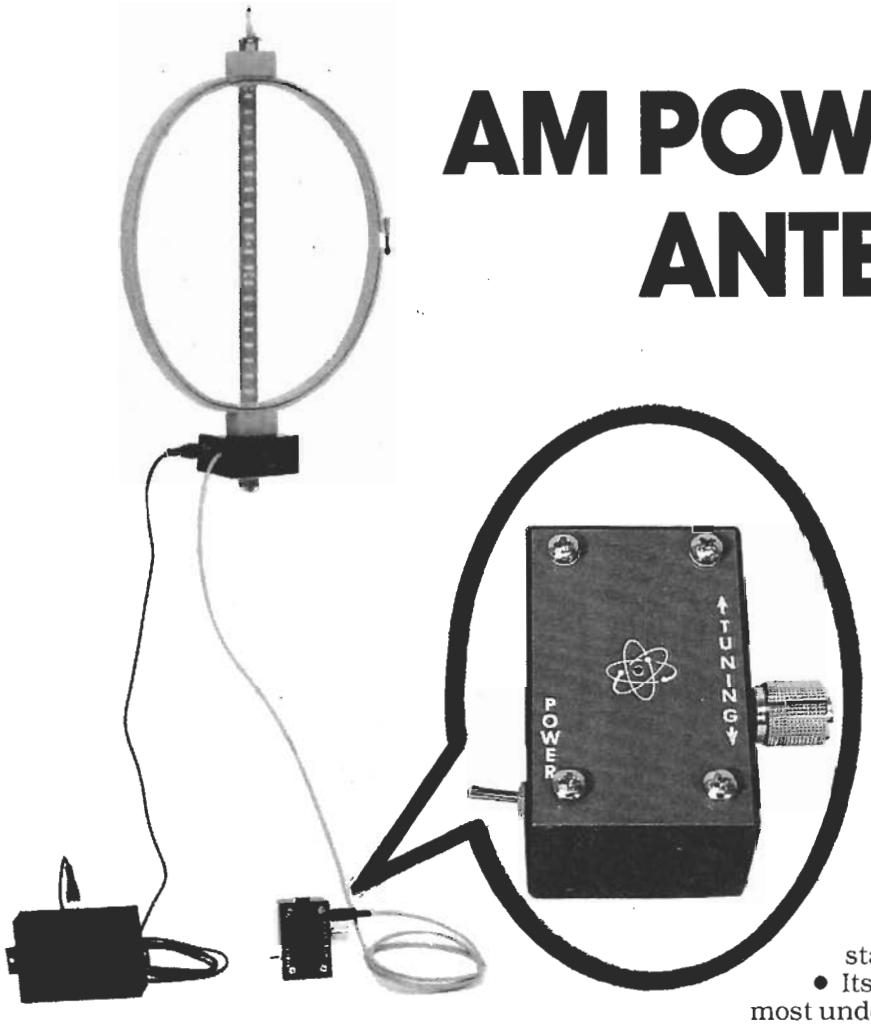
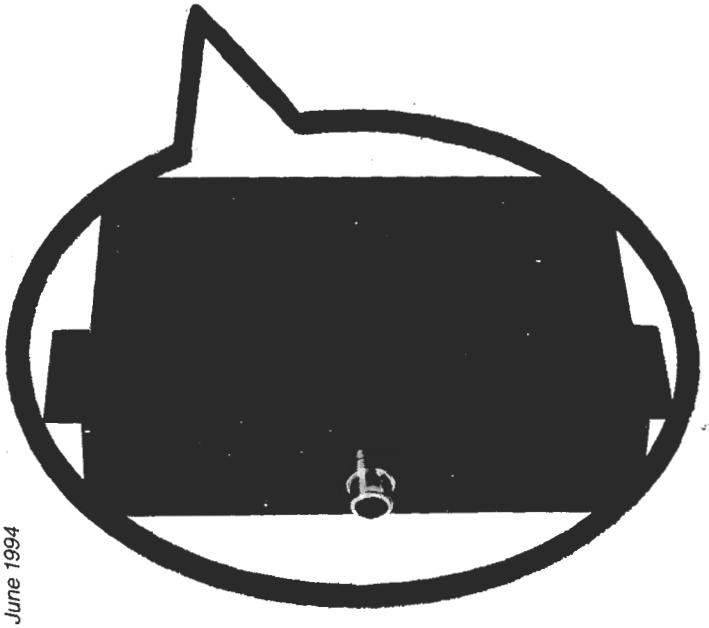
# AM POWER LOOP ANTENNA



***Build this AM radio antenna booster and receive distant stations that you never expected!***

ALLEN A. GAULT

IF ANY OF YOUR FAVORITE AM RADIO stations is hard to receive because it is so far away, the Power Loop, an AM radio antenna booster, is the project for you. When coupled to your AM receiver, the improved signal-to-noise ratio it makes possible to boost the reception of any station in the 535 to 1705 kHz AM band. It will help out in poor reception areas, and you might even find yourself listening to AM stations that you never knew existed!

Here are some reasons you'll want to build this compact, easy to operate Power Loop:

- It eliminates the need to "jockey" your radio around to get the best signal from the AM station you want to hear.
- Its directivity reduces or eliminates most undesired interference, including radiated AC hum.
- It reduces or eliminates annoying heterodyne whistle.
- It compensates for AM receiver antenna circuit *tracking error*," assuring ideal RF tracking across the entire band.

The Power Loop is an easy to build, high-performance accessory for your AM radio. It contains no costly, hard-to-get components or critical wiring. Both circuit board construction and a modest amount of mechanical crafting are needed to build the project. Its power consumption is very low—a matter of milliwatts, and no special tools or test instruments are needed. However, a multimeter will be helpful for troubleshooting if the Power Loop does not work correctly when it is first turned on.

The high-Q loop can be remotely tuned with a rotary potentiometer control. The loop, the largest component in the system, can be attached to the wall above your AM radio. No electrical connections to your radio are needed because the loading coil, an important system component, is inductively coupled to the ferrite "stick" antenna in your radio. If the enclosure on your AM receiver is large enough, the loading coil can be placed inside.

## Power Loop system

The Power Loop has four components and five functional sections, as shown in Fig. 1:

1. *Tuner amplifier*—includes the loop antenna and the tuner-amplifier. The varactor-tuned antenna is connected to the low-noise amplifier mounted at the base of the loop. The assembly consisting of the tuner amplifier and loop antenna can be attached to the wall near your AM receiver with a picture hook, suction cups or adhesive pads.
2. *Remote tuning control*—contains the power switch, tuning potentiometer and power indicator LED. Its rectifier-filter circuit converts the 24-volt AC input from the wall outlet-mounted transformer to filtered DC. The unit provides the variable voltage required to tune the loop to the desired frequency.
3. *Loading coil*—is placed near the AM receiver to couple the amplified RF signal to the host AM radio receiver inductively.
4. *Transformer*—a plug-in, wall-outlet-mounted transformer that supplies 24-volt AC to the remote tuning control from the 120-volt AC line.

## Circuit operation

Figure 2 is the schematic for the tuner-amplifier. The loop antenna is connected to the gate input of transistor Q1, and it is tuned by varactor D1. Tuning voltage is available through R1, which is connected to the remote tuning control with a two-wire shielded cable and plug PL1. The drain output of Q1 is coupled to the gate of Q2 for additional amplification. The drain output of Q2 is coupled to the gate of Q3, which is connected as a source-follower.

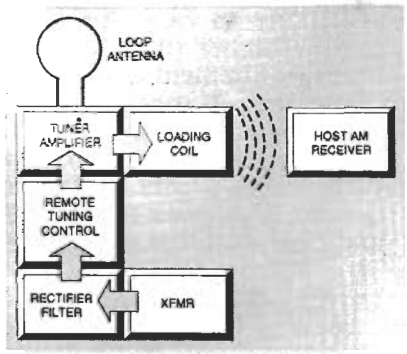



**FIG. 1—AM ANTENNA POWER booster block diagram. The loop antenna can be mounted on or near the host AM radio. The loading coil field couples to the AM radio's antenna.**

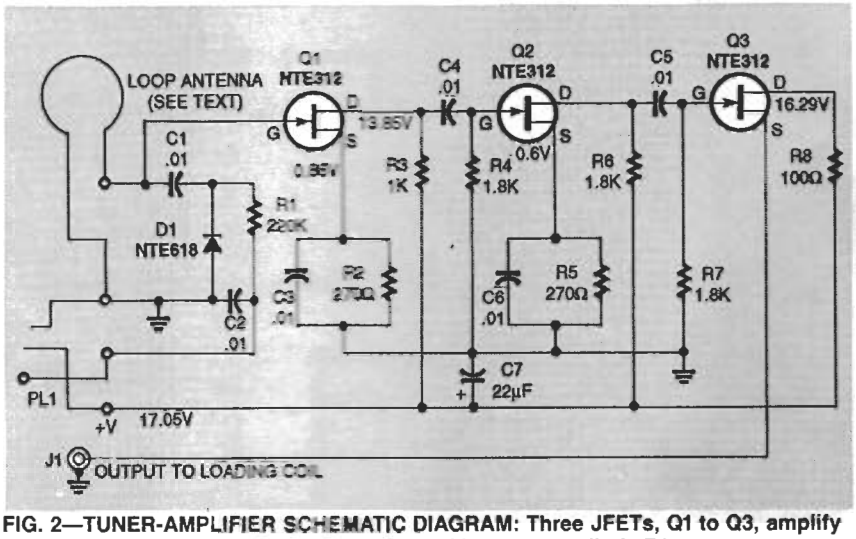



**FIG. 2—TUNER-AMPLIFIER SCHEMATIC DIAGRAM: Three JFETs, Q1 to Q3, amplify the signal. Loop antenna tuning is performed by varactor diode D1.**

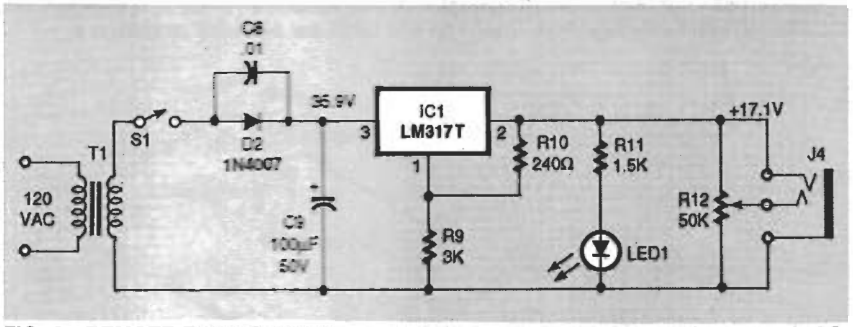



**FIG. 3—REMOTE TUNING CONTROL UNIT SCHEMATIC DIAGRAM. Raw 24-volt AC input is rectified and regulated in this circuit designed for improved filtering. Potentiometer R12 permits fine tuning.**

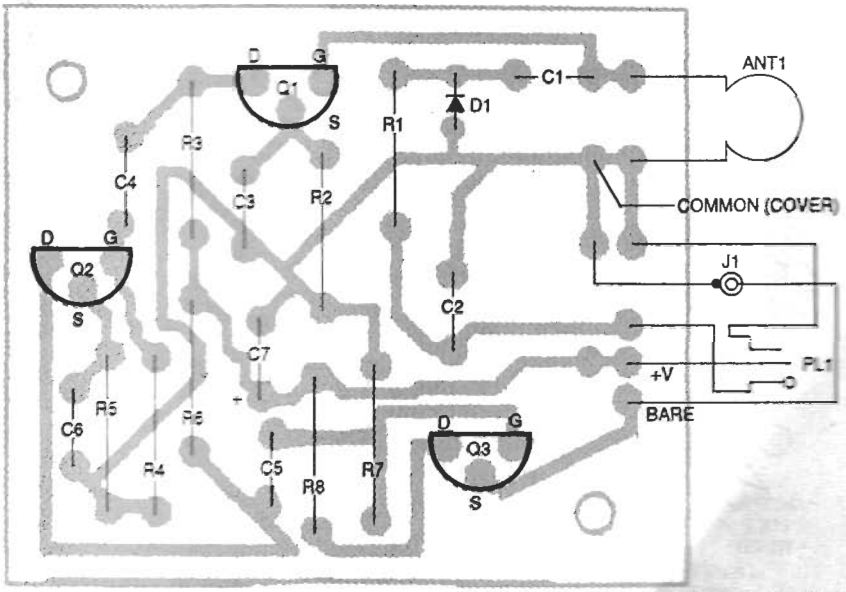



**FIG. 4—PARTS PLACEMENT DIAGRAM FOR TUNER-AMPLIFIER. Jack J1 and plug PL1 are mounted on the case.**

The high input impedance of Q1 presents minimal loading on the tuned loop. The Q3 source-follower powers the loading coil

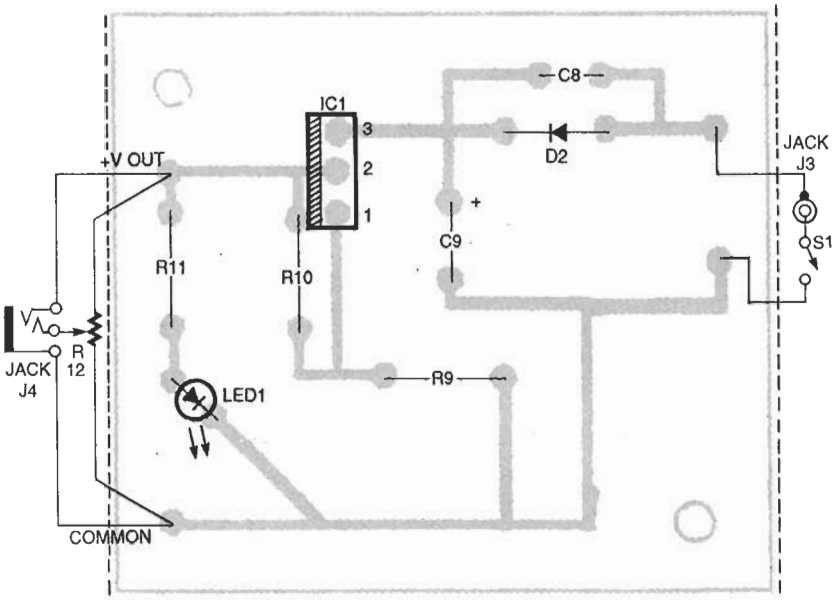



**FIG. 5—PARTS PLACEMENT DIAGRAM FOR THE REMOTE TUNING CONTROL. Jacks J3 and J4, potentiometer R12, switch S1 and LED1 are mounted off the case.**

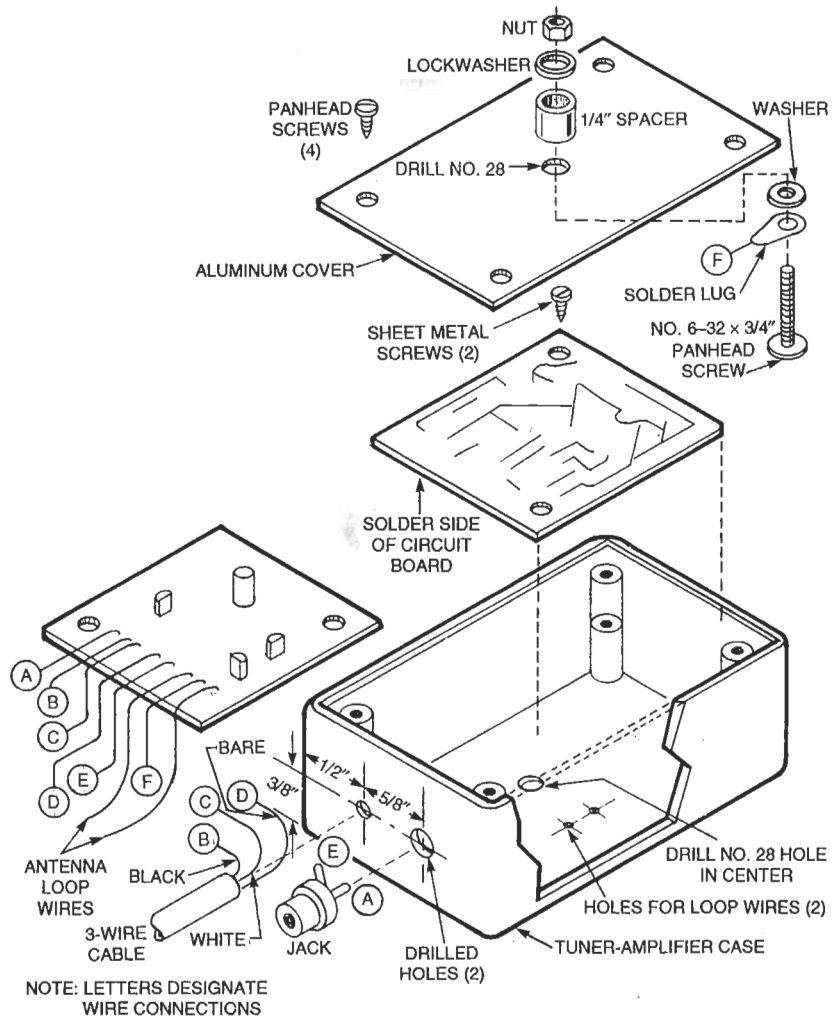


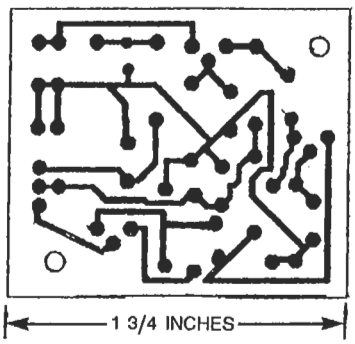

**FIG. 6—ASSEMBLY DIAGRAM FOR THE TUNER AMPLIFIER. The circuit board is mounted in an inverted position, and the complete unit moves with the loop antenna.**

through a shielded phono cable. The voltage values to be expected at various test points in the circuit are given.

Figure 3 is the schematic for the remote tuning control. The 24-volt AC from the wall-outlet transformer via cable can be turned on and off by switch S1. Diode D2 rectifies the input AC voltage, and C8 filters out AC line hum. Capacitor C9, part of the "L" input filter, filters the rectified voltage.

Three-terminal TO-220-packaged voltage regulator IC1 can be adjusted to provide about 17 volts DC by setting the ratio of the value of resistor R9 at pin 1 with respect to that of R10 shunting pins 1 and 2.

The rectification and filtering function are included in the remote tuning control to eliminate tunable hum likely to be present if a stock wall outlet-mounted AC-to-DC adapter were used. Capacitor C8, in parallel with diode D2, blocks tunable hum.




**FOIL PATTERN FOR TUNER amplifier PC board.**

At least a 17-volt output is needed to tune the loop over over the entire AM broadcast band, but the distributed capacitances of each system and the varactors like D1 (see Fig. 2) are likely to vary. A voltage slightly higher than the minimum requirement assures adequate capacitance change to cover the entire AM band. The voltage values to be expected at various test points in this circuit are also given to two decimal places on this schematic.

### Loading coil

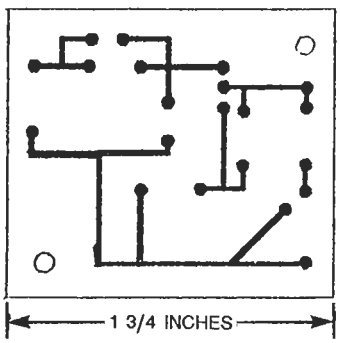
Loading coil L1 in the Power Loop is a ferrite-rod antenna, typical of those found in most AM radio receivers today. It can be salvaged from a discarded radio or purchased from the

source given in the Parts List. Only the high impedance part of the winding is used.

### Electronic construction

*Tuner-amplifier*—Refer to Fig. 2 and the tuner-amplifier parts-placement diagram Fig. 4. A foil pattern for the tuner-amplifier circuit board is included in this article if you want to make your own, but a finished board is available.

Insert and solder the components to the circuit board following conventional practice. Be sure the soldering iron is appropriate for the small size of this circuit board and that it is




**FOIL PATTERN FOR REMOTE tuning control PC board.**

at the at the right temperature for melting rosin-core solder. Observe the orientation of the packages and pins on JFETs Q1, Q2 and Q3, and observe the polarity of electrolytic capacitor C7 when inserting them in the board.

*Remote tuning unit*—Refer to the schematic Fig. 3 and the remote tuning unit parts placement diagram Fig. 5. A foil pattern for the tuner-amplifier circuit board is included in this article if you want to make your own, but a finished and drilled board is also available from the source given in the Parts List.

Insert and solder the components to the circuit board, again following conventional practice. Again, be sure the soldering iron is appropriate and at the right temperature for melting rosin-core solder. Observe the correct positioning of the package and pins of voltage regulator IC1 and the polarities of electrolytic capacitor C9 and diode D2 when inserting them.

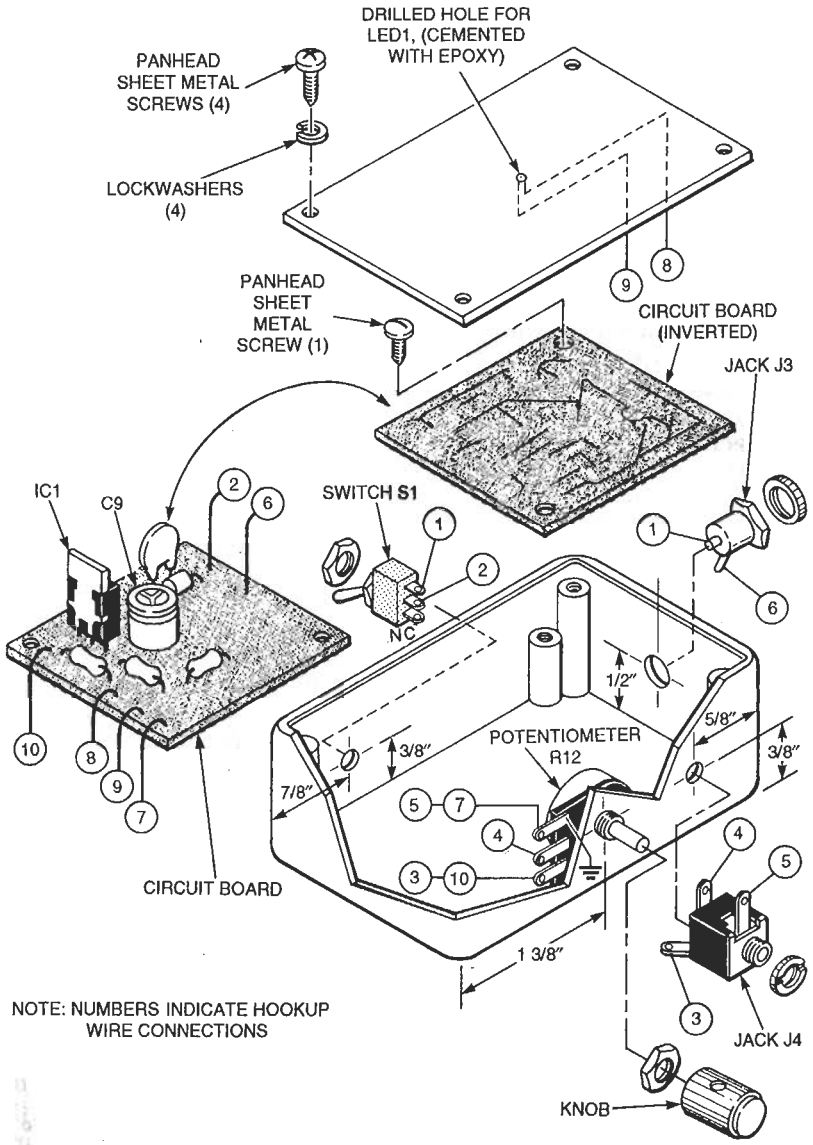
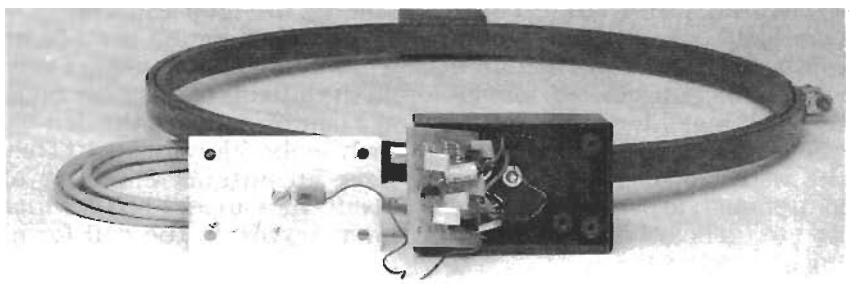



**FIG. 7—ASSEMBLY DIAGRAM FOR THE REMOTE TUNING CONTROL. This unit includes the rectifier and filter for noise-free DC and the tuning potentiometer R12.**



**ANTENNA-TUNER AMPLIFIER ASSEMBLY.**

### Packaging the electronics

*Tuner-amplifier.* The tuner-amplifier case is a stock project case with an aluminum cover that measures 2 11/16 × 1 11/16 × 1 3/16 inches. Refer to the assembly diagram Fig. 6, and drill a hole in the center of the cover with a No. 28 drill.

Cut and strip both ends of a 4-inch length of insulated, No. 22 hookup wire and solder a lug to one end. Place the lug on a No. 6-32 × ¾-inch panhead machine screw as shown in Fig. 6, and assemble a washer before inserting it in the hole and fastening it with a ¼-inch spacer, lockwasher, and nut, as shown. (The free end of the wire will be connected to the ground bus on the circuit board later.)

Drill the five holes in the plastic case as shown in Fig. 6. The central hole in the case must align with the hole in the cover plate. Install the RCA-type phono cable jack J1 in one hole, and insert a ¼-inch ID rubber grommet in the other hole.

Insert the end of the ten-foot, two-wire shielded cable in the grommet and strip the jacket to permit making the three connections as shown in Fig. 6.

Connect the center conductor of jack J1 (A to A in Fig. 6) to the PC board with about 2¾ inches of shielded cable. Keep the unshielded part of the center wire as short as possible on each end. Connect the shield to the ground connection on J1 and the other end to the ground bus on the board. Solder the wire from the solder lug on the cover to the circuit board (F to F in Fig. 6). (The leads from the loop antenna will be soldered later.) SET the tuner amplifier aside.

*Remote tuning control*—The case for the remote tuning control is a stock project case measuring 2 11/16 × 1 11/16 × 1 3/16 inches. Drill a hole in the aluminum cover to admit the lens of the miniature red LED1. Drill the holes as shown in the mechanical assembly diagram Fig. 7 for the switch S1, jacks J3 and J4, and potentiometer R12. Mount those components in the walls of the case.

Complete all of the hookup wiring between the circuit board and the off-board components with No. 22 insulated wire. (Different colored insulation will make troubleshooting easier.) Cut and strip the ends of the wires to lengths that are long enough to permit removing the circuit board without breaking any connections.

When all of the soldering is complete, invert the board and fasten it to the inner stud with a single panhead sheet metal screw as shown in Fig. 7. Cement LED1 in place with its lens projecting through cover with epoxy, and clamp the leads to underside of the cover with an insulating adhesive strip. Close the cover and fasten it with four screws. Set the unit aside.

*Loading coil.* The plastic case for the loading coil measures 4¼ × 2⅛ × 1-inch deep, and it has a plastic cover. Drill a hole for mounting RCA phono jack J2 in one wall of the plastic case, as shown in Fig. 8. Mount the jack in position as shown. Cut, strip, and solder the hookup wires as shown in Fig. 8. from the coil to J1.

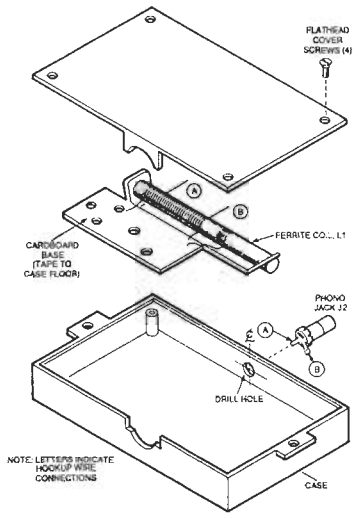



**FIG. 8—ASSEMBLY DIAGRAM for the loading coil. Unit is located in or near the host AM radio.**

Fasten the coil base in the bottom of the case as shown in Fig. 8 with double-sided adhesive tape.(The coil might or might not have a cardboard base.) Close the cover and fasten it with four screws. Set it aside.

### Making the loop antenna

The loop antenna is made by winding insulated magnet wire on the outside of the inner hoop of a pair of standard wooden 10-inch embroidery hoops. (They have an outside diameter of about 10⅜ inches.) The inner hoop serves as the coil form, and the outer loop serves as a protective cover. These hoops are available in sewing supply and craft shops as well as five and ten and department stores, typically for less than $2.

The complete loop antenna will be clamped inside a "C-" shaped support bracket with screws and nuts that will permit it to be moved through almost 360° in either direction, inhibited only by the interference of the attached cables. The antenna is fitted to the bracket with two adapters and screws that form poles 180° apart on the outer hoop, as discussed later.

Obtain a piece of soft wood that measures about ¾ × ¾ inch, about a foot long for making the two adapter blocks shown in the detail of Fig. 9. There are many ways to transfer the contour of the outside of the outer crochet hoop to the end of the wood stock. However, you can carefully position the hoop over the end of the wood and trace part of its circumference directly on the wood with a pencil to obtain an accurate pattern.

Clamp the end of the wood in a vise and carefully cut out the shallow arc with a sharp knife, coping saw or both. Then, using

**PARTS LIST**

**All resistors are ¼-watt, 5%.**
R1—220,000 ohms
R2, R5—270 ohms
R3—1000 ohms
R4, R6, R7—1,800 ohms
R8—100 ohms
R9—3000 ohms
R10—240 ohms
R11—1,500 ohms
R12—50,000 ohms potentiometer, PC board mounting

**Capacitors**
C1, C2, C3, C4, Cr, C6—0.01μF, radial-leaded, Mylar, 50 volts
C7—22μF, 35 volts, aluminum electrolytic
C8—0.01μF, ceramic disk, 100 volts
C9—100μF, 50 volts, aluminum electrolytic

**Semiconductor**
IC1—LM317T voltage regulator, TO-220 package, Motorola or equivalent
Q1, Q2, Q3,—N-channel JFET, NTE 312 or equivalent
D1—varactor, NTE 618 or equivalent
D2—1N4007 silicon diode
D3—light-emitting diode, red, T1 or miniature axial lead.

**Other components**
J1, J2—RCA jacks, panel mounting
J3—audio jack for two-conductor shielded audio cable
J4—jack to mate with 24-volt AC input plug from wall-outlet mounted transformer
L1—loading coil, high-Q ferrite, (see text)
PL1—plug for two-conductor

the hoop as a form, place sandpaper on the outside, grit side up, and carefully sand the cutout arc so that it conforms closely to the hoop's outside diameter.

Measure in ¾ inch from the end of the wood and drill a hole at right angles to the flat edge of the wood through the center of the curved surface with a No. 28 drill bit. Countersink the hole as shown in Fig. 9 to admit a flat head No. 6-32 machine screw so that the end of the screw is completely below the contoured surface when seated.

Cut off a 1½-inch length squarely from the contoured and drilled end of the wood and mark it "A" lightly in pencil. Then repeat the entire process to make a second adapter. Mark the second adapter "B."

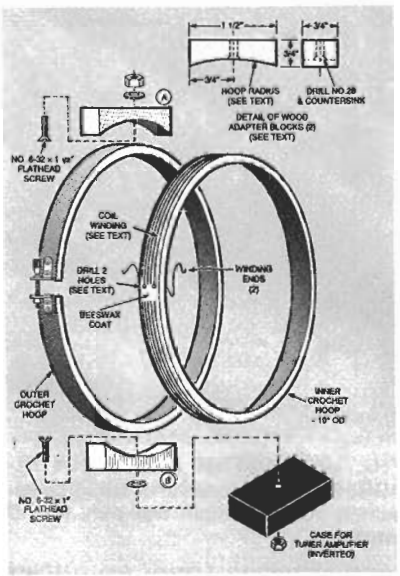



**FIG. 9—LOOP ANTENNA construction. The outer hoop protects the coil windings.**

Insert a No. 6-32 × 1½-inch flat head machine screw in the adapter marked "A" and a No. 6-32 × 1-inch flat head machine screw in the hole of the adapter marked "B." Apply epoxy around the countersunk parts of the holes of both adapters to seat the screws. Avoid getting epoxy on the exposed external threads. Temporarily put a washer and nut on the ends of both screws until the epoxy sets.

When the epoxy has set, remove the clamping nut from adapter "A" and add a second washer, ¼-inch standoff, lockwasher and nut on the screw. Glue the adapters to the outside surfaces of the outer hoop 180° apart but 90° away from the thumbscrew clamp with wood glue, as shown in Fig. 9. Clamp the adapters and set the outer hoop aside for at least 12 hours.

After the glue on the adapters has set, you can paint, lacquer, or varnish both the inner and outer loops. Be sure there is no metallic pigment in any of the finishes you choose.

### Winding the coil

Drill two holes just large enough to accept the No. 26 AWG wire winding ends through the inner hoop as shown in Fig. 9. They should be drilled close to the outer rim but not close enough to weaken the rim edges.

Before starting the coil winding, apply a coating of heated beeswax to the outer surface of the hoop to keep the winding from sliding off. The wax can be obtained from sewing supply stores.

Insert the first 6 inches of a 50-foot length of No. 26 AWG enameled magnet wire in one hole, and bend it back so that it will not slip out. Wind on 16 turns of wire (in either diection) around the outside of the hoop as shown in Fig. 9, pushing the turns close together in the wax layer as you wind.

After you have completed winding the turns on the rim of the hoop, insert the free end in the second hole and allow another 6 inches before cutting off the rest of the wire. Apply more heated beeswax to both ends of the two drilled holes to secure the wire in position.

Insert the inner hoop inside the outer hoop. Clamp the hoops together with the thumbscrew clamp mechanism on the outside of the outer hoop. Shape the two ends of the magnet wire so they lie over the side of the lower adapter.

### Loop supporting bracket

Attach the tuner amplifier case to the No. 6-32 × 1-inch screw on adapter "B" with a lockwasher and nut. Thread the ends of the antenna loop wires through the holes drilled for them in the bottom of the case. Dress the wires to the sidewall of the case, opposite the jack J1 end, allowing enough slack to permit the circuit board to be removed and inverted, but keeping them as short as practical. When you have determined a satisfactory length, cut the wires and strip the insulating varnish back from their ends.

Secure the wires to the outside of the adapter and to the inside end wall of the case with hot beeswax. Solder them as shown in parts-placement diagram Fig. 4 and assembly diagram Fig. 6. Invert the circuit board and fasten it in position inside the case with two sheet

shielded audio cable

S1—toggle switch, SPST, panel mount

T1—transformer, 120-VAC to 24-VAC, 100 mA or greater, wall outlet-mounted with output cable and plug

**Miscellaneous:** PC board for tuner-amplifier; PC board for remote tuning control; shielded phono cable terminated with RCA plugs, both ends, 6 feet; two-conductor shielded audio cable, 10 feet; metal shelf-mounting channel, 3 feet (see text); two spacers, ¼ long; tuner-amplifier case with cover (see text); remote tuning control case with cover (see text); loading coil case with cover (see text); knob for potentiometer; No. 6-32 machine screws, nuts, lockwashers (see text), epoxy cement; wood glue; double-sided adhesive tape; solder; beeswax.

**Note: The following parts are available from Allen A. Gault, 2012 Citrus Avenue, Jessup, MD 20794:**

- **Drilled PC boards for tuner amplifier and remote tuning-control unit—$8.95**
- **High-Q loading coil with mounting tape—$3.95**
- **No. 25 magnet wire, 50 feet—$1.95**
- **Kit of all items listed above—$13.95**

**Add $1.50 for shipping and handling; Maryland residents add local sales tax.**

metal screws. (Use an insulating washer if the screw short circuits any traces on the circuit board when the board is fastened in position.) Assemble the cover to the case with the four panhead sheet metal screws.

Accurately measure the distance between the centers of the heads of the No. 6-32 nuts as shown in Fig. 9 by setting the completed loop antenna on a piece of paper and marking the points on the paper. This is the overall assembly height dimension. Record that measurement. (It should be approximately 13⅞ inches with the 10-inch loop and case specified.)

Then measure the distance from the supporting screws to the rim of the loop antenna, add 1 inch and record that measurement. This dimension should be about 5½ inches. Record that measurement.

Obtain a 3-foot length of ⅝-inch wide, stamped channel stock for mounting light shelving to walls from a hardware or building supply store. Measure off the two arm length dimensions and one length equal to the height of the antenna and tuner amplifier assembly on the channel stock and cut it to length.

Drill ⅛-inch holes close to both ends of the channel to accommodate No. 6-32 machine screws. Cut 90° vee-cuts 5½ inches in from both ends on both edges of the channel stock so the ends can be bent into the C-shaped mounting bracket, as shown in Fig. 10. Carefully bend the stock into the right shape to form the bracket.

Temporarily assemble the

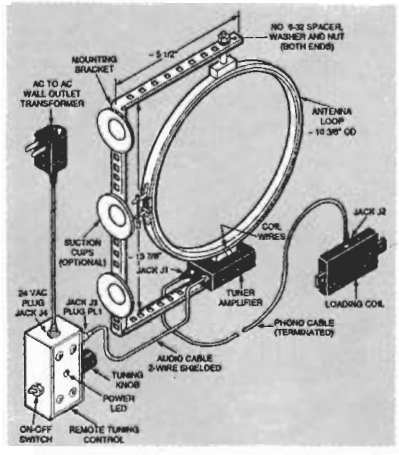



**FIG. 10—SYSTEM ASSEMBLY DIAGRAM. The antenna-tuner amplifier assembly rotates within wall-mounted C bracket.**

loop antenna-tuner amplifier assembly to the bracket to be sure that it fits correctly and there is no interference fit when the loop antenna is turned past the bracket. Once you have determined that the bracket is sized correctly and that the antenna loop-tuner amplifier assembly moves freely, you can remove the assembly from the bracket and paint the bracket.

After the paint is dry, apply either suction cups, a picture-hanging hook, or adhesive pads for mounting the completed assembly on the wall.

### Interconnections

Refer to mechanical assembly diagram Fig. 10. Assemble the mounting bracket to the loop antenna and tuner-amplifier with washers and nuts. Be sure the connection is secure but loose enough to permit the loop to be rotated.

Terminate the two-conductor shielded audio cable with plug PL1 that mates with jack J3. Plug the cable from the tuner amplifier in jack J3 of the remote tuning control. Plug one of the plugs of the six-foot length of shielded phono cable in jack J1 of the tuner amplifier and the one at the other end into jack J2 in the loading coil.

### Operating the Power Loop

Plug wall-outlet transformer T1 into the 120-volt AC outlet and insert the 24-volt AC output plug into the jack J4 on the remote tuning control unit. Turn on the power switch. The LED power indicator should light at thie time.

Tune in a weak AM station on your AM radio. Place the loading coil near the AM radio and rotate the knob on the potentiometer in the remote tuning control to peak the signal. Orient the loop to the best reception position.

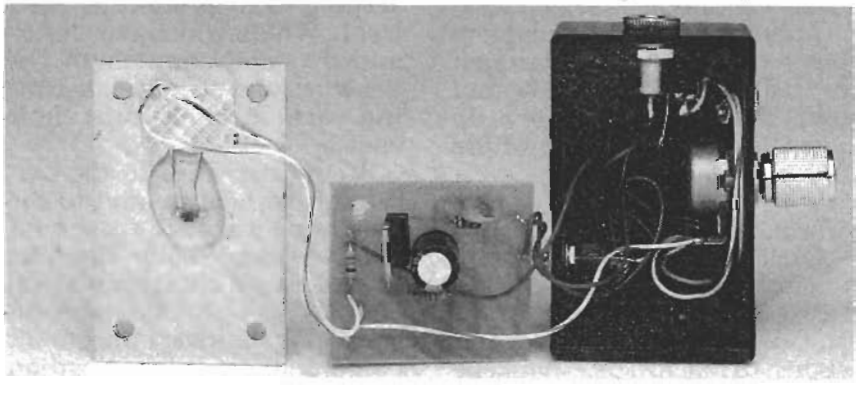
Find the best location for the loading coil with respect to your AM radio. It could be taped to the back of the radio or fastened to the wall with the back of the radio positioned against it. Overall Power Loop gain should be about 350.

The received signal should be noticeably improved as long as the desired signal strength is less than the *desensitize* level of the receiver's automatic gain control (AGC), but greater than the existing "noise floor" level. When the AGC starts to reduce the sensitivity of the receiver, no additional signal enhancement will be evident.

To prevent possible oscillations due to feedback, position the loop antenna-tuner assembly on the wall at least two feet away from the loading coil.

If the system does not work as expected, carefully re-examine all of your work. Check to make sure that there are no loose or open connections.

You can also measure the voltages at the test points indicated by voltage readings in schematics Figs. 2 and 3. Compare your measurements with the values shown. Any significant variations should indicate a fault and help you to isolate it. Correct any faults revealed by this test. Ω



**REMOTE TUNING CONTROL.**