A Simple Transmitter

Now that you are well "organized" for listening on the amateur bands, and are preparing for an amateur license, you are ready to begin thinking about a transmitter with which you can converse with fellow radio amateurs. In the case of a receiver the decision of whether to build or to buy often results in the purchase of a ready-built receiver. In the transmitter field, however, the picture is just the opposite — most amateur stations use a home-built transmitter. The problem of whether to build or buy is much easier to decide when we discuss transmitters, because a transmitter can grow, like Topsy. That is, you can start off with a low-powered oscillator, and add higher-powered amplifiers as your skills and finances permit. So, about the only decision necessary is that of how simple, or how elaborate, you want your first transmitter to be. As in the case of the receiver, we recommend that you build a very simple one to start with — it keeps your initial outlay of cash small, you get a good deal of experience in construction and practical operation, and the components can be used again in later transmitter designs you may decide to build.

What we are going to describe now is a very inexpensive *crystal-controlled* transmitter of one tube. First of all, what do we mean by a "crystal-controlled" transmitter? Basically, a transmitter is simply a vacuum-tube oscillator designed to deliver radio frequency power to a radiating antenna. You'll remember in the section on "How Radio Works" that we discussed *resonance* of tuned circuits. With coil and condenser combinations of the proper sizes we can tune to various frequencies. That's just how we tune our simple receiver (or any receiver, for that matter) — by adjusting the capacity of a variable condenser which is connected across a coil. We could use this same method to control the frequency of a transmitter oscillator, and many amateur transmitters are so constructed. However, rather elaborate precautions are necessary to keep the signal clean and free from "chirps" or other signs of instability. For a beginner, there is a simpler and safer way to control transmitter frequency, and that is by means of a quartz crystal. By using crystal control it is far easier to achieve a clean, stable signal. The crystals used in amateur transmitters are thin wafers of quartz mounted between two metal plates. A crystal has the property of vibrating at some frequency, determined by the size of the quartz plate, when a voltage is applied to it. This is known as the *piezo-electric effect.* The quartz crystal takes the place of a coil and condenser combination, and as a result the transmitter will operate on only one frequency. In order to operate on more than one frequency in the same band it would be necessary to have more than one crystal. But, by using crystal control, you can be fairly certain that the stability of your transmitter satisfies FCC requirements.

This one-tube transmitter is designed to operate in the 80- and 40-meter amateur bands, using but a single 80-meter crystal for operation in both bands. Operation on the 40-meter band is accomplished by "doubling," meaning that the transmitter is adjusted so that the output frequency is twice, or "double," the crystal frequency. Thus, since the telegraph band extends from 7000 to 7200 kc., you should use an 80-meter crystal whose frequency lies between 3500 and 3600 kc. (half of 7000 and 7200, respectively). It would actually be better if you bought a crystal somewhere between 3505 and 3595 kc., thereby allowing yourself a margin of safety. However, if your aim is for a Novice Class license (see later discussion under "Licenses") you will want to get a crystal for one of the 80-meter band frequencies open to Novice operation — that is, between 3700 and 3750 kc.; you could use this only on the one band, of course. For 40-meter Novice operation, you will need a separate crystal since these two Novice bands are not "harmonically-related" (even multiples) and the "doubling" system will not work out to locate you in the Novice frequencies 7175–7200 kc.

Reference to the photographs will show you how simple this little transmitter is. To minimize the tools required, a simple chassis of wood is built. To be really fancy you can finish it with

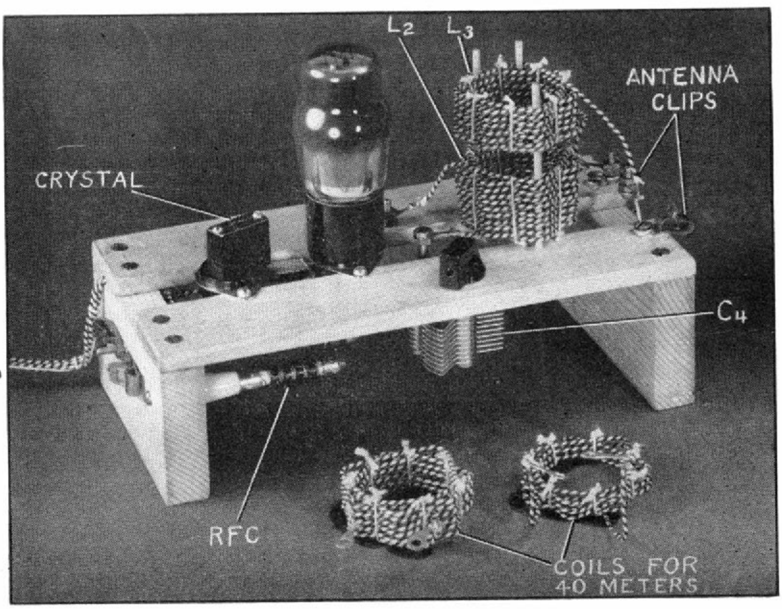


Fig. 13 — A close-up of the simple transmitter, showing details of construction.

clear lacquer or dip it in hot paraffin. This might help its electrical efficiency a bit, but isn't essential. Two 1¾ × 9¾-inch strips of ¼-inch-thick wood are fastened with screws to two 4½ × 2½ × ¾-inch end pieces, leaving enough separation (about 1 inch) between the strips to fasten the octal sockets used for the crystal and the tube. Wood screws can be used to mount the sockets, or they can be bolted to the wood strips with 6-32 machine screws. The key of the tube socket (the key is the little indentation in the round hole through the center of the socket) should be mounted toward the front of the transmitter, for convenience in wiring the plate circuit to the tuning condenser. The tuning condenser (C_4) may not have a long-enough mounting shank (threaded bushing) on it, in which case it will be necessary to first drill a clearance hole for the shank and then dig away — or counterbore — clearance for the nut. The two Fahnestock clips for the antenna are secured under two of the screws used for fastening the wood strips to the right-hand end piece, and the other two clips used for the key leads are held down by machine screws on the left-hand end piece. The r.f. choke (*RFC*) is held in place on the left-hand end piece by a machine screw. The four wires used for a power cable are brought out at the rear left under the wood strip — a half-round hole being filed or cut with a knife to clear the wires.

The plate coil (L_2) and antenna coil (L_3) are held in place on three small sticks set in the top of the chassis — penny suckers are a good source for these sticks! Drill holes a hair larger than the sticks, and then glue them in; if you don't have a drill large enough, whittle the end of the stick to fit the drill you do have. The plate coil connects, at the bottom, to a brass machine screw soldered to a lug which in turn is soldered to the stator terminal of the tuning condenser, and the screw is built up most of its length by adding nuts or small spacers to it. The screen (B+) end of the coil, the top end of the winding, is fastened to a brass screw that runs through the rear wood strip. The coil ends have lugs soldered to them to facilitate band-changing, but this refinement isn't absolutely necessary. The antenna-coil ends are connected by fastening their lugs to two brass screws supported by short lengths of heavy wire (antenna wire, for example), the wire being soldered to the Fahnestock clips and to the heads of the screws.

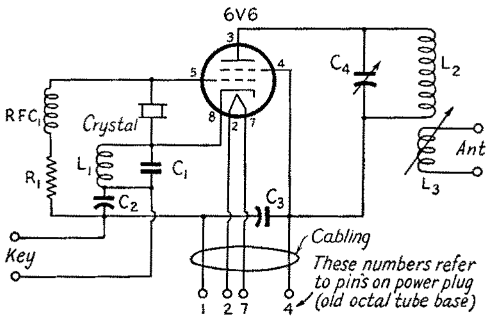


Fig. 14 — Schematic diagram of the wiring of the little transmitter.

Wiring the little transmitter isn't much of a job. See Fig. 14 for the circuit diagram. As can be seen from the photographs, the wiring is done with the same wire that is used for the coils, because a single 50-foot roll of No. 18 bell wire, available in any five-and-ten or hardware store, suffices for the whole rig with some to spare. To ensure good electrical contact, the wire is soldered at every connection, which means that the wire is soldered to the heads of the brass machine screws used for the key leads and the screen end of L_2 before the screws are put in place. One key lead, one end of R_1, the outer foil (usually marked "ground") connections on C_2 and C_3, and the lead to the negative side of the power supply are all connected to Pin 1 of the tube socket. At the crystal socket, two adjacent pins (for example, 1 and 8) are bonded together for the grid side of the crystal and the next two pins (2 and 3) are bonded together for the cathode side. This permits plugging the crystal into either Pins 8 and 2 or 1 and 3.

The coil in the cathode circuit (L_1), consisting of 5 turns of No. 18 bell wire, is wound on a 1¼-inch diameter form and then removed and tied with string at a number of places. One might think that the coil would fall apart when it is removed from the form, but the wax on the insulation of the wire helps to hold it until a few pieces of string have been tied in place. The cathode coil is mounted by its leads only but, being short, they offer adequate support.

The plate and antenna coils are wound in a simple fashion that was popular in the early days of ham radio and that is still practical for anyone trying to save on coil forms. Laboratory tests

Parts List for Simple Transmitter

C_1 — 470-μμfd. mica condenser
C_2, C_3 — 0.01-μfd. 600-volt paper condenser
C_4 — 140-μμfd. variable condenser (Bud MC1876)
R_1 — 0.1-megohm 1-watt composition resistor
L_1 — 5 turns No. 18 d.c.c. (bell wire), 1¼-inch inside diameter
L_2 — *3.5 Mc.*: 19 turns. *7 Mc.*: 12 turns (see text for method of winding)
L_3 — *3.5 Mc.*: 13 turns. *7 Mc.*: 6 turns (requires experiment to get exact number of turns needed)
RFC — R.f. choke, 2.5 mh. (National R-100U)
Type 6V6 tube
2 octal bakelite sockets
1 50-foot roll of bell wire
4 Fahnestock clips, ¾ inch
3 thin dowels (lollipop sticks), 4 inches long
1 knob for tuning condenser
1 quartz crystal — see text for choice of frequency (Peterson, Bliley, etc.)
1 old tube base (for power plug)
3 pieces of wood for chassis (see text for sizes)
1 radiotelegraph key
Soldering lugs and miscellaneous small hardware such as wood screws, 6-32 machine screws and nuts.

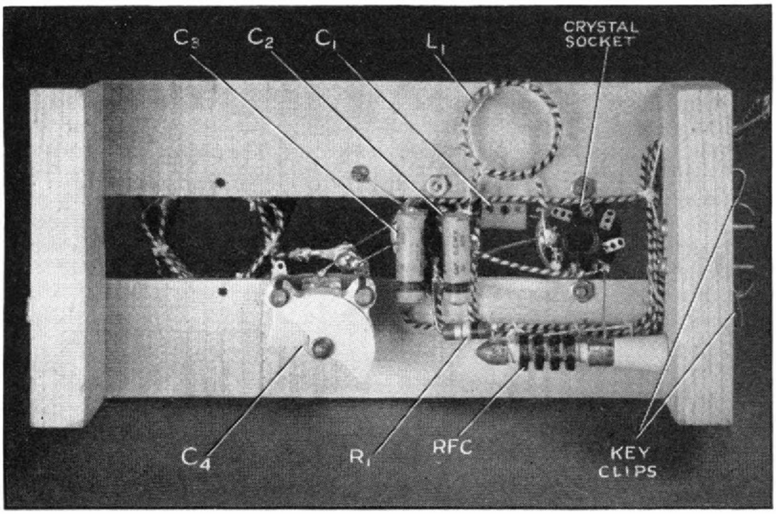


Fig. 15 — Showing the mounting of parts underneath the "chassis."

show that these coils have good characteristics, and so you need have no qualms about using this type of coil construction. They are wound by equally spacing seven nails on a 2-inch diameter circle, driving the nails completely through the board used so that the heads are flush against the board. See Fig. 16. Small spikes can be used, or nails of the "8-penny" size will be satisfactory

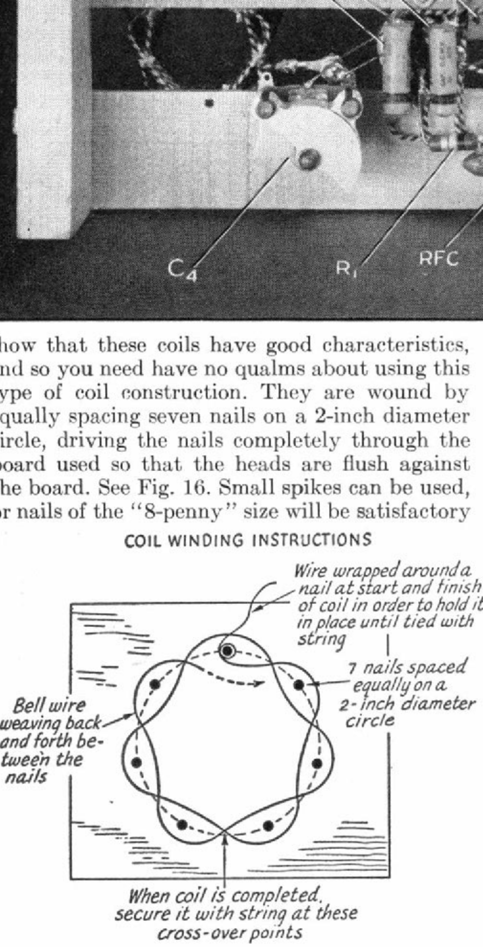


Fig. 16 — Method of winding coils for the simple transmitter.

if a thin board is used. One end of the wire is secured to a nail and the wire is threaded over alternate nails, May pole fashion, so that the coil repeats itself every two turns. When the required number of turns has been made, the end of the wire is wrapped around a nail and the coil tied together with string at the seven cross-over points. The result is an inexpensive coil having fair mechanical properties and good electrical ones, and it is difficult to build one any more cheaply. Soldering lugs are soldered to the ends of the coil for ease in changing bands, though this isn't absolutely necessary, as mentioned earlier. If you don't use lugs, simply wrap the bared end of each wire around the appropriate machine screw and fasten with a nut.

The four wires coming out the side of the chassis that go to the power supply are twisted together slightly and cabled with string to form a neat cable. For convenience they should be labeled for identification using small tabs of paper and Scotch tape. These wires run to an old tube base which plugs into the power socket in the power supply. Get yourself an old octal-base glass tube (any radio service shop has some burned-out tubes of this description), and remove the glass and the cement. Watch out for your eyes in breaking the glass — the best way is to enclose the tube in a rag and hit it with a hammer. Clean out the pins with your soldering iron, removing all the solder and wires already in the pins. Then connect the wires from the transmitter to the appropriate pins in this power plug that you have just made for yourself. See Fig. 14 for the correct pin connections.

Building the power supply is even easier. You could use several B-batteries, but they would run down quite rapidly, so a much better source of power for a transmitter is one which takes the regular a.c. voltage in your house, steps it up through a transformer (T_1, Fig. 17) converts it into direct current through a *rectifier* tube, and then "purifies" it by means of a filter choke (L_1) and two filter condensers (C_1, C_2). This pure direct current is necessary for your plate power supply to ensure a clean, sharp signal. The fila-

Parts List for Simple Transmitter Power Supply

- T_1 — Power transformer, 300 volts each side of center tap, 70-ma. (Thordarson T-24R02)
- L_1 — Filter choke, 12 henrys, 80 ma. (Thordarson T-20C53)
- C_1, C_2 — 8-μfd. 450-volt electrolytic condensers
- R_1 — 25,000 ohms, 25 watts
- 5Y3 rectifier tube
- 3 pieces of wood for chassis (see text for sizes)
- 2 bakelite octal sockets
- 1 male plug for 115-volt supply
- Miscellaneous wood screws, etc.

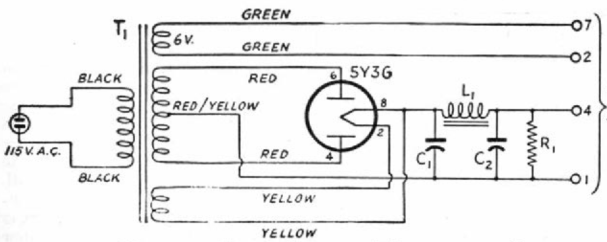


Fig. 17 — Circuit diagram of the power supply.

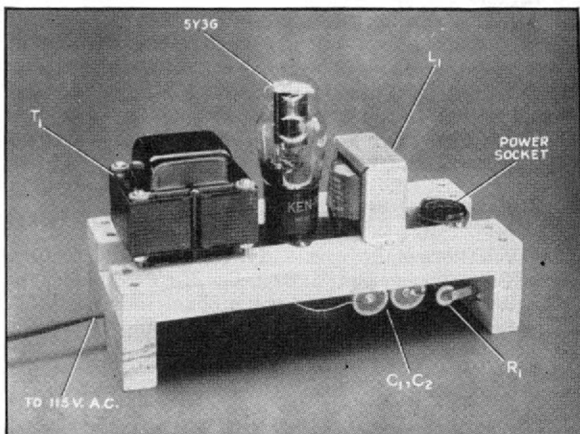
ment voltage can be a.c., so that is taken from a small winding on the transformer.

In this power supply, the same style of construction as in the transmitter is used. The photographs (Fig. 18) will show you the general layout of parts. Two 10 × 1½ × ¾-inch pieces of wood form the top of the chassis, with two pieces 4⅝ × 1½ × ¾-inch for the ends. Eight flathead wood screws 1¼-inch long are used to fasten the pieces of wood together, while roundhead woodscrews ½-inch long hold down the sockets and the filter choke. The power transformer is held in place by means of two roundhead woodscrews 2 inches long. The lead going to the 115-volt a.c. line is passed through a ¼-inch hole drilled through the end piece directly below the power transformer. The socket at the opposite end from the power transformer is for the power plug from the transmitter. It would be quite possible to use Fahnestock clips instead of this socket, and such an arrangement would be a little easier mechanically, but it would be nowhere near as safe, since the high-voltage would be exposed. Even though this is not a high-powered transmitter, it does use about 350 volts. That can easily be lethal, so use the greatest care and respect when working with it. Remember, too, that the same voltage exists at certain points on the transmitter.

See the schematic of Fig. 17 for the wiring diagram of the power supply. There are only about a dozen connections, and no coils or adjustments to be made, so you should have no difficulty.

Okay — now to see if your little transmitter works. Double-check the wiring, and then connect the 7-Mc. plate coil in place. Plug in the crystal (making sure its pins hit the right holes) and the tube, insert the power plug in the power supply, and connect a key or switch to the key clips on the side of the transmitter. Set the plate tuning condenser, C_4, at about 40 per cent meshed and turn on the power. When the tube has had time to warm up — about 30 seconds — close the key and touch a neon bulb to the plate end of L_2. Or a small 10-watt electric lamp can be connected to the antenna posts with the 6-turn antenna coil in place. If C_4 is set properly, the neon bulb will glow or the lamp will light. If this doesn't happen, try tuning the plate condenser until signs of output become apparent. The transmitter can then be checked on the 3.5-Mc. band by putting in the proper coils. Don't forget, however, that you're dealing with electricity, which can be lethal. Turn off that power supply and discharge the filter condensers by closing the key for a second or two. In other words, *don't stick your hand in your transmitter when the power supply is on.*

It is, of course, impossible to specify a transmitting antenna that will suit everyone's location. First of all, a transmitting antenna should not be a haphazard length of wire like that used on your receiver. It must be rather carefully cut to a length which is determined by the frequency on which you will operate, and the manner in which the radiating portion of the antenna is fed from the transmitter requires consideration. The subject of antennas is a fascinating one, and



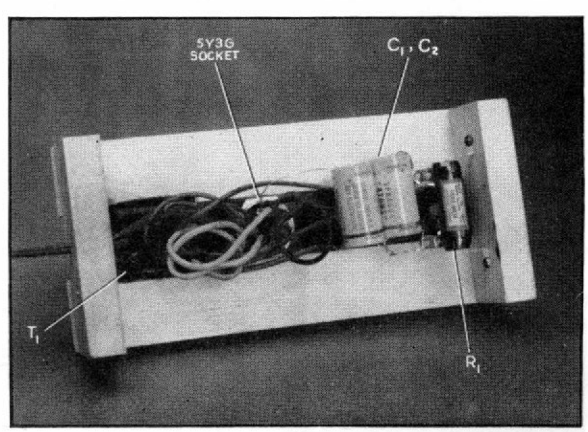


Fig. 18 — Top and bottom views of the power supply for the simple transmitter.

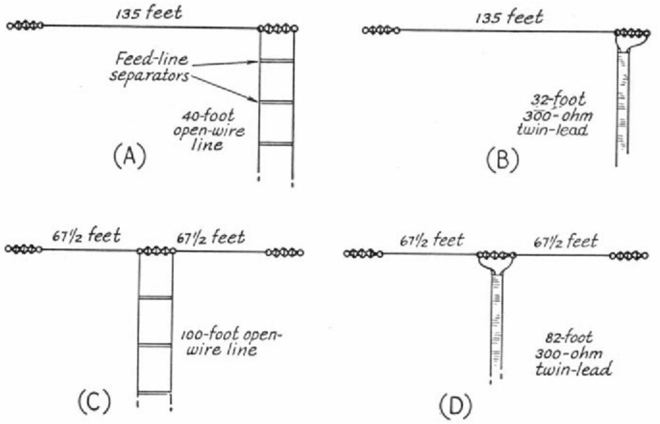


Fig. 19 — These are suggested antennas for use with the simple transmitter. The wire used should be about No. 14 enameled copper. An "open wire" feed line is one in which the two wires of the line are separated by insulated spacers 4 or 6 inches long. In (a) and (b) one side of the feed line connects 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

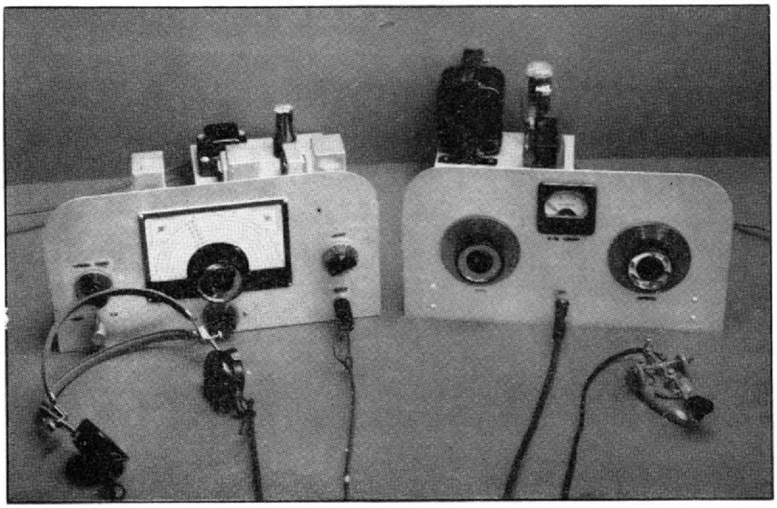


Fig. 20 — This equipment will cost a little more and take somewhat longer to build, but its performance will be greatly superior to that of the units previously described. A four-tube superhet receiver is to the left and an oscillator-amplifier transmitter to the right. Each has its own attached power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