# MARINE RADIO INSTALLATIONS

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PIONEER HOME STUDY RADIO SCHOOL

# STUDY SCHEDULE NO. 52

**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.**






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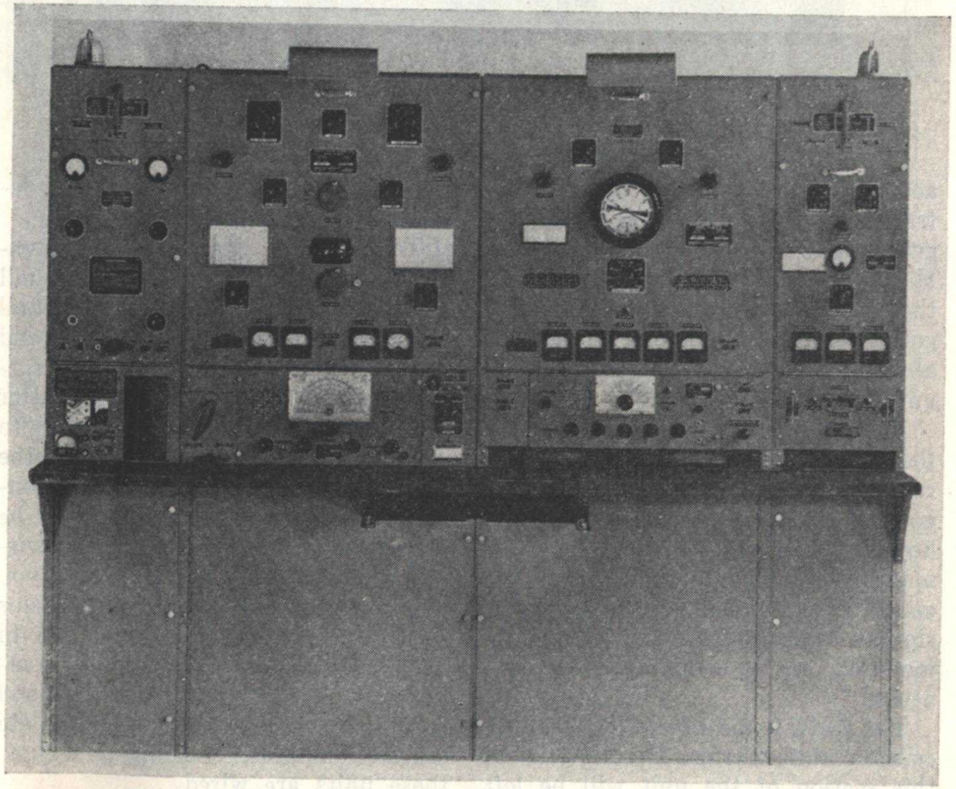
# The Packaged Marine Unit

YOU have already learned that the earlier marine installations consisted of quite a number of different pieces of radio apparatus. In these early installations, the apparatus was more or less scattered around the radio room, and each piece had to be installed separately.

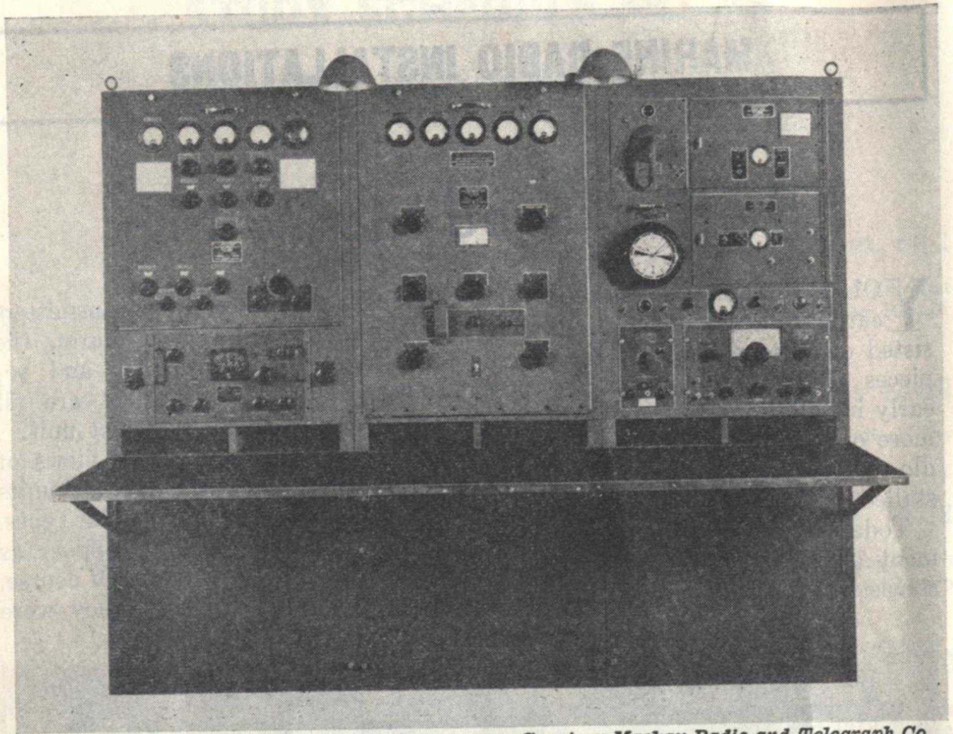
Today, however, the standard equipment on cargo and passenger ships consists of a packaged unit, in which the main and emergency transmitters and receivers, the auto alarm, the high-frequency transmitter and receiver, and the crystal set are all mounted in a single, compact unit.

Figs. 1 and 2 show front views of the RMCA and the Mackay units that are today the most popular types. This is the way the units appear as mounted in the radio room. Of course, to get them aboard ship, they were



*Courtesy RMCA*

**FIG. 1. Front view of the RMCA model 4U marine package unit.**



*Courtesy Mackay Radio and Telegraph Co.*

**FIG. 2. Front view of the Mackay model FT-106 marine package unit.**

actually installed as 3 or 4 individual frames and then were fastened together to make the complete unit. However, once completely installed, the frames are firmly fastened together, and are mounted on shock-absorbing bases so as to form a single unit.

In this Lesson, we shall describe these packaged units because they represent modern practice. If you ever go aboard ship using older equipment, however, you can still use the information contained in this Lesson, because the equipment will be basically similar, even though not so compactly mounted, nor so completely interconnected.

The RMCA and Mackay units both contain auto alarms. Descriptions of this section of the unit will be left for another Lesson. However, the remainder of the equipment will be described fully here.

To make the operation of the various components more clear, we shall use simplified diagrams and partial sketches rather than the complete and complex wiring diagrams that are furnished with these units. The latter diagrams are, of course, intended to show all interconnections, to make the job of servicing easier. Once you understand the *operation*, then it will be far easier to follow the maze of wiring in an actual unit. Hence, you don't need these complete diagrams until you are facing a unit and in need of learning its particular connections. At that time, you can spend several hours with the very complete service manuals, learning just how these units are wired.

An examination of Figs. 1 and 2 will show that these two units have essentially the same apparatus. This is to be expected, since both were designed to meet the requirements of the FCC and of the Safety Convention. However, once you get inside, you will find that each manufacturer has his own way of getting the required results.

## INTERCONNECTIONS ON RMCA MODEL 4U

An outline drawing, indicating the location of the major components of the RMCA 4U is shown in Fig. 3. Reading from left to right, the frames contain the following:

Frame A has the auto alarm master

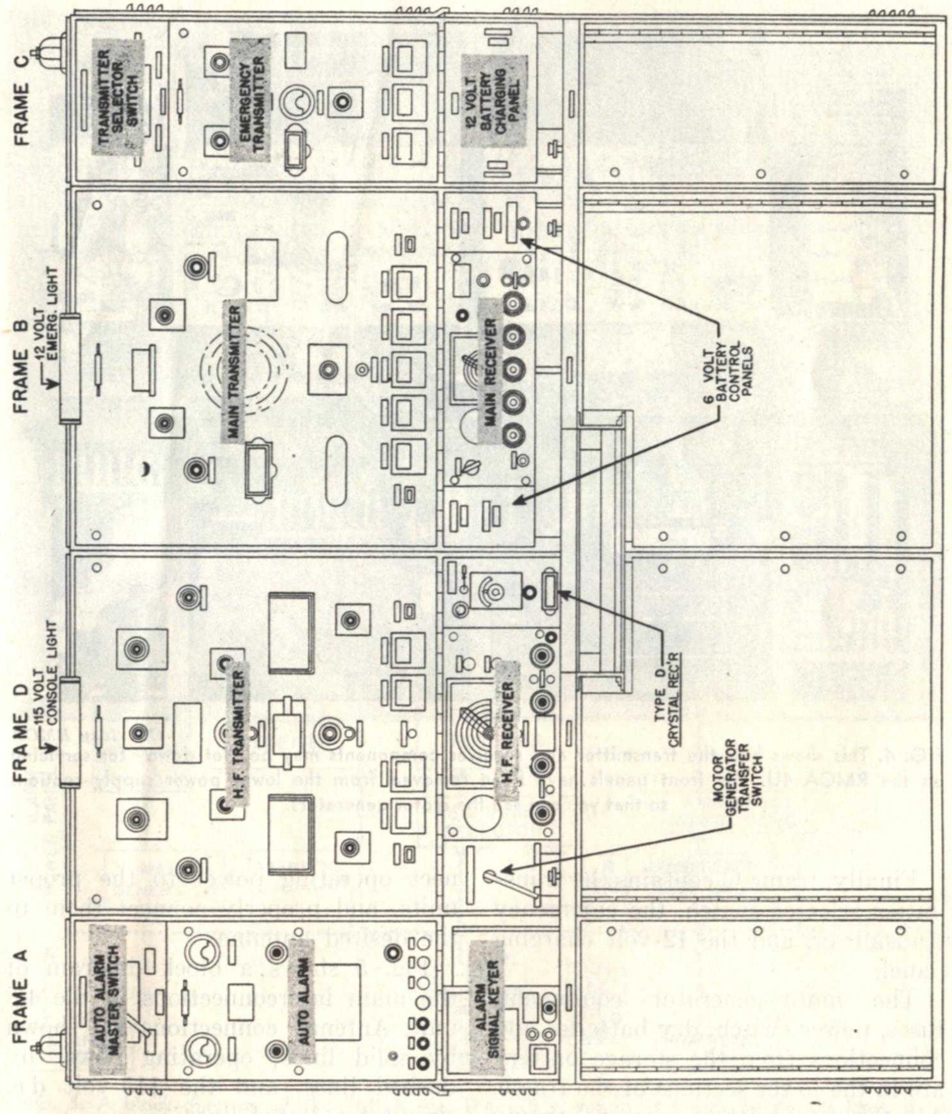
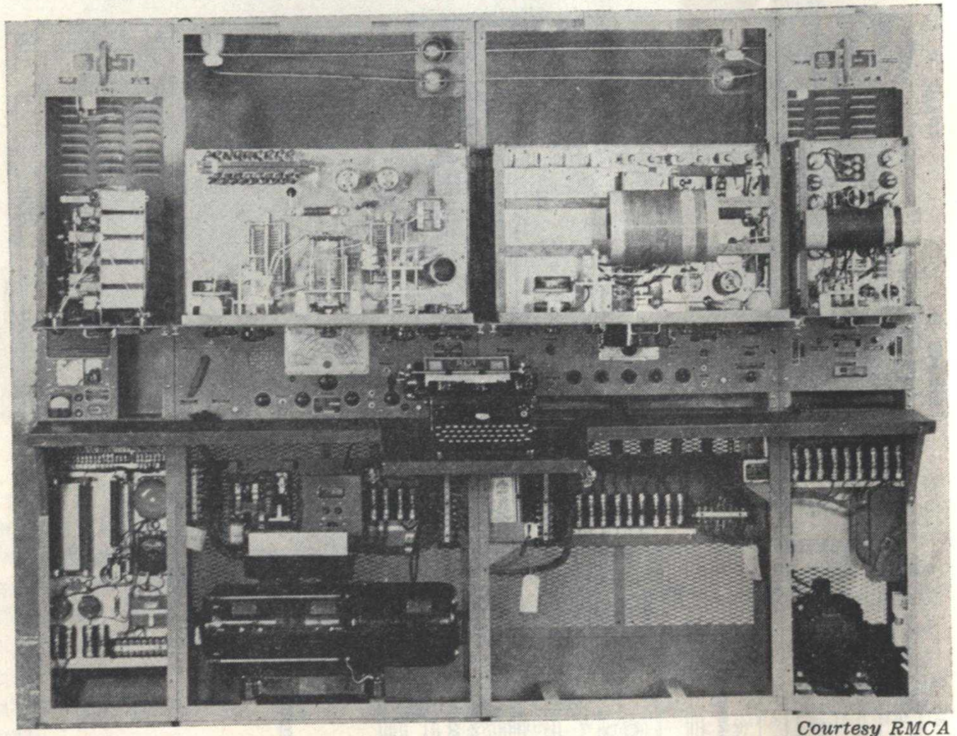



**FIG. 3. This outline drawing identifies the transmitters and receivers contained in the RMCA 4U.**

switch (at the top), the auto alarm, and the auto alarm signal keyer.

Next to it is frame D, which has the high-frequency transmitter and high-frequency receiver, a motor-generator transfer switch, and a crystal receiver.

Frame B contains the main transmitter and main receiver, as well as two 6-volt battery control panels.



*Courtesy RMCA*

**FIG. 4. This shows how the transmitter and receiver components may be "let down" for servicing on the RMCA 4U. The front panels have been removed from the lower power supply sections so that you can see the motor generators.**

Finally, frame C contains the transmitter selector switch, the emergency transmitter, and the 12-volt charging panel.

The motor-generator equipment, fuses, power switch, dry batteries and connections from the storage battery are in the lower sections of the frame. All the transmitters may be swung forward on hinges, as in Fig. 4, for ease in servicing. The receivers pull out of the unit also.

The units are interconnected so that three main switches—the *auto alarm master switch* (sometimes called the antenna selector switch), the *transmitter selector switch*, and the *motor-generator transfer switch* are used to throw into operation the various units. These switches connect operating power to the proper units, and properly connect them to the desired antenna.

Fig. 5 shows a block diagram of the main interconnections in the 4U unit. Antenna connections are shown by solid lines; operating power by dashed lines, and the 115-volt d.c. circuit by dotted lines.

The auto alarm master switch is at





the upper left-hand corner. It serves the purpose of selecting the main and emergency antennas, and at the same time is wired to connect the auto alarm to an appropriate antenna whenever the transmitter is not being used.

The transmitter selector switch at the upper right-hand corner is a 5-position switch. It applies the antenna connection obtained through the auto alarm master switch to the desired transmitter.

The actual operation of these two switches can be seen better in Fig. 6. Refer first to the auto alarm master switch. When thrown to position 1, as shown, the auto alarm receiver is connected to the main antenna, and the antenna bus (going to the transmitter selector switch) is not connected to either the main or emergency antennas. In this position of the switch, the transmitters cannot be operated; the auto alarm is on and receives power through other sections of the switch.

In positions 2 and 3, the auto alarm receiver is turned off, and the antenna bus is connected to either the emergency or the main antenna. This switch is arranged so that, in position 2, the emergency antenna is connected to the bus, and the auto alarm battery is not placed on charge. In position 3 of the switch, the main antenna is connected to the bus and the auto alarm battery is placed on charge.

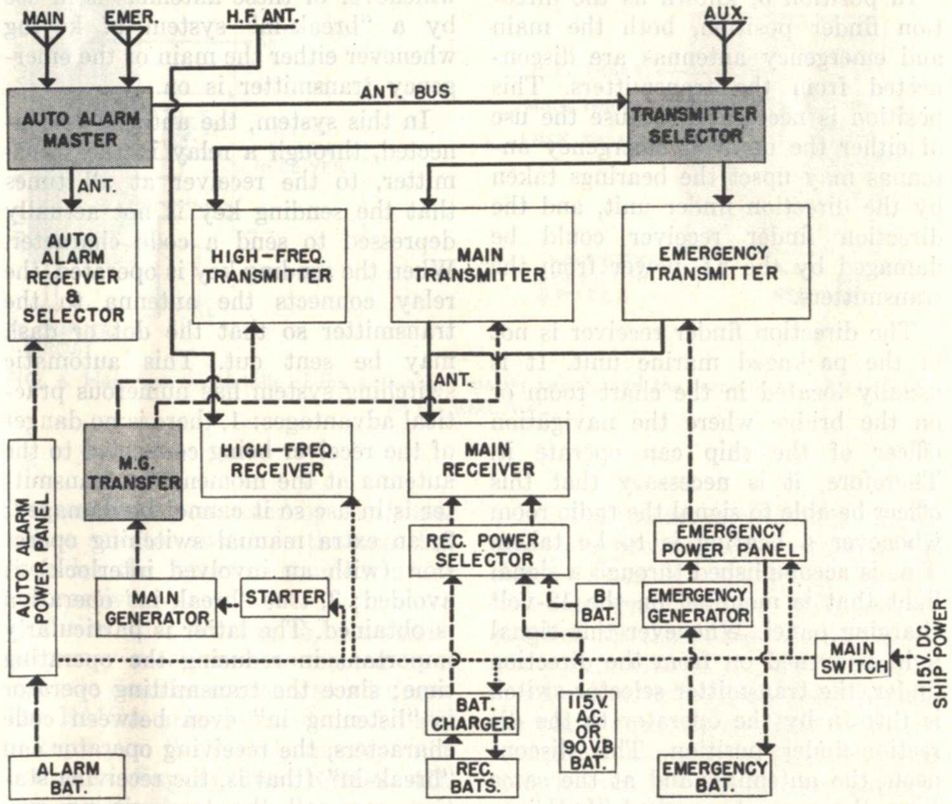



**FIG. 5. A block diagram of the RMCA 4U. The 115 v. supply is shown by dotted lines; d. c. supply by dashed lines; antenna connections by solid lines.**

Position 3 is of course the normal operating position. However, if the auto alarm battery is fully charged, then position 2 can be used. Incidentally, the emergency antenna is practically as effective as the main antenna, being to all practical purposes a duplicate of it in most installations.

Turning now to the transmitter selector switch at the right in Fig. 6, we find that the antenna bus is connected, in position 1, to the high-frequency transmitter; in position 2, to the main transmitter; and in position 3 to the emergency transmitter. Position 4 is provided to ground the antenna. This position is used during electrical storms to protect the equipment.

In position 5, known as the direction finder position, both the main and emergency antennas are disconnected from the transmitters. This position is necessary because the use of either the main or emergency antennas may upset the bearings taken by the direction finder unit, and the direction finder receiver could be damaged by the r.f. power from the transmitters.

The direction finder receiver is not in the packaged marine unit. It is usually located in the chart room or on the bridge where the navigation officer of the ship can operate it. Therefore, it is necessary that this officer be able to signal the radio room whenever a bearing is to be taken. This is accomplished through a signal light that is mounted on the 12-volt charging panel. Whenever this signal light is turned on from the direction finder, the transmitter selector switch is thrown by the operator to the direction-finder position. This disconnects the antennas, and at the same time, the contacts marked "D.F." on the second section of this switch close an interlock circuit which applies power to the direction-finder receiver. Notice that the direction-finder receiver will not operate, and is thus protected, until the transmitter selector switch is thrown to position 5.

**Receiver Antennas.** Position 5 of the transmitter selector switch connects the main receiver directly to the auxiliary antenna so that the watch on 500 kc. may be continued without interruption even for the short time of a bearing. This auxiliary antenna is a relatively short vertical antenna, so positioned that it does not affect the bearings.

There is apparently no connection in Fig. 6 between the main receiver, and the main or emergency antennas. Actually, this receiver is connected to whichever of these antennas is in use by a "break-in" system of keying whenever either the main or the emergency transmitter is on.

In this system, the antenna is connected, through a relay in the transmitter, to the receiver at all times that the sending key is not actually depressed to send a code character. When the sending key is operated, the relay connects the antenna to the transmitter so that the dot or dash may be sent out. This automatic switching system has numerous practical advantages: 1, there is no danger of the receiver being connected to the antenna at the moment the transmitter is in use so it cannot be damaged; 2, an extra manual switching operation (with an involved interlock) is avoided; 3, true "break-in" operation is obtained. The latter is particularly important in reducing the operating time; since the transmitting operator is "listening in" even between code characters, the receiving operator can "break-in" (that is, the receiving station can call the transmitting one, and as soon as the transmitting operator hears the call, he stops sending



and listens) at any time to get a correction instead of having to wait until the end of the message. This allows a word or character that was missed to be filled in, instead of requiring the entire message to be repeated.

Also, this allows higher priority messages to get through faster, since other stations can break in also.

Both the main and the emergency transmitters have break-in relays that connect to the main receiver antenna terminal. Hence, whichever

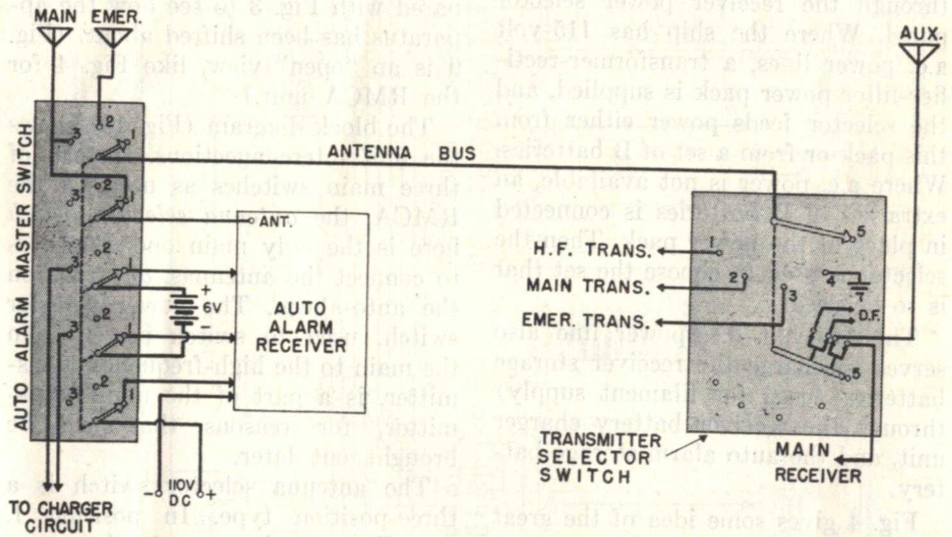



**FIG. 6. Here are the details of the auto-alarm master switch, and the transmitter selector switch on the RMCA 4U.**

transmitter is connected by the transmitter selector switch is the one that provides the antenna connection for this receiver.

Notice that in Fig. 5, the high-frequency receiver is connected to a separate doublet antenna at all times. The RMCA unit does not use break-in keying on the high-frequency unit.

**Power Supply for RMCA 4U.** Fig. 5 gives the power supply system for this packaged unit also. A connection near the lower right-hand corner of the diagram shows where the 115-volt d.c. power from the ship's power line is obtained. This power passes through a main switch that serves to disconnect the power line completely from the unit. From this point, the 115-volt d.c. power is supplied to the emergency power panel, the high-frequency receiver, the main motor-generator (through a starter), and the auto-alarm power panel. (It also goes to one of the lights over the unit.)

In the emergency power panel, there are provisions for utilizing the ship's power line to charge the 12-volt emergency battery. This battery supplies all the power for the emergency transmitter; the tube filaments operate directly from the battery, and the plate power is obtained from the emergency motor-generator, which in turn is run by the 12-volt battery. (All storage batteries are in an adjoining battery room; they are not inside the marine unit.)

The main motor-generator operates only from the 115-volt ship power line. Incidentally, the main motor-generator is a three-section generator, delivering an 80-volt, 83-cycle a.c. for filament supply, a 1400-volt d.c. for plate supply, and a 140-volt, 500-cycle a.c. for tone modulation. This supply is fed through the *motor-generator transfer switch* to either the main transmitter or to the high-frequency transmitter, as desired.

The main receiver gets its B power through the receiver power selector panel. Where the ship has 115-volt a.c. power lines, a transformer-rectifier-filter power pack is supplied, and the selector feeds power either from this pack or from a set of B batteries. Where a.c. power is not available, an extra set of B batteries is connected in place of the power pack. Then the selector is used to choose the set that is to be used.

The 115-volt d.c. power line also serves to charge the receiver storage batteries (used for filament supply) through the receiver battery charger unit, and the auto alarm storage battery.

Fig. 4 gives some idea of the great number of fuses used in these units—they are visible in the lower sections. It is particularly important for the radio officer to study the service manual carefully, to learn the locations, sizes, and types of the fuses for each piece of equipment. The spare parts assortment always includes a number of spare fuses and fuse links. (The links fit certain of the cartridges so that only the fuse element itself is replaced.) A typical interconnection and fusing diagram is shown in Fig. 7. The fuses are repeated on the schematic diagrams, but of course their positions in the base cabinets are not as clearly shown as in the inter-unit wiring diagrams.

## INTERCONNECTIONS ON MACKAY FT-106

The Mackay packaged unit, shown in Fig. 2, is designed for the same general service as the RMCA 4U, so it is basically similar in its output and functions. However, the physical appearance and electrical connections are considerably different from the unit we have just described.

Fig. 8 gives the positions of the major components, and can be compared with Fig. 3 to see how the apparatus has been shifted about. (Fig. 9 is an "open" view, like Fig. 4 for the RMCA unit.)

The block diagram (Fig. 10) shows the unit interconnections. Instead of three main switches as used on the RMCA, the *antenna selector switch* here is the only main one. It serves to connect the antennas, *and* turn on the auto-alarm. The power transfer switch, used to switch power from the main to the high-frequency transmitter, is a part of the main transmitter, for reasons that will be brought out later.

The antenna selector switch is a three-position type. In position 1, (see Fig. 11), it connects the emergency antenna to the high-frequency transmitter (through the antenna grounding switch that we will explain in a moment). The main antenna is connected to the main transmitter.

In position 2, the antenna connections are interchanged, with the main antenna going to the high-frequency unit, and the emergency one going to the main transmitter.

Position 3 is labeled "DF-AA." In this position, the emergency antenna is connected to the main transmitter, and the main antenna is connected to the auto alarm receiver. In addition, a number of other switching operations are performed by sections of the





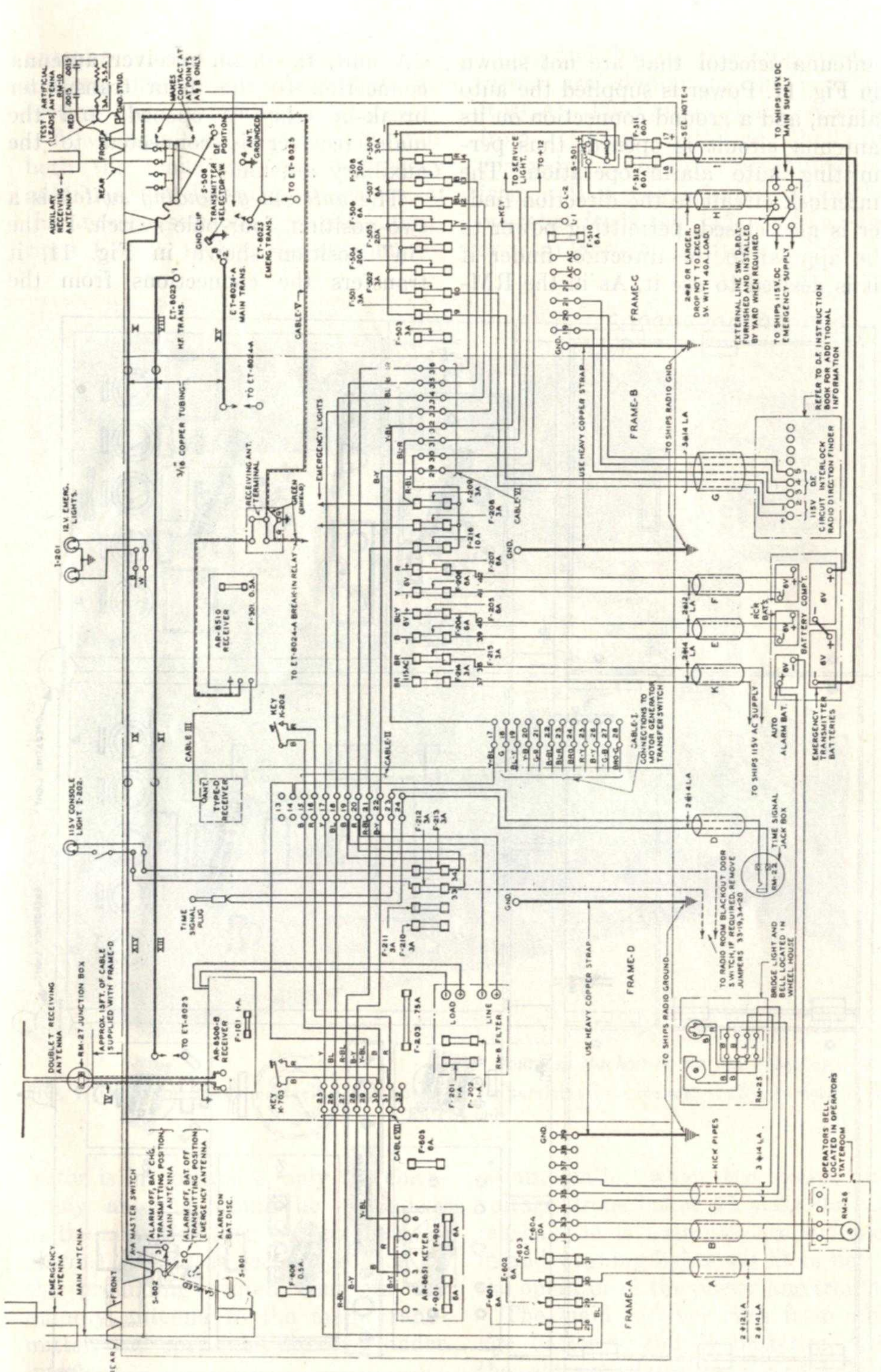


FIG. 7. Interconnection diagram for the RMCA 4U.

antenna selector that are not shown in Fig. 11. Power is supplied the auto alarm, and a ground connection on its antenna circuit is opened, thus permitting auto alarm operation. The interlock circuit to the direction finder is also closed, permitting power to be applied to the direction finder if it is desired to use it. As in the RMCA unit, the main receiver antenna connection to the main transmitter break-in relay is opened, and the main receiver is connected to the auxiliary antenna.

The *antenna grounding switch* is a two-position, four-pole switch. In the "in" position shown in Fig. 11, it transfers the connections from the

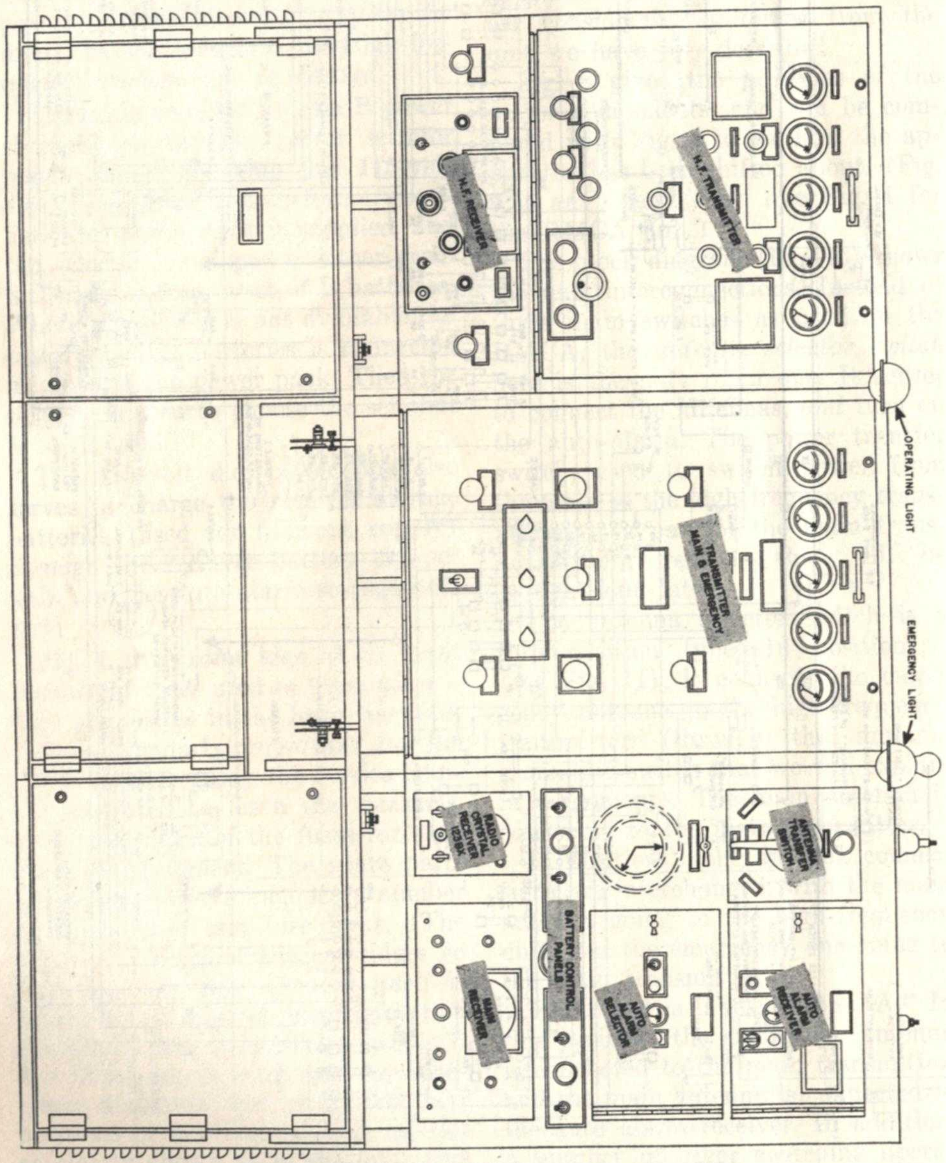



**FIG. 8. An outline sketch of the front panel of the Mackay FT-106.**



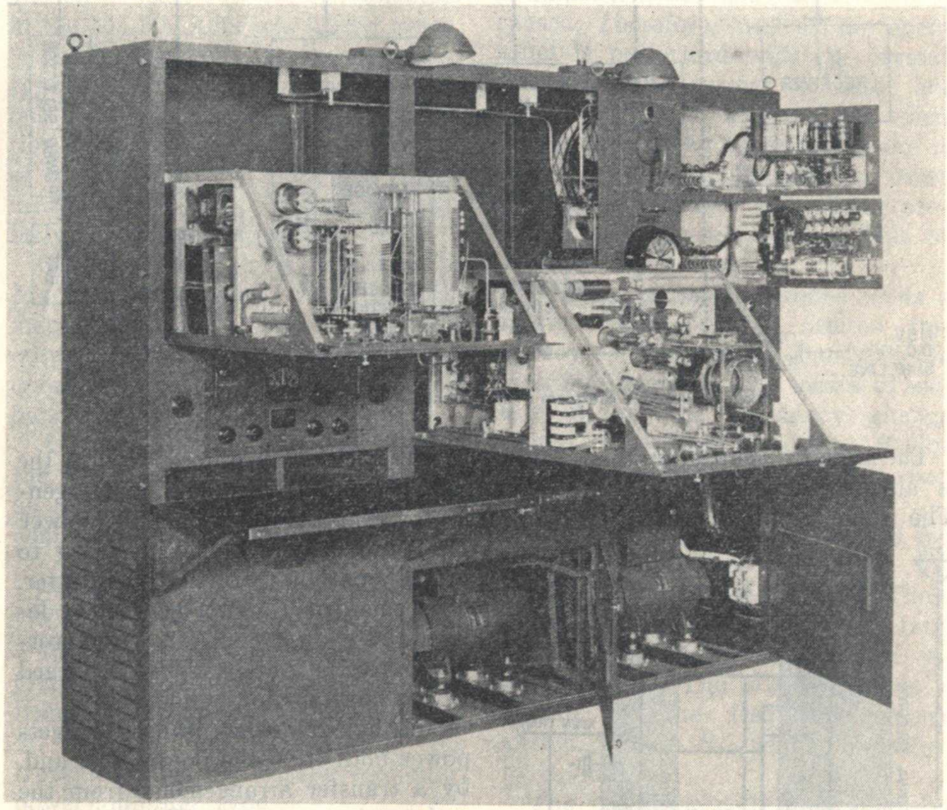


antenna selector to the proper transmitters, and closes another of the direction finder interlocks.

When in its "out" position, it grounds both the main and the emergency antennas for lightning protection, if the antenna selector is in either positions 1 or 2. (When the antenna selector is in position 3, only the emergency antenna would be grounded, as the main one then goes to the auto alarm.) Also, this second position of the grounding switch connects the dummy antenna to the main transmitter, and opens the direction finder interlock.

**Power Supply.** Going back to Fig. 10, we find that the powering arrangements are similar to those of the RMCA. The auto alarm operates from storage batteries that are charged from the ship's power line, and from a B supply selector that either operates from the 115-volt d.c. line, or from 90-volt B batteries. This unit is automatic; when the power line voltage drops below 70 volts for any reason, the B batteries are switched in and warning lights are lit to notify the operator of the power line trouble.

The main receiver runs from storage batteries and B batteries, with the storage batteries charged from the d.c. power line.



*Courtesy Mackay Radio and Telegraph Co.*

**FIG. 9. This shows that the Mackay unit opens up for servicing in a manner similar to that of the RMCA unit.**

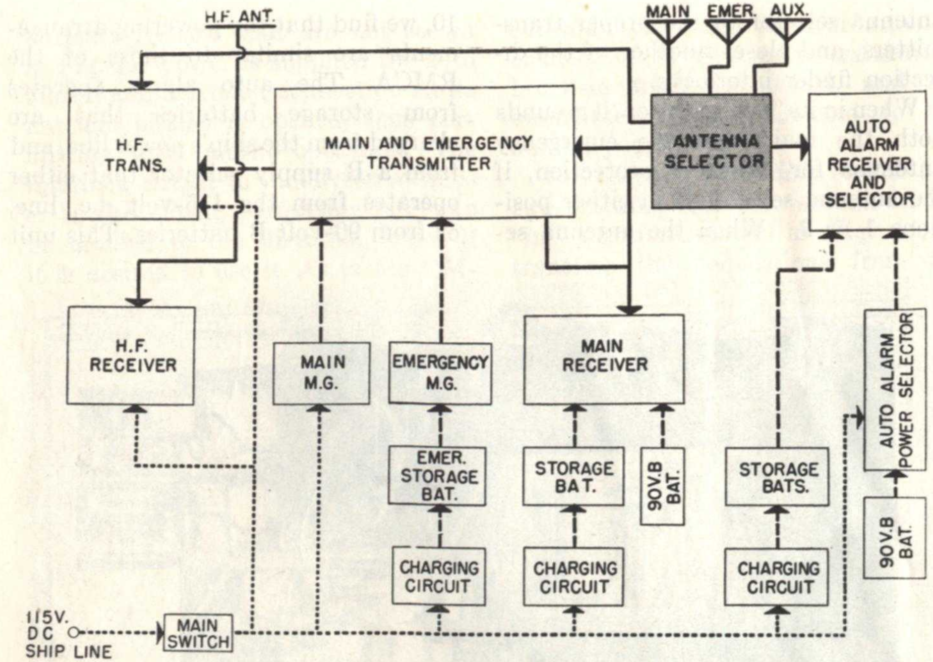



FIG. 10. A block diagram of the Mackay unit interconnections.

The main transmitter on the FT-106 is also the emergency transmitter.* The same circuit is used for both services; the only difference is in the power supply. The main motor-generator operates from the ship's power lines and delivers sufficient power to get full output from the transmitter. The emergency motor-generator delivers less power, and runs from storage batteries that have been charged from the ship's power line.

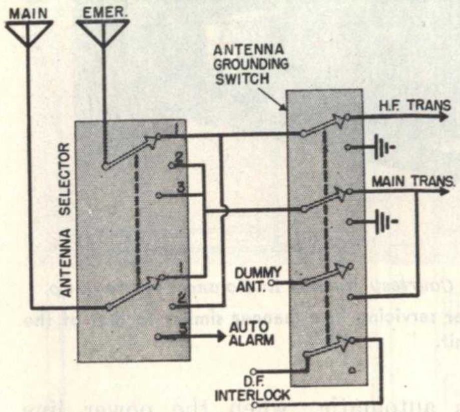



FIG. 11. The Mackay switching details.

The high-frequency transmitter gets power both from the power line, and, by a transfer arrangement, from the main motor-generator. This transmitter cannot be operated if the ship's power fails.

The high-frequency receiver also operates from the ship's power line.

► Now that you have a general idea as to how the apparatus is interconnected, let's study the individual components, piece by piece. We will start with the main transmitter.

*Recently, Mackay has placed into use a type MRU-10/11 unit that uses a separate emergency transmitter and emergency receiver. The combined transmitter of the FT-106 is permitted only in cargo vessels; a separate emergency transmitter is required for passenger ships.



# The Main Transmitter

As was indicated in another Lesson, the main transmitter aboard ship must be capable of a day-time range of about 200 miles. It must be capable of operating on 500 kilocycles and on at least two other frequencies in the 365-500 kilocycle tuning range.

The transmitter must be capable of type A-1 emission which is continuous waves, code keyed only. In addition, it is desirable to have it capable of sending out type A-2 (tone-modulated, code keyed) waves, particularly for distress purposes.

Of course, both the RMCA and the Mackay units meet these requirements. Both are capable of 200 watts output, and both operate on eight frequencies in the 350-500 kilocycle band.

Another point of similarity is that the oscillator may be operated either as a crystal-controlled or as a self-controlled master oscillator.

## THE RMCA MAIN TRANSMITTER

In Fig. 12 there is a simplified diagram of the Model ET-8024-A main transmitter that is used in the Model 4U Marine unit. Essentially, the transmitter is a master-oscillator, power-amplifier type.

Tube $VT_1$ is the oscillator tube, and is used either as a crystal-controlled oscillator or as a Colpitts master oscillator. Fig. 13 gives more details. At A, the circuit is that of the master oscillator, with condensers $C_1$ and $C_2$ dividing the tank voltage. $C_3$ is a coupling condenser used to feed the following stage. At B is shown the crystal oscillator. The crystal is inserted by removing a jumper across a crystal mounting panel and installing the proper crystal. When the crystal is used, the tank circuit is tuned as a plate tank for proper crystal oscillation. Insofar as possible, crystal operation is preferred, as the frequency drift is minimized, hence less interference is caused. Therefore, most of the operating is performed with the crystal oscillator. The master oscillator arrangement is provided for use when unusual operating conditions make it desirable to use frequencies other than those for which crystals are provided, or when the crystal fails to operate.

Whether crystal controlled or as a master oscillator, the desired frequency is selected by changing the tank inductance coil by means of section $S_2$ of the frequency change switch. (See Fig. 12 again.) $S_1$ inserts the proper crystal, when used as a crystal oscillator.

The output of the oscillator is fed to a pair of tubes in parallel, arranged as the power amplifier. These tubes feed into a tuned plate tank $L_{10}$-$C_{13}$, that utilizes a tapped inductance coil. The proper coil tap is chosen by the frequency change switch, section $S_3$, which is ganged to $S_1$ and $S_2$.

The oscillator coils have variable iron cores for making the tuning adjustment. A variable core is also used on the plate tank of the power amplifier. However, this latter core adjustment is for changing the over-all conditions. Individual frequencies here are resonated by the proper positioning of the taps on the coil. In other words, the taps are adjustable on the coil.

Power is fed to the antenna across the coupling condenser $C_{11}$. The antenna circuit itself is tuned to resonance by means of a tapped loading coil $L_{12}$ and the variometer $L_{11}$, both of which are adjustable from the front panel of the main transmitter. This flexible tuning arrangement makes it possible to resonate a wide variety of antennas, including emergency types.

The break-in keying relay serves the purpose of actually code modulating the transmitter, and also of

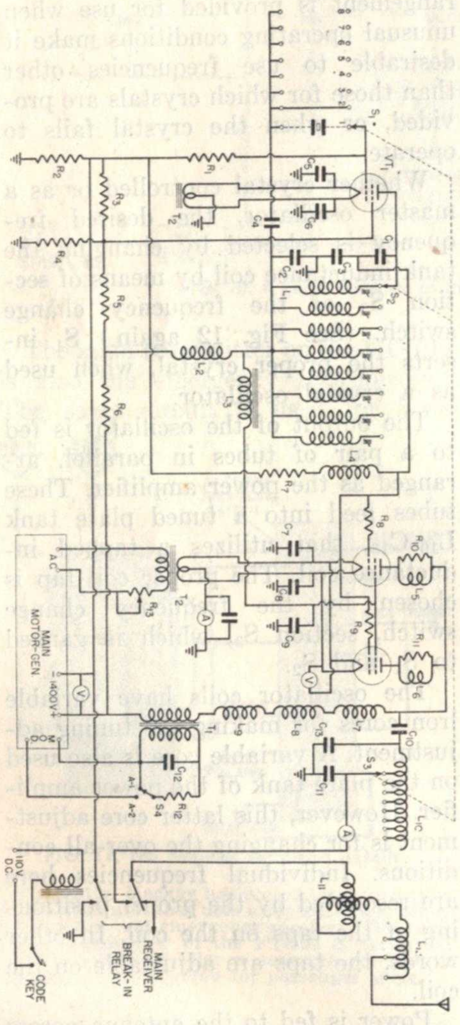



FIG. 12. This is a simplified sketch of the main transmitter of the RMCA 4U.

transferring the antenna from the transmitter to the main receiver. When the code key is not operated, the antenna is automatically connected to the main receiver. On the other hand, when the code key is depressed, the antenna is transferred to the transmitter, and resistor $R_2$ is short circuited. This resistor is between the tube cathodes and B—, so the resulting bias voltage blocks the grids of both the oscillator and power amplifier stages. When the resistor is shorted, the grids are unblocked.

Tone modulation is accomplished by means of the transformer $T_1$ in series with the plate supply for the power amplifier tubes. The primary of this transformer is connected to a 140-volt, 500-cycle section of the main motor-generator unit. When the emission switch $S_4$ is set to the A-2 position, this a.c. voltage is applied to the transformer. It is stepped up to the value required to modulate the output of the transmitter to somewhere between 70 and 100% modulation.

Notice that the tone frequency is 500 cycles. Although the a.c. voltage is applied to this transformer continuously when the switch is set for A-2 emission, no output can be obtained from the transmitter until the key is depressed, as it is necessary to have the plate voltage on both the oscillator and power amplifier before operation is obtainable.

**Operating Procedure.** From the foregoing, this particular transmitter is basically a very simple one. Its actual operation is also quite simple, and is as follows:

To operate the main transmitter, the *auto alarm master switch* must be set to either position 2 or 3. Position 3, which connects the main antenna to this transmitter, is the one commonly employed, because this posi-



tion also permits charging of the auto alarm batteries.

Next, the *motor-generator transfer switch* is thrown to the right, to connect the motor-generator to the main transmitter instead of to the high-frequency transmitter.

The *transmitter selector switch* is set to position 2, then the *motor-generator starting switch* is thrown to the "start" position.

The *frequency selector switch* has eight positions and is set to the operating frequency desired. Next, the *emission switch* is thrown to either the A-1 or A-2 position, depending upon whether tone modulation is desired.

The filament voltage is adjusted to 10 volts, by adjusting the rheostat $R_{13}$, located in the primary of the filament transformer. The plate voltage is adjusted to its normal value of 1400 volts by properly setting the field voltage on the main motor-generator. A rheostat not shown on this diagram is provided to make this adjustment.

This completes the initial starting adjustments. The next operation is to close the key so that r.f. power will be applied to the antenna circuit, and then to tune the antenna to resonance by adjusting the antenna loading switch and the antenna variometer so that the antenna ammeter indicates the proper output.

In normal operation of marine equipment, it is customary to use no more power output than is absolutely necessary. This is a requirement of the FCC. In this particular transmitter, the output is varied by adjusting the plate voltage. Once the contact has been made, the generator field rheostat can be adjusted to reduce the plate voltage to whatever amount is required to give sufficient output to maintain the contact, but not enough to cause excessive interference.

**Antenna Loading.** In normal operation, the plate current for the power amplifier tubes will be about .4 ampere. Should the tubes be changed, or should a different antenna arrangement be employed, it may be necessary to adjust the coupling to the antenna circuit to load the stage properly to draw this plate current.

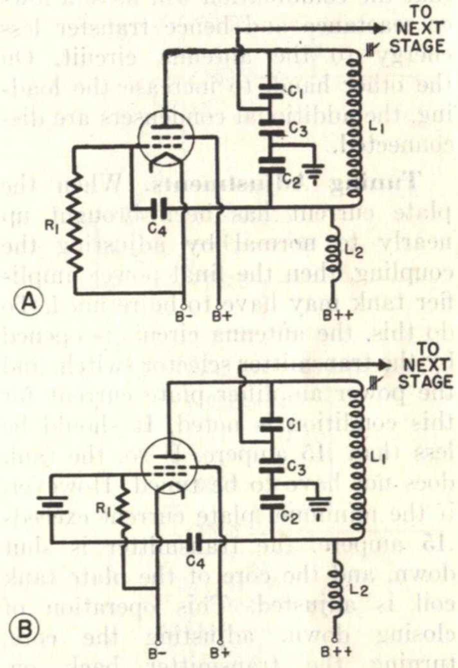



FIG. 13. The oscillator in the main transmitter of the RMCA 4U is either run as a Colpitts (A) or as a crystal-controlled type (B).

The antenna loading is adjusted, by varying the capacity ($C_{11}$ in Fig. 12) that is employed to couple the antenna to the plate tank. One condenser, corresponding to $C_{11}$ is permanently connected, and a group of three additional condensers are mounted on a panel in such a manner that they can be connected in various series or parallel groups, in parallel with the permanently mounted condenser.

Where an adjustment of the loading is necessary, the plate current of the final power amplifier is noted. If the current is above .42 ampere, the antenna coupling should be decreased, but if it is below .35 ampere, the antenna coupling may be increased. When the coupling is too high, it is necessary to increase capacity by adding other condensers in parallel with the fixed coupling capacitor, so that the combination will have a lower reactance and hence transfer less energy to the antenna circuit. On the other hand, to increase the loading, the additional condensers are disconnected.

**Tuning Adjustments.** When the plate current has been brought up nearly to normal by adjusting the coupling, then the final power amplifier tank may have to be retuned. To do this, the antenna circuit is opened by the transmitter selector switch, and the power amplifier plate current for this condition is noted. It should be less than .15 ampere. If so, the tank does not have to be tuned. However, if the minimum plate current exceeds .15 ampere, the transmitter is shut down, and the core of the plate tank coil is adjusted. This operation of closing down, adjusting the core, turning the transmitter back on, and noting the plate current, is continued until the best possible minimum value of current is obtained on both 355 and 500 kilocycles. When this adjustment is found, the core is locked in position.

Whenever a crystal is placed into use or is changed, it may be necessary to readjust the crystal oscillator. To do this, a 50-ma. meter is connected in the oscillator plate circuit by opening a "meter link" provided for this purpose. With the plate voltage adjusted down to about 1,000 volts, and the key closed, the iron core of the corresponding plate inductance coil is adjusted until the meter indicates a minimum of about 24 ma. Then, the adjusting screw is turned about one-half turn counterclockwise so that operation will be in the optimum position on the crystal oscillator characteristic curve. This increases the minimum plate current about 1 ma. After this operation is obtained, the current meter is removed and the meter link is closed again.

## THE MACKAY MAIN TRANSMITTER

As you will recall, one of the major differences between the Mackay and the RMCA units is the fact that the Mackay main transmitter is also the emergency transmitter. However, the only change for emergency operation is in the power supply; the transmitter itself operates the same in either case. Of course, there are the necessary switches on the transmitter to change the operation from the main to the emergency supply.

A glance at the diagram (Fig. 14) will show that the Mackay unit is more elaborate than the RMCA unit. The frequency change switch has been omitted for simplicity. Let us first go through the signal circuits.

Tube $VT_1$ is a crystal oscillator tube. The circuit is arranged with a grid tank inductance $L_1$ so that it will operate as a tuned-grid, untuned-plate oscillator at a frequency slightly below that of the corresponding crystal if the crystal is removed or becomes defective. The frequency is changed by interchanging crystals and tapping $L_1$. Both operations are performed by sections of the frequency change switch.

When the crystal oscillator is employed, tube $VT_2$ is a buffer amplifier having a tuned plate circuit. The



frequency selector switch chooses the proper tap on the tank inductance $L_6$ and also the proper condenser $C_2$ to resonate this tank inductance to the output frequency.

Tube $VT_3$ is an intermediate power amplifier, operating as an untuned amplifier. The final power amplifier is the parallel connected $VT_4$ and $VT_5$, which feeds into $L_9$ which is designed to resonate to approximately the middle of the 355-500 kc. band. It then offers a reasonable output impedance to any frequency in this band, so it does not have to be tuned for each operating frequency.

The antenna is inductively coupled to this tank by means of coil $L_{10}$, which has a number of taps. The proper amount of loading on the power amplifier is obtained by the proper adjustment of these taps.

The antenna circuit itself is made resonant to the transmitting frequency by means of variometer $L_{12}$. The variometer shaft also operates the switch that changes the inductance of $L_{11}$ in the antenna circuit as necessary.

When it is desired to operate this transmitter with the master-oscillator system instead of the crystal, the changeover switch $S_1$ in the grid circuit of $VT_2$ is thrown to the position marked E. This disconnects the crystal oscillator unit entirely, and utilizes $VT_2$ in a tuned-plate, untuned-grid circuit. It couples the grid coil $L_{13}$ to the plate tank $L_6$ so that this tube then becomes the oscillator.

**Power Supply.** Turning now to the power supply for the Mackay unit, we find that a rectifier-filter unit is employed. The main motor-generator delivers 75 volts a.c. at 120 cycles for operating the tube filaments. It also delivers 200 volts a.c. at 720 cycles. This a.c. voltage is stepped up by the power transformer and is utilized,

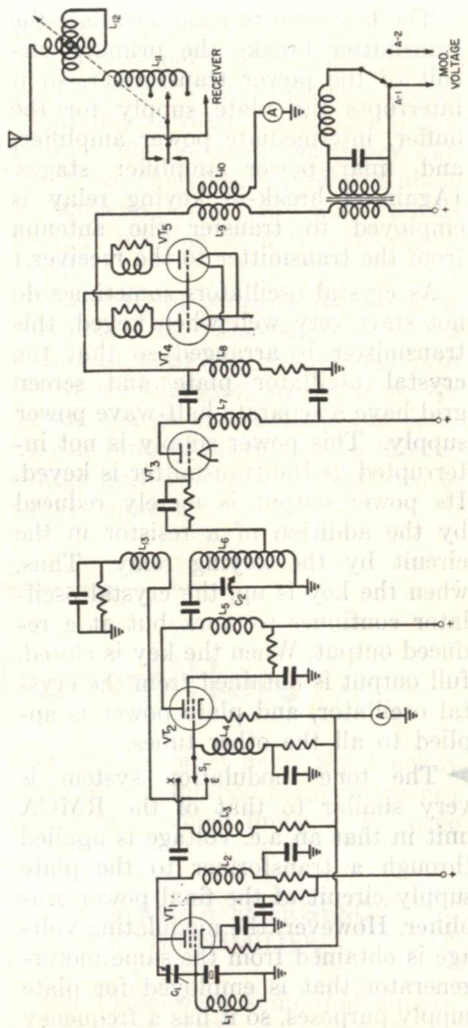



FIG. 14. A simplified sketch of the main transmitter of the Mackay FT-106.

through the rectifier-filter assembly, as the plate supply. The plate supply voltage is adjusted by means of a field rheostat on this generator.

Since mercury-vapor rectifier tubes are employed, it is necessary that the filament supply come on before the plate supply. Therefore, the generator starter has a time delay system arranged so that about 15 seconds delay will occur between the application of the filament voltage and that of the plate voltage.

The key used to code modulate the transmitter breaks the primary circuit of the power transformer, so it interrupts the plate supply for the buffer, intermediate power amplifier, and final power amplifier stages. (Again, a break-in keying relay is employed to transfer the antenna from the transmitter to the receiver.)

As crystal oscillators sometimes do not start very well when keyed, this transmitter is arranged so that the crystal oscillator plate and screen grid have a separate half-wave power supply. This power supply is not interrupted as the transmitter is keyed. Its power output is merely reduced by the addition of a resistor in the circuit by the keying relay. Thus, when the key is up, the crystal oscillator continues to work but at a reduced output. When the key is closed, full output is obtained from the crystal oscillator, and plate power is applied to all the other tubes.

► The tone modulation system is very similar to that of the RMCA unit in that an a.c. voltage is applied through a transformer to the plate supply circuit of the final power amplifier. However, the modulating voltage is obtained from the same motor-generator that is employed for plate supply purposes, so it has a frequency of 720 cycles.

► When used as a main transmitter, the Mackay unit will deliver 200 watts when class A-1 modulation is employed. As an emergency transmitter, it delivers about 40 watts under the same condition. Essentially, the only change that occurs is the change in the motor-generators. The main motor-generator operates from the 115-volt d.c. ship line. The emergency transmitter operates from 24-volt batteries, and therefore cannot deliver as much power output and still operate over the required 6 hours of time. Therefore, the emergency motor-generator delivers the same 75-volt power for filament supply, but delivers only 100 volts instead of 200 volts to the primary of the power transformer. This of course, reduces the power output greatly, but does permit emergency operation. Except for this difference in the voltage output, the two motor-generators are basically alike.

**Operation.** The operation of the Mackay main transmitter is as follows:

On the power control panel, there is a switch labeled *power*, used to change the operation from the main to the emergency generator. In the "main" position it connects 115 volts to the main motor-generator unit, and in the emergency position, batteries are connected to the emergency generator. For main operation, this switch is thrown to the main position.

Next, the *transmitter selector switch*, which is located on the front panel of this main transmitter, is thrown to the proper position. This switch is labeled "IF-HF" and serves to select either this main (intermediate-frequency) transmitter or the high-frequency transmitter. It is thrown to the "IF" position to operate the main transmitter.

The third switch is the *battery switch*. This switch has three positions—off, charge and start. In the "start" position it connects the batteries to the emergency motor-generator. However, in the charge position, the emergency batteries are placed on charge and the main transmitter can be used.

When the *line switch* is thrown to the "on" position, the motor-generator starter is actuated, which starts the main motor-generator. As the main motor-generator comes up to speed, the filament rheostat is adjusted until





the filament voltmeter shows 6.3 volts. The plate voltage is adjusted next by means of the plate rheostat.

When power is applied, the *frequency control switch* is set to the proper position, and the *emission switch* is set to the CW (A-1) or MCW (A-2) position.

This transmitter is somewhat different in that the plate current meter can be plugged into any of the stages by means of the plate current switch. With this switch set so as to read the plate current of the final power amplifier, the antenna tuning and the loading may be adjusted. The correctly loaded plate current is about 350 ma. at 400 kilocycles.

There is one other switch on the panel of this transmitter, labeled "charging switch." In the "full charge" position, the emergency batteries are charged at a rate of about 8 amperes, and in the "trickle charge" position at a rate of .5 ampere.

The charging resistors dissipate considerable heat. This transmitter has a fan to keep the entire unit cool. When the charging switch is in the trickle charge position, the fan operates at lowered speed, but in the full charge position, the fan speeds up to deliver more air.

# Emergency Transmitters

In addition to the main transmitter, it is required that the ship carry an emergency transmitter capable of transmitting a signal for at least six hours, when operated from a source of power entirely independent of the ship's power line. This emergency transmitter must have a normal range of at least 100 nautical miles by day and must be capable of being put into operation within at least one minute.

On passenger vessels, it is required that the emergency installation be an actual, separate, and complete transmitter, entirely distinct from the main unit. However, on cargo ships, if the main installation complies with all the requirements of the emergency installation, then it may be used as the emergency unit.

At once, we see that the RMCA unit is capable of being used both on passenger and cargo vessels because a separate emergency transmitter is used. On the other hand, the Mackay unit uses a combined main-emergency transmitter, which limits it to cargo ships.*

## THE RMCA EMERGENCY TRANSMITTER

Fig. 15 shows a somewhat simplified diagram of the emergency transmitter used in the RMCA 4U. The manufacturer believes in "getting the most from the least" here, which is desirable in emergency equipment. The six tubes are all the same type, and are connected so that as long as either the upper or the lower three are good, the transmitter will work (with reduced output, of course).

The oscillator is again a Colpitts type using the tank circuit $L_1$-$C_1$-$C_2$-$C_3$. The two oscillator tubes $VT_1$

*The new Mackay MRU-10/11 has a separate emergency transmitter, so it meets the passenger ship requirement.

and $VT_2$ are operating in push-pull because of the plate supply connections. That is, $VT_1$ gets power from one half of the secondary of $T_1$, while $VT_2$ operates from the other side of this secondary.

This brings up the rather interesting method of supplying power. The emergency motor-generator, operated from the 12-volt emergency battery, generates 115 volts *a.c.* at 350 cycles. This is supplied through transformer $T_1$ directly to the tube plates and screens. Therefore, the tubes operate with a.c. plate and screen grid voltages. The tubes then rectify this voltage themselves. The connections to the power transformer are such that only one tube plate at a time is made positive. The result is that the plate currents of the tubes are actually pulsating currents varying at twice the frequency of the a.c. source (at 700 cycles). From this, the output of the transmitter is directly modulated with this frequency, so the output is class A-2 emission.

Because of this unique power-supply connection, first one oscillator tube works and then the other, much as in a push-pull circuit. The tank output across $C_2$ is fed to the four power amplifier tube grids. Here again the plate power connection is arranged to give push-pull operation of the tubes in pairs so that the tubes effectively operate in parallel push-pull.

This particular transmitter has the same antenna tuning arrangement as the main transmitter in that the antenna loading coil taps and variometer are brought out to front panel controls. This makes it possible to match to any type of regular, emergency, or spare antenna without having to get inside the unit.

Frequencies are changed by the frequency selector switch, which inserts different oscillator tank coils, and adjusts the tap on the power amplifier tank coil $L_6$.

**Operation.** The operation of this transmitter is similar to that of the main transmitter in the unit. The *transmitter selector switch* is set to position 3, which connects the antenna bus to the emergency transmitter. The *auto alarm master switch* can then be set to either position 2 or 3. In position 3 the main antenna is connected, and in position 2 the emergency antenna is connected to the transmitter.

On the battery control panel, the *charge-discharge switch* is thrown to the "discharge" position. This connects the storage battery to the emergency generator and to the transmitter.

The emergency generator is started by operating its *start-stop switch*. It takes only about five seconds for the tubes to heat up and the emergency generator to come up to full operating speed.

The *frequency-control switch* is adjusted to whichever of the five frequencies is to be used. A proper tap is then chosen on the antenna loading coil, the key is closed, and the antenna variometer tuned for maximum antenna current.

The filament voltage may be adjusted by means of the filament rheostat so that the filament voltmeter reads 10 volts.

► Associated with the emergency transmitter is a *charge switch*. When the emergency transmitter is not in use, the charging rate can be adjusted to full charge of about 9 amperes, or to a trickle charge position of about 1.5 amperes.

► At the top of frame B, there are emergency lights, that run from the 12-volt battery which operates the emergency transmitter. A switch to



the left of the main receiver in frame B will turn on these lights when the charge-discharge switch is in the discharge position. However, when this switch is in the charging position, these lights will not operate. These lights are provided so that it is possible to see all the controls even if the ship's power fails. The emergency battery, to meet the required specifications, must supply sufficient power to operate these lights, in addition to the transmitter, for the required six hours. (That is, the light drain is added to that of the transmitter to determine the total drain per hour. This must be multiplied by the number of hours of operation to find the ampere-hour drain, and hence the battery capacity.) Of course this is impossible unless the battery is kept properly charged, which requires that the operator be particularly careful to check the batteries, and their charging rates, and to adjust the charging switches accordingly.

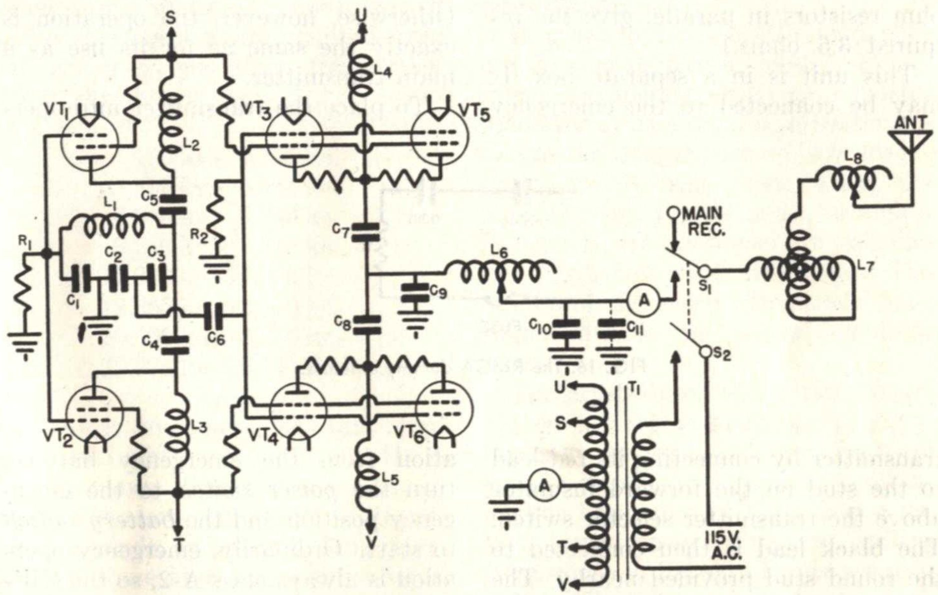


**FIG. 15. The RMCA emergency transmitter.**

There is an auxiliary 12-volt light in the lower section of frame C, with its own on-off switch. This light may be used at any time that it is necessary to work inside the transmitter, but the light should be kept off at all other times. It illuminates the fuses and other components in frame C.

**Dummy Antenna.** It is required that an artificial antenna be provided for use in testing the emergency transmitter. The law provides that the emergency installations shall be tested by actual operation prior to the vessel's departure from each port, and once each day when the vessel is outside the harbor or port. This test, while in port, must be made on the dummy antenna. At sea, the test may be made on the dummy antenna, although it is permissible to operate the emergency transmitter for not more than one hour each day in carrying on the regular ship's communications, where such operation does not reduce the ability of the emergency equipment to operate its full six hours when required for emergency purposes.

For this purpose, there is provided with the RMCA unit a type RM-10 artificial antenna unit. This is shown in Fig. 16. It consists of a group of resistors, a pair of condensers and a fuse. It is arranged to simulate an antenna of 3.5 ohms, having a capacity of .00075 mfd. (Fourteen 50-ohm resistors in parallel give the required 3.5 ohms.)

This unit is in a separate box. It may be connected to the emergency transmitter by connecting its red lead to the stud on the forward insulator above the transmitter selector switch. The black lead is then connected to the round stud provided nearby. The transmitter selector switch is then placed in position 4 (antenna grounded position), leaving only the dummy antenna connected to the emergency transmitter.

This artificial antenna is for use only with the emergency transmitter. Whenever combination units are employed, it is necessary to be sure that they are adjusted for emergency operation. As soon as the test is completed, this artificial antenna unit must be disconnected and stored. Be certain, when this is done, that the antenna tuning controls on the emergency transmitter are restored to their normal positions.

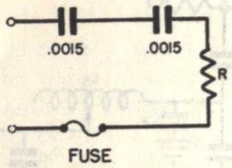


**FIG. 16. The RMCA dummy antenna.**

## THE MACKAY EMERGENCY TRANSMITTER

In the Mackay FT-106 unit, the main transmitter is also the emergency unit.* The only basic difference is that the transmitter is operated from an emergency motor-generator, which in turn operates from the emergency storage battery supply. The result is that lower plate voltages are supplied, hence the output of the transmitter is reduced. Otherwise, however, the operation is exactly the same as for its use as a main transmitter.

To place the transmitter into operation from the emergency battery, turn the *power switch* to the emergency position and the *battery switch* to start. Ordinarily, emergency operation is always class A-2, so the *CW-MCW switch* should be set to the MCW position.

When the battery switch is turned to the start position, the emergency motor-generator will come up to speed. The filament voltage is to be adjusted to 6.3 volts, and after waiting about fifteen seconds for the time delay to function, press the telegraph key and resonate the antenna, just as for main operation.

In this unit, the dummy or artificial antenna is built into the transmitter assembly. When the antenna grounding switch is placed in the grounded position, this artificial antenna is automatically connected to the transmitter. Be sure the set up is for emergency operation, however, when the dummy antenna is being used.

*In the new Mackay MRU-10/11 unit, there is a separate emergency transmitter as there is in the RMCA 4U.





# High-Frequency Transmitters

At the present time, there are available to the Marine services eight so-called high-frequency bands, within which ship stations are assigned fixed calling and operating frequencies. These ship bands are:

4,140 kc.- 4,165 kc.
5,510 kc.- 5,535 kc.
6,210 kc.- 6,240 kc.
8,240 kc.- 8,330 kc.
11,020 kc.-11,070 kc.
12,360 kc.-12,480 kc.
16,500 kc.-16,600 kc.
22,025 kc.-22,140 kc.

There is no *requirement* that ships use these high-frequency bands. However, because of the crowded conditions on the low- and intermediate-frequency bands, and the resulting interference, these higher frequency bands are coming into wider use despite the greater operating difficulties encountered on these frequencies. Therefore, high-frequency transmitters capable of operating in these bands are made available in the package units we are describing.

## THE RMCA HIGH-FREQUENCY TRANSMITTER

The RMCA high-frequency transmitter is designed to give continuous coverage of all frequencies between 2,000 kilocycles and 24,000 kilocycles. This permits the transmitter to cover the eight ship bands listed above, and in addition, provides for operation in any other ship band which may be allocated at any time between these frequencies.

In order to get this frequency coverage, the oscillator circuit is arranged to operate either as a master oscillator or as a crystal oscillator between the frequencies of 1.5 megacycles and 3 megacycles. Then, the second, third, fourth, sixth, or eighth harmonics are employed by utilizing two frequency multiplier stages. The output of the second frequency multiplier drives the power amplifier tubes.

The crystal oscillator circuit is arranged so that as many as ten crystals may be used, but only four are usually provided. However, by utilizing the harmonics of these four crystals, seventeen working and calling frequencies in the ship bands are provided. Then, for any other frequencies, the master oscillator may be used, or additional crystals provided.

A simplified diagram is shown in Fig. 17. Again, notice that the master oscillator is the Colpitts type, which is changed to a standard crystal oscillator at other settings of the frequency control switch $S_1$. The output of the oscillator feeds into the first buffer or frequency multiplier $VT_2$, which in turn operates the second buffer (or multiplier) $VT_3$. The buffer stages and the power amplifier are automatically tuned to the right frequency *band* by the use of tapped inductance coils and a gang switch $S_2$-$S_3$-$S_4$ having nine positions. The gang switch is turned to the frequency band desired, then final tuning of the multiplier and power amplifiers is brought about by tuning condensers $C_7$, $C_9$, and $C_{11}$. The condensers $C_7$ and $C_9$ that tune the buffer or multiplier stages are ganged together, but the power amplifier condenser $C_{11}$ has a separate knob.

The coupling from the power amplifier into the antenna is somewhat elaborate because this unit is designed to operate into the standard shipboard antenna. As a result, it is operating into an antenna that is not designed for operation over this wide range of frequencies. Hence, the antenna presents a very wide range of impedances and it is necessary to tune the antenna in each instance so that proper loading can be obtained. For this reason, it takes considerably longer to get this high-frequency transmitter into operation than it does the main transmitter.

The keying relay is operated from the break-in relay on the main transmitter, which in turn is actuated by the operating key. The keying relay interrupts the B— return circuit, thus cutting off plate power from all tubes. This is the same system as is used on the main transmitter.

When type A-2 emission is desired, the modulation switch is thrown to this position, which inserts the modulation transformer $T_1$ in series with the plate supply for the power amplifier tube. As in the main transmitter, the 500-cycle a.c. generator section of the main motor-generator unit is utilized to supply the modulation voltage.

**Operation.** The operation of the unit can be better understood by running through the starting operation.

First, as for the main transmitter, the auto-alarm switch may be set to position 3 for connecting the main antenna, or to position 2 for connecting the emergency antenna to this unit. Then, the transmitter selector switch is set to position 1, which connects the antenna to the high-frequency transmitter.

The motor-generator transfer switch is thrown to the left, which connects the main motor-generator to the high-frequency transmitter.

The motor-generator is started, and the filament voltage is adjusted to 10 volts by means of a rheostat in the primary circuit of the filament transformer, just as in the main transmitter. Similarly, a rheostat on this high-frequency transmitter is used to adjust the motor-generator field excitation to set the plate voltage at 1400 volts. In effect, the same controls for voltage adjustments are on the high-frequency transmitter as are on the main transmitter, and the motor-generator transfer switch determines which unit power is supplied to, and hence which unit is capable of controlling the motor-generator output.

The *emission switch* may be set to A-1 or A-2 as desired once the transmitter is operating, but when first starting up, the switch is set to the A-1 position.

This transmitter is furnished with a calibration card that indicates the setting of the various frequency controls. From this card, the band switch is set to the desired band, then the crystal switch is set to pick out the proper crystal or to provide for master oscillator operation.

The oscillator tuning is now set from the calibration card. A high-gear-ratio vernier-tuning arrangement is employed. The oscillator inductance is a 29-turn coil, and is arranged with a slider, so that anything from one turn to the full



twenty-nine turns may be used. The tuning control moves the slider along the coil. A counter is used to indicate the number of turns and tenths of a turn that are in use, and the vernier dial indicates even smaller fractions of a turn. The vernier dial must make a complete rotation to move the slider one turn along the coil. Hence, it is possible to tune accurately to the desired frequency.

The band switch setting has automatically selected the proper buffer or multiplier coils, as well as the tank coil for the power amplifier. The buffer tuning condensers are now adjusted to the approximate position indicated on the calibration card. Because of the number of stages involved, tuning must be carefully carried out, and it is not desirable to tune with full power on. Therefore, for the remainder of the tuning operation, the tuning key is used. This key closes B— to ground, but as shown in Fig. 17, it closes the circuit through a 500-ohm resistor $R_1$. This resistance greatly reduces the plate voltage so that even though the circuits are not properly tuned, the plate current will not be excessive. With the tuning key depressed, the next step is one of readjusting the buffer tuning for maximum power-amplifier grid current.

Then, the power-amplifier plate tuning adjustment is made, and the proper coupling to the antenna is set up from the tuning chart. The power amplifier plate circuit is now retuned for minimum plate current. When adjusted this far, it is safe to close the main key for the final adjustments. (When the tuning key is released, it short-circuits $R_1$ so that full power is available.) If the power amplifier plate current is less than .3 ampere, or more than .4 ampere, then

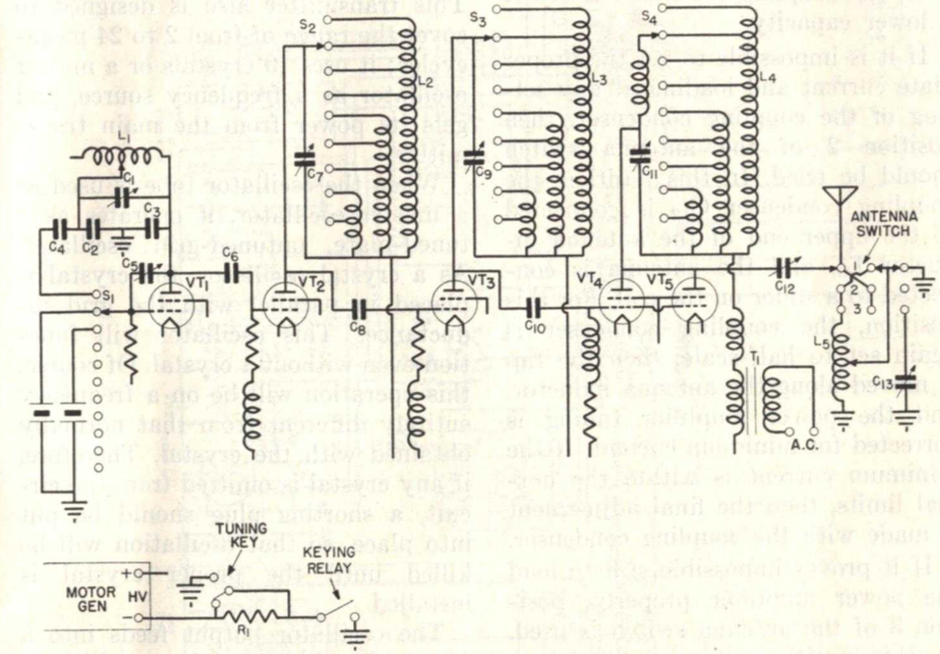



**FIG. 17. The RMCA high-frequency transmitter.**

the antenna coupling must be adjusted.

With the antenna switch in position 1, the antenna is coupled through the coupling condenser $C_{12}$ to the tank. This condenser is set to half-scale, and the power amplifier tuning is adjusted for minimum current. If the minimum current is less than .3 ampere, the coupling condenser is increased in capacity and the power amplifier tuning is readjusted. If the cathode current is more than .4 ampere, the coupling condenser is set to a lower capacity.

If it is impossible to get the proper plate current and loading at any setting of the coupling condenser, then position 2 of the antenna switch should be tried. In this position, the coupling condenser $C_{12}$ is connected to the upper end of the antenna inductor $L_5$, and the antenna is connected to a slider on the coil. For this position, the coupling condenser is again set to half-scale, then the tap is moved along the antenna inductor, and the power amplifier tuning is corrected for minimum current. If the minimum current is within the normal limits, then the final adjustment is made with the coupling condenser.

If it proves impossible still to load the power amplifier properly, position 3 of the antenna switch is used. In this position, the coupling condenser and inductance are as before, but now a tuning condenser $C_{13}$ is connected between the antenna and ground, which in effect forms a parallel resonant circuit with the portion of the antenna coil that is in the circuit. The two condensers are set at half-scale and the inductance adjusted. If this does not load, different condenser settings are tried until the proper loading is obtained. Normally you use the lowest capacity setting of the antenna capacitor that will give reasonable results, because otherwise extremely high voltages may be built up across the resonant circuit formed by the antenna coil and antenna condenser.

## THE MACKAY HIGH-FREQUENCY TRANSMITTER

A complete diagram of the Mackay high-frequency transmitter is given in Fig. 18. An examination of this diagram and a check of the specifications shows that it is basically rather similar to the RMCA unit. This transmitter also is designed to cover the range of from 2 to 24 megacycles; it uses 10 crystals or a master oscillator as a frequency source, and gets its power from the main transmitter.

When the oscillator tube is used as a master oscillator, it operates as a tuned-plate, untuned-grid oscillator. As a crystal oscillator, the crystal is placed in parallel with the grid inductance. This oscillator will function even without a crystal. Of course, this operation will be on a frequency entirely different from that normally obtained with the crystal. Therefore, if any crystal is omitted from the circuit, a shorting plug should be put into place, so that oscillation will be killed until the proper crystal is installed.

The oscillator output feeds into a 6L6 buffer amplifier stage which is untuned. From here, the signal goes to a chain of multipliers. Multiplier No. 1 is a doubler, multiplier No. 2 is a doubler and No. 3 is either a doubler or tripler, as necessary.

The output from the proper multiplier tube is fed to the power amplifier, which consists of parallel power tubes, through section No. 1 of the frequency range switch $S_4$.

The oscillator produces a frequency within the range of from 1 to 2 megacycles. If operation is to be from 2



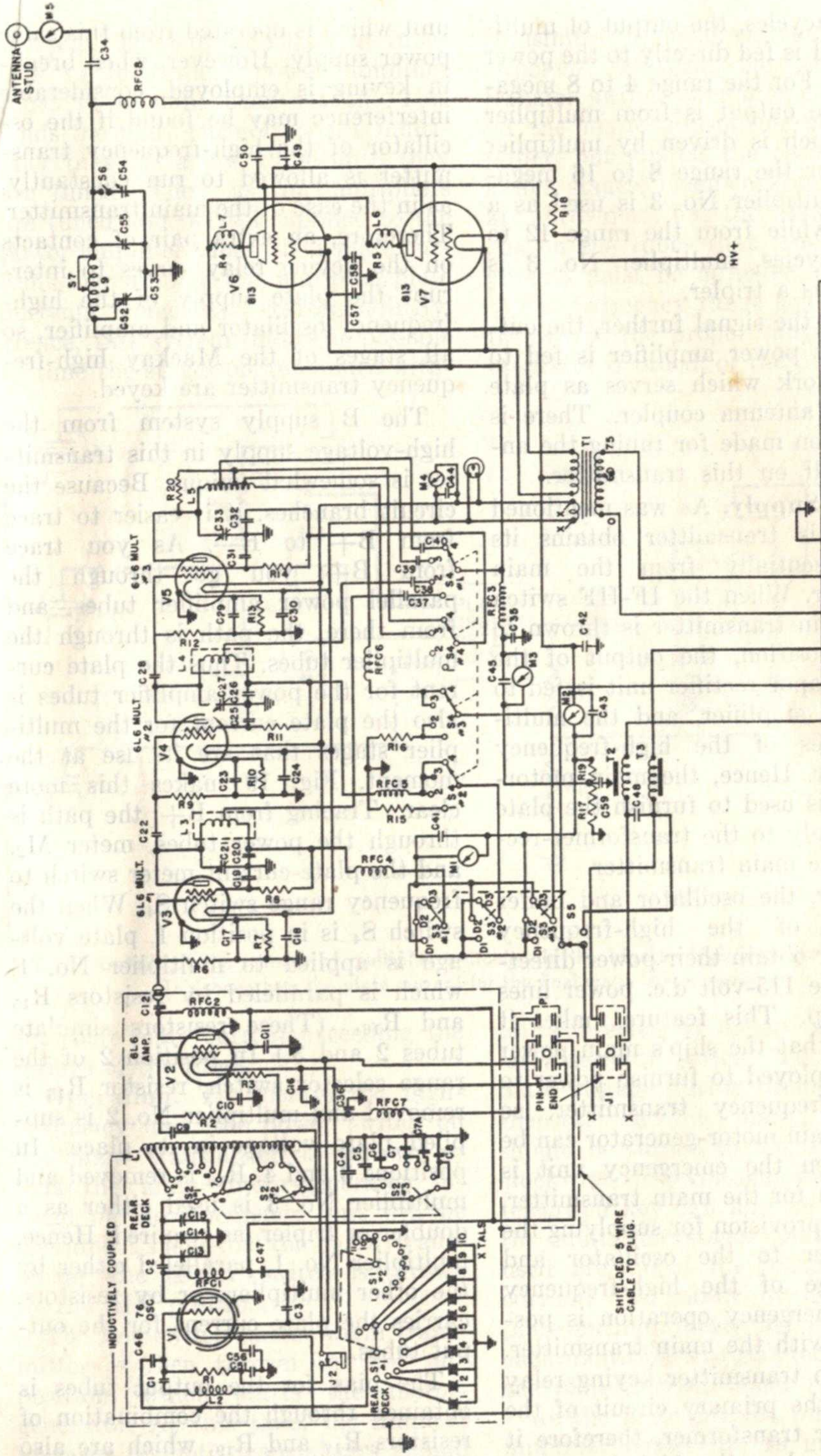



FIG. 18. A complete schematic of the Mackay high-frequency transmitter.

to 4 megacycles, the output of multiplier No. 1 is fed directly to the power amplifier. For the range 4 to 8 megacycles, the output is from multiplier No. 2 which is driven by multiplier No. 1. For the range 8 to 16 megacycles, multiplier No. 3 is used as a doubler, while from the range 12 to 24 megacycles, multiplier No. 3 is operated as a tripler.

Tracing the signal further, the output of the power amplifier is fed to a pi network which serves as plate tank and antenna coupler. There is no provision made for tuning the antenna itself on this transmitter.

**Power Supply.** As was mentioned earlier, this transmitter obtains its power essentially from the main transmitter. When the IF-HF switch on the main transmitter is thrown to the HF position, the output of the mercury vapor rectifier unit is fed to the power amplifier, and the multiplier stages of the high-frequency transmitter. Hence, the main motor-generator is used to furnish the plate power supply to the transformer-rectifier of the main transmitter.

However, the oscillator and buffer amplifiers of the high-frequency transmitter obtain their power directly from the 115-volt d.c. power lines of the ship. This feature makes it necessary that the ship's main power line be employed to furnish power to the high-frequency transmitter, so only the main motor-generator can be used. When the emergency unit is switched in for the main transmitter, there is no provision for supplying the plate power to the oscillator and buffer stage of the high-frequency unit, so emergency operation is possible only with the main transmitter.

The main transmitter keying relay interrupts the primary circuit of the plate power transformer, therefore it acts also to key the high-frequency unit which is operated from this same power supply. However, when break-in keying is employed, considerable interference may be found if the oscillator of the high-frequency transmitter is allowed to run constantly, as in the case of the main transmitter. Therefore, an extra pair of contacts on the keying relay serves to interrupt the plate supply of the high-frequency oscillator and amplifier, so all stages of the Mackay high-frequency transmitter are keyed.

The B supply system from the high-voltage supply in this transmitter is somewhat unique. Because the circuit branches, it is easier to trace from B+ to B—. As you trace from B+ you go through the parallel power amplifier tubes, and from there, the path is through the multiplier tubes. Thus the plate current for the power amplifier tubes is also the plate current for the multiplier stages that are in use at the moment. Fig. 19 makes this more clear. Tracing from B+, the path is through the power tubes, meter $M_2$, and the plate-current meter switch to frequency range switch $S_4$. When the switch $S_4$ is in position 1, plate voltage is applied to multiplier No. 1, which is paralleled by resistors $R_{15}$ and $R_{16}$. (These resistors simulate tubes 2 and 3.) In position 2 of the range selector switch, resistor $R_{15}$ is removed and multiplier No. 2 is supplied plate voltage in its place. In positions 3 and 4, $R_{16}$ is removed and multiplier No. 3 is used either as a doubler or tripler, as required. Hence, multiplier No. 1, paralleled either by the other multipliers or by resistors, carries the plate current for the output tubes.

The bias for the output tubes is obtained through the combination of resistors $R_{17}$ and $R_{19}$, which are also in parallel with this group. Hence,





the plate current for the final tubes acts to bias these power amplifier tubes to a point near cut off. This holds the plate current for the multiplier tubes to a low value until they are tuned. Then, as the multipliers are tuned and drive is applied to the power amplifier tubes, their plate currents increase and the multiplier plate currents come up correspondingly. Hence, this system makes it possible to tune the stages off resonance without their plate current exceeding the ratings of the tubes.

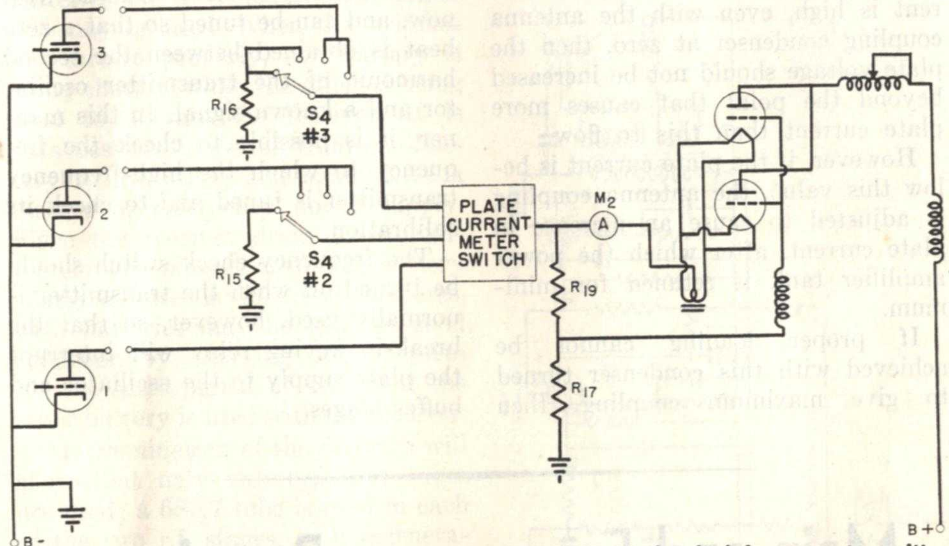



**FIG. 19. Details of the manner of multiplier switching in the Mackay high-frequency transmitter. This shows how the plate current for the final stage is kept constant.**

**Operation.** To operate the high-frequency unit, the power switch on the main transmitter is thrown so that the main motor-generator instead of the emergency unit will be operated. Then, on the main transmitter, the IF-HF switch is thrown to the HF position.

The line switch on the main transmitter is then thrown to the "on" position, which starts the motor-generator. At this time, the filament voltages on both transmitters should be adjusted to 6.3 volts. The main transmitter filament voltage has to be adjusted because the transmitter transfer switch cuts filament voltage off the main transmitter power amplifier, but not off the oscillator and buffer stages. Compensating resistors are thrown in, but the filament voltage on the tubes that remain in the circuits must be adjusted.

The frequency range switch is now thrown to the proper range, and the oscillator is tuned, or the proper crystal is inserted by means of the oscillator selector switch. To reduce the plate voltage during tuning, the field rheostat on the main transmitter should be turned to the full counter-clockwise (low-voltage) position. The telegraph key can now be closed and the multiplier stages that are being used are tuned for maximum plate current. As shown in Fig. 18, the plate current meter $M_1$ is placed in each multiplier circuit successively by the plate current meter switch $S_3$.

As the plate current for the power amplifier comes up, as indicated by meter $M_2$, it is now possible to tune this power amplifier and adjust the antenna loading. The proper tap on the tank coil $L_9$ is set from the tuning chart. Then, the power amplifier tuning condenser is adjusted for a maximum tip in the plate current.

Next, the antenna coupling is increased to give the amplifier plate current of 380 ma. This is the maximum plate current that should flow, even when the field rheostat is turned full clockwise and maximum plate voltage is supplied. If the plate current is high, even with the antenna coupling condenser at zero, then the plate voltage should not be increased beyond the point that causes more plate current than this to flow.

However, if the plate current is below this value, the antenna coupling is adjusted to cause an increase in plate current, after which the power amplifier tank is retuned for minimum.

If proper loading cannot be achieved with this condenser turned to give maximum coupling, then switch $S_6$ is closed to add other antenna coupling condensers. This condenser is adjusted until proper loading is obtained.

The high-frequency transmitter has a switch on the panel marked "frequency check." When this switch is turned to the "on" position, power is applied to the oscillator-buffer but not to the other stages. The transmitter is started in the normal manner, but the key is not used. The high-frequency receiver can be used now, and can be tuned so that a zero beat is obtained between the second harmonic of the transmitter oscillator and a known signal. In this manner, it is possible to check the frequency to which the high-frequency transmitter is tuned and to check its calibration.

The frequency check switch should be turned off when the transmitter is normally used, however, so that the break-in keying relay will interrupt the plate supply to the oscillator and buffer stages.

# Main and Emergency Receivers

As you know, the main receiver aboard ship is the one having the same frequency range as the main transmitter. This receiver is usually a tuned radio frequency type having a rather simple circuit arrangement.

Strictly speaking, the *emergency* receiver is the crystal set aboard ship, which has been described elsewhere in this Course. However, in general the practice is to make the main receiver satisfy all the legal requirements for an emergency receiver as well, in that it is capable of operating on the distress band, and of operating for at least six hours entirely independent of the ship's power supply.

## RMCA MAIN RECEIVER

Fig. 20 shows a simplified diagram of the RMCA main receiver. All tube filaments are operated in parallel from a 6-volt storage battery supply. Plate supply is 90 volts. Where the ship has 115-volt a.c. power lines, this receiver is furnished with a transformer-rectifier tube-filter power supply capable of supplying 90 volts. In addition, 90-volt B batteries are employed. The receiver power switch is arranged so that operation may be either from this rectifier unit or from





the B batteries. On ships that do not have the a.c. power line, an additional set of B batteries are connected so that the power switch of the receiver may be used to operate from either set of B batteries. Therefore, the receiver has a normal and reserve B supply, so that it can be used for emergency purposes.

The A supply is also arranged for emergencies in that two 6-volt storage batteries are employed. These batteries are arranged so that either one may be used. When the switches are thrown properly, one battery is being charged while the other is being used to operate the receiver. It is thus possible to switch from one battery to the other, and again have a reserve or emergency power supply. Since the receiver drain is approximately 1.8 amperes, while the battery charging rate is about 3 amperes, both batteries may be kept in good condition by charging one of them for the same period of time that the other battery is used with the receiver.

An examination of the diagram will show that only two types of tubes are used; a 6SK7 tube is used in each of the two r.f. stages, as a regenerative detector, and as a first audio stage, and a 6V6 tube is used as a power amplifier. This arrangement of tubes permits the fewest number of tubes to be carried as spares.

The antenna for this receiver is either the main or the emergency antenna, as it comes through the break-in keying relay on the main transmitter. On the receiver panel, there is another switch that either connects this incoming antenna to this main receiver, or connects it to the crystal set.

The frequency range of the main receiver covers the low and intermediate frequency bands from 15 to 650 kilocycles in four bands. The band change switch selects the proper coils for each band.

After going through two stages of radio-frequency amplification, the signal is fed into a regenerative detector. The regeneration control varies the screen voltage of the detector. By proper adjustment of this control, the sensitivity of the set can be increased greatly by using regeneration, or the detector stage can be allowed to oscillate so that reception

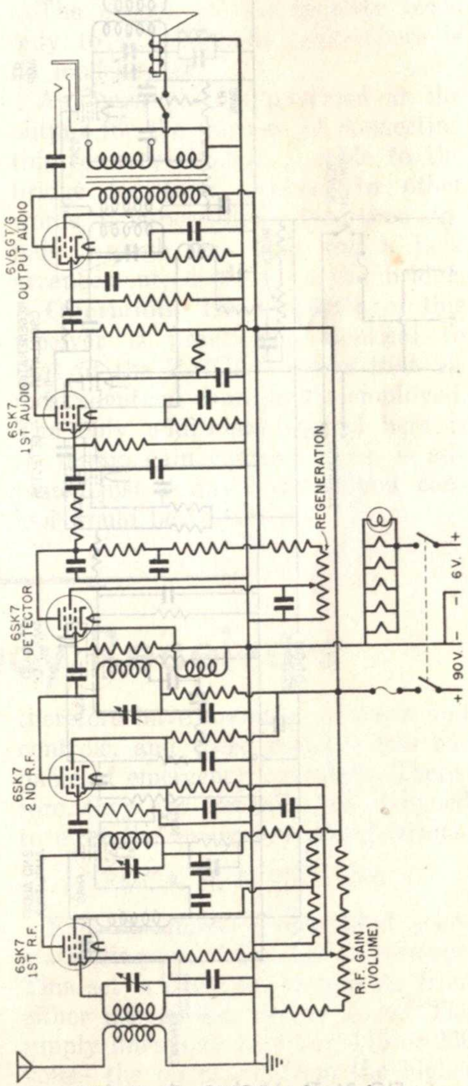



FIG. 20. The RMCA main receiver.

of class A-1 signals is possible. In order to get the needed beat note for reception of continuous waves, the tuning condensers are detuned slightly, so that the detector stage can oscillate at a frequency different from that of the incoming signal. When this operation is desired, the two r.f. stages can be brought back to resonance by adjusting the individual

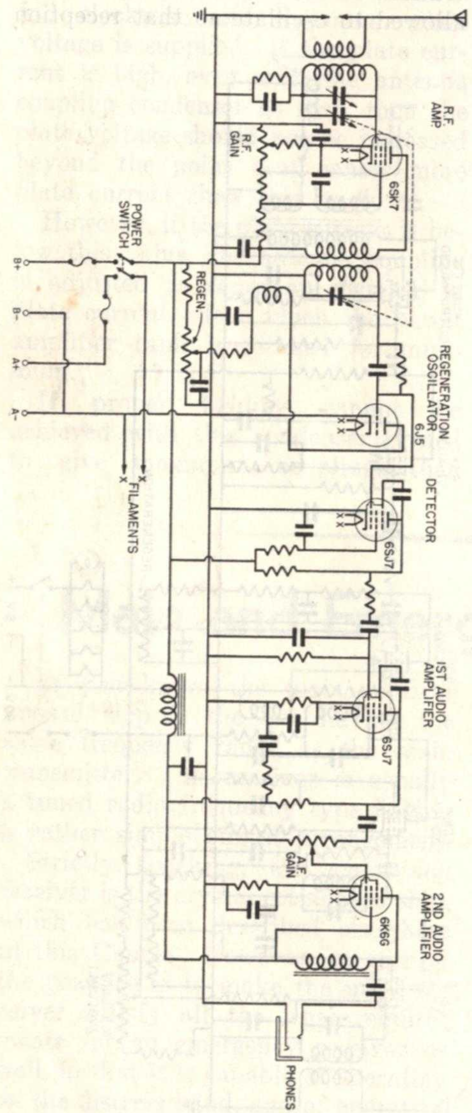



**FIG. 21. The Mackay main receiver.**

trimmer condensers which come to front-panel controls on the receiver.

From the detector, the signal travels through a resistance-coupled audio stage and then to the power amplifier. At the output of the amplifier, there are two phone jacks in parallel, so that two pairs of phones can be used. A loudspeaker is also provided on this receiver, with an on-off switch, so that it can be used if desired. The output transformer has extra impedance taps of 8, 15, 250 and 500 ohms, so that it could be used for other applications.

**Operation.** To operate this receiver, either storage battery 1 or storage battery 2 is placed on discharge at the battery control panel. Then, the antenna switch on the receiver panel is set to the main position so that the antenna is connected to this set. The panel battery switch is placed in the "on" position and the receiver power switch is set to either rectifier or B-battery operation.

A headphone is plugged in, or the loudspeaker is turned on. The band switch is set to the proper frequency range and the main tuning control, which varies the three tuning condensers, is adjusted to the desired frequency. The r.f. gain is controlled by varying the C bias, through use of a variable resistor in the cathode circuit of the two r.f. tubes.

Once the signal is tuned in, the regeneration control can be advanced to the point where regeneration is obtained, or for oscillation to receive CW signals. The gain control can then be readjusted, along with the two individual trimmer condensers, to give the desired output.

### THE MACKAY MAIN RECEIVER

This receiver, as shown in Fig. 21, is basically very similar to the RMCA unit. It covers the same frequency range from 15 kilocycles to 650 kilocycles and it operates from the same power-supply arrangement. There are two 6-volt storage batteries, either of which may be used to operate the set while the other is on charge. Operation may be obtained from either a 115-volt a.c. or d.c. power line because an a.c.-d.c. power supply is used. However, B batteries are also available to operate the receiver for emergency purposes.





The same switching arrangement is used to change the incoming antenna from this receiver to a crystal set. Therefore, the only major difference is in the signal circuits themselves. This receiver uses only one r.f. amplifier tube, and obtains its regeneration by the use of a supplementary tube. In other words, the detector tube operates only for that purpose. The regeneration is obtained through the use of a supplementary triode tube that uses the detector tuned circuit to generate oscillation for class A-1 reception, or to provide regeneration for increasing the sensitivity of the set.

The tuned circuits are arranged so that dual-tuned circuits are used on two of the bands. An antenna trimmer condenser can be used on these bands as an additional tuning control.

The r.f. gain is controlled by a resistor in the cathode circuit of the r.f. tube. However, in addition, there is an audio gain control in the grid circuit of the output tube. Hence, it is possible to adjust the sensitivity of the r.f. stage and also to control the final volume in the audio stage.

The output of this receiver feeds only to a headphone jack—there is no loudspeaker.

An extra plug is provided at the output for the purpose of connecting this receiver through a cable to the bridge for time signals. In other words, it is possible to feed time signals through this plug and a jack arrangement, directly to the bridge.

**Operation.** The operation of this receiver is practically identical to that of the RMCA type in that almost identical controls are employed. The only additional control here is the audio gain control, which is adjusted just as any other volume control would be.

## High-Frequency Receivers

It is, of course, necessary to have a receiver with the same frequency range as the high-frequency transmitter that is now coming into wider use aboard ship. The high-frequency receivers therefore cover this range. In addition, to make them somewhat more useful, they usually also cover the intermediate ship band, thus overlapping the tuning range of the main receiver.

The high-frequency receivers cover such a wide frequency range that they must be superheterodynes. We therefore have many more parts and controls, and these sets are less capable of emergency operation. Therefore, they are normally not designed to meet the emergency specifications.

### RMCA H. F. RECEIVER

Fig. 22 shows a simplified schematic diagram of the RMCA receiver. This set is designed to operate from either a.c. or d.c. supply lines. The supply lines may be either 115 or 230 volts—the operation from the higher voltage line is obtained through the

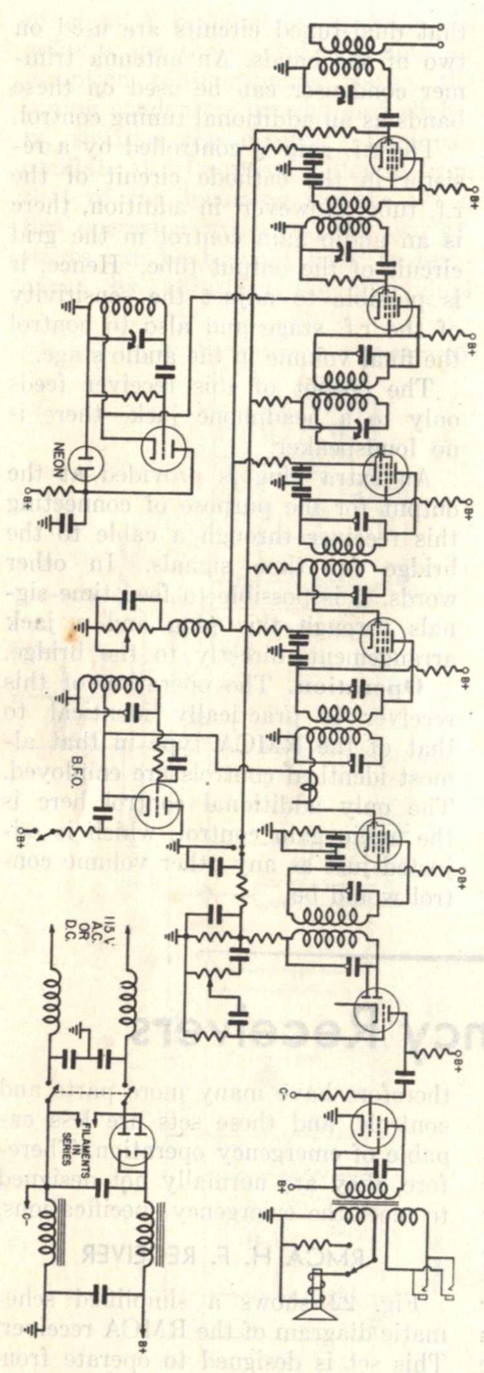



FIG. 22. The main features of the RMCA high-frequency receiver are shown here, except for the wave-band switching, which has been omitted for simplicity.

use of a dropping resistor in series with the power input circuit.

The frequency range of this particular receiver is from 85 kilocycles to 550 kilocycles, then, after skipping over the broadcast band, the range is from 1.9 megacycles to 25 megacycles. A total of 5 bands is used to cover this frequency range.

The high-frequency receiver operates from its own doublet antenna. The input signal passes through an r.f. stage, then is mixed with the local oscillator signal in a standard mixer circuit. From here, the signal goes to a three-stage i.f. amplifier, using a frequency of 1700 kilocycles. For reception of class A-1 emission, a beat-frequency oscillator is connected to the third i.f. stage. This beat-frequency oscillator is detuned slightly from the i.f. frequency, so that its frequency will be somewhat different in frequency from the incoming one. This makes it possible for the two to beat together and produce an audible output when the signal passes through the second detector. From the second detector, the signal is fed through two audio stages to either a loudspeaker or headphone.

This set is operated practically as any other standard communication receiver would be. The frequency range switch is set to the proper band, the power switch is turned on, and the beat - frequency oscillator is turned on if required. The r.f. gain is adjustable by means of a resistor in the cathode circuits of the r.f. and first two i.f. stages. The signal is tuned in by using the main tuning control, and the volume is regulated by means of the volume control at the input of the first a.f. stage.

It is possible to turn the a.v.c. network off if this feature is not desired.

Because ship's power lines vary somewhat in their output, the voltage





supply to the oscillator in this set is voltage-regulated by using a neon tube and series resistor. This circuit is arranged so that, as the voltage varies, the current drawn by the neon lamp varies to such an extent that the voltage on the oscillator tube plate is held relatively constant.

Since the intermediate frequency ship band is overlapped by this receiver, it is possible to monitor and even operate with the high-frequency receiver, thus conserving the batteries on the main receiver. Also, this duplicate facility permits normal operation even when the main receiver is being used on other frequencies or is out of order.

## THE MACKAY H. F. RECEIVER

The high-frequency receiver of the Mackay unit, shown in Fig. 23, is more nearly like the high-frequency RMCA unit than are any of the other comparable parts. The tuning ranges are almost identical and both operate from doublet antennas. Each has a single r.f. stage feeding into a mixer stage, and each utilizes a separate oscillator which is voltage regulated by means of a neon bulb. The i.f. stages also operate at 1700 kilocycles. A beat-frequency oscillator is used, and it is possible to turn the a.v.c. circuit on or off. Both r.f. and a.f. gain controls are used.

The Mackay unit does not have a built-in loudspeaker, but it has connections so that a separate loudspeaker may be used if desired. The power supply is a transformerless a.c.-d.c. type, designed to operate from 115 volts a.c. or d.c., and is shown in Fig. 24.

## LOOKING AHEAD

This completes our technical description of the apparatus in the packaged units, except for the auto alarm, which is covered in another Lesson. Also, the direction finder equipment is to be described fully.

We must repeat the earlier statements about the manufacturer's manuals—they are very complete and detailed, and should be studied with

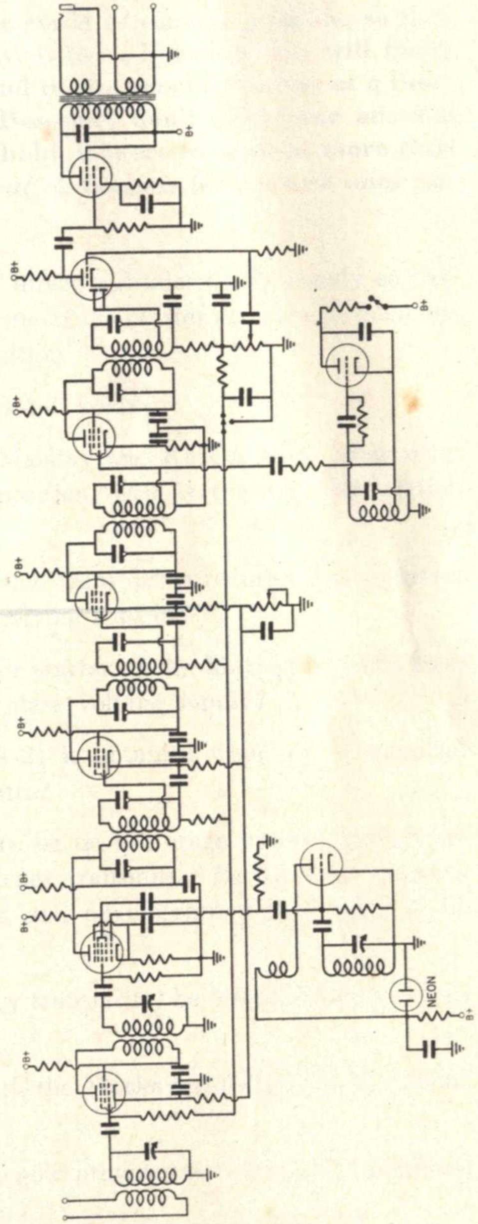



FIG. 23. The Mackay high-frequency receiver.

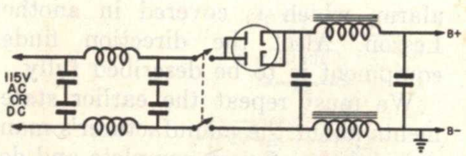



FIG. 24. This is the power supply of the Mackay high-frequency receiver.

great care. If you should become a marine operator, always be sure the proper manuals are aboard; this equipment is changed from time to time, and you need the instruction manual that covers the exact model you are to operate.





# Lesson Questions

**Be sure to number your Answer Sheet 52RC.**

**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. Give two reasons for arranging the direction finder power supply so that this unit cannot be turned on until one of the master switches in the main "packaged" unit is in a "DF" position.
2. Give three reasons for using "break-in" keying.
3. When the emission switch on the Mackay and RMCA main transmitter is in the tone-modulated (A-2) position, how is the tone modulation obtained?
4. How is the power output of a marine transmitter reduced when contact has been made with the desired receiving station?
5. Why does the main motor-generator starter of the Mackay FT-106 have a time-delay relay system in the plate voltage supply?
6. What type of emission (A-1 or A-2) is obtained when a.c. is supplied directly to the M.O.P.A. tube plates?
7. What ampere-hour drain will there be on a storage battery that is required to operate a 50-watt emergency transmitter for 6 hours, assuming a transmitter load of 30 amperes, and an emergency light load of 1.5 amperes?
8. How frequently must the emergency transmitter be tested while the vessel is at sea?
9. What type of circuit is used in both the Mackay and the RMCA "main" receivers?
10. Why is high-frequency equipment now provided in marine installations?

# MAKE DECISIONS

It is a very fine thing to have an "open mind." But it is a fine thing ONLY if you have the ability to make a *decision* after considering all sides of a question.

Failure to make a decision after reasonable consideration of all facts will quickly mark a man as being unfit for any position of responsibility.

So practice making clear cut, well thought out decisions.

Not all your decisions will be correct. No one is perfect. But if you get the habit of making decisions, experience will develop your judgment to a point where more and more of your decisions will be right.

J. E. SMITH