CHAPTER EIGHTEEN

U. H. F. Receivers and Transceivers

56 MC. CONVERTER

For receiving stabilized amplitude modulated signals on 56 Mc., an ordinary communications receiver can be used in conjunction with a suitable converter. The converter illustrated in figures 1 and 2 will be found highly sensitive and ideal for the job.

A high gain mixer using either an 1852 or 1231 receives injection voltage from a 6C5, 6J5, or 7A4 "hot cathode" oscillator.

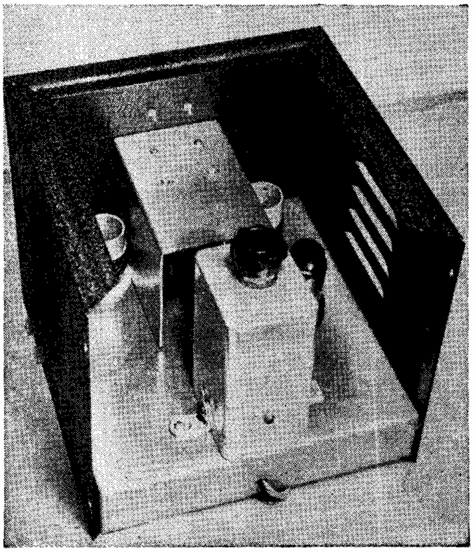


Figure 1.
INSIDE THE 1852 U.H.F. CONVERTER CABINET

The two-gang tuning condenser is under the U-shaped shield between the two coils. The can in the foreground houses the output coil, L_4, and its trimmer, C_6. Directly behind this can and hidden from view is the 1852; the 6C5 may be seen to the right.

Construction

The photograph illustrates the layout. A small stock cabinet and the chassis designed for it form the basis for the unit. Mounted in the center of the panel is a small 25 $\mu\mu$fd. per section dual-stator variable. The section nearer the panel, tuning the mixer input, has only one remaining stator plate; the rear portion, for the oscillator, has all but two stator plates removed. This condenser is mounted with the four tapped holes in the frame pointing upward. These holes are then used to support a shield which in addition to covering the condenser also acts as a baffle between the two coils.

Directly back of the tuning gang is the 1852 mixer; to the left is the oscillator coil, and to the right, the mixer coil. The can behind the 1852 contains a tuned output coil and link coupling to the receiver used as an i.f. channel. Below the tuning gang is a 15-$\mu\mu$fd. trimmer on the mixer to eliminate tracking problems on separate bands.

All oscillator leads should be made rigid to avoid shock detuning of the circuit. The ground leads are all brought to one point, which is even more advisable in the mixer circuit where an extra fraction of an inch in the cathode lead, common to both the grid and plate returns, is undesirable in that it affects the gain.

The converter is designed to work into a receiver tuned to a spot between 3000 and 3500 kc. The output coil L_4 is simply a midget b.c.l. antenna coil of the type having a low impedance primary. The coil is tuned by the mica trimmer C_6 and used backwards, the "primary" acting in this case as the secondary.

In some cases operation will be improved by connecting a .0005 μfd. midget mica condenser directly from the plate of the 6C5 to ground.

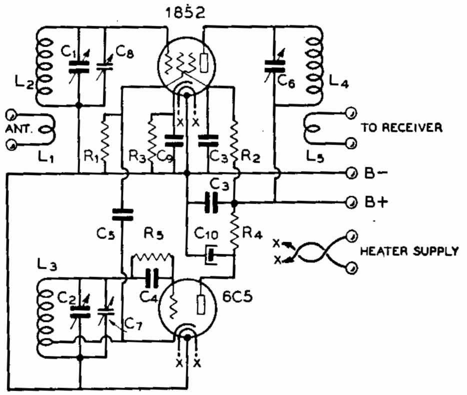


Figure 2.
GENERAL WIRING DIAGRAM OF THE 1852 CONVERTER.

C_1, C_2 — Dual 25-$\mu\mu$fd. midget, altered as described in text
C_3—.01 mica
C_4, C_5—.00005-μfd. mica
C_6—100-$\mu\mu$fd. mica trimmer
C_7—25-$\mu\mu$fd. air trimmer
C_8—17.5-$\mu\mu$fd. midget
C_9—.01-μfd. mica
C_{10}—8-μfd. 450- volt electrolytic
R_1—25,000 ohms, 1/2 watt
R_2—40,000 ohms, 1 watt
R_3—1500 ohms, 1 watt
R_4—5000 ohms, 1 watt
R_5—50,000 ohms, 1/2 watt
L_1—3 turns at cold end of L_2
L_2—3 turns on 1" form spaced dia. of wire
L_3—3 3/4 turns on 1" form spaced dia. of wire. Cathode tapped 3/4 turn from cold end.
L_4, L_5 — Solenoid type midget b.c.l. antenna coil, half of turns removed from both windings

Adjustment

The first step in lining up the converter is to adjust the output circuit to resonance with the receiver used as an i.f. amplifier. This is easily done inasmuch as the receiver noise, due both to shot effect in the mixer tube and signal or background racket at the i.f., increases when the circuit is brought in tune. The oscillator can be tuned around to locate a signal, but an easier way to set the oscillator is to listen for it in an all-wave receiver and set it at 28 Mc. plus the i.f.

When this adjustment has been made, there remains only to line up the mixer input circuit on outside noise or on a signal, using the trimmer on the panel (which also acts as a gain control). Ordinarily it will be necessary to obtain proper antenna coupling, inasmuch as high antenna pick-up and transfer to the mixer input will be important in determining weak-signal sensitivity and signal-to-noise ratio.

Voltage Regulation. If plate voltage fluctuations are sufficient to cause an objectionable shift in the oscillator frequency, as might be the case with an a.c. power pack running from a line to which several large intermittent loads are connected, the oscillator plate voltage can be stabilized simply by hooking a VR-150-30 type voltage regulator tube between the low side of R_4 and ground. The VR tube should be shunted by a .05-μfd. tubular condenser. The plate supply should have at least 225 volts for the VR tube to function properly.

U.H.F. SUPERHET WITH R/C COUPLED I.F.

A simple 2½- and 5-meter resistance-coupled superheterodyne is shown in figures 3, 4, and 5. The receiver utilizes a 1232 or 1853 autodyne converter (oscillator and mixer), two 6SK7 resistance coupled i.f. stages, a 6C5 second detector, and a 6H6 noise limiter to minimize auto ignition interference.

The values of resistors and condensers in the i.f. amplifier are such that only intermediate frequencies are passed; the coupling condensers are too small to pass audio frequencies. The i.f. amplifier has a broad peak around 50,000 cycles, the selectivity being increased slightly by the resonant coil L_2, which is simply an 85-mh. radio-frequency choke. The resonant circuit formed by C_5 and L_2 would result in an order of selectivity too great to receive the less stable of the modulated oscillators heard on 2½ meters; hence the selectivity is broadened by the insertion of R_4. The selectivity can be altered by changing the

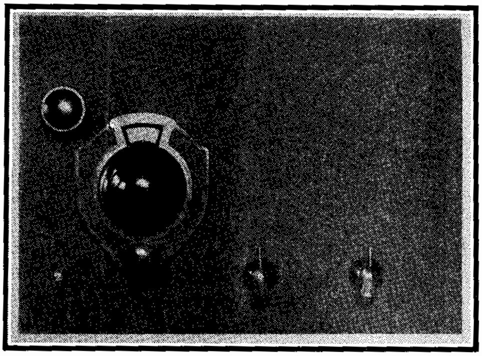


Figure 3.
SIMPLEST INEXPENSIVE 2½ AND 5 METER SUPERHET.
This receiver uses an autodyne converter and resistance coupled i.f. amplifier. It is more selective than a superregenerative receiver and does not have the background hiss common to superregenerative receivers.

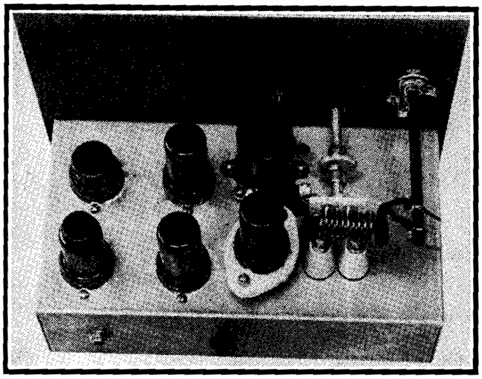


Figure 4.
BACK VIEW OF THE R/C COUPLED SUPERHET.
Five metal tubes are used. The 85-mh. radio frequency choke L_2 may be seen directly in front of the 1853. Note the method of obtaining variable antenna coupling.

value of R_4; lowering the resistance will sharpen the circuit and vice versa. Selectivity will be greatest with the resistor left out of the circuit.

The receiver also works fairly well on frequency modulated signals, so long as the deviation ratio does not exceed about 25 kc. However, because there is no limiter in the r.f. section, the signal-noise ratio will be no better than with amplitude modulation of the same carrier.

The 1853 oscillates weakly about 50 kc. to one side of the signal being received, thus acting both as first detector and h.f. oscillator. If there is too much regeneration or the antenna coupling is too loose, the tube will have a tendency to go into superregeneration, which prevents the rest of the receiver from functioning properly. Superregeneration is identified by a howl or loud hiss in the phones. Because the i.f. is such a low frequency and the first detector tank circuit shows no discrimination between signals only twice the i.f. (100 kc.) apart, all amplitude modulated signals are heard at two closely spaced spots on the dial. The points are so close that signals appear to come in at one point on the dial but with a "double hump." Another way of explaining it is to say that the i.f. is so low and the first detector frequency so high that the customary superheterodyne "image" is every bit as loud as the main signal, but so close to it in frequency as to appear as part of the main signal.

In spite of the "double hump" the receiver is much more selective than a superregenerative receiver, is very sensitive (especially when used with a resonant antenna), and costs less to build than a regular superheterodyne. It is the only practical form of amateur superheterodyne for 2½-meter operation. There is only one dial to tune, and as the tuning condenser has but one section there are no circuits to align.

The 500-ohm resistor R_{17} usually is necessary in order to reduce the very strong regeneration resulting from the use of a cathode r.f. choke. Without this resistor the stage often has a tendency to superregenerate even when heavy antenna coupling is used. The receiver should be tried both with and without this resistor on both 2½ and 5 meters to ascertain whether its incorporation is advisable.

Variable antenna coupling is necessary for maximum response to weak signals, but the coupling need seldom be touched after it is once adjusted, except when changing antennas. Regeneration in the 1853 is controlled by the resistor R_2, and the antenna coupling should be adjusted so that the 1853 goes into weak oscillation with R_2 advanced just a little more than half way. A piece of quarter-inch bakelite rod turning in a phone jack as a bearing makes the antenna coupling adjustable from the front panel, as is illustrated in figure 4.

The 1853 socket is mounted above the chassis on ¾ inch collars. The socket must be of the ceramic or polystyrene type, though the rest of the sockets may be of the inexpensive fiber wafer variety. All r.f. grounds in the 1853 stage are made directly from the tube prongs to a lug placed under one of the screws holding the socket. This lug (the one closest the front panel) connects with a short piece of no. 14 copper wire to the rotor of the midget tuning condenser, the latter being mounted back from the panel as illustrated in figure 4 in order to obtain the shortest possible leads. The condenser and coil jacks (jack type standoff insulators) are mounted so that the terminals on the tuning condenser can be soldered directly to the coil jacks without the need for connecting wires. All r.f. leads must be kept extremely short for good 2½-meter performance.

Both the 2½- and 5-meter coils are wound of no. 14 enamelled copper wire and are self-supporting. The ends are fastened to the small type banana plugs, which fit into the coil jacks. The 5-meter coil consists of 10 turns ½ inch in diameter and spaced to 1¼ inches. The 2½-meter coil consists of 3 turns ⅜ inch in diameter spaced to 1 inch. The antenna coil consists of about 2 turns of insulated hookup wire fastened to the bakelite shaft al-

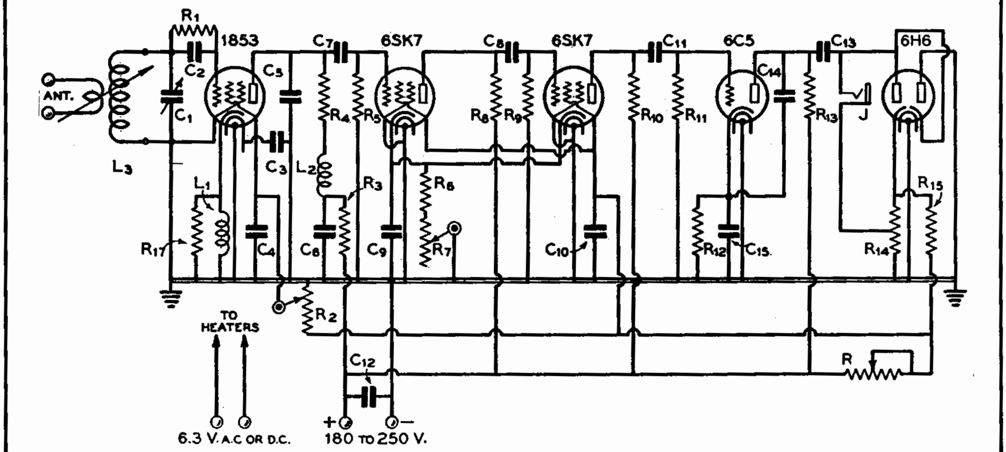


Figure 5.
WIRING DIAGRAM OF THE R/C SUPERHET.

C_1—10$\mu\mu$fd. 2 or 3 plate ultra midget u.h.f. condenser
C_2 — 50-$\mu\mu$fd. midget mica
C_3—.001-μfd. midget mica
C_4—.005-μfd. midget mica
C_5—.0001-μfd. midget mica
C_6—0.1-μfd. tubular, 600 v.
C_7 — 50-$\mu\mu$fd. midget mica
C_8 — 50-$\mu\mu$fd. midget mica
C_9, C_{10}—1-μfd. tubular, 200 v.
C_{11}—50-$\mu\mu$fd. midget mica
C_{12}—1-μfd. paper, 400 v.
C_{13}—0.25-μfd. tubular, 400 v.
C_{14}—.005-μfd. midget mica
C_{15}—0.5-μfd. tubular, 200 v.
L_1—5 meter r.f. choke (solenoid type)
L_2—85-mh. r.f. choke
L_3 — 5-m. or 2½-m. plug-in coil. See text
R—10,000 ohms for 250 v. supply; 5000 ohms for 180 v. supply. (10 watts with slider)
R_1—100,000 ohms, ¼ watt
R_2—50,000 ohm pot. (det. regeneration)
R_3—10,000 ohms, ½ watt
R_4—500 ohms, ¼ watt
R_5—0.5 meg. ¼ watt
R_6—200 ohms, ½ watt
R_7—50,000 ohm pot. (gain control)
R_8—100,000 ohms, ½ watt
R_9—0.5 meg., ¼ watt
R_{10} — 100,000 ohms, ½ watt
R_{11} — 0.5 meg., ½ watt
R_{12}—25,000 ohms, ½ watt
R_{13}—50,000 ohms, ½ watt
R_{14}—100 ohms, center tapped
R_{15} — 2000 ohms, 5 watts
R_{17} — 500 ohms, ¼ watt (see text)

ready mentioned, as illustrated in figure 4. For mobile work the 5-meter coil should be stiffened with polystyrene coil dope to prevent vibration of the turns.

The i.f. amplifier can be made to oscillate by advancing the gain control R_7 full on when the receiver is run at full plate voltage. If this is found objectionable the resistor R_6 should be increased to 1000 ohms. The lower value of resistor permits greater sensitivity when only a low voltage plate supply is available, as might be the case when the receiver is used with B batteries for portable work.

The receiver will work quite well on about 90 volts, though operation is improved by increasing the plate voltage to 180. If the receiver refuses to oscillate satisfactorily on 2½ meters with low plate voltage, resistor R_{17} should be temporarily disconnected.

Disconnecting the resistor R will reduce the battery drain considerably, but the noise silencer will no longer function. If a regular a.c. power pack furnishes power, the receiver should be used exactly as shown in the circuit diagram.

If loudspeaker operation is desired, a conventional 6V6 or 6F6 pentode output stage can be added, the 6C5 stage having sufficient output to drive the 6V6 or 6F6 to full loudspeaker volume.

112 MC. SUPERHET FOR EITHER AMPLITUDE OR FREQUENCY MODULATION

The 112 Mc. superheterodyne illustrated in figures 7-10 provides excellent performance on either amplitude modulated (AM) or frequency modulated (FM) signals. The i.f. channel is broad enough that amplitude modulated oscillators can be received satisfactorily if the oscillator is reasonably stable.

High sensitivity is provided by the use of an acorn pentode and a coaxial pipe tank circuit

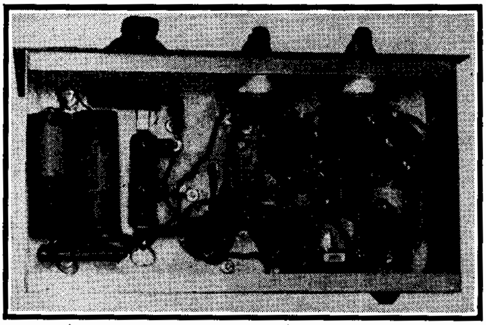


Figure 6.
UNDER-CHASSIS VIEW OF R/C SUPERHET.
Under the chassis are placed all resistors except the grid leak, and all paper by-pass condensers.

in the mixer, in conjunction with control grid injection of the oscillator voltage.

For reception of amplitude modulated signals, the limiter is "opened up" by means of switch S_2 (which is operated by turning R_{17} full off) and the 6H6 discriminator is changed to a diode demodulator by means of switch S_2.

Construction

The chassis, which is surmounted by an 8" x 17" panel, measures 7 by 15 by 3 inches. The 956 is located near the left rear corner of the chassis, with its concentric grid tank running along the rear of the chassis, as is apparent from the photographs. The concentric tank is held to the chassis by two copper straps, one near each end. The mixer grid condenser is placed between the 956 and the left edge of the chassis, making it convenient to secure short leads to both the mixer and the inner conductor of the tank circuit.

To help in obtaining short leads, the oscillator socket has been mounted with its base above the chassis, making it necessary that the 6J5GT be located under the chassis. The oscillator grid coil is supported from the tuning condenser on one end and the no. 1 socket terminal on the other. The plate by-pass C_{24} is located right at the socket and connected in the shortest possible manner between the plate and no. 1 terminal. A dial having a built-in planetary reduction unit is used on the oscillator to allow accurate tuning.

To aid in isolating the oscillator and mixer from each other so that the injection may be controlled by pushing the lead from the mixer grid in and out of the outside conductor of the mixer tank circuit, a 3 by 4 inch copper shield is placed between the two stages. The shielding is supported by small angle brackets.

The first i.f. transformer, T_1, is located di-

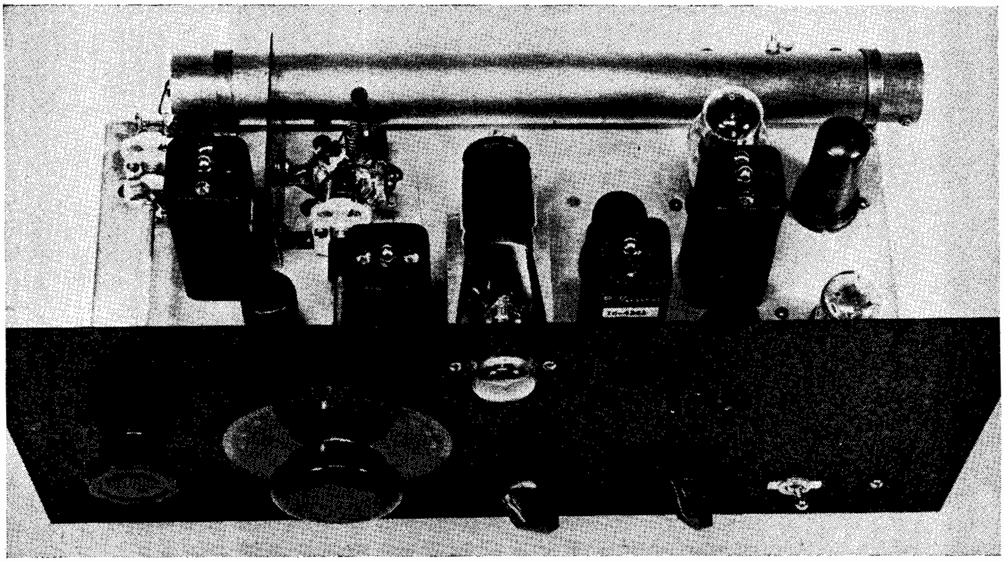


Figure 7.
LOOKING DOWN FROM THE FRONT OF THE 112-MC. F.M.-A.M. RECEIVER.
The adjustable coupling lead from the oscillator grid through the concentric mixer grid tank is visible in this photograph. The controls are, from left to right, mixer tuning, oscillator tuning, limiter "threshold" and limiter cut out, audio gain, and f.m.-a.m. switch.

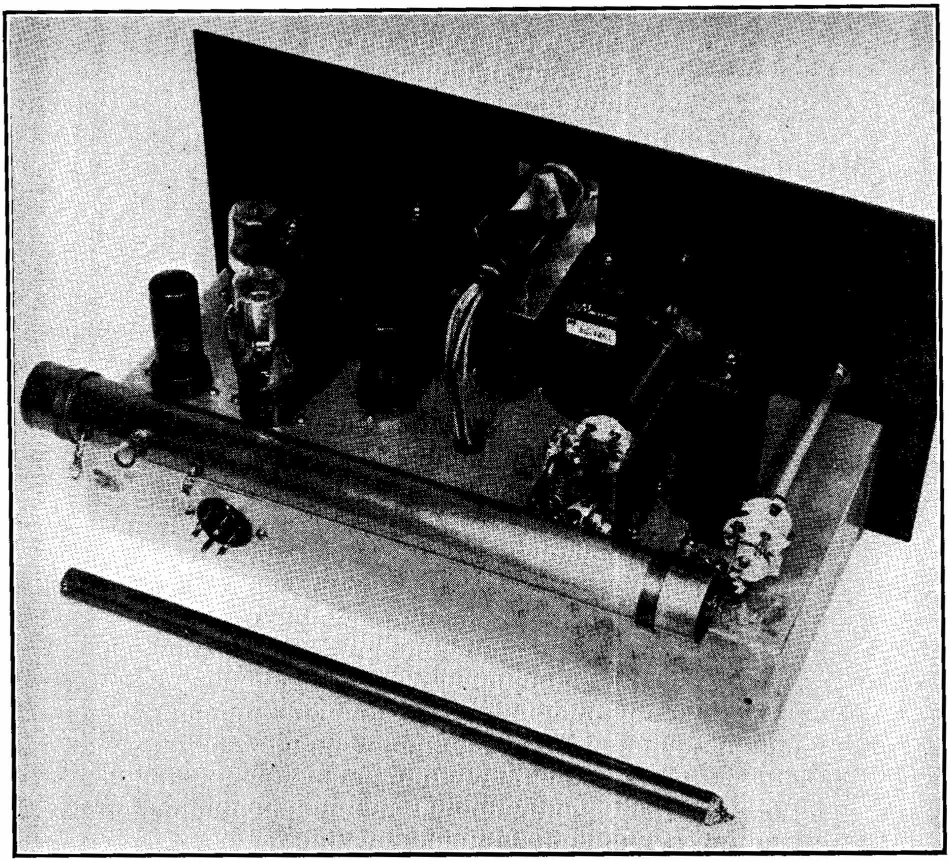


Figure 8.
SHOWING CONSTRUCTION DETAILS OF THE 112-MC. F.M.-A.M. RECEIVER.
The outer conductor of the concentric pipe tank is held firmly and grounded electrically to the chassis by means of a narrow copper strap at each end of the tank. The shield partition between the oscillator and mixer circuits is necessary for good stability. The smaller diameter tank shown in the foreground works almost as well as the large one, and may be substituted if desired. The inner conductor of the smaller tank is held in position at the unshorted end by means of a polystyrene spacer.

rectly in front of the mixer, with the first 1852 between this transformer and the panel. The second i.f. stage with its associated transformers, T_2 and T_3, runs along the front of the chassis from left to right. Behind T_3 is the 6SJ7 limiter, which feeds through the discriminator transformer at its right to the 6H6 discriminator between the transformer and the panel. The audio follows along the right edge of the chassis, while the VR-150 regulator is located behind T_4.

The only wiring precaution that need be observed is keeping the grid and plate leads short. This holds for the i.f. section as well as for the high frequency circuit. No regeneration trouble in the i.f. section should be experienced if the grid and plate leads run directly from small holes below the i.f. transformer to their proper terminating point of the sockets.

The mica by-pass and coupling condensers in the mixer and oscillator sections should be of the smallest physical size available, since a physically small .00005-μfd. condenser will often prove to be a better by-pass or coupling device at 112 Mc. than a .002-μfd. or larger mica condenser having proportionately larger dimensions.

The Coaxial Tank. The mixer tank consists of a 14 inch length of 1⅜-inch copper pipe as the outer conductor and a 3/16-inch copper tubing inner conductor. These con-

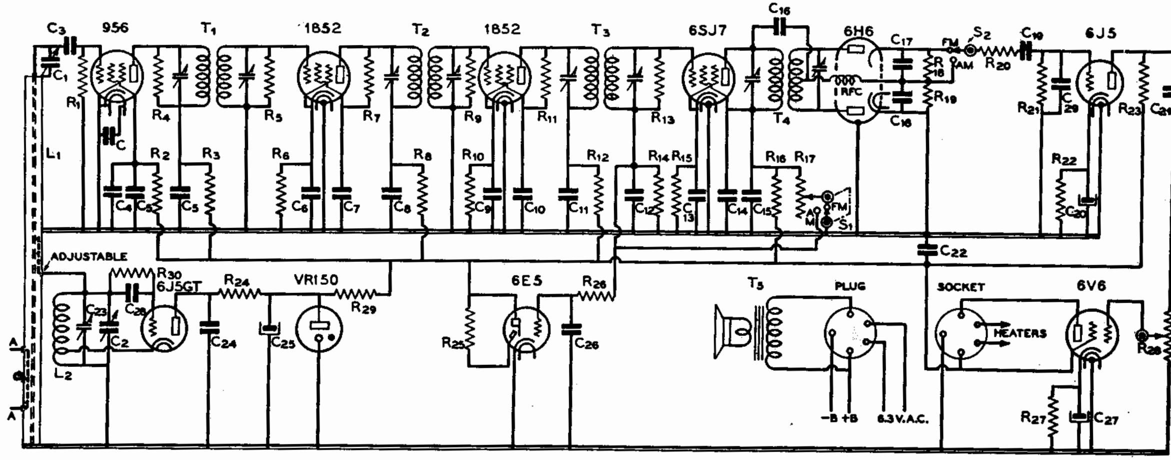


Figure 9.
WIRING DIAGRAM OF THE F.M.-A.M. RECEIVER.

VALUES OF COMPONENTS

C—.0001-μfd. mica
C_1 — 7-μμfd. midget with one stator plate removed
C_2 — 15-μμfd. midget variable
C_3, C_4 — .0001-μfd. mica
C_5, C_6, C_7, C_8, C_9, C_{10}, C_{11}—.01-μfd. 600-volt tubular
C_{12}—.0001-μfd. mica
C_{13}, C_{14}, C_{15}—.01-μfd. 600-volt tubular
C_{16}—.00005-μfd. mica
C_{17}, C_{18} — .0001-μfd. mica
C_{19}—.01-μfd. 600-volt tubular
C_{20} — 10-μfd. 25-volt electrolytic
C_{21}—.01-μfd. 600-volt tubular
C_{22}—0.1-μfd. 600-volt tubular
C_{23}—2-35-μμfd. mica trimmer
C_{24}—.0005-μfd. mica
C_{25} — 8-μfd. 450-volt electrolytic
C_{26}—.01-μfd. 600-volt tubular
C_{27} — 10-μfd. 25-volt electrolytic
C_{28}—.0001-μfd. mica
C_{29}—.0005-μfd. mica
R_1 — 5 megohms, 1/2 watt
R_2—100,000 ohms, 1 watt
R_3—2000 ohms, 1/2 watt
R_4, R_5—50,000 ohms, 1/2 watt
R_6—150 ohms, 1/2 watt
R_7—30,000 ohms, 1 watt
R_8—2000 ohms, 1/2 watt
R_9—50,000 ohms, 1/2 watt
R_{10}—150 ohms, 1/2 watt
R_{11}—30,000 ohms, 1 watt
R_{12}—2000 ohms, 1/2 watt
R_{13}—50,000 ohms, 1/2 watt
R_{14} — 250,000 ohms, 1/2 watt
R_{15} — 100 ohms, 1/2 watt
R_{16}—75,000 ohms, 1 watt
R_{17}—10,000-ohm wire-wound potentiometer
R_{18}, R_{19} — 100,000 ohms, 1/2 watt
R_{20}—50,000 ohms, 1/2 watt
R_{21} — 500,000 ohms, 1/2 watt
R_{22}—2000 ohms, 1/2 watt
R_{23}—50,000 ohms, 1 watt
R_{24} — 3000 ohms, 1 watt
R_{25} — 1 megohm, 1/2 watt (supplied with 6E5 socket assembly)
R_{26} — 1 megohm, 1/2 watt
R_{27} — 500 ohms, 10 watts
R_{28}—500,000-ohm potentiometer
R_{29}—3000 ohms, 10 watts
R_{30}—100,000 ohms, 1/2 watt
T_1, T_2, T_3, T_4—3000 kc. output i.f. transformer. See text for alterations to T_4
T_5 — Pentode-plate-to-voice coil transformer (on speaker)
S_1—S.p.d.t. switch (on R_{17})
S_2—S.p.d.t. toggle switch
RFC—2½ mhy
L_1—14" copper concentric line. Outer conductor 1⅜" o.d., inner conductor 3/16" o.d. See text.
L_2—5 turns of No. 16 bare copper, ¼" inside diameter and wound to a length of ½". Cathode tap 1½ turns from ground end.

ductors give a radius ratio of approximately 7-1, which seems to be a good compromise between impedance, Q, and overall tank size.

No actual "shorting disc" is used with the line shown in the receiver. The inner conductor is merely flattened at the "closed" end of the tank and two short right-angle bends made to allow it to be held to the outer conductor with a screw. This method is perfectly permissible where extremely high Q in the line is not necessary.

The antenna coupling "loop" is a piece of no. 10 wire covered with "spaghetti" where it is inside the tank, and supported within the tank by being run through tight fitting grommets in the outer conductor. A lead soldered to the center of the loop inside the tank is brought out and provided with a lug to enable the center of the loop to be grounded when a balanced, two-wire feeder is used. The end of the loop nearest the shorted end of the tank is grounded when a single-feeder type antenna is used. The loop is 2½ inches wide, but experiment will probably be necessary to obtain optimum coupling with lines of different impedance than the 400-ohm feeder used with the original receiver. Coupling adjustments are made by pushing the loop toward or away from the inner conductor.

If desired, a smaller diameter tank may be used, so long as the outer conductor is at least ½ inch in diameter and the conductor ratio is kept between 6 and 10. Unless the ratio is exactly 7, the length of the tank will have to be altered slightly. The performance will be practically as good as with the 1⅜ inch diameter tank.

The Discriminator Transformer. As received from the manufacturer the transformer, T_4, specified in the diagram has no center tap on its secondary and lacks sufficient coupling to serve as a discriminator transformer. Consequently the transformer must be altered as follows: After removing the transformer from its shield can, the lower winding, which is to become the secondary, is completely unwound from the dowel. If the unwinding is done carefully a narrow ridge of the compound with which the windings are impregnated will be left on each side of the space the winding occupied. These ridges will form a sort of "slot" in which to rewind the wire which has been removed. It will be found

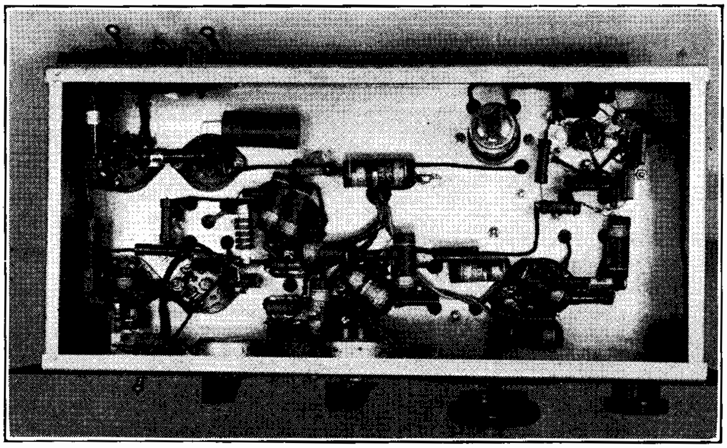


Figure 10.

UNDER-CHASSIS VIEW.

The 956 mixer and the 6J5GT oscillator may be seen under the chassis of the receiver. The two lugs protruding from the concentric tank at the upper left of the photograph are for antenna connections.

that about 65 turns of wire were on the winding but it will be impossible to get more than 55 to 58 turns back in the slot by hand scramble-winding methods. In the receiver shown, a trial rewinding of the wire indicated that 56 turns could be replaced, necessitating that the center tap be brought out at the 28th turn.

After the secondary has been rewound on the dowel it should be thoroughly covered with Duco cement or a similar coil compound and allowed to dry for an hour or more. When the cement has dried thoroughly it will be found that a firm pressure against the winding will allow it to be slid along the dowel toward the primary to increase the coupling between the windings. The proper location for the secondary is a position where the distance between the adjacent edges of primary and secondary is about 1/8 inch. Another coating of the coil dope will hold the winding in place, and the transformer may be reassembled in its shield can and installed in the receiver.

Adjustment

Aligning the I.F. Channel. There is no really simple way of accurately aligning the i.f. and discriminator in a f.m. receiver. The inclusion of a 6E5 "magic eye" tube operating from the voltage developed across the limiter bias does help considerably, however, aside from its intended use as an accurate tuning indicator for placing f.m. signals "on the nose." Probably the easiest method of aligning the receiver is first to couple loosely an ordinary tone-modulated signal generator to the plate of the mixer stage. With both switches set for "a.m." make a rough alignment for maximum audio output. This assumes that the i.f. transformers are somewhere in the vicinity of alignment so that some sort of signal may be forced through the i.f. channel to get a start on the trimming process. If no signal is heard at the output when the signal generator is applied at the mixer plate and tuned around over a narrow range around 3000 kc. it must be assumed that the i.f. transformers are considerably out of alignment and the usual procedure of first coupling the signal generator to the primary of the last i.f. transformer (T_4) and then working back toward the mixer stage must be followed.

After a rough setting of the trimmers has been made the alignment may take on a more exact nature. With the signal generator still applied to the primary of T_1, but with switch S_1 changed to the "f.m." position by cutting in all of R_{17}, each trimmer on the first three i.f. transformers should be adjusted for maximum voltage across R_{14}, as indicated by the closing of the "eye." Next, the setting of the trimmer across the secondary of T_4 should be tackled—and here is where the trimming becomes critical. Since the trimmer adjusting screw is "hot" for r.f., the tool used for this adjustment should be of the low-capacity type having a long composition or wood handle. The discriminator output switch, S_2 should be thrown to the "f.m." position and—assuming that the primary of T_4 has been set up somewhere near resonance in the previous rough alignment—tuning the secondary winding through resonance should give a very sharp and definite drop in the audio output, the audio-tone volume increasing on either side of resonance but dropping to a very low value or disappearing entirely at exact resonance. The signal from the signal generator should be kept at i.f. resonance, as indicated by the 6E5, during the alignment.

The last adjustment to be made should be that on the primary of T_4. There are two ways of getting this circuit properly tuned. Probably the simplest method is to keep the signal generator tuned right in the "notch" of the secondary winding but increase the amount of signal applied to the i.f. channel until a small amount of audio comes through at this frequency and then tune the primary winding for maximum decrease or "dip" in the remaining audio.

The other method of trimming the primary involves rocking the signal generator back and forth across the resonant frequency previously obtained observing the strength of the peaks in audio output which are heard on each side of the "notch." When the primary is properly tuned these peaks will be symmetrically located, one on each side of the "notch" frequency, and of equal strength. If the i.f. loading resistors are of the values indicated under the diagram and the coupling between the primary and secondary of T_4 has been properly adjusted the peaks will be approximately 130 kc. apart.

Those who find it more convenient to use an unmodulated signal at the i.f. frequency and a vacuum-tube voltmeter or zero-center high-resistance voltmeter to align the i.f. and discriminator may do so by connecting the indicating instrument between the top of R_{18} and ground and, after aligning the i.f. transformers up to T_3 by the 6E5, adjusting T_4 so that zero voltage is obtained at the center of the i.f. band, and equal and oppositely-polarized voltages are obtained for equal and opposite shifts in signal-generator frequency from center frequency. When a vacuum-tube voltmeter is used for this adjustment it will be necessary to place a battery in series with the instrument to bring it somewhere near half scale.

R.F. Alignment. There is little that need be said about tuning up the front end of the receiver, since the only problem is to find the band. The simplest way to do this is to hunt for a 2½-meter signal with the oscillator padding condenser, C_{23}, keeping the mixer grid aligned by following with C_1. In the absence of signals the best procedure would be to set the oscillator tuning condenser at mid scale and adjust the padding condenser so that the oscillator is on a frequency 3000 kc. lower than the center of the band, or 111 Mc. The frequency should be measured by Lecher wires, the proper distance between points being very close to 53 inches. A detailed discussion of the use of Lecher wires is given in *Chapter Seventeen.* The glow in the VR-150 makes a fairly good resonance indicator for this purpose.

Lining up the mixer grid involves only tuning the mixer grid condenser and adjusting the antenna and oscillator coupling for maximum background or signal. The two coupling adjustments will be found to be somewhat interdependent and should be adjusted simultaneously. The mixer coupling is not extremely critical, however, and optimum results should be obtained over a wide range of injection voltage. Two inches of wire available for pushing through the grommet and into the mixer grid tank will provide sufficiently wide range of coupling from the oscillator. Too little coupling will result in a loss of sensitivity, while too much coupling will cause bad pulling of the oscillator by the mixer tuning. Fortunately maximum sensitivity is realized with quite a bit less coupling than is required to cause serious pulling.

56 Mc. Operation. This receiver makes an excellent 56 Mc. FM superheterodyne if a suitable coil is substituted for the coaxial mixer tank and a larger coil is substituted for the h.f. oscillator tank. No other changes need be made.

COMPACT 112 MC. SUPERREGENERATIVE RECEIVER

Illustrated in figures 11 and 12 is a compact and inexpensive 112 Mc. superregenerative receiver that will give excellent results on amplitude modulated signals either for mobile or fixed station use. It will also work fairly well on frequency modulated signals, especially if the deviation (frequency swing) is comparatively large, but should be considered primarily as an amplitude modulation receiver.

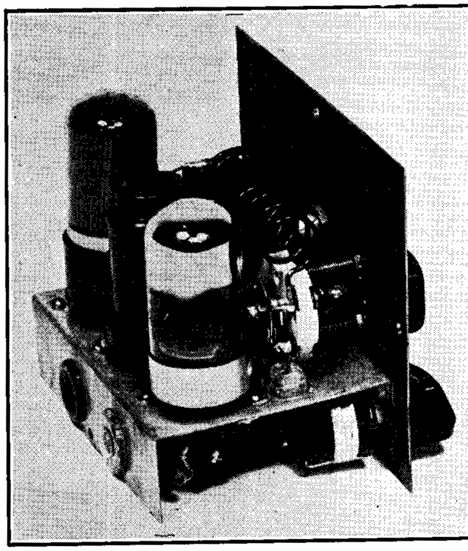


Figure 11.
INTERIOR VIEW OF THE RECEIVER.
The tuning condenser is supported from the front panel by means of two long bolts. The variable antenna coupling coil may be seen in back of the tank coil.

Figure 11 illustrates the arrangement of components. If desired, the receiver need not be made quite so compact; this will simplify the wiring job somewhat.

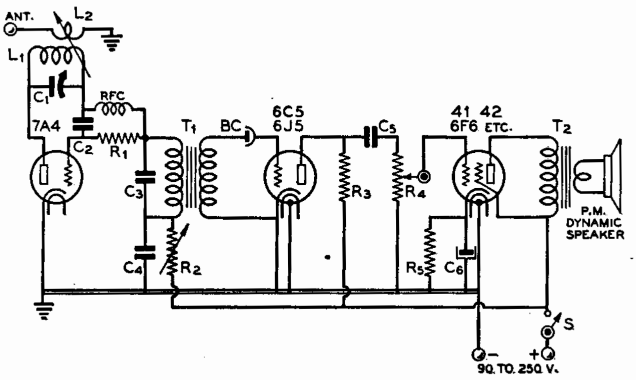
It is important that a polystyrene or low loss (mica filled) bakelite loktal socket be used for the 7A4 for best results. Also, care should be taken to see that the rotor of the tuning condenser goes to the grid and the stator to the plate. A bakelite or hard rubber shaft extension must be used with the tuning condenser in order to prevent body capacity detuning effects. As an alternative, an insulated coupler may be used in conjunction with a short piece of metal shafting and a panel bearing. Both r.f. choke and grid leak should be connected with the shortest possible leads to the r.f. circuit.

The tank coil, which is soldered directly to the tuning condenser terminals, consists of 4 turns of no. 14 enameled wire, ½ inch in diameter, spaced and trimmed as necessary to hit the band (as determined by Lecher wires).

One of the features of the receiver that results in vastly increased performance and

Figure 12.
CIRCUIT FOR THE SUPERREGENERATIVE 3-TUBE RECEIVER.

C_1—7-μμfd. sub midget variable condenser
C_2—100-μμfd. midget mica
C_3—.01-μfd. tubular, 400 v.



C_4—0.25-μfd. tubular, 400 v.
C_5—.05-μfd. tubular, 400 v.
C_6—10-μfd. electrolytic, 25 v.
R_1—500,000 ohms, ½ watt insulated
R_2—250,000 ohm midget pot. or a 5000 ohm 1 watt fixed resistor (see text)
R_3—50,000 ohms, 1 watt insulated
R_4—100,000 ohm midget pot., a.f., taper
R_5—600 ohms, 5 watts, insulated
T_1—1-3 ratio a.f. transformer
BC—Bias cell, outside shell to grid
L_1, L_2—See coil data
RFC—U.h.f. choke
T_2—Output transformer (on p.m. speaker)

easier tuning is variable antenna coupling. This control has been found of greater importance than the regeneration control, as the latter may be set and left alone if variable antenna coupling is provided. In fact, the regeneration control may be omitted, if desired, in which case a 5000 ohm 1 watt resistor is substituted for R_2.

The antenna coil consists of two turns of wire one inch in diameter, supported at the grid end of the tank coil. These are cemented with Amphenol 912 to a piece of Lucite or polystyrene ¼-inch shafting, which is supported from the front panel by a pinch-fit shaft bearing. The bearing is placed slightly below the level of the bottom edge of the tank coil in order to permit sufficient variation in coupling. Flexible, insulated wire is used for making connection to the two turn antenna coil.

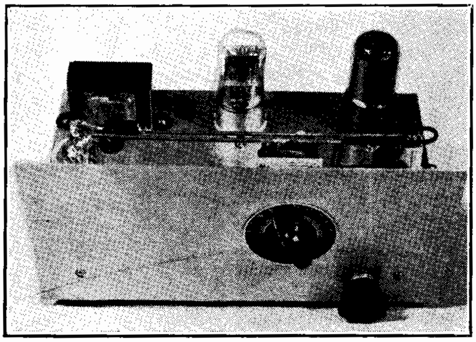


Figure 13.
224-MC. SUPERREGENERATIVE RECEIVER.
An HY-615 triode oscillator and linear tank circuit provide high sensitivity.

When tuning the receiver, the tightest antenna coupling which will permit superregeneration should be used.

224 MC. SUPERREGENERATIVE RECEIVER

Except for the substitution of a linear tank circuit and an oscillator tube better adapted for use at the higher frequency, the 224 Mc. receiver of figures 13-16 is substantially the same from an electrical standpoint as the 112 Mc. superregenerative receiver of figures 11 and 12. The mechanical construction is somewhat different, however, as may be seen from figures 13, 14, and 16.

The receiver is constructed on a 5½ by 11 inch chassis, 1½ inches high, which supports a 5 by 9 inch front panel. The HY-615 oscillator tube is placed at one end of the chassis as illustrated in order to permit horizontal mounting of the linear tank circuit. This tank circuit consists of a length of no. 10 bare copper wire, bent back on itself so that the spacing of the two wires is approximately equal to the wire diameter. The grid wire is cut off shorter than the plate wire, in order to allow the insertion of the small grid condenser and grid leak. The overall length of the tank, from the center of the tube caps to the center of the bolt in the standoff insulator which supports the closed end of the "U" and acts as the plate voltage connection is 7⅜ inches. This pillar type standoff insulator is 2 inches high.

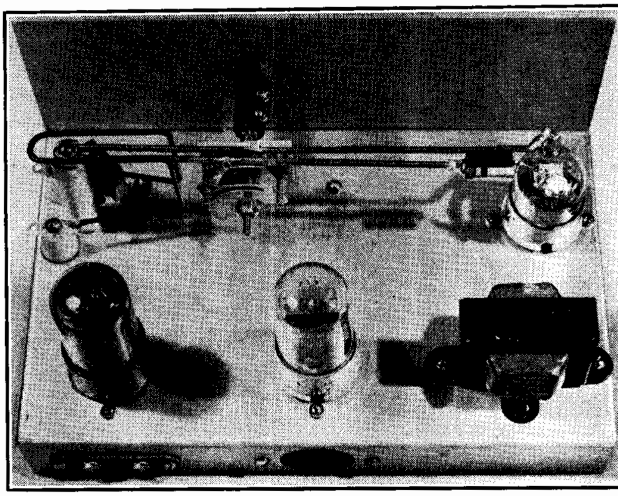


Figure 14.
ILLUSTRATING MECHANICAL CONSTRUCTION OF 224-MC. RECEIVER.
Note particularly the modified tuning condenser and the arrangement of the linear tank and the antenna coupling "hairpin loop."

Tuning is by means of an improvised split-stator type condenser, the rotor of which is left "floating." A Cardwell ZR-35-AS "Trim Air" is operated upon as follows. Disassemble the condenser so that all rotor and stator plates are removed. Discard all except four rotor and two stator plates. The four remaining rotor plates are not altered, but the two stator plates are trimmed with a pair of heavy shears so that each plate is supported by only *one* of the two stud bolts which originally supported all stator plates. The condenser then is assembled, making use of the original spacing washers, so that the two stator plates are 5/16 inch apart, one plate being supported by one stud bolt and the other plate being supported by the other stud bolt. The four rotor plates are then attached, spaced so that each stator plate is enveloped by two rotor plates with the original spacing of .03 inch between adjacent rotor and stator plates. Inspection of figure 14 shows how the condenser looks when reassembled.

Connection from each stator to the parallel wires is made by means of two 7/8 inch solder lugs, the lugs being bent in towards each other as illustrated in order to permit connection at approximately the same point on each tank wire with respect to the closed end of the tank. The tuning condenser is mounted inverted by

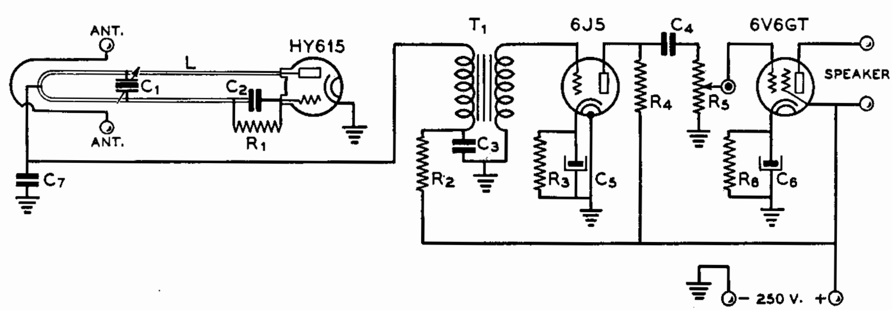


Figure 15.
SCHEMATIC DIAGRAM OF 224-MC. RECEIVER.

C_1—Modified midget condenser, see text
C_2—50-$\mu\mu$fd. smallest fixed mica
C_3—0.25-μfd. tubular, 400 v.
C_4—.05-μfd. tubular
C_5, C_6—25-μfd. 25 or 50 v. electrolytic
C_7—.005-μfd. midget mica
R_1—500,000 ohm 1/4 or 1/2 watt midget resistor
R_2—10,000 ohms, 1/2 watt
R_3—2000 ohms, 1/2 watt
R_4—50,000 ohms, 1 watt
R_5—100,000 ohm pot., a.f. (audio gain) taper
R_6—400 ohms, 10 watts
T_1—Small 1-3 interstage a.f. trans.
L—See text

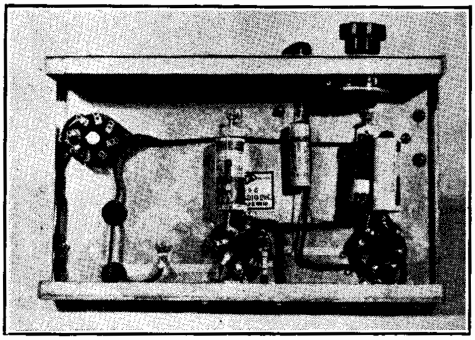


Figure 16.
UNDER-CHASSIS VIEW OF 224-MC. RECEIVER.

means of a Trim Air bracket so that the lugs attach to the tank wires 2¾ inches up from the bolt through the bottom of the "U." The condenser is driven by means of an insulated shaft extension.

The antenna coupling loop is made of no. 12 enameled wire, bent as shown in figures 13 and 14, and varied with respect to the tank wires in order to vary the coupling.

Condenser C_7 should be grounded directly to the chassis with the shortest possible lead.

The receiver runs at full plate voltage at all times, the antenna coupling being adjusted to the closest value which will still permit superregeneration.

When the receiver is initially put into operation, the frequency range should be checked on Lecher wires. If slightly off, the frequency range can be altered sufficiently by varying the spacing between the two tank wires: spreading the wires slightly *lowers* the frequency. If the frequency is very far off, it will be necessary to alter the length of the tank wires slightly as required to enable the tuning condenser to cover the band.

112 MC. MOBILE TRANSCEIVER

With a few minor circuit changes and additional components, the 112 Mc. superregenerative receiver illustrated in figures 11 and 12 makes an excellent transceiver for mobile

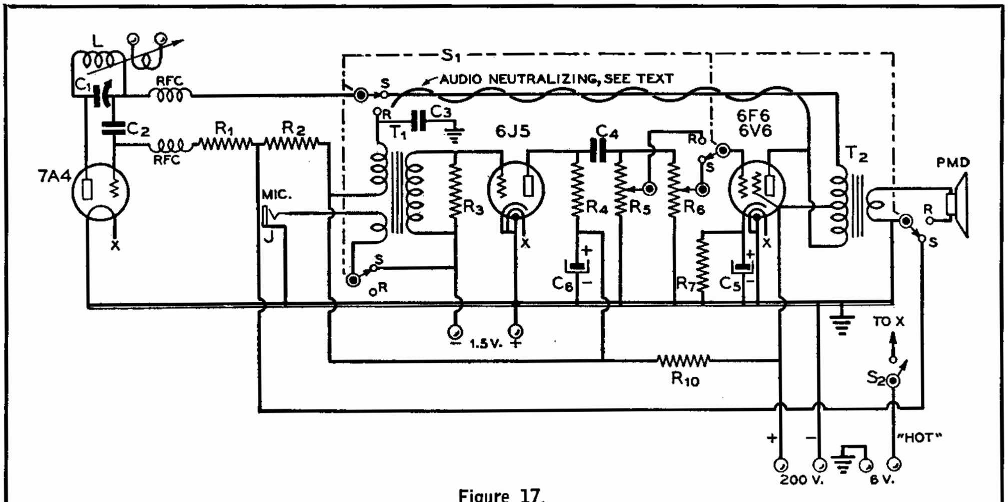


Figure 17.
112-MC. MOBILE TRANSCEIVER SCHEMATIC DIAGRAM

C_1—5-μμfd. double spaced midget condenser (with mounting bracket and ceramic shaft coupling)
C_2—100-μμfd. smallest mica condenser
C_3—.01-μfd. tubular condenser, 400 v.
C_4—.05-μfd. tubular condenser, 400 v.
C_5—10-μfd. 25 v. electrolytic
C_6—8-μfd. midget tubular electrolytic, 450 v.
R_1—2500 ohms, 2 watts
R_2—1 meg., 1 watt
R_3—100,000 ohms, ½ watt
R_4—100,000 ohms, 1 watt
R_5, R_6—100,000-ohm potentiometer, a.f. gain taper
R_7—500 ohms, 5 watts
R_8—7500 ohms, 1 watt
RFC—Midget u. h. f. chokes
J—Open circuit jack (a closed circuit jack will short the microphone battery)
S_1—4-pole 2-throw rotary switch
S_2—S.p.s.t. toggle switch
T_1—Transceiver transformer: plate and s.b. mike to single grid
T_2—Universal output transformer: 14,000 ohm c.t. pri., adjustable voice coil winding
PMD—Small p.m. dynamic speaker

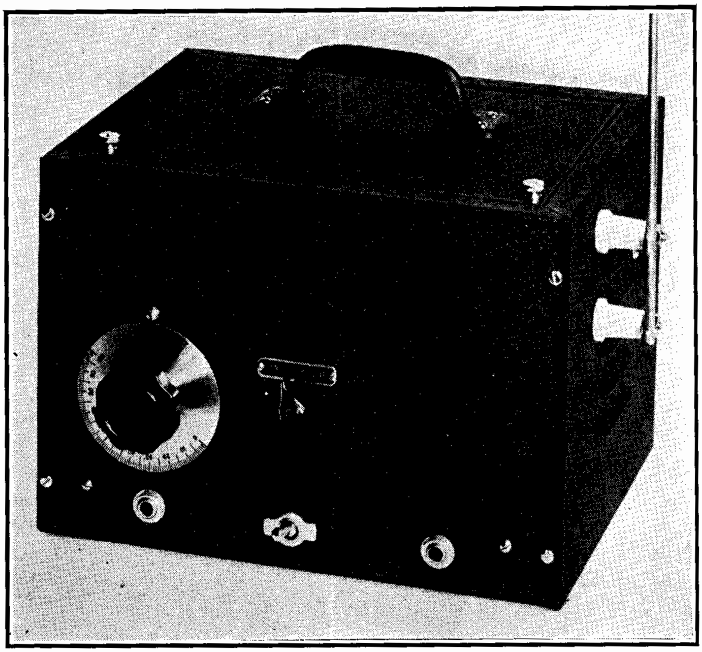


Figure 18.
SELF-CONTAINED 112-MC. TRANSCEIVER.
From a good vantage point, this little self-contained 112-Mc. transceiver has a range of several miles. The vertical rod radiator is supported as shown. Two bolts are soldered to the front lip supporting the hinged lid, and by removable thumb screws the lid either may be held down tightly for carrying by the handle or opened for access to the "works."

work. An output of between 2 and 3 watts, enough to deliver a strong signal over considerable distance, is obtainable at the maximum recommended plate voltage.

The layout is substantially the same as that for the receiver, illustrated in figure 11, and therefore is not shown here. Also, the remarks pertaining to the r.f. portion of the circuit, including tank coil, tuning condenser, and adjustable antenna coil, apply to the transceiver.

Dual volume controls are provided to permit independent adjustment of gain when receiving and when transmitting. Microphone voltage is obtained from a standard 1½ volt dry cell, in order to avoid the possibility of vibrator or generator hash getting into the speech system through the 6 volt supply lead. The battery also provides C bias for the 6J5 speech or audio amplifier. Because the drain on the battery is so low, many hundreds of hours of transmission are possible before replacement is required.

To prevent a.f. feedback it may be found necessary to neutralize the capacity which exists between contacts on the send-receive switch. Should the a.f system go into oscillation when the gain control is advanced, simply run a length of insulated wire from the plate of the output tube to the switch, this wire being twisted around the wire running from the opposite end of the transformer to the switch. At the switch, the end of the free wire is adjusted with respect to the wire from T_1 (thus varying the capacity between them) until it is possible to run the gain full on both on transmit and on receive without a.f. feedback.

Occasionally such feedback can be eliminated simply by transposing the two secondary wires on T_1, in which case the neutralizing lead will not be required.

The two r.f. chokes should have their leads clipped off short on the "hot" end to minimize the length of connecting wire between r.f. chokes and the tank circuit.

The adjustable antenna coupling serves as regeneration control, the detector running at high plate voltage at all times. The coupling always is adjusted to the closest value which will still permit superregeneration. This provides maximum sensitivity when receiving and maximum output when transmitting.

The plate supply voltage should not greatly exceed 200 volts on transmission, as excessive plate voltage will cause the 7A4 to overheat and the plate current to "run away."

An antenna system suited for mobile use with this transceiver is described in chapter 21. The distance which can be worked depends upon the antenna and the location; 50 miles is common from an elevated location.

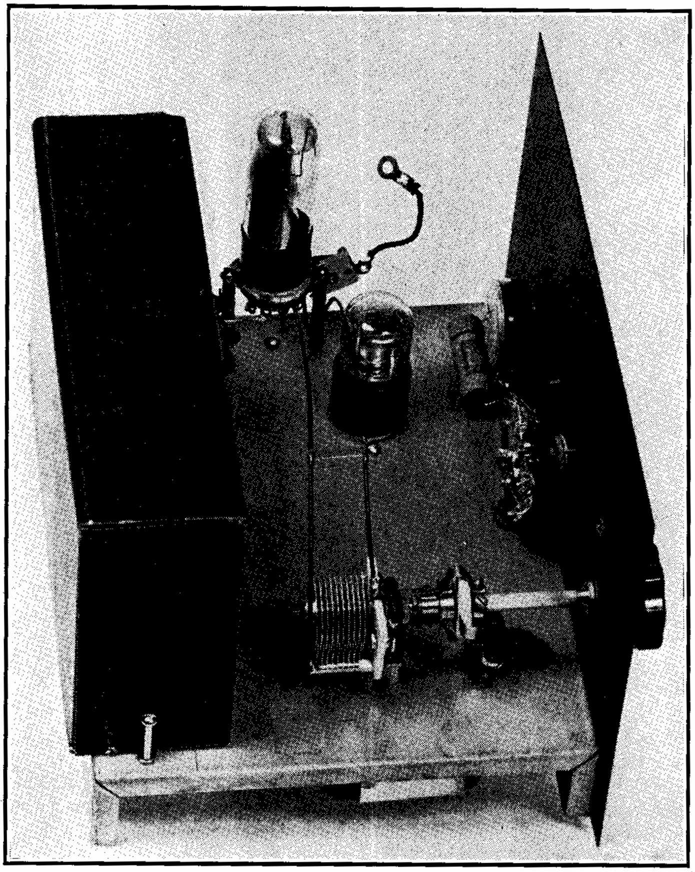


Figure 19.
LOOKING DOWN ON THE TRANSCEIVER WITH CABINET REMOVED.
The flexible lead terminated in a solder lug must be unfastened from the lower antenna feedthrough insulator before the unit can be slid out of the cabinet.

SELF-CONTAINED, BATTERY POWERED TRANSCEIVER FOR 112 MC.

The small transceiver illustrated in figures 18-21 will provide reliable communication over a maximum distance of 20-25 miles when both stations (or their antennas) are within line of sight. It is entirely self-contained, being powered by a standard pack, and weighs but 13 lbs. (not including microphone or earphones). Cost of operation will be about ½ cent per hour, the battery drain being quite low.

Construction. The transceiver is constructed in a standard manufactured cabinet measuring 7 x 10 x 8 inches deep, a 7½ x 9 inch sub-chassis measuring 1½ inches high being supported from the front panel. These items are made by a well known manufacturer and are commonly stocked throughout the country.

The 1G4G socket, which should be of polystyrene, is mounted by means of two 1½-inch bushings and 1¾-inch bolts. The bolts are mounted in holes drilled exactly ¾ inch in from the edge of the chassis. The holes should be located so that the center of the socket is exactly 4 inches from the front panel. The socket should be oriented so that the ridge on the locating pin on the tube points towards the rear.

The socket for the 1T5-GT is mounted with the center about 2¼ inches back from the front panel, and about 2¼ inches in from the right hand edge of the chassis.

As both sides of the tuning condenser C_1 are "hot," the condenser is mounted by means of an accessory bracket offered by the manufacturer of the condenser. This bracket bolts to the ceramic portion of the condenser, and does not touch either rotor or stator. The bracket is raised up off the chassis by means of two ½-inch collars and ¾-inch 6-32 bolts.

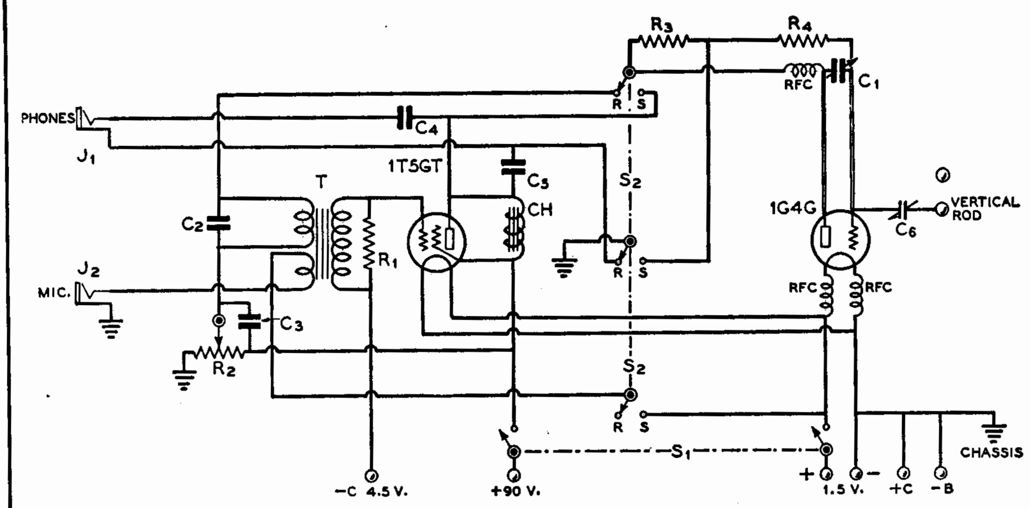


Figure 20.

WIRING DIAGRAM OF THE SELF-CONTAINED TRANSCEIVER.

C_1—100-μμfd. midget condenser, ceramic insulation

C_2—.001-μfd. midget mica

C_3—0.1-μfd. 200 or 400 volt tubular

C_4—0.1-μfd. 200 or 400 volt tubular

C_5—.01-μfd. 400 volt tubular

C_6—3-30-μμfd. mica trimmer, ceramic insulation, screw removed

R_1—100,000 ohms, ½ watt

R_2—100,000 ohm potentiometer

R_3—1 meg., ½ watt

R_4—25,000 ohms, ½ watt

CH—Midget 7 to 10 hy. choke, 15 ma. or more

T—Transceiver type midget dual purpose a.f.t., plate and single button mike to grid

S_1—D.p.s.t. toggle switch

S_2—4 pole 2 throw rotary "send-receive" switch

J_1, J_2—Open circuit jacks

RFC—U.h.f. type chokes, not over 1 ohm d.c. resistance

If this were not done, the tuning dial would sit too low on the front panel.

Holes for mounting the condenser bracket should be so drilled that the condenser shaft is exactly 1¾ inch in from the edge of the chassis or 2¼ inches in from the edge of the front panel. A hole is drilled in the front panel bearing, 2¼ inches in from the edge of the panel and at the same height as the condenser shaft. A flexible, ceramic insulated coupling unit is used to drive the tuning condenser. A short piece of ¼-inch steel, brass, lucite, or bakelite rod is used to connect the dial to the flexible coupling. The condenser should be mounted so that the ceramic front plate is exactly 3 inches back from the panel.

The send-receive switch S_2 is mounted so that the shaft is at the same height as the tuning condenser shaft, and midway between the right hand and left hand edges of the panel. The regeneration control R_2 is mounted exactly 2¼ inches in from the right hand edge of the front panel and at the same height as the other controls. As may be seen from the illustration of the front panel, the two jacks and the on-off switch are lined up directly underneath the three controls, ¾ inch from the bottom edge of the panel.

The small 4½-volt C battery is held in place by means of a bracket bent out of a small piece of galvanized iron, soldered to the edge of the chassis. The battery is slipped under this bracket and held firmly in place by means of a small angle bracket which is screwed to the positive battery terminal and bolted to the chassis. This not only holds the battery in place, but furnishes a connection from C plus to chassis (ground).

In order to permit mounting of the small u.h.f. filament chokes as close as possible to the 1G4G, two ½-inch holes are drilled near the socket. The chokes are mounted half above and half below the chassis, the leads to the socket pins being only a fraction of an inch long when the chokes are mounted in this manner. Each choke should have not over 1 ohm d.c. resistance or the filament will not receive rated voltage.

The linear tank consists of two lengths of no. 12 enamelled wire, spaced about ½ inch. Enamelled wire should be used; tinned wire will have higher losses and bare wire endan-

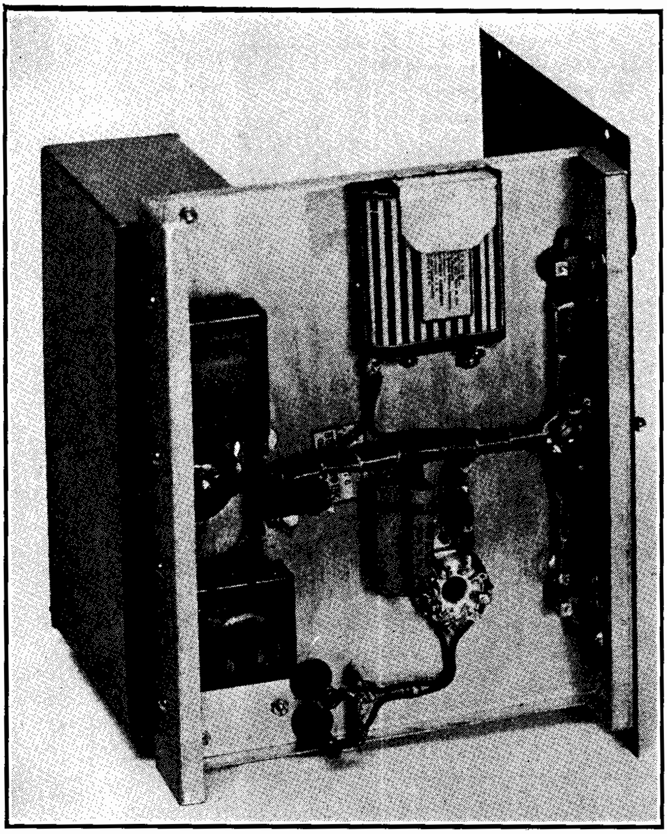


Figure 21.
UNDER-CHASSIS VIEW OF THE TRANSCEIVER.
Wires underneath the chassis need not be made short. Observe method of holding C battery by means of large stationary and small removable bracket, latter bolted to positive terminal and chassis.

gers the tube. When bare wire is used, the 1G4G can be permanently damaged with the switch on the "receive" position simply by touching both grid and plate wires with a hand moist with perspiration. This puts a positive bias on the grid, and the tube does not have a husky enough filament to stand such treatment without harm.

Some alteration of the length of the tank elements may be necessary after the transceiver is fired up and the frequency checked by means of Lecher wires, but to start off with the following dimensions should be used. Grid (front) wire: 9 inches. Plate (rear) wire: 9½ inches.

The grid wire is deliberately made shorter than the plate wire, because the extra half inch is made up when the antenna coupling condenser is soldered to the grid prong of the 1G4G socket.

The grid wire solders directly to the rotor lug of the tuning condenser and the plate wire to the *farthest* stator lug. The wires are bent in the shape of a half moon, as shown in the illustration. The small grid resistor R_4 and the plate r.f. choke are soldered to the tuning condenser with the shortest possible leads. As previously mentioned, the antenna coupling condenser C is soldered directly to the grid prong of the 1G4G socket; be sure that the *stationary* plate is soldered to the grid prong.

The battery pack is mounted upside down as far to the rear as the cabinet will allow. This means that the battery overhangs the rear of the chassis about ½ inch. A socket size hole is punched or drilled in the chassis to accommodate the leads from the battery. This is all clearly illustrated in the bottom view.

To keep the battery firmly against the rear of the cabinet, a piece of brass rod or tubing is cut the exact width of the cabinet and tapped at each end for a 6-32 bolt. Two holes are drilled in the sides of the cabinet so that when the tubing is bolted in place the battery pack is held firmly in position. Small blocks of wood between battery and cabinet or a couple of 1-inch 6-32 bolts protruding from the chassis can be used to keep the battery pack from slipping sidewise.

The antenna consists of a vertical half-wave rod, capacitively coupled to the grid of the tube. Better results, both receiving and transmitting, are obtained with the antenna coupled to the grid rather than the plate. The length of the antenna, *overall,* from the tip of the rod to the coupling condenser C_6 should be exactly 3 feet 6 inches. This is not quite as long as the usual 114-Mc. dipole, but it is an electrical half wavelength just the same because of the loading effect of the coupling condenser C_6.

The antenna rod proper is 3 feet 3 inches long. The rest of the length is made up by the feed-through insulator bolt and the 1½ inch flexible lead to the coupling condenser. The two medium-sized feed-through insulators are mounted one above the other, their centers 2⅜ inches back from the front edge of the cabinet. They are spaced 1¾ inches and the top insulator is ⅞ inch below the top edge of the cabinet. The top insulator does not connect to anything; it merely serves to hold the antenna rod vertical. The two threaded rods for the feed-through insulators should be sawed off so that they are no longer than necessary, in order to reduce the stray capacity to ground (cabinet) as much as possible.

Inspection of the wiring diagram will show that the filament switch S_1 also opens the B negative. This is necessary to prevent a continuous drain on the B battery by R_2.

When the linear tank covers the band correctly (a small amount of leeway on either side), the circuit elements should be stiffened up to make them less susceptible to vibration. A small piece of celluloid or victron is cut to make a "spreader" by cutting it about ⅛ inch longer than the separation of the parallel wires at a point about one-third of the way up from the tuning condenser. The ends of the spreader are notched with small "V" indentations with a pair of diagonals and the wires are pulled apart slightly to take the spreader. The wire is crimped a little either side of the spreader to provide a "bite" for duco cement, which is applied to hold the spreader firmly in place.

The circuit will not oscillate when the tuning condenser is tuned to less than 1/3 of maximum capacity. This means that only two-thirds of the scale is usable, but this is unimportant because the entire 2½ meter band covers less than half the dial.

Next, the antenna coupling should be varied by adjusting the distance between the movable and the stationary plate. Closer spacing provides tighter coupling. The coupling should be increased to as much as will still permit superregeneration over the entire band, and then left alone. Ordinarily this adjustment will be about the same as the position assumed by the movable plate when the adjusting screw is removed.