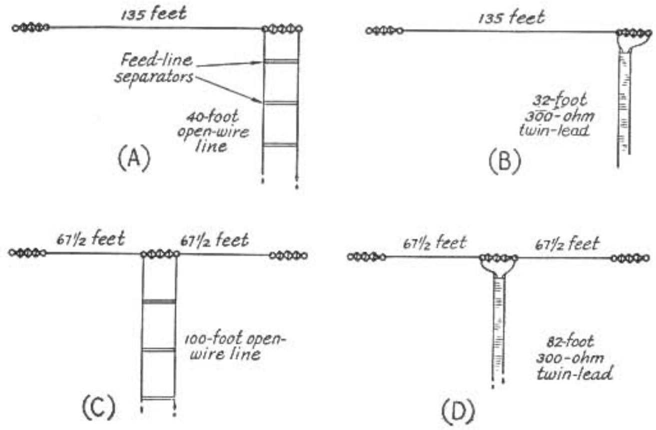

Fig. 19 — These are suggested antennas for use with the simple transmitter. The wire used should be about No. 14 enameled copper. An "open wire" feed line is one in which the two wires of the line are separated by insulated spacers 4 or 6 inches long. In (a) and (b) one side of the feed line connects to the antenna proper, while the other side terminates in no connection at all. This is known as a "Zepp" antenna. In (c) and (d) the antenna is cut in the center and held together by another antenna insulator; the feed lines connect to each side. The Twin-Lead feed line shown in (b) and (d) is very convenient. Rope halyards can be used to support the antenna between a couple of houses or trees. In general, the higher the antenna above the ground, the better it will radiate.

the construction of a good antenna system really pays off in increased station efficiency. Fig. 19 shows some simple antenna systems which will enable you to get on the air. Connect a flashlight bulb between the end of one antenna "feeder" wire and its clip on the transmitter. This routes the antenna current through the bulb so you can make adjustments of tuning, spacing between L_2 and L_3, and the number of turns on L_3, to get the brightest light. If you get no indication of current, you may have to put a 100-$\mu\mu$fd. variable condenser in parallel with (across) the antenna terminal clips — or in series (between one feed line and its clip) — to hit resonance.

If room for only a short length of wire is available for the antenna, say 40 or 50 feet, it is best to connect its end to one antenna post and a good ground to the other. Here again some experimentation will be necessary to determine the optimum size of L_3.

Going back for a moment to this business of testing your transmitter, *don't connect it to an antenna unless you have your amateur license.* There are severe penalties for putting a signal on the air without a license. If you build a transmitter before your license comes through, use that 10-watt lamp as a load for your transmitter. A lamp connected across the antenna coil in that fashion is known as a "dummy antenna," and should always be used when you wish to test a transmitter without causing interference to other stations.

More Advanced Equipment for the Beginner

The limitations of the regenerative receiver and the one-tube transmitter have been discussed earlier. It has been said that it will probably not be long before you will be looking toward equipment with better performance and operating conveniences. One of the things that makes amateur radio the intriguing hobby that it is, is that there are always new horizons to look to — in equipment as well as in operating.

While a simple regenerative receiver will permit you to get on the air at a minimum of cost and time devoted to construction, most of today's amateurs use receivers of the superheterodyne type. The performances of the two types can

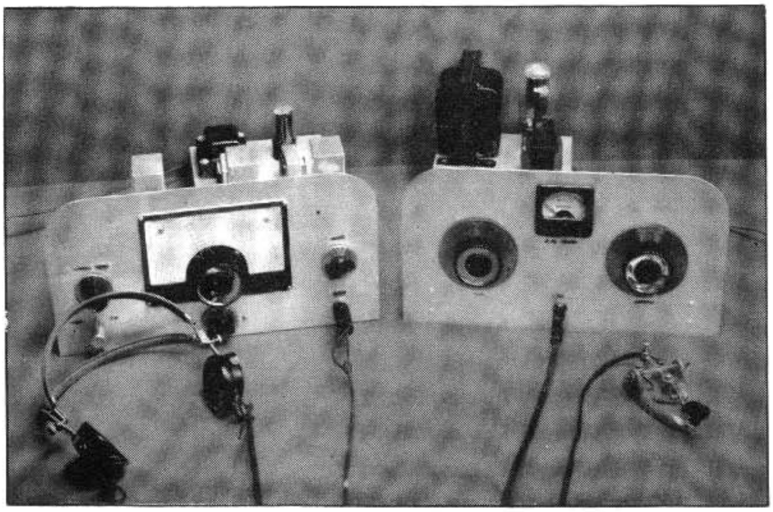

Fig. 20 — This equipment will cost a little more and take somewhat longer to build, but its performance will be greatly superior to that of the units previously described. A four-tube superhet receiver is to the left and an oscillator-amplifier transmitter to the right. Each has its own attached power supply at the rear.

hardly be compared. Signal strength, stability (steadiness of frequency) and selectivity (ability to separate signals near the same frequency) will be much superior with the superhet, and the critical adjustments associated with the regenerative receiver are eliminated.

In the same way, while results satisfactory for low-power work are readily obtained with a single-tube transmitter, it is possible to secure greater output and to strike a better balance between simplicity and cost in proportion to power by the addition of a simple amplifier.

A Four-Tube Superhet Receiver

Perhaps the word "superheterodyne" sounds ominous and seems to imply great complexity. This impression should be dispelled at once. Actually, a simple superhet is no more than a grouping of several circuits, each one of which is no more difficult to understand than the regenerative-receiver circuit, while the adjustment for satisfactory operation usually is much easier. Almost anyone capable of mastering the regenerative receiver should have little difficulty with the superhet shown in Figs. 21, 23 and 24. The cost will be greater — approximately $45.00 exclusive of power supply and headphones if all components are purchased new — and it will take a little longer to build. But it should take less time and experience to adjust.

The Superhet Circuit

The circuit is shown in Fig. 22. Note how the different sections are labelled, and digest them one at a time. The converter section — from L_2 to T_1 — is the important part. It serves to *convert* the frequency of the incoming signal to another frequency before it is amplified. The signal from the antenna is fed through the wave trap (which will be explained later) to the antenna coupling coil, L_2. L_2 serves to transfer the signal to the input circuit of the converter. The input circuit consists of L_3 and C_2. It is tuned to the frequency of the incoming signal by C_2. The signal is applied to the control grid (Pin 8) of the 6SB7Y.

C_3, C_4, L_4 and L_5 are the essentials of a high-frequency oscillator circuit. The screen of the 6SB7Y serves as the "plate" in this oscillator circuit. Although arranged somewhat differently, its resemblance to the regenerative-detector circuit may be recognized. The difference here is that the circuit oscillates strongly all of the time without the necessity for critical adjustment. The oscillator signal combines with the antenna signal in the 6SB7Y to produce in the plate circuit a signal whose characteristics are the same as those of the original signal except that the frequency has been changed. This new frequency is called the *intermediate* frequency (i.f.). The signal is now fed to an amplifier tuned to the new frequency. T_1 and T_2 are tuned permanently to the i.f. Since all incoming signals will be converted to this same i.f., there is no need to retune the i.f. amplifier after it has been set initially. The gain or amplification in the i.f. amplifier (and thereby the signal volume) may be varied by R_5.

Now we have a signal at the output of T_2 that looks exactly like the signal coming from the antenna except that it is at a different frequency. So it must now be passed to a detector. Since the signal has been amplified by other means, regeneration is not needed. The signal is detected by the simple diode-rectifier section of the 6SQ7. The rectified signal appears across the resistor R_9. A modulated signal is now at audio frequency, and it could be heard if the headphones were con-

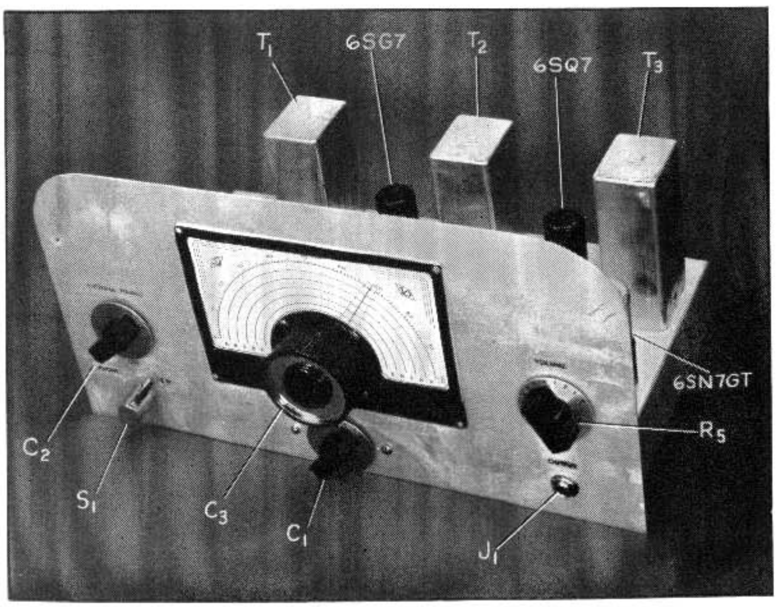

Fig. 21 — A four-tube superhet receiver covering the 3.5-, 7- and 14-Mc. bands as well as spots in the commercial point-to-point and short-wave broadcast bands with only two pairs of coils.

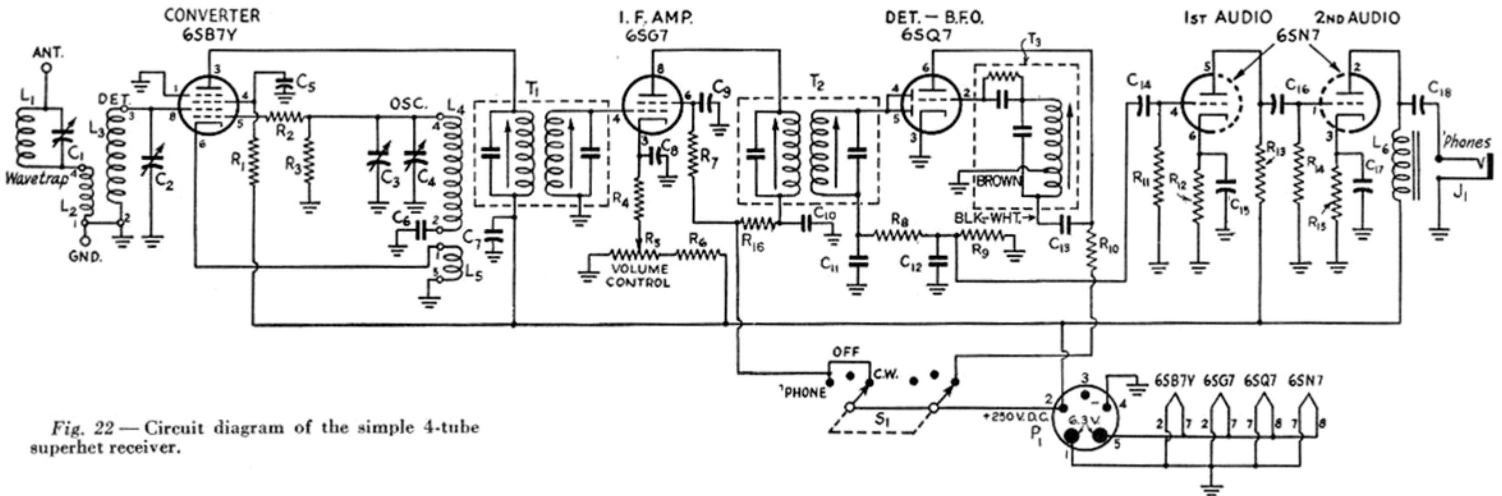

Fig. 22 — Circuit diagram of the simple 4-tube superhet receiver.

C_1 — Wave-trap tuning condenser — 335-μμfd. variable (National STH-335 or Bud MC-1860).
C_2 — Input-circuit tuning condenser — Same as C_1.
C_3 — Oscillator bandspread tuning condenser — 50-μμfd. variable (National ST-50 or Bud MC-1853).
C_4 — Oscillator padder or band-set condenser — 150-μμfd. mica compression-type trimmer condenser (El-Menco 463).
C_5 — Converter screen by-pass condenser — 0.1-μfd 150-volt paper.
C_6 — Oscillator grid blocking condenser (prevents short-circuit of R_3 through L_4) — 0.001-μfd. disk ceramic (Sprague 29C4).
C_7 — Converter plate by-pass — 0.1-μfd. 600-volt paper.
C_8 — I.f. cathode by-pass — 0.1-μfd. 150-volt paper.
C_9 — I.f. screen by-pass — 0.1-μfd. 150-volt paper.
C_{10} — I.f. plate by-pass — 0.01-μfd. disk ceramic (Sprague 36C1).
C_{11}, C_{12} — I.f. filter condensers — 100-μμfd. mica.
C_{13} — B.f.o. plate blocking condenser (prevents shorting of d.c. through T_3) — same as C_6.
C_{14}, C_{16} — Audio coupling condensers — 0.01-μfd. paper.
C_{15}, C_{17} — Audio cathode by-pass condensers — 10-μfd. 25-volt electrolytic.
C_{18} — Headphone coupling condenser — 0.1-μfd. 600-volt paper.
R_1 — Converter screen voltage-dropping resistor — 12,000 ohms, 2 watts.
R_2 — V.h.f. parasitic-suppressor — 47 ohms, ½ watt.
R_3 — Oscillator grid leak — 22,000 ohms, ½ watt.
R_4 — I.f. cathode biasing resistor — 220 ohms, ½ watt.
R_5 — I.f. gain control (varies bias) — 5000-ohm volume control.
R_6 — I.f. gain-control voltage-dropping resistor — 82,000 ohms, 1 watt.
R_7 — I.f. screen voltage-dropping resistor — 47,000 ohms, 1 watt.
R_8 — I.f. filter resistor — 47,000 ohms, ½ watt.
R_9 — Detector load resistor — 0.33 megohm, ½ watt.
R_{10} — B.f.o. parallel-feed resistor — 47,000 ohms, 1 watt.
R_{11}, R_{14} — Audio grid resistors — 0.22 megohm, ½ watt.
R_{12}, R_{15} — Audio cathode biasing resistors — 1500 ohms, 1 watt.
R_{13} — Audio plate resistor — 47,000 ohms, 1 watt.
R_{16} — 4700 ohms, ½ watt.
L_1 — Wave-trap inductance — 24 turns No. 20 wire, 1 inch diam., 1½ inches long (B & W 3015 Miniductor).
3.5- and 7-Mc. coils:
L_2 — Antenna coupling coil — 6¼ turns No. 22 d.s.c. wire, 1 inch diam., turns close-wound (see text).
L_3 — Converter input coil — 14¼ turns No. 22 d.s.c. wire, 1 inch diam., close-wound (see text).
L_4 — Oscillator tuning inductance — 16½ turns No. 22 d.s.c. wire, 1 inch diam., close-wound (see text).
L_5 — Oscillator feed-back coil — 3¼ turns No. 22 d.s.c. wire, 1 inch diam., close-wound (see text).
14-Mc. coils:
L_2 — 3¼ turns No. 22 d.s.c. wire, 1 inch diameter, close-wound (see text).
L_3 — 8¼ turns No. 22 d.s.c. wire, 1 inch diameter, close-wound (see text).
L_4 — 3½ turns No. 22 d.s.c. wire, 1 inch diameter, turns spaced to occupy length of 7/16 inch. 320-μμfd. silvered mica condenser connected across this winding (see text).
L_5 — 2¼ turns No. 22 d.s.c. wire, 1 inch diameter, close-wound (see text).
L_6 — Audio parallel-feed choke — 20-h. 15-ma. filter choke (Stancor C-1515).
J_1 — Open-circuit headphone jack.
S_1 — 'Phone-c.w. switch — Double-pole, triple-throw rotary switch (Mallory 3123J).
T_1, T_2 — 1500-1600-kc. i.f. transformers (Millen 64161).
T_3 — 1500-1600-kc. b.f.o. unit (Millen 65163).

nected across this resistor. However, the signal will be much louder if it is amplified in an audio-frequency amplifier. Therefore, the signal across R_9 is fed to the grid of the first section of a dual-triode audio-amplifier tube. The signal output from the first section is fed to the grid of the second section. The headphones are connected in the output circuit of this second amplifier. The choke, L_6, makes it unnecessary to pass the d.c. plate current of the 6SN7 through the headphones (parallel plate feed).

Now we remember that in order to hear c.w. (unmodulated) signals in the regenerative receiver we had to make the *detector* oscillate. A diode detector cannot be made to oscillate. So, instead, we provide a separate oscillator called the *beat-frequency* oscillator (b.f.o.). The b.f.o. operates at the i.f. The triode section of the 6SQ7 and T_3 are used for this purpose. The b.f.o. is turned off by the switch S_1 when the switch is in the 'phone position where the b.f.o. is not needed. The switch also silences the receiver when it is turned to the mid position. This is desirable while the transmitter is being operated.

Converter Tuning System

Returning to the converter circuit, when the oscillator is tuned to some chosen frequency, the superhet can be made to respond to any antenna signal whose frequency *differs* from the oscillator frequency by the frequency to which the i.f. amplifier has been tuned. This means that there are two signal frequencies to which the receiver will respond for each setting of the oscillator frequency — the oscillator frequency *plus* the i.f., and the oscillator frequency *minus* the i.f. Thus if the *oscillator* is tuned to 5000 kc. and the i.f. amplifier is set at 1500 kc., the *system* will respond to signals at 5000 plus 1500 = 6500 kc. and at 5000 minus 1500 = 3500 kc. Either of these two signals may be selected by tuning the input circuit, L_3C_2 to one or the other. If the input circuit is tuned to 3500 kc., the signal at 6500 is called the *i.f. image* signal. If the input circuit is tuned to 6500 kc., the 3500-kc. signal then becomes the image. In other words, the *unwanted* signal is always called the image. The degree to which the input circuit can discriminate against the image signal is known as the receiver's *image rejection.*

In more-advanced superhet design, the tuning condensers of the input circuit and the oscillator circuit are ganged together so that the input circuit always will be tuned to the desired side of the oscillator frequency. However, in this instance, the tuning controls are independent so that advantage may be taken of the dual-response characteristic. The oscillator is designed to cover, by adjustment of C_3, the range of 5000 to 5800 kc. and the i.f. is set permanently at 1500 kc. Therefore, when we *subtract* 1500 kc. from the oscillator range, we get the signal range of 3500 to 4300 kc. and when we *add* 1500 kc. to the oscillator range, we get the signal range of 6500 to 7300 kc. The *input* circuit is designed to tune over both of these ranges. It will be seen that the amateur 80-meter band lies in the first range, while the 40-meter band is included in the second range. It is necessary merely to shift the setting of C_2 to select either range.

Since the selectivity of the single tuned circuit L_3C_2 may not be sufficient to exclude a strong image, the additional tuned circuit L_1C_1 in the wave trap is made available. Connected in series with the antenna as shown, this circuit will tend to *reject* any signal to which it is tuned. Thus, if we are listening to a signal in one of the two ranges and we get interference (as we may) from a strong signal in another range, adjustment of C_1 to the frequency of the interfering signal will help greatly to eliminate it.

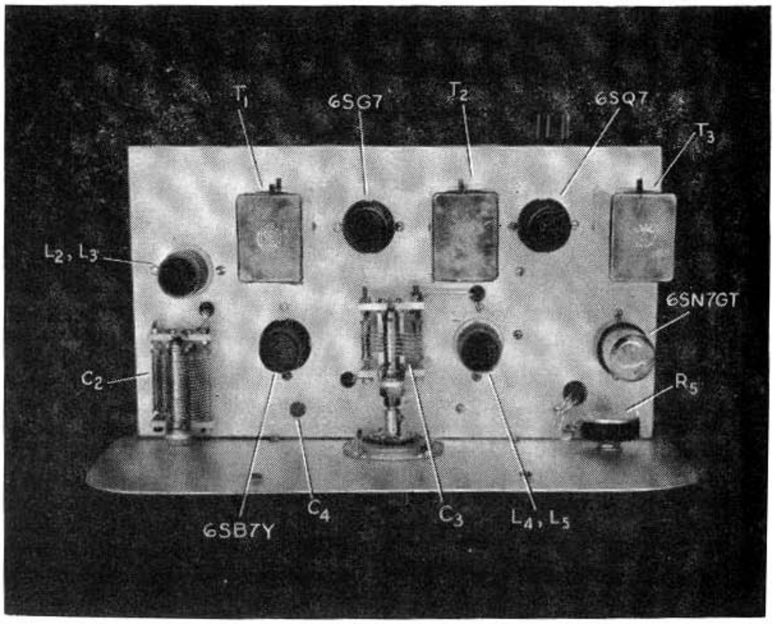

Fig. 23 — Rear top view of the superhet receiver showing the placement of parts on top of the chassis.

Additional Tuning Ranges

The output of the usual type of oscillator — whether in a receiver or transmitter — is seldom confined exclusively to the fundamental frequency to which its circuit is tuned. It always produces output to a greater or less degree at exact multiples of the fundamental frequency. These multiples are called *harmonics*. The output at twice the fundamental frequency is called the second harmonic; output at three times the fundamental frequency is called the third harmonic, and so forth. The power output usually falls off quite rapidly as the number of the harmonic increases. However, the output of the oscillator at the second harmonic in this receiver is great enough so that use may be made of it in obtaining two additional listening ranges from the same set of coils.

The oscillator's fundamental range we know is 5000 to 5800 kc. The second-harmonic range therefore will be twice this, or 10,000 to 11,600 kc. Now when we add the 1500-kc. i.f. we get a signal range of 11,500 to 13,100 kc. When we subtract the i.f. we get the range of 8500 to 10,100 kc. These ranges are also included within the coverage of L_3C_2.

Construction

In building this receiver and the two-tube transmitter which follows, a few tools in addition to the usual hand tools, such as screwdriver, pliers, etc., should be borrowed or purchased. Socket holes are most easily cut with a socket-hole punch (such as Greenlee or Pioneer). Large holes also may be cut readily in aluminum with an adjustable circle cutter in an ordinary carpenter's brace. Small holes can be drilled with a hand drill of the "egg-beater" type and reamed out to larger size with a large drill held in the brace. Small drills can also be used in the brace, if a hand drill is not available. Always mark the hole centers with a prick punch before attempting to use the drill.

Don't start to build this receiver with the idea that you are going to complete the job over a weekend. Take your time and do a careful job. By this we don't mean that the mechanical workmanship must be perfect. Simply make sure that the parts are mounted securely and that the wiring doesn't end up in a rat's nest. It will pay you in results and freedom from trouble in getting the receiver into operation.

The unit is assembled on a standard chassis 7 by 13 by 2 inches. Aluminum is much easier to work with than steel — particularly with simple tools — and the cost is about the same. The panel is cut from a sheet of 1/16-inch aluminum 7½ inches high and 14 inches long. If it is desired to put the receiver in a cabinet, the panel furnished with the cabinet may be substituted.

In laying out the chassis, the first thing to do is to spot the centers for the components on top of the chassis using Fig. 23 as a guide. The exact placement is not at all critical. To provide for a good-looking arrangement of controls on the panel, the oscillator tuning condenser, C_3, should come at the center and the input tuning condenser, C_2, should be placed at the left-hand end of the chassis where its shaft will balance the shaft of the volume control on the right. C_3 will have to be elevated about ¼ inch on metal spacers so

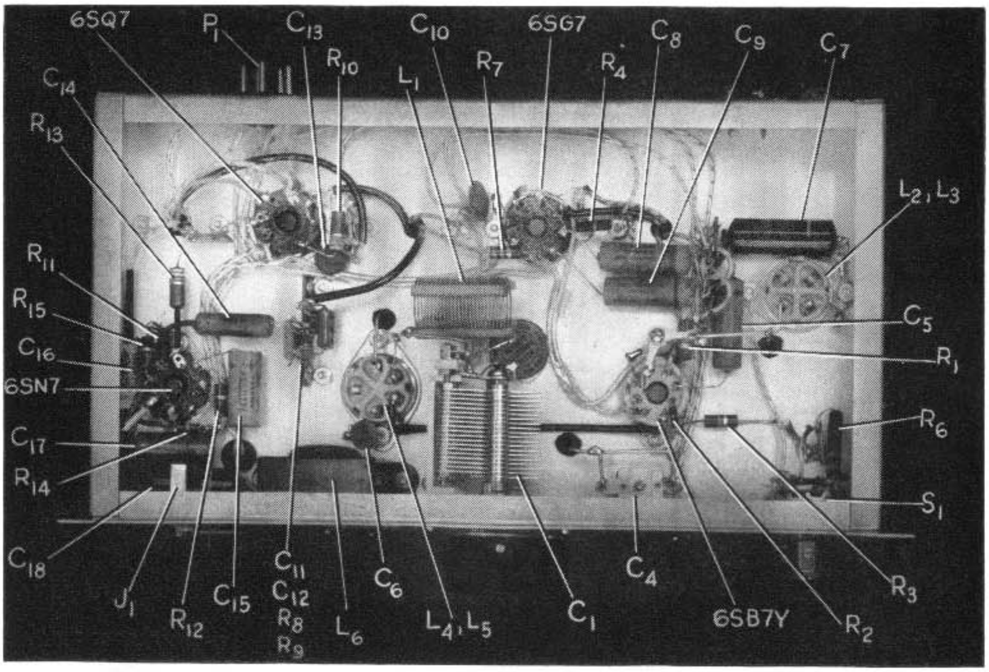

Fig. 24 — Bottom view of the simple superhet receiver. Components in the circuit diagram are identified by the arrows

that the mechanism of the National SCN dial can clear the chassis. C_2 is fastened directly to the chassis without spacers. The socket (4-pin) for the input coil (L_2L_3) should be near C_2 and the socket (5-pin) for the oscillator coil (L_4L_5) should be fairly close to C_3. The 6SB7Y socket (octal) should be about midway between the two variable condensers. The i.f. transformers and the i.f. and detector-b.f.o. tubes are lined up along the back, with the adjusting screws of the transformers toward the rear. The 6SN7 is placed in front of the b.f.o. can (T_3) in line with the oscillator coil socket and the 6SB7Y.

A 1⅛-inch punch is required for the Amphenol MIP bakelite octal sockets for the 6SG7, 6SQ7 and 6SN7, while a 1¼-inch punch is needed for the Millen ceramic sockets for the 6SB7Y and the two coil forms. The 1¼-inch punch is used also for the power plug at the rear. A similar hole should be punched in the middle of the front edge of the chassis with its center ⅞ inch above the bottom edge. You will also need a hole for adjusting the trimmer C_4 located near the 6SB7Y, and clearance holes for connections to the stator terminals of C_2, C_3, and the volume control, as well as a hole under the center of each of the i.f. cans for the transformer leads. A cut-out is required in the rear edge near the left-hand end for the antenna terminal strip, unless you decide to use a pair of small feed-through insulators as terminals. Shaft holes must be cut in the front edge for the switch and headphone jack. They should be placed at either end to balance.

C_1 is mounted under the chassis, insulated by fastening it to the center of a piece of ⅛-inch polystyrene sheet (Millen No. 55001) 3 inches long and 1¾ inches high. The insulating strip is then fastened with 6–32 screws against the inside front edge of the chassis so that the shaft of C_1 will be central in the large punched hole. C_1 is mounted with its ceramic stator bars running vertically to provide access to the mounting screws for C_3. The choke, L_6, is fastened under the chassis, next to C_1.

Before the switch, the jack and C_1 are mounted, the panel should be placed against the front edge of the chassis with the bottom edges even and the panel centered. Then the mounting holes should be transferred to the panel by marking with a scriber from the rear. The centers for the shaft holes for C_2, C_3 and the volume control should then be measured out and marked. A 1½-inch hole is needed for the mechanism of the main tuning dial.

Wiring

Time will be saved if a soldering lug is placed under each of the socket-mounting nuts when the sockets are fastened in place. They will be needed for ground connections to the chassis. Fiber lug strips fastened to the chassis by the mounting screws of the i.f. cans will provide convenient insulated anchorages for condenser and resistor terminals that should not be grounded. As Fig. 24 shows, a separately-mounted lug strip is used for mounting C_{11}, C_{12}, R_8 and R_9. The assembly is placed immediately in front of the 6SQ7 socket and fastened with a 6–32 screw.

The filament wiring should be done first, keeping the wiring down close against the chassis. The two wires of the circuit should run parallel and close together wherever possible. They may be bound together with bits of Scotch tape to keep them from spreading. Next, resistors and by-pass condensers which connect directly to tube-socket terminals should be placed, and the insulating lug strips installed wherever the free ends of the resistors and condensers must be kept away from contact with the chassis. The leads furnished with the i.f. transformers should reach the proper tube-socket terminals or to a ground lug as required, but the red leads to the plus-B line should be anchored at an insulating lug-strip terminal and the wiring extended from there. When using the Millen 65163 b.f.o. unit, the brown wire should go to ground and the black-and-white to C_{13}.

Very little r.f. wiring is required. This is the wiring between the stator terminals of C_2 and C_3 and the coil and tube terminals. No. 14 tinned antenna wire should be used and the wiring should be kept well spaced from the chassis and other components wherever possible. A small cone insulator threaded onto the rear mounting screw of the 6SB7Y socket will serve as an anchorage for the wire running from L_2 to Terminal 8 of the 6SB7Y. A lead from the front stator terminal of C_3 (a lug will have to be added at this terminal) passes down through a clearance hole in the chassis to R_2 which is soldered to Terminal 5 on the 6SB7Y socket. One terminal of C_4 is connected to this wire; the other terminal of C_4 is grounded. The mica trimmer can be supported by its connecting leads. Be sure to locate it under the adjusting hole you have drilled in the chassis. A wire from the rear stator terminal of C_3 runs to the right and then through a hole in the chassis close to the rear of the oscillator-coil socket where it is connected to Pin 4. The long wire connecting Terminal 6 of the 6SB7Y socket to Pin 1 of the coil socket is insulated with a sleeve of spaghetti and run under C_1 (in Fig. 24). Ordinary hook-up wire may be used for this connection if it is cemented to the chassis. L_1 is cut from a section of Barker and Williamson "Miniductor" and this coil is mounted directly across the rear terminals of C_1 on short lengths of No. 14 wire. Check the wiring as you proceed and go over it again after the job is completed to make sure that there are no mistakes or accidental short circuits to the chassis or other parts.

Coil Winding

In winding the coils, be sure that No. 22 d.s.c. wire is used and that the turns are tight and wound snugly together. *The proper frequency range depends on this.* Both oscillator and input coils are wound on National or Millen plastic forms 1 inch in diameter. The form for the input coil has 4 pins, while the oscillator form has 5 pins for identification. In winding L_2 and L_3, measure up on the form ¼ inch directly above Pin 4. At this point drill a small hole to pass the No. 22 wire. Next, measure up 7/16 inch directly above Pin 1 and drill another hole. Starting with the wire at the hole above Pin 4, wind 6¼ turns in a clockwise direction with the pins facing you. This should bring you out at the second hole. Now drill a hole ½ inch above Pin 2 and another ⅞ inch above Pin 3. Starting with a new piece of wire at the lower of these two holes, wind 14¼ turns in a clockwise direction as the pins face you. This should bring you out at the top hole. The windings may be cemented in place with Duco cement or coil dope.

Special care should be used in winding the oscillator coil. Both windings *must* be wound in the same direction. Drill holes ¼ inch above Pin 5, ⅜ inch above Pin 1, 7/16 inch above Pin 2 and 15/16 inch above Pin 4. Starting at the bottom hole, wind 3¼ turns in a clockwise direction, with the pins facing you. This should come out at the second hole. Then starting at the third hole, wind

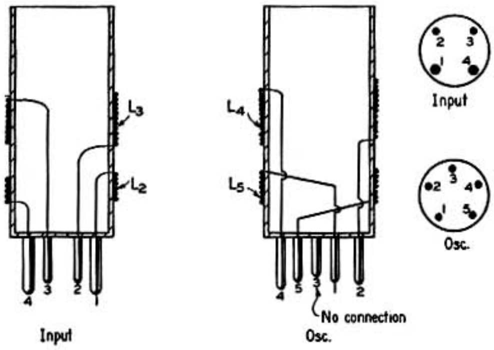

Fig. 25 — Sketch showing pin connections in coil forms. Figures at right are bottom views of the coil-form bases.

16½ turns in the same direction. This should bring you out at the top hole. The ends of the wire should be scraped and fed through the proper pins, as shown in Fig. 25, and soldered. Be sure that you have followed the pin numbering shown for the coil sockets in Fig. 22. *The receiver will not work if connections to coil pins are switched or if the oscillator coils are wound in opposite directions.*

Power Supply

The receiver is designed to work from any small receiver power supply delivering 250 volts at 40 ma. or more. A suitable unit is shown in Figs. 26 and 28 and the wiring diagram is given in Fig. 27. The unit is built on a 7 × 7 × 2-inch aluminum chassis. The components may be placed in any convenient arrangement; the length of wiring leads is of no consequence. The only important point is to keep the line from the rectifier filament to

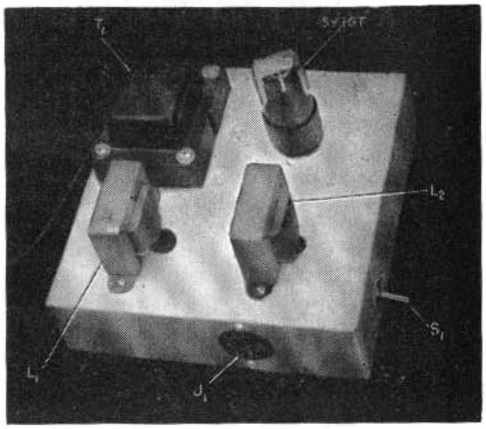

Fig. 26 — A simple power supply for the superhet receiver.

the output socket (the positive high-voltage line) well insulated from the chassis. The output socket is set in one edge of the chassis so that it will line up with the plug in the receiver, and the switch and a.c. cord are placed on the side. Then the two units may be connected with a plug-in cable, or the power-supply unit can be plugged directly into the receiver chassis.

Adjustment

The receiver can be adjusted quite readily with the help of almost any superhet broadcast receiver. The Millen transformers are pretuned to 1600 kc. so must be readjusted for 1500 kc. First the b.f.o. is turned on by throwing S_1 to the c.w. position. The b.c. receiver, placed close to the ham receiver, is tuned as accurately as possible to 1500 kc. Then the slug in the b.f.o. can (T_3) is adjusted until the swish of the b.f.o. is heard in the b.c. speaker. This sets the b.f.o. at approximately 1500 kc. Next, wind several turns of insulated hook-up wire around two or three fingers. Twist one end of the wire around the turns to hold the coil in shape and leave a lead of three or four feet at the other end.

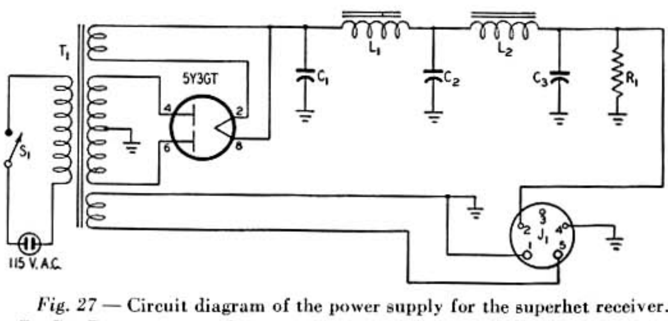

Fig. 27 — Circuit diagram of the power supply for the superhet receiver.

C_1, C_2, C_3 — Filter condensers — 8-μfd. 450-volt tubular electrolytic.
R_1 — Bleeder resistor (discharges condensers when power is turned off) — 50,000 ohms, 10 watts.
L_1, L_2 — Filter chokes — 8 h., 40 ma. (Thordarson T-20C52).
S_1 — Power switch — s.p.s.t. toggle.
T_1 — Power transformer — 250–0–250 volts r.m.s., 40 ma.; 5 volts, 2 amps.; 6.3 volts. 2 amps. (Thordarson T-22R00).

Make sure that the ends of the wire are not bare (if necessary cover them with Scotch tape) and insert the bunched wire into the back of the b.c. receiver somewhere near the tuning-condenser gang. Now put the end of the free lead into the hole in the side of the second i.f. transformer can (T_2). If the can has no hole, push the end of the wire up into the can from the bottom. Now tune the b.c. set until a whistle is heard in the headphones. It may be weak at first, so listen carefully. The whistle should be heard when the b.c. receiver is tuned to approximately 1045 kc. if the b.c. receiver has the usual 455-kc. i.f. Starting with the second i.f. transformer, T_2, adjust first the bottom slug screw and then the top screw for maximum signal in the headphones. Now transfer the lead wire to the first i.f. transformer, T_1, and adjust similarly for maximum response. Remove the test lead and turn off the b.c. receiver. The i.f. amplifier should now be tuned up at approximately 1500 kc.

Next, turn off the b.f.o. (switch in 'phone position) and set C_1 at minimum capacitance and C_2 and C_3 at maximum capacitance. Connect the antenna and adjust C_4 with a screwdriver until the background noise comes up to a maximum. By this time you should be hearing signals. Now set the main tuning dial at 50 and adjust C_2 for maximum background noise. Adjust C_4 very carefully until 75-meter 'phones are heard. Note where the high-frequency end of the 'phone band stops, and trim C_4 slightly until 4000 kc. falls at about 50 on the dial. Pick out a steady 'phone signal and go back and trim up the i.f. tuning for maximum signal (or you can use background noise). Now tune in a 'phone signal as closely as possible on the nose. Then switch on the b.f.o. and, *without additional touching of the main tuning dial*, readjust the b.f.o. (T_3) to bring the beat note (whistle) to the desired pitch.

If the oscillator coil has been wound carefully to dimensions, the receiver should now be tuned to cover 3500 to 4300-kc. In covering this band, it will be necessary to keep C_2 tuned for maximum signal. Signal strength will remain quite satisfactory if C_2 is reset only two or three times across the band, although a more accurate setting may be necessary for maximum selectivity.

To cover the 6500-to-7300-kc. range, all that is required is to set C_1 at *maximum* capacitance and readjust C_2 lower in capacitance until a second peak in background noise is heard. Then signals in and around the 7-Mc. band should be heard over the first half of the dial range. Similarly, to tune to the 8500-to-10,000-kc. and 11,500-to-13,100-kc. ranges, tune C_2 still lower in capacitance to find two more respective points where the background noise comes up. This must be done carefully for the latter two bands, since the maximum response points come quite close together near the minimum capacitance of the condenser.

14-Mc. Band

If it is desired to cover the amateur 20-meter band, a second set of coils will be required. For L_2 and L_3, drill the first hole in the 4-pin coil form ¼ inch above Pin 4, the second hole ⅜ inch above Pin 1, the third hole ½ inch above Pin 2 and the last hole ¾ inch above Pin 3. Starting at the bottom hole, wind 3¼ turns of No. 22 d.s.c. wire in a clockwise direction with the pins facing you. This will bring you out at the hole above Pin 1. Starting again at the third hole, wind 8¼ turns in the same direction. This should bring the winding to the hole above Pin 3. Solder each wire end to the pin immediately below the hole.

For L_4 and L_5, drill holes ¼ inch above Pin 5, ⅜ inch above Pin 1, ½ inch above Pin 2 and 1⁵⁄₁₆ inch above Pin 4. Start at the bottom hole, wind clockwise 2¼ turns, ending up at the hole over Pin 1. Now, in the same direction, wind 3½ turns, spacing the turns out so that the winding will reach the top hole. Before soldering the ends of the wire to the pins, two *silvered* mica condensers are needed. (Silvered mica condensers hold their capacitance more constant with changes in temperature than those of the ordinary type. This helps to prevent "creeping" of the signal after it has been tuned in.) One of the condensers

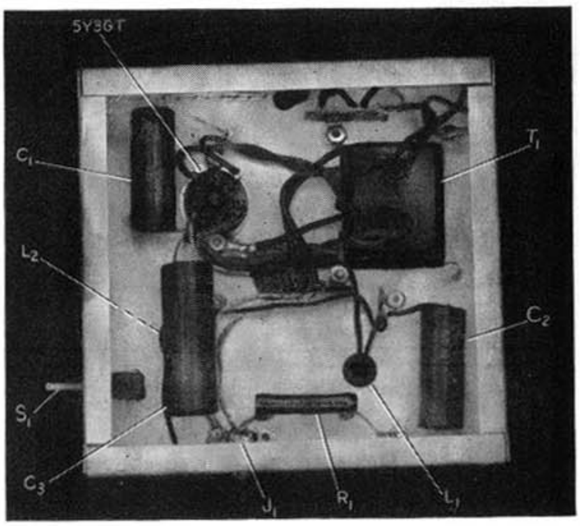

Fig. 28 — Bottom view of the superhet-receiver power supply.

should have a capacitance of 220-$\mu\mu$fd., while the other should be a 100-$\mu\mu$fd. unit. Place the two condensers with their flat sides together and solder the terminal wires together at each end, close to the condensers. This connects the two condensers in parallel so that the total capacitance is 320 $\mu\mu$fd. Cut off the excess lengths of terminal wire. Now solder a piece of the No. 22 wire about 6 inches long to each end of the condenser assembly. Remove the insulation, straighten the wires out and fish one of them through the inside of the coil form and down through Pin 2, along with the end of L_4. Fish the other wire similarly down through Pin 4. By pulling the wires carefully from the bottoms of the pins, draw the condensers as far down into the form as possible. (It doesn't matter if the condensers are tipped inside the coil form, so long as one end is close to the bottom.) Cut the wires close to the ends of the pins and solder each pin.

The input coil may be coated immediately with Duco cement or coil dope, but the oscillator coil must first be adjusted to the band. Plug the coils in and turn on the receiver. Turn C_1 and C_3 to maximum. Starting at minimum, tune C_2 carefully for the first point of maximum background noise. Set it at the point of maximum noise. Now with C_3 search the range for 20-meter 'phone or c.w. signals. If none are heard, push the turns of L_4 slightly closer together, or spread them slightly apart, until by trial the 20-meter band is found. When the band is located, place the high-frequency end at about 40 on the dial by very careful adjustment of the spacing of the turns. The winding can then be cemented in place. The tuning range now should extend approximately from 13,850 to 14,600 kc.

If C_2 is increased slightly, another point of maximum background noise will be found. This is the i.f. image response. With C_2 at this setting the range of approximately 10,850 to 11,600 kc. is covered. When the receiver is tuned for reception in the 20-meter band, any interfering images may be reduced by adjustment of the wavetrap.

The Wavetrap

In case an image signal or harmonic response from one of the bands not in use causes interference, it can be wiped out almost completely by accurately tuning C_2 for maximum response of the *desired* signal and tuning the wavetrap to the frequency of the *interfering* image. If you suspect that the interfering signal is an image, simply tune C_1 until the interfering signal becomes weaker or disappears altogether. If the *desired* signal and the interfering signal disappear together, the interfering signal isn't an image! If the *desired* signal becomes weaker without affecting the strength of the interfering signal, the wavetrap is tuned to the wrong frequency and a search should be made for the proper spot. The only thing to watch out for is that the trap isn't left tuned to the portion of the band where you want to listen. That is the reason for the preceding instructions regarding the preliminary setting of C_1 at minimum and maximum — to keep the trap tuned away from the band where you're listening.

A Simple 30-Watt Oscillator-Amplifier Transmitter

A transmitter of the oscillator-amplifier type is shown in Figs. 29, 33 and 34.

The circuit of such a transmitter is shown in Fig. 31. The oscillator circuit — that portion between R_1 and RFC_2 — is known as the Pierce circuit. It is one of the simplest crystal-oscillator circuits, since no tuning control is required. Although it is not feasible to couple an antenna to such a circuit, it works well when used to drive an amplifier. To explain the action of the circuit, we must go back to an earlier version shown in Fig. 30A. This circuit is known as the Colpitts

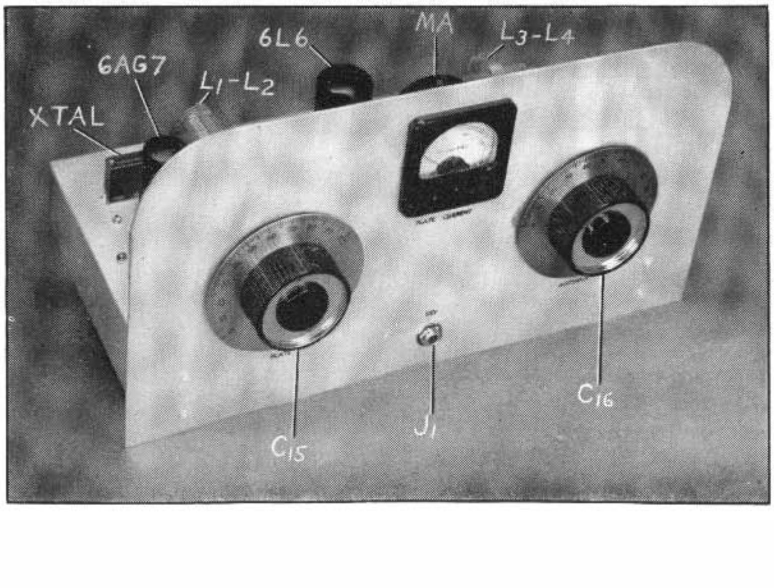

Fig. 29 — A 2-tube crystal-controlled transmitter for the 80- and 40-meter bands. The panel is a sheet of 1/16-inch aluminum 7½ inches high and 14 inches long. The dials are National type HRT-O

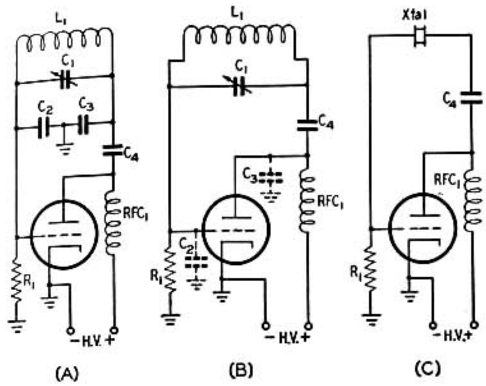

Fig. 30 — Development of Pierce oscillator circuit.

circuit. Oscillations can be obtained by proper connection of the tube to a tuned circuit, such as that consisting primarily of L_1 and C_1. To obtain oscillation, the plate is connected to one end of the tuned circuit and the grid to the other end. C_2 and C_3 form a capacitive tap across the circuit, just as if a tap were placed on the coil. The cathode is connected to this tap (through "ground"). Feed-back is adjusted by changing the ratio of C_2 to C_3, just as it would be by a change in the ratio of turns on either side of a tap on the coil when the tap is moved. R_1 is the grid leak which provides the necessary operating grid bias. Voltage is fed to the plate through RFC_1 to prevent grounding of the plate through the power supply (parallel feed). C_4 keeps the d.c. plate voltage from being applied to the grid through the tank coil.

Fig. 30B shows a circuit called the ultraudion circuit. It is identical to the circuit of A except that the grid-to-cathode capacitance of the tube takes the place of C_2 and the plate-to-cathode capacitance serves for C_3.

Since a crystal is the equivalent of a tuned

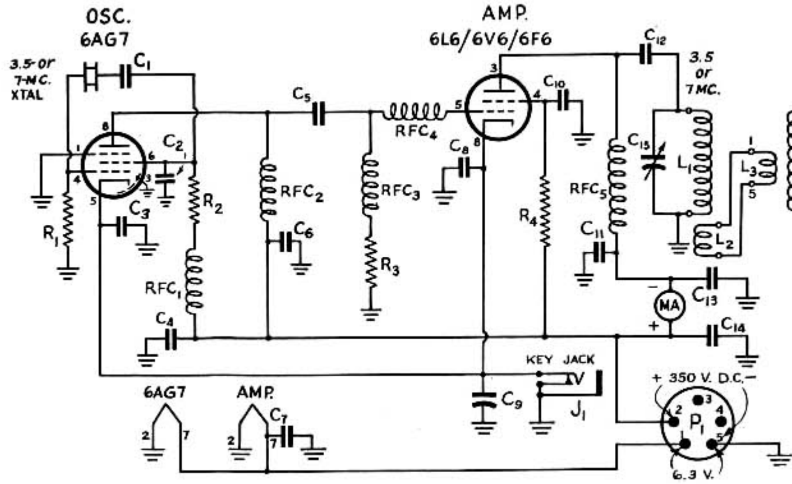

Fig. 31 — Circuit diagram of the oscillator-amplifier transmitter.

C_1 — Oscillator screen blocking condenser (takes d.c. off crystal) — 0.005-μfd. disk ceramic (Sprague 29C1).
C_2 — Feed-back adjusting condenser — 220-μμfd. mica.
C_3 — Oscillator cathode by-pass — same as C_1.
C_4 — Oscillator screen-circuit by-pass — same as C_1.
C_5 — Amplifier grid coupling condenser — 100-μμfd. mica.
C_6 — Oscillator plate by-pass — same as C_1.
C_7 — Heater r.f. by-pass — same as C_1.
C_8 — Amplifier cathode by-pass — same as C_1.
C_9 — Key-click condenser — 8-μfd. 450-volt electrolytic.
C_{10} — Amplifier screen by-pass — same as C_1.
C_{11} — Amplifier plate by-pass — same as C_1.
C_{12} — Amplifier plate blocking condenser (prevents d.c. short circuit through L_1) — same as C_1.
C_{13}, C_{14} — Meter r.f. by-pass — same as C_1.
C_{15} — Amplifier output tuning condenser — 325-μμfd. variable (National STH-335).
C_{16} — Antenna tuning condenser — same as C_{15}.
R_1 — Oscillator grid leak — 56,000 ohms, ½ watt.
R_2 — Oscillator screen-voltage-dropping resistor — 22,000 ohms, 1 watt.
R_3 — Amplifier grid leak — 18,000 ohms, ½ watt.
R_4 — Amplifier screen-voltage-dropping resistor — 18,000 ohms, 2 watts.
L_1 — Amplifier output coil —
3.5 Mc. — 17 turns No. 22 wire, 1¾ inches diam., 1⅜ inches long. L_2 — 4-turn link (Bud OEL-40 with 2 turns removed from end opposite link or B & W JEL-40 with 3 turns removed).
7 Mc. — 14 turns No. 16 wire, 1¾ inches diam., 1¼ inches long. L_2 — 4-turn link (Bud OEL-20 or B & W JEL-20).
L_4 — Antenna tuning coil —
3.5 Mc. — 22 turns No. 22 wire, 1½ inches diam., 1¾ inches long overall, ½-inch space at center. L_3 — 6 turn variable link (Bud OLS-40 or B & W JVL-40).
7 Mc. — 12 turns No. 16 wire, 1½ inches diam., 1½ inches long overall, ½-inch space at center. L_3 — 5-turn variable link (Bud OLS-20 or B & W JVL-20).
J_1 — Key jack — closed-circuit.
MA — Amplifier plate-current milliammeter — 150- or 200-ma. scale.
P_1 — Five-pin chassis-mounting plug (Amphenol).
RFC_1 — Oscillator screen-feed choke — 2.5-mh. r.f. choke (National R100-S).
RFC_2 — Oscillator plate-circuit inductance — 100-μh. r.f. choke (Millen).
RFC_3 — Amplifier grid-feed choke — 2.5-mh. r.f. choke (National R100-S).
RFC_4 — V.h.f. parasitic-suppressor choke — 2-μh. r.f. choke (National R60).
RFC_5 — Amplifier plate-feed choke — 2.5-mh. r.f. choke (National R100-S).

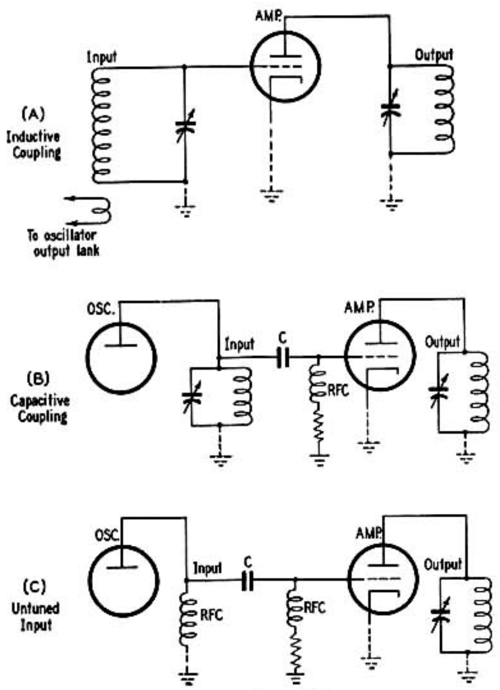

Fig. 32 — **Development of amplifier arrangement.**

circuit, we arrive at the circuit of Fig. 30C — the Pierce circuit which we are to use in the transmitter. In the latter, the *screen* of the 6AG7 is used as the plate of the oscillator circuit. Feedback is adjusted to the proper value by C_2 which is in parallel with the screen-to-cathode capacitance. R_2 is a series resistor to reduce the voltage for the screen.

The output of the oscillator is coupled to the 6AG7 output plate circuit principally through the electron stream within the tube. This is known as *electron coupling*. The r.f. output from the plate circuit appears across RFC_2. A tuned circuit could be used instead of RFC_2 with greater output from the oscillator, but this would mean an additional tuning control and a more complicated amplifier circuit.

The Amplifier

An r.f. power amplifier usually has two tuned tank circuits — the input tank circuit connected between grid and cathode and the output circuit between plate and cathode. The input tank circuit may be an independent one, as shown in Fig. 32A, or the output tank circuit of the oscillator may serve the same purpose, as shown at B. In the case of A, the output circuit of the oscillator is coupled to the input circuit of the amplifier by inductive means. The arrangement at B is called capacitive coupling, and C is the coupling condenser. Unless special precautions are taken the amplifier will oscillate when the input and output circuits are tuned to the same frequency. This is primarily because the two circuits are coupled through the plate-to-grid capacitance of the tube. We do not want the amplifier to operate as an oscillator; we want it to amplify the signal from the oscillator. To avoid the complications involved in other means, oscillation can be prevented by keeping either the input circuit or the output circuit tuned away from resonance. We want the greatest power possible from the output circuit. Therefore we make the grid circuit nonresonant. While this will result in less than maximum power output from the oscillator, we can afford to sacrifice efficiency at this point. Therefore, instead of the customary tuned tank circuit, we substitute an r.f. choke for the oscillator output tank circuit, as shown in Fig. 32C. Thus we arrive at the arrangement shown in Fig. 31 in which RFC_2 is the untuned circuit common to the output circuit of the oscillator and the input

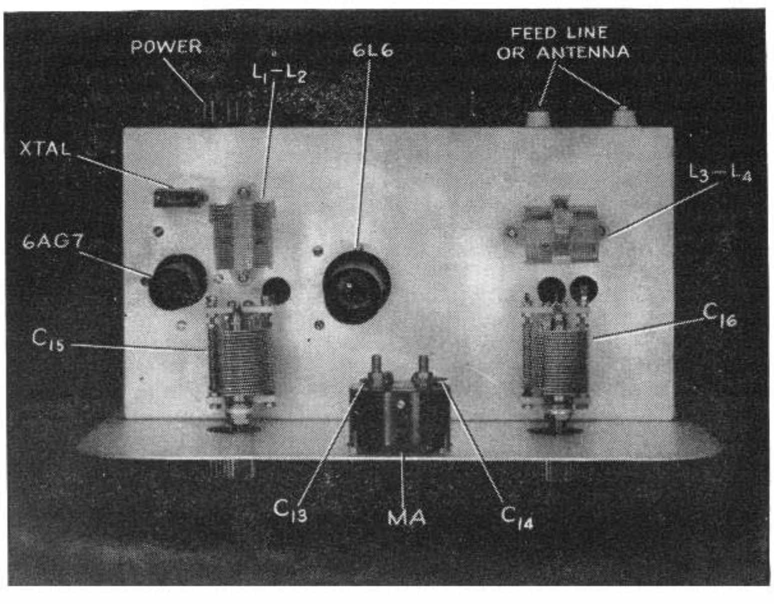

Fig. 33 — **Top view of the oscillator-amplifier transmitter. The clearance holes for the wiring to the tuning condensers are lined with rubber grommets.**

Forty-meter coils are used for 80, and 20-meter coils for 40 to obtain the desired tank-circuit Q.

Note: Bud and B & W Coils use 5-prong sockets, instead of 6 prongs as shown in Fig. 34.

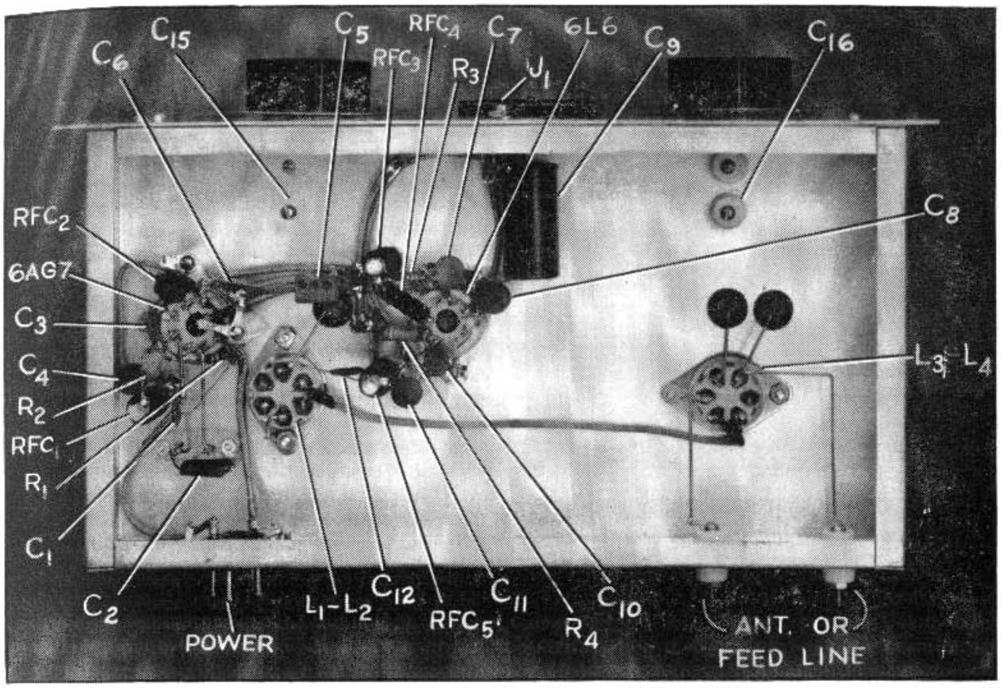

Fig. 34 — **Bottom view of the two-tube low-power transmitter. The chassis measures 7 by 13 by 2 inches.**

circuit of the amplifier, and C_5 is the coupling condenser. Here, a beam tetrode tube is used, instead of a triode, because the beam tube has greater *power amplification.*

R_3 is the amplifier grid leak. The impedance of RFC_3 in series with R_3 prevents r.f. currents from flowing through the grid leak and wasting power from the oscillator. C_{15} and L_1 make up the output tank circuit. Parallel feed is used to the amplifier plate through RFC_5, and C_{12} is the blocking condenser which passes r.f. but prevents short circuiting the d.c. plate supply through L_1. R_4 is a series resistor that reduces the voltage for the screen. C_3, C_4, C_6, C_7, C_8, C_{10}, C_{11}, C_{13} and C_{14} are all by-pass condensers designed to prevent the flow of r.f. (fundamental and harmonics) in the power-supply leads. The cathodes of the two tubes are connected together and the key jack is connected between the common cathode connection and negative h.v. which is connected to the chassis. This interrupts the plate-current flow to the tubes when the key is open. C_9 is for the purpose of reducing clicks on the transmitted signal which may cause unnecessary interference to amateurs operating near the same frequency as yours, as well as to nearby broadcast receivers.

Parisitic Oscillation

We know that as we go higher in frequency, the inductance and capacitance necessary to tune to resonance becomes smaller. In the regenerative receiver, for instance, the coils covering the higher frequencies are much smaller than those for the lower frequencies. If we go high enough in frequency, we come to the point where the inductance and capacitance of a short piece of connecting wire will be resonant. In most r.f. amplifiers, such small unavoidable factors combine to cause oscillation at frequencies in the neighborhood of 150 Mc. This must be avoided to prevent the wasting of power and to eliminate radiation at spurious frequencies. The small choke, RFC_4, which offers a high impedance to very-high frequencies, is inserted in series with the grid of the amplifier to prevent this type of oscillation.

Antenna Tuner

C_{16} and L_4 make up an antenna tuner. Its purpose is to provide means for resonating the antenna system and coupling it to the output circuit of the amplifier. The tuner is coupled to the amplifier tank by means of an inductive-link line as shown. The condenser may be connected in series with the coil or in parallel with it by proper connections between the pins on the plug-in base of L_4. Plate and filament power is fed to the transmitter through the chassis plug, P_1. The diagram of a suitable power supply is shown in Fig. 35. It is similar in circuit and principle to those discussed earlier. The single-section filter provides adequate smoothing for transmitting.

Construction

The general construction of the transmitter is designed to match that of the superhet receiver. Therefore the chassis and panel dimensions are the same and the unit will fit into a similar cabinet. As in the receiver, the exact placement of parts on top of the chassis is not critical. The two variable condensers, C_{15} and C_{16}, are placed at either end of the chassis to balance (shafts about 3 inches in from the ends). C_{16} must be insulated

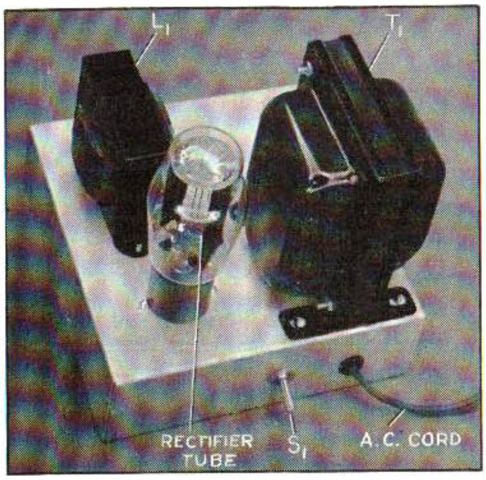

Fig. 35 — **A power supply for the oscillator-amplifier transmitter. It is built on a 7 × 7 × 2-inch aluminum chassis following suggestions laid out for the superhet receiver supply. The output socket is placed to match up with the plug in the rear of the transmitter chassis.**

from the chassis, so it is mounted on Millen 32100 feed-through insulators which require ⅜-inch holes. C_{15} need not be insulated, but metal spacers are used to bring its shaft up level with that of C_{16}. The respective coil sockets are mounted directly behind the condensers, with their axes at right angles to minimize direct inductive coupling,

The sockets (Millen) for the crystal and the oscillator tube are placed in the space at the left-hand end of the chassis and the amplifier tube an inch or two to the right of C_{15} and L_1. The Millen ceramic sockets require 1¼-inch holes. The oscillator socket is mounted with its key toward the front, while the key of the amplifier socket is toward the right. The amplifier-coil socket (5-prong) is turned so that the large Pins 1 and 5 are toward the right. The link prongs of the antenna-coil socket (5-prong) are to the rear. Two solder lugs should be placed under each socket-mounting nut for ground connections.

Clearance holes are drilled at the rear of the tuning condensers for the connecting wires. A hole is also required near the front of the chassis at the center for the wires running to the meter if one is to be used. A hole for the key jack is needed in the front edge of the chassis at the center. In the rear edge the power plug is mounted at the left-hand end and the two output terminals, which are a pair of ⅜-inch feed-through insulators similar to those mounting C_{16}, are at the opposite end.

RFC_1, RFC_3 and RFC_5 are mounted with a single screw in the locations near the tube sockets shown in Fig. 34. A fiber lug strip is fastened under RFC_5 to provide an insulating anchorage for the bottom end of R_4. A ¾-inch ceramic cone insulator is fastened to the right-hand mounting screw of the 6AG7 socket (in bottom view), and another similar insulator is fastened to the chassis immediately above the socket. Two soldering lugs are fastened to the top of each insulator.

Wiring

As pointed out in the discussion of the oscillator in the superhet receiver, oscillators (and amplifiers too) can generate harmonics. Experience has shown that even a low-power transmitter operating at 80 or 40 meters can cause interference to television receivers in the immediate neighborhood if one or more of the higher order of harmonics falls in a television channel — even though the power generated at such a high frequency is, of course, very small indeed. Therefore, at least the most essential steps should be taken to reduce harmonics in the power-supply leads and the antenna. This consists of the use of shielded power wiring, low inductance by-pass condensers with short leads, and the link-coupled antenna tuner. Under some circumstances it may be necessary to take further measures to suppress TVI, but those mentioned should suffice in most cases. In particular, it may be necessary to shield the transmitter by placing it in a metal cabinet. If this is done, the panel furnished with the cabinet will be used, rather than the one described, of course.

Shielded wire consists of an insulated conductor covered with copper braid. It using it, care must be exercised in keeping the ends of the copper braid away from contact with the inner conductor. In preparing the end of the wire, wrap three or four turns of No. 22 bare tinned wire (or cotton- or silk-covered magnet wire with the insulation removed will do) tightly around the shielding braid of about one inch from the end, leaving a lead of 2 or 3 inches at one end of the binding wire. Then fray the braid back to the binding and trim the braid off close with cutting pliers or shears. Flow solder around the turns of bare wire. Then remove the insulation from the end of the conductor for a distance of about ½ inch. This should leave about ½ inch of insulation

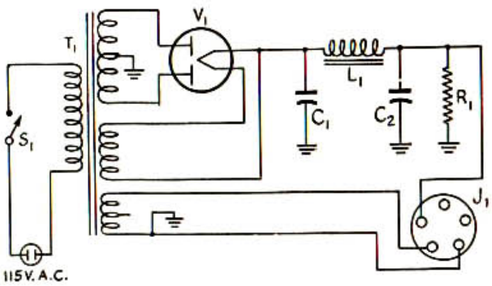

Fig. 36 — Wiring diagram of the power supply for the oscillator-amplifier transmitter.

C_1 — Filter input condenser — 8-μfd. 500-volt electrolytic.
C_2 — Filter output condenser — 8-μfd. 450-volt electrolytic.
R_1 — Bleeder resistor (discharges condensers when power is turned off) — 50,000 ohms, 10 watts.
L_1 — Filter choke — 10.5 h., 110-ma. (Stancor C1001).
J_1 — Five-prong chassis-mounting socket (Amphenol).
S_1 — Power switch — s.p.s.t. toggle.
T_1 — Power transformer — 360-0-360 volts r.m.s., 120-ma.; 5 volts, 3 amps.; 6.3 volts, 4.5 amps (Stancor PC8410).
V_1 — Rectifier tube — Type 80 or 5Z3.

between the conductor wire and the braid. Both ends of each piece of shielded wire should be prepared in the same way. The loose lead fastened to the shielding should be grounded to the chassis after the wire is installed.

Pins 1 and 2 of the amplifier-tube socket, Pins 1, 2 and 3 of the oscillator-tube socket, and Pin 4 of the amplifier-coil socket are connected directly to ground at one of the adjacent grounding lugs. Pin 5 of the power plug also is connected to the chassis. Then a short length of shielded wire is run from Pin 1 on the power plug to Pin 7 on the 6AG7 socket, and another section of shielded lead from there to Pin 7 on the amplifier-tube socket. Another section of shielded wire is run from Pin 2 on the power plug to the bottom terminal of RFC_1, another piece from there to the lug on top of the cone insulator holding RFC_2, another from this point to connect to R_4, and the last piece goes up through the chassis to connect the latter point to the positive terminal of the milliammeter. Another section of shielded wire runs from the negative terminal of the milliammeter back down to the bottom end of RFC_5. If a meter is not used, a connection is made directly from the fiber lug-strip termination of R_4 to the bottom end of RFC_5. The two cathode terminals of the tube sockets are connected together with shielded wire and another piece of shielded wire is run from Pin 8 on the amplifier-tube socket to the key jack. When the shielded wiring is completed, those wires running parallel, or crossing, should be spot-soldered together at intervals.

The various small by-pass condensers are installed next, soldering them directly between the tube-socket or r.f.-choke terminals and the nearest grounding lug with the shortest possible leads. R_1 is placed directly between Terminal 4 of the 6AG7 socket and ground, and R_3 between the bottom end of RFC_3 and ground. R_2 is connected between the top end of RFC_1 and Pin 6 of the 6AG7 socket. R_4 is wired directly between Pin 4 of the amplifier-tube socket and the fiber lug strip. C_9 is connected between Pin 8 of the amplifier-tube socket and the grounded terminal of the key jack. A section of 75-ohm Twin-Lead or parallel-conductor lamp cord connects the link terminals (1 and 5) of the two coil sockets.

The top terminal of RFC_5 is wired to Pin 3 of the amplifier-tube socket and C_{12} is connected between the top of the same choke and Pin 2 of the amplifier-coil socket. RFC_4 is connected directly between the top terminal of RFC_3 and Pin 5 of the amplifier-tube socket.

The r.f. wiring, of which there is very little, should be done with stiff wire, No. 16 or larger. It should be kept well spaced from the chassis and other components. One wire connects one side of the crystal socket to Pin 4 of the 6AG7 socket. Another is run from the second crystal-socket terminal to Pin 6. After the wire is soldered in place, a ½-inch section is cut out of the center and C_1 is inserted.

A wire connects Pin 2 of the amplifier-coil socket to the rear stator terminal of C_{15}. C_5 is soldered between the top of RFC_3 and the anchoring lug on top of the second cone insulator near the 6AG7 socket. A short piece of wire runs from there to Pin 8 of the 6AG7 socket.

The antenna-coil socket is wired according to the pin numbering in Fig. 31.

The panel is fastened to the chassis with two machine screws at each end. A hole is required to match the hole in the chassis for the key jack. The 1¼-inch socket punch is used to make clearance holes in the panel for the shafts of the two tuning condensers. The hole for the meter can be cut with a circle cutter in a carpenter's brace. The size of the hole will depend upon the dimensions of the meter used, of course. The meter shown is of the 2-inch variety, but panel space is available for a 3-inch meter. After the meter wires have been connected, C_{13} and C_{14} should be added. They are connected directly between each meter terminal and the shielding braid of the meter wires. The braid of each meter wire is then grounded to one of the meter-mounting screws. Since the meter terminals are exposed high-voltage points, they should be covered with sleeves of rubber tubing to remove the hazard.

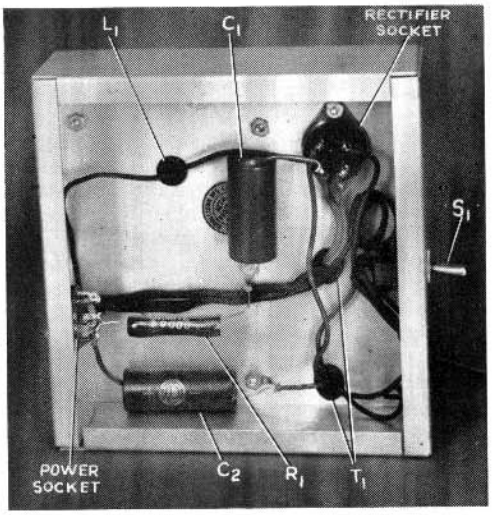

Fig. 37 — **Bottom view of the oscillator-amplifier transmitter power supply.**

Power Supply

The transmitter power supply shown in Figs. 35 and 37 will deliver 350 volts under a full load of 110 ma. Any other power supply delivering up to a maximum of 350 to 375 volts under load will do. Naturally, if the voltage applied to the transmitter is lower, the power output will be reduced correspondingly. The circuit diagram is shown in Fig. 36. The principles are similar to those discussed in connection with the power supply for the simple oscillator transmitter and the construction parallels that of the supply for the superhet receiver. Since the transformer is not of the flush-mounting type, no cut-out in the chassis is required; only two holes for the leads are needed.

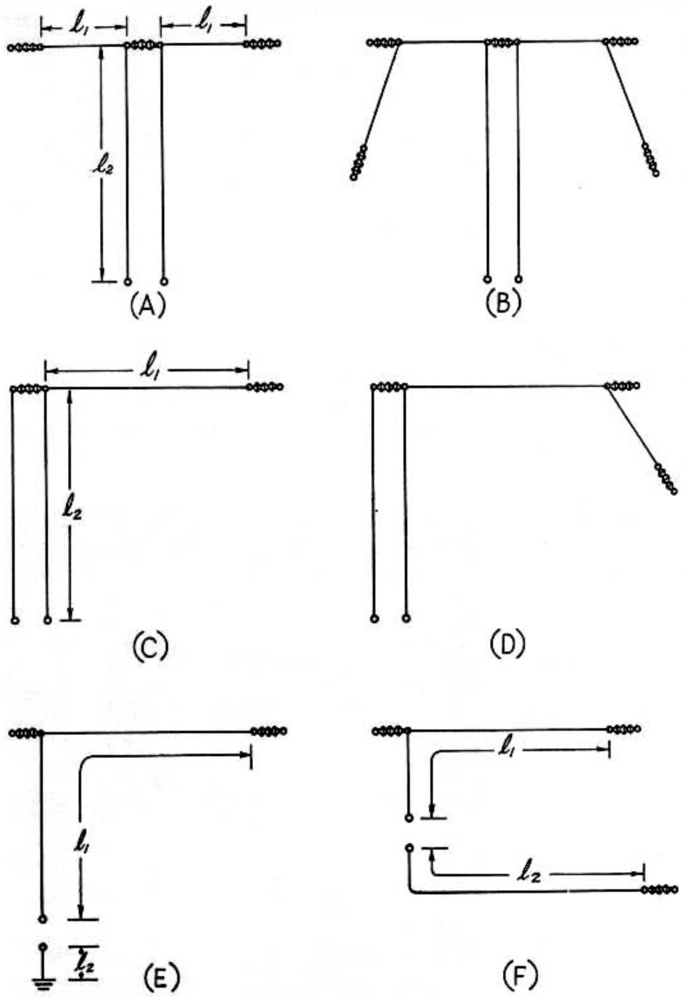

Fig. 38 **— Various types of antennas recommended for use with the beginner's transmitter for 40 and 80 meters. See table for dimensions.**

Choosing Crystal Frequencies

Following current amateur practice, an operator, after he has called CQ, listens first on or quite near his own transmitter frequency. Therefore, it follows that you will stand a better chance of raising him if your transmitter frequency is as close as possible to his. In other words, you will usually be more successful in making contacts if you call stations working on frequencies close to your own transmitter frequency. Also, when you call CQ, you will usually find that most of the stations answering you will be close to your transmitter frequency. For this reason it is an advantage to have several crystals at different frequencies.

Although c.w. operation is permitted on any frequency in the bands assigned to amateurs, you will seldom find any c.w. operation in the bands assigned to 'phone.

The holder of a Novice Class license *must* choose crystal frequencies between 3700 and 3750 kc. for 80-meter operation, for 40-meter operation, the operating frequencies must lie between 7175 and 7200 kc. These frequencies can be obtained either by using crystals of these frequencies, or by doubling frequency using crystals between 3587.5 and 3600 kc.

To avoid the 'phone bands, a holder of a General Class or Extra Class license should choose frequencies between 3500 and 3800 kc. for 80-meter work. When operating in the 40-meter band, the crystal frequencies should lie between 7000 and 7200 kc., or between 3500 and 3600 kc. if frequency is doubled.

Antennas

A single antenna can be made to serve for both 40 and 80 meters. It may take any one of several forms. Where space is available, the preferable antenna consists primarily of a horizontal wire one half wavelength long for 80 meters (approximately 135 feet) running in a straight line and elevated as high as possible. An antenna of this type is connected to the transmitter through a *transmission line* or *feeder line*, which is simply a pair of parallel wires spaced 2 to 6 inches. The feed line may be attached to the antenna at one end, as shown in Fig. 38C but, wherever it is at all feasible, it should be connected at the center, as shown in Fig. 38A. Where a choice in direction exists, the center-fed antenna should be in a line at right angles to the direction in which it is most desired to work, while the end-fed antenna should be in a direction approximately 45 degrees from the most-desired path.

Antenna Data Table

	l_1	l_2	*80 M.*	*40 M.*
Figs. 3A and 3B	67 ft.	67 ft.	par.	par.
	33 ft.	33 ft.	ser.	par.
	$l_1 + l_2 = 134$ ft. (l_1 long as possible)		par.	par.
	$l_1 + l_2 = 67$ ft. (l_1 long as possible)		ser.	par.
Figs. 3C and 3D	134 ft.	67 ft.	ser.	par.
Fig. 3E	$l_1 + l_2 = 67$ ft. (l_2 short as possible)		ser.	par.
Fig. 3F	67 ft.	67 ft.	ser.	par.

If space does not permit running the antenna in a straight line, it may be bent to accommodate the length, or the ends may be dropped down, as shown in Figs. 38B and 38D. The angles at the bends should be as wide as possible. Although such bending will have some influence on the performance of the antenna, it will still work quite well. The center-fed antenna is much more tolerant as to dimensions than one which is end fed. In restricted space, the horizontal antenna portion may be made as long as space permits and the deficiency in length added to the feed line, keeping the over-all length the same. It is not advisable to do this with the end-fed antenna.

When a feed line is used, power from the transmitter can be fed more readily to the antenna if the feed line is cut to certain lengths. These lengths together with other essential dimensions of various recommended systems are shown in the accompanying table.

Another type of antenna is known as the Marconi antenna. This consists of a wire whose total length is one quarter wavelength instead of one half wavelength. For 80 meters this means a length of about 67 feet. This antenna is shown in Fig. 38E. When such an antenna is used, the remaining output terminal of the transmitter must be connected to a ground (such as a water pipe) or to another quarter wavelength of wire which may be suspended a few feet above the ground, as shown in Fig. 38F. It is not essential that the lower wire run exactly under the antenna.

The table of antenna dimensions also shows whether series or parallel tuning should be used, that is, whether C_{16} should be connected across L_4 or in series with it and the feed line.

The antenna may be strung between any existing supports, such as trees or buildings, or some type of mast may be used. When a feed line is used, the antenna may be of No. 12 or No. 14 antenna wire, while the feed line may be made of No. 16 wire to minimize the weight. Plastic spreaders are recommended for spacing the feeder wires because of their light weight. They can be obtained in several different lengths. When the feed line is long, the wider spacing will give less trouble from twisting. Fairly-strong glass or porcelain insulators should be used for the antenna, especially if the antenna is to be strung between trees.

Adjustment

Aside from the 6L6, a 6V6 or 6F6 may be used in the amplifier without circuit change. The smaller tubes will not handle as much power as the 6L6, of course.

The power supply should be connected to the transmitter. The 80-meter coil should be plugged into the amplifier circuit and an 80-meter crystal placed in the crystal socket. The antenna-coil socket should be empty. With the power turned on, and the key plugged in and closed, the milliammeter should show a reading (80 to 125 ma. with a 6L6 and 350-volt supply). Starting at maximum capacitance, C_{15} should be adjusted carefully until the plate current dips to a minimum. This indicates resonance at the crystal frequency. A further decrease in condenser capacitance should reveal another slighter dip in plate current. This indicates resonance at the second harmonic or twice the crystal frequency. This setting should be avoided.

The 80-meter antenna-coil plug should now be connected up for either series or parallel tuning as indicated in the table. The coil center-tap wire should be disconnected from Pin 3. For series tuning, the antenna or feeders should be connected to output terminals *B* and *C*. For parallel tuning, they should be connected to terminals *A* and *B*, and Pins 3 and 4 on the *coil* base should be wired together as shown in dotted lines, Fig. 31.

Now connect one of the feed-line wires to one transmitter output terminal. Connect the other feed-line wire to one terminal of a dial-lamp socket and the other dial-lamp terminal to the remaining output terminal, as indicated in Fig. 31. If series tuning is required, use a No. 41 (white bead) 2.5-volt 0.5-ampere lamp in the socket. If parallel tuning is specified, use a No. 48 (pink bead) lamp rated at 0.06 ampere.

Set C_{16} at minimum capacitance, close the key and retune the amplifier to resonance at 80 meters. The dip in plate current probably will not be so pronounced as it was before the antenna coil was plugged in. Then adjust C_{16} and watch the plate current. At some point in the range of C_{16}, the plate current should rise to a maximum. Adjust C_{16} to this maximum. At this point the lamp in the feed line should indicate output. If it doesn't show at least a glow when series tuning is used, try a lamp with a lower current rating, such as the No. 46 (blue bead) which has a rating of 0.25 ampere. If, on the other hand, the lamp burns out with parallel tuning, use a lamp with a higher current rating, such as the No. 40 (brown bead) rated at 0.15 ampere.

Now readjust C_{15} for maximum lamp brilliance. A slight further readjustment of C_{16} and then C_{15} may improve the output. At this point, detuning C_{15} in either direction should show at least a slight rise in plate current. If it doesn't, the coupling should be reduced by bending the adjustable link away from the antenna coil. Use the tightest coupling that will permit a discernible dip in plate current when C_{15} is tuned through resonance. When tuning is completed, the lamp may be shorted out with a clip lead.

Forty-meter output can also be obtained with an 80-meter crystal, simply by plugging in the 40-meter coils and following the same procedure. However, the output in this band will be greater if a 40-meter crystal is used. Be sure to note from the table if there is a change between series and parallel tuning in going from 80 to 40 meters and wire up the 40-meter antenna-coil plug and change the dial lamp accordingly, if required.

Depending upon the output voltage of the power supply, it should be possible to load the 6L6 up to a plate current of 90 ma. Plate current to a 6F6 or 6V6 should be limited to 50 ma.