Chapter 10

Building Transmitters

Many elements go into the making of a good transmitter, but most amateurs would agree that a most important one is stability. A signal that can't be held in tune by the receiving operator isn't going to get many contacts. Of course, you want to get the maximum possible power from the outfit, consistent with the amount of power put into it; the more r.f. power radiated, the bigger the signal. But if the signal does not stay put on one frequency, well enough to be copied on a highly-selective receiver, all the attention you may put into other details will be wasted.

At this point it would be a good idea to go back to the latter part of Chapter 8 and read what is said there about oscillator stability. All the effects described there, and the remedies suggested, apply just as much to the oscillator in a transmitter as to the oscillators in receivers. However, it takes even more care to stabilize a transmitting oscillator, simply because it is associated with higher-power amplifier stages than is the case in a receiver. These stages can "kick back" on the oscillator in various ways.

Generally, too, we try to get more power out of a transmitting oscillator than out of a receiver oscillator. This tends to exaggerate the effects of temperature, of voltage changes, and so on. Therefore it's good practice to operate the oscillator at a very low power level and build up the power by amplifiers, even if it takes more stages. It is well worth the sacrifice of some simplicity.

The crystal-controlled oscillator offers the easiest way to get satisfactory stability. It would be an exaggeration to say that a crystal oscillator is foolproof in this respect. However, it does avoid many of the problems that have to be solved in constructing a good self-excited variable-frequency oscillator. That is the reason why Novice licensees are required by the amateur regulations to use crystal control. The disadvantage is that you can't move around in the band at will, unless you have a whole selection of crystals. However, this is by no means a fatal defect, especially in the Novice bands.

Crystal Frequencies

When using harmonics of a crystal frequency you want to be sure that the harmonic falls in the band it should. Bear in mind that *all* of your signal, including key clicks in c.w. and sidebands in phone, must be inside the limits of the band or sub-band assigned for that type of operation. Table 10-I gives the fundamental crystal frequencies that will keep you inside the various band limits. The frequencies shown for phone include a 3000-cycle allowance for sideband width at the output frequency. All frequencies include an allowance for the manufacturer's tolerance, which is approximately 1 kc. in the 3.5-Mc. band, 2 kc. in the 7-Mc. band, and so on. The frequencies have been rounded off to the nearest kilocycle (on the safe side) because that is the way crystal frequencies usually are specified. The table is thus useful for ordering crystals by mail.

Table 10-I
Crystal Frequencies for Various Output Frequencies

Output Frequency	"80-Meter" Crystals	"40-Meter" Crystals
	General Class Licensees	
80-meter c.w.	3501-3999 kc.	
40-meter c.w.	3501-3649 kc.	7002-7298 kc.
20-meter c.w.	3501-3586 kc.	7002-7173 kc.
15-meter c.w.	3501-3574 kc.	7002-7148 kc.
10-meter c.w.	3501-3711.5 kc.	7002-7423 kc.
75-meter phone	3804-3996 kc.	
40-meter phone	3603-3647 kc.	7205-7295 kc.
20-meter phone	3552-3585 kc.	7104-7171 kc.
10-meter phone	3564-3711 kc.	7128-7422 kc.
	Novice Class Licensees	
80-meter c.w.	3701-3749 kc.	
40-meter c.w.	3576-3599 kc.	7152-7198 kc.
15-meter c.w.	3518-3539 kc.	7035-7081 kc.

These figures include allowances explained in the text.

If you're tempted to crowd the edge of a band, stop and think for a moment. Besides the manufacturer's **tolerance** and the bandwidth allowance, the frequency at which a crystal actually operates depends on the circuit you use it in, how much voltage you put on it, the circuit tuning

conditions, and the crystal temperature. It's dangerous to assume that your actual frequency is exactly what is marked on the crystal holder—it may be a kilocycle or two off. Unless you can measure frequency very accurately, it is best to choose your crystal frequencies a couple of kilocycles, at least, inside those given in Table 10-I. Remember that the responsibility for staying inside the band is entirely yours, in the eyes of the FCC monitors.

Tubes for Crystal Oscillators

In any crystal oscillator some of the power fed back from the plate circuit is used in keeping the crystal in mechanical vibration. In vibrating, the crystal develops the r.f. voltage that drives the oscillator tube. If the tube is one that will give a large output with a small driving voltage, we can look for a relatively large amount of power output without danger of overheating or damaging the crystal. Also, for the electron-coupled circuits (see Chapter 4), we want a tube with a screen grid that does the best possible job of shielding the plate from the control grid and cathode.

The best tubes for this purpose, if a moderate amount of power is wanted, are those made for use as video amplifiers in television receivers. The 6AG7 has long been a standby for this application. Newer types with equivalent performance are the 6CL6 and 12BY7. Audio pentodes such as the 6AQ5 and comparable types are also frequently used. All of these, when operated with 100 to 150 volts on the screen grid and 200 to 300 volts on the plate, can give outputs of a few watts on the fundamental frequency of the crystal. This type of operation is not dangerous to the crystal. When the plate tank circuit is tuned to a crystal harmonic the output is less; about half as much on the second harmonic, and one-third or a quarter as much on the third harmonic. These may seem to be rather small amounts of power, but the fact is that they are quite sufficient for driving even a fairly good-sized beam tetrode amplifier. There is no real need to have more.

Crystals

Besides the fact that crystals can handle only a small amount of r.f. power, there are some limitations on the frequencies for which they can be manufactured. Two kinds of crystals are available—**fundamental** and **overtone** types. The former oscillate on a frequency which is determined by the thickness of the quartz plate. This is called the fundamental frequency of the crystal.

Fundamental-type crystals are not usually made for frequencies higher than 10 Mc. or so. They have to be very thin at much higher frequencies, and are mechanically weak. For this reason, the design of transmitters for the amateur bands up to and including the 28-Mc. band commonly is based on using fundamental crystals operating at frequencies no higher than the 7-Mc. band. Frequency multiplication is needed if output is to be obtained in the 14-, 21- and 28-Mc. bands from such crystals.

Overtone crystals have higher frequencies marked on their holders—frequencies that often are in the v.h.f. part of the spectrum. In suitable circuits, they vibrate in a complex way at a frequency that is a close approximation to an odd-numbered harmonic of the fundamental frequency determined by the thickness of the crystal. The term overtone is used in preference to harmonic because a crystal having a fundamental frequency of, say, 10 Mc. will not have its **third overtone** at exactly 30 Mc. The actual frequency will be slightly different. The third and fifth overtones are the ones most used.

Almost any crystal, whether fabricated for overtone operation or not, can be made to operate on its third overtone. Many of them will also oscillate on the fifth overtone. However, for best overtone operation the crystal must be specially processed. Even so such crystals are less **active** than the fundamental types—that is, getting them to oscillate reliably requires more care in adjustment of the circuit.

Overtone crystals help to eliminate frequency-multiplying stages in a v.h.f. transmitter. Also, starting out at the highest possible frequency reduces the number of spurious frequencies that may give trouble. For example, if you want to work on 144 Mc. you can start out with a 48-Mc. overtone crystal oscillator and triple directly to 144 Mc. in a frequency-multiplier stage. The frequency multiplier probably will develop a small amount of output on the second (96 Mc.) and fourth (192 Mc.) harmonics of 48 Mc., too. However, the selective circuits associated with the tripler and the final amplifier will pretty effectively suppress these frequencies.

Suppose, though, that you start out with a 6-Mc. fundamental crystal, as many 144-Mc. transmitters do. This requires a total frequency multiplication of 24 times, and the outputs of the multipliers will contain *some* energy at 6-Mc. intervals all along the way and beyond. Among these will be birdies 6 Mc. either side of the final output frequency—that is, at 138 Mc. and 150 Mc. To get completely rid of them may take more selectivity than an ordinary transmitter can supply. Problems of this sort can be avoided by using the highest possible crystal frequency.

Crystal Frequencies for the V.H.F. Bands

Table 10-II is prepared on the same basis as Table 10-I, but for the 50- and 144-Mc. v.h.f. bands. That is, the crystal frequencies listed are between limits that you should observe in ordering crystals for multiplication into these bands. The figures include allowances for the manufacturer's tolerance and for the band occupied by a phone signal, in the case of phone. They do *not* include allowances for variations in frequency resulting from the oscillator operating

Table 10-II

Crystal Frequencies for 50 and 144 Mc.

Output Frequency	6-Mc. Crystals	8-Mc. Crystals	12-Mc. Crystals	24-Mc. Crystals
	General Class Licensees			
6-meter c.w.	6252-6748 kc.	8336-8997 kc.	12,501-13,499 kc.	25,003-26,997 kc.
6-meter phone	6265-6747 kc.	8353-8997 kc.	12,527-13,498 kc.	25,054-26,996 kc.
2-meter c.w.	6002-6165 kc.	8003-8220 kc.	12,002-12,332 kc.	24,003-24,664 kc.
2-meter phone	6002-6160 kc.	8003-8214 kc.	12,002-12,323 kc.	24,003-24,647 kc.
	Technician Class Licensees			
6-meter c.w. and phone same as General Class. 2-meter c.w. and phone	6044-6123 kc.	8058-8164 kc.	12,084-12,248 kc.	24,170-24,497 kc.
	Novice Class Licensees			
2-meter c.w. and phone	6044-6123 kc.	8058-8164 kc.	12,084-12,248 kc.	24,170-24,497 kc.

conditions. Play safe and stay well inside the limits given when ordering by mail.

Of course, if you have a good frequency standard against which you can check your actual frequency (see Chapter 14) you can work anywhere within the FCC assignments, just so long as you keep all your sidebands inside the assigned band limits. It's a good idea to have such a standard whether or not you try to crowd the band edges with your actual operating frequency.

Equipment in This Chapter

The transmitting circuits and equipment shown in this chapter were chosen primarily to satisfy the requirements of the Novice regulations. In most cases, though, the circuits look ahead a bit—to the day when the Novice will become a General Class licensee. Thus other bands than those the Novice can use may be provided for. Also, the equipment may be capable of running a higher power input than Novices are permitted. If you are a Novice licensee, you simply stay inside the Novice assignment and keep your power input down to 75 watts. Then on the happy day when the "General" arrives, you branch out into wider fields wherever they attract you.

Money is an important factor in ham radio just as it is in most other human activities. Partly because of economics—but from preference, too, in a very great many cases—most amateur transmitters at frequencies up to 30 Mc. run no more than around 150 watts input. You'll be right in there with the majority, in power, if you use transmitters of the type shown here.

In the constructional examples described, there is considerable emphasis on saving money by using salvaged parts. There is a wealth of useful material available in obsolete TV receivers and in military surplus. These transmitters make liberal use of such components.

The General Class licensee usually wants freedom in choosing an operating frequency within the band. This is done by substituting a variable-frequency oscillator for the crystal oscillator. A v.f.o. can be added to practically any transmitter shown, and a v.f.o. design is given later.

Finally, the transmitters can be put on amplitude-modulation phone. This conversion is covered in Chapter 13.

On the 50- and 144 Mc. bands there is a great deal of low-power operation, nearly all of it on phone. The transmitter for these two bands is one that the Novice or Technician will find quite practical, even though its power is small compared with the transmitters for the lower frequencies.

A Low-Cost Transmitter

The two-stage transmitter shown in Fig. 10-1 will operate from a power supply such as you might find in an obsolete television receiver. You can often pick up old TV sets in service shops—sets that will, in most cases, be junked because it isn't worthwhile to try to restore them to operating condition. A few inquiries should unearth a chassis that you can get for a few dollars—maybe even just for the asking. Look around for one that has a power transformer in good condi-

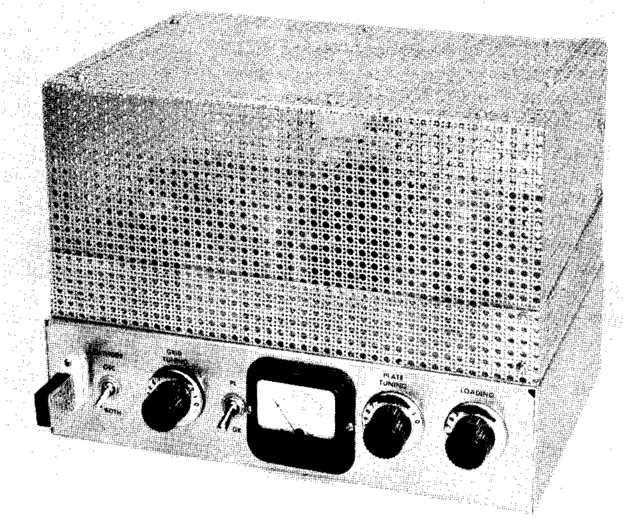

FIG. 10-1—This crystal-controlled transmitter uses receiving tubes and will operate from a power supply of the type usually found in television receivers. It has two stages, as shown in Fig. 10-2. Along the front of the chassis, from the left, are the crystal, oscillator cathode switch, oscillator tuning control, meter switch, meter, and the amplifier plate-tank tuning and loading controls.

tion. Most transformer-type receivers will give you 300 to 350 volts at about 200 milliamperes —plenty for a small transmitter—plus heater current for as many tubes as you're likely to need.

The man from whom you get the chassis probably can tell you whether the transformer is good. If he doesn't know, look it over carefully for damage. If it is burned out, your sense of smell probably will warn you—burned transformer insulation has an unmistakable odor! If the transformer is good, the chances are excellent that the rest of the power supply is in good shape, too. Although an old TV chassis is a rather bulky thing to have around, you can save some trouble by using its power supply just as it comes, without remounting and rewiring the parts. However, if you prefer a neater power supply on its own chassis, it isn't a very ambitious undertaking to transfer the essential components to a new and smaller chassis, using the same circuit.

The transmitter circuit of Fig. 10-2 has been designed around tube types that you're likely to find in an old TV chassis, too. Although a 6K6-GT and 6BG6GAs are shown, other types intended for the same purposes can be substituted. The 6K6GT is an audio power amplifier, primarily, and any similar power pentode such as the 6AQ5, 6V6GT, or 6AG7 will work satisfactorily. The 6BG6G is a TV horizontal-deflection tube; you can substitute the 6BQ6 or 6DQ6 for it. The ratings of these latter tubes are somewhat lower, particularly in the case of the 6BQ6, so if you use a pair of this type the transmitter input should be kept down to 50 watts or less.

You may be able to salvage some of the other parts, such as resistors, sockets, and ceramic bypass capacitors, from the TV receiver chassis. In fact, one of these chassis gives you a first-rate start toward that treasure-house of every ham builder—the junk box. The one thing you won't have any use for, at least in the ham station, is the picture tube. Disposing of picture tubes is a real safety problem, so avoid taking it when you get the chassis, if you possibly can.

The Transmitter Circuit

The transmitter operates on five bands, 3.5 through 28 Mc. The power input to the amplifier stage will depend on the plate voltage available, and will range up to 60 watts or so with a 300- to 350-volt supply.

The crystal oscillator circuit is one that has been discussed in Chapter 4 (Fig. 4-13), and will give output at harmonics of the crystal as well as at the fundamental frequency. A plug-in coil, L_2, is used in its plate circuit to select the desired harmonic. For 3.5-Mc. fundamental-frequency output L_2 is not used; the plate tank circuit then consists of L_1 and C_3. L_1 is left in the circuit all the time, the various coils used at L_2 being adjusted so that with L_1 and L_2 in parallel the resultant inductance has the right value for the desired output frequency. The feedback in the oscillator portion of the circuit is adjusted by means of C_1, a small trimmer capacitor.

The amplifier has two tubes in parallel. Two are used in order to take advantage of the amount of plate power that can be obtained from a TV receiver power supply. However, if you don't mind cutting the power input in half you can use just one tube. In that case, ignore the wiring to the second tube. When two are used, the corresponding elements are connected together at the sockets. The plates, which are top-cap connections on these sweep tubes, are not directly connected; each has a **parasitic suppressor** right at its cap, before the parallel connection is made.

The amplifier operates straight-through on all bands except 28 Mc., where it is used as a doubler. For working in the 3.5-Mc. band you need

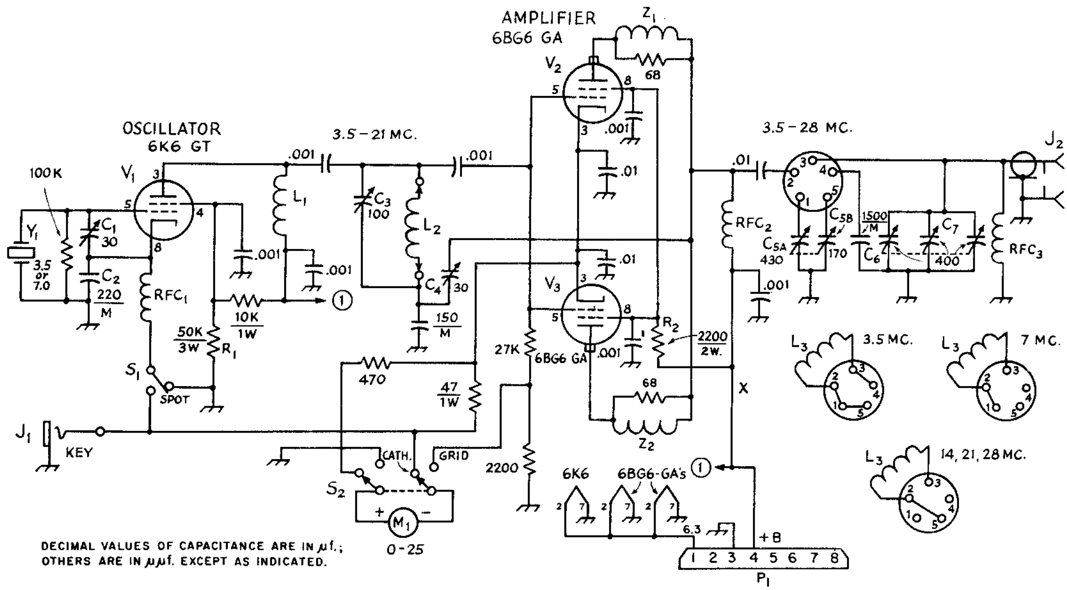

FIG. 10-2—Circuit diagram of the inexpensive transmitter. Unless otherwise indicated, resistances are in ohms, resistors are ½ watt. Fixed capacitors marked M are mica; others are disk ceramic.

C_1, C_4—3–30-$\mu\mu$f. mica trimmer.

C_2—220-$\mu\mu$f. mica.

C_3—100-$\mu\mu$f. variable (Hammarlund HF-100).

C_5—Two-section receiving variable, approx. 170 $\mu\mu$f. and 430 $\mu\mu$f. (Allied Radio 61-H-065 or Philmore 9045).

C_6—1500-$\mu\mu$f. mica.

C_7—Three-section receiving variable, approx. 400-$\mu\mu$f. per section (Allied Radio 60-H-726 or Philmore 9047).

J_1—Open-circuit phone jack.

J_2—Coax chassis receptacle, SO-239 or phono jack.

L_1—25-μh. r.f. choke (Millen 34300-25).

L_2, L_3—See coil table.

Z_1, Z_3—3 turns No. 14 wound on a 68-ohm 1-watt resistor (parasitic suppressors).

M_1—0-25 milliammeter (Shurite Model 950 or 550).

P_1—Four-prong plug, cable mounting (Amphenol 86PM4).

R_1—50,000 ohms, 3 watts (three 150,000-ohm 1-watt resistors in parallel).

R_2—See text.

RFC$_1$, RFC$_2$, RFC$_3$—1-mh. r.f. choke (Millen 34300-1000).

S_1—S.p.d.t. toggle.

S_2—D.p.d.t. toggle.

Y_1—3.5-or 7-Mc. crystal, as required.

3.5-Mc. crystals. Crystals in this same band also can be used (provided their harmonics fall within the proper higher-band limits, of course) for 7- and 14-Mc. work. The oscillator doubles frequency in the first case and quadruples in the latter. These and the other bands can be covered with 7-Mc. crystals, doubling in the oscillator for 14-Mc. amplifier output, tripling for 21-Mc. output, and doubling for 28-Mc. output, where the amplifier also doubles. These combinations are shown in a table.

The amplifier plate tank is a pi network designed for working into 50- to 75-ohm loads. The tank capacitor, C_5, is a two-section variable of a type found in many small broadcast receivers. The one used here has a maximum capacitance of 430 $\mu\mu$f. in one section and 170 $\mu\mu$f. in the other. The loading capacitor, C_7, is a three-section broadcast-receiver type variable having a capacitance of about 400 $\mu\mu$f. per section. Any capacitor that has a total of 1000 to 1200 $\mu\mu$f. with the sections parallelled will do. An additional 1500 $\mu\mu$f. is connected in parallel with the loading capacitor for 3.5 Mc. This is a fixed mica capacitor.

The amplifier is neutralized by the capacitive-bridge method. C_4 is the neutralizing capacitor, while the remaining arm of the neutralizing bridge is the 150 $\mu\mu$f. mica capacitor connected from the junction of L_2, C_3 and C_4 to ground.

Metering and Keying

The transmitter has an inexpensive d.c. milliammeter, 0–25 range, for checking grid and cathode currents. For reading grid current it is connected across a 2200-ohm resistor that is in series with the grid-leak resistor. Since the meter resistance is low compared with 2200 ohms, practically all the current flows through the meter. Thus the range in this case is 0–25 ma. For reading cathode current a 470-ohm resistor is connected in series with the meter, and the combination is connected across a 47-ohm resistor in the amplifier cathode circuit. This multiplies the scale by 10, making the meter read 250 ma. full scale. The 47-ohm resistor also gives the amplifier tubes a little **protective bias** in case the r.f. excitation should fail.

The amplifier is keyed in its cathode circuit. The oscillator cathode also can be keyed along with the amplifier, for break-in operation. Alternatively, if the arm of S_1 is grounded (**spotting** position of S_1), the oscillator runs continuously and only the amplifier is keyed. Sometimes the keying is better, especially on the higher bands such as 14 Mc. and above, when only the amplifier is keyed. There is usually less tendency to **chirp** if the oscillator runs all the time. Listen critically to your keying, using your receiver with the antenna disconnected, and then decide which is better. If the oscillator is keyed, the setting of C_1 will have a marked effect on chirpiness, and the setting of C_3 probably also will affect this keying characteristic.

Power Supply

If you follow the suggestion of using the power supply as it comes on the TV chassis, remove all the tubes from the chassis except the rectifier, which no doubt will be a 5U4G. Three output leads will be needed. One, connected to the chassis, carries one side of the 6.3-volt heater supply and the negative side of the high-voltage d.c. supply. The second is the "hot" side of the heater wiring; you can pick this up at one of the tube sockets. The third is B-plus, which should be taken from the positive terminal of the last filter capacitor in the set. You may have to trace the power-supply wiring from the rectifier through the filter choke to find this point.

In the circuit as shown here, these three connections are made through an octal socket and a corresponding octal plug which is on a cable from the transmitter. Take the existing wiring off an octal socket in the TV set and use three of the prongs for this purpose.

If you prefer to strip the power-supply parts from the TV chassis and build up a separate supply, Fig. 10-3 gives a suitable circuit. The values used in the filter, $C_8C_9L_4$, can be almost anything you can salvage from the TV set, as they aren't critical. You can readily identify the electrolytic capacitors in the TV filter since they are nearly always marked with the capacitance and working-voltage rating. Generally they will be of the metal-can type that mounts on the chassis. Capacitance values range from 8 to 40 μf. or more, and frequently two or more capacitors will be in the same can. If so, the metal can is usually the negative terminal for all units in the can. Divide the available capacitance nearly equally between C_8 and C_9, but if the division doesn't come out even, use the larger value at C_9. Be sure that you use only those capacitors having at least a 450-volt working rating. In the case of the filter choke, use what you find in the receiver.

In the circuit shown in Fig. 10-3, S_4 is for turning off the high voltage (as when receiving) without turning off the heater power for the tubes in the transmitter.

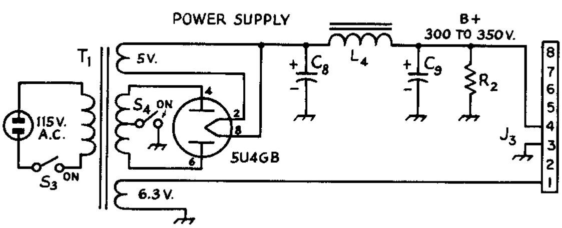

FIG. 10-3—Power supply circuit. If parts are salvaged from an old TV receiver, use the components available; see text. Suitable values for a supply built from new parts are:

C_8, C_9—8 μf. or more (electrolytic), 450 volts working.

L_4—Approximately 2 henrys, 200 ma.

J_3—Octal tube socket.

R_2—50,000 ohms, 10 watts.

S_3, S_4—S.p.s.t. toggle.

T_1—Power transformer, 675 volts center-tapped, 200 ma.; 5 volts, 3 amp.; 6.3 volts, 5 amp. (Stancor P-5059 or equivalent).

Construction

A 3 × 8 × 12-inch aluminum chassis is used for the transmitter. Follow the general arrangement shown in the top and bottom views, Figs. 10-4 and 10-5. C_3 must be insulated from the chassis; fiber washers are used for this purpose. Be sure to allow sufficient room between C_5 and C_7 so the two rotors won't strike each other when set near minimum capacitance.

The top shield, which is necessary for TVI reduction, is made from a section of Reynolds' "do-it-yourself" perforated aluminum stock. The "fence" that runs around the top of the chassis is made from two sections of the same stock, each 2 inches wide and 21 inches long. The perforated stock comes in a 36 × 36-inch piece, so it is impossible to get a single length long enough to go around the entire chassis. The completed fence is 1¾ inches high, with a ¼-inch lip which is secured to the chassis top with machine screws and nuts. The two sections are each formed into

Crystal and Coil Combinations for the Low-Cost Transmitter

Amplifier Output Band	Crystal	L_2	L_3
3.5 Mc.	3.5 Mc.	None	C
7 Mc.	3.5 Mc.	A	D
14 Mc.	3.5 Mc.	B	E
7 Mc.	7 Mc.	A	D
14 Mc.	7 Mc.	B	E
21 Mc.	7 Mc.	B	F
28 Mc.	7 Mc.	B	G

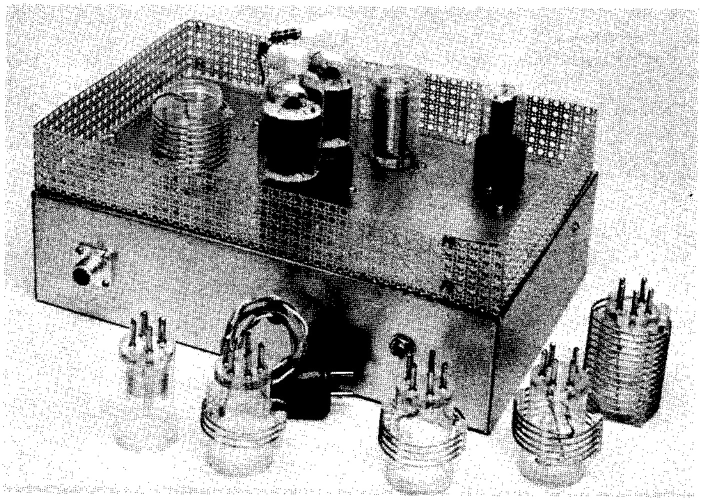

FIG. 10-4—The transmitter with the top screen removed. L_2 is between the oscillator tube (at the right) and the amplifier tubes. The amplifier coil is at the left. Along the back (facing side) of the chassis from the left are the output jack, power cable, and key jack.

an L shape measuring 8 × 12 inches, the remaining inch being used at two of the corners for an overlap to fasten the two sections together with screws and nuts.

The sides of the shield are made from two pieces of perforated stock measuring 6½ × 20½ inches before folding. The side dimensions of the two pieces after folding are 7¾ and 11¾ inches; the extra inch is used for the overlap to connect the two pieces together. A one-inch flange is folded in around the top so that the overall height is 5½ inches. The top is made from a piece of stock 7¾ by 11¾ inches and is secured to the sides with machine screws and nuts. When the completed cover is slid down inside the fence and flush with chassis, the overlap is sufficient to prevent harmonic leakage, provided care has been used in folding the stock tọ insure a snug fit. No screws are needed to hold the cover down. This makes coil changing simple because the cover can be removed and replaced quite easily.

The cable used to connect the transmitter to the power supply can be made any length, depending on where you install the power supply.

Making the Coils

The plug-in coils are made from commercially-wound coil stock, the oscillator coils being mounted inside the plug-in coil forms and the amplifier coils on the outside. The Air Dux coil stock specified has exactly the right diameter to fit over the forms.

When cutting the oscillator coils from the original stock, allow three extra turns on the 20–15-meter coil and five extra turns on the 40-meter coil. When these extra turns are unwound you'll have sufficient lead length to reach through the prongs on the forms.

When making the amplifier coils, put jumpers between the prongs as shown in Fig. 10-2.

Tuning

The first step in testing is to neutralize the final amplifier. The lead that feeds the plates and screens of the 6BG6Gs should be disconnected at point X in Fig. 10-2 so that the only voltage on these tubes is the heater voltage. Plug in a 7-Mc. crystal and the 7-Mc. grid and plate coils. Turn on the power and let the oscillator tube warm up. Set S_2 to read grid current. Next, close the key and adjust C_3 for a grid-current reading of 4 to 5 ma. Set C_7 at maximum capacitance (plates fully meshed) and then tune C_5 through its range. At one point (where the amplifier tank circuit is resonant at the crystal frequency) you should notice a dip in the meter reading. Next, carefully

Plug-In Coil Data for the Low-Cost Transmitter

L_2—(A)	7 Mc.	29½ turns No. 20, 16 turns per inch, ¾-inch diam.
(B)	14-21 Mc.	7½ turns same (B & W Miniductor 3011 or Illumitronic Air Dux 616T).
L_3—(C)	3.5 Mc.	13 turns No. 14, 6 turns per inch, 1¾-inch diam.
(D)	7 Mc.	8 turns same.
(E)	14 Mc.	5 turns same.
(F)	21 Mc.	3½ turns same.
(G)	28 Mc.	2½ turns same. (Illumitronic Air Dux 1406T).

Note: A single length of Illumitronic 616T or B & W 3011 will suffice for the 7- and 14-21-Mc. oscillator coils. One length of Air Dux 1406T is sufficient for all the amplifier coils. The L_2 coils are mounted in four-prong plug-in coil forms, 2 required (Amphenol or Allied Radio 24-4P), and the L_3 coils in five-prong forms, 5 required (Amphenol or Allied Radio 24-5H).

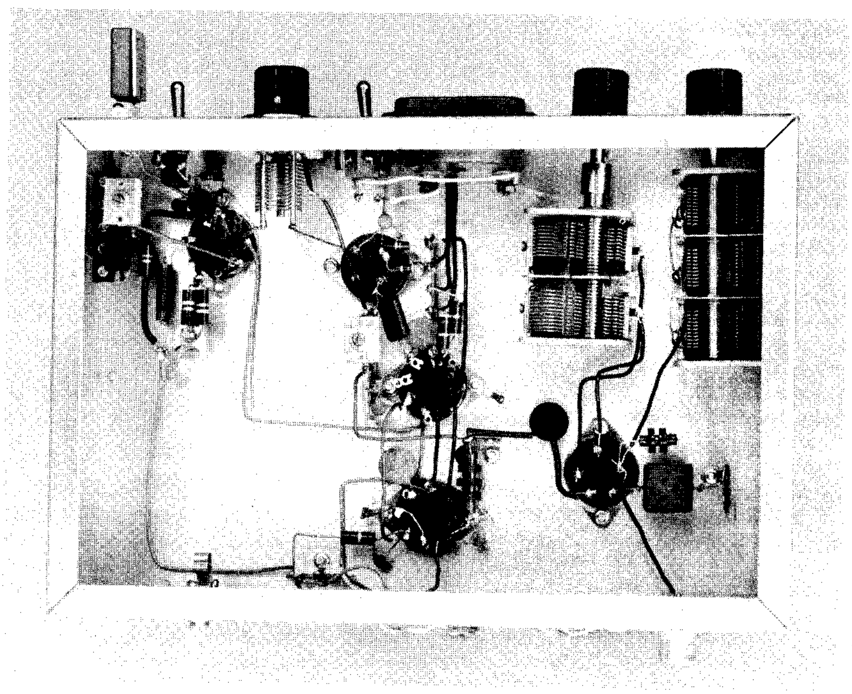

FIG. 10-5—The oscillator components are grouped around the 6K6 socket at the upper left. Below the toggle switch, next to the meter, is the coil socket for L_2. The two 6BG6 sockets are at the center of the chassis. The two-section variable capacitor at the upper right center is C_5. C_7 is to its right. The coil socket for L_5 is below C_5. To the right of the socket are C_6 and RFC_3.

adjust the neutralizing capacitor C_4 so that the *least* amount of change occurs in the meter reading when C_5 is tuned through resonance. When you find this point, the amplifier will be neutralized. The plate and screen leads may now be reconnected—*remembering to turn off the power first.*

A dummy load should be used for testing the amplifier. A good load for this purpose is a 60-watt lamp bulb. Connect a lead from the inner terminal of J_2 to the center contact on the base of the bulb and another lead from the chassis to the threaded part of the lamp base.

Now turn on the power and set both C_5 and C_7 at maximum capacitance, plates fully meshed. Set S_2 to read grid current and close the key. Tune C_3 for a grid-current reading of 2 to 4 ma. Don't hold the key down very long, because the final tank will be off resonance and the amplifier will take excessive plate current. This could cause permanent damage to the tubes.

Next, set S_2 to read cathode current and close the key again. Tune C_5 for a dip in the meter reading; this will indicate that the final is tuned to resonance. Start decreasing the capacitance of C_7 while keeping the amplifier in resonance (at the dip in the meter reading) by adjusting C_5. The lamp should start to light and should get brighter as you adjust C_5 and C_7. The 6BG6Gs are good for 100 ma. per tube, so you can load the amplifier to about 200 ma. However, don't increase the loading beyond the point that results in maximum brightness of the lamp. When you get to that point, try readjusting C_3 to see if you can get more output. When you've reached the limit of output, note the amplifier cathode-current reading. This is the value of current you should adjust for when the amplifier is feeding an actual antenna. The settings of C_5 and C_7 probably will be different with a real antenna system. This simply means that the antenna load is not the same as the load the bulb gives you. The bulb test is to show you what the transmitter is capable of doing, and to familiarize you with the proper tuning procedure. The procedure itself should be followed with any kind of load on the transmitter.

The tuning method is the same on all bands. One point to watch out for is that the 14- and 21-Mc. bands are both covered on one coil with C_3. Thus there are two settings of this capacitor that will result in maximum final-amplifier grid current. The one nearest maximum capacitance is 14 Mc. and the one near minimum capacitance is 21 Mc. Be sure you use the right setting for the band you want to work on. Try out all the bands on the lamp dummy to get familiar with the settings, and check your output with a wavemeter if you have one. Chapter 14 tells how to make an inexpensive one.

The feedback capacitor, C_1, in the oscillator circuit should be adjusted with the transmitter on 21 Mc. Adjust C_1 for a grid-current reading of no more than 4 ma. on this band. This adjustment need not be changed for other bands with crystals of ordinary activity.

You'll find antenna systems suitable for use with this transmitter in Chapter 6. Some types of antennas will require a feeder-matching circuit or "transmatch" between the transmitter and the feeder. Details on making such circuits are given in Chapter 11.

One final point: The plate current that the amplifier tubes will take depends more on the screen voltage than on the plate voltage. To get the tubes to take 100 ma. each it is necessary to have 300 volts on the screens. You may have to tinker with the value of R_2 to get this voltage. With the transmitter operating into the lamp dummy load, measure the voltage at the 6BG6G screens with the plate tank controls adjusted for maximum lamp brightness. *Don't touch any of the wiring when making this measurement.* If the voltage is low, try less resistance at R_2. If it is appreciably higher than 300 volts, make R_2 larger until you get about 300. The right value of R_2 will depend on the voltage, under full load, available from the power supply. Since this will depend on the components used, it will be necessary to check the voltage and change R_2 accordingly, if you want to get the maximum output from the set consistent with operating the tubes within safe ratings.

A 100-Watt Transmitter

A somewhat more advanced transmitter circuit than the one just described is shown in Fig. 10-6 and the accompanying photographs. Although more powerful, it is a comparatively inexpensive set to build, since the amplifier tubes can be obtained very cheaply from surplus dealers and the power transformer can be salvaged from an old TV receiver. If you're a Novice licensee, you can run the transmitter at 75 watts input until you move up to the General Class.

Circuit Details

The transmitter can be operated on any band from 3.5 Mc. through 28 Mc. at inputs up to 100 watts. It uses a 6AG7 crystal oscillator driving a pair of 1625s. Either 80- or 40-meter crystals are used, depending on the band.

The plate circuit of the oscillator is tuned by the combination of C_3 and L_1L_2, Fig. 10-7. The correct inductance for each band is selected by using S_1 to short out part of L_2. The oscillator can be operated either straight-through, doubling, or tripling, depending on the crystal used. An 80-meter crystal is used for 3.5-Mc. operation, and the same crystal will provide more than enough excitation for 40 meters with the oscillator working as a doubler. However, the

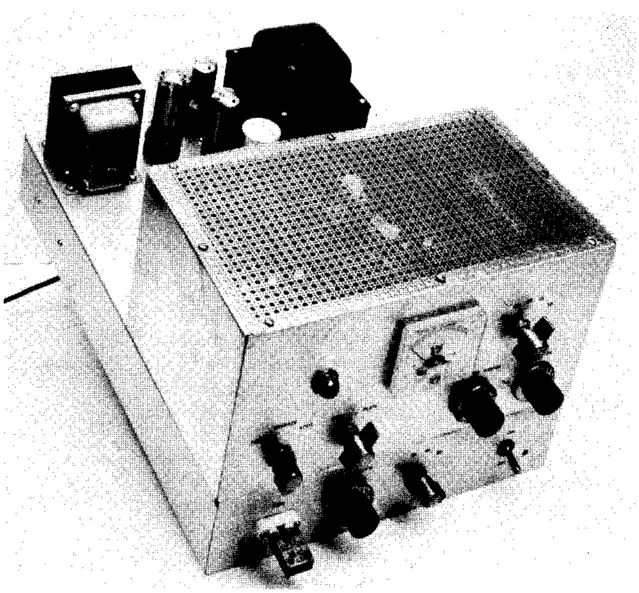

FIG. 10-6—A 100-watt transmitter for five bands, using salvaged TV power transformer and surplus 1625 amplifier tubes. Across the bottom on the front of the chassis are the crystal, amplifier grid (or oscillator plate) tuning capacitor, oscillator band switch, and power switch. On the box panel, from the left, are the tune-operate-spot switch, meter switch, and amplifier plate tuning and loading controls. The amplifier band switch is at the upper right.

At the rear of the chassis are L_8, the 5U4 and 6DE4s (see Fig. 10-7) and the power transformer. The key jack, not visible in this view, is mounted on the rear chassis wall.