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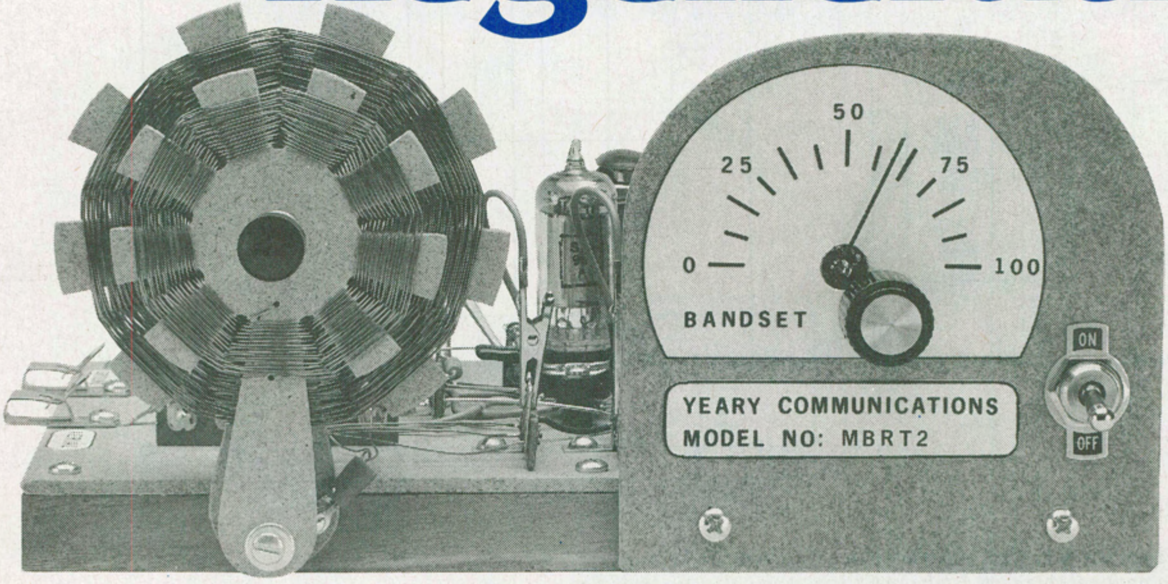
Build A Regenerative



Vacuum-Tube Receiver

BY STANLEY A. CZARNIK

Recreate the feel of the early days of radio with this fun-to-build and fun-to-use regenerative radio receiver

Prior to the first commercial success of semiconductor devices in the 1950's, many vacuum-tube types were developed for a variety of applications. Since then, the use of tubes has steadily decreased. The transistor, developed in 1947, was for most purposes a superior device. Some of its advantages are that it has no glass to break, requires no warm-up time, has nothing to burn out, and is lighter, smaller, and faster than its predecessors. So, it is no wonder that traditional vacuum tubes have, for the most part, given way to solid-state components.

Still, the vacuum tube receives considerable attention. The physical principles that manifest themselves in the operation and design of vacuum tubes appear frequently in many spheres of electronic research and fabrication. Therefore, the study of those principles is certainly worth the effort.

The operation of most common vacuum tubes depends on two elementary electronic phenomena. The first is the emission of electrons by certain elements and chemical combinations when the energy of the atoms on the surface of the material is raised by the addition of heat. Such thermal agitation and electron release is called *thermionic* emission. The second is that the movement of electrons within an evacuated chamber can be controlled by the manipulation of magnetic and electric fields.

The internal structure of a typical thermionic vacuum tube consists of an arrangement of at least two (usually three) different types of electrode: an electron emitter (usually called the cathode or the filament), an electron collector (the anode, usually called the plate), and one or more electron controllers (called grids).

A Look At The Circuit. Figure 1 shows a complete schematic diagram of the Regenerative Vacuum-Tube Receiver, plus a 1-tube resistance-coupled audio

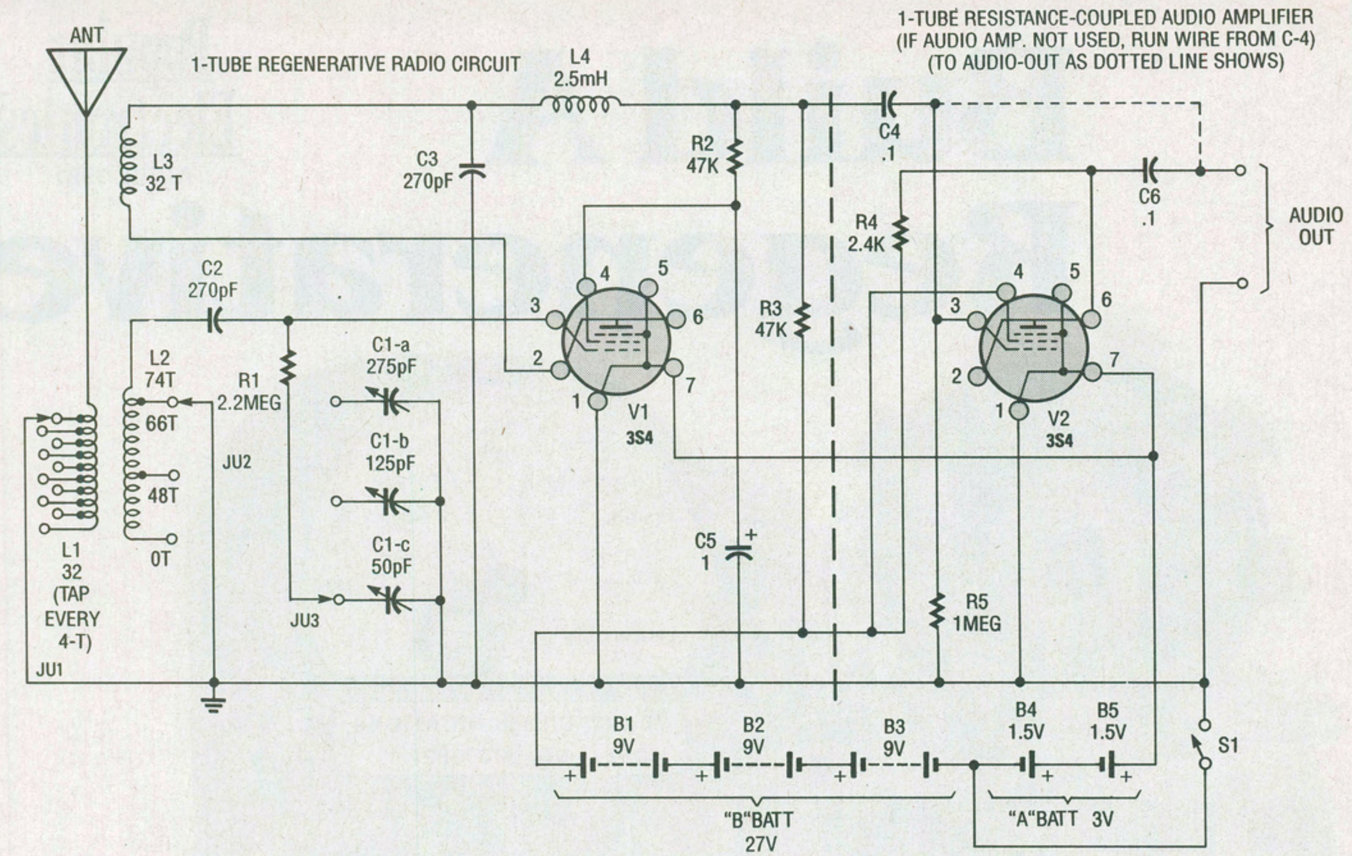


Fig. 1. Here is the complete schematic diagram of the Regenerative Vacuum Tube Receiver, feeding an optional (see text) 1-tube resistance-coupled audio amplifier.

amplifier. In the Fig. 1 circuit, the untuned radio-frequency (RF) signal picked up by the antenna (ANT) and applied to L1, a multi-tapped coil. The taps on L1 help to match the impedance of the antenna to the input impedance of the receiver, ensuring maximum signal transfer.

The RF signal from the antenna is inductively coupled to L2. The taps on L2 set the range of frequencies that can be tuned by the receiver (sort of a coarse-frequency control), while C1 determines the precise frequency (station) to which the receiver is tuned (in essence, a fine-frequency control). Components C2 and R1—which are connected to the first grid of V1 (a 3S4 pentode) at pin 3—comprise the "grid-leak" or "detector" portion of the circuit, which converts the incoming RF to an audio-frequency signal. The filament of V1 (at pins 1 and 7) is energized by the 3-volt "A" battery. That starts electron-flow through the four remaining elements of the tube where amplification, detection, and regeneration take place. A DC bias voltage is applied to the second grid of V1 at pin 4 through R2 and R3. Capacitor C5 bypasses any AC component superimposed on V1's DC bias voltage to ground. The third grid of V1 at pin 5 is internally connected to ground through pin 1 of V1's filament.

The plate of V1 (pins 2 or 6) is the output portion of the tube. That element is positively biased from B+ through R3, L3, and L4. So, how is the signal amplified? Note that each element of the tube from grid 1 (pin 3) through the plate has a negative, positive, negative, positive potential, respectively. With the filament starting the

PARTS LIST FOR THE REGENERATIVE VACUUM-TUBE RECEIVER

RESISTORS

(All resistors are ½-watt, 5% units.)
R1—2.2-megohm
R2, R3—47,000-ohm
R4—2400-ohm
R5—1-megohm

CAPACITORS

C1—Variable capacitor (see text for specifications)
C2, C3—270-pF, mica
C4, C6—0.1-µF, ceramic disc
C5—1.0-µF, 50-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

V1, V2—3S4 pentode vacuum tube
L1–L3—See text
L4—2.5-mH RF choke
S1—SPST or DPDT toggle switch
B1—Two 1.5-volt C-cell batteries
B2—Three 9-volt transistor-radio batteries
Baseboard, baseboard rails, tube sockets, battery holders, terminal strips, Fahnestock clips, crystal earphone, magnet wire, hook-up wire, hardware, etc.

Note: The Regenerative Vacuum Tube Receiver kit (with audio amplifier circuit) is available from Yeary Communications, 12922 Harbor Boulevard #800, Garden Grove, CA 92640. The stock number is MBRT2-MBAT2 and the price is $34.95. A set of three spiderweb coil forms (stock number SWCF3) is available for $5.00. The five-section variable capacitor (stock number VTC55) is available for $4.00. The radio kit without the audio amplifier option (stock number MBRT2) is available for $29.95. The audio amplifier option alone (stock number MBAT2) is $7.50. Add 12% of total cost for shipping, plus $2.00 for handling to all orders. California residents add 6.25% sales tax.

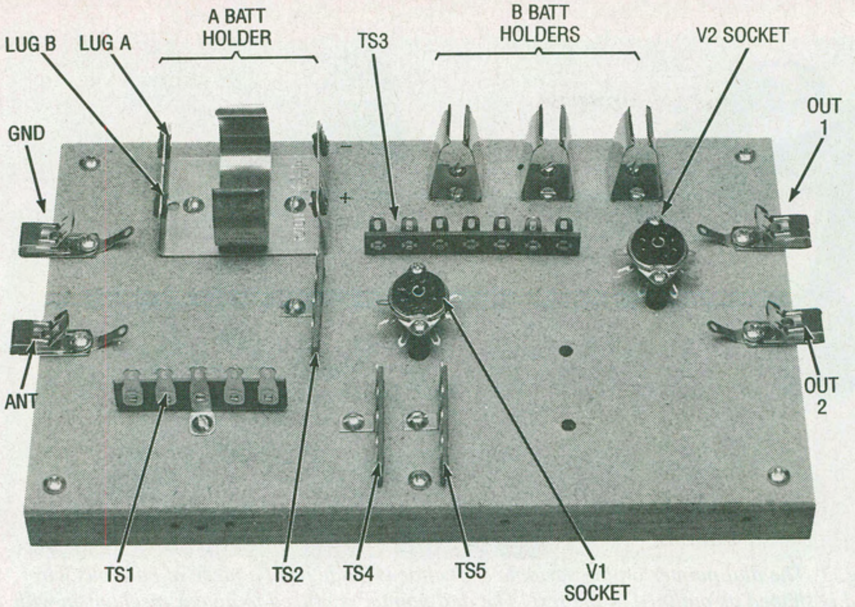


Fig. 2. Once the terminal strips, Fahnestock clips, battery holders, and vacuum-tube sockets have been mounted, the baseboard of your radio should look something like this. Refer to this illustration for the general layout of the baseboard and the locations of the terminal strips to which the interconnecting wires and components are connected.

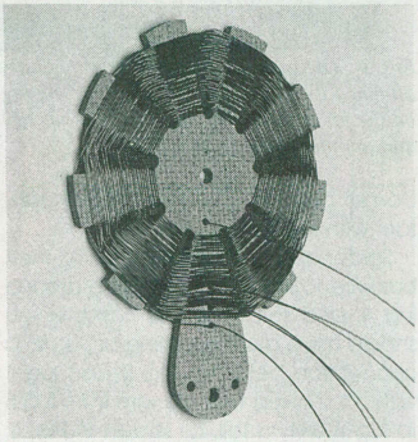
electron-flow, the signal is collectively amplified from grid 1 through the plate as electrons flow from negative to positive, accelerating at each element.

Coil L3 (the tickler coil) and capacitor C3 make-up the "feed-back" or "regeneration" circuit. Regeneration is not difficult to understand since it is little more than a form of positive feedback. For those not familiar with the operation of regenerative circuits, let's take a closer look.

Note that the plate of V1 at pin 2 is connected to L3, and V1's control grid at pin 3 is connected to L2. When L3 is moved towards L2, a portion of the output signal from pin 2 of V1 is inductively coupled from L3 to L2 and fed back to the first grid of V1, thus regenerating the original signal. The reinforcement of the original voltage is possible because the frequency in the plate circuit is equal to the frequency in the grid circuit.

The fundamental principle involved in this type of regenerative circuit is electromagnetic induction. The amount of feedback cannot be increased beyond a certain point. Here's why: The energy fed back to the tuned circuit is impressed on the grid of the vacuum tube along with the original signal. If too much feedback is applied to the input of the circuit, the detecting action of V1 would soon be replaced by the tendency of the tube to oscillate at a frequency set by the coils in the plate and grid circuits.

The amount of feedback is controlled by the degree of coupling between L3 and L2. As such, L2 and L3 act as a variable-coupling transformer. The farther you move L3 from L2, the lower the coupling. The farther you move L3 toward the center of L2, the more coupling, or regeneration, will be obtained. The maximum regenerative effect is realized when the tickler is moved to a point just prior to the point of oscillation. In other words, you want to obtain maximum feedback without the circuit going into oscillation.



The rear surface of L2 should look something like this before it is mounted to the frame of the radio. Remember that the taps after turns 48 and 66 consist of two wires each, one coming from and one going to the coil form. The start wire extends up from the small hole on the left. The finish wire is pushed through the small hole on the right after turn 74.

The RF choke (L4) is used to prevent RF from being introduced to the audio-output circuit. The audio output of V1 is fed through C4 to grid 1 of V2 (a second 3S4 pentode tube, configured for Class-A audio-amplifier operation) at pin 3. Resistor R5 connected to pin 3 of V2 provides a negative bias and a high-impedance input resistance, as well. Grid 2 of V2 (at pin 4) is connected directly to B+ to provide maximum charge to that grid. A negative charge is provided through the filament for grid 3 of V2.

A 2.4k resistor, R4, connected between the plate and B+ is used as the plate-load. That value was chosen for maximum gain with minimum distortion. Capacitor C6 is used as a DC blocking capacitor to prevent DC from reaching the output device. Amplification in this stage of the circuit is produced in a similar manner to the action occurring in V1. The main difference is that no feedback is used and there is no detector.

Construction. The Regenerative Vacuum Tube Receiver can be built from scratch by the enterprising hobbyist, however, it is available in kit form from the supplier listed in the Parts List. The kit includes a wooden frame plus baseboard and all the necessary hardware to build the receiver. The supplier also makes available separately the audio amplifier portion of the circuit shown in Fig. 1. The amplifier may be installed at any time, even after the radio is built, however, the following instructions assume both are being installed at the same time.

If you wish to build the unit without benefit of a kit, you'll have to fabricate the baseboard, face plate, etc., yourself from wood. The layout is not critical, though you should follow the general scheme discussed. Use some scrap ½-inch stock to fabricate the chassis rails, and a 9 × 5¾-inch piece of thin particleboard stock for the baseboard. The balance of the article will assume that you are working with the kit.

Start by attaching the four baseboard rails to the bottom of the baseboard. Fasten the front and rear chassis rails to the bottom of the baseboard with five screws; three in front, two in back. The baseboard rail with five holes goes to the front of the baseboard, with the small cluster of three holes at the left (for the spiderweb coil forms), and the other two holes at the right (for the face plate).

Before inserting the screws, it will be necessary to punch small starter holes in the chassis rails with an awl or similar tool. Likewise attach the two side rails.

Then attach the four Fahnestock clips, with soldering lugs, to the baseboard (as shown in Fig. 2) with the screws provided. Those screws also hold the antenna, ground, and audio-output terminals. Next pick up the tube sockets, turn them over, and bend each of the seven metal pins outward from the body of the socket. Cut off the tiny metal cylinder attached to the center of the socket; halfway will be fine. Mount the tube sockets on the baseboard using plastic spacers. Mount the five terminal strips (TS1–TS5) and then mount the dual C-cell battery holder and three 9-volt battery holders where indicated in Fig. 2.

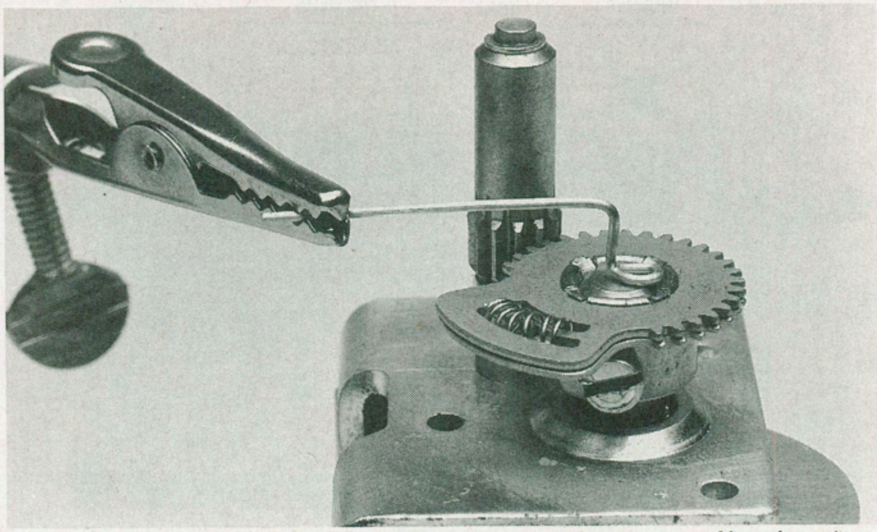


Fig. 3. The dial pointer on the variable capacitor is made from a piece of bare bus wire and is shaped as outlined in the text. The dial pointer is affixed to a gear mechanism with a bit of solder.

The Variable Capacitor. The variable capacitor requires a bit of preparation before it can be mounted. That unit has five sections: The first section is 250 pF, the second is 125 pF, and the remaining three sections are 20 pF each. Cut a piece of bus wire about 1½-inch long and straighten it. Fashion one end of the bus wire into a tiny circle, then bend the wire so that it forms a right angle with the little loop. About 3⁄16 inch from the first bend, bend the wire again. After the second bend, the remaining long section of wire should be parallel to the plane of the loop and extended in the opposite direction.

Support the loop over the middle of the central gear drive of the variable capacitor. Secure the pointer in the proper place (see Fig. 3) with a drop of solder or glue. The section of the pointer that moves over the surface of the dial plate should be about 1 inch long. Once the pointer is attached, turn the capacitor over with the gear drive mechanism at the right. Be careful not to bend the wire dial pointer. With the capacitor flipped over, a row of five rectangular metal lugs should be visible. Mentally number the lugs 1 through 5, going from left to right.

Cut three pieces of bus wire; two to about 3½ inches long and the other about 4½ inches. Take one of the shorter sections of wire and solder one end to lug 2 of the capacitor, and bend the section back and away from the other lugs. Solder one end of the 4½-inch bus wire to lug 3 (the one in the middle) of the capacitor. Now manipulate that section away from lug 2 (see Fig. 4), bend it once around lug 1, and solder.

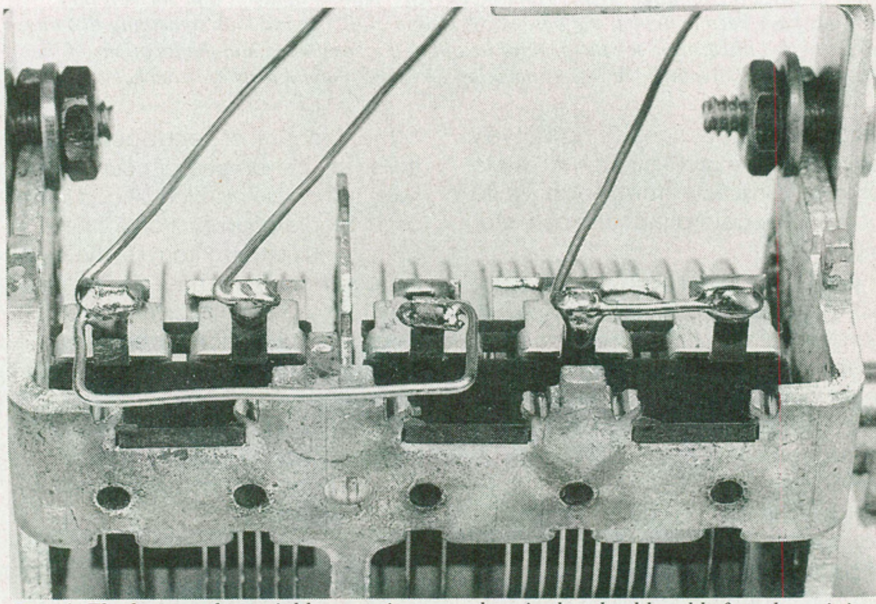


Fig. 4. The lugs on the variable capacitor must be wired and soldered before the unit is attached to the baseboard. Number the lugs in your mind (lug 1 on the far left and lug 5 on the far right), and then run sections of bare wire from lug 5 to lug 4, lug 3 to lug 1, and another piece from lug 2.

Do not permit that wire to make contact with lug 2.

Solder one end of the other 3½-inch bus wire to lug 5, bend it once around lug 4, and solder. When finished, you should have a wire coming off lug 2; a connection between lug 3 and lug 1 with a tail at lug 1, and a wire from lug 5 to lug 4 with a tail, as shown in Fig. 4. Once that's completed, look under the capacitor and locate the lug attached to the middle of the frame. That lug should be cut off. Otherwise, it may make contact with one of the bus wires.

With that out of the way, mounting brackets must now be attached to the frame of the capacitor. For the bracket furthest away from the tuning shaft, place a solder lug on the bracket's retention screw. After preparing the capacitor, mount the unit to the base board. Keep all the hardware loose for the moment.

Notice the two rectangular notches cut into the corners of the capacitor's metal frame, one on each end. Mount the entire assembly on the base with two machine screws. Do not tighten those screws. The bus wires should run under the capacitor and be pushed through the lower holes of lugs 2, 3, and 4 on TS5 (see Fig. 2 for position of TS5) as follows: The bus wire coming off lug 4 of the capacitor goes through the lower

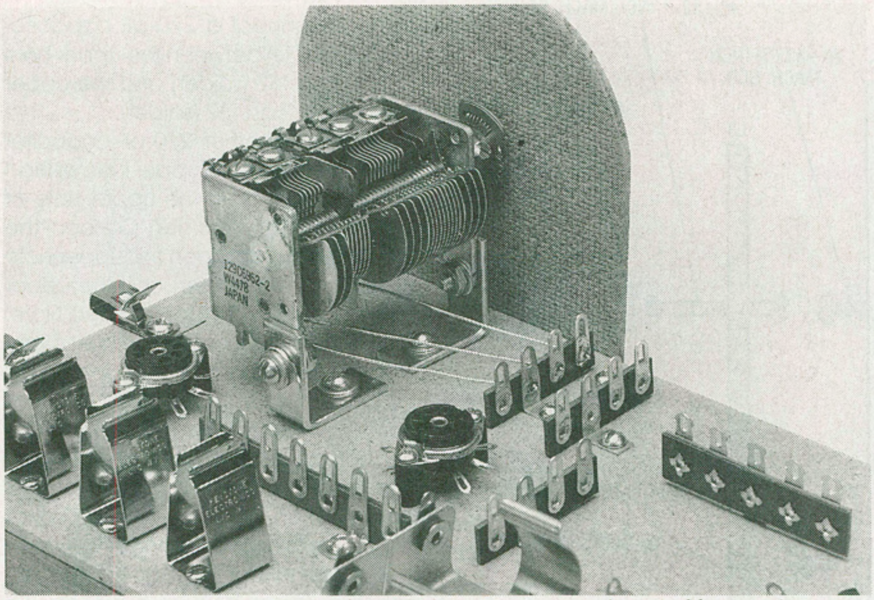


Fig. 5. The lengths of bare bus wire connected to the lugs on the variable capacitor, passed under the body of the unit, and are connected to a terminal strip mounted on the baseboard.

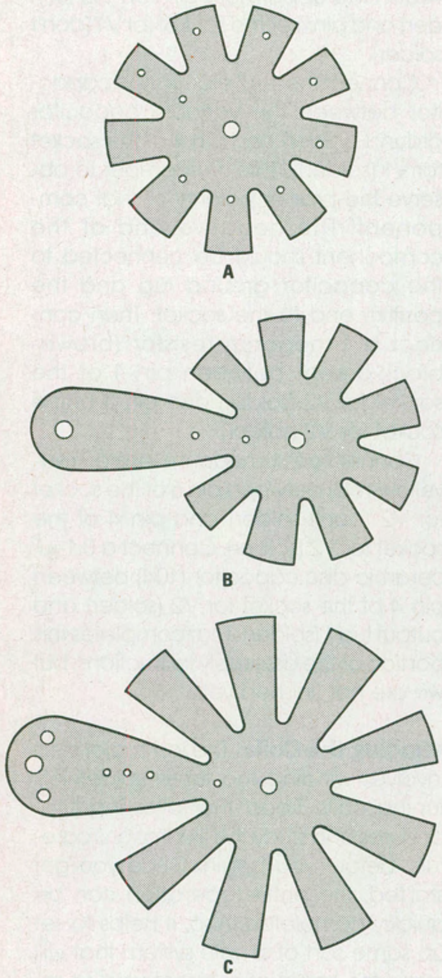


Fig. 6. Templates for the three coil forms on which the L1–L3 are wound are shown here at half size. The circles on the forms indicate the relative size and locations on the form where holes are drilled to accommodate the coil wires and coil-mounting hardware.

hole of lug 4 (as shown in Fig. 5); the wire coming off lug 2 of the capacitor goes through the lower hole of lug 3 of TS5; and the wire coming off lug 1 of the capacitor goes through the lower hole of lug 2 of TS5. Once in position, do not solder, just leave things as they are and go on to the front panel.

The Front Panel. Locate the power switch, the capacitor knob, the paper dial label, and the face plate. Using a sharp hobby knife, very carefully cut out the two circular holes in the paper dial label. Then glue the label to the face plate. Make sure the holes in the label are aligned with the ones in the face plate. Lower the face plate slowly over the wire dial pointer and screw it to the wooden frame of the radio. You may have to bend the pointer slightly in order to get the plate into position.

Once the face plate is in place, adjust the entire tuner assembly so that the pointer and the capacitor shaft are coming out from the center of the appropriate holes. When everything looks right, tighten all the hardware and solder the bus wires on the variable capacitor to the terminal strip. Install the black plastic knob on the capacitor shaft, tighten the setscrews, and install the power switch.

The next task is to interconnect the individual components of the circuit already mounted to the baseboard. Those are not the only components that go into the circuit but merely the ones that we'll be dealing with at this point. Also, because certain wires (bare bus, blue, black, and red) are keyed to different areas of the circuit, each grouping will be taken individually.

Bus Wiring. See Fig. 2 for the locations of various terminal strips (TS1–TS5) referred to in the following instructions. Connect a 1½-inch length of bus wire from the antenna lug (solder) to the lower hole of lug 1 on TS1 (solder). Connect a 2-inch wire from the lower hole of lug 3 on TS1 (solder) to the lower hole of lug 4 on TS3, but don't solder this end. Connect a 2-inch wire from the lower hole of lug 4 on TS2 (solder) to the lower hole of lug 1 on TS5 (solder).

Connect a 1½-inch wire from the lower hole of lug 1 on TS2 (don't solder) to pin 1 of the socket for V1 (solder). Connect another 1½-inch wire from lug A on the A BATT holder (solder) to lug B on the same holder (solder). Connect a 1½-inch wire from the positive lug of the A BATT holder (solder) to the lower hole of lug 1 on TS3 (solder).

Connect a 1-inch wire from the negative lug of the A BATT holder (solder) to the lower hole of lug 2 on TS3 (don't solder). Connect a ⅜-inch wire from lug 1 of the power switch (don't solder) to lug 4 of power switch S1 (solder). Connect a ⅝-inch piece from lug 2 of the power switch (solder) to lug 5 of the power switch (don't solder). That completes the bus wire instructions.

Black Wiring. Again referring to Fig. 2, make the following connections, using the black wire only.

Connect a 2½-inch piece of black wire from lug 1 of the power switch (solder) to output lug 2 (don't solder). Connect a 7-inch wire from lug 5 of the power switch (solder) to the upper hole of lug 2 on TS3 (solder). Connect a 3½-inch wire from output lug J2 (solder) to the capacitor ground (don't solder). Note: the capacitor ground (CG) is the soldering lug screwed to the frame of the variable capacitor. A total of five connections go to the capacitor ground, so keep your wiring neat.

Connect a 3¼-inch wire from the capacitor ground (don't solder) to the lower hole of lug 1 on TS4 (solder). Connect a 2¾-inch wire from the capacitor ground (don't solder) to the lower hole of lug 1 on TS2 (solder). Connect a 2¾-inch wire from unit ground (don't solder) to lower hole of lug 2 on TS2 (solder.) Note: the unit ground is the ground terminal (Fahnestock clip) of the radio itself. It's located right next to the antenna terminal.

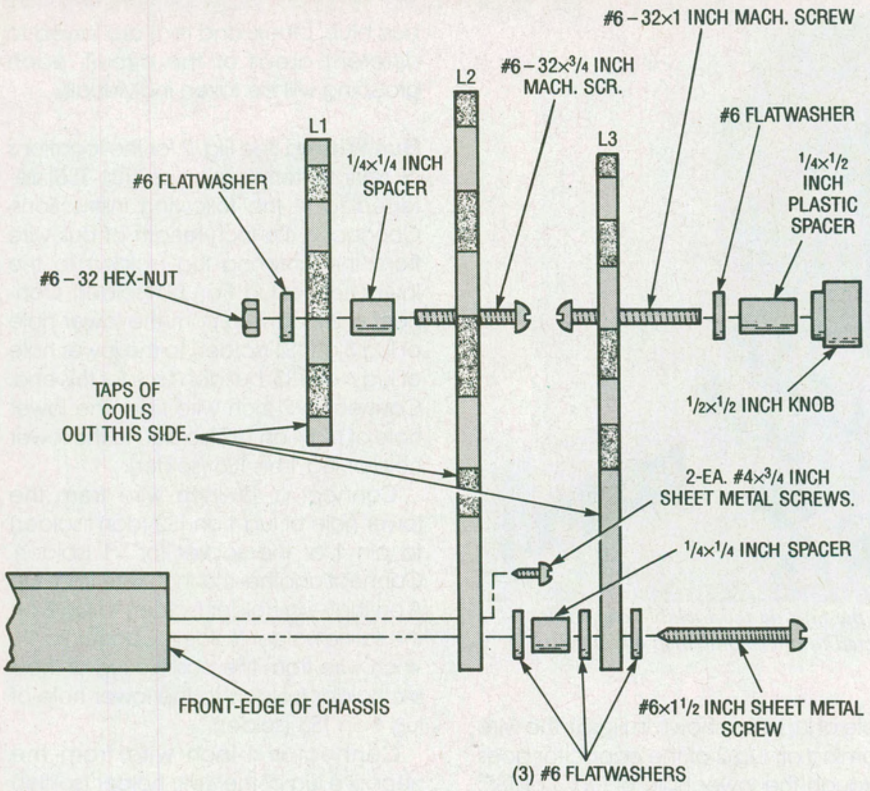


Fig. 7. Shown here are the mounting and final assembly instructions for the three coils. Refer to the text for details.

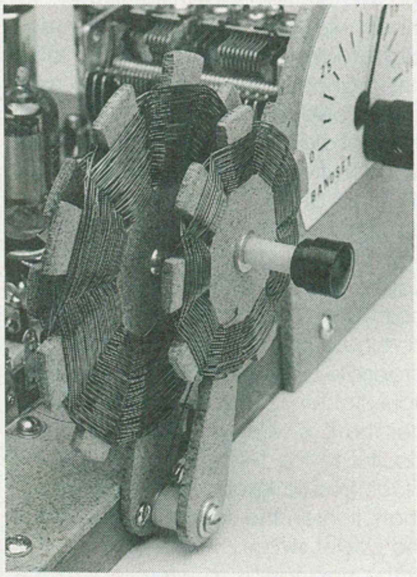
Connect a 3-inch wire from unit ground (solder) to the lower hole of lug 2 on TS1 (solder). Connect a 2-inch wire from the capacitor ground (don't solder) to pin 1 of the socket for V2 (don't solder). That completes this portion of the wiring instructions.

Red Wiring. Connect a 1½-inch length of red wire from the upper hole of lug 1 on TS3 (don't solder) to pin 7 of the V1 socket (solder). Connect a 4½-inch wire from the upper hole of lug 1 on TS3 (solder) to pin 7 of the V2 socket (solder). Connect a 3-inch wire from the upper hole of lug 4 on TS3 (don't solder) to pin 4 of the V2 socket (don't solder).

Blue Wiring. Connect a 4½-inch length of wire from lower hole of lug 4 on TS1 (solder) to the lower hole of lug 3 on TS3 (solder). Connect a 2½-inch length from the lower hole of lug 5 on TS1 (solder) to pin 2 of the V1 socket (solder). Connect a 2-inch wire from the lower hole of lug 2 on TS2 (solder) to pin 3 of the V1 socket (solder). Connect another 2-inch length from the upper hole of lug 7 on TS3 (don't solder) to pin 3 of the V2 socket (don't solder).

That completes the interconnecting wire instructions, however, we still have a ways to go before the Regenerative Vacuum Tube Receiver is complete.

Component Installation. Refer to Figs. 2 and 6 for the proper installation of the following components. Connect a 2.2-megohm resistor (color coded red-red-green) between the upper hole of lug 4 on TS2 (don't solder) and the upper hole of lug 2 on TS2 (don't



Here's how L2 and L3 are mounted to the front of the radio. Regeneration is controlled by moving L3 (the tickler coil) back and forth in front of L2. Note the short plastic spacer between the two coil forms near the bottom of the coil assembly.

solder). Connect a 270-pF capacitor (coded F271J) between the upper hole of lug 4 on TS2 (solder) and the upper hole of lug 2 on TS2 (solder).

Connect another 270-pF capacitor (F271J) between the upper hole of lug 1 on TS2 (solder) and the upper hole of lug 3 on TS3 (don't solder). Connect the 2.4-mH choke between the upper hole of lug 3 on TS3 (solder) and the upper hole of lug 5 on TS3 (don't solder). Note: The choke is the small brown coil of very fine wire. There's only one like it in the kit.

Connect a 0.1-µF ceramic-disc capacitor (coded 104) between the upper hole of lug 5 on TS3 (don't solder) and the upper hole of lug 7 on TS3 (solder). Then connect a 47,000-ohm resistor (yellow-violet-orange) between the upper hole of lug 4 on TS3 (solder) and the upper hole of lug 5 on TS3 (don't solder). Connect another 47,000-ohm resistor (yellow-violet-orange) between the upper hole of 5 on TS3 (solder) and pin 4 of the socket for V1 (don't solder).

Connect the 1-µF electrolytic capacitor between the variable capacitor ground (solder) and pin 4 of the socket for V1 (solder). Note: Remember to observe the proper polarity of that component! The negative end of the component should be connected to the capacitor ground lug and the positive end to the socket. Then connect a 1-megohm resistor (brown-black-green) between pin 1 of the socket for V2 (solder) and pin 3 of the socket for V2 (solder).

Connect a 2.4-megohm resistor (red-yellow-red) between pin 6 of the socket for V2 (don't solder) and pin 4 of the socket for V2 (solder). Connect a 0.1-µF ceramic-disc capacitor (104) between pin 4 of the socket for V2 (solder) and output lug 1 (solder). That completes this portion of the assembly instructions, but we are not finished yet.

Winding the Coils. The last major step involves winding the three spiderweb tuning coils. Read the following procedures and study the illustrations carefully before you begin. Once you get started, the entire operation can be quickly completed. Also, it helps to set up some sort of simple system that will allow the spool of magnet wire to rotate freely without falling on the floor. I recommend putting the spool over a wooden dowel rod clamped vertically in a small vise.

There are a total of three coil forms: two small ones (for L3 and L1), and one

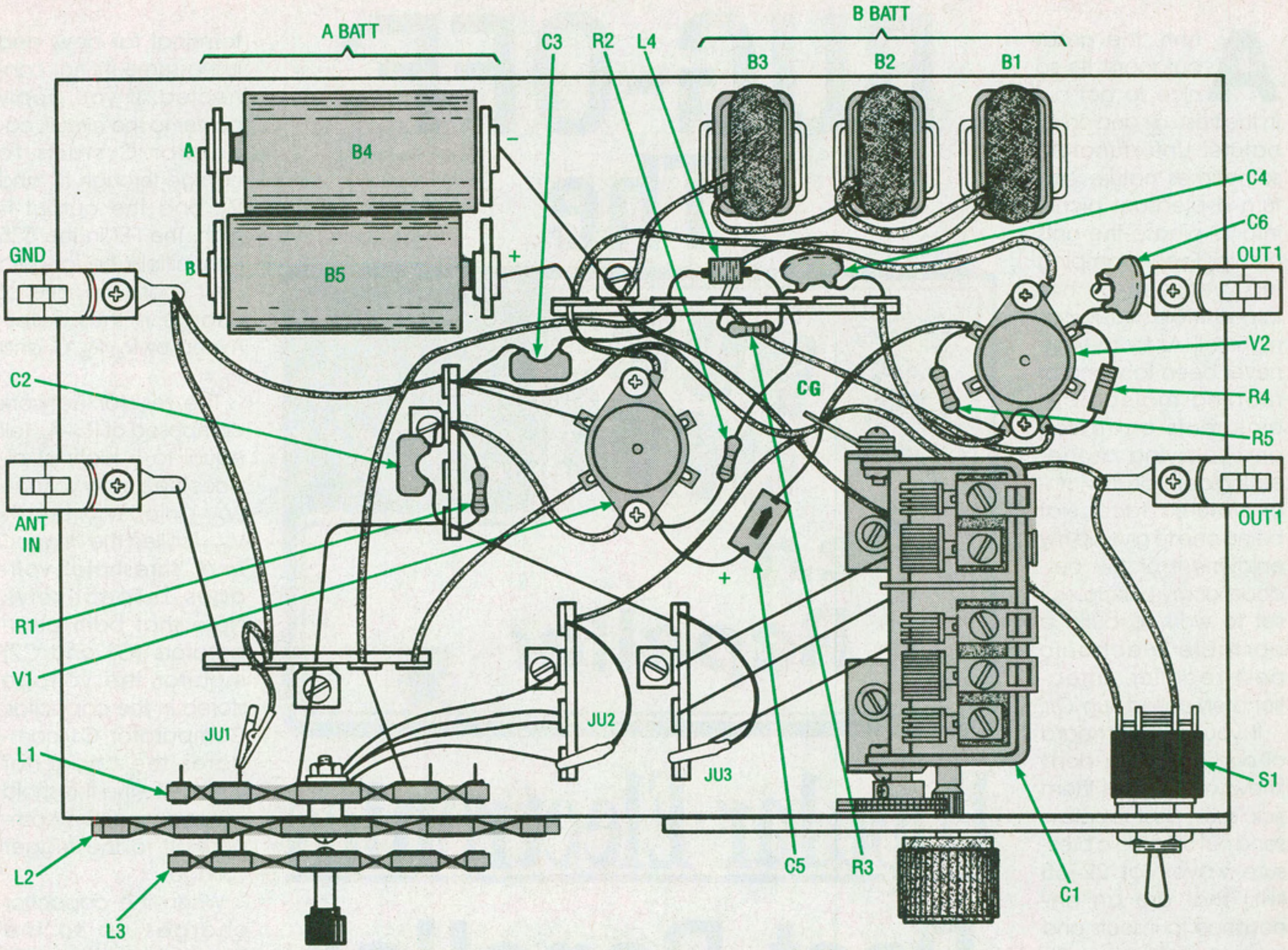


Fig. 8. Here is an overhead view of the finished receiver, showing the locations of the non-baseboard mounted components. Follow closely the instructions in the text while referring to this diagram and Fig. 2 for guidance.

large one (for L2). Full-scale templates for each are shown in Fig. 7 for those who have not purchased the kit. If you are making your own, don't forget to drill holes at the points indicated.

One of the small coil forms has a long arm on it. That one is intended for the "tickler" coil (L3) and is central to the process of regeneration. We'll be winding that coil first. Begin by placing the coil form on your work surface with the long arm pointing down and the smooth surface of the material facing up. You will note four holes: a large one at the center of the spiderweb form (for the handle), another large one at the bottom of the long arm (for attaching the form to the radio), and two smaller holes. The small holes receive the magnet wire.

Thread 6 or 7 inches of wire in through the front and out through the back of the form. Then, begin winding the coil in a clockwise direction. To get the spiderweb effect, the wire must be woven under, then over, then under, and then over the segments of the form. Wind a total of 32 complete turns. Count the turns carefully as you go. When you're finished, measure off another 6 or 7 inch section of wire, cut the wire at that point, and thread it through the second small hole. You're done with L3.

The form for L2 is the large one. The coil is wound in the same manner as L3, with one exception: there are taps on it; one is made after turn 48, and another after turn 66. The coil is complete after turn 74. Again, the wind the turns in a clockwise direction, and make sure to begin with the smooth surface of the spiderweb form facing up. Here's how to make the taps on L2. After turn 48, measure off a 6 inch section of wire, cut it, and push it through the first tap hole. The first tap hole is the small hole nearest the large center hole in the circular portion of the form. Now measure off another 6 inch section of wire and then push it through the first tap hole. Twist the two wires together a few times with your fingers. The double 6 inch section of magnet wire is the first tap.

Continue winding the coil in the same direction and repeat the tap-making procedure after turn 66. Then continue winding in the same direction and finish after turn 74. Remember that the taps will be coming out the back surface (the rough surface) of the form.

Now let's move on to L1. Coil L1 is tapped at every 4th turn for a total of 32 turns and 7 taps. It is also wound in a *counter-clockwise* (the opposite) direction. Winding the wire in the proper direction is very important.

Place the coil form on your work surface with the smooth surface up. You will see a large center hole and a number of smaller holes. The small hole nearest the center hole is the point at which the windings begin. The small hole furthest away from the center hole is where the windings end. All the other holes are for the seven twisted taps, one per hole after turn 4, 8, 12, 16, 20, 24, and 28. The start wire plus the seven taps make for a total of eight connection points on L1.

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(Continued from page 35)

The taps on L3 are made in the same manner as the taps on L2. They are, however, much shorter, only about ¼ to ⅜-inch long. The wires of each twisted tap should be scraped clean of all insulation and soldered carefully together to guarantee a dependable electrical connection. Note that the taps on L3 come out the front surface (the smooth surface) of the coil form.

Mounting the Coils. Take two #4 × ¾-inch sheet metal screws and the large coil L2, find the two starter holes on the left side of the front of the radio's baseboard and attach the coil with the screws. The taps should be coming out of the rear of the coil. Connect the start wire of L2 (that's the one nearest the center) to the lower hole of lug 4 on TS4. Keep the wire between the coil and the strip as short as possible.

Now connect the two wires that identify the tap after turn 48 to the lower hole of lug 3 on TS4. Similarly, the two wires of the tap after turn 66 are attached to lug 2 of TS4. And finally, the last wire after turn 74 is fastened to the upper hole of lug 3 on TS1. The ends of all the tap wires must be scraped clean before making any of the connections permanent.

Take the ½ × ¼-inch plastic spacer, one 6-32 × 1-inch machine screw, one #6 flat washer, the little black knob, and coil L3. Insert the machine screw through the rear of the coil form and use the spacer, washer, and knob to make a small handle as shown in Fig. 8.

Now you'll need the #6 × 1½-inch sheet metal screw, the ¼ × ¼-inch plastic spacer, and three #6 flat washers. Mount L3 to the frame of the radio with the screw, the three washers, and the spacer. The spacer goes between L3 and L2. Note that L3 must be free to move, so don't over tighten the screw.

Solder the start wire of L3 to the upper hole of lug 5 on TS1. The other wire is connected to lug 4 of TS1. The wires must be long enough to allow the coil to be moved all the way to the right and all the way to the left.

Now, attach L1 to the back of L2 with the last plastic spacer, a 6-32 × ¾-inch machine screw, a washer, and a hex nut. The taps should extend back towards the internal area of the radio. The single lead wire coming off L1 is soldered to the upper hole of lug 1 on TS1.

Finishing Up. Take the three 9-volt battery snaps and the three small alligator clips. Each clip has a 3 inch lead wire already attached. Solder one alligator clip lead to the upper hole of lug 2 on TS1, another to the upper hole of lug 1 on TS4, and another to the upper hole of lug 1 on TS5.

Now solder the battery snaps together in series and cover the exposed connections with some heat shrink tubing. Attach the remaining black lead wire to the lower hole of lug 2 on TS3 and the red one to the lower hole of lug 4 on TS3.

Finally, plug the two 3S4 pentodes into the empty sockets, connect one 9-volt battery to each of the three battery snaps, and place two 1.5-volt C-cell batteries in the holder for the B BATT with the positive and negative poles in the right place.

Operation. Obtain a piece of wire at least 25 feet long, attach one end to the antenna terminal, and drop the other end out of a window. Hanging it over the top of a nearby door should work, too. Get another long piece of wire and connect one end to a water pipe and the other end to the ground terminal. Then hook up a crystal earphone; one is included in the kit.

Next you must decide what frequency range you wish to receive, and set the taps on TS4 and TS5 accordingly. Table 1 is provided as a guide. Note that the frequencies specified assume an antenna that's resonant at between 3 and 4 MHz. Further, the frequencies given are merely ballpark figures. Experimentation is the best way to achieve maximum performance.

As a starting point, pick up the alligator clip connected to lug 2 of TS1 and attach it to the first tap (the start tap) on L1. Once again, that's the tap nearest the center of the coil. Attach the alligator clip soldered to lug 1 of TS4 to lug 4 of TS4. Then attach the clip connected to lug 1 of TS5 to lug 4 of TS5. Your radio is now ready to receive the standard broadcast band (535 to 1605 kHz).

Finally, swing the tickler coil (L3) all the way over to the left. Turn the radio on and rotate the variable capacitor until you hear a station. If you are not satisfied with the reception, change the tap on L1. You can also try changing the capacitor taps on TS5 and the L2 taps on TS4. Now, slowly move L3 towards the central area of L2. The signal will become stronger. At some point, as the tickler gets closer and closer to the center of L2, the system will begin to oscillate, which means a loud squeal in the earphones. Move L3 back a bit, the squeal will disappear, and the station will return. ■

TABLE 1—FREQUENCY-RANGE CHART

TAPS TS4	TS5	FREQUENCY RANGE
0 T	275 pF	550 kHz to 1350 kHz
0 T	125 pF	850 kHz to 1750 kHz
48 T	275 pF	1150 kHz to 2.5 MHz
48 T	125 pF	1700 kHz to 3.3 MHz
66 T	275 pF	3.0 Mhz to 3.8 MHz
66 T	125 pF	3.5 MHz to 4.0 MHz
66 T	50 pF	3.7 MHz to 3.95 MHz