MARINE RADIO SERVICES

51RC

Finished Nov. 4, 1960

NATIONAL RADIO INSTITUTE

ESTABLISHED 1914

WASHINGTON, D. C.

PIONEER HOME STUDY RADIO-TV SCHOOL

NRI

STUDY SCHEDULE No. 51

For each study step, read the assigned pages first at your usual speed, then reread slowly one or more times. Finish with one quick reading to fix the important facts firmly in your mind. Study each other step in this same way.

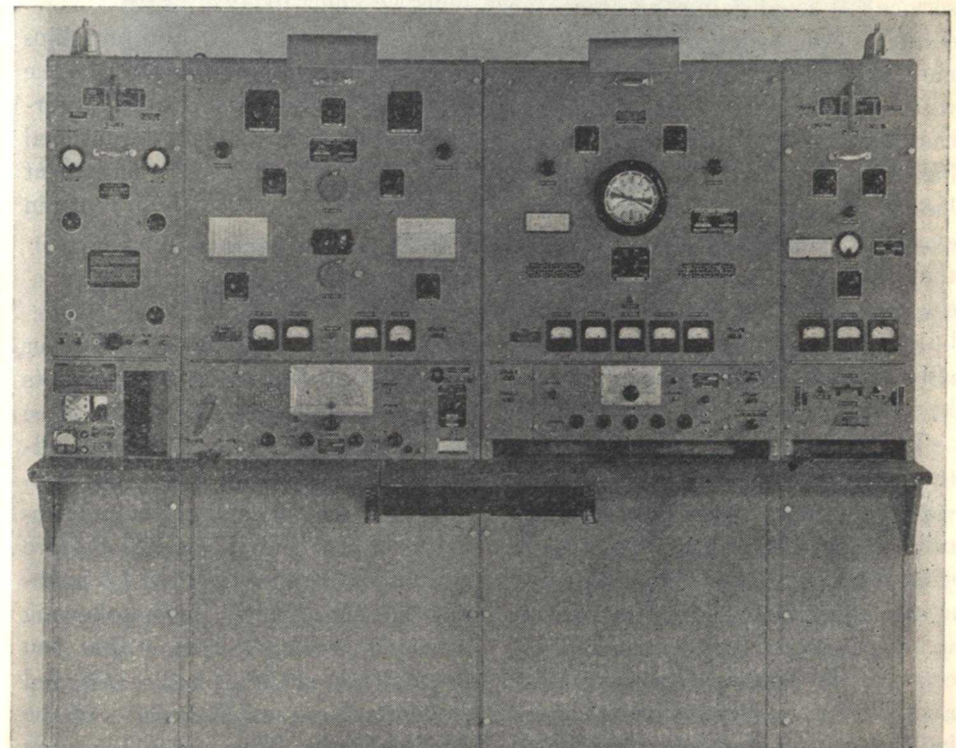
JDL1M1157 1958 Edition Printed in U.S.A.

MARINE RADIO SERVICES

Development of Marine Equipment

BASICALLY, we can divide the large field of Radio Communications into two sections—*broadcasting,* which is the dissemination of entertainment; and *commercial services,* in which some form of message is sent from one point to another. In turn, the latter category can be further subdivided. Some commercial stations are telephone or telegraph stations engaged in sending telegrams or private messages from point to point. Another class deals with aviation exclusively, and involves transmission of messages to and from planes, as you will learn in later Lessons. A third large communications branch is that dealing with marine radio—the sending of messages to and from ships at sea or on the Great Lakes.

It is with the latter class of commercial service that this and the next



Courtesy Radiomarine Corp. of America

This is the front view of the RMCA 4U, a modern all-in-one package unit for shipboard installation.

several Lessons will be concerned. Although the marine service properly includes shore stations that communicate with ships, the shore station equipment is standard in design, and will not be covered here. (You can gather the operating requirements for shore stations from the following Lessons.) We shall deal only with shipboard equipment and its operating procedures in these Lessons on marine radio. Before we go into the technical details of the equipment used, however, let's learn something of the requirements placed on marine equipment.

Perhaps the most important fact to keep in mind about marine radio is that it is classed as an *emergency* service. It is all-important that the equipment operate under even the most adverse circumstances. As you will realize, a breakdown in a broadcast station, or in one handling commercial telegrams may mean only a loss in revenue to the station. However, in an emergency service (such as that dealing with ships or airplanes), the operation of the radio equipment becomes of vital importance—valuable cargoes and even lives may be lost as a result of a radio failure.

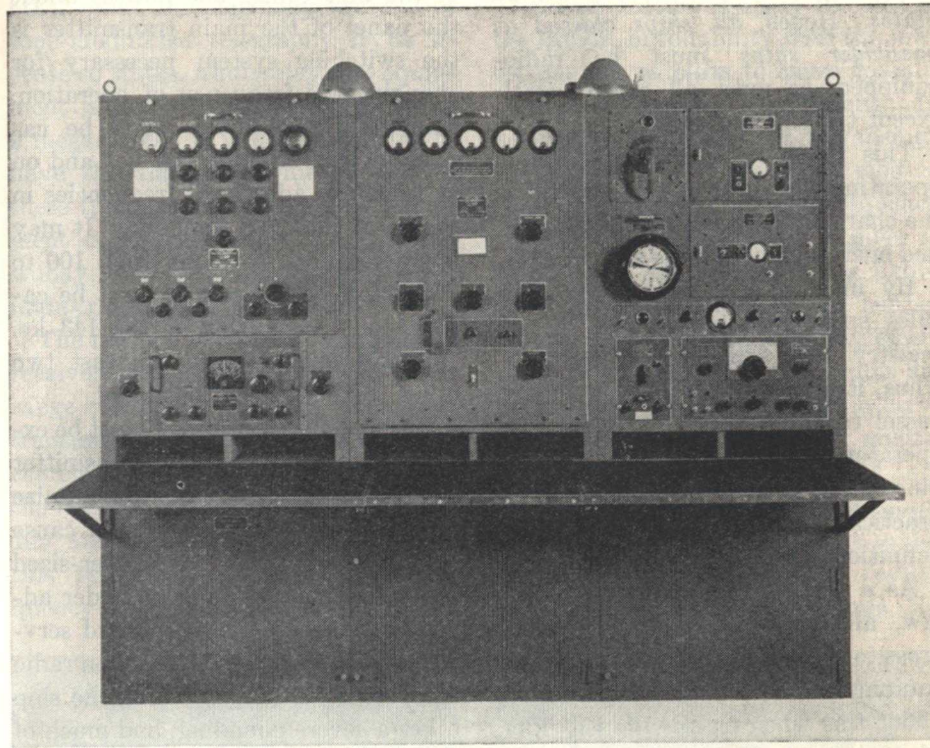
This idea of safety is involved in the entire history of radio aboard ship. One of the first uses to which radio equipment was put was aboard ship. Until the advent of radio, when a ship disappeared over the horizon, it lost all contact with humanity except for an occasional meeting with another ship on the high seas. Ships had no way of knowing what might lie ahead in the way of stormy weather, icebergs, or other dangers to navigation. Should anything happen aboard ship—a fire, or a leak in the hull, or illness among the crew—it had no way of summoning aid until another ship chanced to come in sight, or land was reached.

Almost as soon as it was proved that radio waves would travel beyond the horizon, various forms of shipboard installations were tried out. It took only a few dramatic examples of the power of radio to summon aid, to bring about the formation of companies to develop equipment specifically for shipboard service. Thus was born perhaps the earliest commercial use for radio. Out of this field, and from the field of amateur radio, eventually evolved the complex radio systems we know today.

At first, of course, only a few ships were radio-equipped. However, as the value of radio was proved, international agreements and international laws soon made radio equipment mandatory aboard ships of certain classes.

RADIO-EQUIPPED SHIPS

The United States joined with other countries in setting up requirements for radio-equipped ships. From time to time, these laws have been amended to take advantage of new developments, so that in general, the requirements of the United States today are stricter than those required by international agreements. In the following discussion, we shall assume that you are a citizen of the United States, and therefore come under the laws of the United States. This means that you can become eligible to operate only on ships that are entered in the U. S.



Courtesy Mackay Radio and Telegraph Co.

This is the Mackay FT-106 marine package unit, another typical modern shipboard transmitter-receiver combination.

Registry. In general, only citizens of a particular country may operate aboard ships registered in that country. In any event, anyone interested in operating on a ship other than one in the U. S. Registry should consult the laws of his own country to find exceptions to the following statements.

In the registry of the United States, there are two classes of ships—cargo and passenger. *A passenger ship is any ship that carries or is licensed or certified to carry more that 12 passengers.* A passenger is defined as any person carried *except* the officers and crew actually employed to operate the ship, or persons employed to carry on the business of the ship. (Persons picked up at sea as a result of shipwreck or other similar circumstances are "survivors", not passengers.)

A cargo ship is any ship that is not a passenger ship. Notice carefully this distinction—many freighters are equipped to carry small numbers of passengers. Even if the ship is primarily a freighter, if it carries more than 12 passengers, it is legally classed as a passenger ship in so far as the requirements for the radio installation are concerned.

Under the Communications Act of the United States, *all ships, except cargo vessels under 1600 gross tons, must be radio-equipped before they* *can sail from a port of the United States.* Hence, *all ships classed as passenger ships* must be radio-equipped, as must all cargo vessels except the smallest ones.

This radio equipment must be in operating condition and must be in the charge of, and operated by, qualified operators, before the ship can sail.

By international agreement, these rules apply also to ships of foreign registry that sail from U. S. ports. Thus, it is possible to force a foreign vessel to equip itself and obtain an operator if it is to dock at U. S. ports. Since other nations have similar laws, practically all ships meeting these definitions are radio-equipped.

As a further requirement of U. S. law, all passenger ships over 5000 gross tons must have direction-finding equipment aboard. We will say more about this when we discuss this kind of equipment. Now, let's get a general idea of the pieces of radio equipment that may be found aboard ship.

THE "MAIN" EQUIPMENT

Although radio-equipped vessels may carry a number of different pieces of radio equipment, there will be one transmitter that is recognized as the *main* transmitter. In general, this transmitter normally operates from the ship's power supply and is required to have a daytime range of 200 miles or more.

Because of the necessity for changing frequencies (contacts between stations are established on one frequency and messages are sent on another), all marine radio equipment must be designed to operate on several different frequencies. Hence, one of the first things one notices about the panel of the main transmitter is the switching system necessary for changing the frequency of operation. The main transmitter *must* be capable of operating on 500 kc., and on at least two additional frequencies in the band from 365 to 500 kc. It may operate also in the band from 100 to 160 kc., in which case it must be capable of transmitting on the 143 kc. calling frequency, and at least two other frequencies in that band.

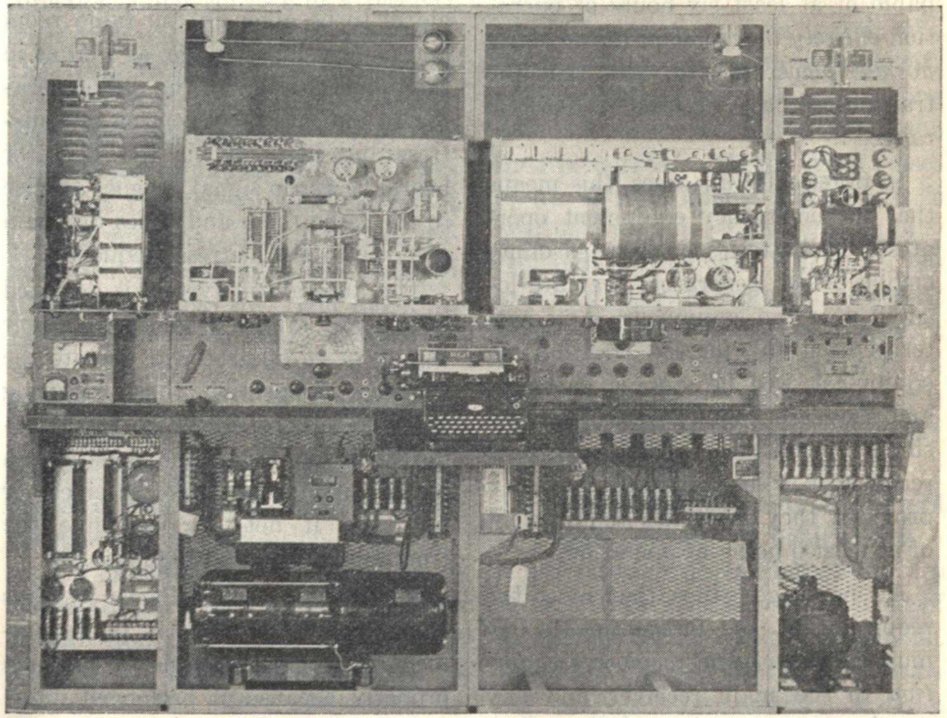
Because the transmitter must be extremely reliable, the main transmitter must have simple circuits to minimize the number of parts that might cause trouble, and will have over-sized parts, designed to stand up under adverse circumstances. Shipboard service can definitely put a strain on radio equipment. During a storm, the ship takes a severe pounding, and much of this shock is transmitted to the radio equipment. Furthermore, the normal operation of the ship itself places a strain on the radio equipment that it would never have to undergo at a land station. As a result, tubes are shock-mounted, and shock absorbers surround most of the transmitting equipment. Every part must be ruggedly constructed to withstand rough voyages, or so mounted that it cannot be damaged.

The main transmitter will be designed for code transmission, and is usually designed for both type A-1 and A-2 emission. Type A-1 (no modulation other than that of keying and thus interrupting the carrier radiation) is the *only* operation permitted in the 143-160 kc. section of the 100-160 kc. ship band. In the

other band, the ship may use A-2 or tone-modulated telegraphy if its license so states. *Radiotelephone* equipment is limited to frequencies above 2 megacycles. It is not customary to have the main transmitter tune to these frequencies, so any such equipment is supplementary, even though it may be in operation more than the main transmitter.

The receiver recognized as the *main* receiver is the one with the same range of frequencies as the main transmitter. In general, this receiver, therefore, is designed to operate in the low-frequency ship bands between 100 and 500 kc. In most instances, this receiver is a tuned-radio-frequency type of rather simple design. The main feature is again the idea of the utmost in reliability with the fewest number of parts to cause trouble.

High-Frequency Equipment. In addition to the usual main transmitter, a number of the more modern ships now carry a high-frequency transmitter and associated receiver to operate on the ship channels above 2000 kc. This equipment is neither considered main equipment nor emergency equipment. The ship bands are interspersed among other radio service bands, with the result that several bands, rather widely separated, are covered by this high-frequency equipment. Because of the difficulty in designing tuned-radio-frequency receivers for wide frequency coverage, the



Courtesy Radiomarine Corp. of America

For ease in servicing, the transmitter and receivers in shipboard package units "open up" on hinges, so as to expose the major parts and tubes, as shown here for the RMCA 4U.

high-frequency receivers are superheterodynes.

EMERGENCY EQUIPMENT

With the requirements of safety constantly in mind, ships must carry emergency equipment to supplement the main transmitter and receiver. If the ship is a passenger vessel, the emergency transmitter and emergency receiver are separate units having no direct association with the main equipment. On cargo vessels, however, if the main equipment can be made to meet the requirements of an emergency unit, then the main equipment may be so used. In general, these requirements are that the emergency transmitter and receiver be capable of at least six hours of operation *entirely independent of the ship's normal power supply,* and that the transmitter have at least a 100-mile range.

In practically all cases, this means that the emergency equipment operates from batteries or from gasoline-engine driven generators that are located near the equipment. Any batteries used to run the transmitting equipment will be storage batteries, and they are kept charged from the ship's power line. (The emergency receiver may use dry-cell batteries, provided they meet the requirement of at least 6 hours of operation.)

All passenger ships that meet the requirements of international law must carry a *crystal receiver, in addition* to the main receiver and any supplementary receiver. This crystal receiver must be capable of being tuned from 350 kc. to 515 kc., so reception can continue even if the *emergency* power supply should fail.

AUTO-ALARM EQUIPMENT

Ships that are required to be equipped with radio are also required to maintain a continuous watch on the international distress frequency of 500 kc. If the ship does not carry enough operators to permit twenty-four-hour operation of the radio room, it must be equipped with an automatic alarm (abbreviated as auto-alarm) system. The auto-alarm is a receiver that is tuned to the distress frequency, and a selector system that is designed to respond to the international auto-alarm signal. When this coded signal is received, the automatic selector system causes an audible alarm to be given in the radio room and on the ship's bridge, as well as in the living quarters of the radio operator, to indicate the reception of a distress message. When the operator hears the alarm signal, he goes at once to the radio room and tunes his main receiver to the distress frequency.

The auto-alarm system is designed so that any failure of the alarm power supply or equipment will operate the warning apparatus, thus requiring that the radio operator go to the radio room to determine whether an alarm signal has been received or not, and if not, to determine the trouble with the alarm equipment.

Furthermore, auto-alarm systems are designed so that, if the equipment is blocked or fails to function properly because of prolonged interference or static, a visual indicator will be operated on the ship's bridge. The radio operator will be warned by

the officer of the deck of this condition, so that he can readjust the sensitivity control of the alarm receiver.

When the operator is on duty, he is required to listen in on the distress frequency at regular intervals in order to catch any distress messages. The auto-alarm system is turned off when there is an operator on duty to monitor the distress band.

DIRECTION-FINDING EQUIPMENT

As was mentioned earlier, passenger ships of more than 5000 gross tons must carry direction-finding equipment. Many other ships even of the cargo category also carry equipment of this kind. Basically, the shipboard direction finder consists of a receiver with a directional antenna system of the loop variety. This receiver is tuned to a station having a known geographic position. The loop is then rotated for minimum response. Because of the directional qualities of a loop antenna, this minimum response will occur when the plane of the loop antenna is at right angles to the direction of the approaching radio wave. Hence, by means of a calibrated indicator system, it is possible to determine the direction of the transmitter from the ship, and by means of two or more bearings, to determine the ship's position.

The direction-finding equipment is under the care of the radio operator aboard ship, but he may not actually operate it. This equipment may be located on the bridge of the ship or in the chart room, and it may be operated by another of the ship's officers. However, the radio operator is required to maintain this equipment in good working order.

Loran. Another way of determining a ship's position is called "Loran" (*LO*ng *RA*nge *NA*vigation). In this system, groups of stations on shore send out accurately timed pulses. These signals are picked up aboard ship, and the difference in time between the reception of pulses from one source and the reception of pulses from another source is determined electronically. By referring to charts, it is possible to determine from this time difference a "line-of-position" on which the ship is located. The point where this line crosses a similar line-of-position, determined from the pulses of two other stations, is the ship's position.

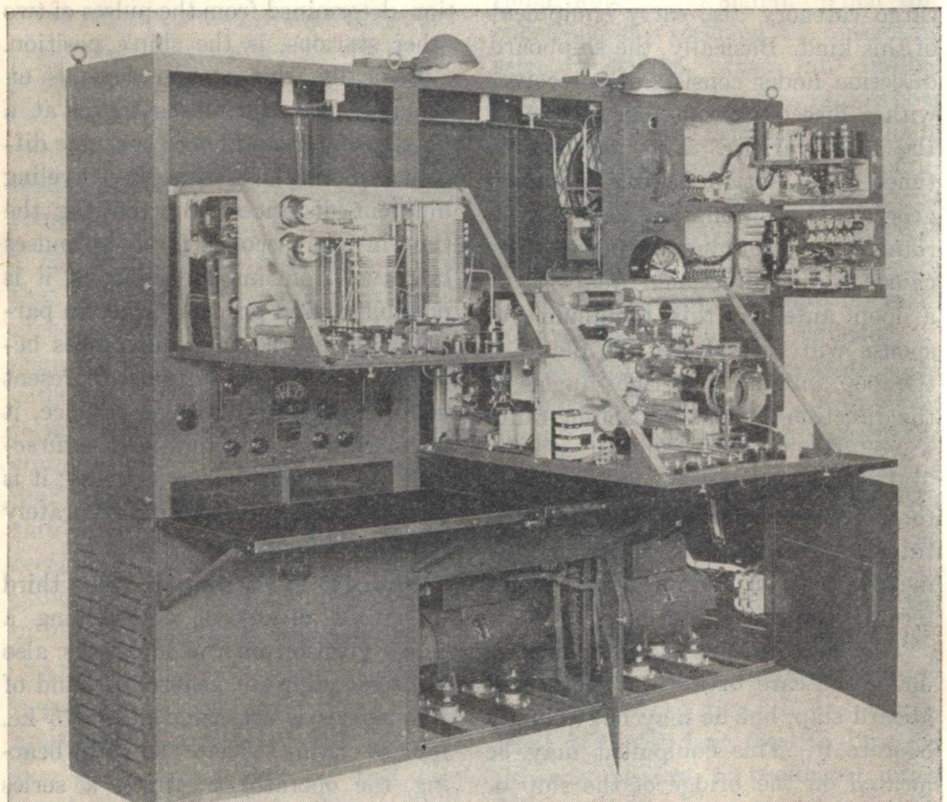
Basically, this system depends on the fact that the pulses travel at a fixed velocity, and hence consume differing intervals of time in traveling different distances. By plotting the time in microseconds for these pulses to travel from known positions, it is possible to find positions wherein particular measured time differences between a pair of stations represent fixed geographic positions. Hence, it is unnecessary to determine the *direction* from which the waves come; it is only necessary to measure accurately the *time difference.*

Shore D.F. Equipment. The third important means of determining a ship's position on the high seas also utilizes equipment ashore. A band of frequencies is set aside near 375 kc. for use of this service. To get a bearing, the operator transmits a series of dashes, and the receivers in several shore stations take bearings on the transmission by means of loop antennas. The bearings of the shore stations are then correlated and the ship's position determined by triangulation.

Radar. Finally, today, certain radar equipment is finding use aboard ship. Although this radar equipment is more generally used to determine obstacles in the ship's path, it can, to a certain extent, determine a ship's position because of its ability to render certain geographic details visible on the sweep pattern.

You are going to study more about all this equipment in later Lessons. However, in this brief description, we are merely trying to acquaint you with the kind of equipment that is found aboard ships. As you doubtless gather by now, a large ship carries a large amount of radio equipment.

Other Radio Apparatus. In addition to the foregoing equipment, many modern ships now have a certain number of radio-equipped lifeboats. Some lifeboats carry the type of transmitter that has an automatic clockwork mechanism to send a distress signal; this type can be operated by anyone. (Other ships use their direction-finding equipment to locate the position of the lifeboat transmitter



Courtesy Mackay Radio and Telegraph Co.

This is the open view of the Mackay FT-106. It and the RMCA unit were made to practically the same basic specifications, so they are quite similar to each other.

and thus effect rescue.) Other lifeboat equipment is simply a small portable unit that the radio operator must carry and operate.

Furthermore, many modern ships have a radio receiver for the entertainment of the crew when off duty. This receiver is usually located at a central point, and loudspeakers are installed in the crew's quarters and mess hall. Also, the luxury passenger liners all have elaborate radio receiver units and public address systems for the entertainment of passengers, and there may be several other receivers aboard for the use of the officers when off duty.

From all this, you can see that a large ship is really a floating radio station. The radio operator aboard ship has a far greater variety of equipment to operate and service than does the operator in most other fields. Before we go into the technical details of this equipment, however, let's learn more about the marine service in general, and see just what the operator is required to do.

Duties of Marine Radio Operators

Now that you have a general idea of the variety of radio equipment aboard the average ship, let us learn what is required of the radio operator. The exact duties aboard a particular ship will depend upon the number of operators aboard, and the assigned duties of each when there is more than one.

All cargo ships that are required to have radio equipment must have aboard at least one operator and an auto-alarm system, or two operators. All passenger ships that are radio-equipped must have *at least* two radio operators. Under normal conditions, when a ship has only one operator, he must be an operator who has had at least six months' experience as second operator aboard a ship carrying more than one operator.

Thus, you need never worry about going aboard ship absolutely alone—you will first be required to work aboard a ship having an experienced man to supervise your work. However, before going aboard, you will want to know something about the service, and even though experienced, you may run up against equipment you are unfamiliar with. Therefore, let's start from the beginning, by assuming that you have your operator's license and are ready to begin work.

An operator aboard ship must have at least a second-class *radiotelegraph* license. The telegraph license is required because the majority of marine messages are sent and received in the form of code. It is easy to see why this should be true—code signals will get through even heavy interference, and a far narrower band is used for code than for voice messages. There are hundreds of ship stations transmitting constantly, so it is important for a minimum of the ship radio band to be used for any one message. Even as it is, ship stations frequently are required to wait until others have finished before they can send their messages.

MAINTENANCE

The radio operator is required to repair and maintain his radio equipment when aboard ship, just as the radio operator at any land station would. However, since it is so important that the equipment be ready for any emergency, the test routines are far more detailed. The transmitters present few problems, as they are standard and are simple master-oscillator, power-amplifier types. The procedures used for any other transmitters apply here.

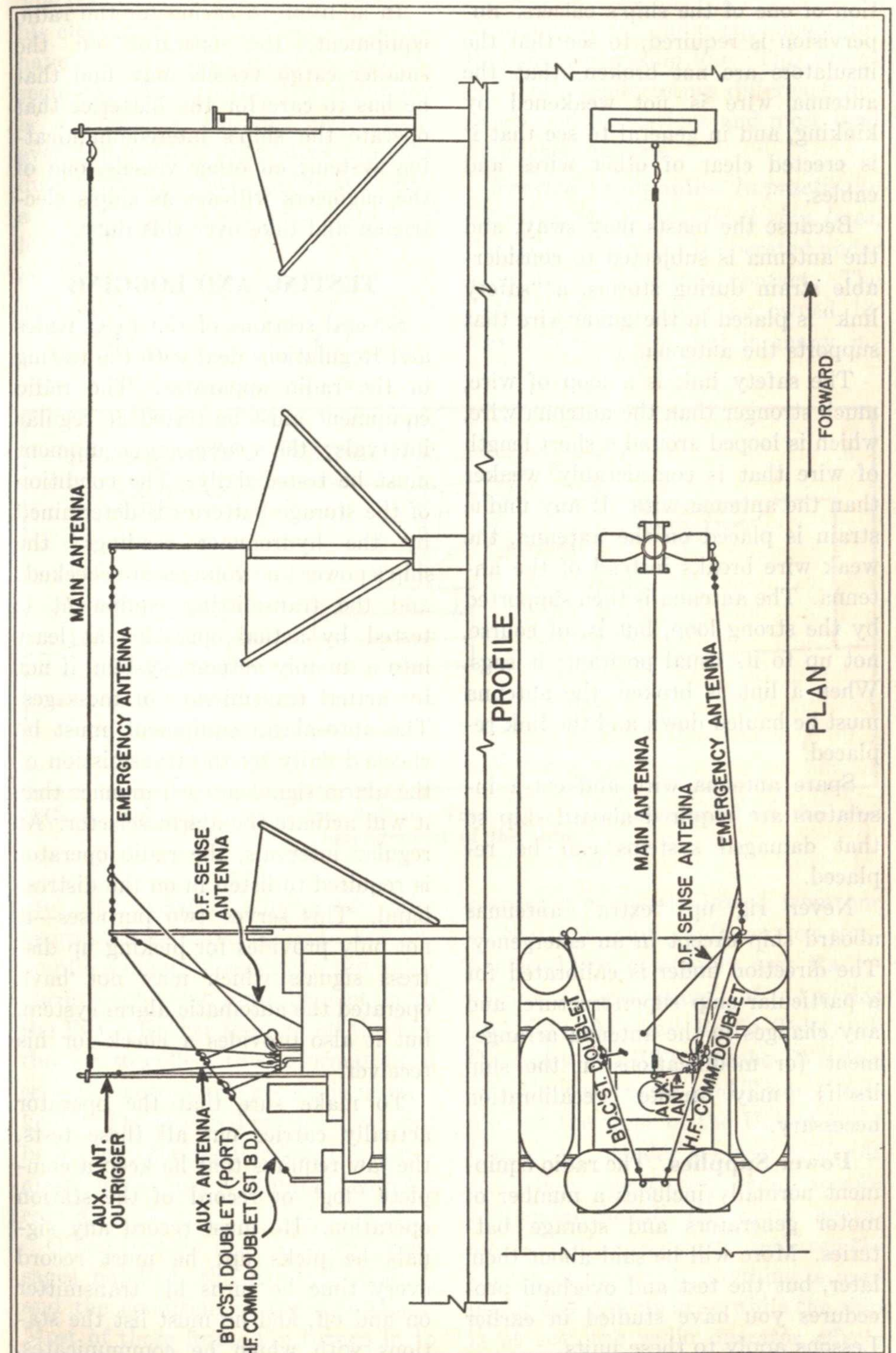
Perhaps one of the greatest differences about this portion of the operator's duties is that he must look after a large number of receivers. Although the main receivers are of the simpler types, it is well for any radio operator contemplating entering the marine service to pay particular attention to the theory and operation of radio receivers, and to learn to locate trouble in them. The receivers in the main radio room will not present nearly as much trouble as will others aboard ship such as the ones belonging to the crew and the officers, which may need repairing from time to time. Although repair of these receivers is outside the *legally* required duties of the radio operator, nevertheless, as the only one aboard ship with the technical knowledge necessary, he will be expected by his fellow workers to keep their equipment running, also.

In general, therefore, the radio operator is expected to look after all the radio equipment aboard.

Antennas. This radio equipment, of course, includes antenna systems. Aboard ship, an antenna is something of a problem. It must be erected as high as possible so as to give the greatest coverage, and at the same time, it must not interfere with any ship operation. The masts used aboard ships to support the antenna frequently serve double duty in that they may also support cargo booms that are used in loading and unloading the ship, so the antennas may have to be lowered when the ship is in port. It will be necessary, therefore, for the operator to see to it that these antennas are properly erected and removed. (Typical installations are shown in Figs. 1 and 2.) Also, the antenna is exposed to the elements, so that the insulators soon become coated with soot and salt spray. Such leakage paths cause a loss in power output, so it is necessary to take down the system from time to time to clean or replace the insulators. (Leakage is particularly troublesome because shipboard antennas are quarter-wave Marconi types, and hence have their point of maximum potential at the end farthest from the transmitter.)

The radio operator does not have to do this work himself—he merely supervises the job. The actual labor involved in antenna erection and removal is normally performed by members of the crew, under the direction of the radio operator.

FIG. 1. On the opposite page is a typical antenna arrangement on a modern cargo ship.



tion of one of the ship's officers. Supervision is required, to see that the insulators are not broken, that the antenna wire is not weakened by kinking, and in general to see that it is erected clear of other wires and cables.

Because the masts may sway, and the antenna is subjected to considerable strain during storms, a "safety link" is placed in the guide wire that supports the antenna.

The safety link is a loop of wire, much stronger than the antenna wire, which is looped around a short length of wire that is considerably weaker than the antenna wire. If any undue strain is placed on the antenna, the weak wire breaks instead of the antenna. The antenna is then supported by the strong loop, but is, of course, not up to its usual position; it sags. When a link is broken, the antenna must be hauled down and the link replaced.

Spare antenna wire and extra insulators are required aboard ship so that damaged systems can be replaced.

Never rig up "extra" antennas aboard ship except in an emergency. The direction finder is calibrated for a particular ship superstructure, and any changes in the antenna arrangement (or modifications in the ship itself) may make recalibration necessary.

Power Supplies. The radio equipment normally includes a number of motor generators and storage batteries. More will be said about them later, but the test and overhaul procedures you have studied in earlier Lessons apply to these units.

In addition to caring for the radio equipment, the operator on the smaller cargo vessels may find that he has to care for the batteries that operate the ship's intercommunicating system; on other vessels, one of the engineers will act as ship's electrician and take over this duty.

TESTING AND LOGGING

Several sections of the FCC Rules and Regulations deal with the testing of the radio apparatus. The radio equipment must be tested at regular intervals; the *emergency* equipment must be tested daily. The condition of the storage batteries is determined by the hydrometer readings; the ship's power line voltages are checked; and the transmitting equipment is tested by actual operation at least into a dummy antenna system, if not by actual transmission of messages. The auto-alarm equipment must be checked daily by the transmission of the alarm signal in such manner that it will actuate the alarm selector. At regular intervals, the radio operator is required to listen in on the distress band. This serves two purposes—it not only provides for picking up distress signals which may not have operated the automatic alarm system, but it also provides a check for his receiver.

To make sure that the operator actually carries out all these tests, the law requires that he keep a complete "log" or record of the station operation. He must record any signals he picks up; he must record every time he turns his transmitter on and off, and he must list the stations with which he communicates.

The result of his tests, the accuracy of his clock, and even the ship's position have to be entered on these records regularly. In general, the radio log is a complete running account of everything the operator does while on duty. Although the actual forms vary, a typical log is shown in Fig. 3. This log must be completed as events occur, and is turned in to the proper authorities at the end of each voyage.

In addition to the log itself, there are other records which the radio operator is required to keep. For example, a monthly report on the auto-alarm equipment must be sent in to the FCC. Rather than go all through the log to collect this information, a separate auto-alarm record is usually kept. (The required entries must still be made in the regular log; this auto-alarm log is just a running duplicate record.)

Other records deal with the messages handled, the money collected, and the condition of the equipment. Most of these forms are turned in to the service company that is required to maintain the radio equipment for that particular ship line. This brings up another interesting difference between marine stations and most land broadcast stations.

Service Companies. *In practically all instances of organized ship lines,* the radio equipment is operated under some form of service contact. The radio equipment may be owned by the ship company, but in many instances it is merely leased from one of the four main raido service companies. These companies are: Radiomarine Corporation of America (RMCA), Mackay Radio Telegraph Company (MRT), Globe Wireless (mostly west coast), and Tropical Radio (on the ships of the United Fruit Company). *Under contract with the steamship companies, these service companies install the radio equipment, supply spare parts, and keep the station in repair.* If anything is used up, or any defects arise while the ship is at sea, the radio operator effects

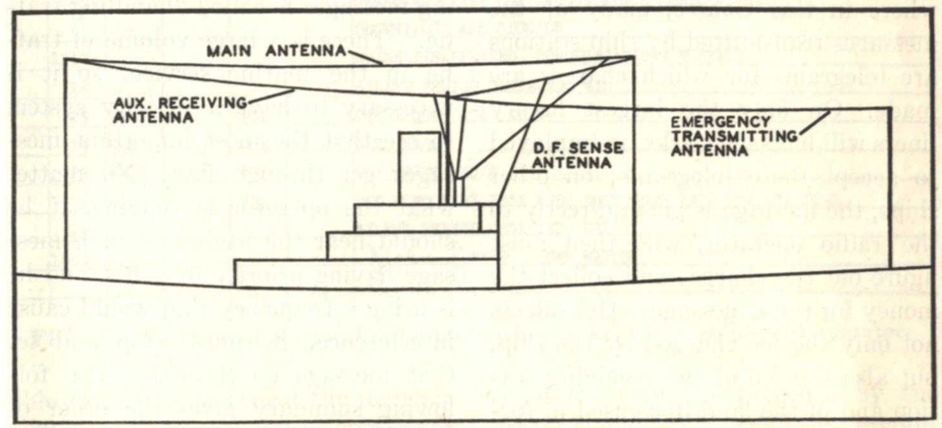


FIG. 2. Another antenna installation. The actual positions depend on the mast arrangement of the ship.

such repairs as he can. Then, when the ship comes into port, the service company takes over, replaces any defective parts, and restores the spare parts to their normal number. Therefore, the operator must report to his service company, on the forms they furnish, the condition of his equipment, the nature of any repairs needed, and any needed supplies.

In no other field is the *radio operator* required to keep financial records. However, as will be pointed out elsewhere in this Course, many of the messages transmitted by ship stations are telegrams for which charges are made. On only the largest luxury liners will message clerks be employed to accept these telegrams; on other ships, the message is given directly to the radio operator, who then must figure out the charges and collect the money for these messages. He collects not only the fee charged by the ship, but also the fee of the receiving station and of the land lines used in forwarding the message. Hence, the operator must keep complete records of the message income. Furthermore, he records incoming messages because the ship collects a handling fee for these from the message originator. Generally, all income of the station goes to the service company, which then settles with all who are owed money. However, practices vary, and each company issues its own detailed instructions to operators: in general, all necessary forms for keeping complete records will be furnished by the service company itself.

ACTUAL OPERATION

The operator on board ship is not only required to keep his equipment in order, he is usually the actual originator of the message. He uses the telegraph key, or in some instances the microphone, to send the actual message from his equipment. It is only on the largest of the passenger liners, where the volume of messages is extremely heavy, that extra operators are employed to send messages while others are on duty monitoring the transmitter equipment.

The process of sending and receiving messages is called "handling traffic." There is a large volume of traffic in the marine service, so it is necessary to have a priority system to see that the most important messages get through first. No matter what the operator is sending, if he should hear the beginning of a message having priority over his, and he is using a frequency that would cause interference, he must stop and let that message go through. The following summary gives the order of priority, as established by international law:

The highest priority is given to a distress message—one preceded by the international auto-alarm signal and by the code group SOS. This type of distress message is sent by ships only when immediate assistance is needed. Such messages (and in fact, all messages from the ship's radio) may be sent only upon the authority of the master of the ship. Depending upon the emergency, the operator may or may not have time to send the ship's position and a complete description of the help needed. However, the operator sends as complete a message as possible, and, if possible, continues to repeat the message until he receives an acknowledgment and is notified that help is on the way.

FORM OPM 18

MACKAY RADIO AND TELEGRAPH COMPANY SHEET No. 73
MARINE DIVISION

RADIO LOG

CHIEF OPR. John Jones SHIP OR STATION Traveller CALL WCXC
1ST ASS'T OPR. ______ FROM ______ TO ______
2ND ASS'T OPR. ______ MONTH ______ 194__

DATE	G. M. T.	STATION CALLED		STATION CALLING		NOTICE—ENTRIES MUST BE MADE EVERY 15 MINUTES WHILE ON WATCH
		CALL	FREQUENCY	CALL	FREQUENCY	
22	1405	KFHI	500	KRGH	500	QTC 1 QSY 425 KC/S
	09	CQ		WSL		QTC HYDRO QSW 474 KC/S
	18					SILENT PERIOD OBSERVED, NIL
	30	CQ		WMH		QRU AR
	33	CQ		WXSX		HEAVY FOG 3820N 6212W COURSE 260 SPEED 12 KNOTS
						(REPORTED TO BRIDGE 1435Z - JJ)
	40			WWV	5000	TIME TICKS, BUREAU OF STANDARDS, RADIO ROOM CLOCK
						12 SECONDS FAST. RESET.
	48				500	SILENT PERIOD OBSERVED, UNIDENTIFIED INTERFERENCE
	55					OBSERVED HEAVY CONTINUOUS ATMOSPHERIC NOISE.
						DROWNS OUT ALL SIGNALS.
	1510					NOISE DISAPPEARED, COMMUNICATIONS NORMAL.
	18					SILENT PERIOD OBSERVED, NIL
	23	KRGH		WSL		QTC 1 QSW 474 KC/S
	23	WSL		WOE		QRZ KRGH
	23	KRGH		WSL		QSY 8280 KC/S
	30	CQ		WSL		QTC WLMQ KAMZ KBIX KDRB KHIT KQBS KWRB QSW 474 KC/S
	48					SILENT PERIOD OBSERVED, NIL
	1600					John Jones OFF WATCH

FIG. 3. A section of a typical radio log, such as is kept by a shipboard operator.

The second in priority are messages dealing with navigational conditions that may be a hazard to other ships, and those dealing with the safety of the crew and of the passengers. In these two classifications are messages dealing with the presence of such navigational hazards as icebergs or derelict ships, or of hazardous weather conditions. Those dealing with the safety of the crew include instances where sickness or an injury requires medical attention beyond that provided on the ship.

Signals having to do with the safety of the crew are preceded by the urgent signal XXX, and those involving navigational safety by the signal TTT.

The next in priority are messages dealing with direction-finding bearings. It is very important that a ship's position be known exactly (to avoid endangering itself and other ships); therefore, direction-finding messages must get through.

In addition to the foregoing *emergency* classes of messages, there are a number of other classes of messages, which have varying degrees of priority. For example, government messages, or messages dealing with the operation of the ship have priority over paid radiotelegrams, which in turn take precedence over deferred rate (night letter) messages, etc. We won't go into all these classes here. If you go into the marine service, you will learn all about them from the documents that are required on board ships. We will say that a code signal is prefixed to each message to indicate its type and thus its priority.

To summarize, the radio equipment is *basically* for the purpose of summoning aid, or of learning of another's distress so as to give aid. However, in the normal course of events, emergency messages are but rarely heard or sent. The radio equipment does not lie idle, however; it is used particularly in handling traffic relating to the ship's business, and also in the handling of certain private messages. Some of these messages may even change the course of the voyage, because getting a particular ship into a particular port at a certain specified time is an important factor in the amount of money made by the shipping concern. The particular cargo may be subject to fluctuating prices, so it may be advantageous to have it arrive at the proper moment. As a ship approaches port, there are a number of items of business to be handled—they may not know exactly which dock they are to use, pilots may have to be arranged for, and the services of tugs obtained. The proper crew to assist in unloading the ship must be rounded up, and must be available at the proper time. These are just a few examples of the many messages that may travel from ship to shore dealing with the business of the ship itself.

Finally, the radio operator aboard ship may at any time assist in forwarding messages. There are many occasions when one ship is unable to contact a particular shore station or another vessel because of interference or other difficulty. Any other ship in a position to help forward the message normally does so with the expectation that it, too, may need this type of assistance some day.

Receiver Operation. When we turn to the duties of receiving, we find the operator has a number of definite tasks. First, and foremost, he must keep a continuous watch on the distress frequency band if not actually engaged in radio traffic handling. Naturally, if he is receiving a message, and he is the only operator, then it is impossible for him to monitor the distress frequencies at that time. However, this is provided for—by international agreement, there are two silent periods each hour, during which nothing but distress messages may be transmitted. To make sure that everyone uses the same time, all marine radio clocks are set to "Greenwich mean time." This is the time of day at the zero meridian which passes through Greenwich, England. (All log entries are made in G. M. T., as read from the radio room clock, regardless of the actual local time.) The silent periods are for three minutes each, beginning at 15 and 45 minutes after the hour, G. M. T. During these silent periods, all other traffic ceases, and the operator proceeds for three minutes to listen for distress messages. Near the end of these international silent periods, stations may come on the air with urgent or safety messages, but all other classes

of messages are strictly forbidden.

Hence, when the operator is not actually engaged in the handling of his own traffic, he listens to the distress band. This does not mean that he just sits by his receiver and listens to static—because the distress band is used as a calling frequency band except during the silent periods. (See Fig. 3.) That is, since this is the frequency to which all stations are listening anyway, a station wishing to contact another sends out the proper call on this band of frequencies to make the contact.* As soon as the called station has answered, they both then shift to the *working* frequencies assigned to carry on their traffic. Therefore, the operator monitoring the 500-kc. distress band frequently hears stations calling each other. To prove that he has been performing his duties properly, the radio operator is required to enter in his radio log such calls that he hears at least to the extent of an entry every 15 minutes. He puts down the exact time, and the station calls that he hears. (His radio log is subject to inspection, and it is always possible for the radio inspectors to check with the stations in question, to determine whether or not the operator was actually on duty.)

The Navigation Officer must know the exact time. An error of a few minutes in the ship's clocks may make an error in the position reckoned for the ship. Time signals are sent out by many stations at varying hours during the day, and the radio operator is required to pick up suitable time signals so that the ship's clocks may be checked. Since the ship's position is usually determined near noon, the officers want time signals taken near noon. The radio operator, therefore, must determine what stations are broadcasting time signals at the most useful hour. Naturally, as the ship moves, the local noon time changes with each time zone, so the hour at which the time signal must be picked up may change during the ship's voyage.

Direction-finding bearings with the ship's direction finder have already been mentioned. The radio operator may be called to go to the direction-finding equipment and take the bearings himself.

Most ships subscribe to a news service. Sometimes, this news service comes through shore stations owned by the radio service companies that operate the ship's equipment. In other instances, this service is subscribed to by the ship station. Naturally, the happenings of the day are of interest to the crew, so some form of disseminating this news is found aboard practically all ships. On the smallest cargo vessels, the radio operator may merely copy the news flashes and post them on a bulletin board. In other instances, a simple form of newspaper is mimeographed or otherwise duplicated for distribution among the crew and possibly the passengers. The large ocean liners actually print small tabloid newspapers.

One very important point about this gathering of news flashes is that

*Where messages are regularly interchanged with particular coastal stations, the calling and working frequencies of the coastal station are used, or else the coastal station may transmit messages at stated hours. In such cases, 500 kc. need not be used.

the operator *must obtain his news only from the station whose services have been hired.* One of the fundamental laws dealing with radio messages is the one regarding the secrecy of messages. In other words, to protect everyone from unwarranted interception of their messages, laws provide very severe penalties for anyone divulging the contents of *any* radio message *not actually addressed to him.* This law is used to protect the news services—if you divulge to anyone a news flash picked up from a station whose service you do not have, you make yourself liable to severe penalties. It is very important, therefore, when going aboard ship as radio operator, to find out exactly the stations whose press may be copied by your particular ship.

From the foregoing, you can see that the 8-hour day of the radio operator aboard ship is reasonably well filled. He sends and receives messages, he tests and services his equipment, and keeps complete records of his work. In return, he is paid a good salary and has many unique privileges.

Radio Operator As A Ship's Officer

The radio operator aboard ship has the status of an officer; he is quartered with officers, he eats with the officers, and where dress is required, he wears an officer's uniform. He is completely in charge of the radio room and its equipment. However, unlike other ship's officers, the radio man has no authority over anyone on board ship (except, where there is more than one operator, the chief operator is in charge of the other operators). As another oddity of his position, the radio man is responsible only to the master* of the vessel.

Although the radio man has no authority to *order* anyone to give him assistance, he will get any help he requires by merely requesting it from the proper officer. If he needs sailors to raise or lower the antenna, he asks the deck officer (mate in charge) for them. If his check of the ship power line voltage shows it to be abnormal, he can get this voltage corrected by calling the engineer on watch and informing him of the voltage irregularity. In the case of any trouble with the electrical wiring, the same engineer is consulted, etc.

The appearance and condition of the radio room is the responsibility of the radio operator. Because of the possibility that someone else might damage the radio equipment, the operator keeps the radio room clean himself. However, his quarters are cleaned by a crew member, just as are those of the other officers.

---

*The master of a ship is the officer in supreme command, and is also designated as the captain. Under the captain are a series of deck officers (called "mates") and the operational officers (called "engineers"). There is a chain of command from the officers of lower class up through their second class (second mate or second engineer), to the chief (first mate or chief engineer) to the captain. When the captain is not on the bridge, the ship is under the command of the highest ranking deck officer (mate) on duty. However, the radio operator is responsible only to the master, so if he is issued any *questionable* orders by any other officer, he must check with the master before carrying them out.

At sea, under normal conditions, the radio operator serves a standard 8-hour day. His hours of operation are under the control of the master. However, in most cases, the operator is allowed to determine his own hours of on and off duty provided he suits his day to the requirements of the ship, and provided his hours are not otherwise fixed by law. As the ship moves into different time zones, the operator may have to come on duty at different hours each day, in order to meet the schedule of the coastal stations with which he carries on his normal traffic, and in order to pick up time signals at the proper intervals. In general, however, when only one operator is aboard ship, he works during the daytime. Where there is more than one operator, they take turns, generally providing a 16-hour service, although they may even provide a twenty-four hour service. (Of course, in an emergency, the master can order overtime work—even up to a full 24 hours on watch if weather or other conditions require it.)

In port, the duties of the radio operator are rather light. Upon arriving in port, he is supposed to have all his records up-to-date. These records are delivered to the master or to the service company. If there is anything peculiar about the operation of the equipment, or if any supplies are needed, he prepares a request for the master of the ship and, when this is signed, a supply requisition is prepared and forwarded to the service company.

The ship's radio installation is subject to inspection when in port, and the radio operator must be aboard during such an inspection. Ordinarily, he will be notified well in advance when to expect the inspection, or can call the local inspector's office to arrange the inspection so that he can be on hand. Otherwise, the radio operator normally enjoys complete freedom from duty when the ship is in port, and up to that time approximately two hours before the ship sails. He does have to report back on board from time to time, to make certain tests as are required on the equipment, if the ship is to stay in port for a considerable length of time. In this matter of shore leave, the radio operator has an easier position than most others aboard ship, many of whom must remain aboard to supervise the unloading of the ship, and the loading of fresh supplies and cargo.

When the ship is in a foreign port, approximately the same shore leave is available to the radio operator, provided he has the necessary passport and other documents. (However, it is well for the radio operator to realize that there may be numerous restrictions placed on his movements in foreign ports by the laws of that particular country. Before going ashore in any strange port, it is well to learn all one can about the laws of that particular country, and perhaps to visit the American Counsul in that port for additional pointers.)

The areas of the world one sees as a radio operator depend, of course, upon the class of ship in which one travels. The large ocean liners customarily sail only between stated ports, so the sightseeing possibilities on such vessels are soon exhausted.

Similarly, many of the cargo ships have very definite sailing routes. On the other hand, there are many cargo vessels that accept any kind of shipment, for any port. These may travel almost anywhere, and on a ship of this type, crew members see much of the world. Of course, it is possible to transfer from ship to ship, and thus vary one's route even more.

Requirements for Sailing

As has been pointed out previously, a man is not expected to be sole operator aboard ship without previous experience. The normal state of affairs is for the new operator to sail as a second or third operator until he learns the procedures. Therefore, you will be instructed as to your duties once you are aboard ship. Naturally, however, the more one knows about the job before-hand, the easier it will be to follow instructions and perhaps to anticipate them. This is particularly true in regard to the initial check-up of the equipment, because it is quite possible that the chief operator may not be on board when you arrive. Let's assume you are about to enter the marine service for the first time, and learn what is required of the beginner. First of all, you should obtain a copy of:

1. Federal Communications Commission Rules and Regulations; Part 8, entitled "Rules Governing Stations on Shipboard in the Maritime Service." This is obtainable from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., for 25 cents.
2. The "Conventions and Regulations of the Cairo and Madrid International Telecommunications Conventions"; Treaty series 948, also available from the Government Printing Office for $1.00.

You should study these until you are thoroughly familiar with their contents. The FCC Rules and Regulations in particular must be minutely studied, because the equipment and spare parts requirements are given in detail. Although both these booklets are required aboard ship, your preliminary study of them will make your first duties far easier to perform.

Personal Papers. Before anyone can sail as a radio operator, he must have several important documents. Of course, his radio license of the proper class (second class radiotelegraph or better) must be in his possession. The radio man must have a certificate of identification, and a certificate of service, both of which are obtainable from the inspector of the Bureau of Marine Inspection and Navigation at any port. To obtain these certificates, you must take your radio operator's license, several passport-size photographs, and your birth certificate or other evidences of citizenship to the inspector.

A seaman's passport is required for sailing on all ships that leave the territorial waters of the United States. Passport applications may be filed with the nearest U. S. District Court, clerk's office. It takes some time to issue a passport. However, the receipt for the fee accompanying the application will be accepted as proof that a passport was applied for on at least one voyage on the ship. When the passport is issued, you will have to go in person to the office at which the application was made to obtain it.

In certain cases, a coast guard identification card may be required. You can inquire about this at the customs office or at the office of the Shipping Commissioner at the port from which you plan to operate.

All these papers are exceedingly valuable and they are not easily replaced. For this reason, it is advisable to get what is known as a seaman's wallet. This wallet has several compartments, each designed to hold a certain paper, and to protect it in celluloid. These wallets come with a short metal chain which allows them to be fastened to the clothing, so that one is less likely to lose his papers.

Signing On. Once in possession of the necessary papers, the next step is getting a job. The exact procedure will depend upon the ship line with which you plan to operate. In some instances you can apply directly to the officers of the Steamship Company. In other instances, one of the several radio operators' unions may do the hiring. In any event, when you are offered a position, it is necessary to find out the type of ship, the exact location of the ship, and to settle such details as wages before beginning the voyage. Seamen, and this includes the radio operator, sign a ship's "articles of agreement," which amounts to a contract, agreeing to work for a stated voyage or stated period of time for a stated pay. However, before signing this contract, you are allowed to inspect the particular ship and to determine the conditions under which you will work. After going through these preliminaries, the actual signing of the ship's articles is done in the presence of a port officer known as a "shipping commissioner." The shipping commissioner is a federal officer appointed to look after the interest of sailors in general. The wage agreements are signed in his presence and seamen are paid in his presence at the end of the voyage. If there is any dispute about working conditions or salary, appeal to the shipping commissioner.

When you have been paid, the articles for that particular voyage are completed, and the shipping commissioner issues you a certificate of discharge. This slip certifies that you have served for the specified length of time. These slips should be saved, because they back up your service record and are particularly important as you advance to the position of chief operator or sole operator aboard ship.

When you have signed the ship's articles, you are then a member of the crew and subject to the orders of the master of the ship. Normally, you next report aboard ship. If the chief operator is not present, ask to be introduced to the master or officer in charge. After introducing yourself as a radio operator, the next procedure is to ask for the keys to the radio room and to your quarters. Both of these should be inspected thoroughly (if not previously inspected before signing on the ship).

If the chief operator (or a previous operator) is present, it will be much easier to make the inspection of the radio room. However, if no other radio operator is present, you should proceed on your own to see that everything is normal.

RADIO ROOM DOCUMENTS

One of the first things to determine is that the necessary ship's documents are all present and accounted for. There must be a *station license* for the radio equipment aboard and this license must be posted conspicuously in the radio room. After reading the license to be sure it is still valid, and checking to see that the equipment is as described, you should post your own radio operator's license on the wall in the radio room. There is usually a frame provided for this purpose.

In addition to the ship's station license, a Safety Radio Certificate is necessary for ships that come under the provisions of the International Convention for Safety of Lives at Sea. This certificate contains a list of the equipment and personnel requirements for the particular class of ship station.

There must be available a supply of log forms so that the ship's radio log can be kept.

Also, there must be a quantity of stationery and forms such as will be needed for writing radio telegrams, keeping records of the amount of money collected, equipment reports, and so forth. Somewhere among the ship's papers you may find a check list giving a list of all the equipment and forms that should be aboard. If you find such a list, it will be quite helpful.

In addition to the foregoing, there are several publications that are *required* for ship stations. Theses are:

1. Alphabetical List of Call Signals. (This is an international list of all call signals and is known as the Berne publication.) From this list the operator can learn the name of any ship or coast station when he knows the call signal.

2. Nomenclature of Coast and Ship Stations. (Berne.) This is a complete list giving the name, call signal, frequencies used, location, services performed, etc., of coast and ship stations.

3. List of Stations Performing Special Services. (Berne.) This list gives data about stations giving time signals, direction-finding bearings, etc.

4. The Conventions and Regulations of the Cairo International Communication Convention, and the International Radio Regulations adopted at Atlantic City in 1947.

5. Coast Station and Land Line Telegraph Rates of the countries to which the station most frequently sends telegrams. (This is included in the Nomenclature of Coast and Ship Stations.)

6. Copy of FCC Rules and Regulations, Part 8.

7. *A complete set* of instruction books and circuit diagrams covering all pieces of radio equipment aboard.

In addition to the foregoing *required* publications, the service company may provide additional publications including its own rules and

regulations, and you should have copies of the pamphlets entitled "Radio Weather Aids" (Hydrographic Office No. 206) and "Radio Navigational Aids" (Hydrographic Office No. 205). Copies of the latter may be found in the chart room if not in the radio room. (Incidentally, a number of other useful Hydrographic Office reports and bulletins will be found in the chart room. Plan to spend some of your spare time reading these to learn more about coastal radio-beacon services.)

EQUIPMENT CHECK

Here is an important point for you to remember. If no other radio operator is on board when you go aboard for your first voyage, or if you are the sole operator aboard a new ship, *remember the radio service company.* Call them up — they will send an experienced man around to help you check over the equipment.

The radio equipment aboard requires certain spare parts. A list of these spare parts will be given in the instruction manual for each piece of radio equipment. In addition, the service company may supply a check list, and another list is in the FCC Rules and Regulations, Part 8. You should study these lists, and check through all the spare parts aboard ship, to be certain that a complete set is available. If any document or part is missing, make a note of this part or document. When you have finished your inspection, take this list as well as your report to the chief operator, or to the master of the ship, and he will see that the radio service company provides the necessary supplies or equipment.

The equipment itself must be checked. The law requires, for example, that a check be made of the specific gravity of the storage battery cells used in the emergency equipment, that the emergency transmitter and lifeboat transmitters be checked, and that any automatic keying device or auto-alarm system be checked while the ship is in port. An important point to remember is that operation with an antenna is not permitted in harbors except during inspection by FCC inspectors. However, the dummy antenna system can be used for testing equipment.

If anything appears wrong with any of the radio equipment, the radio service company *must be notified at once,* so that the equipment can be put into working order before the ship sails. This is important—the inspection must be made early, so that repairs can be made in plenty of time before the ship is due to sail. However, no matter when trouble is discovered, it must be cleared up and the radio equipment must be in good working order before the ship sails.

If you are not familiar with the rules and regulations regarding ship services, it would be well to spend considerable time reading through all the documents aboard, to be absolutely certain you do not overlook anything. In particular, notice tool lists, spare parts lists, and rules and regulations about how and where these parts and tools must be kept.

LEARNING SHIP ROUTINES

After you have checked over the

radio equipment itself, and have initiated supply requisitions and supervised repairs, you should inspect your living quarters. Your room should be clean and supplied with fresh linen, or the steward should be informed so that it can be cleaned up. At the same time, you should find out your place at the table for meals, and make other inquiries about life aboard ship. Find out about uniforms and the dress required. On cargo ships, it may be unnecessary to have anything except ordinary business suits, shorts, and ties. (Don't buy any kind of uniform unless it is required.) Learning the arrangements for laundry service will help you to decide how much clothing you should carry. You should learn the layout of the ship.

You must always be prepared for emergencies, so you should look up the "station bill." This is a list, showing each crew member's position during "general alarm" emergencies and "abandon ship" orders. It is important that you understand exactly what is expected of you. At various times on a voyage, "general alarm" drills may be held.

As the radio officer, your emergency station will usually be at the radio equipment, but wherever it is, you are to report to that position and carry out orders explicitly. You are not to leave your emergency station without direct orders from the captain or the officer in charge.

It will be particularly important for you to learn what is expected if an "abandon - ship" order comes through. You will be assigned a particular lifeboat, so you must know where it is. In all probability, your lifeboat will be radio-equipped, or else there will be a portable radio unit that you are expected to carry along with you. In inspecting such equipment, and the lifeboat in which it is to be used, you should at the same time see that the lifeboat is otherwise properly provisioned, as required by law. Report any shortages of any kind in lifeboat equipment to the captain.

By the time you have completed your inspection and checked other radio equipment, and perhaps have explored the ship, it will probably be time to sail. If this is your first voyage, the other operator (or operators) will be aboard at least two hours before sailing time, and from then on, you will be under the guidance of the chief operator. He will assign your exact duties, and of course will see that you learn how to carry them out.

Once you "know the ropes" about life aboard ship, from then on, going aboard ship will be purely a matter of repeating the routine of initial inspection, and the necessary routine of becoming familiar with the particular equipment and procedures aboard that ship. As you will have learned by then, ships differ considerably in the classes of service that they offer, and in the hours during which the radio room is open.

We can turn now to the equipment that you will normally encounter. In the remainder of this Lesson, we shall cover some of the earlier forms of radio equipment, and shall lead up to

the modern "packaged unit" installations that are aboard the latest ships. These units will be described fully in another Lesson. Future Lessons in this series will cover the auto-alarm and direction finders.

Early Radio Equipment

It is necessary to make some study of early radio equipment for two reasons: 1, the FCC operator's license examination still contains a number of questions on some of this equipment; and 2, an understanding of this equipment helps to show how some of the modern practices and equipment were developed. Therefore, let us briefly consider transmitters that do not use vacuum tubes.

SPARK TRANSMITTERS

One of the earliest radio transmitters is shown at A in Fig. 4. This type of transmitter operates on the principle that a voltage above the breakdown level of the air gap between the spaced plates of the spark gap will cause a spark to jump the gap. To get the necessary voltage, an a.c. voltage is applied through a *step-up* transformer. Two types of gaps were used; one had adjustable spacing for use with fixed voltage supplies; the later type had fixed spacing and was used with an adjustable voltage supply.

During the initial charging process, before the gap breaks down, the condenser C_1 is being charged up to the peak voltage of the secondary of transformer T. When the gap breaks down and suddenly becomes a conductor across the gap terminals, condenser C_1 will discharge through coil L_1 and the gap. This builds up an oscillatory current between C_1 and L_1 through the spark gap, thus generating a radio-frequency wave. The frequency of this wave is dependent upon the values of C_1 and L_1.

Even when ionized, the gap has considerable resistance, and this resistance is in the resonant circuit. Therefore, energy is dissipated at such a rate that the r.f. oscillation dies out rapidly. Hence, the voltage across the gap falls to the point where the gap can no longer conduct. The circuit is now ready to repeat the operation, which it will do on the next half cycle of the a.c. source voltage. Thus, condenser C_1 is charged up during the first quarter-cycle of the voltage from the a.c. source. The oscillations die out during the next quarter-cycle. The condenser then charges during the third quarter-cycle, and the oscillations die out during the fourth quarter-cycle. Therefore, the output wave is like that shown at B of Fig. 4. *Continuous waves* are not produced by this transmitter; this class of emission is known as a "damped wave" because it dies out. Each of these groups of r.f. cycles is called a "wave train." Notice that there are two of these wave trains for each complete cycle of the a.c. source. Therefore, in effect, *the r.f. output from such a spark transmitter has a tone modulation of twice the frequency of the a.c. source voltage.* Changing the a.c. source frequency is the only way of adjusting the modulation frequency.

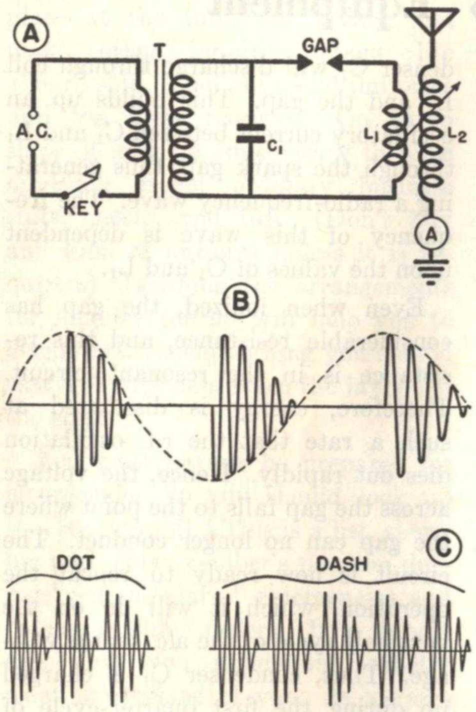


FIG. 4. An early spark transmitter and its output waveform.

To be useful, the output of such a spark transmitter must be keyed according to the telegraph code. Therefore, the key is placed in the low-potential a.c. circuit, as shown in A of Fig. 4. The kind of wave sent out with keying is shown at C. A dot is formed by a few wave trains, and a dash is formed by more, as the key is depressed longer.

To adjust the power output in the circuit shown in Fig. 4A, the coupling between the tank coil L_1 and the antenna pickup coil L_2 is usually variable on spark equipment. Of course, maximum power output is transmitted when the antenna ammeter reads the highest value. If lower power is to be transmitted, reducing the coupling is the simplest way of changing the output.

Aboard ship, a.c. generators are not commonly found. On most ships, therefore, the source of voltage is usually either storage batteries, or a d.c. voltage obtained from the ship's power line. It is necessary to convert from these sources to a.c. in order to step up the voltage.

At A in Fig. 5 is a basic circuit for using a storage battery. The vibrator interrupts the battery current, causing a pulsating current flow through the step-up transformer.

When a 110-volt d.c. power line was used as the source, a motor-driven chopper could be used, as at B in Fig. 5. Essentially, this chopper consists of a rotating disc having alternate contacts and insulating spacers. When the brushes are on the contacts, current flows through the primary of transformer T. When the brushes are on the insulating segments, the circuit is broken, so the effect is the same as that of a vibrator. Notice that in both instances, the telegraph key is in the primary circuit of transformer T.

From the foregoing, you can see that these relatively few parts make up a complete and usable transmitter. The amount of power output is determined solely by the power-handling capability of the parts and the power obtainable from the source.

Therefore, fairly high power can be obtained from even so simple a transmitter.

However, the spark transmitter, even at best, cannot equal the power output of modern tube transmitters. Furthermore, it has a very serious disadvantage—the damped wave results in an extremely broad band of frequencies being covered by radiated energy. As a result, the spark transmitter sends out a very broad, interfering wave. This is all right for emergency use, where it is desired to "ride in" over other signals, but it

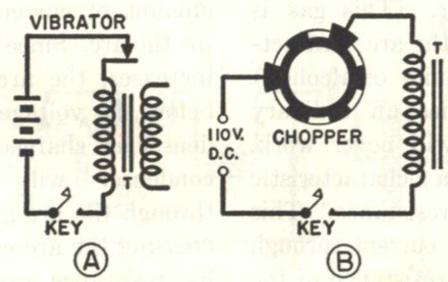


FIG. 5. Two arrangements for producing an a. c. voltage from a d. c. source.

takes up too much of the available radio spectrum to permit its use for ordinary communication purposes. (Incidentally, this kind of damped wave is classed as type B emission, as compared to type A for continuous-wave emission.)

Because of the interference, spark equipment is no longer permitted on any U. S. vessel. The only spark transmitters still in use are a few still found in certain ships in European registry, and these are permitted to operate only for emergency purposes. The use of this kind of equipment is being discouraged as much as possible, and eventually will undoubtedly disappear altogether.

THE ARC TRANSMITTER

Another transmitter that was widely used in the days preceding vacuum-tube transmitters is the arc type. The arc transmitter utilizes a gap system, so it is somewhat similar to the spark transmitter, but it is arranged in a different way so that it generates continuous waves. A basic circuit is shown in Fig. 6. In this diagram, the arc is represented by the electrodes A and B. Anode A was made of copper, and cathode B was made of carbon in the earlier units. Some of the later types use copper for both electrodes. These electrodes are contained in an air-tight chamber. Because of the high heat involved, metal electrodes would be burned up instantly if cooling means were not provided. Therefore, the metal electrodes are hollow, and water is circulated through them continuously for cooling purposes. This water has to be chemically pure, to prevent electrolytic action on the electrodes, and also to prevent the water from conducting electricity away from the electrodes. In the larger units, the cathode is rotated slowly by a motor to prevent uneven burning of its surface.

To start the arc transmitter, the two electrodes are momentarily touched to initiate a flow of current. Then they are separated. This process of touching the electrodes is known as "striking" the arc. Once current starts to flow across the gap, it continues to flow between the electrodes, because the heat of the arc ionizes molecules of gas in the space between the electrodes. To assist this ionization, hydrogen gas is generated in the arc's chamber. (This gas is usually produced by the arc heat acting upon a small quanity of alcohol.)

If the gap becomes an ordinary conductor, the arc will never work. However, it has a characteristic known as "negative resistance." This means that when the current through the gap goes up, the resistance of the gap spacing drops, which causes the voltage across the arc electrodes to drop. On the other hand, when the current through the gap is decreased, the resistance increases, and the arc voltage increases. In effect, therefore, we have high voltage at the same time as low current, and vice versa, which is opposite to the normal characteristics of a resistance. Let's see how this characteristic is used.

After the arc electrodes are touched, current starts to flow from the d.c. generator. This current must flow through the high inductance coil M_1. In effect, coil M_1 has so much inductance that it tends to prevent any rapid change in the current flow through itself.

At the moment the current starts flowing from the d.c. generator, condenser C_1 is uncharged, so it starts drawing current too. Therefore, both the arc and this condenser are trying to draw current through the inductance M_1. Because of the high inductance, the current flow is limited, and the condenser gets most of it. Therefore, the current available for the arc is low, and the arc voltage rises, which further assists in charging the condenser. When the condenser has charged to the voltage developed by the d.c. generator, it ceases to draw current, which means that the full amount of current is now available for the arc. Since the arc current now increases, the arc voltage will drop below the voltage to which the condenser is charged. As a result, the condenser will start discharging through the arc gap, thus further increasing the arc current and lowering its resistance even more. The arc voltage is thus driven to a low level, so that the condenser discharges through the arc gap and through the coil L_1. The condenser C_1 and coil L_1 therefore set up an oscillatory discharge, the frequency of which is fixed by the values of C_1 and L_1. However, the difference is that *a continuous wave* is generated by this system rather than a damped wave. This comes about because the d.c. generator constantly supplies power to make up the losses in the arc gap.

At very low frequencies, the arc circuit will work as described. For higher frequencies, however, the arc voltage would not change quickly enough, because of the high heat developed by the arc, which tends to

keep the gap ionized at a fixed level. To prevent this condition, the choke coil M_1 is mounted so that its magnetic field crosses the arc gap. Since the movement of the ions through the gap represents a flow of current, this magnetic field will deflect the ions. Therefore, this magnet "blows out" the gap at intervals by clearing away the ions. For this reason, coil M_1 is usually called a *blow-out magnet.* (As a third purpose for this coil, it also keeps radio-frequency currents out of the generator.)

Of course, there must be some means of keying the arc transmitter so as to send an intelligence signal. It is not practical to cut the arc off and on, as in a spark transmitter. One of the earlier systems of keying utilized a tap on the tuning coil so that when the key was operated, the amount of inductance in the circuit was changed. This caused radiation on one frequency with the key down, and on another frequency (because of the change in inductance) with the key up. If one listened to the right frequency, one could get the proper dots and dashes. This system, of course, had the disadvantage of radiating on two frequencies, one of which was a useless radiation.

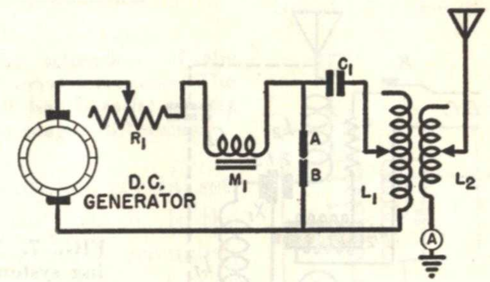


FIG. 6. A basic arc transmitter.

For this reason, one of the most popular methods of keying the arc was the "back shunt" system shown in Fig. 7. Here, a relay, X_1, is used to shift the energy from the antenna circuit to a tuned circuit consisting of L_1, C_1, and resistor R. Normally, relay contacts 1 and 3 are closed. Then the arc is operating into the tuned circuit L_1,-C_1-R.

When the key K is closed, relay coil M_2 is energized, thus pulling the relay over and closing contacts 1 and 2. This feeds energy to coil L_2 and into the antenna. Coil L_2 is used to resonate with the antenna capacity C_2 to form the necessary resonant circuit. Therefore, when the key is closed, energy is radiated by the antenna. When the key is open, the energy is fed into the dummy antenna system consisting of L_1-C_1-R. Thus, energy is radiated only when the key is pressed. For efficient operation the dummy antenna is adjusted to resonate at the same frequency as the antenna circuit, and R is adjusted to equal the normal radiation resistance.

Since the arc transmitter produces a continuous wave, it does not have the disadvantage of a broad interference wave such as the spark transmitter has. However, arc equipment is bulky, and requires careful adjustment because of the high heat developed by the arc, and the need for elaborate cooling methods depending on mechanical devices, the arc has gradually gone into disuse. Although there may still be a few very old ships with equipment of this type, practically all ships today use tube transmitters in one form or another.

EARLY RECEIVERS

Many different receiving devices were tried in the early days of radio.

marine service as an emergency receiver still required by law aboard passenger vessels.

The crystal set is simple, small in size, and in the semi-fixed types, it is easy to adjust. The detector is a mineral in contact with a metal probe. The junction between these dissimilar materials has the property of conducting much better in one direction than in the other. Therefore, it acts as a rectifier or detector of radio waves.

Essentially, the crystal receiver consists of a tuning circuit, a crystal

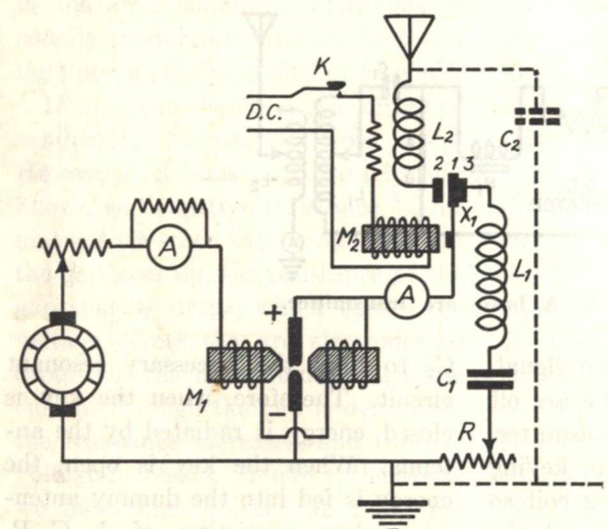


FIG. 7. The back-shunt keying system as used on an arc transmitter.

Some of these used electrolytic cells for detection. Others depended upon the conductivity of various metals. All were crude devices, however, and had the disadvantage of being too easily thrown out of operation by the normal vibrations of shipboard service. Of all the early receivers, the only one in use today is the crystal set. The crystal set remains in the

for the purpose of detection, and a pair of headphones for listening to the signal. The basic circuit of one of the modern types is shown in Fig. 8. Here, L_1 and C_1 form the resonant circuit, which, according to law, must tune over the frequency band from 350 kc. to 515 kc. in the marine service. The rectified voltage across the crystal is fed to the headphone

through the phone jacks. Condenser C_2 by-passes r.f. current around the phone.

This crystal unit is the type used today on RMCA installations. A somewhat more elaborate unit is used by the Mackay Marine Radio Units manufactured by the Federal Telephone and Radio Corporation. Fig.

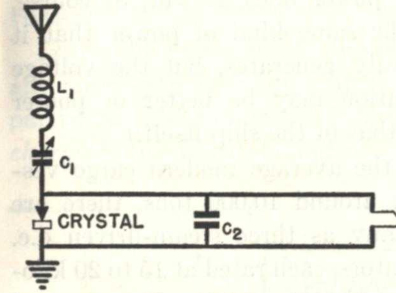


FIG. 8. This is the schematic of the Radiomarine type C crystal receiver. The type D is similar; it has parallel tuning condensers as the major difference.

9 shows a diagram of their crystal set. This set uses an on-off switch. In the off position, the antenna is grounded, and the crystal is short-circuited, thus the crystal is protected from damage from high level transmitter signals.

When the switch is in the "on" position, the antenna-ground circuit is tuned by coil L_1 and condenser C_1. Coil L_1 is tapped to make it possible to resonate over a wide range to compensate for different kinds of antennas.

The secondary tuned circuit L_2-C_2 is coupled to L_1. The energy from this tuned circuit is then fed to the crystal. Its rectified current flows through the headphone unit, which is by-passed for r.f. current by C_3. The use of dual tuning as shown here increases the selectivity considerably.

Although crystal sets of these kinds are required by the present laws, they are used solely as emergency units when complete failure of all power supplies has rendered other receivers useless. One considerable disadvantage of the crystal set is the fact that it can receive only modulated signals, such as type A-2 tone-modulated telegraphy, or type B damped waves. The tendency today is more and more toward the use of type A-1 (continu-

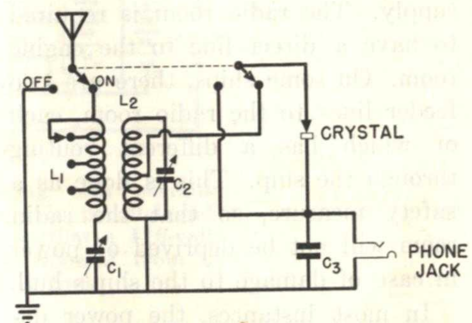


FIG. 9. The circuit of the Mackay crystal receiver, type 123BX. This set is a part of the package unit FT-106.

ous wave, code-keyed) emission, because this form of transmission utilizes the least of the radio spectrum and causes the least interference. Crystal sets are useless on this kind of transmission.

Ship Power Supplies

All ships now have some form of electrical system, and it is required that the ship's main power source connect to the radio room. Here, any of several methods may be used to operate the radio equipment: it may run directly from the ship's power line; the power line may operate motor-generator sets; or the power line may charge batteries that in turn operate the radio equipment.

Because the radio equipment depends on the ship's electrical system, one of the first things you should do after signing on a ship is to get a good basic knowledge of its power supply. The radio room is required to have a direct line to the engine room. On some ships, there are two feeder lines to the radio room, each of which has a different routing through the ship. This is done as a safety measure, so that the radio room will not be deprived of power in case of damage to the ship's hull.

In most instances, the power delivered will be 115 volts, *direct current*. On land alternating current is the most common power supply. However, much of the ship's other equipment requires d.c. power, so this is the kind of power normally furnished. There are exceptions to this rule, particularly on some of the largest passenger lines, which may have a.c. power available. This is something to to find out when you go aboard ship. In particular, watch out for ships that have both a.c. and d.c. outlets in the radio room, to be certain that you use the proper power outlet for the radio equipment.

When the ship is in port, its power may come from dock power lines. When making tests in port, find out whether the ship is generating its own power or is getting it from shore, so as to make the proper entries in your log. (When a ship ties up to shore power lines, it will, of course, use the same kind of power that it normally generates, but the voltage regulation may be better or poorer than that of the ship itself.)

In the average modern cargo vessel of around 10,000 tons, there are as many as three steam-driven d.c. generators, each rated at 15 to 20 kilowatts. Each generator is connected to the main bus through heavy circuit breakers, usually adjusted for about 175 amperes. These generators are medium-speed units, designed for constant duty, and operate at approximately 400 r.p.m. To take care of heavy surges, and give longer life to the engines and generators, two units are generally paralleled at a time, and the load is evenly divided between them by adjusting the field excitation of the units. Unless the ship is large enough to carry an electrician, the third engineer serves in this capacity, supervised of course by the chief engineer. Any questions about the power supply can be directed to whichever officer is in charge of generating equipment. The radio operator is required to note daily in his log the power line voltage, and any irregularities should be called to the attention of the proper officer, so that they can be corrected.

If you are required to maintain the intercommunication (alarm) batteries, go to the chief engineer and have him show you the charging switches, and the location of the fuses. Whenever these batteries are being charged, always advise the engineer officer on watch that you are charging batteries. In this way he can keep track of the load drawn and make proper adjustments in the line voltage.

Learn the location of all fuses in any circuits under your control. Pay particular attention to the location of *charging* fuses, to distinguish them from *operating* fuses. This is important in the case of intercommunicator batteries, where the charging switch may be located in the engine room. It is always possible for someone to throw the wrong switch and thus overcharge the batteries. Many radio operators make the practice of removing the *charging* fuses when these batteries are up to normal. Of course, one should NEVER remove *operating* fuses from the intercommunicator circuit. (In the radio room, removal of charging fuses is unnecessary, as you control all switches yourself).

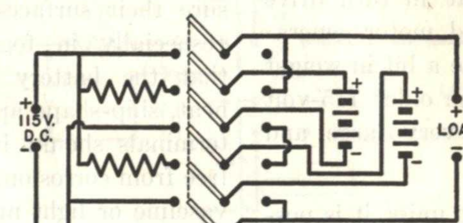


FIG. 10. This switching unit permits charging battery groups in parallel and discharging in series, so that a 110-volt battery group can be charged from a 110-volt d. c. line.

The fact that the ship has d.c. power available makes it relatively easy to charge batteries. All that is necessary is that the power line voltage be above the battery voltage by the required amount to give the charge. The system used depends on the basic design of the battery bank.

Battery-operated shipboard radios are of two basic types. On the older ships, the radio equipment operates from 115 volts d.c. In this case, the battery units also supply 115 volts for emergency operation of the radio equipment whenever there is a breakdown in the power line. As this battery voltage is the same as the power line voltage, the power line cannot charge such battery groups directly. The scheme shown in Fig. 10 is used. The battery group is divided in half, and each half is charged individually through a charging resistor from the power line, while the load is operating from the power line directly. In an emergency, or when the batteries are fully charged, the switch shown in Fig. 10 is thrown to the right, which connects the batteries in series, disconnects the power line, and connects the batteries to operate the load. In practically all cases, the main transmitter operating from such a line uses motor generators to deliver the required low voltage for filament and bias. High voltage is obtained either from a d.c. generator or through the generation of a.c. for step-up and rectification for the plate supply.

Today, the practice is to operate 110-volt motor generator units directly from the power line for the main equipment, then to operate the emergency equipment from 12- or 24-volt batteries that in turn drive correspondingly rated motor generators. This saves quite a bit in weight and maintenance; the older 115-volt battery units were very large and heavy.

With lower voltage units, it is possible to float the battery across the line, keeping it charged through a charging resistor at all times. The batteries are then thrown into use whenever the emergency equipment is switched on.

As an alternate method of operation, when it is desirable to be independent of the lines and to operate from batteries only, a switching system such as that shown in Fig. 11 is used. Here, with the switch in one position, battery A is being charged while battery B is being used to supply the load, and when the switch is thrown to the other position, the opposite action occurs. In this kind of switching arrangement, the load operates directly from the batteries, which are alternately charged from the ship's power line.

CARE OF BATTERIES

Regardless of the method of charging, the batteries must be kept fully charged and ready for any emergency. Therefore, the radio operator must make the daily tests that are required, and record their results. If any of the batteries show signs of losing their charge in an abnormal manner, a replacement should be put into use if available. At the first port of call, the defective battery must be reported to the service company and they will replace it.

When inspecting batteries, make sure their surfaces are wiped clean (especially in foggy weather) and that the battery room presents a neat, ship-shape appearance. Battery terminals should be kept clean and free from corrosion. A thin coating of vaseline or light machine oil may be used on the terminals to keep down corrosion.

The FCC Rules and Regulations require that at least one gallon of distilled water be kept on board for the batteries, but most radio operators like to carry more, particularly when sailing for foreign ports, where it may be impossible to get distilled water.

It is important for the batteries to be securely fastened to their trays, otherwise continued rolling of the ship after putting to sea may damage them. Breakable objects in the battery room, such as hydrometers, flashlights, and water jugs, should be securely fastened for the same reason.

In addition to the normal fusing of the load circuits, the battery charging circuits are also fused. If one of

these fuses blows, the batteries cannot charge, even though the charging switch is set to the proper position. It is important to make a check from time to time to be certain that the batteries are charging. Examinations for bubbling, and the hydrometer readings can be used as checks. Another way to check the operation of battery-charging circuits is to observe the line voltmeter very closely, while slowly switching the charger on and off. If the charger is operating as it should, you will notice a small variation in the line voltage as you turn the circuit on or off. If you do not get this variation, you may have an open charging resistance or an open charging fuse, and should check for these conditions.

(Of course, if the batteries are up to full charge, they will draw so little current that you may not be able to see any variation in line voltage.)

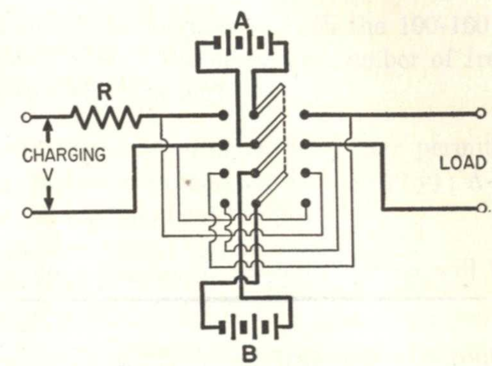


FIG. 11. Here, one battery is in use while the other is being charged. Throwing the switch interchanges the two.

MOTOR-GENERATOR REPAIRS

A set of spare brushes is required among the spare parts for each generator that is used aboard ship. If a brush fails, you can replace it. You should also keep the commutators clean, and oil the units if they require this.

If a motor generator unit overheats and ruins the bearings, it is not likely that a spare bearing will be available. However, on the larger ships, rather complete repair facilities are available, and it may be that one of the engineering officers is experienced enough to pour and install a new bearing.

In general, the service company does not expect you to make major repairs of this kind. Also, they frown on the practice of letting others tamper with the radio equipment. If you expect to make port within a short time, any such major repairs should be put off, and the radio service company should be called upon to make the repair or replace the defective item.

An important point to remember about motor-generator equipment — whenever it is overloaded, and found to be overheated it should never be stopped suddenly. It must be operated and cooled down gradually. Of course, the load must be removed from the generator. Then, if there is any way of reducing the speed of the motor, run it slowly and hold damp cloths on the bearings to cool them. Apply plenty of oil, too, if the unit is dry.

If it is impossible to slow down the speed of the motor, turn it off for a short time, then turn it back on, operating it intermittently until it cools.

In the next Lesson, you will take up complete radio installations, and there will be more about power supplies, particularly about the switching arrangements.

Lesson Questions

Be sure to number your Answer Sheet 51RC.

Place your Student Number on *every* Answer Sheet.

Most students want to know their grade as soon as possible, so they mail their set of answers immediately. Others, knowing they will finish the next Lesson within a few days, send in two sets of answers at a time. Either practice is acceptable to us. However, don't hold your answers too long; you may lose them. Don't hold answers to send in more than two sets at a time or you may run out of Lessons before new ones can reach you.

1. If the main transmitter operates in both the 100-160 kc. band, and the 365-500 kc. band, what is the *minimum* number of frequencies on which it must be capable of operating?

2. Which of the following types of emissions are permitted in the 143-160 kc. ship band: A-1 (continuous-wave telegraphy); A-2 (tone-modulated telegraph); A-3 (radiotelephony).

3. At what point on a shipboard antenna system will the potential be a maximum?

4. What is the effect on a shipboard transmitter output of dirty or salt-incrusted antenna insulators?

5. While the vessel is at sea, how frequently must the emergency equipment be tested?

6. When making entries in the log, which one of the following time zones is used: (1) local mean time; (2) Greenwich Mean Time; (3) Eastern Standard Time?

7. How frequently must an entry be made in the marine radio log while a watch is being maintained?

8. What is the best method of reducing the power output of a spark transmitter?

9. What is the purpose of the hydrogen gas, liberated from alcohol, in an arc chamber?

10. What type of emission, commonly used today, is the crystal set incapable of receiving?

INITIATIVE

The man who does only the routine tasks, the ordinary jobs in his profession, always waiting for the other fellow to take the lead, can expect only moderate returns for his labors. He who is continually on the alert to grasp each new opportunity —gets the greatest profits.

The immediate financial returns from work in a new and specialized branch of your profession may not be great, but the reputation you gain for progressiveness will soon result in more profitable routine jobs. It all boils down to these simple facts —you must do out-of-the-ordinary things, stand above the crowd in some way, to attract favorable attention. People remember you first for the unusual, then for your ability to do ordinary work well.

J. E. SMITH