CHAPTER 26

Marine Radiobeacons

CONTENTS

ILLUSTRATIONS

26–1 GENERAL DESCRIPTION

26–1–1 Purpose and Use—

A. *Location.*—Marine radiobeacon stations are distributed along the coasts of the continental United States and at other points under the jurisdiction of the United States and are located principally at light stations, on lightships or at other points as shown on charts. They are maintained by the Coast Guard. Each radiobeacon transmits a distinctive identifying coded tone signal, enabling navigators to take bearings by means of shipboard radio direction finders. (Radio direction finders are special radio receivers, with rotating coil antennas, capable of receiving radiobeacon signals.) Such bearings are usually accurate within two degrees or less, depending on the equipment used and the skill of the operator. The latitude and longitude of the radiobeacons can be obtained from the Light Lists, which also carry detailed data on all radiobeacons, or from United States Coast and Geodetic, and Lake Survey charts.

B. *Shipboard use.*—In this country, the direction finding equipment on shipboard nearly always is installed in such a way, and the transmitted characteristic signal is such, that the navigator himself can conveniently take distinct and easy-to-recognize radio bearings. The general problems and practice of navigation are then the same when using radio bearings as they are with visual bearings on lighthouses or other known objects. The practical differences between radio and sight bearings are not differences in principle, but in the availability of the former at much greater distances and under all conditions of visibility or fog. The radiobeacon is located at a definite point shown on the chart. It sends out signals by radio in all directions around the horizon, as does a lighthouse by means of light beams, and it is distinguished from the neighboring signals by a definite characteristic, as is the light.

(1) The radiobeacon may be used as a leading mark for which to steer directly, the navigator correcting the course from time to time by successive radio bearings. Thus, such a signal off an entrance or other objectives may be approached with certainty from a considerable distance. This is a valuable use of radiobeacons, especially when these signals are located on lightships, as illustrated by the signals on Nantucket Lightship and Ambrose Lightship, which guide trans-Atlantic vessels to the approaches of New York Harbor.

(2) *Caution.—Mariners must not steer directly for lightship radiobeacons when in close proximity thereof, due to the danger of collision. Always keep the bearing slightly open on the bow.* In this connection, an auxiliary low-powered warning radiobeacon which sends a distinctive signal on the same frequency as the main radiobeacon has been installed on Nantucket Lightship. The auxiliary warning radiobeacon has a range of only a few miles and when heard, serves as additional warning to navigators not to steer directly for the lightship.

C. *Bearings.*—The signal emitted by a radiobeacon follows a great circle course. Radio bearings may be plotted without applying a correction on a Mercator chart if the difference in longitude involved is not in excess of 1° or 2°. When the difference is larger, a correction usually must be applied which will be found in H. O. Publication No. 205, "Radio Navigational Aids," under Radio Bearing Conversion Tables.

(1) A bearing from a radiobeacon station may be combined with information from other sources, as from an intersecting line of position from an astronomical or Loran observation, from soundings, from dead reckoning, etc., to locate the position of the vessel.

(2) A ship may also be located by radio bearings on a single radiobeacon by taking two bearings on a station with an intervening period of time, and plotting these with respect to the distance and course run between bearings. With radio bearings, because the signals are generally not operating continuously excepting during fog, advantage should be taken of bearings at suitable angles as opportunity offers.

(3) The common method of locating a ship by cross bearings may be employed in radio navigation using two or more radiobeacons, or visual and radio bearings in combination. Of course, the usual principles apply as to employing stations which will give good intersections, and as to allowing for the distance run between the times of taking bearings if the interval is appreciable.

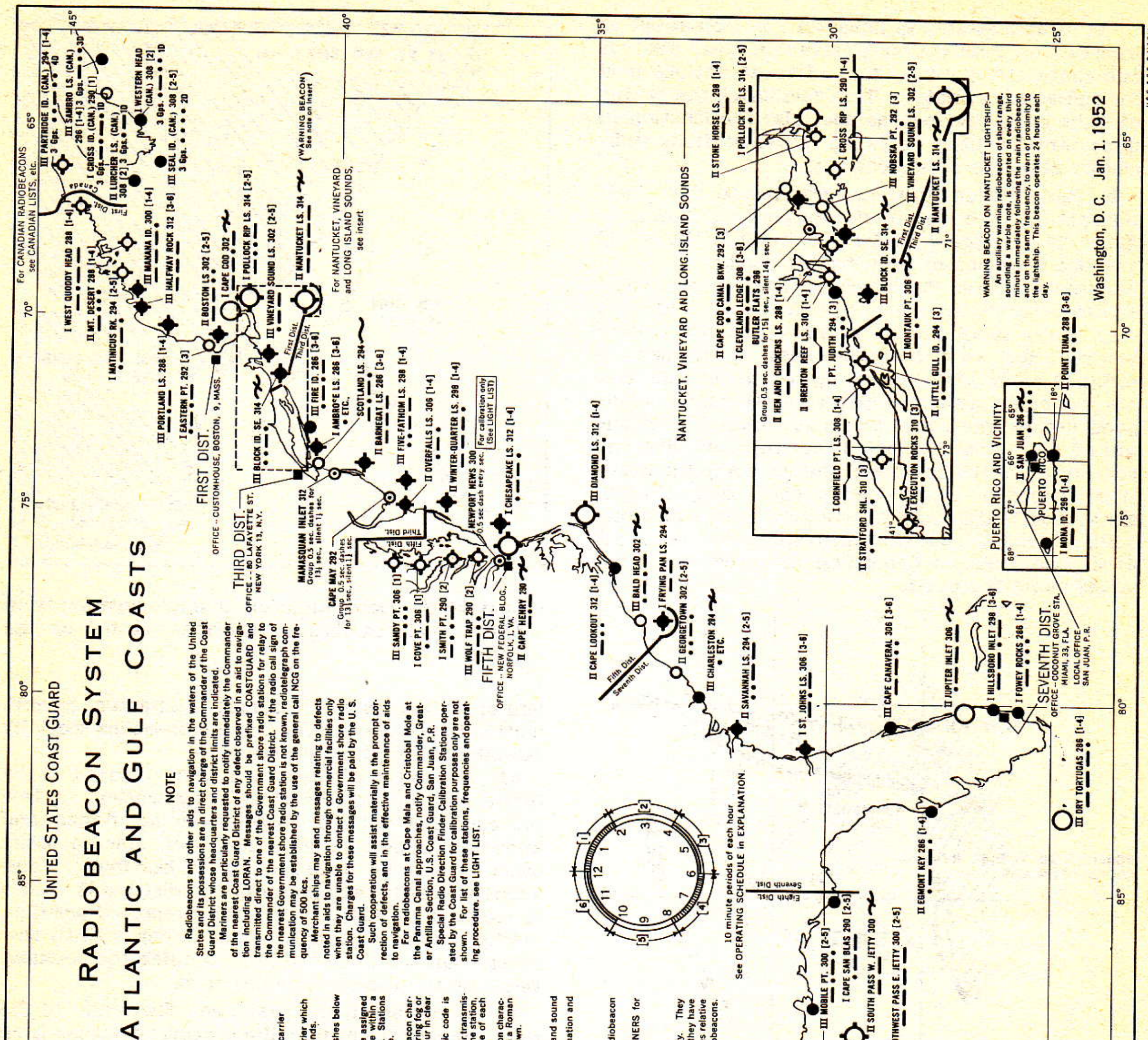


FIGURE 26–1.—Chart of radiobeacon system for Atlantic and Gulf Coasts. (Charts showing radiobeacons on the Pacific Coast and Great Lakes will be found in the respective Light Lists.)

(4) United States radiobeacons are operated at intervals on a fixed time schedule in clear weather and continuously during fog; adjacent stations send for successive minutes. This facilitates the taking of radio cross bearings, as does also the location in important localities of two or three stations sufficiently close for cross bearings.

D. Radiobeacons in the approaches to New York, illustrating their use in navigation, are shown in figure 26–2. Figure 26–3 illustrates how in actual practice a navigator may fix his position by cross bearings on three Pacific coast radiobeacons. The angles between the stations in figure 26–3 are not such that a small triangle of most probable position will be formed as in many instances. Such cases are common along some steamship routes, but the fixes are extremely valuable, nevertheless, and may be good despite the small angle at which two of the lines cross. It will be noted that in figure 26–3 the correctness of the bearing of the station to the north is confirmed or independently checked by that of the station to the south to give the distance offshore, while bearing of the station to the east gives a cut at a good angle to determine the progress of the vessel along the coast.

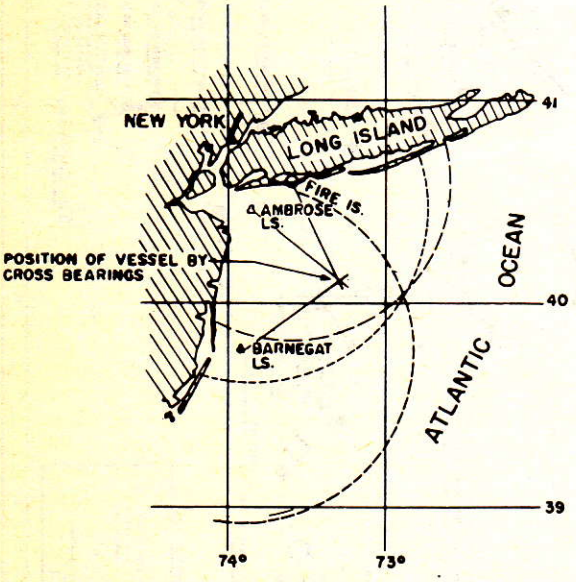


Figure 26–2.—Radiobeacons in the approaches to New York and how they may be used by vessels.

E. *For additional information on accuracy of bearings, plotting, and other matters,* the navigator should consult the current issue of H. O. Publication No. 205, "Radio Navigational Aids."

(1) Radio bearings from a ship may, of course, be taken on any sending station shown on the chart, transmitting on a frequency within the range of the direction finder receiver. A considerable number of such radio stations throughout the world have been listed, on which bearings may be taken from ships equipped with radio direction finder equipment. Many of these stations on request will transmit signals to permit radio bearings being taken. However, because of their dependable and convenient operating system, it is more satisfactory in navigation to use bearings on the radiobeacons specially established for this purpose.

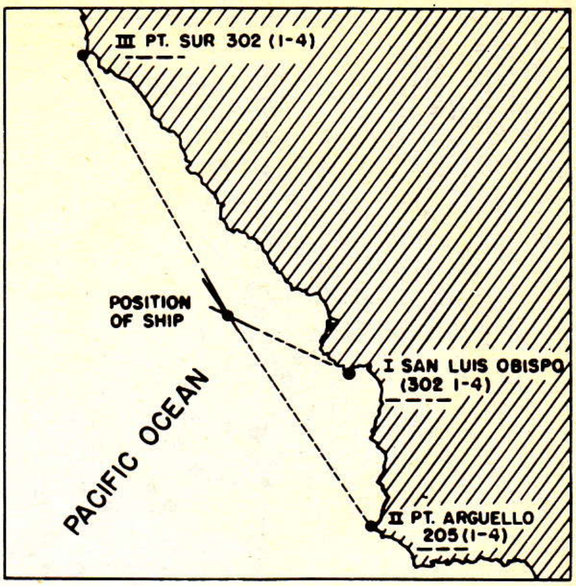
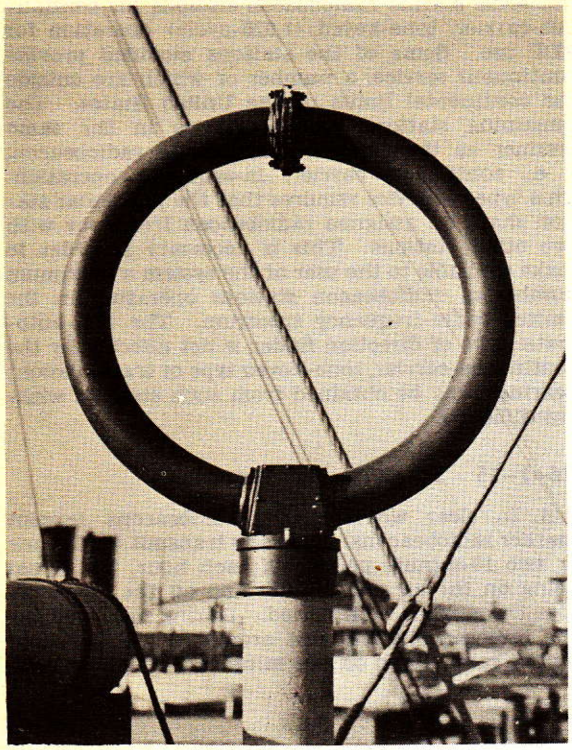


Figure 26–3.—Determination of ship's position from three good radiobeacon bearings plotted on the chart.

(2) A number of cases have been reported of the indirect use of radio bearings in navigation. A vessel equipped with a radio direction finder and knowing its own position has been able to assist other vessels by means of radio bearings. Thus, where a vessel seeking another in distress is unable to locate it because of inaccurate reported position, neither having a radio direction finder, a third vessel so equipped has been able to guide the rescuing vessel by the use of radio bearings.

F. There has, in the past, been discussion of the relative merits of using radio bearings obtained from the ship and from fixed radio direction finder stations on shore, but the question was of importance only in the development stage. As soon as the improvement of the marine radio direction finder made practicable the obtaining of reliable radio bearings from the ship, the advantages became apparent of having such a valuable navigational instrument located so as to be directly available to the navigator for the various and general uses to which it may be applied on shipboard. This system conforms to the standard practice of the sea in retaining the location of the navigating instruments on the ship and placing the responsibility for their use, and for the navigation of the ship, in the hands of the master. The navigator can use such checks as he deems best, and knows what reliance to place on radio bearings in comparison with his other means of guiding the vessel. Any number of vessels properly equipped may take bearings simultaneously on a radiobeacon, just as they can on a lighthouse, without interference with each other. The United States Coast Guard no longer operates fixed direction finder stations.



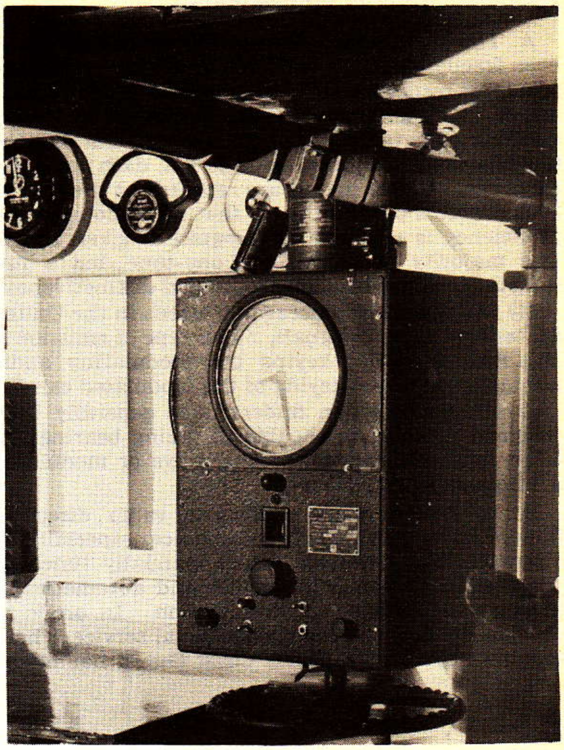


FIGURE 26–4.—Topside and inside views of a modern radio direction finder installed aboard ship. Loop antenna is inclosed in weatherproof housing.

G. *Monitor service.*—In order to insure the best possible service to mariners, arrangements have been made that every radiobeacon be monitored by some United States Coast Guard radio-equipped shore unit where constant radio watches are stood. Tabulated monthly reports are made on this monitoring work to the district commander concerned, so that he can readily determine the relative efficiency of operation of his radiobeacons and take steps to correct all unsatisfactory conditions. Immediate action is taken by radio and special reports are made whenever serious errors occur, such as no signal or signal operating at improper times, etc., permitting prompt correction of the operational defect. Investigation is made of these serious cases and explanations for the error must be submitted by the unit concerned.

26–1–5 Useful Range—

A. In the United States the radiobeacons are divided into four general classes, as follows:

Class A.—Reliable average range of 200 miles.
Class B.—Reliable average range of 100 miles.
Class C.—Reliable average range of 20 miles.
Class D.—Reliable average range of 10 miles.

(1) The most powerful sound-in-air fog signals under favorable conditions may be heard at distances of 10 to 15 miles, but their ordinarily dependable range is not over 5 miles, and under unfavorable conditions, they are lost at distances shorter than this. The coast lights are visible for 15 to 20 miles and large lighted buoys for about 9 to 12 miles. It is therefore readily seen that the radiobeacons have a much greater range of usefulness, in fog as well as in clear weather. This is illustrated by the fact that on the outside Atlantic coast of the United States, north of Cape Hatteras, there are but 19 radiobeacons. This length of coast requires five times this number of sound fog signals, and they are effective over only 2 percent of the area served by the radiobeacons. The same length of coast has 150 outside lights.

(2) In order to lessen interference, the power of radiobeacons is limited to that which is necessary, according to the various purposes of the stations. For the same reason, the primary stations are restricted to a few widely separated points of strategic importance to navigation, which are valuable as landfall stations or for long distance approach.

26–1–10 Signals Transmitted—

A. The radiobeacon transmitter transmits on an even frequency in the band 286 to 324 kilocycles, and is in most respects similar to a communication transmitter. The distinctive signal is obtained by keying a tone-modulated carrier with a simple but distinctive characteristic, such as dash, dot, dash; or dash, dash, dot. These signals are repeated at the rate of 30 characters per minute, so that no radiotelegraph proficiency is required to recognize a given signal. The majority of signals are one-tone, but a few radiobeacons use two-tone for added distinctiveness.

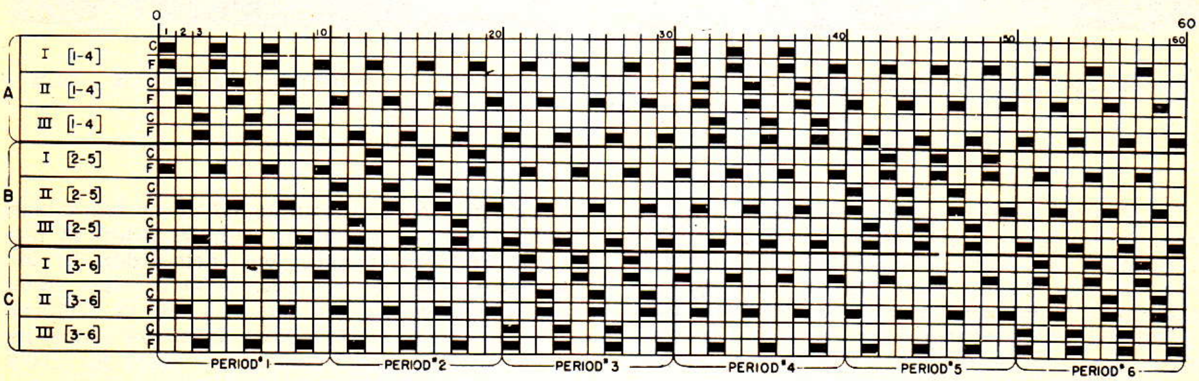
(1) All marine radiobeacon stations in the United States emit type A2 signals. This type of emission is obtained by either keying the modulating audio frequency or by the keying of the modulated carrier.

(2) Radio direction finders have generally been designed so as to be capable of taking bearings on either unmodulated continuous wave or modulated continuous wave signals.

B. In recent years automatic radio direction finders have made their appearance, especially in aircraft. These devices, when manually tuned to the desired station, will rapidly and automatically indicate the bearing of that station. In order to provide the best possible navigational service, where required, the United States Coast Guard has modified some marine radiobeacon stations for continuous-carrier, tone-keyed (1,020-cycle) operation for ADF use. Some of the stations modified provide continuous service, a number of which are outside the continental limits of the United States. The remaining stations provide service in the same manner as the conventional marine radiobeacon, i. e., continuous carrier, in-sequence operation. This type of service requires that the particular station share an assigned radiobeacon frequency with two other stations. This is necessary in order to make available to the user of the system a maximum number of radiobeacon stations operating in the limited radio-frequency spectrum. The non-automatic type of direction finder is not affected by the continuous-carrier, tone-keyed type of transmission; bearings may be obtained from such stations without difficulty.

26–1–15 Schedules of Operation—

A. In clear weather the radiobeacons (except marker radiobeacons) generally transmit during one or two 10-minute periods of each hour, the signal being on the air one minute and off the next two, etc., throughout each period. During haze and fog the radiobeacons transmit around the clock, being on one minute and off two minutes throughout each



NOTE: (C) MINUTES OF TRANSMISSION DURING CLEAR WEATHER.
(F) MINUTES OF TRANSMISSION DURING FOG.

1. THE HOUR IS DIVIDED INTO SIX 10-MINUTE PERIODS, NUMBERED 1 TO 6 CHRONOLOGICALLY.
2. THREE STATIONS HAVING THE SAME CARRIER FREQUENCY COMPRISE A GROUP. GROUPS ARE LETTERED A, B, C, EACH STATION IN A GROUP TRANSMITS EVERY THIRD MINUTE IN SEQUENCE, HENCE SIMULTANEOUS TRANSMISSION CANNOT OCCUR BETWEEN STATIONS OF ONE GROUP.
3. THREE GROUPS ARE POSSIBLE WITHOUT SIMULTANEOUS TRANSMISSION ON CLEAR WEATHER SCHEDULE. SIMULTANEOUS TRANSMISSION DOES OCCUR DURING FOG, BUT EACH GROUP IS ASSIGNED A DIFFERENT CARRIER FREQUENCY.
4. IN CLEAR WEATHER, STATION GROUPS OPERATE FOR ONE OR TWO 10-MINUTE PERIODS PER HOUR, WITH THE LAST MINUTE OF THE PERIOD SILENT. WITHIN A PERIOD, EACH STATION HAS 3 TRANSMISSIONS OF 1 MINUTE EACH.
5. IN FOG ALL STATIONS TRANSMIT CONTINUOUSLY, EACH STATION IN SEQUENCE ON ITS ASSIGNED MINUTE. THIS SCHEDULE IS THE BASIC ONE ON WHICH THE CHART IS LAID OUT. THE CLEAR WEATHER SCHEDULE IS MERELY A PARTIAL CURTAILMENT OF THIS BASIC SCHEDULE. THUS A STATION ADHERES TO THE SAME SEQUENCE AND THE SAME "MINUTE OF THE HOUR" IN CLEAR WEATHER OPERATION OR IN CONTINUOUS OPERATION DURING FOG.
6. THE ROMAN NUMERAL (I, II, III) INDICATES THE MINUTE OF THE HOUR ON WHICH THE STATION STARTS ITS SIGNALS ON THE BASIC (FOG) SCHEDULE. ✱ A (I) STATION IS CALLED A "FIRST MINUTE STATION," AND ETC.
7. THE PERIODS DURING WHICH THE STATION OPERATES ON CLEAR WEATHER SCHEDULE ARE SHOWN IN BRACKETS, THUS [1-4], [2-5], [3-6].

✱ NOTE
A FIRST MINUTE STATION BEGINS TRANSMISSION ON THE HOUR AND TRANSMITS DURING THE FIRST MINUTE.
A SECOND MINUTE STATION BEGINS TRANSMISSION ONE MINUTE AFTER THE HOUR AND TRANSMITS DURING THE SECOND MINUTE.
ETC.

FIGURE 26–5.—Operating schedules.

hour. This scheduling enables adjacent stations to operate on the same radio frequency without interference. Such scheduling obviously requires accurate timing of signals.

B. *Time schedules.*—Radiobeacon stations are usually set up in groups cf three. Within the group all three operate on the same carrier frequency and the same hourly (clear weather) schedule. Interference between the three stations of a group is prevented by operating each station on successive minutes. The group operates 9 minutes out of each half hour, remaining silent the tenth minute. Since there are three 10-minute periods in each half hour, three such groups of three radiobeacons can be operated during clear weather without any of the nine stations transmitting simultaneously. (See fig. 26–5.) Because the groups operate continuously on 3-minute cycles during fog, interference could result if geographically adjacent groups were operated on the same carrier frequency. Consequently each adjacent group is operated on a different radio frequency, insofar as this is possible with the frequency channels available.

C. It will be noted by examination of figure 26–5 that if a station is assigned operating minute I, it does not necessarily mean that the station will operate the first minute of the clear weather period; for example, if the station's operating periods were 3 and 6, then operating minute I would be the second operating minute of both the 3d and 6th periods. In periods 2 and 5, operating minute I would be the third minute of the period. Also it should be noted that the last, or 10th minute of each period is not used during clear weather, although it might be an operating minute in some cases. A first minute station begins transmission on the hour and transmits during the first minute. Subsequent transmissions based on this initial start fit together in such a manner that fog schedules do not interfere with clear weather schedules. They dovetail into one timed operation.

D. Each station should have its operating minutes and periods plainly marked on its clocks so that a glance will indicate whether the radiobeacon should be operating.

E. *Timing method.*—It is obvious from the foregoing that a means of accurate timing is necessary to maintain the assigned schedule and that intricate

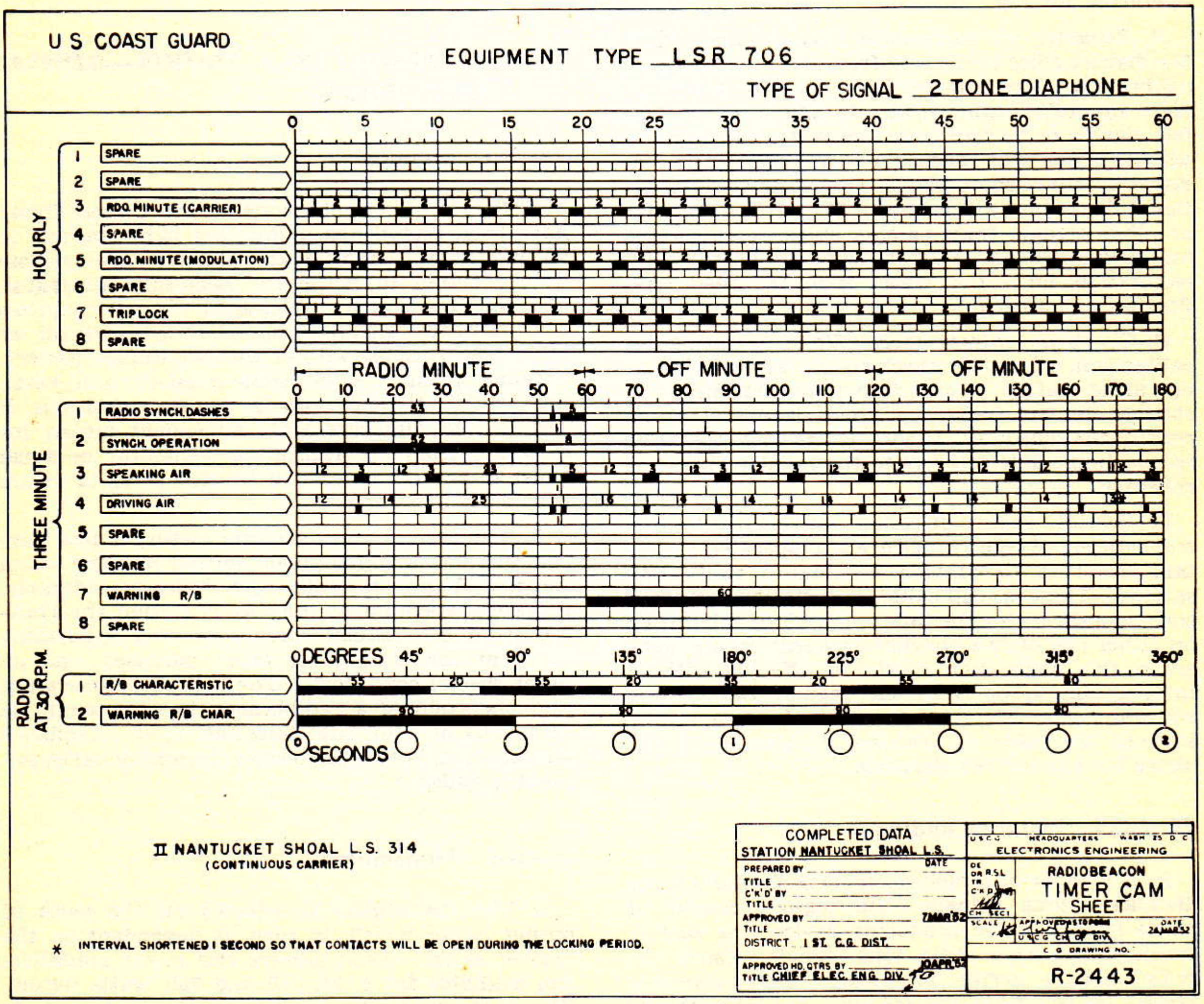


FIGURE 26–6.—Sample coder cam sheet.

control systems are involved. Accurate timing of radiobeacon signals is accomplished by a beacon, which in turn is controlled by a master clock. The latter is checked frequently against Naval Observatory time signals. This method of timing makes it possible to operate adjacent radiobeacons with little interference or at most a momentary overlap, short in comparison with the length of the transmitted signals. In addition, the beacon coder controls all timed functions of the light station in synchronism with the radiobeacon. This includes distance finding signals, main light, engine-generator starting, and warning transmitters.

26–1–20 Calibration Service—

A. *Calibration broadcasts.*—Upon request, United States radiobeacons will broadcast in clear weather to enable vessels to swing ship for the purpose of calibrating direction finders. The transmission consists of steady signals (without the 1 minute on, 2 minutes off cycle), but must be discontinued during each clear weather schedule or whenever other radiobeacons in the same frequency group are operating for fog.

B. *Requests for calibration* may originate from the district office or directly from the vessel desiring calibration. The request from the vessel may be given by radiotelephone, whistle signal, searchlight, flag signals or by hail from the vessel. Request by whistle signal will consist of three long blasts followed by three short blasts. Requests by international flag signal will be J over K. All flag, whistle, or other signals from passing ships are answered and acknowledged. Radiobeacons are operated for calibration until the vessel indicates they have finished calibrating.

C. *Check for interference.*—While operating for calibration, a frequent check should be made by the operating station to ascertain if one of the other stations in the frequency group is operating on continuous schedule. If such is the case, operation should immediately revert to the regular operating schedule.

D. *Special radio direction finder calibration transmitters* of short range are also operated at certain localities to provide continuous calibration service. These special calibration stations transmit continuously during the time required for calibration on either one of two assigned frequencies, and generally this calibration service is effected without interruption to or from the regular radiobeacon stations. Requests for operation of these special stations are made as described in paragraph (B) above for regular radiobeacons.

26–1–25 Distance finding—

A. A number of radiobeacon stations also provide distance-finding signals. The signals consist of blasts from a sound-producing device (fog signal) synchronized with radio tone signals. Since the radio signals arrive practically instantaneously (speed 186,000 miles per second), the later arrival of the sound signal (speed approximately 1,100 feet per second), gives an indication of the distance traversed by the latter, and therefore of the vessel's distance from the station. At distance-finding stations, transmission of the characteristic radiobeacon signal is curtailed 8 seconds before the end of the operating minute, and a 1-second dot followed by a 5-second dash are transmitted simultaneously with blasts of corresponding lengths from the sound signal device. Any ship within audible range of the sound signal, and equipped with a receiver tunable to the radiobeacon signal, plus a watch with second hand, or a stop watch, can utilize the distance-finding signals.

B. An observation consists of noting the time difference with reference to any distinctive part of the signals—for example, the end of the long radio dash and the end of the long sound blast. Dividing the time in seconds by 5.5 gives the distance in nautical miles within an error of ±10%. The distance-finding signals are transmitted only in thick or foggy weather when the fog signal is operating.

C. All distance-finding stations and their method of operation are shown in Coast Guard Light Lists covering areas where radiobeacons are located.

26–2 EQUIPMENT OF A STATION—GENERAL DESCRIPTION

26–2–1 General—

A. Nearly all radiobeacons of the United States have been established at existing light stations or on lightships. Additional buildings have seldom been required to house the necessary apparatus. The equipment of a radiobeacon station comprises a transmitter, signal timer, electric generator or other power supply with or without storage battery, antenna, primary clock, radio receiver, and warning device. All apparatus, so far as practicable, is installed in duplicate with convenient means for switching from one transmitter, generator, or signal timer to another in case of trouble, so as to insure continuity of service.

B. The cost of a radiobeacon station is less than that of a powerful fog-signal station emitting sound signals. The installation cost varies considerably, however, depending on the class of station, the availability of commercial current or of a generating plant at the station for other purposes, and on other special conditions. The cost of maintenance and operation of a radiobeacon is quite small, as ordinarily no additional personnel at an established station should be required after the additional equipment is added.

26–2–5 Transmitter—

A. The transmitter is selected on the basis of output power which, in turn, is dependent on the desired range. Transmitters and power amplifiers are available for 5, 25, 150 and 750, watts output. The radiobeacon transmitter is in most respects similar to a communications transmitter.

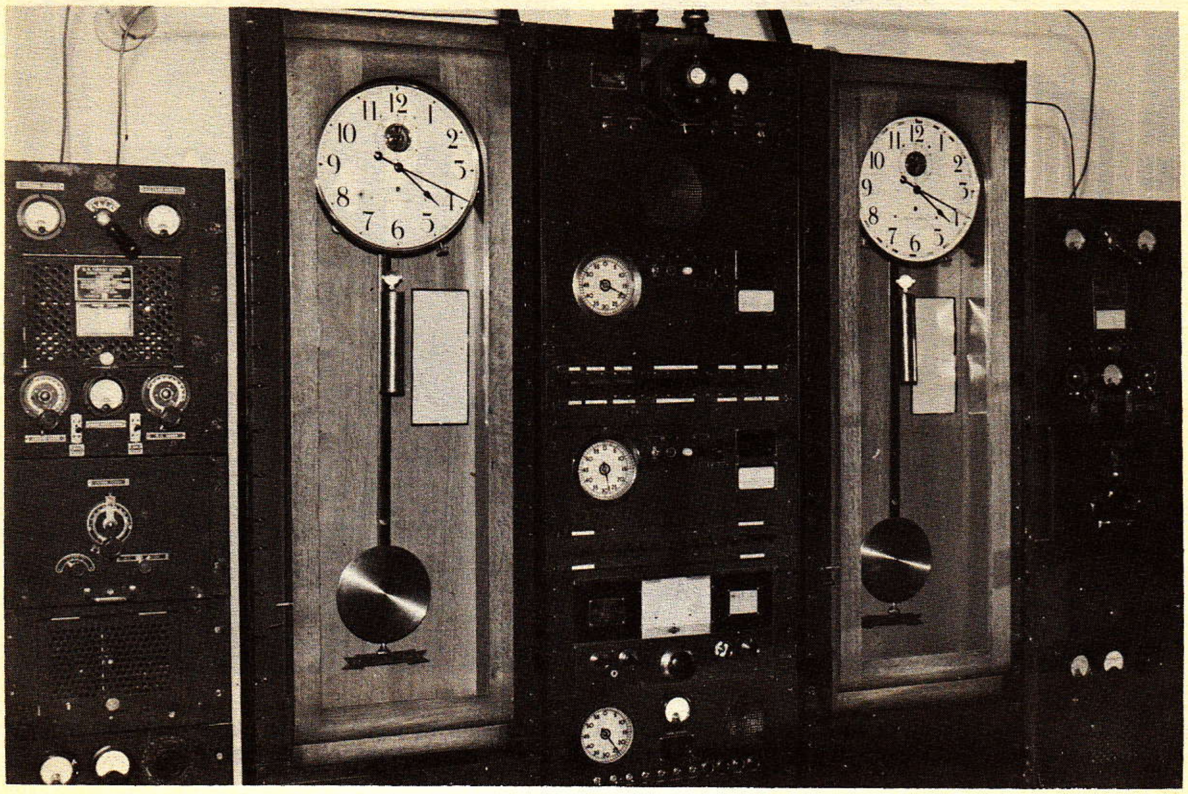


FIGURE 26–7.—Equipment of class B radiobeacon at Pidgeon Point Light Station, California, showing duplicate arrangement.

26–2–10 Master (Primary) Clocks—

A. *Types.*—Two types of primary clocks are employed to exercise control over timed functions at the radiobeacon stations. One is a jewelled, weight-driven, pendulum clock capable of maintaining an accuracy within 2 seconds in 24 hours. These clocks are installed at shore radiobeacons where vibration is not excessive. The second type is a jewelled, temperature-compensated, marine-escapement clock which has an accuracy within 5 seconds in 24 hours. This latter type is used at all lightship radiobeacons, and at shore stations where vibration is excessive. The function of either type clock is to make an electrical contact once each minute to furnish impulses to a stepping relay of the coder which, in turn, regulates the functions of the radiobeacon station.

B. *Frequent time checks.*—Since the correct sequence of automatic operation of all radiobeacon equipment depends on the proper timing of the primary clocks, frequent time signal checks should be made and the clocks adjusted as necessary.

(1) To obtain the correct time (time tick) for the accurate setting of primary clocks, proceed as follows:

Using the R–115, or sequel receiver, tune in radio station WWV, Washington, D. C. This is the Bureau of Standards radio station which continuously transmits the correct time to the exact second. Station WWV may be received on the following frequencies: 2.5, 5, 10, and 15 megacycles. Station WWVH, established in Hawaii, broadcasts on 5, 10, and 15 megacycles.

(2) *How recognized.*—The time signals are recognized by the steady clock beat at one second intervals. The fifty-ninth-second beat is eliminated however, as a means of distinguishing the end of each minute. Time announcements are given at 5 minute intervals by voice, in Eastern Standard Time, and by code in the Universal Time 24-hour system. The standard 440-cycle audio transmissions alternate with a 600-cycle tone, which is broadcast for 4 minutes beginning on the hour, and every 10 minutes thereafter.

(3) *Steady tone.*—When WWV is tuned in at any time during the first 4 minutes of an interval, either the 440-cycle or the 600-cycle tone will be heard. The tones are in the nature of a steady hum, interposed by a clock tick or beat. This tone will stop at the end of the 4th minute. During the 4th minute no tone will be heard, but at the start of the fifth minute a new tone will begin, after a vocal

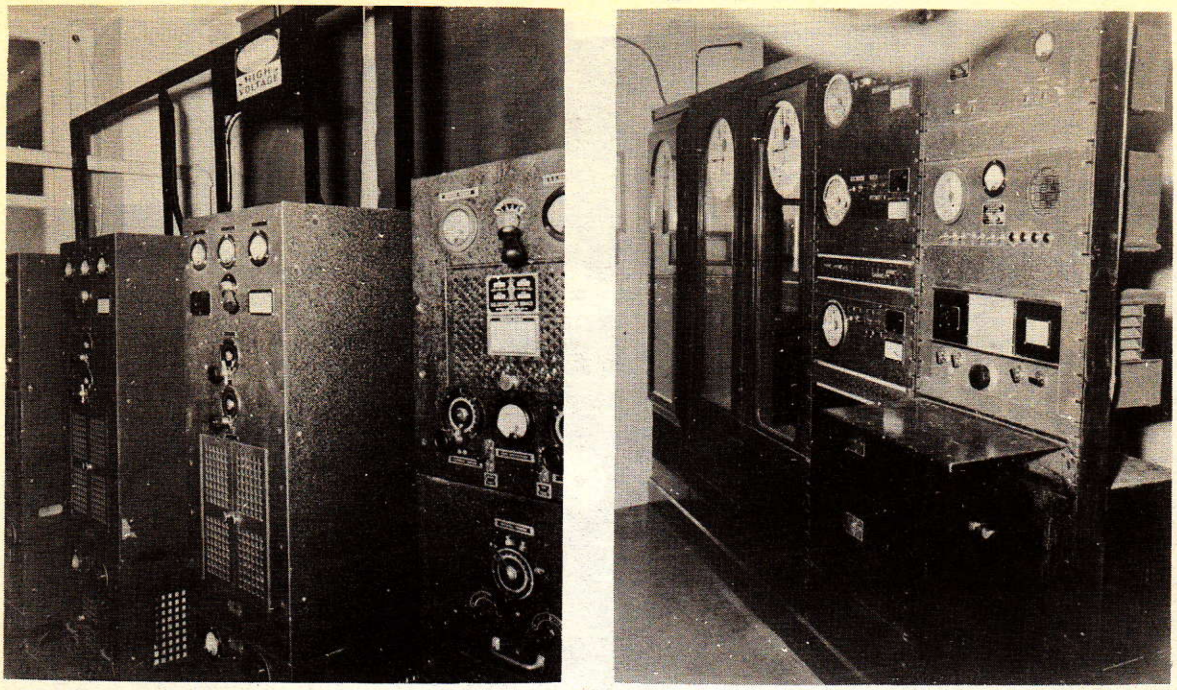


FIGURE 26–8.—The line-up of equipment at the class A radiobeacon at Cape Henry Light Station, Virginia. Transmitters are located on the left, timing equipment on the right.

announcement. In other words, the 440-cycle tone will be heard during 4 minutes of one 5-minute time interval, then the 660-cycle tone, during the succeeding tone interval, alternating around the clock.

(4) *How often.*—Time ticks should be taken and clocks checked at least once every 6 hours, for accuracy.

C. *Another source of radio time signals* is the United States Naval Radio Station NSS located at Annapolis, Md.

(1) The transmission of signals begins at 55 minutes 0 seconds of every even hour (E. S. T.) and continues for 5 minutes. Signals are transmitted on every second during that time, except that there is no signal on the 29th second of any minute, nor on certain seconds at the ends of the minutes, as shown in the following diagram:

Minute	Second										
	50	51	52	53	54	55	56	57	58	59	60
55	—	—	—	—	—	—	----	----	----	----	—
56	—	—	----	—	—	—	----	----	----	----	—
57	—	—	—	----	—	—	----	----	----	----	—
58	—	—	—	—	----	—	----	----	----	----	—
59	—	----	----	----	----	----	----	----	----	----	—

The dashes in the above diagram indicate seconds on which signals are transmitted. The seconds marked "60" are the zero seconds of the following minutes. All seconds from 0 to 50, inclusive, are transmitted except the 29th second, as explained above. The dash on the beginning of the hour (shown as 59 minutes 60 seconds above) is much longer than the others (i. e., 1.3 seconds). In all cases the beginnings of the dashes indicate the beginnings of the seconds, and the ends of the dashes are without significance.

It will be noted that the number of dashes sounded in the group at the end of any minute indicates the number of minutes of the signal yet to be sent.

(2) *Hours of Transmission.*—For 5 minutes immediately preceding each even hour (Eastern Standard Time) (average error is less than 0.01 second).

Frequencies.—122 kc., 4390 kc., 9425 kc., 12630 kc. and 17000 kc. (A1 emission).

(3) *Repetitions.*—In the event of a failure or an error occurring in any of the time signals another time signal will be transmitted one hour later on the same frequency.

26–2–15 Beacon Coder—

A. The heart of the control system of the radiobeacon station is the mechanism. The beacon coder is a mechanical device having a series of cams accurately rotated with respect to standard time. The cams actuate contacts to which are connected the various circuits of the radiobeacon and auxiliary equipment, controlling them in desired sequence and at predetermined intervals accurately based on standard time.

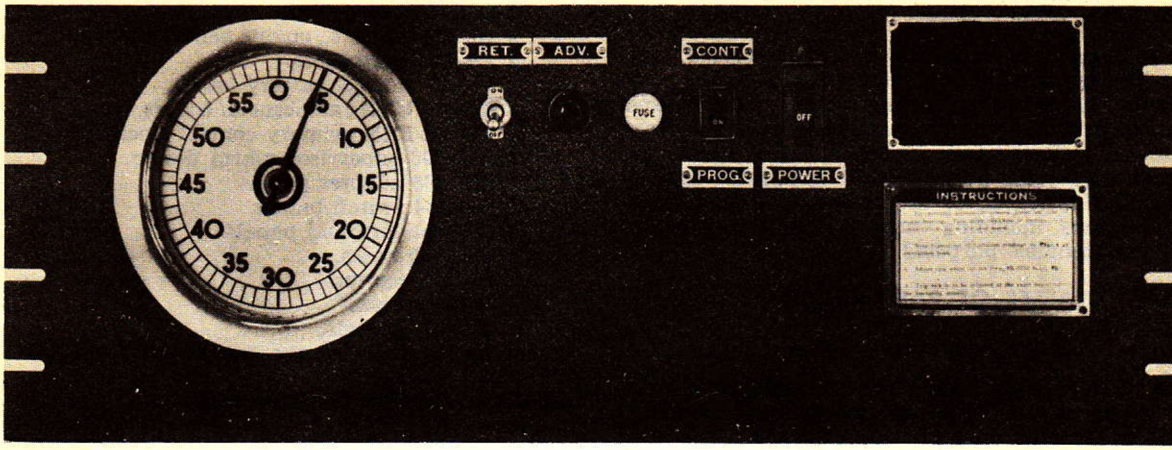


FIGURE 26–9.—Beacon Coder (front view).

B. *Use of coders.*—The coders are used at shore stations and on lightships not only for controlling the program characteristics of radiobeacons but, in addition, for coordinating the timing of lights, sound fog signals, engine generator starting, and warning signals with the radiobeacon signals. The mechanism of the coder consists principally of three sets of cam-actuated contacts which can be set up to control the various timed functions in the desired sequence.

C. *Synchronizing control* over the coder is exercised by a primary clock by means of a pair of contacts which the clock closes for a brief period each minute. Inasmuch as the primary clocks at all radiobeacon stations are kept accurately set to standard time, the transmission schedules of a group of adjacent radiobeacons can be arranged to avoid simultaneous transmissions that would cause interference.

26–2–20 Supervisor and Alarm Unit—

A. In order to insure reliable service from the radiobeacon, an automatic warning device is used in the station which rings a bell whenever the transmitted signal is interrupted, out of time, or seriously impaired in strength or modulation. Aural reception of the radiobeacon signal is also provided for monitoring purposes. The unit, known as the radiobeacon supervisor and alarm, consists of a radio receiver fed from a short antenna of sufficient length to pick up the radiobeacon signal, a clock which drives cam-operated contacts, and various rectifiers, relays, resistors, etc., which serve to operate a spring-wound warning bell under contingencies noted above. A loud-speaker and an output meter provide the operator with data on the radiobeacon signal.

26–2–25 Power Supply—

A. *Type of power.*—For radiobeacons at lighthouses, commercial current is used when it is available, and on lightships current from the electric power installation is used. Local conditions determine whether direct-current generators with rotary converters or alternating-current generators are used. To provide against interruption of service owing to power or line failure, a duplicate source of power is provided; in the case of the use of commercial current, the reserve is an engine-driven electric generator. Storage batteries are also used on many ship stations and confined land stations where the storage of gasoline would constitute a hazard. Where radiobeacons are operated on a frequent time schedule, such as hourly periods, this is accomplished automatically. Such stations are now in effective service, using commercial power, or automatic engine generators with or without storage batteries.

B. *Control for fog operation.*—All radiobeacons are manually controlled as respects starting and stopping of operation during fog.

C. With the increasing use of electric power at light stations and on lightships, it has been found convenient in a number of cases to combine the installation of a radiobeacon with a complete electrification of the station, including the provision of electricity as illuminant for the light, and for the operation of the sound fog signal.

D. For 115-volt d. c. radiobeacon installation, a 54-cell storage battery, two d. c. engine generators, and two rotary converters, are required. If 115-volt a. c. power is available, the only power equipment needed is an auxiliary 115-volt a. c. engine generator, and special rectifiers to provide d. c. power for the radiobeacon timers.

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26–2–30 Accessories—

A. In addition to the major items described, various accessory items are required at a radiobeacon station. Accessories include racks and special panels, carrying switches, terminals, cable adaptors, storage lockers, and shelves. These items are necessary for the proper installation, inter-connection and switching of the radiobeacon equipment. Spare parts, including vacuum tubes, are provided for maintenance purposes.

26–3 CLASSES OF RADIOBEACONS

26–3–1 Class A Radiobeacon—

A. The average class A radiobeacon has a range of 200 nautical miles based on a standard 50 microvolt per meter field at this distance. The field strength at 1 nautical mile required to give a range of 200 nautical miles is 14,000 microvolts per meter. In order to lessen interference, the field strength of radiobeacons is limited to that which is necessary, according to the various purposes of the stations. For the same reason, class A stations are restricted to widely separated points of strategic importance to navigation, which are valuable as landfall stations, or for long distance approach. Special high power class A stations have been placed in operation at Cape Cod, Mass., and Point Arguello, Calif. These radiobeacons, although rated as class A, are provided with special LSR–1101 top-loaded vertical radiators which give a range of approximately 400 nautical miles based on a standard 50 microvolt field. The field strength at 1 nautical mile required to give a range of 400 nautical miles is 74,000 microvolts per meter. Both types of class A radiobeacons utilize duplicate LSR–420–520 or subsequent models TB–142–143 exciter-amplifiers and associated timing equipment.

B. *List of class A equipment.*—A complete list of equipment for a typical class A radiobeacon (see fig. 26–8) at a 115-volt d. c. installation consists of the following:

2 TB–143 amplifiers.
2 TB–142 exciters.
2 LSR–806 converters.
2 10–KW 120 d. c., engine generators.
2 ES–DC controllers.
1 54-cell storage battery bank.
2 KY–76/URN radiobeacon coders.
3 TD–66/FRN primary control clocks.
1 MT–196 supervisor alarm device.
2 MP–185 adapter panels.
2 MP–184 switch panels.
4 MP–181 terminal panels.
5 MR–180 racks.
1 R–116 receiver.
1 radio analyzer.
4 HST–4 crystals.

Tubes as required for the equipment furnished.

26–3–5 Class B Radiobeacon—

A. A class B radiobeacon omits the LSR–520 or TB–143 power amplifier used at a class A station, but in other respects the two classes require identical equipment, allowing for differences in vacuum tubes and power supply. The advertised range for a class B radiobeacon is from 50 to 150 nautical miles, or an average range of 100 nautical miles. The calculated field strength to give this average range is 5200 microvolts per meter at one nautical mile.

B. *List of class B equipment.*—A complete list of equipment for a typical class B radiobeacon (see fig. 26–7) at a 115-volt d. c. installation consists of the following:

2 TB–142 transmitters.
2 G–120 converters.
2 5–KW 120 volt d. c. engine generators.
2 ES–DC controllers.
1 54-cell storage battery bank.
2 KY–76/URN radiobeacon coders.
3 TD–66/FRN primary control clocks.
1 MT–196 supervisor alarm device.
2 MP–185 adapter panels.
2 MP–184 switch panels.
4 MP–181 terminal panels.
5 MR–180 racks.
1 R–115 receiver.
1 radio analyzer.
4 HST–4 crystals.

Tubes as required for the equipment furnished.

26–3–10 Class C Radiobeacon—

A class C radiobeacon normally utilizes duplicate TB–107 or ERN/18 transmitters (see fig. 26–15) but otherwise the equipment required is identical to that for a class A station, making allowance for tubes and power supply. The advertised average range for a class C radiobeacon is 20 nautical miles. The calculated field strength to give this range is 1000 microvolts per meter at one nautical mile. Due to the cotninual expansion of the radiobeacon system, particularly in areas of considerable marine traffic, it has been necessary to use tone variation to make certain radiobeacons especially distinctive. A number of class C radiobeacons on lightships in Vineyard and Long Island Sounds have varying tones in addition to the identifying characteristics. Since these signals are of short range, it is important that they be identified quickly as a warning of approach to a lightship; and the varying tone signal serves this purpose. A similar tone variation was formerly employed in a special low-powered "warning radiobeacon" of short range which supplemented the main radiobeacon on Nantucket Shoals Lightship. The "warning radiobeacon" warned approaching vessels of proximity to the lightship.

B. *List of class C equipment.*—A complete list of equipment for a typical class C radiobeacon at a 115-volt d. c. installation consists of the following:

2 AN/FRN–18 transmitters.
2 LSR–803A converters.
2 KW 120-volt d. c. engine generators.
2 ES–DC controllers.
1 54-cell storage battery bank.
2 KY–76/URN radiobeacon coders.
3 TD–66/FRN primary control clocks.
1 MY–196 supervisor alarm device.
2 MP–185 adaptor panels.
2 MP–184 switch panels.
4 MP–181 terminal panels.
5 MR–180 racks.
1 R–115 receiver.
1 radio analyzer.
4 HST–4 crystals.

Tubes as required for the equipment furnished.

NOTE.—See note at end of paragraph 26–3–1 (B) above.

26–3–15 Class D Radiobeacon—

A. Since there are many harbor entrances and channels where careful approach is required and where it is not practicable to establish the large structures to house the power sound-in-air signal equipment which would supplement existing radiobeacons, the Coast Guard has for several years been using automatic low power, and small battery-operated, radiobeacons which are located on pierheads, piling structures, and even on buoys. A number of such radiobeacons are now in use and are termed "marker radiobeacons." They are not intended for long range accurate bearings but serve rather as local marks to indicate channel entrances, turning points, and pierheads. Marker radiobeacons operate continuously in all weather, and since they have a characteristic of several dashes during each 30-second period they are not synchronized with other radio beacons.

B. *List of class D equipment.*—A complete list of equipment for a typical class D radiobeacon (see fig. 26–10) buoy or battery-powered installation consists of the following:

2 TB–107–B.
2 MT–190A keyers.
1 MP–84 switch panel.
2 MP–181 terminal panels.
2 MR–180 racks.
4 HST–4 crystals.

Tubes as required for the equipment furnished.

NOTE.—See note at end of paragraph 26–3–1 (B) above.

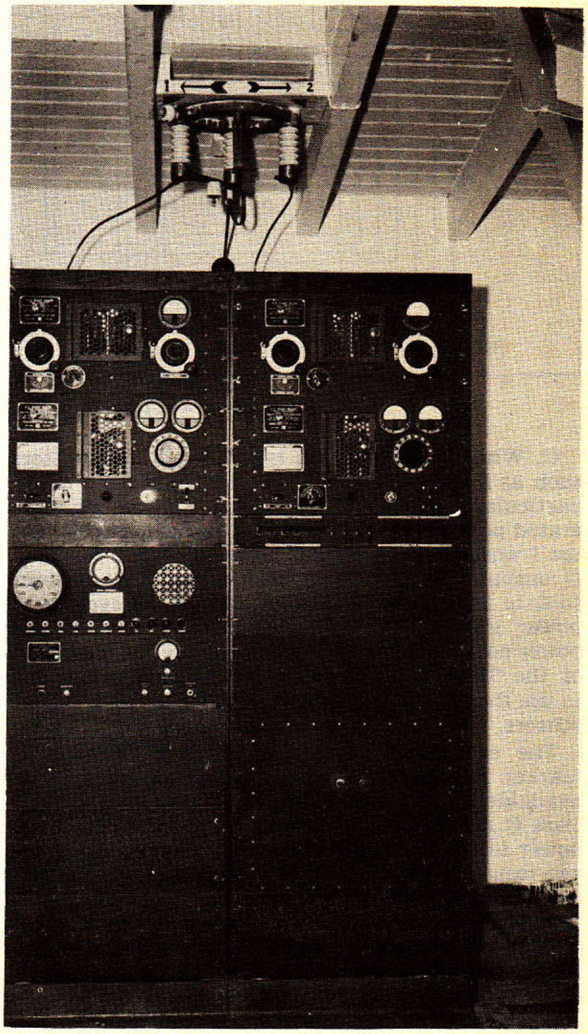


FIGURE 26–10.—Class D radiobeacon located at Point Bonita Light Station, Calif.

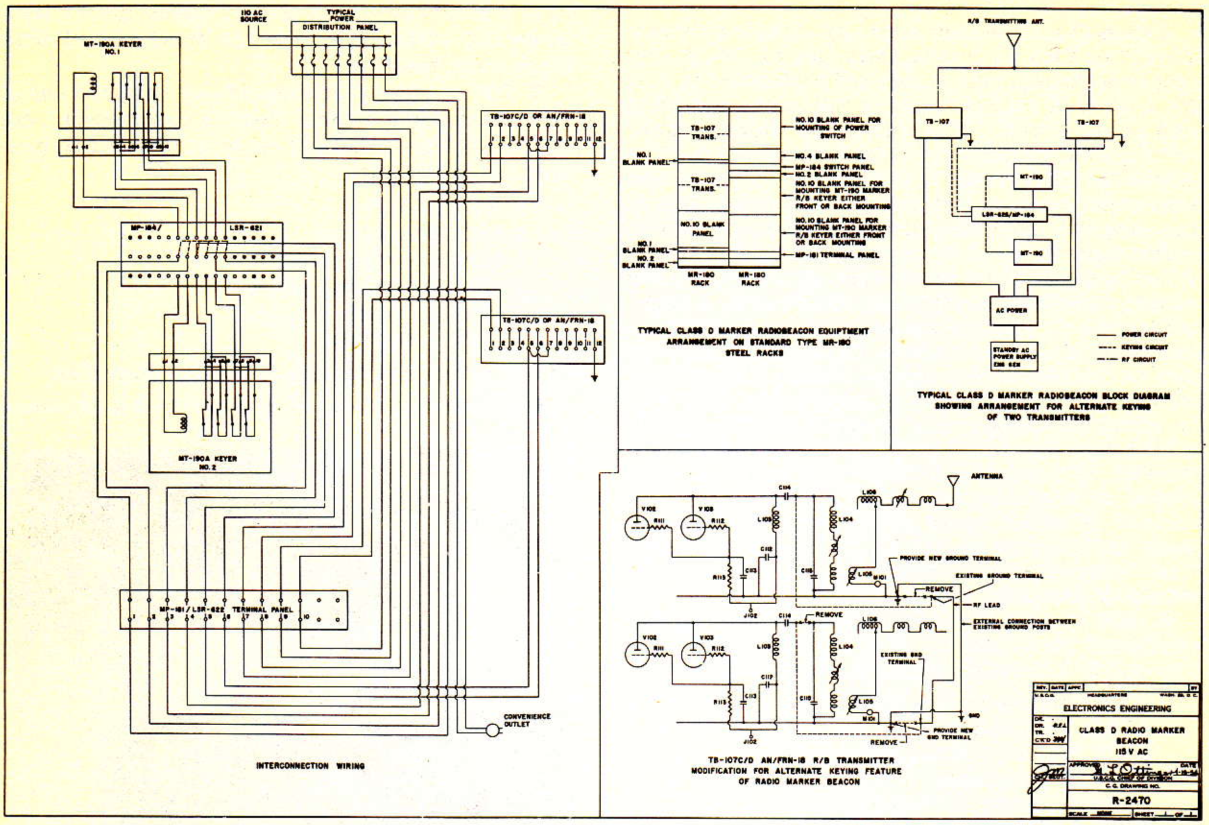


FIGURE 26–11.—Class D radio marker arrangement and wiring.

C. While installations of type TB–113 transmitters such as mentioned above are used in certain cases, particularly on buoys and stations where no generated power is available, it has been the practice to use transmitters of class C power modified for class D output. Most marker radiobeacon installations to date have been at locations where 60-cycle a. c. power is available, and rather than provide the power conversion equipment necessary for operation of the TB–113 transmitter, it has been preferable to use the TB–107 or FRN/18, and later series transmitters, with its associated equipment.

The equipment used in such cases at class D marker radiobeacons, where 115V a. c. or d. c. is available, is in general similar to that installed at class C radiobeacon stations except that the input power to the antenna is reduced to obtain an average range of 10 miles. The desired keying characteristic is provided by a special power-driven keyer, type MT–190, in lieu of the signal timers used at class C or higher powered radiobeacons. Figure 26–10 shows a typical class D marker radiobeacon installation.

D. When class D marker radiobeacon installations are made on pierheads and piling structures, the type of antenna varies with the type of antenna structure and available space. The majority of existing class D stations utilize vertical "spike" antennas approximately 35 feet high. Where space is available, wire antennas with associated tuning and coupling units are sometimes used.

E. A complete list of equipment for a typical class D radiobeacon at a 115-volt a. c. installation, as outlined in paragraph 26–3–10 (C) above, consists of the following:

- 2 TB–107 or FRN/18 transmitters.
- 2 MT–190 keyers.
- 1 LSR–621 switch panel.
- 1 LSR–626 tube locker.
- 2 LSR–622 terminal panels.
- 2 LSR–623 racks and miscellaneous blank panels.
- 4 HST–4 crystals.
- 20 807 tubes.
- 10 523 tubes.
- 1 Navy-type CGR–66047 35-foot vertical antenna.
- 1 Navy-type 61350 base insulator (or other appropriate type antenna).

26–3–20 Miscellaneous Notes—

A. All the above transmitters are designed for 115-volt 60-cycle alternating current operation (except for the class "D" buoy installation which is battery operated). Suitable capacity converters are used where direct current is the power source. They are designed for operation at any frequency in the assigned radiobeacon band. Frequency of operation is held within a tolerance of one-tenth of one percent by the use of a crystal controlled oscillator in each transmitter. Duplicate crystals are installed in each transmitter and may be switched instantaneously in case of failure.

26–4 INSTRUCTION BOOKS

26–4–1 General—

A. All major radiobeacon equipment is complete with instruction books, i. e., primary clocks, timers, transmitters, receivers and alarm units, power supply units, etc., all have their individual instruction books which completely describe the principles or theory of operation, and installation, operation, and maintenance instructions. Lists of parts are also included to facilitate the procurement of spares.

B. All instruction books now being supplied are of the standard joint Army-Navy type (JAN) in which all information is outlined in a standard form to facilitate their use. Instruction books previously furnished, while containing all necessary information, are arranged in a different style.

C. *It is imperative that all personnel concerned with the operation or maintenance of radiobeacon equipment be thoroughly familiar with the arrangement of information in the respective instruction book* in order to maintain the highest degree of integrity of radiobeacon operation, and to effect repairs as expeditiously as possible. A full understanding of the equipment in use is possible only by frequent and thorough study of the respective instruction book. The assembly or arrangement of the present JAN instruction books (as described below) facilitates this study and reference.

D. Instruction books shall always be maintained readily accessible at the unit. Any unit not having a complete set of instruction books will request same through proper channels.

E. Corrections and amendments may be issued from time to time to JAN instruction books. Officers-in-charge of radiobeacon-equipped units will promptly enter such corrections and amendments in their respective instruction books.

26–4–5 Specific Contents of JAN Instruction Books—

A. In order to facilitate and encourage the extensive use of instruction books for radiobeacon equipment, this section is devoted to describing the contents of the standard JAN-type instruction book. Although the paragraphs below are devoted to one specific book describing one particular piece of equipment, the similarity of arrangement of all JAN-type books is such that any desired information can readily be found once the format of the instruction book is understood. As stated above, the older-type instruction books contain approximately the same information; however, it is arranged in a different form.

B. The JAN instruction book for Radiobeacon Transmitter Coast Guard Type TB–142 will be described. The instruction book consists basically of the following:

Front matter.
Section 1. General description.
Section 2. Theory of operation.
Section 3. Installation.
Section 4. Operation.
Section 5. Operator's maintenance.
Section 6. Preventive maintenance.
Section 7. Corrective maintenance.
Section 8. Parts list.
Index.

The book is of the loose-leaf type.

C. *The Front Matter* referred to above consists of: cover, title page, list of effective pages, correction page, table of contents, list of illustrations, list of tables, contractual guarantee, installation record, report of failure, ordering parts, destruction notice, safety notice, resuscitation.

(1) *The list of effective pages and record of corrections* are most important if the book is to be kept up to date. Enter all corrections promptly and record them on the appropriate page.

(2) *The table of contents* gives a complete breakdown of the subject matter for each section. For example, section 2, Theory of Operation, is broken down into the following:

General.
Oscillator stage.
Buffer-amplifier.
Power-amplifier.
Audio-oscillator.
Audio preamplifier and phase inverter.
Push-pull AF driver.
Modulator.
Modulator plate supply, etc.

(3) *The list of illustrations, list of tables and contractual guarantee* are self-explanatory. *The installation record* should be filled out at the time of installation.

(4) *The ordering parts* instructions should be carefully followed when pertinent. Lack of information delays procurement.

(5) *The destruction notice* is self-explanatory.

(6) *The safety notice* shall be carefully studied and the precautions listed therein must be observed. There is no possible justification for disregard of safety in connection with radiobeacon equipment. Safety or caution notes will be found included throughout the text of the book.

(7) *Resuscitation.*—All personnel shall familiarize themselves with the latest approved method of resuscitation as adopted by the Coast Guard.

D. *Section 1, General Description.*—The first section of the instruction book includes all the basic information required to give a general picture of the equipment. A full-page photograph or detailed drawing of the complete equipment, illustrating the relative size of each unit and how they fit together functionally, is included. Each unit is identified by name. A brief description of the equipment as a whole is given, stating its purpose and basic principles of operation. Detailed theory of operation is given in another section. Each major unit is described and illustrated so as to impart a general understanding of the unit's physical characteristics and function in the equipment as a whole. Complete reference data are listed as to nomenclature of all equipment involved, contractor, shipping data, frequency and other electronic specification data. Tables are given listing equipment supplied and equipment required, but not supplied on the contract. A brief table or description is also given listing the basic similarities and/or differences between various equipments of the same equipment series. A statement is included to indicate the extent to which the book may be used in describing the installation, operation, and maintenance of the other equipments of the series.

E. *Theory of Operation.*—This section consists of a detailed description and discussion of the electrical theory of operation and mechanical functioning of the entire equipment. Elementary electrical theory and descriptions of the physical construction and operation of ordinary vacuum tubes, motors, generators, or circuits which are covered in basic radio, radar, or sonar courses are not covered in detail. However, all circuits which are not generally understood, unusual or new circuit arrangements, special types of vacuum tubes not widely employed, special methods or complicated mechanical features shall be clearly explained using sketches, photographs, and drawings to supplement text. In the general description of circuits, an over-all functional block diagram to show the relationships of the various circuits comprising the system is included. An analysis of each circuit of the equipment is given. Conventional radio circuits are covered briefly, but special circuits are explained in detail using simplified schematics and other diagrams to aid their understanding. The theory of any new or complicated test procedures is given. Appropriate illustrations and schematics are shown.

F. *Installation.*—This section contains all explanations and diagrams necessary to enable technicians to install each unit in place with proper relation to other units and put the equipment in proper operating condition. Special unpacking instructions are given when necessary. Descriptive matter of installation is clarified by detail photographs and drawings. Initial adjustments following installation and necessary prior to operation are given along with applicable drawings and illustrations.

G. *Operation.*—This section outlines the operation procedure and is written entirely for the operator. Adjustments which should be made only by technical personnel are included in the appropriate maintenance section. Reference to controls and adjustments are made by the control designation or illustration reference symbols provided, and are confined to those controls normally required for use during operation. Instructions are complete and in logical sequence. Where provisions exist for local or remote operation of the equipment, operating instructions are complete under each type of control stations. The introductory paragraph states the basic principles of operation from the operator's point of view. Illustrations of control panels are shown with the normal sequence of operations indicated. Capabilities and limitations of the units and the precaution to be observed during operation are stated, along with warnings necessary to prevent faulty use or misinterpretation of readings or other results obtained from the operation of the equipment. A description is included of how to operate the equipment in order to accomplish each function for which the equipment was designed. Mention is made of those controls readily available to the operator which should be used only by technical personnel. Included also is a complete list of tuning adjustments (also shown diagrammatically) which are to be made by the operator. The operation is summarized in proper sequence of using the controls.

H. *Operators' Maintenance.*—This section contains information on such maintenance procedures as can be performed by a nontechnical operator. Routine check charts of normal operation covering items to be checked hourly and/or at the beginning of each watch are shown. A subsection is included on emergency maintenance and describes the replacement of tubes, fuses, etc.

I. *Preventive Maintenance.*—This section contains all maintenance procedures and adjustments which should be performed periodically for the purpose of preventing failure or impairment of the equipment. Included are routine maintenance check charts showing what to check, when, how and the precautions to be observed.

J. *Corrective Maintenance.*—This section includes all information necessary to permit a technician to locate trouble and to make repairs or the necessary adjustments to the equipment. The section is amply illustrated and includes data on all adjustments, alignments, calibration, and test methods required to get maximum performance from each unit of the equipment. Trouble-shooting charts, a servicing block diagram and a system or unit schematic diagram are shown, along with photographs of units with parts clearly labeled.

K. *Parts Lists.*—This section contains the following tables of information:

- Weights and dimensions of spare parts boxes.
- Shipping weights and dimensions of spare parts boxes.
- List of major units.
- Combined parts and spare parts list.
- Cross reference parts list.
- Color codes and miscellaneous data.
- List of manufacturers.

26–5 INSTALLATION OF EQUIPMENT

26–5–1 General—

A. *Initial checks.*—As soon as radiobeacon transmitting and timing equipment is unpacked, all covers and outside shielding plates should be removed and the units carefully examined to ascertain that no damage has been sustained to any of the parts or wiring during transportation. All controls and switches should be checked for smooth operation. The rotary converters should be carefully examined, turning the shaft of each by hand to see that it turns freely, and seeing that the brushes slide freely in the holders. The nameplate data should be checked to make certain that the rating is correct for the available power supply. The starter unit should be inspected to assure that all of the parts work freely, nuts and screws are tight, and terminals and current-carrying parts are clean and making good contact.

B. *Space allowance.*—The instruction books for each item of equipment will give dimensions, conduit location, etc., which will permit each unit to be installed properly. Care should be taken to allow as much room as possible for removal of the rear shields from the radiobeacon transmitter units. The location for rotary converters and associated starters should be clean, dry, and well ventilated. Sufficient space should be allowed on all sides to facilitate inspection and servicing of the converters. The converters should be mounted on a perfectly level plane at land station installations. When installed on shipboard they should be mounted with shaft fore-and-aft and parallel with load water line. This precaution is necessary to eliminate as much as possible a continual end thrust on bearings, which shortens operating life.

26–5–5 Precautions—

A. After the equipment has been properly and permanently located, the power and control wiring should be put in place. The interconnection diagrams applying to the particular installation should be followed carefully both as to connections and size of wire to be used. *Before making any connections, be certain that all of the lines to be handled are electrically dead.*

B. Connect leads according to the diagrams in the instruction books, making connections to the power leads last. The operator should become familiar with the wiring diagram and various adjustments for each unit before attempting to operate the equipment. All transmitters utilize voltages in practically all portions of the equipment which might be fatal to the operator should he come in contact with them. Safety interlocks have been placed on all doors to protect careless persons or those not cognizant of the dangers in apparatus. No interlock protection is usually provided on side panels as these are normally semipermanently screwed in place. *These panels must never be removed while power is on, except by radio personnel.*

C. When adjustments are made by radio personnel, they should be made in the presence of another

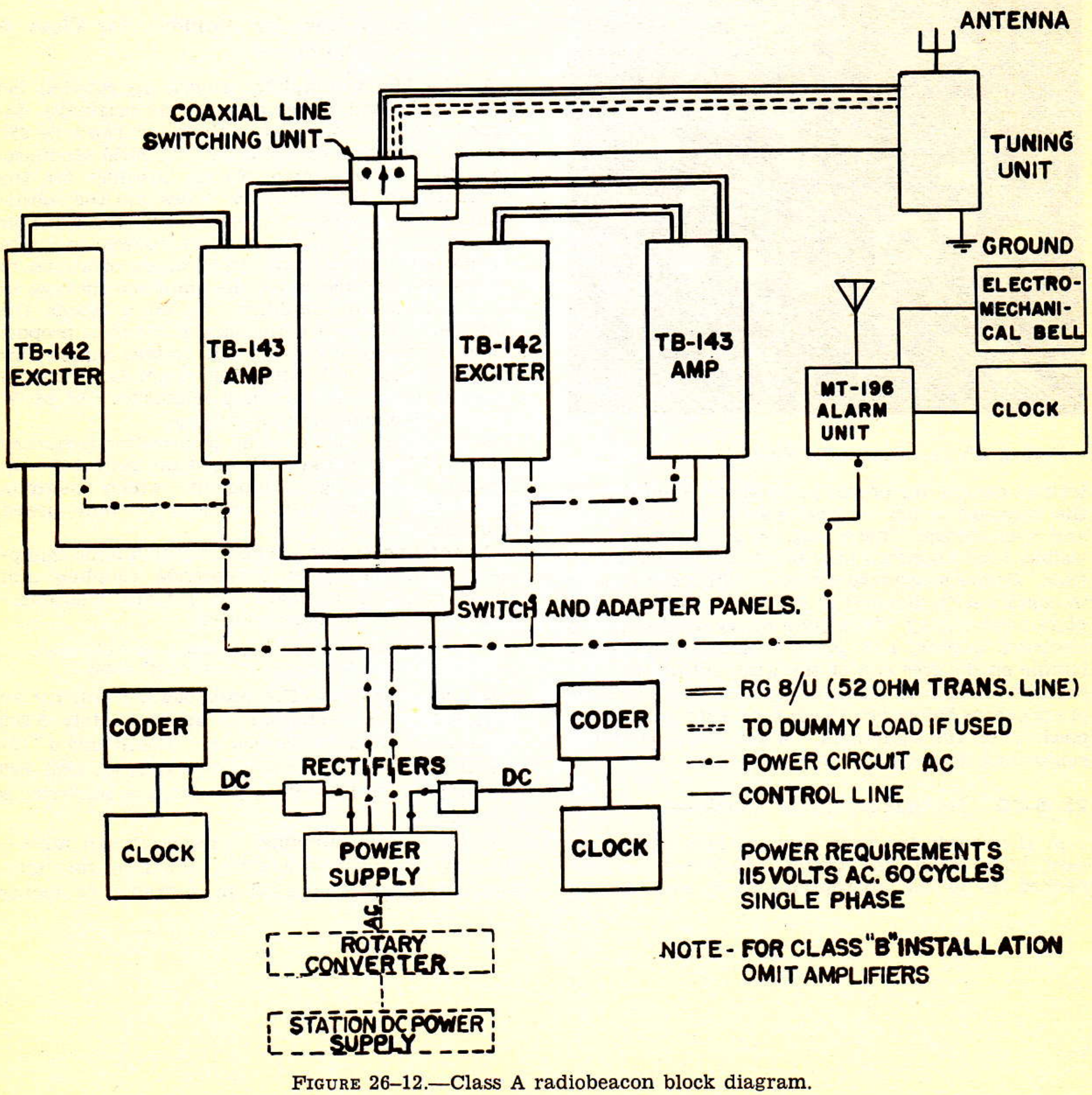


FIGURE 26–12.—Class A radiobeacon block diagram.

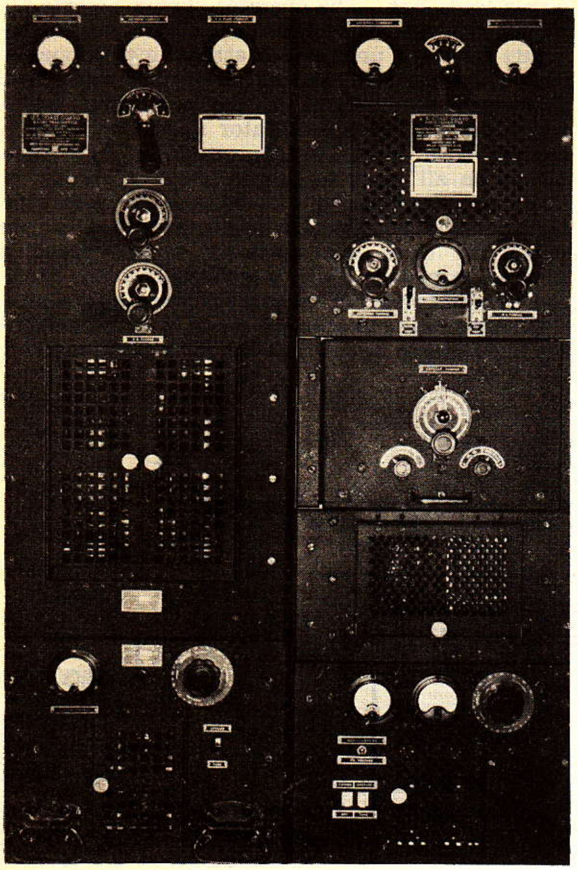


FIGURE 26–13.—Complete class A transmitter.

trained person, for proper protection. Even though the transmitter key or keying relay may be open, and even though there may be no plate current visible, tube filaments may be at dangerous potentials. *Before measuring filament voltages or coming in contact with filament or any other leads, be sure plate voltage is off.* Connect a heavy wire to a good electrical ground, and place a suitable insulating handle on the free end of the wire, letting the wire protude. Touch this grounding wire to every piece of apparatus before you touch it or work on it, when power is off the equipment. *When power is on the equipment, do not touch any inside part.*

25–5–10 Preliminary Timer Checks—

A. It is suggested that, prior to making permanent installation, the timing equipment be first hooked up to the appropriate power source, and after the time cams and program contacts are set up and adjusted, the coders should be run in order to check the operation of various control circuits, motor speed, etc. At the same time, all parts should be cleaned and lubricated in accordance with the instruction book, and the operating personnel should familiarize themselves with the various functions of the equipment.

26–6 SPECIFIC DESCRIPTIONS OF RADIO-BEACON EQUIPMENT

NOTE.—In view of the fact that improvement of equipment is constantly being made, and name plates and identifying designators are being changed from time to time, the term "or sequel" is used throughout this chapter to mean subsequently developed models of the particular equipment under discussion.

26–6–1 High-Powered Amplifier for Class A Operation—

A. The TB–143 Amplifier is normally rated at 750 watts modulated power output. As originally designed it may be operated with one or two type 851 tubes for one-half or full power. A Field Modification Kit, (Field Change No. 2) provides for the elimination of the 2 type 851 tubes and the substitution of four type 450–TL tubes. Two, three or four type 450–TL tubes may be used as required to obtain the desired power output. In all cases, regardless of the number of tubes used, the amplifier operates as a class B linear amplifier. In other words the amplifier develops a power output which is proportional to the square of the grid voltage supplied by the exciter unit. The amplifier is intended primarily for radio-beacon use, but may be used for CW, MCW or radiotelephone communications.

B. *Frequency range.*—The transmitter frequency range is 275 to 510 kc. All units are provided with frequency-changing equipment which permits reasonably rapid setting to any of four preset frequencies.

C. *Antenna tuning.*—The antenna tuning equipment in the amplifier or antenna coupling unit allows proper adjustment for antenna characteristics within the following limits:

Antenna capacitance________	0.0004 to 0.001 mfd.
Antenna resistance__________	10 to 35 ohms.

D. *Power supply.*—The peak power drain for an LSR–420–520 combination is approximately 5,800 watts on 110 volts 60 cycles a. c. Where only a 115-volt d. c. source of power is available, an LSR–806 115-volt d. c. to 115-volt a. c. kva rotary converter is required.

E. *Size.*—Each amplifier consists of two units—the power supply unit and the radio frequency unit. Both units are contained in a frame 63 inches high, 25 inches deep, and 18 inches wide. Access to both units may be had from both front and back.

F. *For class A operation* it is necessary to add a medium-powered transmitter (such as the LSR–420, TB–142, or sequel) to serve as an exciter to drive the amplifier described above.

26–6–5 Medium-Power Transmitter for Class A and B Operation—

A. See paragraph 26–6–1 (F) above when this equipment is used for class A operation.

B. This (LSR–420, TB–142, or sequel) transmitter is nominally rated at 150 watts output fully modulated. It is capable of operating with one, two, or three tubes in the power amplifier stage, giving power outputs of approximately one-third, two-thirds, and full power respectively. (See typical operation sheets in instruction book.) At class A stations the transmitter is used as an exciter for the amplifier, and at class B stations it is coupled to the antenna. This transmitter is intended primarily for radiobeacon use, but provision has been made for radiotelegraph communication using CW or MCW signals.

C. *Modified Types.*—The LSR–420–G and 420–H transmitters differ from each other in minor details mechanically and electrically. Their power output capabilities are equal. The latest model (TB–142) contains improvements in design, circuitry and material. The tube complement is also changed.

D. *Frequency range.*—The frequency range of all transmitter types is 275 to 510 kc. All units are provided with frequency-changing equipment which permits reasonably quick setting to any of four preset frequencies. All four frequencies may be crystal-controlled, using a T–4 crystal for each frequency. Noncrystal control can also be used.

E. *Antenna tuning.*—The antenna tuning equipment in the transmitters or antenna coupling unit allows proper adjustment for any antenna having characteristics within the following limits:

Antenna capacitance	0.0004 to 0.001 mfd.
Antenna resistance	10 to 35 ohms.

F. *Power supply.*—The peak power drain is approximately 1800 watts on 110 volts 60 cycles a. c. Where only a 115-volt d. c. source of power is available, an LSR–807 115-volt d. c. to 115-volt a. c. 2 kva rotary converter is required.

G. *Mechanical data.*—The transmitters are constructed in a frame 59 inches high, 24 inches deep, and 18 inches wide. The frame is supported on legs, bringing the over-all height to 63 inches. The weight of the LSR–420 unit is approximately 900 pounds. The main power supply, audio amplifier and control panel, crystal box, and power amplifier shelf are separately removable units. If spare units are available, operating personnel may insert them in place of defective units, allowing repairs to be made at a district repair shop, thereby reducing the difficulties and cost of field maintenance. Relays, fuses, and other components are conveniently located and can be inspected, adjusted, or replaced with a minimum of effort.

FIGURE 26–14.—Class B.

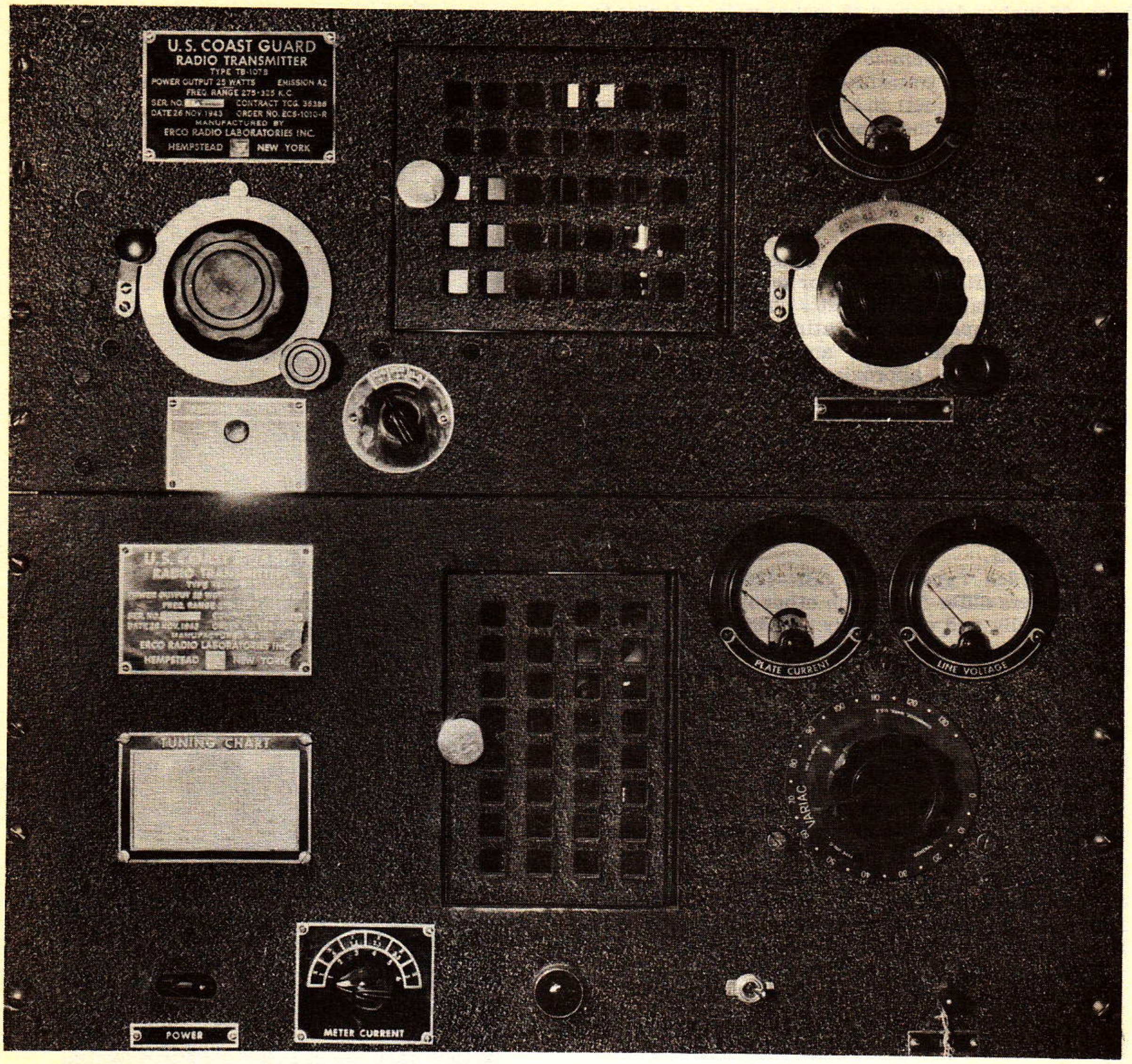


FIGURE 26–15.—Class C transmitter.

26–6–10 Low-power Transmitter for Class C Operation—

A. This (TB–107, FRN/18 or sequel) radiobeacon transmitter has a modulated output of 25 watts. (Operating and maintenance data will be found in the instruction books.)

B. *Modified types.*—The TB–107 series transmitters (TB–107–107A–107B) vary from each other only in minor mechanical and electrical details; the tube complements are identical. The new FRN/18 is also similar.

C. *Frequency ranges.*—The frequency range of all types is 275 to 325 kc. The transmitter is crystal controlled, with provisions for mounting two T–4 crystals, one of which is spare. Noncrystal control can also be used. The modulating audio frequency is variable in four steps, as follows: 750, 900, 1000, and 1150 cycles per second. These are selected by timer cams to give any desired combination for tone variation at class C stations. For single tone use, 1000 cycles is usually selected.

D. *Antenna tuning.*—The antenna loading variometer has five taps for matching any antenna having characteristics within the following limits:

Antenna capacitance	0.0004 to 0.001 mfd.
Antenna resistance	10 to 35 ohms.

E. *Power supply.*—The power requirement is approximately 400 watts on 110 volts 60 cycles a. c. Where only a 115-volt d. c. source of power is available, an LSR–803A rotary converter is required.

F. *Mechanical data.*—The complete transmitter consists of two units having the following over-all dimensions when mounted on an LSR–623 rack: 16½ inches deep, 21½ inches wide, 22¾ inches high.

26–6–15 Marker Radiobeacon Transmitter for Class D Operation—

A. The TB–107, FRN/18, or sequel can be reduced in power for class D operation, and is generally used where commercial- or station-generated power is available. A special type commercial power-operated keyer or coding device is used.

B. The TB–113 equipment is specially constructed to allow installation in a buoy pocket designed to take A–300 acetylene cylinders although it may be installed on other types of aids where battery power is the only type available. It consists of dual identical transmitters in a single frame, each complete in itself except for the use of a common final amplifier tank circuit. Each transmitter comprises a dual high-voltage vibrator-type power pack, an audio tone-generating modulator, a crystal-controlled oscillator, and an r-f amplifier, the latter working into the common final tank circuit. The transmitters are operated alternately at intervals by the MT–121 flasher mechanism so that failure of one transmitter results only in longer-than-normal periods of silence between transmissions. The nominal power output is 5 watts and the effective range is 5 to 15 miles, depending on the antenna system. Operation is unattended except for necessary battery recharging. For adjusting or testing the equipment, a metering set is provided having a cable with polarized plug for connection to sockets on each transmitter section. (Detailed data will be found in the instruction books for TB–113 series transmitting equipment.)

C. *Modified types.*—The TB–113 series transmitters (TB–113–113A–113B–113C–113D) vary only slightly from each other in mechanical and electrical details, and the tube complements are identical.

D. *Frequency range.*—The frequency range is 280 to 324 kc. Each transmitter section uses a T–4 crystal to control the frequency. The modulation frequency is 1000 cycles per second.

E. *MR–118 antenna system.*—The output circuit is arranged to match a concentric transmission line having a surge impedance of 65 to 85 ohms. The antenna originally used on buoys consisted of a 15-foot welder monel tripod mast. This was mounted on a waterproof welded aluminum alloy housing containing a tuning unit. The latter consisted of coupling condenser, coils, and r-f ammeter to allow the antenna to be properly matched to the 73-ohm transmission line. This antenna system was designated MR–118. (See par. 26–7–25 (B) for other type antenna also used with this transmitter.)

F. *Power supply.*—One or more 7-cell banks of low-discharge type storage batteries are required to power the TB–113 equipment. The over-all power drain is about 900 ampere-hours per month; the transmitter alone draws about 6 amperes at 14.2 volts while being keyed. The equipment will operate on as low as 12.4 volts. Sufficient battery capacity should be provided to allow operation over the desired period between recharges.

G. *Construction.*—The transmitter is constructed on a welder frame chassis, which is shock-mounted in a 10-gage steel cylindrical can 23 inches in diameter and 36 inches high over-all. The total weight is 257 pounds. The metering set consists of 4 milliammeters mounted in a portable metal case and equipped with cable and plug.

H. *MT–121 flasher.*—The MT–121 flasher required for the TB–113 equipment is similar to flashers used to control buoy light characteristics, but has additional cam-operated contacts to turn on the transmitting equipment at intervals and to key the output according to the specified characteristic. A normal schedule consists of groups of quarter-second dashes for seven or more seconds, followed by a silent period of about the same length of time. The MT–121 flasher is normally mounted in the lantern housing.

I. The stock of TB–113 Transmitters is depleted except for several spares which are on hand for the maintenance of the one remaining radiobeacon of this type.

26–6–20 T–136 Calibration Transmitter—

A. The purpose of this transmitter is to provide a calibration facility for shipboard radio direction finders that can be maintained under continuous operation throughout the desired calibrating time. Either one of two assigned frequencies can be used, one in the radiobeacon band and the remaining one in the vicinity of the international distress frequency of 500 kc. At the present time a frequency of 480 kc. is being used for this latter calibration frequency.

B. *Location.*—The transmitters are located either at light or lifeboat stations as required. They can be operated either locally or from a remote station up to a distance of 20 miles. The latter is accomplished by means of a remote control unit (see fig. 26–16), which is furnished as part of the equipment and may be connected to it for control of the transmitter over a pair of Coast Guard-owned or leased telephone lines.

FIGURE 26–16.—Remote control unit.

C. *Frequencies.*—The transmitter will operate on any one of five frequencies in the range of 200 to 1500 kilocycles, depending upon the crystals installed in either of the five radio frequency units. The proper operating frequencies as required for each particular installation are assigned by Headquarters.

D. *How keyed.*—The transmitter may be keyed either manually by means of an external hand key or automatically, which is accomplished by means of the keyer unit (see fig. 26–17), a part of the equipment. When the latter is used, the transmitter sends out a coded identifying characteristic.

E. *Power supply units.*—Two identical power supply units are installed in the transmitter cabinet. When the equipment is operated, one power supply is used and the other left idle as a reserve in case of emergency. The units are rotated occasionally so that each will get the same amount of usage. The unit in use is selected by the power unit switch located on the panel of the transmitter control unit. The power requirement for operation of the equipment is 115 volts, 60 cycle, single-phase a. c., 1 kva., either from a commercial power source or in some cases from the station d. c. power source through a suitable rotary converter.

F. The modulator unit tone modulates any one of the five radio frequency units that is being used with a 1,000 cycle per seconds (cps) when A–2 emission is selected.

G. *Control of the transmitter,* i. e., turning it on and off, selection of any one of the five frequencies desired, and selection of the type of emission desired, is entirely dependent upon the proper positioning of switches and a telephone dial which are located at both the remote control unit and the transmitter control unit. Both the remote control unit and the transmitter control unit have switches marked A–1 (carrier signal only) and A–2 (tone modulated carrier signal) for selection of the type of emission desired.

The following functions are controlled by the telephone dials which are located at both the transmitter control unit and remote control unit:

Dial 1—Channel No. 1.
Dial 2—Channel No. 2.
Dial 3—Channel No. 3.
Dial 4—Channel No. 4.
Dial 5—Channel No. 5.
Dial 6—Automatic keying—interrupted carrier (A–1) or interrupted tone-modulated carrier (A–2) at station' characteristic. (The type of emission is dependent upon the positioning of the A–1 or A–2 emission selector switch.)

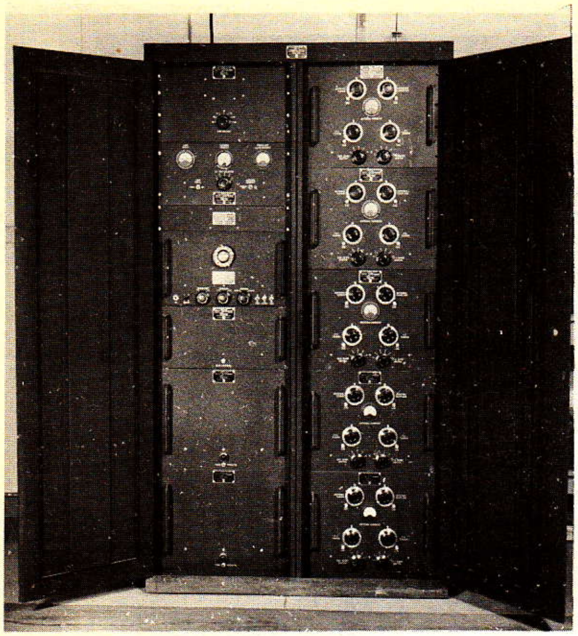


FIGURE 26–17.—T–136 calibration transmitter.

Dial 7—Automatic keying—continuous carrier (A–1) with the tone signal superimposed on the carrier signal at the station's characteristic code when the emission selector switch is in the A–2 position. (NOTE.—The emission selector switch should not be in the A–1 position, as this does not represent a normal operating condition.)

Dial 8—Manual keying—transmitter keyed manually by means of an external hand key. (The type of emission is dependent upon the position of the A–1, A–2 emission selector switch.)

Dial 9—Secures transmitter.

Dial 0—Secures transmitter.

26–6–25 Signal Timer—

A. The LSR–706, MT–179, KY76/URN and sequel (figs. 26–9 and 26–18) signal timer is a mechanical device having a series of cams accurately rotated with respect to standard time. The cams actuate contacts to which are connected the various circuits of the radiobeacon and auxiliary equipment, controlling them in desired sequence and at predetermined intervals accurately based on standard time. The timers are used at shore stations and on lightships not only for controlling the program characteristics of radiobeacons but, in addition, for coordinating the timing of lights, sound fog signals, engine generator starting, and warning signals with the radiobeacon signals. The mechanism of the timer consists principally of three sets of cam-actuated contacts which can be set up to control the various timed functions in the desired sequence (see fig. 26–18).

Synchronizing control over the timer is exercised by a master clock (LSR–221 or 222) by means of a pair of contacts which the clock closes for a brief period each minute. Inasmuch as the master clocks at all radio beacon stations are kept accurately set to standard time, the transmission schedules of a group of adjacent radiobeacons can be arranged to avoid simultaneous transmissions that would cause interference. Such scheduling, which is set up by proper arrangement of the timer cams, is described in section 26–1–15 and illustrated in figure 26–5. (Complete details of operation and adjustment are given in the instruction books for the LSR–706 series timers.)

B. *Modified types.*—The LSR–706 and sequel series timers vary only slightly from each other in mechanical and electrical details, and terminal arrangements are uniform on all models. Cam setups vary for each individual radiobeacon installation.

C. *Three-minute and radio cams.*—One set of 8 cams, called the 3–minute cams, are rotated at one-third revolution per minute on a shaft driven through a clutch and gears from another camshaft rotating at 30 revolutions per minute. The 30 revolutions per minute shaft is geared to a governor-controlled motor, and carries two "radio cams" which produce the characteristic signal of the radiobeacon transmitter (and warning transmitter if used). The 3-minute cams key the characteristic for main light and fog signal, and also produce the distance finding signals. Each cam is a metal wheel having the desired characteristic cut around the periphery. (See figs. 26–19 and 26–20.)

D. *Hourly cams.*—The third set of 8 cams, known as the hourly cams, are rotated one-sixtieth revolution per minute by a solenoid energized ratchet movement called the hourly secondary clock. This movement turns in steps of one-sixtieth revolution each minute in response to impulses fed to the solenoids from the master clock contacts; hence it is substantially as precise as the master clock. Each of the 8 cams rotates 1 revolution per hour, and each cam has 60 slots into which pins can be inserted to set up the desired contact-operating schedule for radiobeacon transmitter starting, clear-weather operating program, engine generator starting, etc. This secondary clock is mounted on the timer panel and has a clock face showing the minute of the hour.

E. *Motor synchronizer.*—One of the cams of the hourly secondary clock actuates a trip-lock device which resynchronizes the one-third revolution per minute motor-driven camshaft every 3 minutes. Thus the ability of the governor-controlled motor to hold the speed of the one-third revolution per minute shaft constant is relied upon only for the 3-minute periods between synchronizing pulses. The trip-lock device operates as follows: On the end of the one-third revolution per minute camshaft is a disk carrying a pin near its outer edge. Once per revolution (once in 3 minutes) this pin engages a catch which is coupled to a magnet. There is a slip-clutch between the one-third revolution per minute shaft and the motor, so that when the pin engages the catch, the one-third revolution per min-

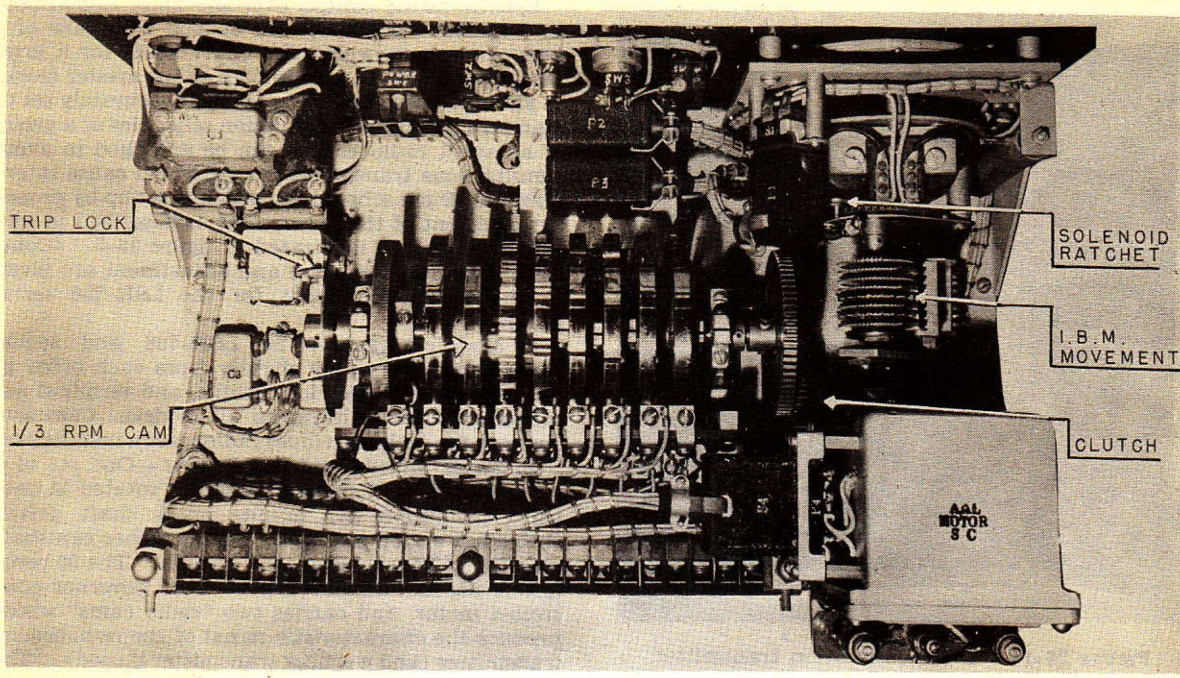


FIGURE 26–18.—Beacon coder (top view).

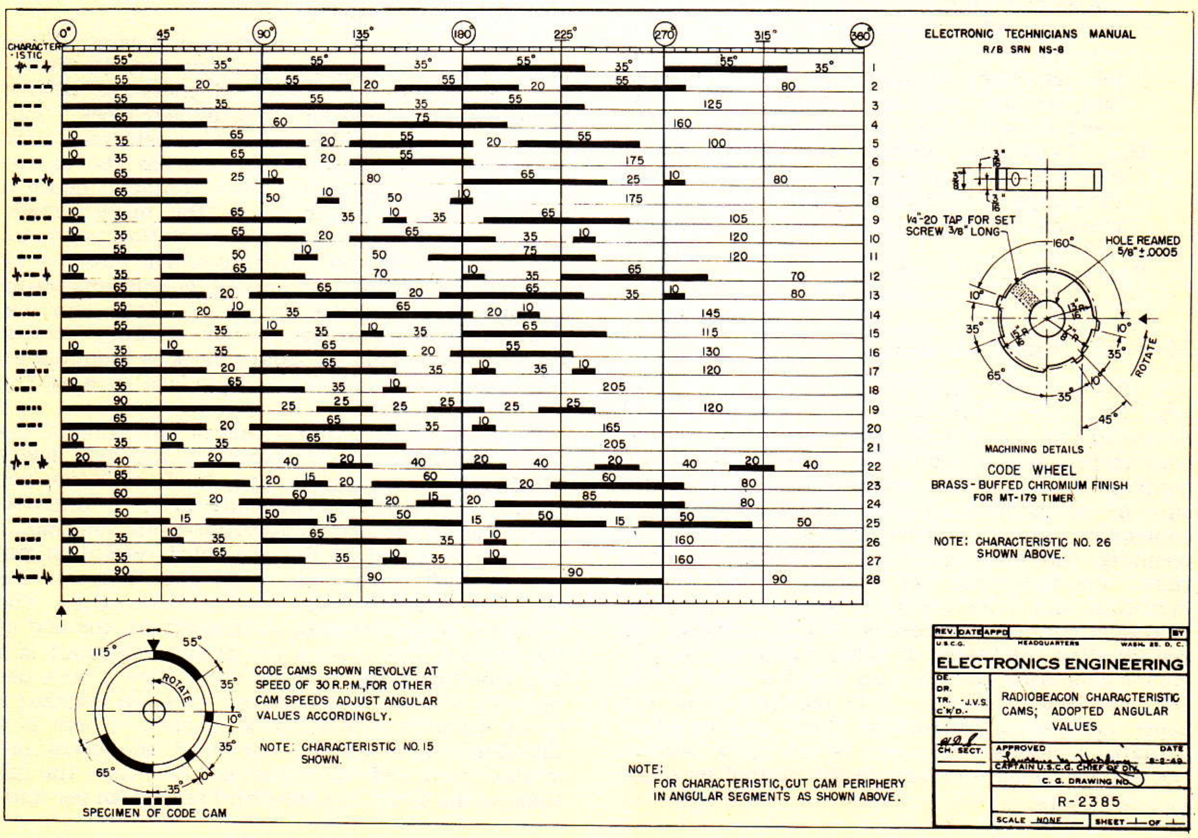


FIGURE 26–19.—Characteristic cams; adopted angular values.

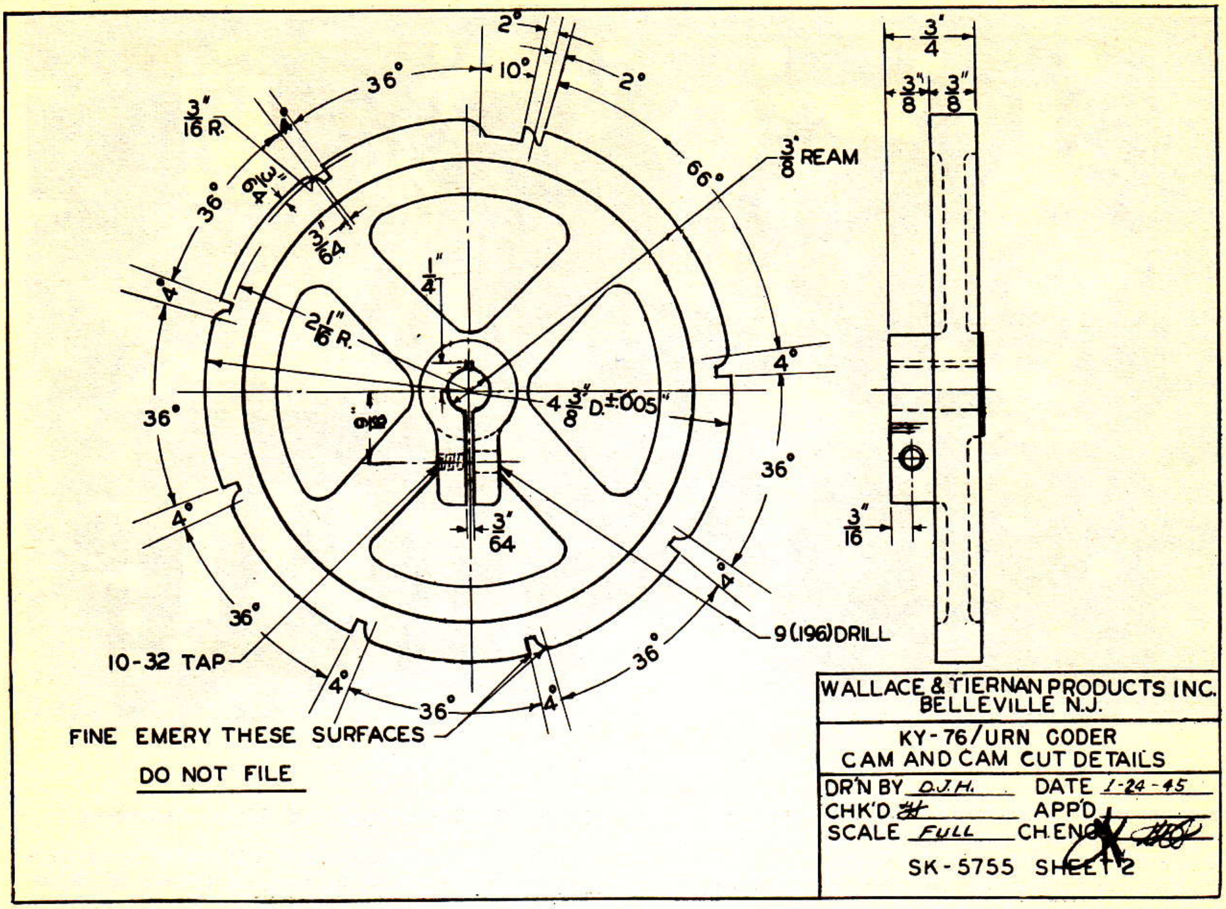


FIGURE 26–20.—Beacon coder and cam cut details.

ute shaft stops. At the beginning of the operating minute of the radiobeacon transmission schedule, an impulse from an hourly secondary clock cam-contact energizes the magnet, which pulls the catch away from the pin, allowing the one-third revolution per minute shaft to rotate. Thus it begins its rotation exactly at the beginning of the operating minute.

Over the period of 3 minutes required for this shaft to make a full revolution, the governor adjustment is such that the shaft is one or two seconds fast, so that the pin reaches the catch again and stops the shaft slighly before the beginning of the next operating minutes. Thus it is ready to be again released at the start of the operating minute. It should be noted that revolution of the one-third revolution per minute camshaft in one second less than 3 minutes produces an error of only one-third second during the operating minute, which is acceptable. This arrangement is used only on continuous (fog) schedule. The clear weather schedule is controlled entirely by the hourly secondary clock.

F. *Power supply.*—The timer operates from a d. c. power source of any voltage from 95 to 140 volts. The timer operates best at its normal voltage rating of 115 volts and this unvarying value of voltage should be maintained at all times. If the supply voltage is 110 volts a. c., an LSR–805/GF–119B dry disk rectifier will be required.

G. *Construction.*—The timer is constructed on a 10½- by 24-inch rack panel having a cast chassis approximately 14 inches deep. It mounts on a standard LSR–623/MR–180 rack. The LSR–805 rectifier is also constructed on a 10½-inch rack panel. A Type GF–119 Rectifier is available that operates from 220 volts, 50 cycles, single phase power.

26–6–30 Marine Escapement-type Primary Clock—

A. The function of the LSR–222/MT–188 marine escapement radiobeacon clock is to make an electrical contact once each minute to furnish correcting impulses to the timer and, in turn, control all timed and recurring operations of a radiobeacon with respect to basic time. This clock is a 15-jewel, 8-day, spring lever, temperature-compensated movement mounted in an insulated metal case. Its variation from accuracy is not more than 5 seconds per day. The hand winding knob for the clock is on the front panel, and the slow and fast adjustment is to the right on the front panel. The contacting mechanism is so designed that the exact instant of

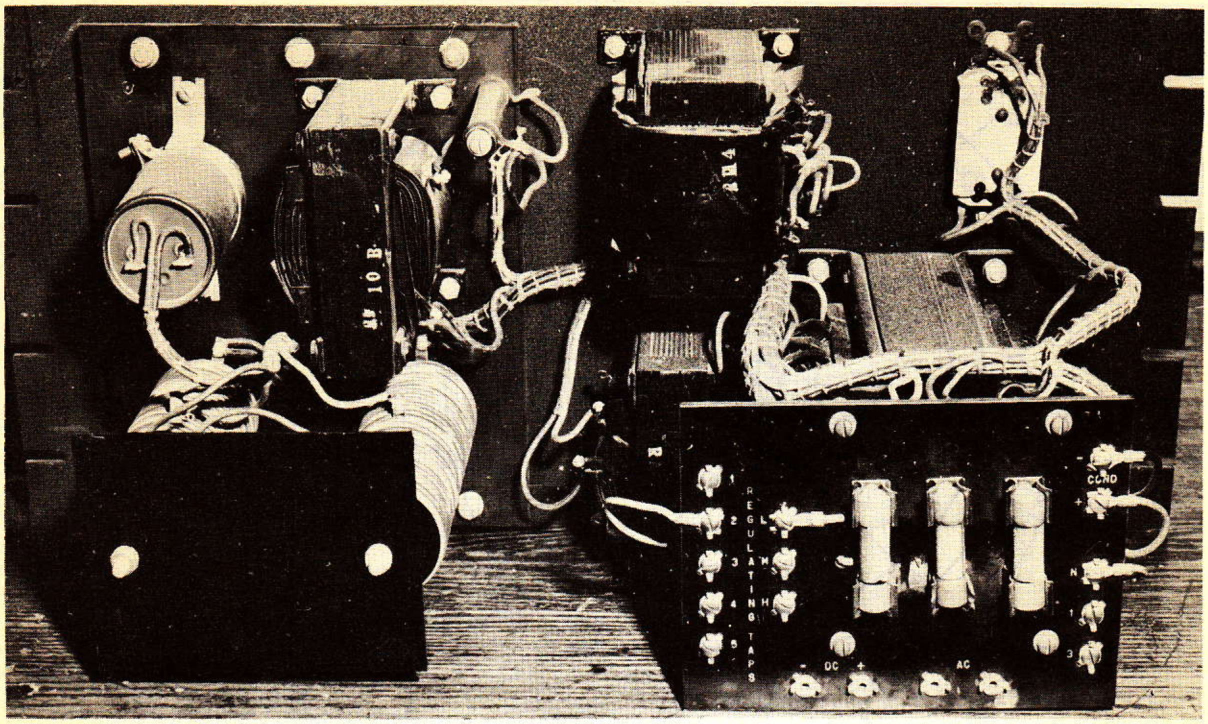


FIGURE 26–21.—LSR–805/GF–119 rectifier unit.

making contact may be advanced or retarded by a manually operated calibrated dial or indicator which is marked circumferentially in 1-second divisions. *Continuous* advance or retardation will return the indicator to its initial position with respect to basic time through sixty 1-second divisions, and provides a means of resetting the minute contactor to exact time or in time sequence with other radiobeacon stations in a group.

B. Marine escapement clocks are used on all lightship radiobeacons, and at some shore radiobeacons where there is excessive vibration. Two clocks will mount on a 10½ x 24-inch panel.

26–6–35 Pendulum-type Primary Clock—

A. The LSR–221/MT–178, TD–66/FRN, or sequel pendulum clock also closes a make-contact once each minute. This clock is weight-driven, jeweled, temperature-compensated, and accurate to the extent that adjustment to within 2 seconds error in a 24-hour period is easily practicable. The instant of contacting is also adjustable in seconds by a revolving housing, so that the instant of contact may be advanced or retarded, thus making it possible to keep the instant of control in step with other clocks without resetting the clock mechanism. These clocks are installed at shore radiobeacons where the vibration is not excessive. If properly installed, these units are thoroughly dependable as to timekeeping qualities and will operate for years with a minimum of maintenance. Each clock requires a 59½-inch mounting space on a standard LSR–623/MR–180 rack.

26–6–40 Supervisor and Alarm Device—

A. The MT–196 supervisor and alarm is an electromechanical device to indicate phases of radiobeacon transmitter operation. It is used to continuously monitor radiobeacon operation, either locally or remotely, and to sound a warning alarm when a failure occurs. This equipment is designated to be controlled by a master clock such as is used in timing radiobeacons. A failure or fault occuring in any part of the radiobeacon operation or in the monitoring system will cause an alarm bell, which is normally interlocked with the alarm device, to sound.

B. *Failures to which the alarm device will respond* are as follows:

(1) Failure of the transmitter to synchronize properly.

(2) Failure of alarm device to synchronize properly.

(3) Failure or drop in transmitter modulation.

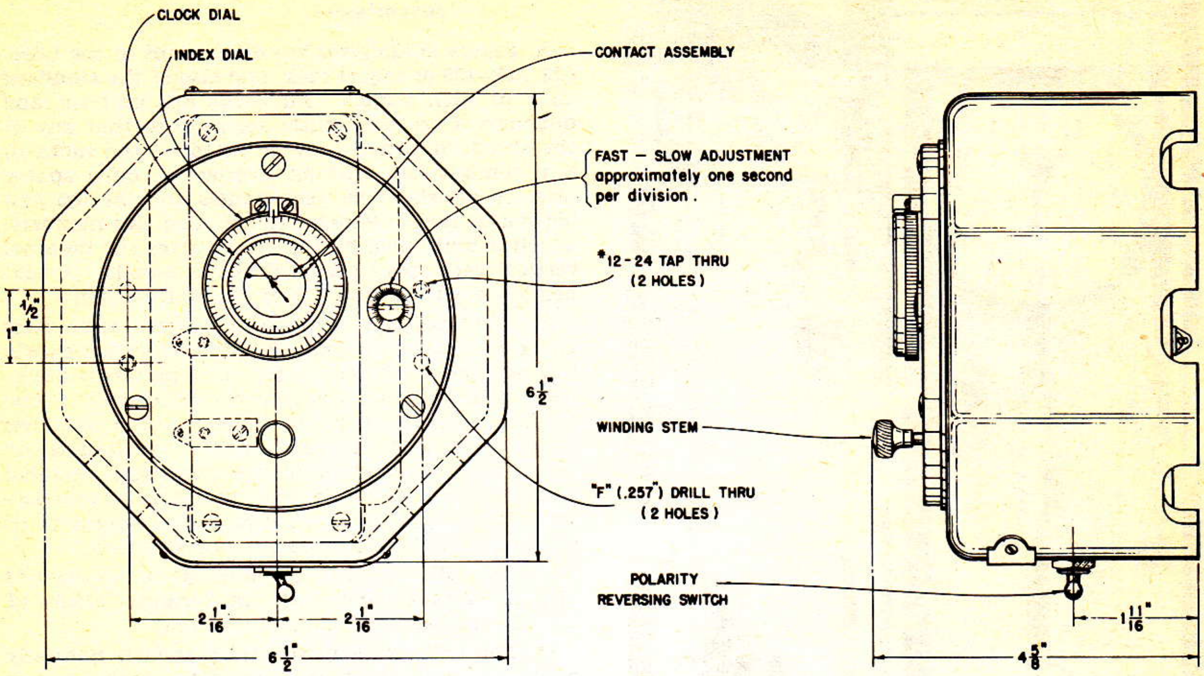
(4) Frequency deviation in excess of 2 kilocycles.

(5) Transmitter output failure or a drop below 3 db.

(6) Alarm device failure.

(7) Power source failure or excessive drop in line voltage.

C. *Operation.*—The unit consists of a radio receiver fed from an antenna of sufficient length to pick up the radiobeacon signal. The audio output of the receiver is fed to a monitor speaker in addi-



By rotating knurled calibrated dial on top of case synchronizer can be adjusted to make contact at any desired instant. The actual duration of contact is approximately 1 to 1½ seconds which is ample to operate the external relay. Magnetic switches on other equipment are actuated by external relay as desired. Contact starts at instant the hand reaches "60" on the inner dial.

To synchronize the time of contact with a given signal, note the number of seconds either side of the "60" indicated by revolving pointer at instant the desired time signal is received. Then revolve the knurled calibrated dial which carries the contact a proper number of seconds either way to correspond to the number of seconds that the time of contact was out of synchronism with the desired time signal.

FIGURE 26–22.—Marine escapement-type primary clock.

tion to the alarm control circuit consisting of a rectifier and holding relay. A series of circuits of an IBM movement which is controlled by the master clock governs the synchronization of the alarm device with the radiobeacon operation and causes the alarm to sound when improper operation takes place. A signal intensity meter provides a visual indication of the signal strength as well as serving for the adjustment of the receiver operating level. Various switches and indicator lamps are provided to maintain the alarm device for all types of station operation.

D. The receiver has a frequency range of 250 to 350 kilocycles and may be used as a self-controlled or crystal-controlled frequency oscillator.

E. *Power*.—The MT–196 alarm device requires a continuous source of 105 to 125 volts a. c. or d. c. power. Maintaining voltage unvarying from 115 volts results in better equipment operation, fewer equipment failures and less maintenance.

F. The alarm bell used with the device is of an electromechanical spring-wound type and is not affected by failure of power. The warning bell will sound when any of the above-mentioned operating deficiencies occur, including power failure. The only requirement in assuring the proper functioning of the alarm device is to regularly check its synchronization with the radiobeacon timer and to maintain the electromechanical bell in fully-wound condition.

G. The MT–196 alarm device is designed for mounting on the standard MR–180 steel rack in a space 15¹¹⁄₁₆ inches high or approximately equal to a No. 9 blank panel. (See fig. 26–25.)

H. The tube complement of the type MT–196 receiver is as follows:

1 type 6SA7	1 type 6SK7
1 type 6J5	2 type 25L6
1 type 6SJ7	2 type 25Z6
2 type 6SQ7	2 type NE–42

The tubes required for the supervisor and alarm unit are as follows:

1 type VR–105/30	1 type 12H6

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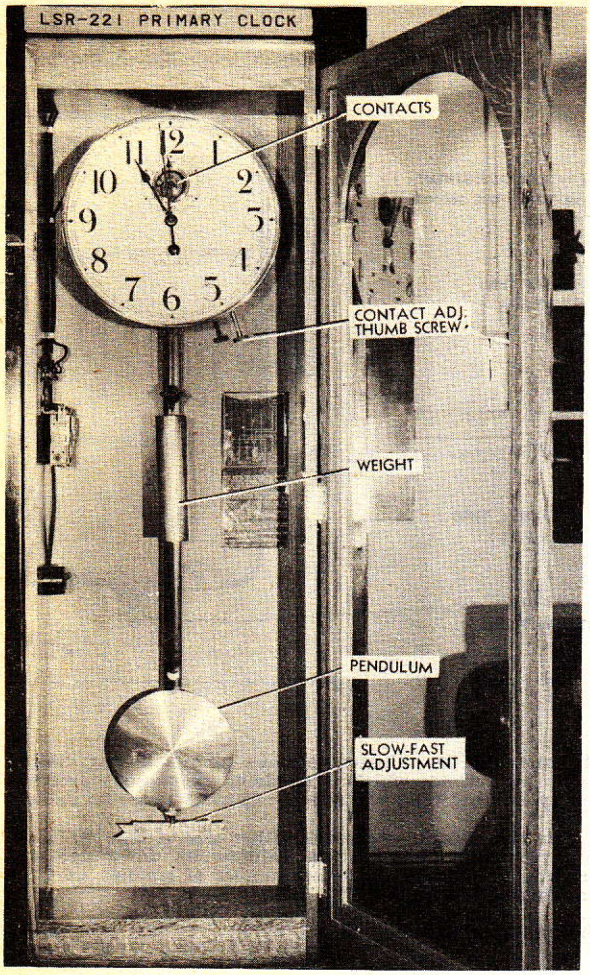

FIGURE 26–23.—Pendulum-type primary clock.

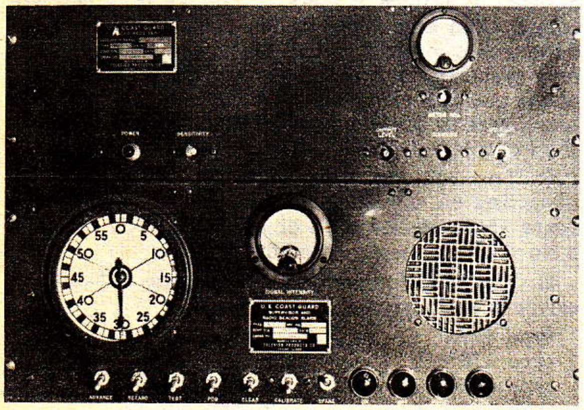

FIGURE 26–24.—Supervisor and alarm unit.

26–6–45 Racks, Switch Panels and Other Accessories—

A. Figure 26–25 gives the dimensions of the LSR–623/MR–180 or sequel rack, and also of the standard sizes of rack panels. All racks are uniform and dimensions are sufficiently accurate so that any of the standard panels may be fitted on the racks in any combination without overlay or open spaces between panels or between panels and the top and bottom of rack. Panels are assigned size numbers, which if multiplied by 1¾ inches gives the nominal vertical rack space occupied by the panels. Actual height of panels is $\frac{1}{32}$ inch below this figure.

B. Practically all radiobeacons except some class D are equipped with LSR–621/MP–184 switch panels having green and red switch nameplates to designate main and stand-by controls respectively. The switch panel consists of sixteen 3-way switches mounted on a No. 2 rack panel. Two designation strips with celluloid protective strips are mounted on each panel. A tandem switch connector or gang-way strip is provided to facilitate the operation of a number of the above-mentioned switches.

C. The LSR–622/MP–181 terminal panel consists of a No. 2 rack panel with two terminal blocks of the 12-terminal type mounted thereon.

D. The LSR–624 general utility shelf is normally mounted on the rear channel of the rack, as it is used for supporting batteries, power packs, and other accessory items of equipment.

E. The LSR–625/MR–182 writing shelf is mounted on a No. 7 rack panel and is so constructed that when it is opened the shelf portion is held rigidly in position. When closed, the shelf falls down and lies flat against the panels.

F. The LSR–626/MA–183 locker is used for storing tubes and spare parts. It is mounted on a No. 10 rack panel.

G. Convenient interchange of LSR–706 and sequel timer control circuits with respect to radiobeacon transmitters or fog signals by LSR–627/MP–185 adapter panel is practicable. These panels are size No. 1 and are furnished with plugs which are wired to the timers before the latter are installed.

26–6–50 Radio Receiver—

A. All radiobeacon stations are furnished with a receiver suitable for monitoring the radiobeacon frequency band and capable of receiving time ticks for checking the primary clocks.

B. The receiver presently in use at most stations is the R–115. It is planned to replace these units by another type as such receivers become available.

26–6–55 Power Supply—

A. At all radiobeacon installations (except some Class D) both 115-volt a. c. and d. c. are needed. At shore stations it is usually more practical to use commercial power when available. When commercial power is used, it is only necessary to use an LSR–805/GF–119B rectifier unit to supply d. c. power for operation of the timers.

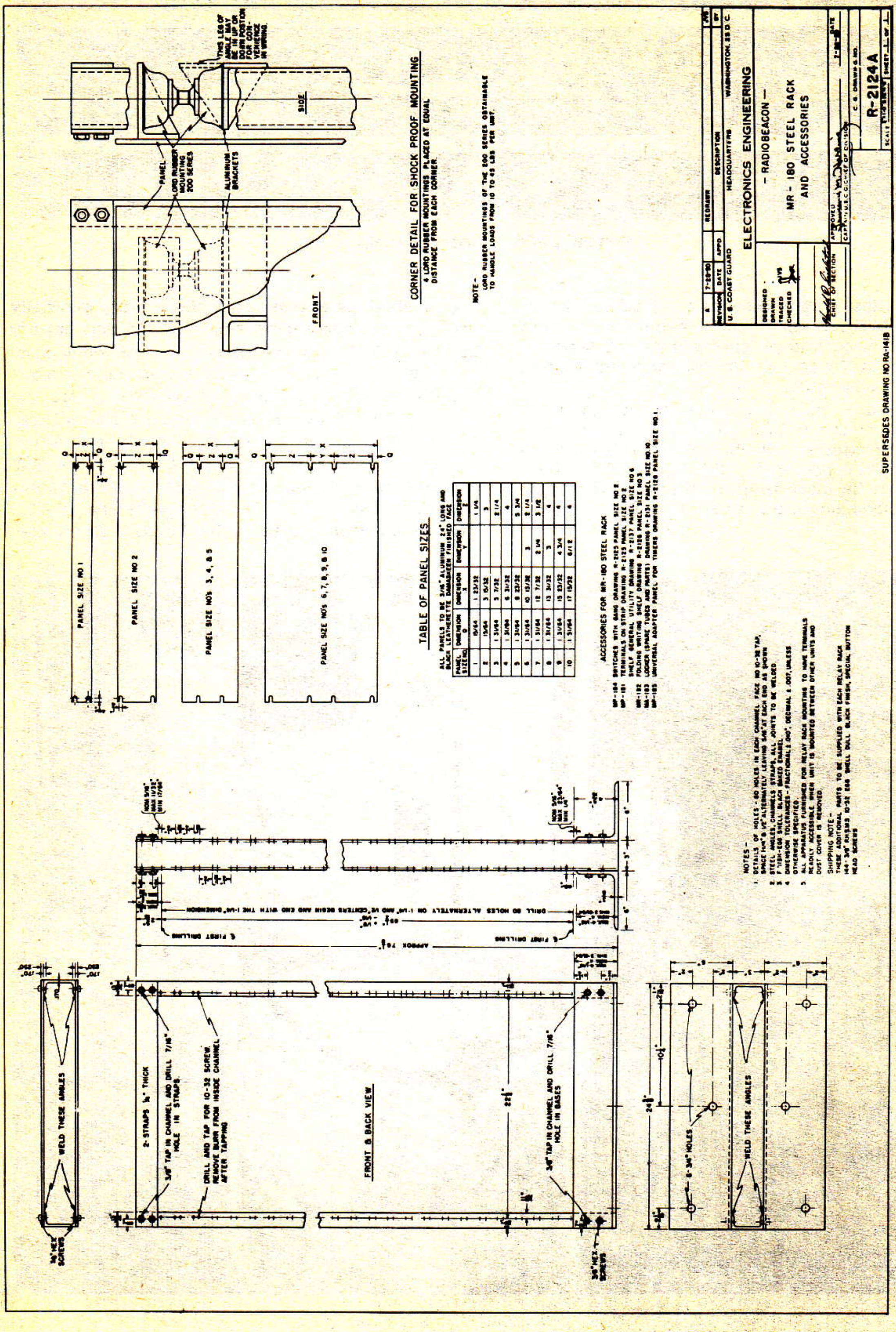

FIGURE 26-25.—Steel rack and accessories.

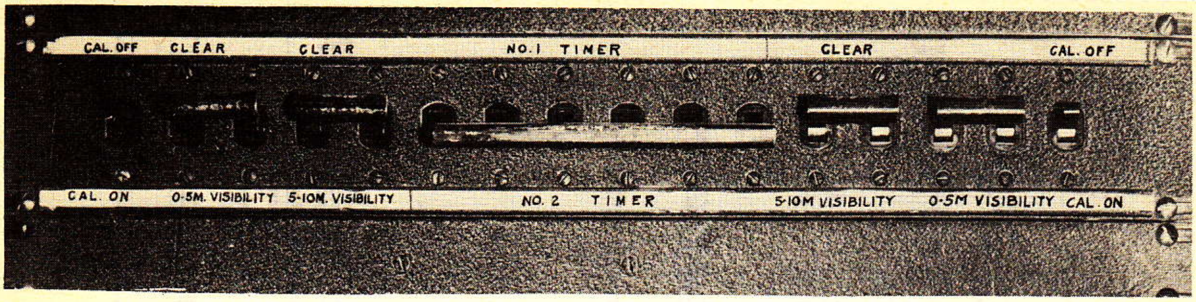

Figure 26–26.—Switch panel.

At most Class D radiobeacons a special keying device, type MT–190, operated by commercial power is generally used and no special rectified power is required as in the case of the standard timers used at other radiobeacons.

B. To assure continuous operation in event of commercial power failure, an emergency internal combustion engine-driven generator which starts up automatically, is provided. (See fig. 26–27.) There should never be more than a minute or two lapse in radiobeacon operation when transfer of power is affected.

C. Lightships and isolated shore units generally use a power source consisting of a 115-volt battery bank and engine-driven generators. In some cases the battery bank is used alone during the day when the load is light. During the heavy load hours, the load is supplied by the generators which recharge the batteries at the same time. At these stations, 115-volt d. c. to a. c. converters are used to supply the 115-volt a. c. power for operation of the radiobeacon transmitters. (See figs. 26–29 and 26–30.) The present trend on board lightships is to use a. c.

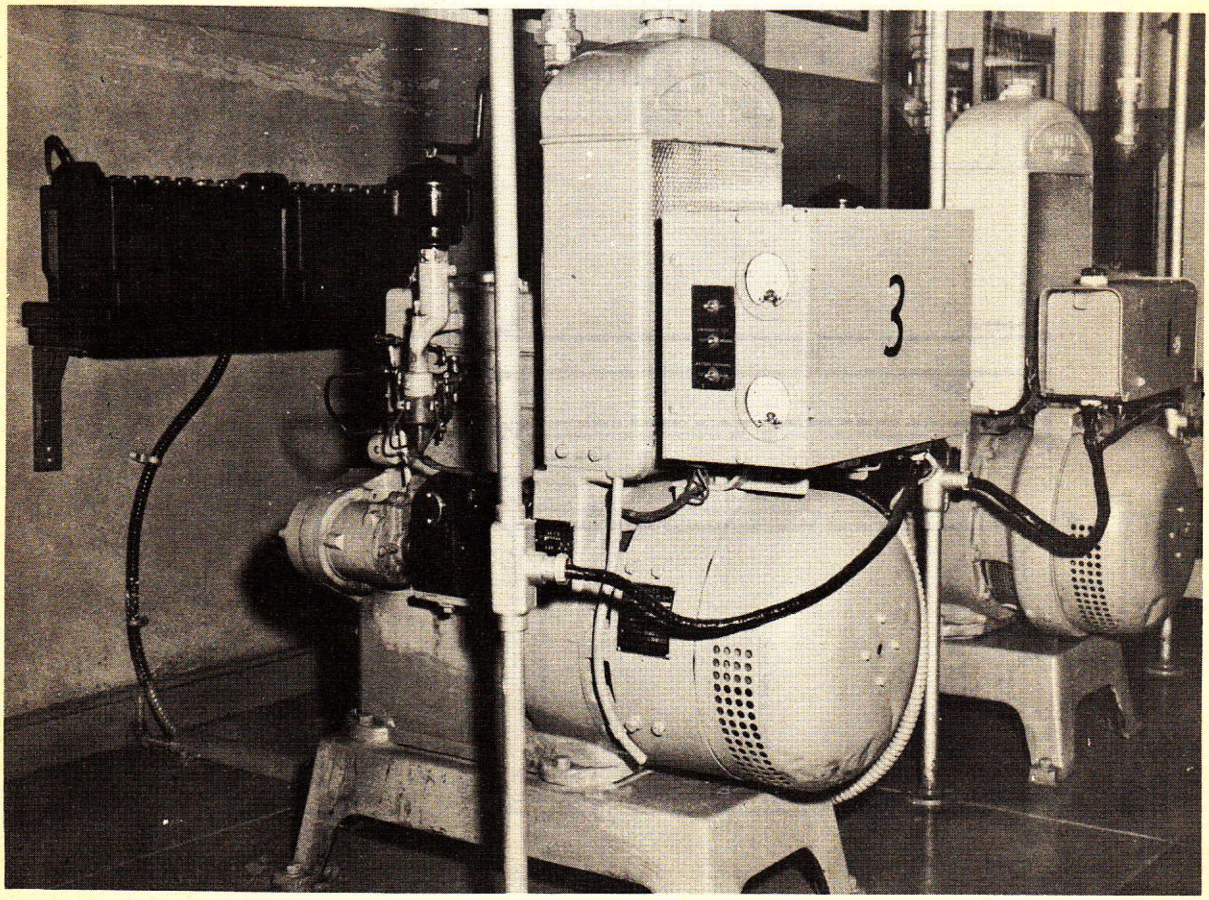

Figure 26–27.—Internal combustion engine generator.

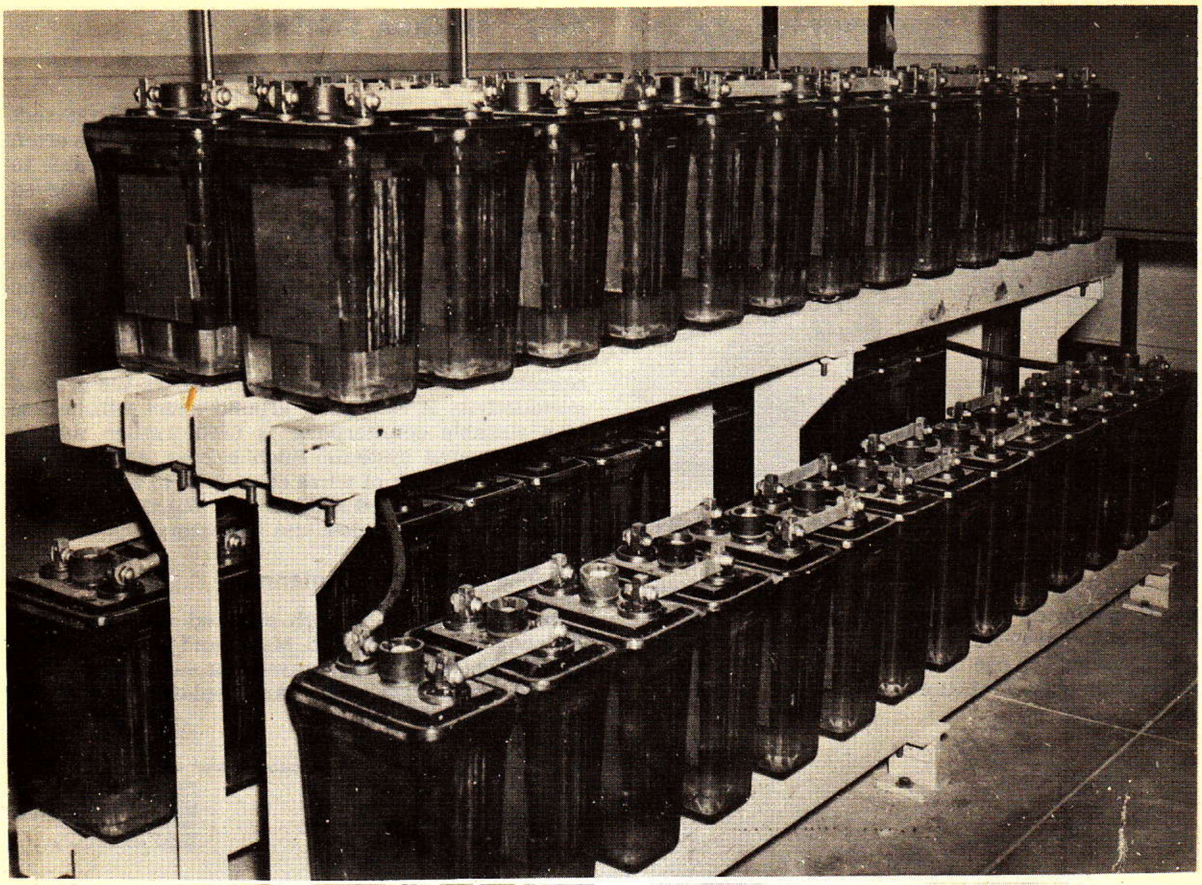

FIGURE 26–28.—110-V battery bank.

power supply from continuously-operated engine generators and dispense with the use of the storage batteries.

The following paragraphs list power supply devices and the classes of stations to which they apply.

D. The LSR–803/G–121 rotary converter is used on class C stations for operation of the low-powered transmitters, where the source of power is d. c. It has an output of one-half kva.

E. The LSR–805/GF–119B rectifier (fig. 26–21) is used where alternating current is available, and serves the purpose of rectifying the alternating current to direct current for operation of the radiobeacon signal timers. This rectifier is of the dry-disk type and has an output of 1 ampere.

F. The LSR–806/G–122 rotary converter (fig. 26–29) is a d. c. motor-driven a. c. generator, the purpose of which is to provide alternating current to the combination exciter and amplifier units required for the operation of a class A station. It has an output of 6 kva. This converted is provided with an automatic controller which serves to apply power to the d. c. motor in two steps, i. e., first, to start the motor, and second, to apply full power after a short starting period.

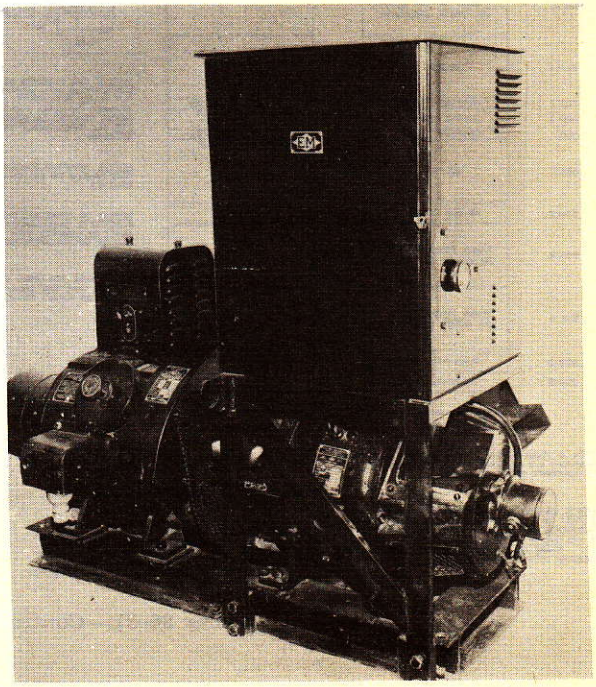

FIGURE 26–29.—LSR–806/G–122 rotary converter.

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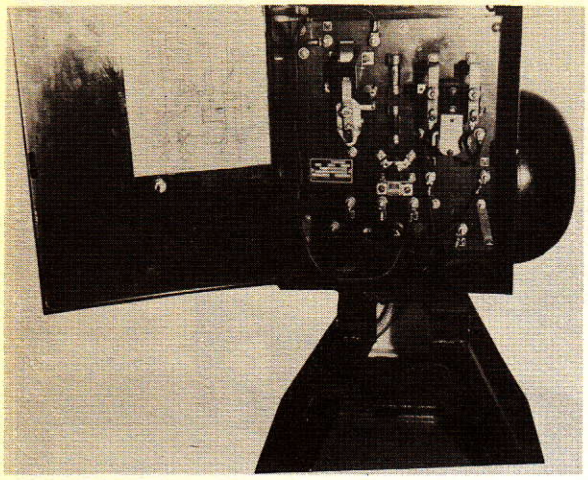

FIGURE 26–30.—LSR–807/G–120 rotary converter.

G. The LSR–807/G–120 rotary converter (fig. 26–30) performs the same function as the LSR–806/G–122. However, its output is only 2 kva and it is designed for use in connection with the transmitters for class B stations.

26–7 ANTENNA SYSTEMS

26–7–1 LSR–1100 Antenna—

A. At class A and class B radiobeacons, 125-foot insulated self-supporting LSR–1100 towers are often used. Where local conditions make it preferable to locate the antenna at a distance of several hundred feet from the transmitter house, the antenna tower is energized through type Special Armored RG/8U or other type underground shielded transmission line and an CU–330/UR antenna coupling unit, the latter housed in a weatherproof container at the tower base. A radial ground system similar to that proposed below for the type LSR–1101 antenna is normally adequate. At locations where the ground conductivity is very poor, ground losses will be less if a suitable counterpoise is used, rather than a buried ground system. Such a counterpoise consists of a network of wires elevated 6 to 8 feet above ground and centered around and joined to the base of the tower just below the insulators.

26–7–5 LSR–1101 Antenna—

A. At locations of high-powered class A radiobeacons such as Cape Cod, Mass., and Point Arguello, Calif., special 140-foot guyed, base-insulated, top-loaded towers are used. An insulated can at the

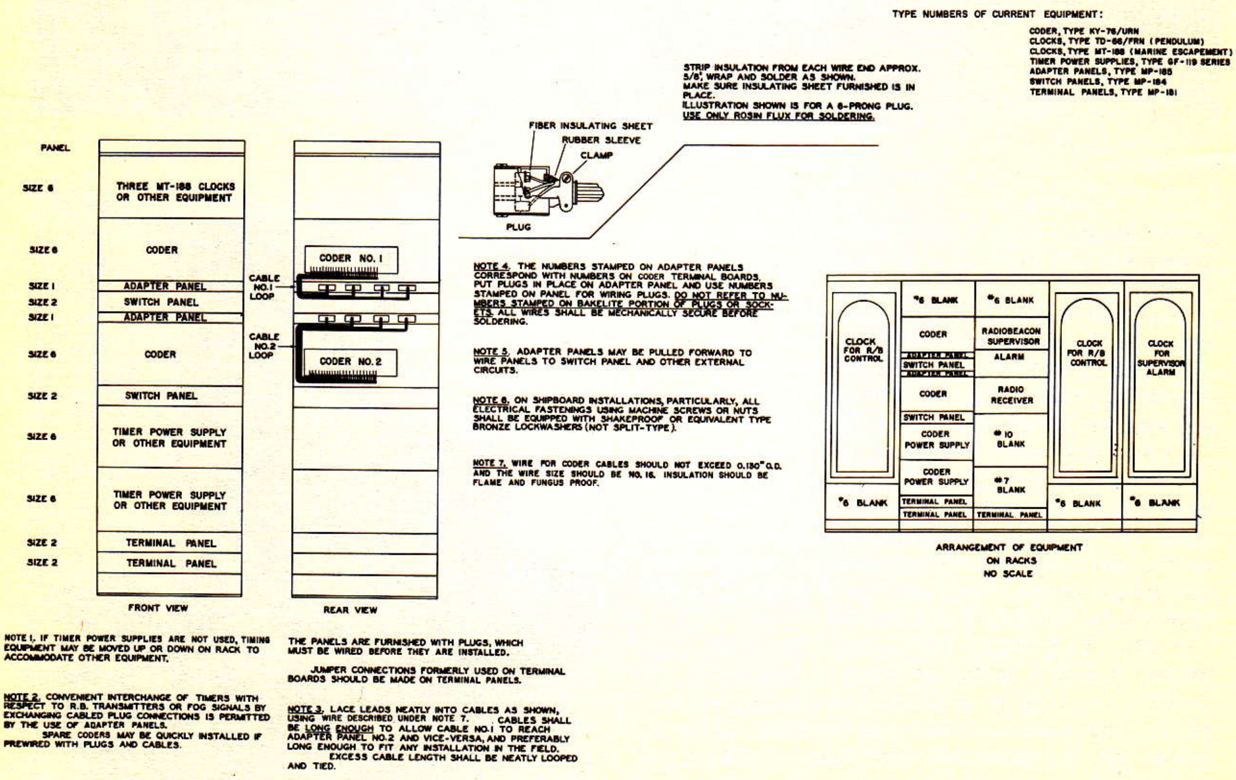

FIGURE 26–31.—Control equipment-rack layout.

FIGURE 26–32.—LSR–1101 antenna at Cape Cod Light Station, Mass.

top contains an inductor in series with the tower and the can, which is adjusted by trial for best field strength. (See fig. 26–32.) The tower base rests on a single insulator, and all guy wires are sectionalized by insulators. The tower is energized through a type RG–148/U coaxial cable transmission line and a type CU–330/UR antenna coupling unit. The ground system should consist of approximately 120 radials of #8 copper wire 200 feet long (minimum length), spaced three degrees apart, buried in trenches 6 to 12 inches deep, with extreme ends terminating on a 6-foot by ¾-inch ground rod driven to full length into the ground. The center or "hub-ends" of the radials to terminate at a common transmitting ground junction at the base of the tower. This common junction may consist of a ring 10 feet in diameter made of 2-inch by ⅛-inch copper strip brazed or soldered at the joining ends and brazed or soldered to six 8-foot by ¾-inch ground rods driven full length into the ground at 60 degree intervals. The ground terminal of the antenna tuning unit should be connected to the common ground junction ring through a copper strip not less than 2 inches wide and ⅛ inch thick. Also, each of the four static arrestors across the tower base insulators (ground side) should be so connected. Where ⅛ inch thick copper strip is not available, wider widths may be used provided copper strip less than $\frac{1}{16}$-inch thick is not used. All connections between the radials and ground rods and the common junction ring, and, between the copper strips leading to the antenna tuning unit and static arrestors, where not brazed, shall be soldered with non-corrosive flux. The only known non-corrosive flux is rosin. Where it is not possible to bury the radials and common center junction ring, due to solid rock formations, etc., the radials may be stretched on the rock, extended into the water if possible, and clipped at 15-foot intervals by means of expansion inserts and bolts. If sand or soil is available, cover the ground system with several inches of sand or soil to prevent damage to the radials. Where the minimum length of radials cannot be laid due to lack of available space, the maximum length of radials possible should be used. In some instances buildings and small rock formations may be skirted with radial trenches and the radials routed around them and then extended out to at least the minimum length. Ground radials should be as long as practicable up to ¼ wavelength. At 300 kilocycles, ¼ wavelength is approximately 800 feet. Since this length of radial is seldom possible due to space and other limitations a minimum length of 200 feet is specified. All metal masses in the vicinity of the antenna, such as roofs, tanks, machinery, rain gutters and drains, should be grounded to prevent spurious re-radiations and noise effects. Where limited space is available and a radial type of ground system is not possible, such as on small submarine sites and steel structures, the steel foundation may be used where it extends into the water, or, a long stretch of interlocking sheet steel piles may be used by spot welding the piles together at several points along their vertical length.

26–7–10 LSR–1102 Antenna—

A. *Lantern-mounted vertical radiator type.*—An insulated guyed antenna approximately 40 feet high resting on a single base insulator is sometimes placed on top of a light tower above the lantern at radiobeacon stations. The antenna is usually energized through RG/8U or other type transmission line and an MR–209 or sequel antenna coupling unit (indoor type).

26–7–15 LSR–1103 Antenna—

A. *Single masted lightship antenna system.*—This type of antenna usually consists of a short cage which is supported at the highest point by a tripod above the lantern so that the down lead is nearly vertical.

26–7–20 LSR–1104 Antenna—

A. *Two-masted lightship antenna system.*—In this case the antenna is elevated above the lantern on tripods, and the down lead is kept vertical to provide a symmetrical T-antenna with small horizontal top.

26–7–25 LSR–1106 Antenna—

A. *Vertical radiator type.*—These insulated self-supporting towers approximately 45 feet high are sometimes placed on the top of light towers at radiobeacon stations of short range where the antenna will not interfere with the main light. This antenna is supported by four base insulators.

B. Insulated base whip-type antennas of 18 to 25 feet in height are also used at marker radiobeacons (Class D).

26–7–30 Wire Antennas—

A. *Symmetrical* T-*type wire antennas with wood or steel poles.*—For such antenna installations, the location of the antenna poles should, if practicable, be arranged so that the down lead is vertical and enters the radio room near the radiobeacon equipment. Inverted L-type antennas should not be used for radiobeacons, as this type radiates a considerable horizontal polarized component which causes useless long-range interference and, in addition, is directional.

B. *A ground system* consisting of radial copper wires buried in shallow trenches is recommended for use with a wire antenna. If practicable, six ground rods on a 5-foot radius should be driven in directly under the entrance insulator and connected to the same terminal as the radials. If it is not possible to bury the radials in shallow trenches, the wires may be laid on the surface and secured at 15-foot intervals with suitable galvanized steel clips. If sand or soil is available, it is used to cover the wires from 2 to 3 inches to avoid mechanical damage. The ground system radius should be as large as practicable up to ⅓ wavelength with a maximum of 120 radial wires.

C. All metal roofs within the immediate vicinity of the radiobeacon antenna should be grounded to avoid spurious reradiation and noise effects.

26–7–35 Antenna Coupler—

A. The antenna coupler is installed at the base of the antenna. It contains tuning coils which, once adjusted at the time of installation, should require no further attention. Usual cleaning, painting, and maintenance duties should, of course, be performed as required.

The latest type antenna tuning and coupling unit has refinements such as entrances for two types of transmission lines and a control circuit to permit frequency changing by the use of a built-in transfer relay. A dummy antenna load is also incorporated into the unit to facilitate tuning of the installation. See figure 26–12 showing the cable connection of an amplifier and antenna coupling and tuning unit.

Two types of antenna coupling units are available; Type MR–209 for low power radiobeacons, up to class B, and Type CU–330/UR for shipboard installations and shore installations where extra protection against the weather is desired.

26–8 FIELD STRENGTH MEASUREMENTS ON NEW RADIOBEACONS

26–8–1 Procedures—

A. Procedure in making and submitting measurements.—Field strength measurements should be submitted for all new radiobeacons; also, whenever the transmitter power output is changed at any existing station. If the radiobeacon antenna is modified so as to either increase or decrease the field strength, new measurements should be submitted. The following paragraphs give the procedure for making field strength measurements.

B. Use the IM–101/U and Field Strength Meter available to your district.

C. Calibrate the IM–101/U as described in the instruction book.

D. Check radiobeacon equipment to see that it is functioning properly (normal antenna current, ground system intact, etc.).

E. Obtain if practicable an extra thermoammeter of suitable range and check its calibration against a reliable a. c. ammeter, using resistors and low voltage 60-cycle power. Do not attempt to use the thermo instrument in transformer primary circuits or with any other inductive load, as peak starting surges may burn out the thermocouple. After calibration, this meter is to be inserted in the antenna circuit as follows:

(1) Wire antennas—Insert calibrated ammeter in antenna lead-in at the entrance insulator.

(2) LSR–1100 tower antennas fed by concentric line and an antenna tuning unit—Insert calibrated ammeter in antenna lead-in to tuning house at the entrance insulator.

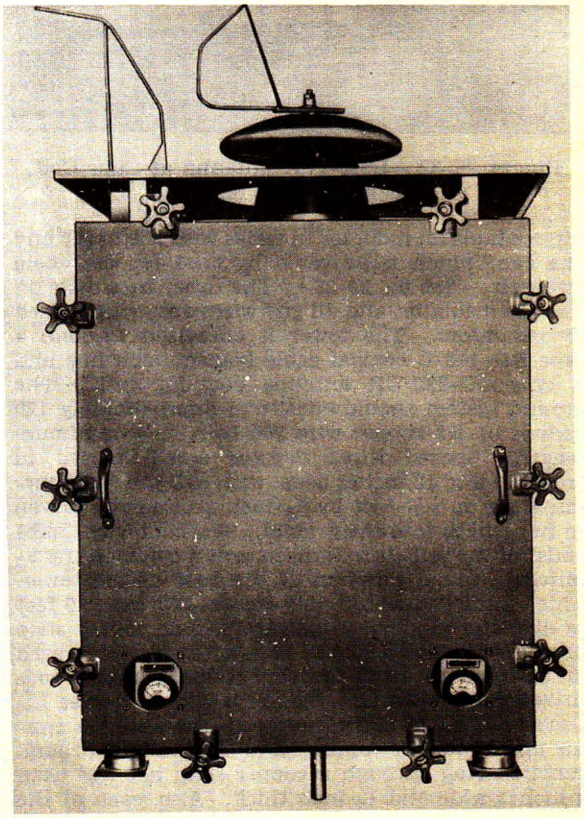

FIGURE 26–33.—Antenna coupler unit type CU–330/UR.

F. Antenna current readings to be recorded will vary with the type of antenna system, as follows:

(1) Wire antennas—Record calibrated ammeter reading and transmitter ammeter reading. After tests, the calibrated ammeter is removed and the reading of the transmitter ammeter is maintained at the established value to insure uniform field strength.

(2) Tower antennas—Record calibrated ammeter reading and tuning house ammeter reading. Here again the calibrated ammeter is removed after the tests and the tuning house ammeter reading is maintained at the established value. The transmitter ammeter will, in this case, show line current, hence is not an accurate indicator of radiated power.

G. Select two or three suitable points approximately one nautical mile from the radiobeacon antenna for measurement of field strength. The intervening terrain should be relatively free of hills or other large obstructions, and of overhead telephone and power lines. If such locations ashore are not obtainable, the measurements should be made in a small boat having a minimum of rigging which might cause errors by distorting the signal pattern. Distances other than one mile (from ¼ to 3 miles) may be used if more convenient. Select one of these check points, preferable one that can be easily reached on foot or by small boat, as a future rechecking point and indicate it as such on the submitted report. Also, indicate the point of the copy of the report that is posted in the vicinity of the transmitting equipment for ready reference of electronics maintenance and inspection personnel.

H. To provide a steady carrier while making field strength measurements, arrange for locked key conditions for 1 minute following the regular clear weather 10-minute operating schedule and during the assigned radiobeacon minute. If a check measurement is desired, repeat test for next regular operating minute.

I. Record the following data:

(1) Name of radiobeacon.

(2) Serial number of IM–101/U

(3) Distance from radiobeacon antenna to point of measurement (accuracy within 5 percent). State nautical or statute miles.

(4) Direction from antenna to point of measurement, referred to true north.

(5) Antenna current reading—calibrated ammeter. (State location of meter.)

(6) Antenna current reading—tuning house meter (where applicable).

(7) Antenna current reading—transmitter ammeter.

(8) Transmitter final amplifier plate current.

(9) Transmitter final amplifier plate voltage.

(10) Reading obtained from IM–101/U in microvolts.

(11) Coaxial line current and type of line.

(12) Comments.

26–8–5 Maintenance of Established Values—

A. After the antenna current has once been adjusted to give the desired field strength, all maintenance and operating personnel should be instructed to make no change in the value of the antenna current nor in the field strength without obtaining prior authorization from Headquarters. Post the approved values of antenna current and field strength near the radiobeacon equipment so that the information will be readily available.

26–9 CALIBRATION OF SERVICE ARC OF NEW RADIOBEACONS

26–9–1 Procedure—

A. *Procedure in making and reporting calibration.*—In the case of a new radiobeacon station, arrangements are to be made to have a direction-finder-equipped cutter make the calibration described below as soon as practicable after the radiobeacon equipment installation is completed. A report of the calibration, including a copy of the data form, is to be forwarded to Headquarters for approval before the radiobeacon is officially placed in operation. From the data shown in the report, the existence of any unreliable sectors of the service arc can be determined so that corrective measures may be taken; or if the latter are impracticable, the limits of the unreliable sectors may be published. The following procedure shall be used:

(1) Set up a pelorus aboard the vessel (if not installed); carefully align fore and aft.

(2) Swing ship to check calibration of direction finder, and to check deviation card of magnetic compass, if not gyro-equipped.

(3) Check alignment of pelorus and D. F. scales so both are dead ahead at 0° (D. F. repeater disconnected and zero set on ship's head).

(4) Sail on an arc of one mile or more radius (essentially constant) from radiobeacon antenna. Radius should be as near 1 mile as practicable according to obstructions; maximum usable radius is the range of visibility. Keep target—antenna tower or lead-in—as near beam as practicable (90° or 270° relative). Complete the arc as nearly from shore line to shore line as local conditions will permit.

(5) At approximately each 10° of sailing arc take the following three readings simultaneously, recording them on forms made up similar to the one shown below.

(*a*) Relative visual bearing on target (by pelorus). Enter in column 1.

(*b*) Relative radio bearing on target (by D. F.). Enter in column 2.

(*c*) Ship's head per gyro compass, or per magnetic compass if not gyro-equipped. Enter in column 6.

(6) The balance of the columns in the form are completed as follows:

- Col. 3—From D. F. calibration curve.
- Col. 4—Algebraic sum of column 2 and column 3.
- Col. 5—Column 4 minus column 1.
- Col. 7—Column 6 corrected for magnetic compass deviation, and local variation; or, if gyro-equipped, corrected for gyro compass error.
- Col. 8—Column 1 plus column 7.
- Col. 9—Column 8 plus 180°.

Calibration of service arc of radiobeacon

Radiobeacon Station.. Date of Calibration..............................

Vessel.. D. F. Type.. Serial Number..............................

Conducted by.. Approved by..
(Commanding Officer)

(1)	(2)	(3)		(4)	(5)	(6)	(7)	(8)	(9)
Visual bearing of beacon—*Relative*	Radio D. F. bearing of beacon—*Relative*	Radio D. F. correction		Radio bearing—*Relative* (Col. 2+3)	Beacon calibration error (Col. 4−1)	Ship's head—p. m. c. ☐ p. g. c. ☐	Ship's head—*True*	Bearing of beacon from ship—*True* (Col. 7+1)	Bearing of ship from beacon—*True* (Col. 8+180°)
		−	+						

B. *Use of calibration data.*—Column 9 is the true bearing of the ship from the radiobeacon, and enables sectors of radiobeacon service arc to be identified for degree of reliability. Column 5 shows the error to be expected. Such errors are caused by irregularities of wave propagation due to local conditions. These errors are not likely to be fixed under all weather conditions, hence are not specified on charts as corrections to be applied to D. F. bearings. Instead, the sectors in which errors are known to exist are designated "UNRELIABLE" on sailing charts showing the radiobeacon stations.

26–10 OPERATING AND MAINTENANCE INSTRUCTIONS

26–10–1 Importance—

A. Officers-in-charge of units operating a radiobeacon shall impress upon their subordinates the great importance of this aid. The constant use of an operating radiobeacon by mariners within the large area which it serves should be stressed. Officers-in-charge shall instruct their subordinates thoroughly, so that efficient operation and maintenance will be assured, and irregularities and failures held to a minimum. See the A. to N. Op. Bill.

26–10–5 General Instructions—

A. Instruction books furnished with the radiobeacon equipment installed should be consulted for precautionary measures to be taken in making internal adjustments to the equipment and other pertinent information regarding the operation and maintenance of the equipment.

B. *Caution.*—Make internal adjustments to the equipment, such as changing voltage taps on resistors, changing taps on coils, retuning, modifying units or changing wiring, etc., only as authorized by the district commander, and then not until power is disconnected from the particular unit. It should first be determined by trial that clocks, timers, or other remote controls will not turn on or operate the equipment during repair. Extreme care shall be observed and a danger sign shall always be kept posted to describe conditions under which internal adjustments are permitted.

C. *Operation.*—The radiobeacon must first of all be under instant control and every watch stander shall be fully instructed how to turn the radiobeacon off immediately on receipt of proper orders. Similar training and instructions for turning on the radiobeacon shall be made effective. It is of great importance that the clocks be kept in time and all apparatus kept in instant readiness to operate. Therefore, whether the radiobeacon is operating regularly or only at long intervals, the clocks and timers shall be checked regularly so that if orders are received to operate that radiobeacon at any time, it will be timed exactly as assigned. *This is important.*

D. *Emitted signals.*—Use the radiobeacon receiver (or supervisor and alarm unit where available) to insure that the characteristic signal is being correctly transmitted. Observe transmitter antenna current meter for strength of signal only not for clearness, and use the receiver or supervisor and alarm unit to determine that the modulation tone is present. The approved antenna current and field strength readings should be posted near the radiobeacon equipment, and all maintenance and operating personnel should be instructed not to change the antenna current and field strength without first obtaining prior authorization from Headquarters. Check at regular intervals the strength, characteristic, speed (30 characters per minute), frequency, clearness, and timing (operation on the assigned minute and on the specified schedules). Where the station transmits synchronized radio and sound signals for distance finding, the long and short radio dashes and the long and short blasts of the fog signal as observed at the station *must begin and end at the same instant*. This shall be checked frequently.

E. *Schedules and timing*.—A Time signal chart and simplified operating instructions for each major piece of equipment shall be posted near the radiobeacon equipment. Adhere to published minute and schedule under all circumstances when operating, by frequent checks day and night on standard official time signals. (*Time variation from standard time shall never be permitted to exceed plus or minus 5 seconds.*) Operating time shall not be taken from any other single radiobeacon, but if time signals are not immediately available, the proper operating minute may be determined temporarily by observing two or more other radiobeacon signals and referring to their operating minutes as shown on the posted chart. The operating minute shall then be verified at the time of next available time signals. In case it is observed that any other radiobeacon station is operating on the wrong minute or schedule, the District Commander shall be notified immediately by the most prompt means available. Weight- and spring-driven clocks shall be wound at appropriate regular intervals. Spring-operated alarm bells shall be checked daily and rewound after each check unless found fully wound.

F. *Radiobeacon station equipped with radiophone*.—Radiobeacon and fog signal operation must not be interrupted for communication without due cause. In matters of extreme urgency, callings and brief communication can be carried out on the proper frequency during the two-minute silent intervals of the radiobeacon where simultaneous communication facilities are not installed.

G. *5–10 mile visibility*.—When so ordered, operate radiobeacon when any of the following conditions occur: Fog, mist, haze, snow, fog on horizon, visibility less than 10 miles. Operate also when the presence of vessels within audible range is revealed by the sound of their whistle signals in fog.

H. *0–5 mile visibility*.—When visibility is less than 5 miles, and, when so ordered, operate all fog signals, including distance finding, where station is so equipped. Frequent checks, as specified for "Emitted Signals," shall be made during operation for distance-finding.

I. *Failure of radiobeacon*.—Whenever, for any reason, there is a failure of the radiobeacon or distance-finding equipment to transmit on authorized schedule, in periods of fog, or to transmit characteristics correctly, the fact shall be reported immediately to the District Commander. The time the deficiency occurs and definite advice as to steps necessary for its correction shall be reported. Also, Form CG–2643 shall be submitted promptly for each equipment failure.

J. *Calibration*.—It is important that existing instructions concerning calibration operation be thoroughly reviewed and understood. Personnel on watch shall be alert to observe and respond to requests for calibration, which may be received through the District Commander, or directly from mariners by radio, telegraph, telephone, whistle signals, flag signals, or hail from the vessel. When so ordered, requests by whistle signals consisting of three long blasts followed by three short blasts, or requests by display of the international flag signal ("J over K") shall be acknowledged by starting the transmitter. Normal calibration operation (steady signals without the 2-minute off period) must be discontinued during each clear weather period or whenever other radiobeacons in the same frequency group are operating for fog. During operation for calibration purposes, listen in a few seconds every five minutes to determine whether other radiobeacons are being interfered with, and, in case of interference, revert to "one on and two off" in assigned R/B sequence operation immediately. See section 26–6–20 for data relative to special calibration transmitter.

K. *Switching*.—Switching arrangements must be plainly labeled so that calibration operation can be instituted without delay, and so that newly assigned operating personnel, technicians, or any visiting inspector can readily operate main and stand-by equipment in any prescribed manner.

L. *Testing*.—Testing, when authorized and necessary, shall be done in clear weather between the regular periods of operation, and then only on the assigned station minute if other stations in the group are operating.

M. *Main and stand-by radiobeacon equipment*.—Where the equipment consists of two identical modern transmitters and accessories, the sets shall be given an equal amount of use. Where the transmitters are not identical, the more modern of the two shall normally be designated as "main" and the other as "stand-by." The main transmitter shall be operated for all regular schedules and for all low visibility operation. The stand-by set shall be used as a radiobeacon only when the main set is inoperative, except that it shall be operated for 10-minute test periods twice each week at a time other than during regular schedules or low visibility operation. If either set or any accessory equipment becomes inoperative, inform the District Commander immediately with details, and submit requisition for necessary replacements as soon as the requirements have been determined. Whenever practicable, the main equipment shall be designated by green tag or nameplate and the stand-by by similiar red designation. Practically all radiobeacons are now equipped with LSR–621 or sequel switch panel and colored switch nameplates to designate main and stand-by controls.

N. *Maintenance*.—The radiobeacon, when so ordered, operates every hour of the day and, accordingly, requires more frequent examination than some other signal equipment. A regular schedule shall be adhered to for cleaning and maintaining the radiobeacon equipment. Typewritten instructions shall be prepared by the district electronic engineer-

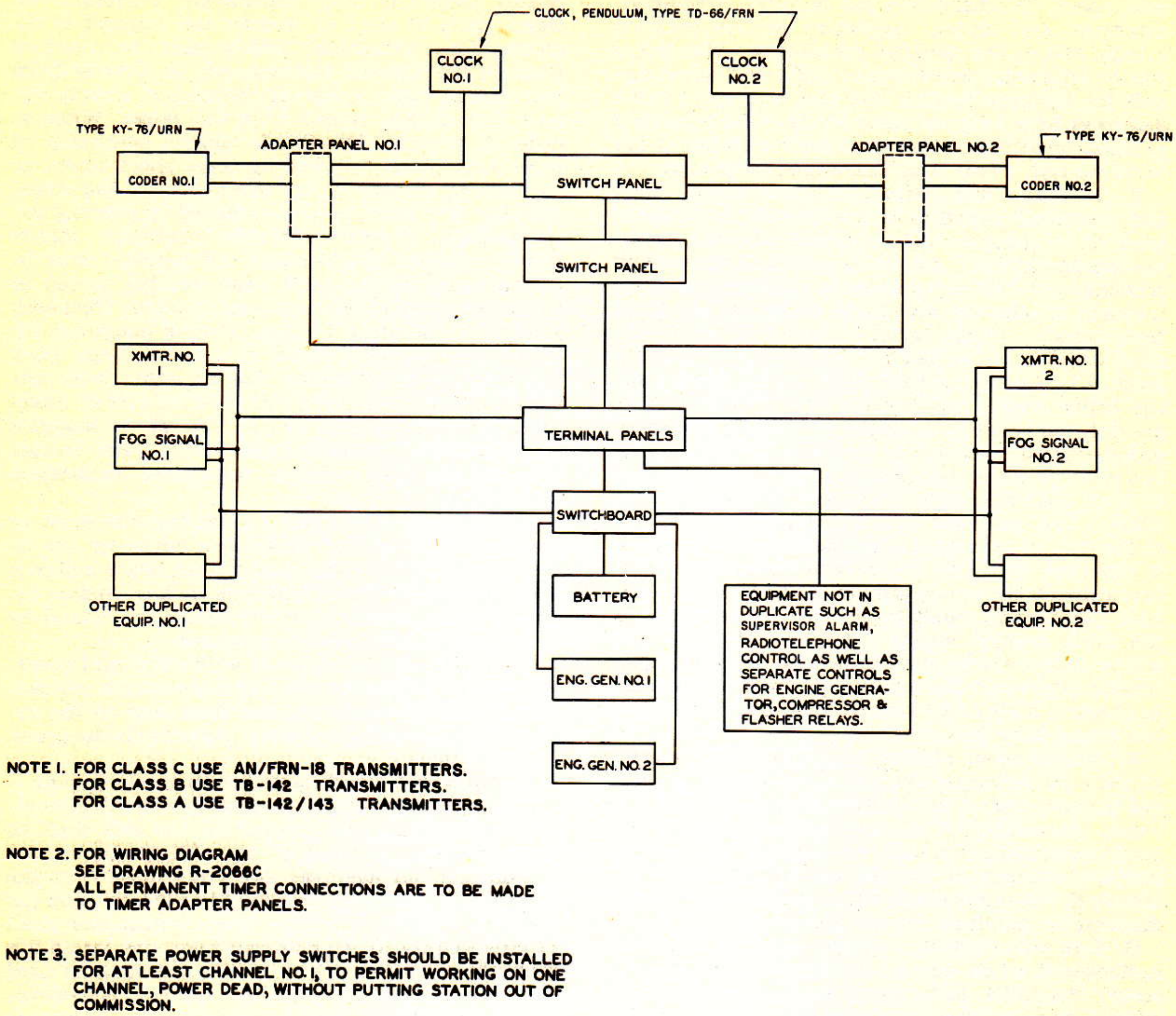

FIGURE 26–34.—Coding and timing equipment—block diagram.

ing officer and posted near the radiobeacon to aid the personnel in maintaining and servicing the apparatus. The instructions should include sufficient data to enable the station personnel to locate minor trouble and properly replace tubes, fuses, and brushes, adjust speed of timers, clocks, etc., and to clean and lubricate the equipment properly.

O. *Tube replacement.*—Each tube installed in transmitters having tube life meters shall be plainly marked with paint on the side of the base (not bottom) with reading of meter when tube is installed and again when tube is removed. The other meters, particularly the antenna ammeter, show when tubes are becoming defective. All meter readings shall be marked on a tuning chart on the front of each transmitter so that variations from normal meter-readings can be detected readily. Tubes should be replaced when antenna current and grid current meter readings show a progressive decrease in current. Senior officer present shall be responsible for bringing to the attention of Radio Maintenance Shop personnel any tubes in doubtful condition so they can be tested and marked.

P. *Maintenance repair parts.*—

(1) Units having spare parts boxes.

(*a*) The spare parts boxes furnished with the electronic equipment shall be maintained complete at all times.

(*b*) A list of authorized spare parts and tubes shall be prepared by the district electronic engineering officer for use with equipment for which spare parts boxes were not furnished. The quantities specified on this list shall be maintained complete at all times.

(2) *Units having the integrated electronic maintenance parts system.*—

This system shall be maintained in compliance with instructions issued with the system.

(3) *General*—

(*a*) Requisitions shall be submitted promptly for replacement parts as required.

(*b*) All defective parts and tubes shall be tested by inspection or maintenance personnel so that surveys can be made at regular intervals.

(*c*) A file of Stock Number Identification Tables shall be maintained for all installed equipment.

26–11 SAFETY

26–11–1 General—

A. Radiobeacon equipment employs voltages which are dangerous and may be fatal if contacted by operating personnel. These dangerous voltages are found in practically all portions of the transmitter. Although every practicable safety precaution has been incorporated in this equipment, the rules stated in the following paragraphs *must be strictly observed.*

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

C. *Don't service or adjust alone.*—Under no circumstances should any person reach within or enter the enclosure for the purpose of servicing or adjusting the equipment without the immediate presence or assistance of another person capable of rendering aid.

D. *Don't tamper with interlocks.*—Do not depend upon door switches or interlocks for protection but always shut down motor generators or other power equipment. Under no circumstances should any access gate, door, or safety interlock switch be removed, short-circuited, or tampered with in any way, by other than authorized maintenance personnel, nor should reliance be placed upon the interlock switches for removing voltages from the equipment. No interlock protection is provided on the side panels which are semipermanently screwed in place. These panels must never be removed while power is on except by qualified technical personnel.

E. Even though the key or keying relay may be open or not energized, and even though there may be no plate current visible, tube filaments may be at *dangerous potentials.* Before measuring filament voltages or coming in contact with filaments or any other leads, be sure plate voltage is off.

F. Connect a heavy wire securely to a good electrical ground, and place a suitable insulating handle on the free end of the wire, letting the wire protrude. Touch this grounding wire to every piece of apparatus before you touch it or work on it when power is off the equipment. When power is on the equipment, do not touch any inside part.

G. It should be determined by trial that clocks, timers, or other remote controls will not turn on or operate equipment during repairs. Extreme care shall be observed and a DANGER SIGN kept posted to describe the conditions under which internal adjustments are permitted.

H. Antenna and lead-in wires can be a source of extremely harmful burns if contact is made while a transmitter is operating. DO NOT WORK ON EQUIPMENT WHILE IT IS OPERATING AND NEVER WHILE ALONE.

I. Danger signs are placed in plain view adjacent to high voltage equipment. *DO NOT REMOVE.*

J. *Resuscitation.*—All operating and maintenance personnel should be thoroughly familiar with approved methods of resuscitation.

K. *Fuses.*—Never replace a fuse with one of higher rating. If a fuse burns out immediately after replacement, do not replace it a second time until the cause of such burnout has been corrected.

L. *Gasoline* must not be used for cleaning purposes. Do not use carbon tetrachloride for cleaning where lubrication is used, or in poorly ventilated spaces.

M. Never measure potentials in excess of 1,000 volts by means of flexible test leads or probes.

N. Under certain conditions *dangerous potentials* may exist in circuits with the power controls in the OFF position due to charges retained by capacitors. Always use a shorting bar to discharge all filter capacitor circuits before touching any parts inside the transmitter covers.

O. *A bull's-eye* is located on the front panel of most lower power supply units and should be observed periodically for proper operation. When lighted it indicates that high voltage is available in the set and that it is dangerous to enter the transmitter.

This light is a safety device but is not infallible since the light may be inoperative and the high voltage still be on. This condition might subject the unsuspecting person to serious injury should he take it for granted that the high voltage is off.

26–12 RADIO DIRECTION FINDERS FOR SHIP USE

26–12–1 Description—

A. The radio direction finder is an instrument for observing, by means of radio, the direction of a station sending radio signals. Briefly, in navigation, it is an instrument for taking radio bearings. As generally used in marine navigation in the United States, it consists of a loop antenna mounted above the ship's pilot house, with its axis extending downward into the pilot house, and carrying a handwheel and reference indicator over a magnetic compass, dumb compass, or gyro repeater in the pilot house. (See fig. 26–4.) This loop can be rotated by the navigator or observer. The loop is connected to a radio receiver in the pilot house. Using this receiver, the navigator picks up the desired station, then revolves the loop and notes the varying strength of the signal until a point is reached where the signal is lost entirely or nearly lost. This is called observing the minimum. At this point the plane of the loop is perpendicular to a line connecting the ship and the station heard, and the reference indicator is so placed with respect to the loop that it then points directly to the station. A "sense" antenna, a separate vertical wire, is then added to the circuit by means of a switch or push button and the signal observed either increases or decreases in volume. An increase in volume of the signal indicates that the radiobeacon observed is in the direction shown by the sense indicator; a decrease in volume of the signal indicates the direction is 180° from that shown by the sense indicator. Such radio bearings may then be used in navigation on the same general principles as sight bearings are used.

B. In a well-designed and adjusted radio direction finder, the point of minimum, or no signal heard, is sharp, and bearings may be taken with an accuracy of 1° or 2°. Even when the minimum is not well defined, a fairly accurate bearing may be obtained by swinging the loop to each side, until the signal becomes just audible, and taking the mean of the readings in these two positions.

26–12–5 Method of Operation—

A. The method of radio direction finding is based on the directive properties of the so-called coil antenna when used for the reception of radio signals. The radio direction finder includes a coil antenna, and operates on the principle that the amount of electromotive force induced in a vertical loop of wire by an arriving electromagnetic wave depends on the angle between the plane of the loop and the wave front. When the plane of the coil is parallel to the direction of the sending station, the intensity of the signal will be a maximum. As the coil is rotated, the intensity of the signal diminishes until a minimum is reached when the plane of the coil comes to a position at right angles to the line of direction of the signal. The directional characteristic of a coil antenna is illustrated by the diagram in figure 26–35 where the distance from the center of the coil to any point in the circumference of the circles is proportional to the strength of the signal from a direction passing through that point.

B. As the diagram indicates, the minimum is well defined, and the maximum is not; that is, the strength of the signal varies rapidly with movement of the coil near the minimum, but varies slowly with movement near the maximum. For this reason the minimum is used in observing bearings. Otherwise there would be important advantages in taking bearings on the maximum, in the way of greater audibility and of thus diminishing the effect of interference.

C. In a rotatable coil of practicable size the voltage induced by a radio signal is very small. For the employment of such small coils for radiocompass purposes it is essential that there be great amplification; therefore the introduction of the multistage electron tube amplifier was an important step in making the instrument usable for navigation.

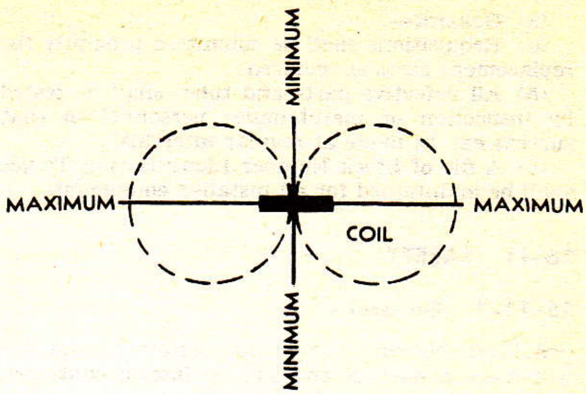

FIGURE 26–35.—Illustrating the directional characteristic of a coil antenna.

D. The radio direction finder should preferably be installed in a position easily accessible to the ship's navigator. The navigator desiring to take a radio bearing simply closes a switch, adjusts a single tuning condenser until the characteristic signal of the desired radiobeacon is heard, and rotates the radio direction finder coil until the sound becomes a minimum or is inaudible, checks the "sense" indicator to avoid the 180 degree ambiguity, and then reads the radio bearing. No knowledge of radiotelegraphy is necessary on the part of the navigator.

E. It is especially important that a radio direction finder should have good selectivity, so as to be able to eliminate interference from other radio signals on other frequencies when taking a bearing. For the usual needs of navigation it is not essential that it be capable of taking radio bearings from great distances.

F. There are several other types of radio direction finders in other countries, the most widely used of which is the fixed-loop (Bellini-Tosi) direction finder, which employs a small rotatable search coil.

26–12–10 Principles of Operation—

A. The radio direction finder makes use of the directional receiving properties of the coil type of antenna. Such an antenna, consisting of several turns of wire wound into a large coil, has the property of receiving a radio signal with maximum intensity when the plane in which the coil is wound is in the line of direction to the transmitting station. When the plane of the coil is at right angles to this line of direction to the transmitting station, a minimum signal is received. A radio wave from a transmitting station spreads out in all directions very much as water waves on the surface of a quiet pond when a stone is dropped in. The length of a radio wave is the distance between successive crests of the wave; the number of crests passing a given point per second is the frequency, and the product of the wave length and frequency gives the velocity of the radio wave. The product of these two factors (wave length and frequency) is always about 300,000,000 meters (186,300 miles) per second. Radio waves are accompanied by a magnetic force which is horizontal and at right angles to the direction in which the waves are traveling. As a radio wave passes a given point, the magnetic force, or field strength, varies from moment to moment from a maximum in one direction through zero to a maximum in the other direction. At a given point the cycle from maximum in one direction back to maximum in the same direction is performed in a very small fractional part of a second.

B. The above discussion considers the behavior of the radio direction finder from the point of view of the magnetic field. Radio waves are also accompanied by a field of electric force which is vertical and at right angles to the direction in which the wave is traveling. The behavior of the direction finder may also be considered from the point of view of this field of electric force. This latter method involves the phase angle between the two vertical sides of the coil. When the plane of the coil is perpendicular to the direction in which the wave is traveling, the crest of a wave reaches both sides of the coil at exactly the same instant, and the voltages induced in the two vertical sides are equal and oppose each other, so that no current flows in the coil circuit. When the coil is turned in any other direction, at the instant when a wave crest reaches one vertical side of the coil the crest has not yet reached or has already passed the other vertical side of the coil, so that the voltages induced in the two sides are not equal and do not neutralize each other, and a flow of current in the coil results.

C. If a coil of wire is held in a fixed position, so that the lines of magnetic force thread or pass through the coil and are not parallel to it, while the magnetic field varies in intensity, as is the case with that accompanying the radio wave, an electromotive force or voltage will be induced in the coil.

D. Since the magnetic force is horizontal and may be thought of as forming circles around the transmitting source, the compass coil when turned with its plane parallel to the direction of the transmitting station is threaded by the maximum number of magnetic lines of force, and the signal heard in the telephone receivers is a maximum. When the plane of the coil is turned at right angles to the direction of the transmitting station no magnetic lines of force thread through the coil, and therefore no voltage and no current are induced in the coil and no signal will be heard in the telephone receivers. At positions intermediate between these two the voltage induced in the coil varies, as indicated in the diagram in figure 26–35.

E. Addition of an auxiliary antenna to the system will add to or subtract from the received signal. The additive signal indicates the plane of the loop is in the direction of the station observed; a subtractive effect indicates that the station observed is 180° from the sense indicated.

26–12–15 Precautions in Use—

A. Reference has already been made to the so-called "land effect" and "night effect," and to the corrections required when plotting long-distance radio bearings on Mercator charts.

B. It is of great importance that the radio direction finder be properly installed and carefully adjusted. After installation it must be calibrated, and the deviations, mainly due to the structure of the ship itself, must be mechanically compensated or tabulated for use as corrections. The calibration results should be fairly constant, but in the present state of development this cannot be depended upon. The correctness of the radio direction finder bearings should be checked at all convenient opportunities, and to facilitate this is one object of the frequent scheduled operation of the radiobeacons in clear weather. A ship in a known position and in sight of a radiobeacon station may readily check the radio direction finder by comparison between the sight bearing and the radio bearing.

C. An observed radio bearing from a ship may be affected by various variable errors, such as changes in position of wiring, bonding of rigging, metallic guys, antenna leads, condition of other radio circuits on board, etc.

D. Care must be taken not to confuse a radio bearing and the reciprocal bearing. In the early days of radio bearings a serious disaster resulted from such confusion. The simple radio direction finder gives the line of direction of the radio signal but does not indicate on which side of the coil the signal originated, so that there may be an uncertainty of 180° in the resulting bearing. Ordinarily, the navigator knows the general direction of a radiobeacon, and this ambiguity may be unimportant, but in certain cases it may become of great importance, as, for example, in seeking a vessel in distress.

E. Methods are readily available of determining from which side the signal comes by an observation separate from that of taking the accurate bearing, and a sense-finding attachment is provided with radio direction finders. For this purpose it is necessary only to destroy the symmetry of the coil's directional characteristic in some way. There are several methods of accomplishing this which have the effect of temporarily coupling a supplementary fixed antenna to the coil antenna, so that when the plane of the coil is in the direction of the signal in one position the effect of the vertical antenna will be additive to that of the coil, and in the reverse position it will be subtractive, and the system is so adjusted that when the fixed antenna is introduced the signal strength will be increased in one position and decreased in the reversed position.

26–12–20 Automatic Direction Finders—

A. Automatic direction finders presently in common use in this service are of two basic types. One type is the "Hunting" loop or null-seeking loop automatic direction finder using needle-pointer type of bearing presentation. This type of bearing presentation is unambiguous, i. e., sense information is continuously and automatically utilized to position the needle-indicator to the proper bearing. In this case, the length of time taken for the needle to reach the proper bearing indication is a function of the strength of the signal and (in the case of keyed signals) the duty cycle of the signal. The second basic type of automatic direction finder is the instantaneous crossed loop type with a cathode-ray tube used for bearing information. This type of direction finder is ambiguous, that is, the direct and reciprocal bearings are both presented on the cathode-ray tube as bearing information. However, provision is available for the operator to quickly resolve this ambiguity.

B. *"Hunting" loop or null-seeking loop automatic direction finder (ADF)*.—This type of ADF is used primarily on Coast Guard aircraft and has had limited use on Coast Guard vessels. The principal advantage of this equipment is one of operation. The bearing is indicated by a needle-pointer on a dial calibrated continuously in degrees. This type of presentation allows the navigator to see the bearing at a glance and at all times to ascertain whether the aircraft or vessel is headed to the right of, to the left of, or towards the transmitting station. Aural monitoring of the signal may be carried on during this operation.

(1) Basically this ADF consists of a rotatable loop antenna, sense antenna, radio receiver with an associated electro-mechanical system for the purpose of automatically positioning the loop to a null position and transmitting this position to the needle-pointer indicator as bearing information. The output of the loop is combined with the output of the sense antenna in the receiver in such a way that the resulting signals are utilized to control, through supplementary circuits, the position of the loop relative to the source of the signal which is being received. The circuits are so designed that the loop automatically rotates until it reaches a null position (position where the loop has minimum pickup). In this null position the loop is physically broadside to the source of the signal as in a standard aural null radio direction finder. Inasmuch as the loop has a bidirectional response pattern (180° ambiguity), the output of the sense antenna is continuously utilized to effect unambiguous bearing presentations for this ADF. The null position of the loop is transmitted to the bearing or azimuth indicator by either mechanical or electrical means. It follows that the angle which the needle-pointer assumes relative to the index, or dead-ahead position will correspond to the angle between the transmitting station and the dead-ahead position of the aircraft or vessel.

(2) This type of equipment is capable of providing the following modes of operation:

(*a*) Automatic visual bearing indication of the direction of arrival of radio frequency signals.

(*b*) Aural-null directional indications of the arrival of radio frequency signals.

(*c*) Aural reception of the signals in either of the two above modes as well as aural reception of the signals with either the loop or the nondirectional sense antenna.

C. *Instantaneous, crossed loop automatic direction finder* (ADF).—Typical of the direction finders used on the larger Coast Guard vessels and on many vessels of the merchant fleet is the instantaneous type, crossed loop automatic direction finder. This type of ADF is instantaneous in that bearing information is presented on a cathode-ray tube immediately upon reception of the signal as tuned in by the receiver.

(1) The antenna system for this ADF consists of fixed crossed loops and a vertical sense antenna. Each loop and the sense antenna is connected to the receiver-indicator through separate, identical transmission lines. The antenna system is designed to permit long lengths of transmission lines which are normally encountered on the larger vessels.

(2) The two crossed loop antennas are positioned at right angles to each other and are shielded, balanced and electrically matched to provide the necessary phase and amplitude tracking over the complete frequency range of the equipment. The loop transmission lines connect to the signal channel of the receiver through a goniometer. The goniometer is a rotating radio frequency transformer which combines the outputs of the two stationary loop antennas in proper relationship and supplies the output from a rotor to the directional input channel of the receiver. Rotation of this motor-driven goniometer produces the same result that would be obtained by rotating a single loop antenna.

(3) Bearings are indicated on the cathode-ray tube in the form of a figure-of-eight pattern or twin leaf pattern. The tips of this pattern indicate, on a graduated scale, the direct and reciprocal bearing of the transmitting station. This 180° ambiguity may then be resolved by momentarily introducing the output of the sense antenna into the receiver with the result that the bearing pattern is distorted into an approximate arrowhead indicating to the operator the direction of the transmitting station.

(4) Two additional modes of operation are available for the purpose of manually taking bearings with this equipment. The first is the matched-line method where a second manually operated goniometer is rotated until two lines, on a 2-inch cathode-ray tube which is also built into the equipment, are matched in height. When this condition is reached the bearing of the transmitting station can be read on the calibrated dial which is attached to the goniometer. The second method available is taking bearings by null methods. The nulls may be observed aurally on the loudspeaker, or visually on the cathode-ray tube in the receiver.

26–13 SOURCES OF ERROR IN RADIOBEACON NAVIGATION

26–13–1 General—

A. The distortion of the direction of radio signals caused by the vessel itself is determined by calibration, and generally is eliminated by mechanical compensation when the installation is made, for the various types of direction-finding instruments on board ship; otherwise calibration corrections are determined and applied to the bearings. While this compensation or correction should, under favorable conditions, be reasonably constant, it is important that the calibration be tested as opportunity offers. This is much facilitated by the frequent operation of the radiobeacons, as on hourly schedules, permitting the direct comparison of radio bearings with sight bearings. Sources of error due to unusual cargo, or extraordinary conditions on the vessel, are to be guarded against, as would be the case with a magnetic compass. With a radio direction finder of suitable design, properly installed, adjusted and calibrated, it should be possible to obtain radio bearings correct to within 1° or 2°.

B. The necessity of allowing for convergency in plotting long radio bearings on Mercator charts has been mentioned.

C. Night effect and land effect are two possible sources of error, outside of the radio equipment itself, but neither of these has been found to be a serious obstacle in the use of this system in this country under the usual limitations.

D. Night effect is an apparent and fluctuating distortion sometimes noted in radio bearings when observations are made near sunrise or sunset or during the night. The results of a special test made on Cape Henry radiobeacon in 1924, and of some years of experience with the radiobeacon system, are that such disturbances do not seriously affect the value of radio bearings for navigational purposes, with the character and limitations of the signals as used. The principal effect of these disturbances is to somewhat increase the difficulty of taking radio bearings, but this difficulty serves as a warning of the need of care and the need of taking repeated bearings. It is found that under these conditions a good direction may often be obtained by taking the average of a number of bearings.

E. It is sometimes stated that radio bearings intersecting the shore line or passing over the land are distorted sufficiently to introduce appreciable error. From the experience thus far had in the United States this is not found to be the case, and the results of a number of tests made indicate that in the practical use of the radiobeacon system as operated here, bearings taken with radiocompasses on ships are not deflected to an amount affecting their use in navigation when they pass over land or intersect or skirt the coast, *provided that the vessel from which the bearings are taken is not at a* dock *or in too close proximity to the shore.*

F. In October 1927 extensive radiobeacon tests were made from 100 steamers on the Great Lakes, and these included 332 bearings which passed in part over the land. When allowance is made for their greater average distance, the bearings partly over land are found to be substantially as correct as the bearings entirely over water. These bearings furnish a rather extreme test of radio bearings over land from the navigational point of view, as many of the bearings cross the land and water boundaries a number of times. There were reported eight bearings taken at distances from 275 to 390 miles, crossing the great peninsulas between the lakes, and in two cases skirting the shore of a lake for long distances. The average error of these eight bearings as reported was 1.1°.

G. Unfavorable results were obtained in several cases where bearings were taken from a vessel at a dock, or from a vessel close to the shore.

H. It is the general experience that fog has no effect on radio bearings in the radiobeacon frequency band.

26–14 PLANNING A NEW RADIOBEACON ESTABLISHMENT

26–14–1 General—

A. *Selection of frequency.*—The frequency, operating structure and characteristic code for a new radiobeacon are selected by Headquarters after an engineering study has been made of the various pertinent factors. Some of these factors are the class, distance, bearing, and frequency of adjacent radiobeacon stations and their probable field strength at the edge of the service range of the proposed radiobeacon, taking into account relative field strength due to directivity of direction finder loops and tolerable interfering signal strength. Such a study may include field measurements in the vicinity of the proposed site, in cases where calculations indicate that interference is probable.

B. *Duplicate installation.*—In order to insure continuity of service, radiobeacon transmitting and control equipment is always installed in duplicate, with means for switching to the standby equipment, as indicated in figure 26–34. Power plants are also installed in duplicate, but only one storage battery is required (where used.) For a typical wiring diagram of a radiobeacon station, refer to figure 26–36.

26–14–5 List of Drawings—

A. The drawings listed below are sources of information on radiobeacon equipment and may, upon request, be obtained from Headquarters in large blueprint form. They are reproduced in this chapter, and are referred to by figure number:

Figure 26–5.—Drawing R–2106: Operating Schedules for Radiobeacons. Radiobeacon Stations.

Figure 26–31.—Drawing R–2107A: Control Equipment—Rack Layout.

Figure 26–6.—Drawing R–2443: Sample Coder Cam Sheet.

Figure 26–37.—Drawing R–2141: Radiobeacon Propagation Data.

Figure 26–25.—Drawing R–2124A: LSR–623, MR–180, Steel Rack and Accessories.

Figure 26–34.—Drawing R–2108: Coding and Timing Equipment—Block Diagram.

Figure 26–36.—Drawing R–2066C: Control Panel Wiring Diagram.

Figure 26–11.—Drawing R–2470: Class D Radio Marker Beacon Arrangement and Wiring.

26–14–10 Instruction Books—

A. The instruction books supplied with each type of equipment should be referred to for detailed information not otherwise available. See part 26–4 for further data on instruction books.

26–14–15 Planning Data to be Submitted—

A. The following data should be submitted with form CG 3439 for new radiobeacon establishments:

(1) Equipment layout sketch (plan and elevation).

(2) Antenna sketch (plan and elevation).

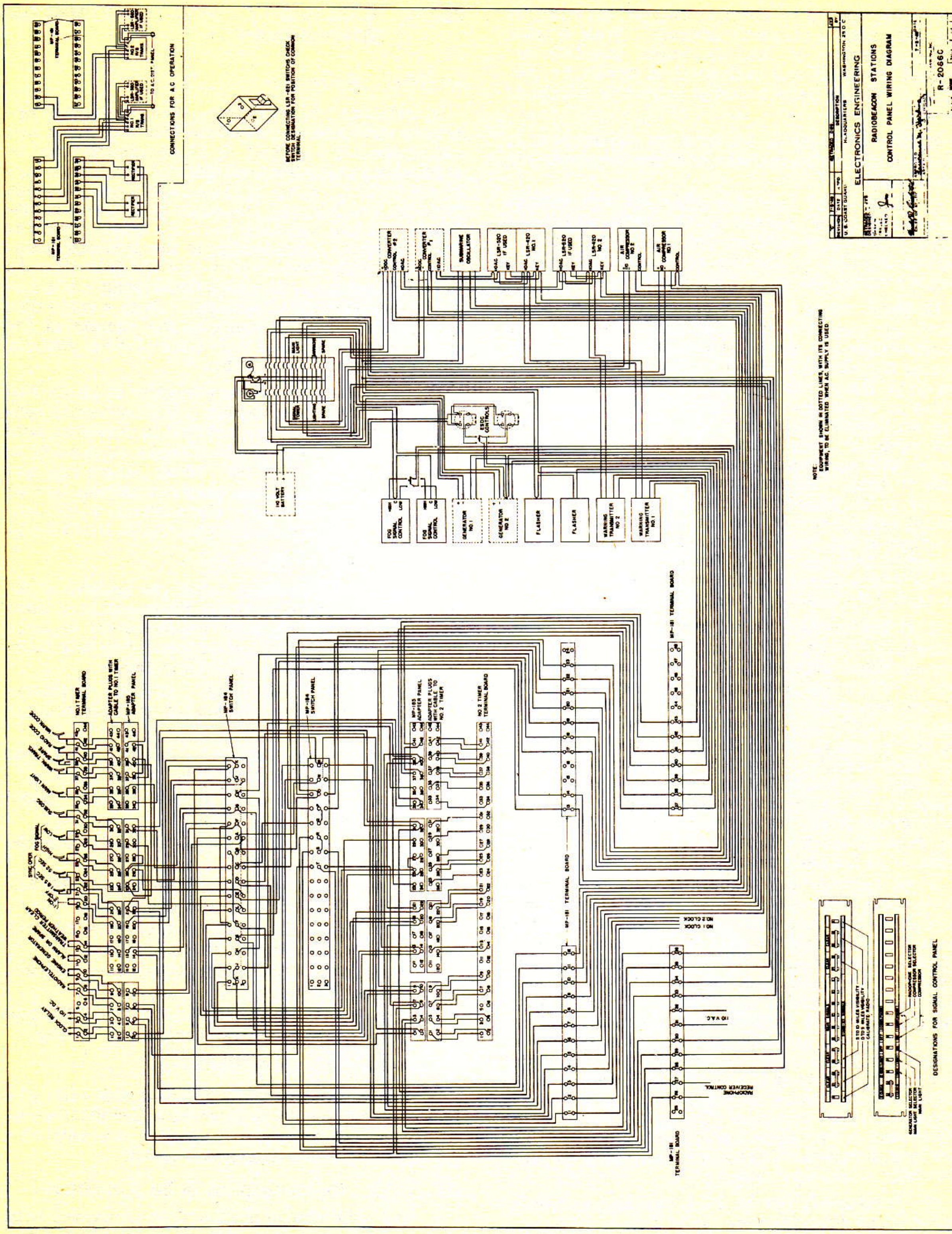

FIGURE 26–36.—Control panel wiring diagram.

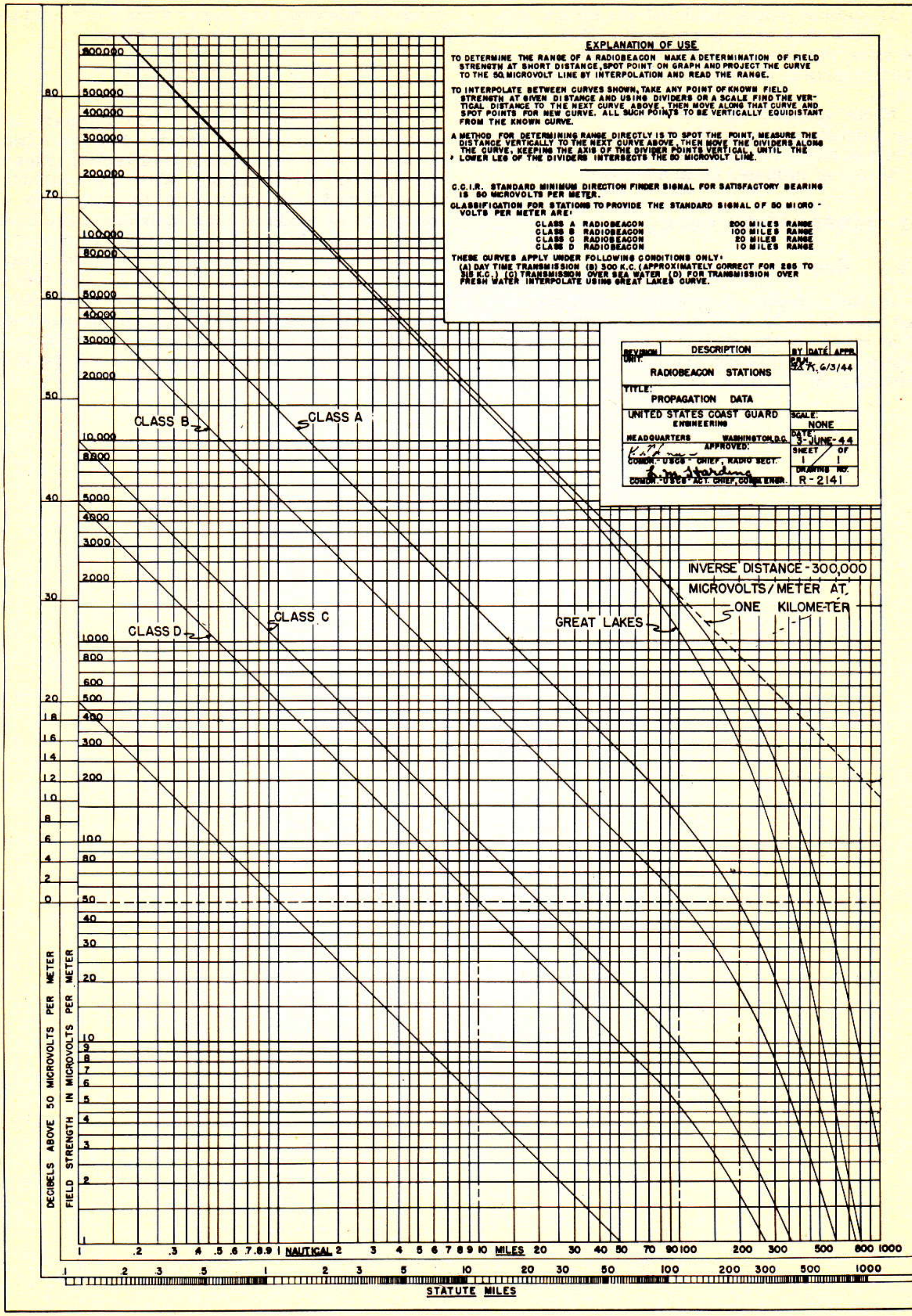

FIGURE 26–37.—Propagation data.

(*a*) At stations where insulated towers are proposed, a plan view only is required. This sketch should show the relative positions of antenna and transmitter house, as well as of other adjacent structures.

(*b*) If an existing light is in the immediate vicinity, indicate its bearing in degrees true and distance in feet from the antenna tower or lead-in.

(3) Sketch of proposed ground system.

26–15 PROPAGATION DATA

26–15–1 General—

A. *Nominal ranges.*—Radiobeacon stations are divided into classes A, B, C, and D, according to the effective range of the signals. The range is dependent on radiated power and effectiveness of the antenna system. Nominal ranges (the distances at which 50 microvolt per meter signals are produced during daylight hours) are listed below:

A—200 miles.	C—20 miles.
B—100 miles.	D—10 miles.

B. *Field strength.*—Ranges were formerly estimated from field strength charts which were based on field strength measurements of typical antennas and on transmitter power. With the availability of small field strength meters, measurements are now generally made on each individual installation. They are usually made at one mile, converted by use of field strength charts to the specified distance (to determine conformity with class), and reduced or increased if necessary by adjustments of antenna current. At present, field strength measurements are being made with the IM–101/V Field Strength Meter, as more precise equipment is not generally available.

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