

V.H.F. Receivers

IN ESSENTIAL principles, modern receiving equipment for the 28- and 56-Mc. bands does not differ from that used on lower frequencies. In view of the higher frequency there are, of course, certain constructional precautions which must be taken to insure good performance. The 28-Mc. band serves as the meeting ground between those ordinarily termed "communications frequencies" and the very-highs, and it will be found that most of the receivers described in Chapter Eleven are capable of working on 28 Mc. In this chapter are described receivers and converters capable of good performance on 56 Mc. and higher.

Federal regulations require that transmitters working on all frequencies below 60 Mc. must meet similar requirements respecting stability of frequency and, when amplitude modulation is used, freedom from frequency modulation. It is thus possible to use receivers for 56-Mc. a.m. reception having the same selectivity as those designed for the lower frequencies. This order of selectivity is not only possible but desirable, since it makes possible a considerable increase in the number of transmitters which can work in the band without interference, as compared to broad-band receivers. Also, high selectivity greatly improves the signal-to-noise ratio, both in the receiver itself and in the response to external noise. This means that the effective sensitivity of the receiver can be considerably higher than is possible with non-selective receivers. Receivers for f.m. signals usually are designed with less selectivity so that they can accommodate the full swing of the transmitter, but, at least for 28- and 56-Mc. f.m. reception, the h.f. oscillator should be as stable as in a narrow-band a.m. receiver.

The superheterodyne type of receiver is used almost universally on frequencies below 60 Mc., because it is the only type of receiver that fulfills the above requirements for stability. A superheterodyne for a.m. reception and one for f.m. reception differ only in the i.f. amplifier and second detector, so the "converter" or high-frequency portion of the superheterodyne can be used for either a.m. or f.m. reception. Although superheterodynes can be built for 112-Mc. reception, the superregenerative type of receiver is much more widely used. The superregenerative receiver has the advantage of low cost and good sensitivity, although its selectivity does not compare with the superheterodyne type of receiver.

A superheterodyne receiver for 56-Mc. work should use a fairly high intermediate frequency

so that image response and oscillator "pulling" will be reduced. At 56 Mc., for example, a difference between signal and image frequencies of 900 kc. (the difference when the i.f. is 450 kc.) is a very small percentage of the signal frequency, consequently the response of the r.f. circuits to the image frequency is very nearly as great as to the desired signal frequency. To get discrimination against the image equivalent to that obtained at 3.5 Mc. with a 450-kc. i.f. would require for 56 Mc. an i.f. 16 times as high, or about 7 Mc. if the circuit Q s were the same in both cases. However, the Q of a tuned circuit at 56 Mc. is not as high as at the lower frequencies, chiefly because the tube loading is considerably greater. As a result, still higher i.f.s. are desirable, and a practical compromise is reached at about 10 Mc.

Since high selectivity cannot be obtained with a reasonable number of circuits at 10 Mc., the double superheterodyne principle is commonly employed. The 10-Mc. frequency is changed to an i.f. of the order of 450 kc. by a second oscillator-mixer combination. Thus the receiver has two intermediate frequencies, at both of which amplification takes place before the signal is finally rectified and changed to audio frequency.

Very few amateurs build complete 56-Mc. superhet receivers along these lines. General practice is to use a conventional superhet receiver to handle the 10-Mc. output of a simple frequency-converter. Thus a regular communi-

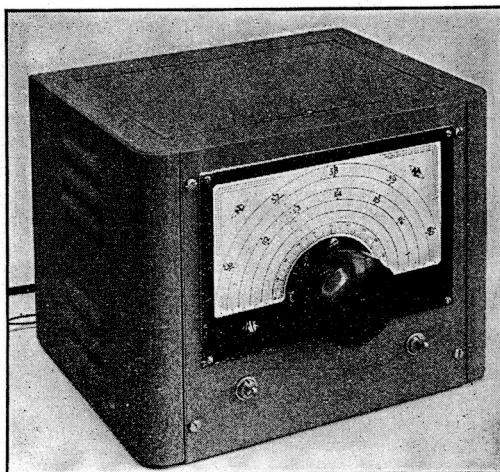


Fig. 1401 — This $2\frac{1}{2}$ - and 5-meter converter, complete with self-contained power supply, is mounted in an $8 \times 8 \times 10$ -inch cabinet. Plug-in coils give bandspread coverage of the 56- and 112-Mc. amateur bands.

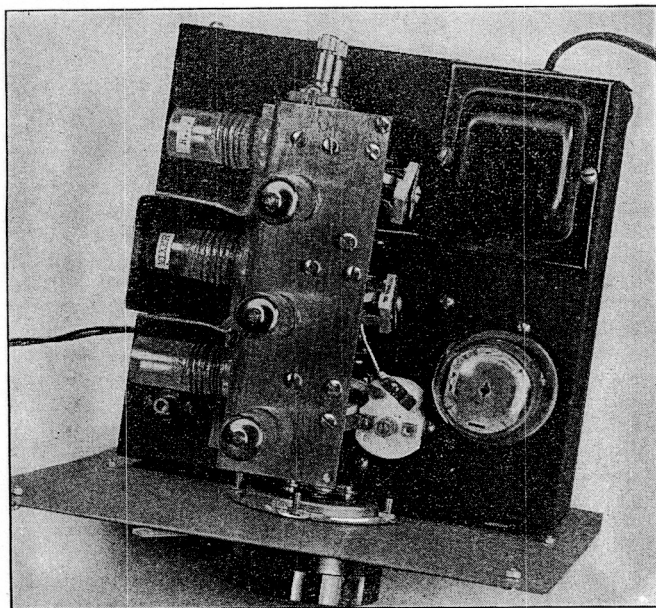


Fig. 1402 — A top view of the converter, showing arrangement of tubes and coils. The shaft projecting through the main chassis at the lower left is the i.f. transformer tuning control. The power transformer is sub-mounted so it does not interfere with adjustment of the r.f. trimmer.

cations-type receiver — or even an all-wave broadcast receiver — can be used with excellent effect on 56 Mc. with the addition of a relatively simple and inexpensive “converter.” Since most amateurs have communications receivers, the construction of a good superhet for 56 Mc. is a relatively simple matter.

From a practical aspect, superregenerative receivers may be divided into two general types. In the first the quenching voltage is developed by the detector tube itself — so-called “self-quenched” detectors. In the second, a separate oscillator tube is used to generate the quench voltage. The self-quenched receivers have found wide favor in amateur work. The simpler types are particularly suited for portable equipment where the apparatus must be kept as simple as possible. Many amateurs have “pet” circuits which are claimed to be superior to all others, but the probability is that the arrangement of their particular circuit has led to the use of correct operating conditions. Time spent in minor adjustment of values will result in a smooth-working receiver free from howling and irregular performance and is well worth the effort.

¶ V.H.F. Converters

If the amateur already has a communications receiver, or even a fairly decent all-wave b.c. set capable of tuning to 5 or 10 Mc., there is little or no need for building a special v.h.f. receiver, particularly for 56 Mc. It is much easier to build a converter and work the converter into the already existing receiver. The output transformer of the converter is tuned to the same frequency as the receiver (5 or 10

Mc.) and the signal is coupled through a low-impedance line to the input of the receiver in much the same manner that link coupling is used in a transmitter. All tuning is done with the converter, and the output volume is adjusted to a suitable level by means of the gain control on the receiver into which the converter is working.

¶ A High-Performance Converter for 56 and 112 Mc.

The converter shown in Figs. 1401, 1402, 1403, 1404 and 1405 uses the new 9000-series “button” tubes, which are quite, similar electrically to “acorn” tubes but are somewhat easier to handle. As can be seen from the diagram in Fig. 1403, a 9001 r.f. stage is transformer-coupled to a 9001 mixer. The h.f. oscillator is a 9002 and it is capacity-coupled to the mixer grid through C_{15} . The output circuit (C_{14} , C_{16} and L_7) is tuned to 10.2 Mc., approximately, although the

converter could be made to work into some other i.f. with suitable changes in the output circuit and the oscillator coil, L_5L_6 , constants.

As indicated in the diagram, the screen and plate by-pass condensers are returned to one cathode lead (the one to which the suppressor is connected) while the other lead is grounded through a condenser to serve as the grid return. In the mixer plate circuit a low-drift mica condenser, C_{14} , is connected directly from plate to cathode, to short-circuit the signal-frequency component in the plate circuit. This condenser is part of the i.f. tuned circuit, and its capacity must be taken into account in calculating the inductance required at L_7 .

The mixer and r.f. tuned circuits are made as low- C as is possible under the circumstances; the use of plug-in coils unavoidably introduces some stray capacity that would not be present if the circuits were made to operate on one frequency only. The tuning condensers are cut down to two plates each, and have just about enough capacity range to cover the 56-Mc. band with a little to spare. The trimmers are mica units operated at nearly minimum capacity, so that the mica is a negligible factor in the operation of the condenser; for all practical purposes, the dielectric is purely air. The L/C ratio compares favorably with those commonly attained in acorn receivers.

The oscillator circuit is of the grid-tickler type, with the tuned tank in the plate circuit. The tuned circuit is made higher- C than the signal-frequency circuits to improve the stability, and as a consequence somewhat more tuning capacity is needed to cover the frequency range. The tuning condenser is a 15- μfd . unit

cut down to three plates and the trimmer is a 25- μ fd. air-dielectric unit. The oscillator and mixer circuits are coupled through a small homemade condenser, C_{15} , tailored to give suitable injection of oscillator voltage into the mixer grid circuit.

The oscillator is tuned to the low side of the signal frequency on both 56 and 112 Mc., to give slightly better oscillator stability. A VR 105-30 voltage-regulator in the power supply adds further to the stability of the oscillator.

The power-supply part of the circuit needs no comment, except to explain that a separate filament transformer was used only because no suitable small plate transformer was available with a 6.3-volt heater winding.

The "chassis" on which the converter is assembled is a piece of sheet copper, somewhat less than 1/16 inch thick, 5 1/2 inches long, and bent as shown in the photographs. The width on top is 1 3/4 inches, the height 2 1/4 inches, and the bottom lip, for fastening to the main chassis, is 3/4-inch wide. The tubes are mounted on top near the bent edge, allowing just enough room to insert the socket mounting ring, and are 1 3/4 inches apart, center to center, with the r.f. tube 1 3/8 inches in from the rear edge. The

coil sockets are mounted on the side, 3/4 of an inch down from the top, so that the connections between socket prongs and the tuning condenser terminals can be made without additional wires. The spacing is such that the lead from the stator connection on the condenser to the grid prong on the tube socket is only about 1/4-inch long.

In building an assembly of this type, it is a practical necessity to do all the wiring before the tuning condensers are mounted. The inside view gives some idea of the arrangement of by-pass condensers; the chief consideration in placing them is to eliminate leads, insofar as possible. Each stage has its own ground point, which, in the case of the r.f. and mixer stages, is on the side of the chassis directly below the tube socket and the length of the cathode by-pass condenser away from it. The screws which hold the ground lugs in place are threaded into the copper, and on the outside also help support the vertical interstage shields. The oscillator ground is also on the side but close to the cathode pin, which is grounded directly; the plate by-pass condenser, C_{13} , is brought to the same point. In the other two stages the ground leads from the tuned circuits are 3/8-inch wide

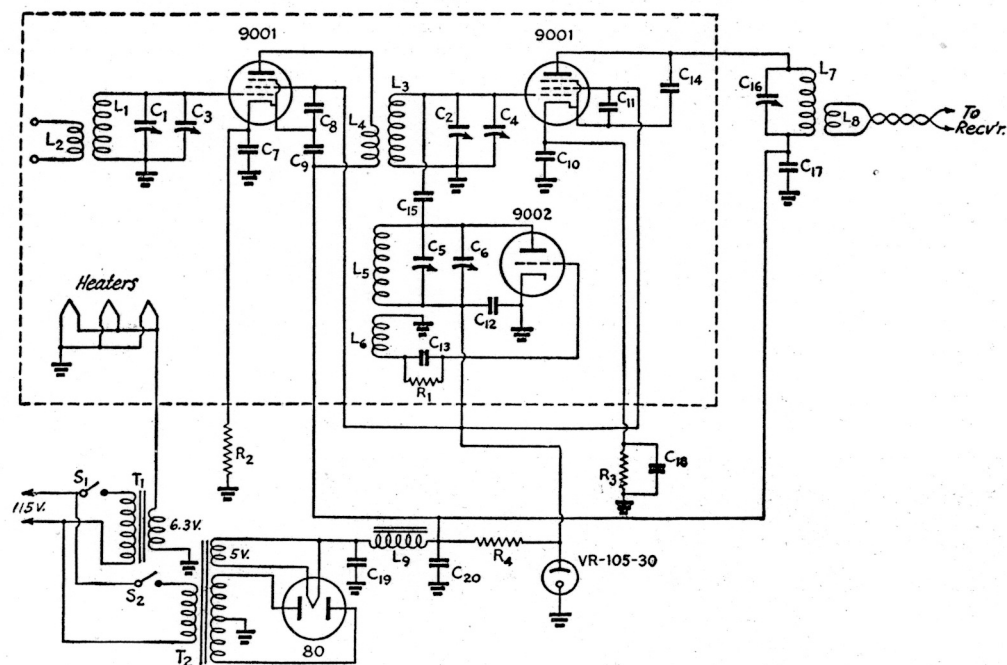


Fig. 1403 — Circuit diagram of the high-performance plug-in coil 56-112-Mc. converter using 9000-series tubes.

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|---|--|--|
| C_1, C_2 — Approximately 5- μ fd. variable (National UM-15 cut down to 2 plates). | C_{15} — Oscillator-mixer coupling condenser (see text). | L_7 — 18 turns No. 22 e., close-wound on 3/8-inch diameter form. |
| C_3, C_4 — 3-30- μ fd. mica trimmer (National M-30). | C_{16} — 25- μ fd. air trimmer (Hammarlund APC-25). | L_8 — 8 turns similar to L_7 , at ground end of L_7 . |
| C_5 — Approximately 8- μ fd. variable (National UM-15 cut down to 3 plates). | C_{17} — 0.002- μ fd. mica. | L_9 — Filter choke, 8 henrys, 55 ma. (Thordarson T-14C62). |
| C_6 — 25- μ fd. air trimmer (Hammarlund APC-25). | C_{18} — 0.01- μ fd. 400-volt paper. | T_1 — Filament transformer, 6.3 volts, 1.2 amperes (Stancor P-6134). |
| C_7 — 500- μ fd. midget mica. | C_{19}, C_{20} — 8- μ fd. 450-volt electrolytic. | T_2 — Power transformer, 560-0-560 volts, 30 ma. (Thordarson T-60R49). |
| C_{13} — 100- μ fd. mica. | R_1 — 50,000 ohms, 1/2-watt. | S_1, S_2 — S.p.s.t. toggle switch, |
| C_{14} — 50- μ fd. silver-mica. | R_2 — 1200 ohms, 1/2-watt. | |
| | R_3 — 10,000 ohms, 1/2-watt. | |
| | R_4 — 6000 ohms, 10-watt. | |
| | L_1 — L_6 — See coil table, p. 291. | |

strips of thin copper, this being used in preference to wire to reduce the inductance.

For electrostatic shielding between the r.f. and mixer stages, two baffle plates are used. One small plate, not visible in the photograph, is fastened to the side of the chassis directly opposite the tube socket and is soldered to the shield cylinder in the center of the socket. It effectively shields the grid wiring from the plate circuit, and is about an inch square. Since it crosses the tube socket and should be placed as close to it as possible, care must be taken to see that the socket prongs are bent away so they cannot touch it. The other shield is almost all on the outside and is used chiefly to prevent electrostatic coupling between the r.f. and mixer trimmer condensers, which are mounted on the sides of the tuning condensers. A transverse shield plate completely boxing off the two stages would be better, but it is an awkward job mechanically in view of the necessity for assembling the condenser gang.

No shielding is required between the mixer and oscillator; in fact, the stray coupling is too small to give good frequency conversion. The trimmer condenser is supported from the top of the chassis by a small bracket made from brass strip, bent to such a size that the rotor connection of the trimmer comes right at the rotor spring on the tuning condenser, where the two are soldered together. A small strip of copper is soldered between the two sets of stator plates, using the soldered mounting on top of the trimmer for its connection. The coupling condenser is a small piece of copper bolted to the trimmer end plate and bent to face the other soldered mounting. The separation is about a sixteenth of an inch.

The vertical shield plates between the coils are $2\frac{3}{8} \times 1\frac{3}{8}$ inches, with bent-over edges to fasten to the side of the chassis. To complete the magnetic shielding the end of the mixer coil must be boxed in, which is done by a piece of copper in the shape of a shallow U, held in place simply by making it fit tightly between the

vertical shields. This piece must be removable for changing the mixer coil.

Care must be used in making soldered connections on the polystyrene sockets and forms, since the material will soften with the application of heat. Have the connections well cleaned before attempting to solder the wires, and hold the iron on the lugs just long enough to get a good joint.

The bottom view shows the arrangement of the power supply and the i.f. output circuit. The transformer for the latter is wound on a National PRE-3 polystyrene form. It is mounted on a bracket to keep it about equally spaced from the top of the chassis and the bottom of the cabinet in which the chassis fits. The various a.c. and d.c. supply connections from the converter are brought to lug strips, as shown; cathode resistors for the r.f. and mixer stages are mounted where they are readily accessible for trying different values. The power-supply parts are arranged to fit in the remaining space. The rubber feet at the rear of the chassis give a little space for circulation of air, since a fair amount of heat is developed by the transformers and regulator tube.

A few mechanical points should be given consideration in assembling the tuning condensers. The screw-on shafts are likely to come loose with use unless they can be anchored in some way, and soldering is about the simplest scheme. The heat tends to cause the lubricant to run out of the shaft bearing, however. Another important point is to get the shafts of the three condensers lined up accurately so that the rotors turn freely. Any twist, particularly at the oscillator condenser shaft, will tend to bend the rotor out of line slightly with respect to the stator, and, since the twisting depends upon the direction of rotation, this means that the assembly will have bad backlash. For the same reason, the dial must be lined up accurately with the condenser shafts. Line up the shafts to run as true as possible and fix the stators where they want to come on the chassis, using shims if necessary.

Alignment of the converter will involve some cut-and-try, using the coil specifications given in the table as a guide. It is best to line up the set with the 56-Mc. coils first before tackling the 112-Mc. band. The first step is to make the oscillator cover the proper range, the object being to spread the band over about 75 per cent of the dial scale. With the 10.2-Mc. i.f., the oscillator range, to cover 56 to 60 Mc., will be from 45.8 to 49.8 Mc.; this may be checked on another receiver, if available. If not, probably it will be necessary to use actual

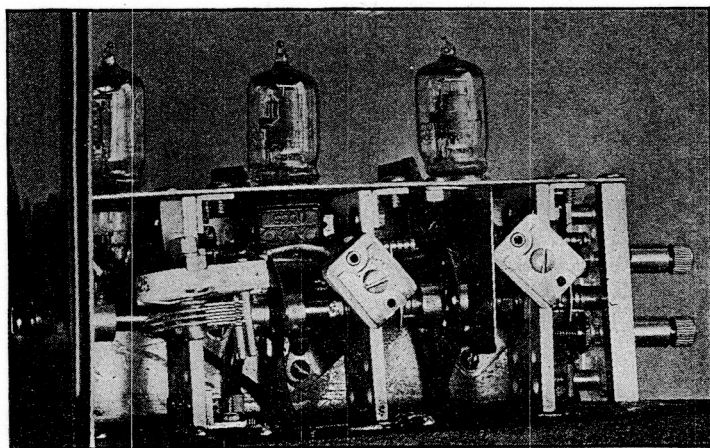


Fig. 1404 — Inside the converter unit, showing arrangement of the tuning condensers. The layout is quite compact, with leads kept as short as possible.

signals in the band for the purpose, which also will involve having at least the mixer hooked up. With the circuit specifications given, the oscillator padding condenser should be set at about half-scale. The inductance of L_5 may be adjusted by closing up or opening out the turn spacing, which can be done within limits without moving the ends of the coil. Once the right range is secured, the turns should be cemented in place. An alternative method of adjustment is to make the coil slightly large at first and then cut down the inductance with a shorted turn of wire which may be slid along the coil form. A limited range of inductance variation can be secured by this method.

The oscillator tickler, L_6 , should be adjusted to give stable oscillation without squegging. Squegging is evidenced by a whole series of signals instead of one and can be cured by reducing the feed-back, either by using a smaller number of tickler turns or by moving the tickler farther away from the plate coil. Incidentally, the oscillator should have a good steady d.c. note if means are available for listening to it on another receiver. For this check to mean anything, the receiver used must introduce no modulation on incoming signals.

Once the oscillator range is set, the mixer should be lined up to match. To do this, place the r.f. tube in its socket but connect a resistor of a few hundred ohms from its grid to ground, instead of using L_1 . The mixer primary, L_4 , must be in place, since it will have some effect on the tuning range of L_3C_2 . Connect the r.f. output leads to the doublet posts on the communications receiver, set the latter to 10.2 Mc. and adjust C_{16} for maximum hiss, with the oscillator tube out of its socket. Then replace the tube and, with the oscillator set for 56 Mc., adjust the trimmer, C_4 , for maximum hiss; reset the oscillator to 60 Mc. and readjust C_4 . If more capacity is needed at C_4 for maximum hiss, the inductance of L_3 is too large; if less, L_3 is too small. Make an appropriate small change in the inductance and try again, continuing the process until C_4 peaks at the same setting at both ends of the band. Adjustment of the inductance of L_3 may be accomplished by the means described above.

COIL DATA					
Band	Coil	No. of Turns	Wire Size	Length Inches	Remarks
112 Mc.	L_1	$1\frac{1}{2}$	18	$1\frac{5}{16}$	
	L_2	$1\frac{1}{8}$	24		$\frac{1}{8}$ " from L_1
	L_3	$1\frac{1}{2}$	18	$1\frac{5}{16}$	
	L_4	$1\frac{1}{8}$	24	$\frac{1}{8}$	$\frac{1}{8}$ " from L_3
	L_5	$\frac{3}{4}$	18		
	L_6	$1\frac{1}{8}$	24		$\frac{1}{8}$ " from L_5
56 Mc.	L_1	$4\frac{5}{8}$	18	$\frac{3}{8}$	
	L_2	$2\frac{7}{8}$	24	$\frac{1}{8}$	$\frac{1}{8}$ " from L_1
	L_3	$4\frac{1}{2}$	18	$\frac{1}{16}$	
	L_4	$2\frac{7}{8}$	24	$\frac{1}{8}$	$\frac{1}{8}$ " from L_3
	L_5	$3\frac{3}{8}$	18	$\frac{3}{8}$	
	L_6	$2\frac{7}{8}$	24	$\frac{9}{32}$	$\frac{1}{8}$ " from L_5
All coils wound on $\frac{3}{4}$ -inch diameter forms (Amphenol type 24-5H, 5-prong).					

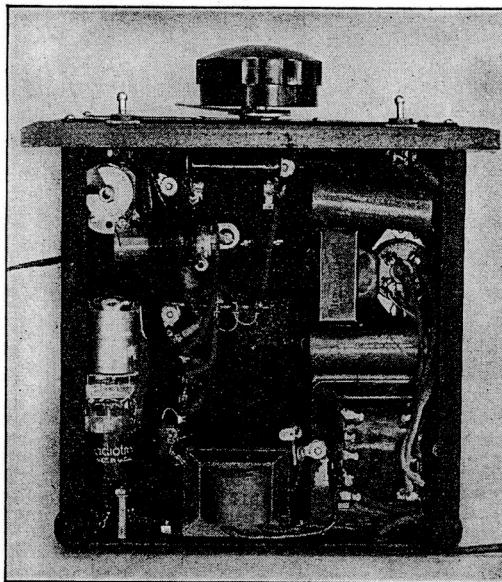


Fig. 1405 — The converter power supply occupies the right-hand section of the chassis in this bottom view. The i.f. output section is in the upper left-hand corner.

When this process is finished, C_4 should be well in the air-dielectric portion of its range. Should the movable plate be close to the mica, L_3 is considerably too small. However, this would be accompanied by reduced tuning range on C_2 , and it is doubtful if high padding capacity would permit full band coverage.

The r.f. stage is aligned in just the same way as the mixer circuit. The initial alignment should be done with nothing connected to the antenna posts. Should oscillation occur, reduce the size of L_4 until the stage is stable. Some slight trace of regeneration may remain, as indicated by an exaggerated peaking in the r.f. stage, but this will disappear with any sort of antenna load on the r.f. tuned circuit.

The procedure for the 112-Mc. coils is similar to that for 56 Mc. It is desirable to adjust the oscillator coil so that the trimmer, C_6 , does not need resetting when changing bands. (Bib. 1.)

◀ A Simple 56/112-Mc. Converter

The converter shown in Figs. 1406, 1407, 1408, 1409, 1410 and 1411 uses a 1232 loktal tube for the mixer and a 7A4 for the h.f. oscillator. Although its sensitivity is not quite as good as that of the converter just described, it affords a simple converter for the v.h.f. range that will prove perfectly satisfactory. By grouping the tuning condenser, coil and tube socket closely together, it is a relatively simple matter to achieve low-enough circuit capacities to work readily on 112 Mc. As can be seen from Fig. 1408, the grid of the 1231 mixer is tapped down on the coil to reduce the loading on the circuit and obtain a better gain in the stage. The plate-tickler circuit in the oscillator permits the cathode to be grounded directly, causing a minimum of hum on the signal.

The oscillator tuning condenser is a 15- μ fd. condenser from which several plates have been removed, and this is paralleled by a 35- μ fd. band-set condenser. With this type of band-spread system the converter can be set to the desired frequency band and the mixer condenser turned to the point where the noise is greatest; thereafter the tuning is all done with the small oscillator condenser. When a signal has been tuned in the mixer can be peaked again, but this is not usually necessary over the range of the bandspread condenser. Pulling of the oscillator circuit by the mixer tuning is slight, because of the loose coupling.

The chassis is made of 1/16-inch thick aluminium; other metals could be substituted, if necessary. The panel is 5½ × 8 inches, but could be trimmed to 6 inches long. The extra length was included to put the dial in the center of the panel and also to provide room for possible future switches for shifting to various i.f. amplifiers. The chassis itself is built from a piece of 5¼-inch wide metal, bent to form a top 3⅞ inches wide and a back 4 inches deep. A ½-inch lip is bent down from the top to fasten the chassis to the panel. The two sides are made by forming shallow Us (with ½-inch sides) to fit between the panel and the back of the chassis. A shield is fitted under the chassis, making the oscillator compartment 2½ inches wide. This shield mounts the oscillator tuning condenser and the National TPB Vietron through-bushing which serves as a coupling condenser between oscillator and mixer.

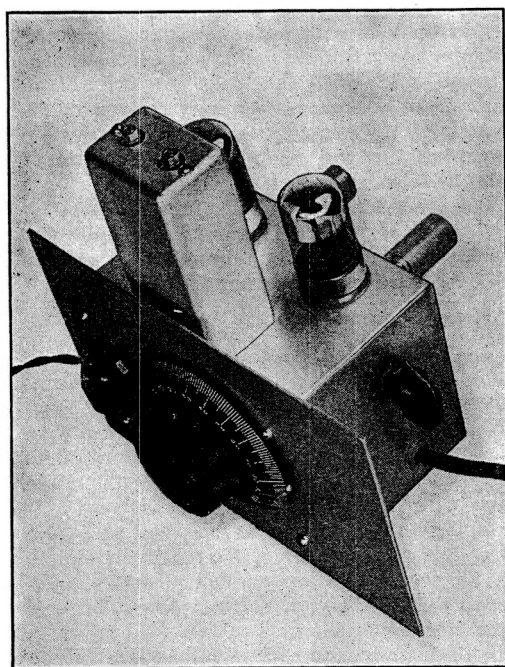


Fig. 1406 — The simple converter uses a 7A4 oscillator and a 1232 mixer. The panel dial is the oscillator tuning dial; the panel knob is the mixer tuning control. Knob on side adjusts the oscillator band-set condenser.

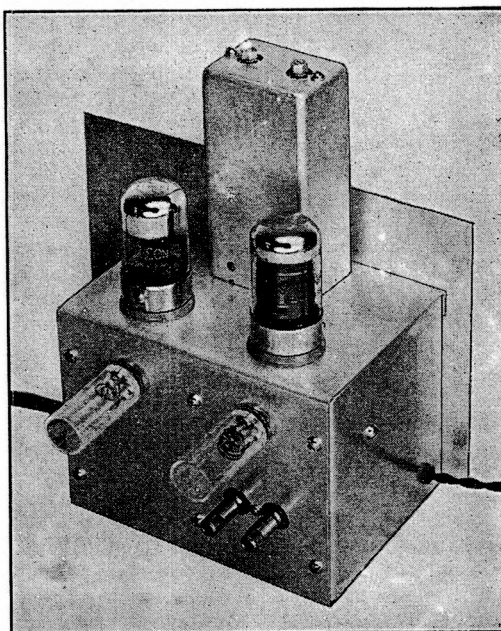


Fig. 1407 — A rear view of the converter, showing the plug-in coils and the antenna terminals. The cable leading off at the left goes to the power supply; the twisted pair on the right carries the output to the i.f. amplifier.

The coil forms are the small ¾-inch diameter Amphenol type made of polystyrene. The coil sockets, also of polystyrene, mount simply by drilling a hole and sliding the retainer rings over the sockets. The tube sockets are mounted in the same fashion. For short leads, the oscillator socket should be mounted with the slot towards the rear and the mixer socket with the slot towards the left-hand side.

As mentioned before, the oscillator tuning condenser, C_3 , is mounted on the shield partition, and the band-set condenser, C_2 , is mounted on the right-hand side of the chassis. The band-set condenser is insulated from the metal by fiber washers, so that there is only one ground point to the chassis for the oscillator circuit — that through the oscillator tuning condenser. The mixer tuning condenser, C_1 , is mounted on the right-hand side of the chassis and grounds the mixer circuit at that point.

The oscillator tuning condenser and the mixer tuning condenser are fastened to their respective panel controls through insulated couplings, to avoid duplication of grounds.

The panel and sides should be left off until all of the wiring that can be done without them has been finished. Heater leads, ground connections, by-pass condensers, and resistors all should be put in before the sides and panel are attached. Do not hold the soldering iron on the polystyrene socket lugs for longer than is necessary to start the solder flowing or the socket contacts will loosen from softening of the polystyrene. A small, pointed soldering iron is best. A lead is run from the grid of the 1232 to the through-bushing on the partition but no

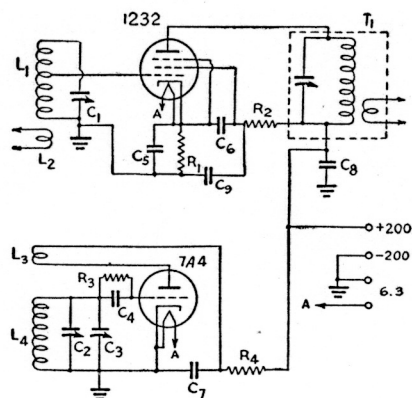


Fig. 1408 — Circuit diagram of the v.h.f. converter;

C₁ — 15- μ fd. midget variable (Hammarlund HF-15).
C₂ — 35- μ fd. midget variable (Hammarlund HF-35).
C₃ — 10- μ fd. midget variable (Hammarlund HF-15 with one stator and one rotor plate removed).

C₄ — 100- μ fd. midget mica.

C₅, C₆, C₇ — 500- μ fd. midget mica.

C₈, C₉ — 0.01- μ fd. 600-volt paper.

R₁ — 500 ohms, $\frac{1}{2}$ -watt.

R₂ — 125,000 ohms, 1-watt.

R₃ — 20,000 ohms, $\frac{1}{2}$ -watt.

R₄ — 10,000 ohms, 1-watt.

T₁ — 3 Mc.: 75 turns No. 30 d.s.c., close-wound; coupling coil 20 turns No. 30 d.s.c., close-wound.

5 Mc.: 45 turns No. 30 d.s.c., close-wound; coupling coil 14 turns No. 30 d.s.c., close-wound.

L₁ — 112 Mc.: $2\frac{1}{4}$ turns No. 20 e., $\frac{3}{8}$ -inch diameter, spaced wire diameter Grid tap $\frac{3}{4}$ -turn from top.
56 Mc.: $4\frac{1}{2}$ turns No. 20 e., $\frac{3}{4}$ -inch diameter, spaced over $\frac{1}{2}$ inch. Grid tap $1\frac{1}{2}$ turns from top.

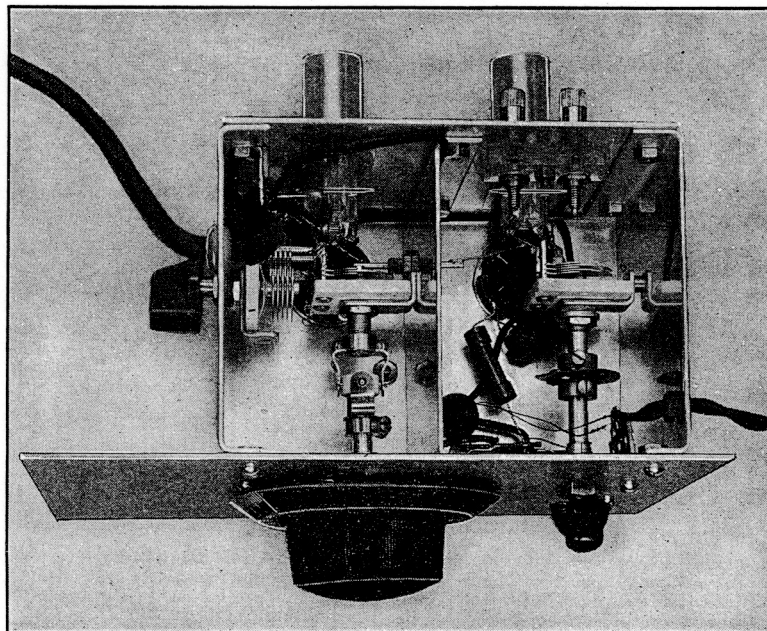
L₂ — 112 Mc.: 3 turns No. 20 e., $\frac{1}{4}$ -inch diameter, close-wound one wire diameter below cold end of L₁.
56 Mc.: 3 turns No. 24 e. close-wound $\frac{1}{8}$ inch below L₁.

L₃ — 112 Mc.: 1 turn No. 20 e. $\frac{1}{4}$ -inch diameter, 3 wire-diameters below L₄.

56 Mc.: $1\frac{1}{2}$ turns No. 24 e. close-wound $\frac{1}{8}$ inch below L₄.

L₄ — 112 Mc.: $\frac{7}{8}$ turn No. 20 e., $\frac{3}{8}$ -inch diameter.
56 Mc.: $1\frac{3}{4}$ turns No. 20 e. spaced over $\frac{1}{4}$ inch.

Fig. 1409 — A view underneath the v.h.f. converter. Note that in the oscillator section (on the left) the band-set and tuning condensers butt into each other for short leads. The band-set condenser, C₂, is insulated from the side panel by washers, and the oscillator circuit is grounded to the chassis at only one point — through the tuning condenser. The Victron through-bushing which serves as the coupling condenser between mixer and oscillator can be seen on the partition just above the oscillator tuning condenser. The bushing connects to the 1232 grid on one side and is blank on the other. The i.f. transformer, T₁ (not visible in this view), is built in a Hammarlund ETU shielded unit. Both sections of the trimmer assembly condensers are used, in parallel.



connection is made on the oscillator side, since the capacity between the bushing and the oscillator leads is sufficient for coupling. All r.f. leads and the leads for the by-pass condensers must be kept short and direct.

The coil for the 56–60-Mc. range is wound in the usual manner on the outside of the coil forms. No trouble should be had in finding the 56-Mc. amateur band, since the tolerance on the range of this coil is fairly wide. The only care necessary is to prevent the pins from loosening up in the forms because of the heat when soldering. The wire should be well cleaned and a spot of flux used on the tip of the pin. No attempt should be made to flow solder on the pin and wire; a drop of solder picked up by the iron can be held against the pin for just an instant, long enough to solder wire and pin together. If the pin loosens up or moves out of place, it can be heated again slightly (by holding the soldering iron against it) and held in the proper position with long-nosed pliers. When the metal (and coil form) cools, it should be as solid as ever. If it isn't it doesn't matter too much, since the form still can be plugged in the socket without difficulty.

The coils for the 112–116-Mc. range are wound *inside* the coil forms. It is a simple matter to adjust them, however, since the forms can first be sawed through near the base and the coils adjusted by spreading the turns. When the necessary adjustments have been made the coil form can be fastened together by Duco cement, thus avoiding danger of its being injured by handling.

The usual rule must be followed with the oscillator coil; i.e., if both grid and plate coils are wound in the same direction, the grid and plate connections should come off at opposite ends (in this case, the outside ends).

The connections for the oscillator coil, looking at the form from the bottom, are (starting with the widely spaced pin and going clockwise): plate, ground, "B" +, grid, blank. In the same manner, the mixer-coil connections are: grid, tuning condenser, antenna, antenna, ground. Both mixer and oscillator coil sockets are mounted with the odd pin at the top.

If connections have been kept short, no trouble should be experienced in making the oscillator oscillate on any of the ranges. For the 112-Mc. band, the oscillator band-set condenser setting will be at minimum capacity. For 56 Mc. it should be set at about mid-scale, varying slightly with the i.f. used.

The converter is coupled into the i.f. amplifier through a low-impedance link. This requires that the input transformer in the i.f. amplifier be modified by winding a number of turns about the grid coil as a link coil. Alternatively, a duplicate of the output transformer, T_1 , can be substituted for the first transformer in the i.f. amplifier. If a receiver is used for the i.f. amplifier, the output leads connect to ground and to the grid cap of the mixer tube in the receiver, replacing the regular grid lead.

Antennas for use with the converter present the same problem that they do with any v.h.f. receiver; the best one for the service required is the one to use. A little experimenting with the antenna coil, L_2 , may help in giving a better

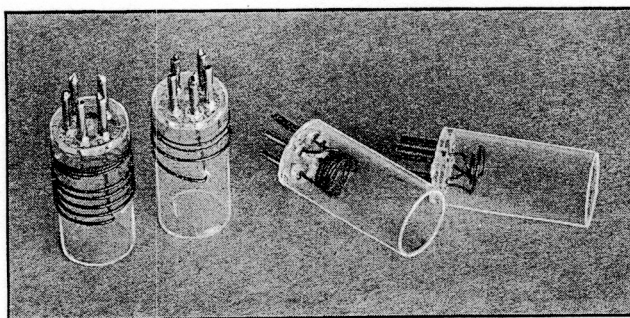


Fig. 1411—The 112-Mc. coils (right) are wound self-supporting inside the coil forms, while the 56-Mc. coils are wound in the usual manner.

match to the antenna system; the dimensions given are average values that work out about right for low-impedance line input.

If signals are weak, the trouble probably can be accounted for by too much or too little oscillator voltage reaching the mixer. This can be adjusted over a considerable range by moving the tickler coil, L_3 , closer to or farther away from L_4 . However, the adjustment does not seem to be too critical.

For maximum performance and stability, it is suggested that a voltage-stabilized power supply be used. (Bib. 2.)

◄ A 56-Mc. Converter with 1852 R.F. Amplifier

The performance of a converter can be improved by equipping it with an r.f. amplifier stage preceding the mixer.

The additional amplification provided is seldom necessary with a communications receiver functioning as an i.f. amplifier, but the improvement in both image rejection and signal-to-noise ratio is worth while. A converter with an r.f. amplifier stage is shown in Fig. 1412. As the circuit, Fig. 1413, shows, an 1852 is used as the r.f. amplifier or preselector, and a triode-hexode converter tube, the 6KS, is used as a combined mixer and oscillator. The intermediate frequency is 10 megacycles.

The metal chassis measures $1 \times 3\frac{1}{2} \times 7$ inches. Shielding between stages is provided by the right-angle partition shown in the photograph. This partition is $2\frac{3}{4}$

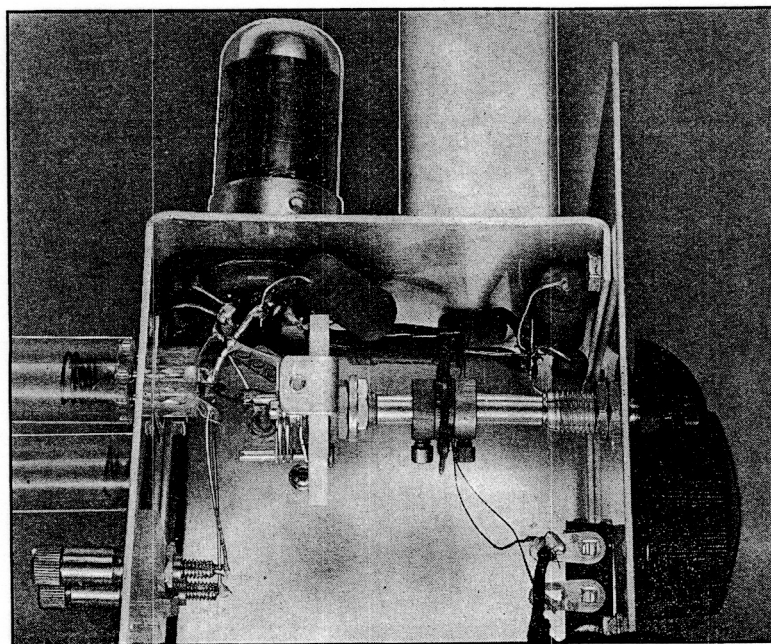


Fig. 1410—The mixer circuit can be seen in this view of the 56/112-Mc. converter with the side panel removed. The tie strip at the lower right takes the output leads from the i.f. transformer. The interstage through-bushing can be seen just to the left of and under the tuning condenser, with a wire from it running to the 1232 grid terminal.

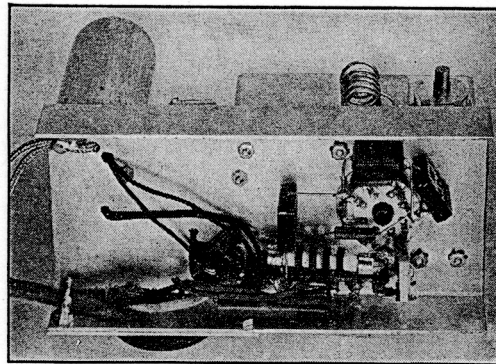
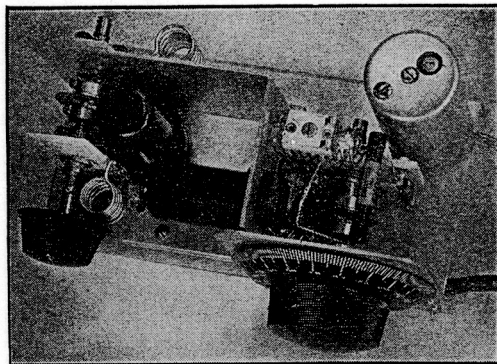


Fig. 1412 — Left — A superheterodyne converter for 56-Mc. reception. Designed for use with a communications-type receiver, this converter has an 1852 r.f. stage and a 6K8 mixer-oscillator. A high i.f. (10 Mc.) gives good image reduction. Right — Below-chassis wiring of the metal-tube converter. The 1852 socket may be seen at the right.

inches high, and the side parallel to the front edge of the chassis is 4 inches long. The portion supporting the 6K8 is $2\frac{1}{2}$ inches long. The 6K8 is mounted at the bottom of the shield, its grid cap facing the left end of the base.

The 1852 grid tuning condenser, C_1 , and coil, L_1 , are mounted to the rear of the 4-inch section of the shield. The 1852, condenser C_2 and coil L_2 are mounted in front of the partition, with C_2 directly in line with C_1 . A hole through the shield permits the two shafts to be connected by a flexible coupling. Both of these coils, and also L_3 , have their terminals soldered directly to the condenser lugs.

The oscillator-mixer section of the circuit is to the right of the $2\frac{1}{2}$ -inch partition, with the tube socket mounted on the same side. C_3 , also mounted on the partition, is located at the rear of the tube socket. The i.f. transformer, T_1 , is mounted at the right rear corner of the chassis. The output leads from this transformer are shielded, to prevent stray pick-up between the

converter and the receiver. By-pass condensers and resistors are closely grouped around the tube socket, assuring short leads. A trimmer condenser, C_4 , soldered across L_3 , allows a small variable capacity to be used as the tuning element and at the same time adds enough capacity to make the circuit fairly high- C for good stability.

A small panel is used to mount a vernier dial for the oscillator condenser. Since the r.f. tuning is broad enough to cover a good portion of the band with one setting, a small knob gives sufficient control.

The output line may be connected to the antenna and ground terminals of the standard receiver used as an i.f. amplifier, or to the "doublet" terminals, if provided. The exact i.f. chosen is not particularly important, so long as it is in the vicinity of 10 Mc. Choose a frequency which is free from audible signals, if possible, so that there will be no unnecessary interference from this source.

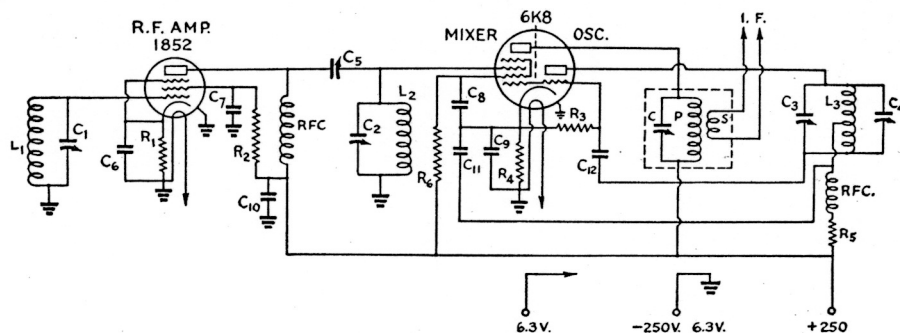


Fig. 1413 — Circuit diagram of the 1852-6K8 56-Mc. metal-tube superheterodyne converter.

C_1, C_2 — 15- μ fd. midget variable (National UM-15).
 C_3 — Same as C_1 but with two rotor plates and one stator plate removed.
 C_4, C_5 — 3-30- μ fd. compression-type mica trimmer.
 C_6 to C_9 , inc. — 0.005- μ fd. mica.
 C_{10} — 0.002- μ fd. mica.
 C_{11} — 250- μ fd. mica.
 C_{12} — 100- μ fd. mica.
 R_1 — 200 ohms, $\frac{1}{2}$ -watt.

R_2 — 65,000 ohms, $\frac{1}{2}$ -watt.
 R_3 — 50,000 ohms, $\frac{1}{2}$ -watt.
 R_4 — 300 ohms, $\frac{1}{2}$ -watt.
 R_5 — 20,000 ohms, $\frac{1}{2}$ -watt.
 R_6 — 20,000 ohms, 2-watt.
RFC — In the 1852 plate circuit, a 2.5-mh. r.f. choke; in the oscillator circuit, a v.h.f. r.f. choke (Ohmite Z-1).
 L_1 — 6 turns No. 14, $\frac{1}{2}$ -inch diameter, length 1 inch.

L_2 — 6 turns No. 14, $\frac{1}{2}$ -inch diameter, length $\frac{3}{8}$ -inch.
 L_3 — 10 turns No. 14, $\frac{1}{2}$ -inch diameter, length $1\frac{1}{4}$ inches, tapped 4th turn from grid end.
I.F. Output Transformer — P , 25 turns No. 28 d.s.c. close-wound on $\frac{1}{2}$ -inch form; S , 6 turns wound over P at bottom; C , 35- μ fd. midget variable.

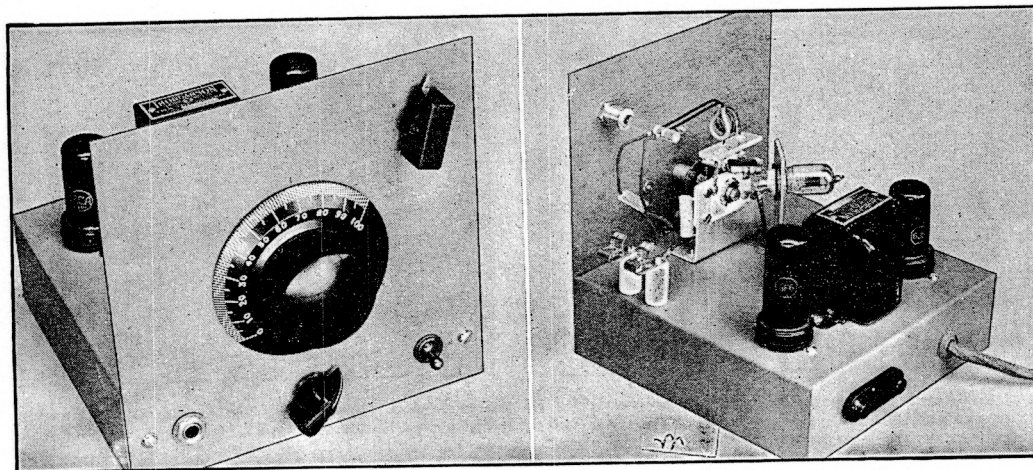


Fig. 1414—*Left*—The panel of the two-band superregenerative receiver measures 7 inches square. The knob in the upper right-hand corner adjusts antenna coupling, while the knob below the tuning dial controls regeneration. *Right*—A rear view of the two-band superregenerative receiver, showing the variable antenna coupling and the placement of parts. Note the 224-Mc. coil in the foreground; the 112-Mc. coil is in the coil socket, in this view.

Tuning of the converter is as follows: With the r.f. and oscillator condensers at about half capacity, the padder, C_4 , is adjusted until 56-Mc. stations of known frequency are heard. After this the padder may be set to bring the high-frequency end of the band near minimum capacity on C_3 . The i.f. transformer should then be tuned for maximum signal strength. The 56–60-Mc. band will occupy approximately 60 to 70 divisions on the dial. The r.f. and mixer input circuits, L_1C_1 and L_2C_2 , may be made to track by squeezing or spreading the turns of L_1 and L_2 until both cover the same frequency range, as determined by loosening C_1 from the coupling and turning it independently to see if it peaks the noise at the same setting as C_2 .

Any type of antenna may be used, so long as it loads the r.f. grid circuit quite heavily. Optimum operation will result under these conditions. A single-wire antenna may be capacity coupled, while a two-wire feeder system should be inductively coupled. The coupling coil may be slightly smaller than the r.f. coil, L_1 .

□ A Superregenerative Receiver for 112 and 224 Mc.

The receiver shown in Figs. 1414, 1415 and 1416 has very good sensitivity on both 112 and 224 Mc., although it is not free from radiation as is a receiver with an r.f. stage. However, for the amateur who wishes to experiment on these two v.h.f. bands this receiver will permit good reception at a minimum of expense. There is nothing unusual about the circuit; it is the familiar type of self-quenched superregenerative detector, followed by two stages of audio amplification.

The receiver is built on a $7 \times 7 \times 2$ -inch chassis. The dial is mounted in the center of the panel and is connected to the tuning condenser by a flexible bakelite coupling. The condenser is mounted on a metal bracket, cut out in the

shape of a U to clear the stator connections of the condenser.

The socket for the plug-in coils is made using contacts taken from an Amphenol 78-7P miniature tube socket. They are obtained by squeezing the socket in a vise until the bakelite cracks, after which they can be easily removed. One contact is soldered to each of the tuning condenser connections and a third is soldered to a lug supported by one of the extra holes in the Isolantite base of the tuning condenser. In mounting the contacts they must all be at the same height, so that the plug-in coil will seat well on them. The band-set condenser, C_2 , is mounted by soldering short strips of wire to the ends and then soldering these wires to the tuning condenser terminals.

The polystyrene tube socket for the 9002 is mounted on a metal bracket, which is placed close enough to the tuning condenser to allow a very short lead from the tuning condenser to the plate connection and just enough room between the rotor of the condenser and the grid connection of the tube for the grid condenser. Heater and cathode leads are brought to the underside of the chassis through a rubber grommet.

The variable antenna coupling coil, L_1 , is mounted on a polystyrene rod supported by a shaft bearing. The rod is prevented from moving axially in the bearing by cementing a fiber washer to the shaft and tightening the knob on the other side so that the shaft does not move too freely. The antenna coupling loop should be adjusted so that, as it is rotated, it will just clear the coils when they are plugged into the socket.

The coils are mounted on small strips of $\frac{1}{8}$ inch polystyrene (Millen QuartzQ) as bases, which have three small holes drilled in them corresponding exactly to the tops of the coil sockets. Each coil is cemented to the strip with Duco cement at the points where the wire passes through the base. The No. 18 wire used

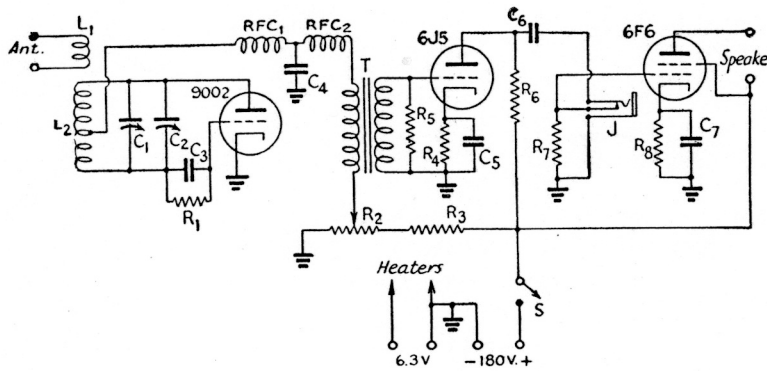


Fig. 1415 — Wiring diagram of the v.h.f. superregenerative receiver for 112 and 224 Mc.

- | | | |
|---|---|---|
| C ₁ — Two-plate variable (National UM-15, 4 plates removed). | R ₃ — 0.1 megohm, 1-watt. | L ₂ — 112 Mc.: 3 turns No. 18 e., 1/2-inch diameter, 1/4-inch long. Tapped 1 1/4 turns from plate end. |
| C ₂ — 3–30-μfd. mica trimmer. | R ₄ — 2500 ohms, 1/2-watt. | 224 Mc.: 2 turns No. 18 e., 1/4-inch diameter, spaced over 1/2 inch. Tapped at center. |
| C ₃ — 50-μfd. mica. | R ₅ , R ₆ , R ₇ — 0.1 megohm, 1/2-watt. | RFC ₁ — 25 turns No. 24 d.c.c. close-wound, 1/4-inch diameter. |
| C ₄ — 0.003-μfd. mica. | R ₈ — 500 ohms, 1-watt. | RFC ₂ — 8 mh. r.f. choke. |
| C ₅ , C ₇ — 10-μfd. 25-volt electrolytic. | J — Closed-circuit jack. | |
| C ₆ — 0.01-μfd. 400-volt paper. | S — S.p.s.t. toggle switch. | |
| R ₁ — 10 megohms, 1/2-watt. | T ₁ — Single plate to single grid audio transformer (Thorndarson T-57A36). | |
| R ₂ — 50,000-ohm wire-wound potentiometer. | L ₁ — 1 turn No. 14 e., 3/8-inch inside diameter. | |

for the coils will fit snugly in the sockets if the contacts are pinched slightly. A coil socket of this type allows very short leads to be used, and is about the only thing practical until some manufacturer brings out a commercial product along these lines. The coils are trimmed to the bands by spreading or squeezing the turns slightly by the procedure previously described. However, in this case the band-set condenser gives some further range of adjustment. In the receiver as described, it is screwed down fairly tightly for the 112-Mc. band and loosened

about four revolutions for 224 Mc. If there are no good marker stations available by which frequency can be checked, an absorption frequency meter or the Lecher wire system described in Chapter Sixteen may be used for spotting the bands.

Two factors which will be found to influence the sensitivity of the receiver are the value of C₄ and the degree of antenna coupling. It is recommended that values of C₄ from 0.001 to 0.005 μfd. be tried. The antenna coupling will, of course, vary greatly with the setting of L₁ and

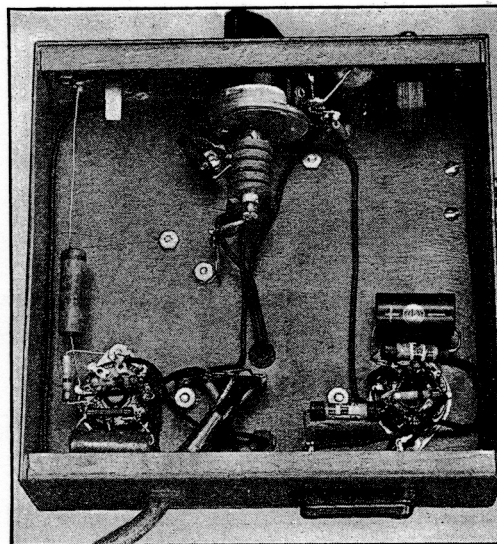
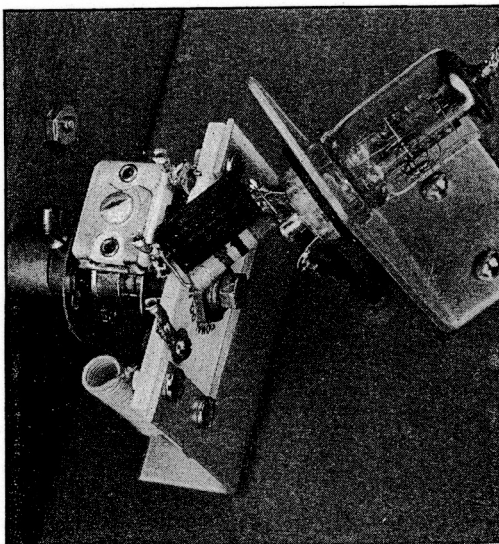


Fig. 1416 — Left — A close-up view of the tuning assembly, showing how the leads from the tuning condenser to the tube socket have been kept short and how the coil socket is mounted on the tuning condenser. Hidden by the grid condenser (the 50-μfd. condenser so prominent in the picture), the plate terminal of the tube socket goes to a lug which has been added to the rotor of the tuning condenser. Right — The arrangement of parts under the chassis may be seen in this photograph. The 6J5 socket is at the left and the 6F6 socket is at the right, near the speaker terminals. The 8-mh. r.f. choke, seen just under the regeneration control at the top center, is supported by tie strips.

with the type of antenna used, and it is well worth while to tune the antenna circuit and then vary the coupling with the panel control. Tight coupling usually will give better results than loose coupling and the coupling can be increased almost up to the point where it is no longer possible to make the detector oscillate, with no ill effects except increased radiation and possible QRM for other receivers in the vicinity.

No audio volume control was included in this receiver because the parts were held down to a minimum, but one could easily be added. In this receiver, the value of R_7 was adjusted until normal loudspeaker output was obtained; this value may be varied to meet any particular requirements. (*Bib. 3.*)

□ A T.R.F. Superregenerative Receiver

The receiver shown in Figs. 1417, 1418, 1419 and 1420 is practically identical to that described in the foregoing section, with the exception that a stage of tuned r.f. amplification and an audio gain control have been added. The 9001 tube used for the r.f. amplifier gives some slight gain, freedom from antenna effects, and — most important of all — prevents radiation from the receiver.

The arrangement of parts, as shown in the photographs, is convenient in that it results in a fully shielded receiver (except for the r.f. tubes) which is easy to work on. The r.f. unit can be demounted from the chassis and worked with separately; once adjusted, it can be replaced and left alone. The receiver is a one-band affair, but the only disadvantage in this is a lack of economy. The main chassis, which

measures $7 \times 7 \times 2$ inches, contains the audio components and the volume and regeneration controls. The r.f. portion is housed in a $3 \times 4 \times 5$ -inch box with everything but the dial and the antenna terminals mounted on the removable cover, enabling the builder to get at the parts easily. Only three leads are brought down from this box to the main chassis, and these are left long enough so that they do not need to be unsoldered when the box is removed from the chassis. A shield mounted on the side of the box helps to prevent coupling between the r.f. and detector coils. Holes on either side of the box allow the trimmer condensers to be adjusted when the receiver has been finally assembled.

As can be seen from the close-up view of the r.f. portion, the two tuning condensers and the two sockets are mounted on the removable top of the box and support all of the components. The trimmer condensers are soldered directly to the tuning condenser terminals and the coils are self-supported by their leads. A tie strip takes the leads that run out of the box and also serves as a convenient point to fasten R_{FC1} , C_9 and some of the other resistors and condensers. The leads are not quite as short in this arrangement as they are in the receiver of Fig. 1414, but that makes no practical difference because this receiver is built only for 112 Mc. and does not have to tune down to 230 Mc.

The coils are wound on small polystyrene forms. It is suggested that the No. 20 wire secondary coils be wound first. The plate tap for L_4 should be soldered, and the coils can then be doped. When the dope has hardened, the fine-wire coils can be more easily wound in between the turns and fastened with dope. The

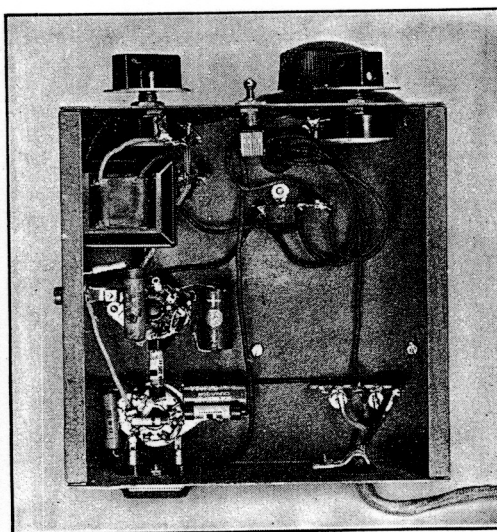
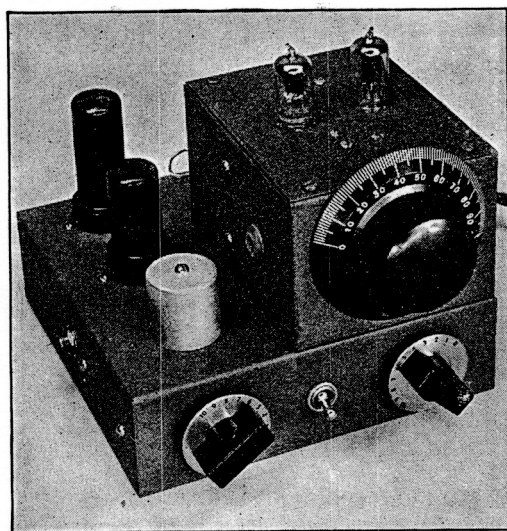
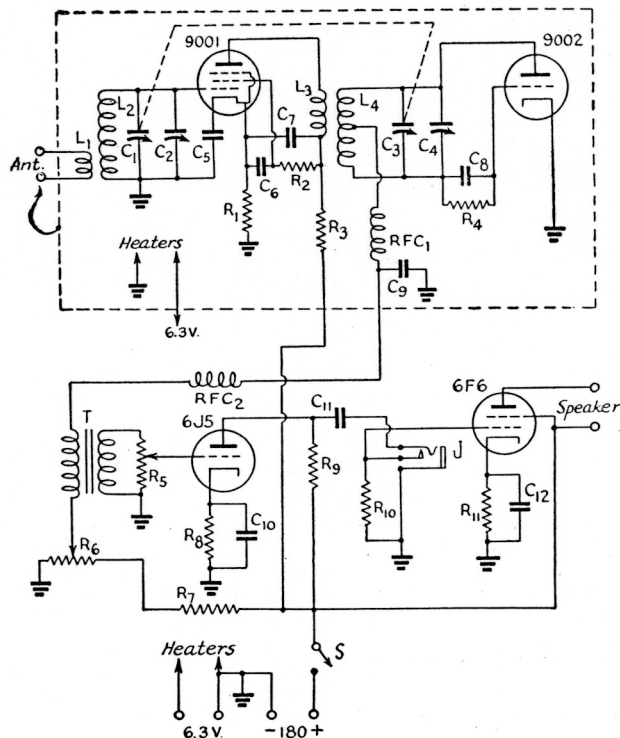


Fig. 1417 — Left — The 112-Mc. t.r.f. superregenerative receiver uses a 9001 in the r.f. stage, 9002 detector, 6J5 first audio, and 6F6 output stage. The knobs along the front are audio volume control (left) and the regeneration control. The rubber grommet on the side of the $3 \times 4 \times 5$ -inch box centers the screwdriver used for setting the detector band-set condenser; a similar one is provided on the other side for the r.f. band-set adjustment. Note the 'phone jack on the side; the speaker terminals are located at the rear. Right — A view under the chassis of the t.r.f. receiver shows the audio transformer and the arrangement of some of the other components. The three wires coming through the chassis to the right of the "B" + switch are the leads from the r.f. section of the receiver.

Fig. 1418 — Wiring diagram of the tuned r.f. superregenerative receiver for 112-Mc.

C₁, C₃ — 2-plate midget variable (National UM-15 with 4 plates removed), ganged.
 C₂, C₄ — 3-30- μ fd. mica trimmer.
 C₅, C₆, C₇ — 500- μ fd. mica.
 C₈ — 50- μ fd. mica.
 C₉ — 0.003- μ fd. mica.
 C₁₀, C₁₂ — 10- μ fd. 25-volt electrolytic.
 C₁₁ — 0.01- μ fd. 400-volt paper.
 R₁ — 200 ohms, $\frac{1}{2}$ -watt.
 R₂ — 0.25 megohm, $\frac{1}{2}$ -watt.
 R₃ — 10,000 ohms, $\frac{1}{2}$ -watt.
 R₄ — 10 megohms, $\frac{1}{2}$ -watt.
 R₅ — 0.5-megohm volume control.
 R₆ — 50,000-ohm wire-wound variable.
 R₇, R₉ — 0.1 megohm, 1-watt.
 R₈ — 2500 ohms, $\frac{1}{2}$ -watt.
 R₁₀ — 0.5 megohm, $\frac{1}{2}$ -watt.
 R₁₁ — 500 ohms, 1-watt.
 L₁ — $1\frac{1}{2}$ turns No. 28 d.s.c. interwound between turns of L₂.
 L₂ — 2 turns No. 20 e., $\frac{1}{4}$ -inch winding length. See text for trimming method.
 L₃ — $1\frac{1}{2}$ turns No. 28 d.s.c. interwound between turns of L₄.
 L₄ — $2\frac{1}{4}$ turns No. 20. e., $\frac{1}{4}$ -inch winding length. Tapped $\frac{1}{2}$ turn from plate end. See text on how to trim.
 (L₁-L₂ and L₂-L₄ on National PRE-1 forms.)
 RFC₁ — V.h.f. r.f. choke (Ohmite Z-1).
 RFC₂ — Low-frequency choke (National OSR with windings in series, "B + " and "Gnd" connected together).
 J — Closed-circuit jack.
 S — S.p.s.t. toggle switch.
 T₁ — Single plate to single grid audio transformer (Thordarson T-13A34).



No. 20 wire leads run through holes in the forms, while dope only is used to keep the fine-wire coils secure. This has the advantage that the fine-wire coils can be trimmed by "peeling off" a small fraction of a turn at a time. The larger coils are trimmed by bringing the last half-turn back through the *inside* of the coil. By moving this half-turn around, the inductance of the coil can be adjusted over a range wide enough to allow the detector and r.f. circuits to track well over the whole band. This method of inductance trimming is described elsewhere in this *Handbook* (§ 7-7).

The r.f. stage is trimmed by adjusting its trimmer condenser to the point where the regeneration control has to be set at a maximum. Either side of this point the control does not have to be advanced as far, indicating that the r.f. stage is not in resonance. When the r.f. and detector circuits are tracking properly, it will not be necessary to change the setting of the regeneration control more than 45° or so over the entire range. The bandspread can be increased by using less inductance and more trimmer capacity. With the coil specifications given, the band covers about 75 dial divisions.

A two-wire line from the antenna usually will prove best.

It should be tried with one side grounded or not, to see which gives the better coupling. In one instance where a single-wire antenna was used some instability of the r.f. amplifier was traced to the antenna wire running too close to the detector tube, and it is recommended that the antenna wire or wires be run away in such a fashion that there is no chance for coupling of this type. (Bib. 3.)

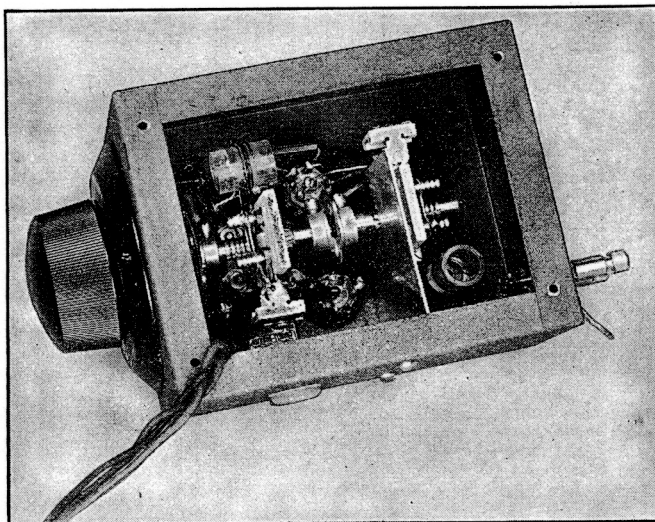


Fig. 1419 — The r.f. section of the 112-Mc. r.f. receiver removed from the chassis. The detector tuning condenser, C₃, is nearest the tuning dial and the detector socket is at the bottom of the picture. The interstage shield is fastened to the side of the box. The trimming loop for adjusting inductance can be seen on the r.f. coil, near the antenna posts at the right.

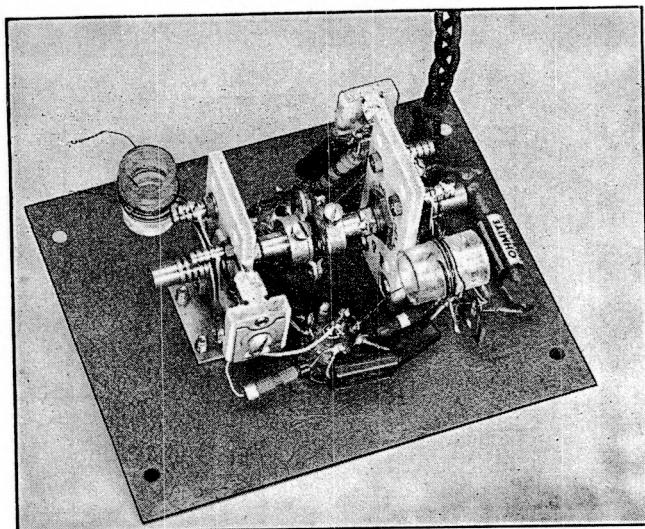


Fig. 1420 — Close-up of the r.f. assembly of the 112-Mc. t.r.f. receiver, showing arrangement of parts. The band-set condensers are mounted on the tuning condensers. The ends of the antenna coil (upper left) are soldered to the antenna posts after the assembly is mounted in the box.

◀ F.M. I.F. Amplifiers

As pointed out earlier in this chapter, an f.m. receiving system differs from an a.m. receiver in that the pass-band is wider and a limiter and discriminator are used instead of a second detector. The front end of an f.m. receiver is conventional, and any of the converters described can be used to feed an f.m. i.f. amplifier. The f.m. i.f. amplifier may be either the i.f. amplifier of an f.m. broadcast receiver (of

which there are several on the market) or it can readily be built by the amateur. If the i.f. system of the f.m. broadcast receiver is used, the i.f. frequency should be learned so that the output of the converter can be tuned to this frequency and coupled to the grid of the mixer tube of the receiver. If the converter is already built, a separate converter to work from the first converter into the f.m. intermediate frequency can be used. Such a device is shown in Fig. 1421.

Since most of the available broad-band i.f. transformers suitable for f.m. reception are built for frequencies of 5, 4.3 and 3 Mc., it is necessary to use a second conversion between the output of the converter (usually 10 Mc.) and the f.m. i.f. system, unless the converter is rebuilt to give output on the f.m. intermediate frequency. Such a converter can be made using a single 6K8 tube. The circuit and

necessary constants are given in Fig. 1421. The combination of C_1L_2 is tuned to the converter output frequency. T_1 is the input transformer of the f.m. amplifier, and L_3C_2 is tuned to the sum of the converter output frequency plus the f.m. amplifier frequency. For example, a converter giving 10-Mc. output and working into a 5-Mc. i.f. amplifier will have the oscillator circuit (L_3C_2) tuned to $10 + 5$ or 15 Mc.

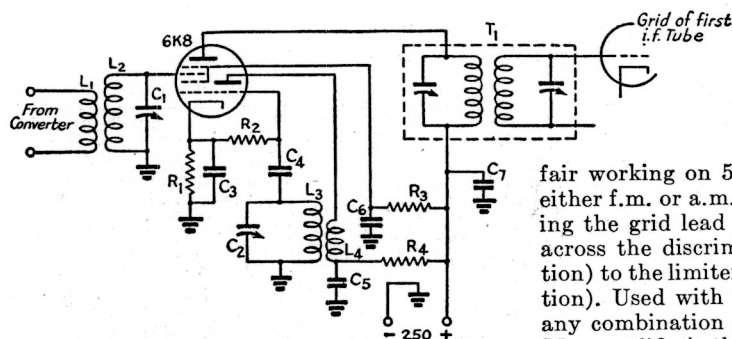


Fig. 1421 — Circuit diagram of a separate frequency converter for use with the f.m. amplifier of Fig. 1423.

- C_1, C_2 — 100- μ fd. midget variable.
- C_3, C_6, C_7 — 0.01- μ fd. 400-volt paper.
- C_4 — 50- μ fd. mica.
- C_5 — 0.002- μ fd. mica.
- R_1 — 250 ohms, $\frac{1}{2}$ -watt.
- R_2 — 50,000 ohms, $\frac{1}{2}$ -watt.
- R_3 — 25,000 ohms, 1-watt.
- R_4 — 50,000 ohms, 1-watt.
- T_1 — Input transformer of f.m. i.f. amplifier.
- L_1 — 4 turns No. 22 d.c.c., close-wound, $\frac{1}{4}$ -inch from L_2 .
- L_2 — 10 Mc.: 11 turns No. 22 d.c.c., close-wound on 1-inch diameter form.
- L_3 — 15 Mc.: 6 turns No. 22 d.c.c., close-wound on 1-inch diameter form. 13 Mc.: 6 turns No. 22 d.c.c., close-wound on 1-inch diameter form.
- L_4 — 2 turns No. 22 d.c.c., close-wound; spacing from L_3 adjusted to give 0.15 ma. d.c. through R_2 .

◀ A 5-Mc. F.M. I.F. System

The i.f. amplifier shown in Figs. 1422, 1423 and 1424 is a broad-band af-

fair working on 5 Mc. which can be used for either f.m. or a.m. reception merely by switching the grid lead of the first audio tube from across the discriminator load (for f.m. reception) to the limiter grid resistor (for a.m. reception). Used with the converters described (or any combination capable of working into a 5-Mc. amplifier), the system can be used for the reception of a.m. and f.m. signals in the 43-Mc. band, a.m. and f.m. amateur signals in the 56-Mc. band, or f.m. and a.m. signals in the 112-Mc. band. If operators of 112-Mc. stations using modulated oscillators will reduce the modulation percentage and thus bring the frequency deviation down to a reasonable range, the system will make an excellent receiver for the reception of modulated oscillators. When operated with reduced modulation even the smallest transceiver will sound many times better, and audio power will be saved, as well.

As may be seen from Fig. 1423, the two stages of high-gain amplification using type 1852 tubes are unconventional only in that re-

sistors are used across the transformer windings to widen the pass band, and no gain control is included. No means of controlling gain is required, because it is always desirable to work the stages preceding the limiter at their highest level. The limiter stage uses a 6SJ7, with provision through R_{18} to control the plate and screen voltage to set the limiting action to meet operating conditions. The use of a grid leak and condenser, R_{16} and C_7 , and low screen and plate voltages allows the tube to saturate quickly, even at low signal levels, and the tube wipes off any amplitude modulation (including noise) and passes only frequency modulation. For a.m. reception, the audio system is switched by Sw_1 to the grid leak, R_{16} , and the grid and cathode of the tube are used as a diode rectifier to feed the audio system. The jack, J , in series with the grid leak, is used for plugging in a low-range milliammeter so that the limiter current can be read. The limiter-current indication is invaluable in aligning the amplifier, and the meter can be used as a tuning meter during operation.

The discriminator circuit uses a 6H6 double diode in the conventional circuit. Audio from the discriminator (or from the limiter stage, in a.m. reception) is fed through the volume control, R_{25} , into a two-stage audio amplifier using a 6SF5 and 6F6 output pentode. The resistor, R_{11} , and condenser, C_{12} , in the input of the audio circuit, serve as a combined r.f. filter and compensating network to attenuate the higher audio frequencies. This is necessary when listening to 43-Mc. broadcast stations, since nearly all use "pre-distortion" (accented higher frequencies). A 0.01- μ fd. condenser across the output terminals will give further high frequency compensation, if necessary.

The power supply uses a two-section filter, and an outlet socket is provided so that the converter power cable can be plugged in. A VR150-30 regulator tube is used for additional stability with changes in line voltage. The regulator tube is not absolutely necessary, and, if desired, it may be omitted.

The amplifier is built on a $7 \times 9 \times 2$ -inch chassis. Reference to Figs. 1422 and 1424 will show the location of the parts on the chassis. After all holes have been drilled the sockets and the transformer should be fastened in place on the chassis, leaving off the variable resistors, switches, binding posts, jack and chokes until after most of the wiring has been done.

If low-impedance input coupling is to be used, as with a converter removed some distance from the amplifier, the first i.f. transformer must be modified. A link winding is made by first winding a short half-inch wide strip of paper over the cardboard tubing used as a form in the i.f. transformer.

Eleven turns of No. 30 d.s.c. wire are then close-wound flat over the center of the paper ring. Holding the wire in place with a finger, paint the coil with Duco cement to secure the turns in place. When the cement has dried, slip the coil off the form. The plate and "B" + wires may be removed from the trimmer condenser in the transformer, and the wires from the plate coil to the trimmer condenser disconnected. By unwinding and cutting off a turn or two of paper from the inside of the paper ring, the 11-turn coil can be slipped easily over the grid coil and fastened in position so that it covers the ground end of the grid coil. A piece of paper between the grid coil and the ground lead will avoid any possibility of this lead shorting against the turns of the coil when the paper ring is slipped in place. The two ends of the link coil are brought out the bottom of the shield can and later fastened to the input terminals of the set.

It is possible to use the transformer by merely running the plate lead to the mixer tube in the converter, but this makes it less convenient to use the converter with other i.f. amplifiers since it would require soldering and unsoldering wires each time the change was made. Furthermore, the long lead to the mixer tube would increase the chances for stray pick-up of signals in the vicinity of 5 Mc.

The screen by-pass condensers, C_1 , C_4 and C_8 , are mounted across the sockets so that they act as partial shields between the plates and grids of the single-ended tubes. Tie-points are used wherever needed for mounting the resistors and condensers. It is recommended that the 1852, 6SJ7 and 6H6 stages be wired first, so that the leads carrying r.f. can be made as short and direct as possible. The rest of the leads may

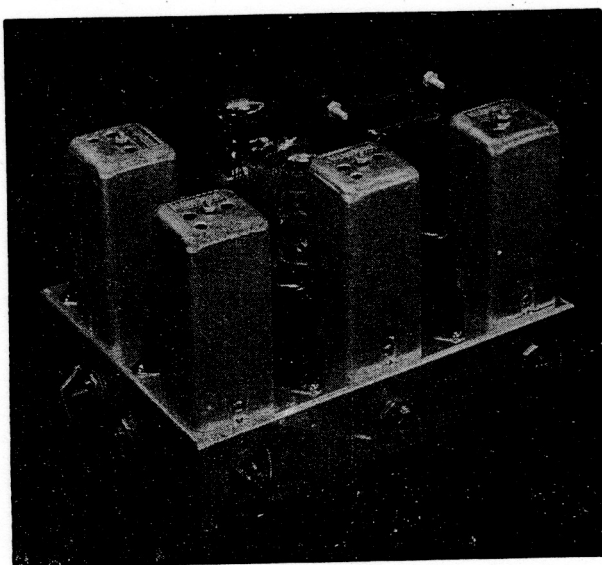


Fig. 1422 — A 5-Mc. f.m./a.m. amplifier, complete with power supply. Controls on the front, from left to right, are the audio volume control, "B" + switch, and the limiter control. The f.m./a.m. switch is on the end. The jack beside it is for the limiter-current meter.

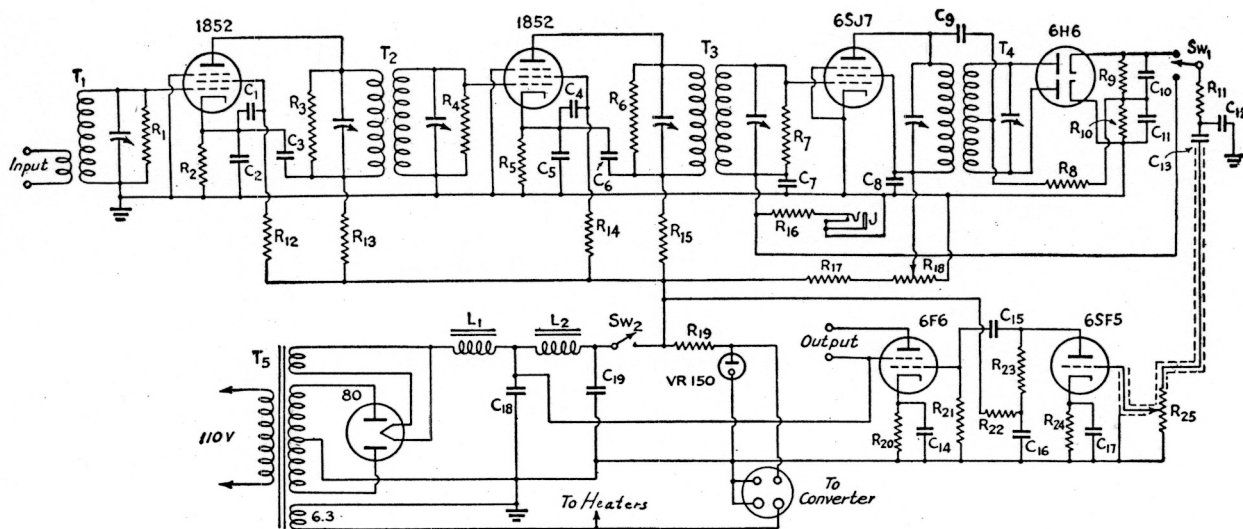


Fig. 1423—Wiring diagram of the broad-band 5-Mc. frequency-modulated/amplitude-modulated i.f. amplifier.

C₁, C₂, C₃, C₄, C₅, C₆, C₈, C₁₃, C₁₅ — 0.01- μ fd. 600-volt paper.
 C₇, C₁₀, C₁₁—100- μ fd. midget mica.
 C₉—50- μ fd. midget mica.
 C₁₂—0.001- μ fd. midget mica.
 C₁₄, C₁₇—10- μ fd. 25-volt electrolytic.
 C₁₆, C₁₈, C₁₉—16- μ fd. 450-volt electrolytic.
 R₁, R₄—55,000 ohms, $\frac{1}{2}$ -watt.
 R₂—200 ohms, $\frac{1}{2}$ -watt.
 R₃, R₆—50,000 ohms, $\frac{1}{2}$ -watt.
 R₅—300 ohms, $\frac{1}{2}$ -watt.
 R₇—40,000 ohms, $\frac{1}{2}$ -watt.
 R₈, R₁₁, R₂₂—75,000 ohms, $\frac{1}{2}$ -watt.
 R₉, R₁₀, R₁₆—150,000 ohms, $\frac{1}{2}$ -watt.
 R₁₂, R₁₄—60,000 ohms, $\frac{1}{2}$ -watt.
 R₁₃, R₁₅—100 ohms, $\frac{1}{2}$ -watt.
 R₁₇—25,000 ohms, 10-watt wire-wound.
 R₁₈—3000-ohm wire-wound potentiometer.
 R₁₉—5000 ohms, 10-watt wire-wound.
 R₂₀—500 ohms, 1-watt.
 R₂₁, R₂₃—250,000 ohms, $\frac{1}{2}$ -watt.
 R₂₄—5000 ohms, $\frac{1}{2}$ -watt.
 R₂₅—500,000-ohm volume control.
 T₁—5-Mc. f.m. i.f. input transformer, modified (see text)

(Millen 67503).
 T₂, T₃—5-Mc. f.m. interstage transformer (Millen 67503).
 T₄—5-Mc. f.m. discriminator transformer (Millen 67504).
 T₅—350-0-350-volt 90-ma. power transformer with 6.3- and 5-volt filament windings.
 L₁—9-henry 85-ma. filter choke (Thordarson T-13C29).
 L₂—10-henry 65-ma. filter choke (Thordarson T-13C28).
 Sw₁—Selector switch (Yaxley 32112-J).
 Sw₂—On-off switch, s.p.s.t. toggle.
 J—Closed-circuit jack.

be filled in wherever convenient. The wires from the audio volume control, R₂₅, are shielded by a length of flexible copper braid. Whenever convenient, spare pins on sockets are used to support resistors, condensers, etc.

The two variable resistors mounted on the front of the chassis will not clear the spade bolts projecting down from the i.f. transformers unless about $\frac{1}{8}$ inch is cut off the bolts before mounting the transformers in place. The input terminal strip (Millen 3300Z) is mounted on the outside of the chassis so that the contacts will clear the limiter control. A handy connector for plugging into this input terminal can be made from an old five-prong tube base or coil form, sawing across the base and removing the two correctly spaced pins and their supporting strip of bakelite.

With a 5-Mc. signal source, such as a signal generator, alignment of the amplifier is an easy matter. If no such source is available a simple e.c.o. can be built using an ordinary receiving pentode such as a 6K7, with the grid circuit on 2.5 Mc. and the plate on 5 Mc. Or, if a converter is available, tune the regular receiver to 5 Mc., couple in the converter and tune in a strong, steady signal. The converter output can then be transferred to the f.m./a.m. i.f. and the transformers aligned. This is done by plugging in a 0-1 ma. meter into the jack, J,

and tuning the trimmers of the transformers for maximum current. It may be necessary to hunt around a bit before the meter shows any indication, but once it starts to read the rest is easy. With a variable-frequency signal source the signal is swung back and forth until some indication is obtained, and then the amplifier alignment is completed. The exact frequency of alignment is unimportant provided every stage can be tuned *through* resonance, which means that each trimmer can be adjusted through a maximum reading of the tuning meter. With the resistors across the circuits, it will be found that the transformers tune somewhat broader than normal; the correct setting is in the mid-point of the broad region. Once the i.f. transformers, T₁, T₂ and T₃, are aligned, it should be possible to switch Sw₁ to a.m. reception and hear signals, or at least noise, provided the converter is on 56 or 43 Mc. There isn't much noise to be heard on 112 Mc.

The alignment procedure can be carried out with a loudspeaker connected to the 6F6 through an output transformer. If no speaker is used at this point, however, the output terminals should be shorted; otherwise, the 6F6 may be injured. The use of a meter for alignment is a practical necessity, and no attempt should be made to line up the amplifier by ear except possibly for only a very rough initial alignment.

If there is an f.m. broadcast station within range, adjustment of the discriminator transformer, T_4 , is a simple matter. Switch the amplifier to a.m., plug in the proper coils in the converter, and tune in the f.m. station. Then switch the amplifier to f.m. and tune the trimmers on T_4 until the signal is heard again. This is best done with the audio gain almost open and the limiter control at about half-scale. The trimmers are best adjusted with an insulated tool, to reduce body capacity effects, and they should be adjusted until the b.c. signal is clearest and loudest. It will be found that the trimmers in the plate circuit will affect the volume mostly, while the trimmer in the grid circuit will have the greatest effect on the quality. During this period of adjustment the receiver should be kept tuned to the signal, as indicated by maximum limiter current. An audio output meter, if available, may be used to determine maximum audio output, but this is not an essential.

In the event there is no local f.m. broadcast station the only alternative is to line up the discriminator on an f.m. signal from an amateur station, or, as a last resort, from a 112-Mc. modulated oscillator. The disadvantage with the self-excited v.h.f. oscillator is that usually it is modulated too heavily and doesn't stay on one frequency long enough to allow the amplifier to be aligned accurately.

The final adjustment of the discriminator tuning can be checked by tuning in an a.m. signal. If the discriminator is properly tuned, the audio output (signal and noise) should practically disappear at the point where the signal, as indicated by limiter current, is a maximum. This is an indication that the discriminator characteristic crosses the axis at the mid-resonance point of the amplifier. Tuning the signal (by tuning the converter), it should be possible to understand the audio output at points either side of this minimum-volume setting. These points should appear symmetrically on either side of the minimum-volume point and should have about the same volume. Slight readjustment of the discriminator-transformer setting will accomplish this result.

When using the amplifier it will be noted that a.m. signals appear to be louder than those from f.m. stations, comparing audio volume-control settings on stations showing equal limiter current. This does not indicate that the amplifier is not working properly or that more audio is obtained from an a.m. signal than from an f.m. signal of similar strength. It is, however, an indication that the discriminator characteristic could have more slope to it and not have its peaks so far apart. With improved discriminator-transformer construction, this apparent shortcoming will disappear.

The performance of the amplifier on a.m. reception could be improved somewhat by the inclusion of a.v.c. on the two 1852 tubes, taking the a.v.c. voltage from the limiter grid leak through the usual filter circuit. However, this was considered an unnecessary refinement because the amplifier was intended to be used primarily on f.m. reception and the provision for a.m. reception was considered of secondary importance. The amplifier should be run "wide open" on f.m. reception. (*Bib. 4.*)

◀ A Compact 112-Mc. Receiver for Mobile Work

The receiver shown in Figs. 1425, 1426 and 1428 is designed especially for mobile installations and particularly as a companion unit to the transmitter of Fig. 1541. The receiver is built in a $3 \times 4 \times 5$ -inch box (the same size as the control box) which can be mounted on top of the control box or alongside it, depending on the available room in the car. As may be seen from the wiring diagram (Fig. 1426), a 6V6 audio output tube is used. This stage will furnish more than enough output to operate a 5- or 6-inch speaker. Power for the receiver can be obtained from the same power supply as is used for the transmitter, and the on-off switching of the receiver may be tied in with the transmitter control to facilitate changing over. Alternatively, any other power supply delivering over 200 volts may be employed.

A 9002 superregenerative detector is used, followed by a 6J5 and 6V6 audio amplifier. The antenna is inductively coupled to the de-

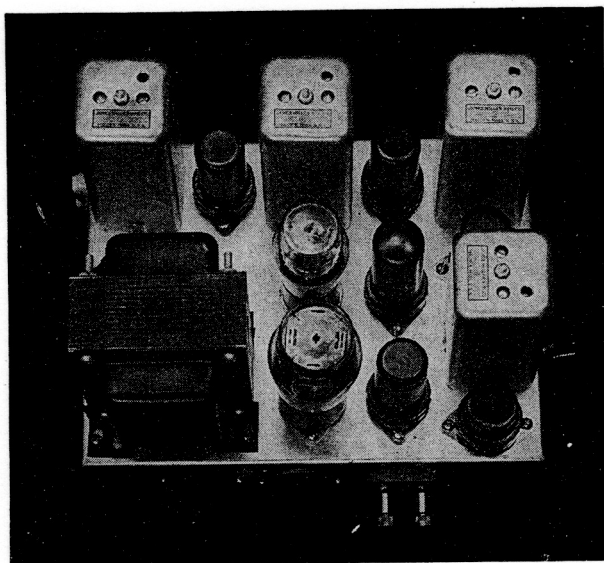


Fig. 1424 — A top view of the f.m./a.m. amplifier. Along the rear, from left to right, are the input transformer, first 1852 tube, interstage transformer, second 1852 tube, and second interstage transformer. In the second row of tubes, from right to left, are the 6SJ7 limiter, 6F6 audio output and VR150-30 voltage regulator. At the right front is the discriminator transformer, with the 6H6 detector below it. To the left of the 6H6 is the 6SF5 first audio. Output terminals, power socket, and 115-volt line cord are on the lower edge.

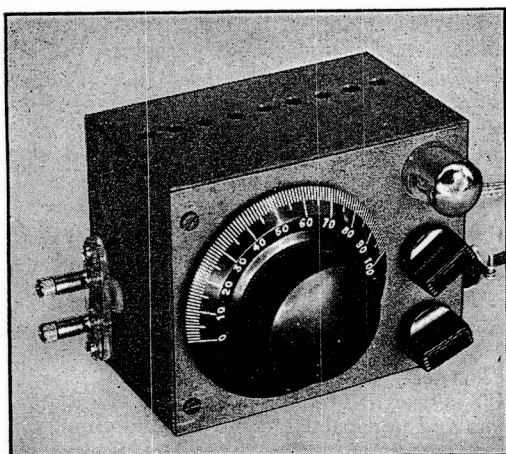


Fig. 1425 — The mobile 112-Mc. receiver is built in a $3 \times 4 \times 5$ -inch metal box. Antenna terminals and the hole used for adjustment of the antenna coupling may be seen on the left side. A pilot light at the top right-hand corner permits easy reading of the dial in night operation. The speaker cable runs out through the rear of the cabinet. Ventilating holes are drilled in the top.

tector, the antenna coupling being adjusted at the time of installation of the receiver. A band-set condenser, C_2 , across the variable tuning condenser, C_1 , allows the band to be centered on the tuning scale and provides adequate bandspread. Regeneration is controlled by the variable resistor, R_8 .

The construction of the receiver is not difficult, but close attention must be paid to the placement of parts in order that all of the components will fit into the box. The first step in laying out the receiver is to drill the holes for the dial. The tuning condenser shaft is centered between the top and bottom of the panel and is located $1\frac{3}{4}$ inches in from the left-hand edge. Mounting holes for the tuning condenser are drilled using the Isolantite end-plate for a template, and the condenser is supported on $1\frac{3}{8}$ -inch spacers. The condenser is coupled to

the dial through a flexible bakelite coupler and a short length of polystyrene rod, insuring adequate insulation between the condenser and the panel. Holes for the variable resistors and the pilot-light socket are drilled at the right-hand edge of the panel, $\frac{3}{4}$ -inch in from the edge. The cabinet must be notched with a file to allow the resistors and socket to clear when the unit is assembled.

A small bracket of $\frac{1}{16}$ -inch metal which supports the 9002 socket is attached to the tuning condenser. A good idea of the shape of this bracket may be obtained from Fig. 1428. The tuned-circuit coil, L_1 , is mounted between the stator terminal of C_1 and the terminal for pin No. 1 on the tube socket. C_2 is soldered across the terminals of C_1 . A hole must be drilled in the bottom of the box, just below the adjustment screw for C_2 , so that any necessary changes in the band-set adjustment can be made after the receiver is completely assembled.

The two audio tubes and the audio transformer are mounted in the metal box itself, as may be seen in Fig. 1428. The tube sockets are supported off the side of the box by small brass spacers, so that the socket pins will not short on the metal of the box. It is convenient to make the connections to these sockets before they are mounted in place. The d.c. power-supply leads are brought to a two-prong female socket, located directly in front of the 6J5 socket. All connections at ground potential are made directly to the panel or case, so that when the unit is assembled the necessary connections will be made automatically.

Three rows of $\frac{1}{4}$ -inch diameter holes, one along the top of the case and two along the rear panel, should be drilled in the box before actual construction is begun. These holes provide internal ventilation for the unit and prevent excessive heat from causing possible failure of the paper condensers.

The receiver may be connected to the power supply and antenna to be used for testing be-

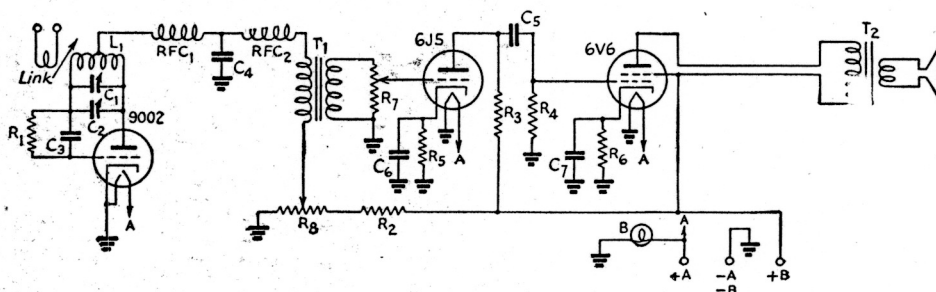


Fig. 1426 — Wiring diagram of the compact 112-Mc. superregenerative receiver for mobile operation.

C_1 — 15- μ fd. variable with four plates removed (National UM-15).

C_2 — 3-30- μ fd. mica trimmer.

C_3 — 50- μ fd. mica.

C_4 — 0.003- μ fd. mica.

C_5 — 0.01- μ fd. mica.

C_6, C_7 — 10- μ fd. 25-volt electrolytic.

R_1 — 10 megohms, $\frac{1}{2}$ -watt.

R_2, R_3 — 0.01 megohm, $\frac{1}{2}$ -watt.

R_4 — 0.25 megohm, $\frac{1}{2}$ -watt.

R_5 — 2500 ohms, $\frac{1}{2}$ -watt.

R_6 — 500 ohms, 1-watt.

R_7 — 0.5-megohm volume control.

R_8 — 50,000-ohm variable.

L_1 — 3 turns No. 12, $\frac{1}{2}$ -inch diameter, spaced diameter of wire.

Link — 1 turn No. 12, M-inch diameter.

RFC1 — V.h.f. choke (Ohmite Z-1).

RFC2 — R.f. choke (Meissner 19-1995).

T_1 — Plate-to-grid coupling transformer (Inca G-52).

T_2 — Speaker output transformer, 10,000 to 4 ohms (Jensen Z2362).

Speaker — 5-inch p.m. dynamic (Jensen ST-443).

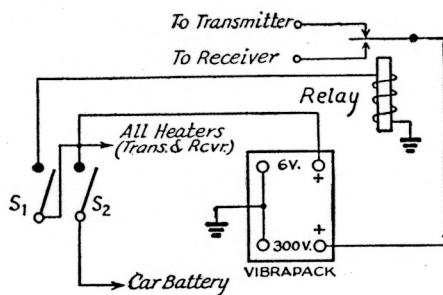


Fig. 1427 — Wiring diagram of the control circuit for the mobile station. S_1 and S_2 are mounted in the control box, along with the microphone jack and battery (see Fig. 1535). The vibrator supply and relay are mounted in the trunk compartment along with the transmitter.

S_1 — S.p.s.t. toggle switch.

S_2 — S.p.s.t. heavy-duty toggle switch.

Relay — 6-volt s.p.d.t. relay.

fore it is installed in the car. Testing in this manner allows accurate setting of the band and preliminary adjustment of the antenna coupling. The antenna coupling is finally adjusted so that the receiver will superregenerate well over the whole range of the dial without any dead spots, but too-loose coupling is to be avoided because it will reduce the sensitivity of the receiver. The adjustment that requires that the regeneration control be set towards the maximum end of its range before the set will superregenerate is the correct one.

The control unit shown in Fig. 1427 allows the operator to use only one switch to turn the receiver on and the transmitter off, and vice versa. When putting the station into operation, S_1 should be closed first and then S_2 . Closing S_2 will apply voltage to the heaters of both transmitter and receiver tubes, turn on the vibrator supply, and close the relay. This last action places the plate voltage on the receiver. When switching over to "transmit," S_1 is opened, releasing the relay and placing the vibrator output on the transmitter. During a QSO, it is necessary only to throw S_1 when changing from "receive" to "transmit" and back again. Separate antennas are recommended — one located at the usual front position of the car for the receiver, and one at the rear of the car for the transmitter. The receiving antenna may be a $\frac{1}{4}$ -wavelength or $\frac{1}{2}$ -wavelength vertical rod fed by a concentric line. If a $\frac{1}{2}$ -wavelength receiving antenna is used, it is advisable either to make the length of the concentric line an odd multiple of a quarter wavelength or to adjust the antenna length for optimum coupling to the receiver.

If concentric-line feed from the antenna is used it is recommended that the type of concentric line which has insulation over the outer conductor be employed, with the outer conductor grounded at both the antenna end and the receiver end. If there is no insulating covering over the outer conductor the vibration of

the car may cause occasional grounds at points along the external conductor, changing the loading and consequently the tuning of the receiving during operation.

In general, noise reduction procedure is the same as that followed for automobile receivers used on the broadcast band. Anything which contributes to quieter broadcast reception will be of help in connection with 112-Mc. operation. However, since every car is essentially an individual problem, no specific instructions can be offered.

If the car does not have a light located conveniently on the dashboard the cap may be removed from the pilot light, giving enough light by which to see the log book and note pad.

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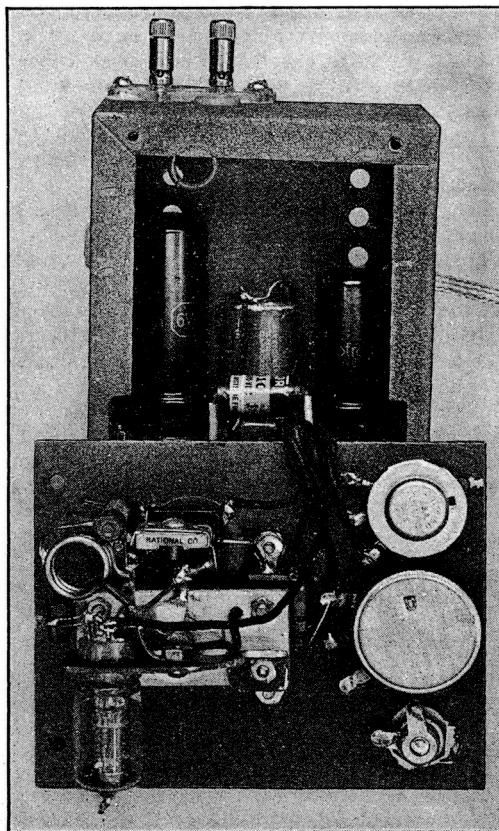


Fig. 1428 — An interior view of the mobile receiver, exposing the detector assembly on the side panel and showing the audio tubes mounted inside the box. The antenna link is connected to the antenna terminals and fits into its proper position when the unit is assembled.