in smeared records and shall not be used.

There are some important points which should be kept in mind when filling out the form. All information should be given in full and not in abbreviated form. Model designations, serial numbers, and unit type numbers should be secured from the proper name plates. The Instruction Book box should be checked only if the final instruction book has been received. Any external evidence of trouble should be entered in as precise and succinct manner as possible. If field changes are made which affect the unit, the field change numbers and title should be entered. The most important column is CAUSE OF FAILURE. How the trouble was traced and what corrective measures were taken should be described in full. Peculiarities and weaknesses of the unit should be noted. The information entered in this column is of great value since it aids in the development of better and more reliable equipment. In the LIFE HOURS column, the total life of the part in hours should be estimated as closely as possible. Whatever data is available to arrive at this estimate should be used, but NOT the manufacturer's tube life estimate or guarantee.

18–18–15 RECORD OF FIELD CHANGES, FORM NAVSHIPS 537.—

Field change records are of paramount importance. There is no record more essential than that which rescribes the changes made to equipment since initial installation. Without such a record, it is often extremely difficult to determine whether or not a particular unit is dangerously out-of-date, and no one can be sure what changes have been made. This information is important not only for keeping equipment up-to-date, but is also of absolute necessity for routine maintenance, trouble-shooting, and for ordering spare parts which belong to the improved apparatus.

The official name and Navy type number (or other official identification) of each equipment unit affected by a field change should be shown parenthetically after the title of that change. The name of the person making the change, and date should be recorded. When a unit of major equipment is surveyed or exchanged, it is necessary to correct the field change records to show what equipment actually remains on board.

18–18–20 TUBE PERFORMANCE RECORD, FORM NAVSHIPS 538.—

This form is for use with Service Life Guaranteed Tubes, and where tube performance is recorded. The column headings are self-explanatory.

18–18–25 ELECTRONIC FAILURE REPORT, FORM DD–787.—

This report is submitted for each and every mechanical and electrical failure of electronic equipment, and furnishes valuable data for a number of vital functions. Among these are: (1) achieving the ultimate objective of the Electronic Parts Inventory Control Program, (2) procurement of maintenance parts, (3) location of design and manufacturing defects, and (4) development of field changes.

The form was designed to permit simplicity in its preparation. It is small in size and may be easily carried by maintenance personnel for use on any job. In addition, the forms are bound in pads with carbon paper affixed and may be prepared by using pencil, pen, or typewriter.

It is believed that a large majority of electronic equipment failures are not reported for the reason that many units and individuals harbor the philosophy that too many failure reports reflect inefficiency. Actually, the reverse is true. It should be understood that prompt submittal of this form for all mechanical and/or electrical failures is of inestimable aid in revealing equipment defects and component weaknesses and thus providing valuable data for use in future planning and design and development of modifications. Therefore, this report must be submitted promptly for each and every failure.

18–18–30 LORAN STATION OPERATION AND ELECTRONICS ENGINEERING REPORT, FORM CG–2899.—

Each LORAN Transmitting Station shall submit the combined Operation and Engineering report on Form CG–2899 prior to the 10th day of each month. The report shall cover the period from the first through the last day of the month preceding, and shall be prepared in accordance with the instructions on the report form.

The report shall include, in addition to other data required, a complete summary of all LORAN technical matters of interest, such as equipment failures, field changes and modifications completed, condition of electronic equipment, technical matters pending and recommendations to improve station efficiency.

The report shall be carefully prepared, with special attention to accuracy and completeness of information. If necessary to complete information, extra sheets may be used.

Personnel preparing the electronic information for this report should bear in mind that the data submitted is used by the Commandant EEE in developing and improving equipment in the entire LORAN system.

INDEX