

Transmitter Construction

IN THE descriptions of apparatus to follow, not only the electrical specifications but also the manufacturer's name and type number have been given for most components. This is for the convenience of the builder who may wish to make an exact copy of some piece of equipment. However, it should be understood that a component of different manufacture, but of equivalent quality and having the same

included in this chapter will be found in the vacuum-tube tables of Chapter Twenty-One.

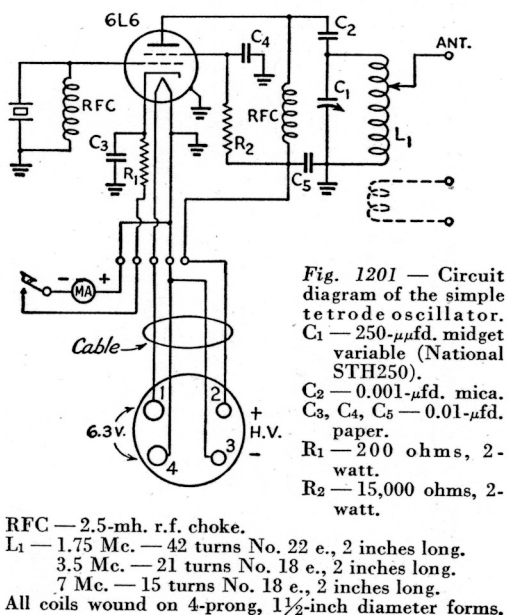
To reduce repetition and make possible a treatment of wider scope, liberal reference will be made to other chapters in this *Handbook*.

A Simple Tetrode Oscillator

The unit shown in Figs. 1201-1202 represents one of the simplest types of amateur transmitters. The various parts are assembled on a breadboard purchased already finished at a "dime" store. Rubber feet at the corners elevate the base to clear mounting screws. A "ground" wire is run from one side of the crystal socket to one side of the coil socket, to which all ground connections shown in the diagram are made.

Since parallel plate feed is used, the only exposed high-voltage points are the plate-circuit r.f. choke and the high-voltage power terminal. Grid bias is obtained entirely from the cathode resistance. Either simple voltage feed to a half-wave antenna or an antenna a multiple of one-half wavelength long, or link coupling to an antenna tuner by adding a link winding at the bottom of the form as indicated in the diagram, may be used.

Although a 6L6 tube is shown in the photograph, a 6V6 might be used at lower plate voltage without circuit alteration. Any available power supply delivering up to 450 volts or so may be used, the power output obtainable increasing with the voltage applied. The unit shown in Fig. 1203 is suitable. The two units



electrical specifications, may be substituted in most cases.

Any unusual characteristics in tuning or operation are explained in the text describing the construction of each unit in this chapter.

For straightforward transmitter adjustments, such as the tuning and neutralizing of standard circuits, the reader should consult Chapter Four. Chapter Ten contains the information on the adjustment of antenna tuners with various types of antennas. Keying systems are treated in Chapter Six. The construction of meter shunts is covered in Chapter Nineteen, while operating data on transmitting tubes not specifically

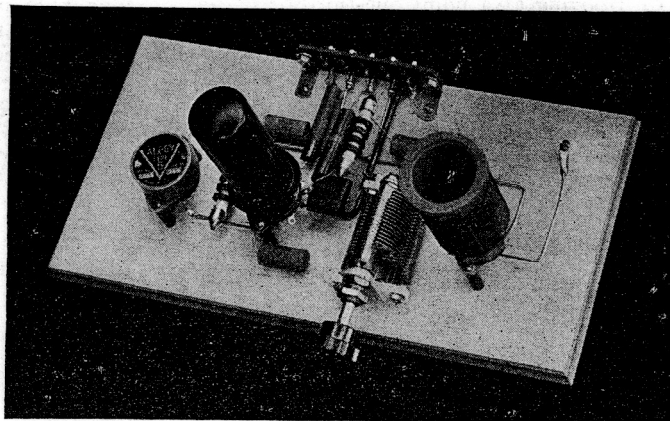


Fig. 1202 — A simple breadboard crystal-controlled transmitter. The grid r.f. choke is located between the crystal and 6L6 and the plate choke is to the right of the tube. The cathode and screen resistors are to the rear of the 6L6. The blocking condenser, C2, is between the tube and tank condenser.

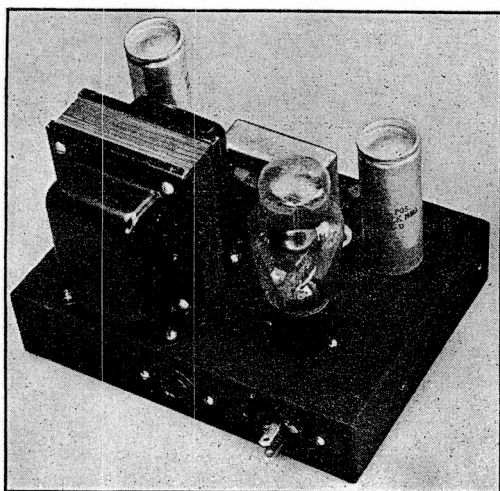


Fig. 1203 — This power supply delivers 450 volts at a full-load current of 130 ma., with 0.3 per cent ripple and measured regulation of 17 per cent. If converted to a choke-input filter by inserting a similar choke between the rectifier and present filter, the output voltage is reduced to about 300 volts. The chassis measures $7 \times 9 \times 2$ inches. Filament and plate voltages are brought out to a four-prong socket. The circuit is given in Fig. 1204.

are connected by a four-wire battery cable with a four-prong plug at the power-supply end to fit the outlet in the power supply.

Since the circuit is not designed for frequency doubling, a separate crystal will be required for each frequency to be used.

Tuning — A milliammeter with a scale of 100 or 200 ma. should be connected in series with the key, as shown in Fig. 1201, as an aid in tuning. With a suitable coil and crystal in place and the high voltage turned on, a rise in plate current should occur when the key is closed. The plate tank condenser, C_1 , should then be rotated until there is a pronounced dip in plate current at resonance. If the voltage-fed antenna is used, it may now be connected to the antenna terminal and a temporary wire run from the antenna terminal to reach the coil, L_1 . Starting at a point one-third or half-way up from the bottom of the coil, scrape the wire at a spot, being careful not to short-circuit turns, and let the antenna wire rest against the bare spot. Tuning the transmitter as before, the plate-current dip should again be found, although less pronounced this time. The tap should be moved gradually toward the top of

the coil until only a slight dip in plate current is observed as the plate tank circuit is tuned through resonance. At each adjustment of the antenna tap, the transmitter should be tested to make sure that the circuit keys well. Should a point be reached where it is difficult to get the crystal to start, the tap should be backed off somewhat. It will be found possible to load up the circuit more with certain crystals than others, while still maintaining good starting and keying characteristics. When a satisfactory point has been found, the tap may be soldered in place permanently and a connection made through one of the unused pins on the coil form.

With a 6L6 tube and a plate supply delivering 400 volts, the screen voltage will be about 250 volts. The tube will draw about 75 ma. non-oscillating, dipping to about 50 ma. at resonance with the antenna disconnected. It should be possible to load up the circuit until the tube draws about 80 ma. at resonance. Under these conditions, the power output on each band should be 15 to 20 watts.

□ A Low-Power Antenna Tuner

If an antenna with tuned feeders is used, the antenna tuner shown in Figs. 1205-1206 may be used to couple the 6L6 oscillator-transmitter to the feeders. The link winding of the transmitter and that of the antenna tuner should be connected with a pair of closely spaced wires.

The circuit, shown in Fig. 1205, is arranged so that different tuning combinations may be obtained by shifting the clips F, G and H. When F is connected to A, H is connected to D, and B and C are connected together, the two sections of C_1 in series are connected across L_1 , forming a low-capacity parallel-tuned circuit. When H is connected to E and G to D, the other connections remaining the same, a high-capacity parallel circuit is obtained. For series tuning, H is connected to E, F to B and G to C. A low-capacity series-tuned circuit is provided by connecting F to B and H to C.

Dimensions are given for antenna coils of four different sizes, which are approximately correct for the band indicated when parallel tuning is required. For series tuning, the coil for the next-higher frequency band usually will be satisfactory. In some cases, where the feeders are not close to exact multiples of one-quarter wavelength for the frequency in use, slight alterations in coil dimensions may be re-

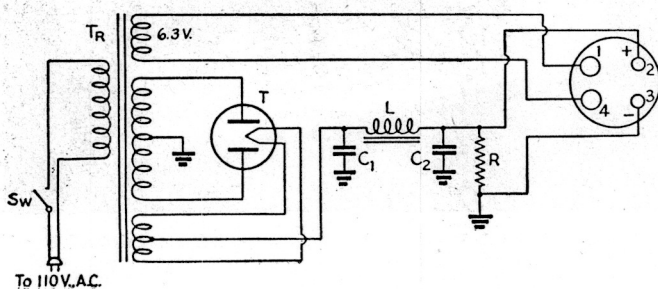


Fig. 1204 — Circuit diagram of the 450-volt 130-ma. power-supply unit.

C_1 — 4- μ fd. 600-volt electrolytic (Mallory HS691).

C_2 — 8- μ fd. 600-volt electrolytic (Mallory HS693).

L — Filter choke, 10 henrys, 175 ma., 100 ohms (Utah 4667).

R — 15,000 ohms, 25-watt.

T — Type 80 rectifier tube.

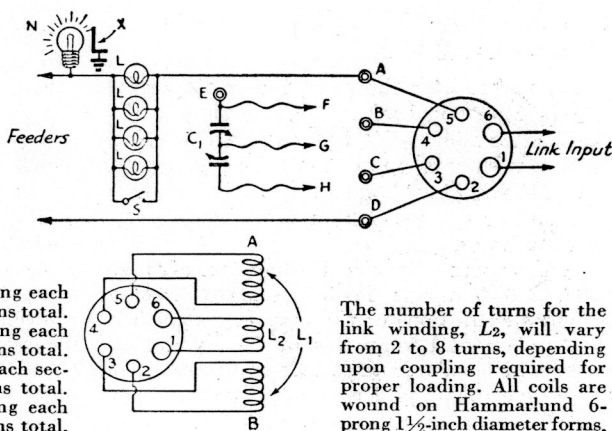
Tr — Power transformer, 400 volts each side of center-tap; rectifier filament winding, 5 volts, 3 amperes; r.f. filament winding, 6.3 volts, 6 amperes (Utah Y616).

Fig. 1205 — A low-power antenna tuner.

A shows connections to the coil socket. C_1 has a capacity of 140 $\mu\text{fd.}$ per section (Hammarlund MCD-140). L is a 250-ma. dial light, No. 46. N is a $\frac{1}{4}$ -watt neon bulb. X is a grounded piece of metal which provides capacitive coupling for igniting the neon bulb. S is a switch or clip used for short-circuiting the lamps after tuning.

B shows the connections to the 6-prong coil form. L_1 , whose approximate dimensions are given below, is wound in two sections, with the link winding, L_2 , in between them.

L_1 — 1.75 Mc. — 20 turns No. 22 e., $\frac{3}{4}$ -inch long each section, $\frac{1}{2}$ -inch between sections, 40 turns total.
 3.5 Mc. — 11 turns No. 20 e., $\frac{3}{4}$ -inch long each section, $\frac{1}{2}$ -inch between sections, 22 turns total.
 7 Mc. — 6 turns No. 20 e., $\frac{3}{4}$ -inch long each section, $\frac{1}{2}$ -inch between sections, 12 turns total.
 14 Mc. — 3 turns No. 20 e., $\frac{1}{2}$ -inch long each section, $\frac{1}{4}$ -inch between sections, 6 turns total.



quired to permit tuning the system to resonance. The high-capacity circuits usually will be required for the lower frequencies, while the low-capacity connections will serve for the higher frequencies. Coupling may be adjusted by altering the number of turns in the windings at each end of the link line.

Construction — The two uprights and the strip supporting the indicating lamps are pieces of "1 by 2" stock. The uprights are each 13 inches long and the cross-strip 12 inches long; these dimensions may be changed to suit the constructor. The shelf for the condenser and coil is made of a piece of crate wood $4\frac{1}{2}$ inches wide. The panel is of plywood 7 inches high.

The dial lamps are soldered to a pair of parallel wires supported at each end on small stand-off insulators. The bottom of the neon bulb is soldered to a short piece of wire between a third pair of stand-offs. The piece of grounded metal next to the neon bulb is about $1\frac{3}{4}$ inches square. This provides a capacity to ground which enables the neon bulb to operate without touching the hand to it.

The socket for the plug-in coil is mounted on the shelf with spacers and wood screws. The shield between the two sections of the variable condenser is removed to permit mounting it by a screw through the hole in the ceramic to the shelf. The shaft of the condenser is cut off and an insulating coupling inserted between the shaft and the control knob. The contacts for shifting connections consist of machine screws set in a small strip of bakelite.

The neon bulb and the dial lamps can be used to indicate resonance in the antenna circuit and relative (not actual) power output. The lamps will be useful whenever the length from the far end of the antenna to the feeder terminals is near an odd multiple of one-quarter wavelength for the frequency of operation, while the neon bulb will be useful where the length is near an even multiple. In tuning with the lamps, all sockets should be filled at the start. If, as an indication of resonance is obtained by an increase in plate current, the lamps show no indication, they should be removed, one at a time, until the remaining

lamps start to glow. Sufficient lamps should be kept in the circuit to prevent danger of burn-out. After the antenna has been tuned for maximum power output, the lamps should be short-circuited with the clip.

When using the neon bulb, the grounded metal plate should be bent near it until the bulb lights (assuming the transmitter is tuned to approximate resonance by the plate-current meter). The plate should be no closer to the bulb than necessary for satisfactory indication.

Complete 15- to 25-Watt Oscillator Transmitter

The three units of Figs. 1202, 1203 and 1206 may be combined to form a simple, inexpensive low-power transmitter, complete from power supply to antenna tuner.

For convenience and economy of space, the units may be assembled on a vertical relay rack. The plate milliammeter may be mounted in the antenna-tuner unit, if desired.

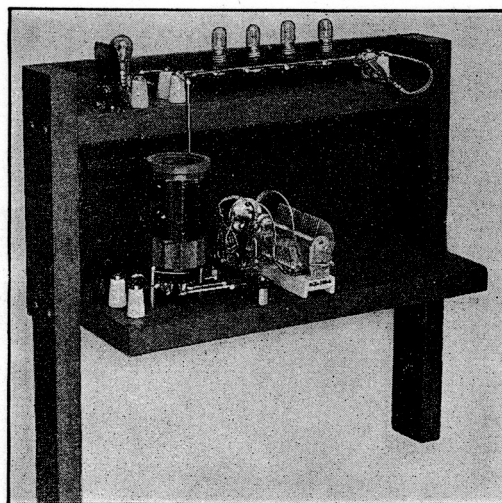


Fig. 1206 — Rear view of an antenna tuner for low-power transmitters. Dial lamps and a neon bulb are used as r.f. indicators. The unit is made to fit over the transmitter shown in Fig. 1202. Circuit is given in Fig. 1205.

Ⓐ A Two-Stage 45-Watt C.W. Transmitter Using 6L6s

The transmitter shown in the photographs of Figs. 1207 and 1209 will handle an input to the final amplifier of 45 watts and will provide output, with crystals of proper frequencies, in any of the amateur bands from 1.75 to 14 Mc. The unit is complete from power supply to antenna tuner.

Referring to the circuit diagram of Fig. 1208, a 6L6 in the Tri-tet oscillator circuit provides excitation for the amplifier at either the fundamental frequency of the crystal or its second harmonic. The second 6L6 is used as an inverted amplifier, which eliminates the necessity for neutralizing and makes an exceptionally fool-proof arrangement. This transmitter is recommended especially for the beginner who has had little previous experience with oscillator-amplifier transmitters. The oscillator output is coupled to the amplifier input by the small winding, L_3 , in the cathode circuit of the amplifier.

Both stages are parallel-fed, permitting mounting the tank condensers directly on the metal chassis without insulation. The transmitter is keyed in the common cathode-return lead of both stages. Key connections are made through the jack, J . Pin jacks are provided at the rear of the chassis for making meter connections. A milliammeter, connected between the center and left-hand pin jacks in the wiring diagram, registers oscillator-cathode current. Connecting the meter between the central and right-hand jack permits reading of the amplifier-cathode current. Shorting the meter jacks when the meter is not in the circuit is not required, since the cathode circuits remain closed through the shunting resistors, R_3 and R_4 .

An antenna tuner with provision for either series or parallel tuning is link-coupled to the amplifier output.

A condenser-input filter is used in the power supply. Resistors R_9 , R_{10} , R_{11} and R_{12} are included to equalize the voltage drop across the sections of the electrolytic filter condensers.

Construction — A rectangular hole for the transformer terminals is cut in the chassis by drilling half-inch holes at the four corners and sawing out with a hacksaw. The shield between the two sections of the split-stator antenna condenser, C_{16} , is removed, leaving a hole by which the condenser may be mounted on the chassis with its shaft $4\frac{3}{4}$ inches from the end of the chassis. The two tank condensers, C_1 and C_2 , are shaft-mounted in the front edge without insulation at a height to bring their shafts level with that of C_{16} . C_2 is mounted at the center, while the shaft of C_1 is located $4\frac{3}{4}$ inches from the end of the chassis to balance C_{16} . The three antenna terminals are jack-top binding posts, insulated from the chassis with National button-type polystyrene insulators which are drilled out to fit the posts.

The small parts, such as by-pass condensers, blocking condensers, resistors and r.f. chokes, are grouped around the points at which they connect. All high-voltage wiring is done with heavily insulated wire. R.f. wiring is done, for the most part, with short, straight sections of heavy bare wire, well-spaced from the chassis and any near-by components.

The crystal and cathode-coil sockets are wired up as shown in Fig. 1260, and pin jacks for making connections to the v.f.o. unit are set in the left-hand end of the chassis. It is very important that the leads between the pin jacks and the cathode-coil socket be kept as short as possible.

The power transformer suggested in the list of components is fitted with two sets of high-voltage secondary terminals. The pair for the lower-voltage secondary, marked Nos. 12 and 14, should be used.

All coils are wound on $1\frac{1}{2}$ -inch diameter forms. Winding data are given in the table of components. Where close-wound coils are not definitely indicated, the required number of turns must be spaced out to fill the specified length on the form.

Tuning — For preliminary tuning, a crystal and set of coils for the band in which the crystal frequency lies should be plugged in. A

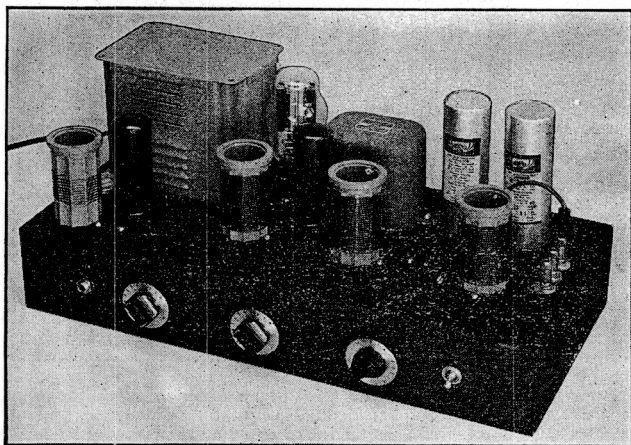


Fig. 1207 — A 45-watt two-stage 6L6 c.w. transmitter, complete with power supply and antenna tuner. The crystal socket is behind cathode coil, L_1 , at the left-hand end of the chassis. The 6L6 amplifier tube is between the oscillator plate coil, L_2 , and the amplifier plate coil, L_4 , at the center. The coil at the right is L_7 in the antenna tuner. Terminals at extreme right are for antenna connections. Power-supply components are arranged along the rear. The three controls in front are for the oscillator plate tank condenser, C_1 , amplifier plate tank condenser, C_2 , and antenna tank condenser, C_{16} , respectively from left to right. The key jack, J , is at the left and the power switch, S_w , at the right. The chassis measures $8 \times 17 \times 3$ inches. An insulated shaft coupling is used between the shaft of the antenna-coupler tuning condenser, C_{16} , and the panel-bearing assembly in the front edge of the chassis.

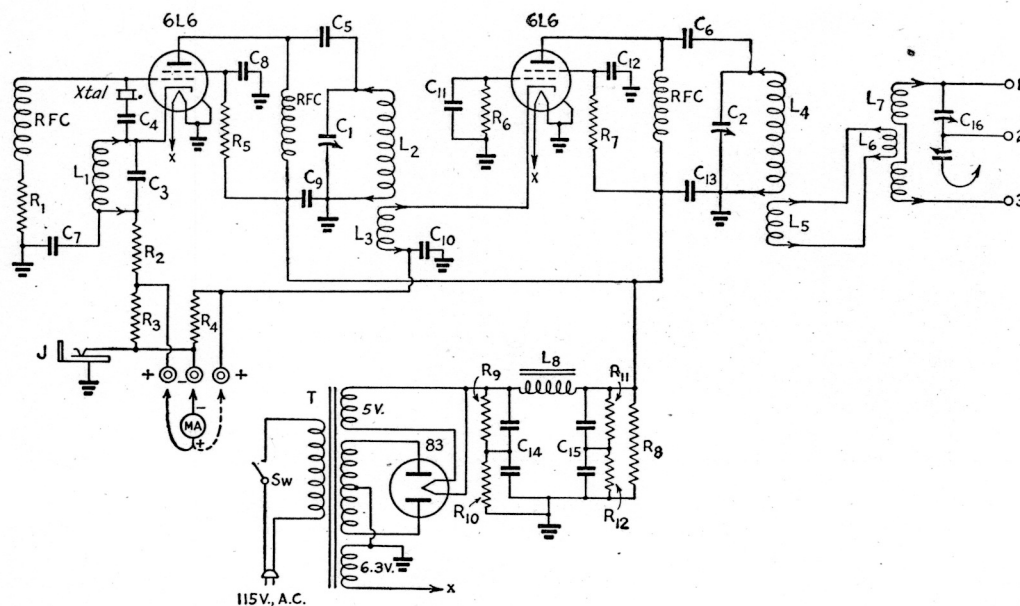


Fig. 1208 — Circuit diagram of the two-stage 6L6 45-watt c.w. transmitter with power supply and antenna tuner.

C₁, C₂ — 150- μ fd. variable (National ST-150).

C₃ — 100- μ fd. mica.

C₄, C₅, C₆ — 0.001- μ fd. mica.

C₇, C₈, C₉, C₁₀, C₁₁, C₁₂, C₁₃ — 0.01- μ fd. paper.

C₁₄, C₁₅ — Dual 8-8 μ fd. 450-volt electrolytic with 4 leads, sections connected in series.

C₁₆ — 140- μ fd. per section variable (Hammarlund MCD-140-M).

J — Closed-circuit jack for key.

R₁ — 0.1 megohm, 1-watt.

R₂ — 500 ohms, 1-watt.

R₃, R₄ — 25 ohms, 1-watt.

R₅ — 50,000 ohms, 10-watt.

R₆ — 25,000 ohms, 1-watt.

R₇ — 25,000 ohms, 10-watt.

R₈ — 50,000 ohms, 10-watt.

R₉, R₁₀, R₁₁, R₁₂ — 0.5 megohm, $\frac{1}{2}$ -watt.

RFC — 2.5-mh. r.f. choke.

Sw — S.p.s.t. toggle switch.

T — Combination transformer: 400 volts each side of center-tap, 150 ma.; 5-volt 3-ampere filament winding for 83 rectifier; 6.3-volt 4-ampere winding for 6L6s (UTC type S-39; low-voltage secondary taps used).

L₁ — For 1.75-Mc. crystals — 32 turns No. 24 d.s.c., close-wound.

For 3.5-Mc. crystals — 10 turns No. 22, 1-inch long; 100- μ fd. mica condenser mounted in form and connected across winding.

For 7-Mc. crystals — 6 turns No. 22, $\frac{5}{8}$ -inch long.

L₂, L₄ — 1.75-Mc. band — 55 turns No. 26, $1\frac{3}{4}$ inches long.

3.5-Mc. band — 26 turns No. 20, $1\frac{3}{4}$ inches long.

7-Mc. band — 15 turns No. 18, $1\frac{1}{2}$ inches long.

14-Mc. band — 10 turns No. 18, $1\frac{1}{2}$ inches long.

L₃ — (Wound close to and below L₂):

1.75-Mc. band — 14 turns No. 26, close-wound.

3.5-Mc. band — 9 turns No. 24, close-wound.

7-Mc. band — 6 turns No. 20, close-wound.

14-Mc. band — 4 turns No. 20, close-wound.

L₅, L₆ — 3 to 6 turns as required for proper coupling to antenna. L₅ wound close to and below L₄; L₆ wound between sections of L₇.

L₇ * 1.75 Mc. — 20 turns No. 22, $\frac{3}{4}$ -inch long each section, with $\frac{1}{2}$ -inch space between sections, 40 turns total.

3.5 Mc. — 11 turns No. 20, $\frac{3}{4}$ -inch long each section, with $\frac{1}{2}$ -inch space between sections, 22 turns total.

7 Mc. — 6 turns No. 20, $\frac{3}{4}$ -inch long each section, with $\frac{1}{2}$ -inch space between sections, 12 turns total.

14 Mc. — 3 turns No. 20, $\frac{1}{2}$ -inch long each section, with $\frac{1}{4}$ -inch space between sections, 6 turns total.

All above coils wound on Hammarlund $1\frac{1}{2}$ -inch diameter forms. Four-prong are used for L₁, five-prong for all others.

L₈ — Filter choke, 6 henrys, 175 ma. (UTC S29).

* See text for usage.

milliammeter with a scale of 150 or 200 ma. will serve for tuning both stages. With the meter connected in the oscillator circuit, the key should be closed and C₁ tuned until the plate current dips near maximum capacity. When the dip has been found, the condenser should be set slightly on the low-capacity side to assure reliable keying. The best setting can be determined by listening to the transmitter signal on a receiver, with the receiving antenna removed to prevent blocking.

With the oscillator correctly adjusted, the milliammeter should next be shifted to the amplifier plate circuit and C₂ similarly tuned for a plate-current dip near maximum capacity.

With the same crystal and cathode coil in use, the coils for the next-higher frequency band may be plugged in and the tuning process repeated for this set of coils. The transmitter will then be tuned to the second harmonic of the crystal frequency, or twice its fundamental frequency. Thus output can be obtained in two bands from any one crystal, providing its second harmonic does not fall outside an amateur band. If the coils are carefully trimmed, it will be possible to tune to the crystal fundamental near the maximum-capacity settings of C₁ and C₂ and to the second harmonic near minimum capacity. It should be borne in mind that the cathode coil requires changing only in case a

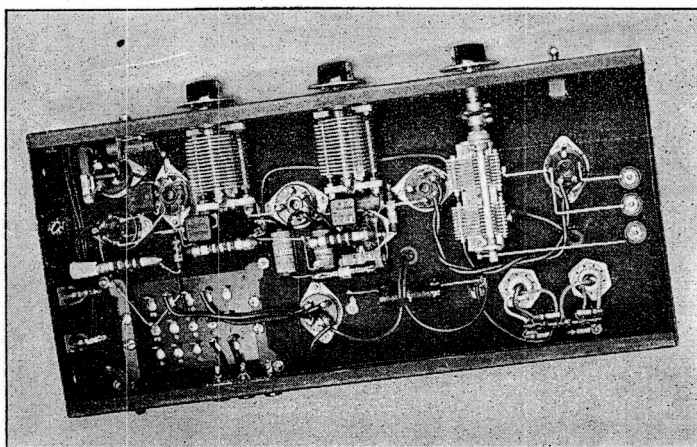


Fig. 1209 — All wiring connections are made underneath the chassis of the 45-watt c.w. transmitter. The sockets, the filter condensers, C_{14} and C_{15} , and the power transformer all are sub-mounted. C_{16} is to the right, C_2 at the center, and C_1 at the left. Meter pin jacks, with shunting resistors, R_3 and R_4 , are mounted along the rear edge of the chassis at the left. The crystal and cathode coil sockets are wired up as shown in Fig. 1260, permitting use either of crystal control or of a variable-frequency oscillator, as desired. The pin jacks along the right end of the chassis are for the v.f.o. input connections, if used. It is highly important that leads between the pin jacks and the cathode coil socket be kept short.

crystal is used whose frequency is in a different band; the same cathode coil serves for fundamental and harmonic operation.

An inverted amplifier does not operate efficiently as a frequency doubler. Therefore, operation of the amplifier as a second doubler is not recommended. This type of amplifier also is not recommended for modulation, and therefore is not suitable for radiotelephony.

The antenna tuner — By changing the position of the banana plug which fits the jack-top output binding posts, as indicated in the circuit diagram several combinations may be obtained. Placing the plug in terminal No. 3 and connecting the feeders to terminals 1 and 3 provides a low-capacity parallel-tuned circuit. By placing the plug in the top of terminal 1, strapping terminals 2 and 3 together and connecting the feeders to 1 and 3, parallel tuning with high capacity is obtained. By keeping the plug in terminal 1 and connecting the feeders between 2 and 3, series tuning with high capacity may be secured. Finally, by leaving the plug open and connecting the feeders to 2 and 3, the circuit becomes one having series tuning with low capacity.

Antenna coils of four sizes are listed among the coil data. Using a combination of one of these coils with various arrangements of tuning, it should be possible to arrive at a satisfactory tuning and coupling adjustment. The dimensions given will be approximately correct for parallel tuning in the band indicated. For series tuning, the coil for the next higher-frequency band will be approximately correct, if feeder lengths are reasonably close to quarter-wavelength multiples. The output coupling may be adjusted, by the process of changing the number of turns at each end of the link line, to load the amplifier to a maximum plate current of 100 to 125 ma.

When resonance points have been found, the proper procedure in tuning is first to set the antenna-tuning circuit well away from resonance, and then to tune the oscillator. Next, tune the amplifier to maximum plate-current dip, and, finally, swing the antenna-tuning condenser

into resonance, as indicated by a peak in the amplifier plate current.

By proper adjustment it should be possible to obtain a power output of 25 to 30 watts in all bands, the higher output power occurring at the lower frequencies. With a plate voltage of 450, an amplifier loading which results in a plate current of 100 to 125 ma. ordinarily represents optimum adjustment; greater loading will usually result in a decrease in output.

The oscillator plate current at resonance normally will run between 22 and 32 ma., depending upon frequency and whether or not the oscillator is doubling frequency. When operating at the fundamental the oscillator plate current will run somewhat higher than when doubling, because of the necessity for tuning off exact resonance to permit reliable keying. With a plate voltage of 450, the oscillator screen voltage should be approximately 200 volts and the screen voltage of the amplifier, when tuned and loaded, about 260 volts.

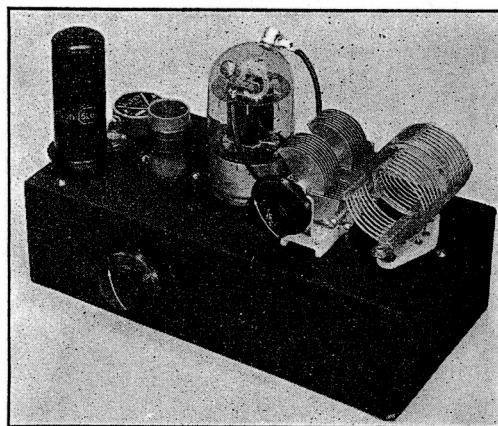
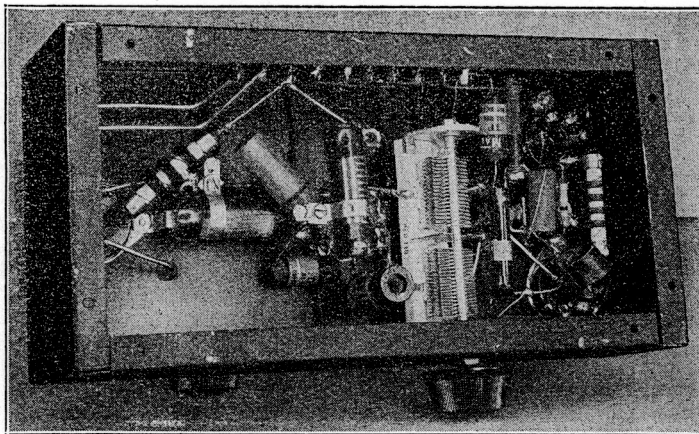


Fig. 1210 — An inexpensive three-band transmitter using an 815 dual beam tetrode as the output tube. The transmitter is assembled on a $3 \times 5 \times 10$ -inch chassis. The oscillator plate coil and amplifier grid coil are wound on the small 1-inch form between the 6L6 and the 815. The lower control is for the amplifier grid condenser which also controls the tuning of the oscillator plate tank.

Fig. 1211 — Bottom view of the 815 transmitter, showing the under-chassis arrangement. The dual-section amplifier grid tuning condenser, C_1 , is placed between the 815 socket and the coil socket for L_2 and L_3 , so that the connections for the tuned circuit can be kept short. The cathode coil, L_1 , is wound on a $\frac{1}{2}$ -inch diameter form with a sheet of paper placed between the winding and the form, to facilitate removal. Before it is removed the winding is given a coating of Duco cement or coil dope. The coil terminals are soldered directly to the oscillator tube socket. The normal power output of the transmitter at the maximum rated plate voltage of 500 should be 50 to 55 watts.



❶ An Inexpensive Three-Band Transmitter Using the Type 815

Figs. 1210 and 1211 show an inexpensive transmitter designed to operate in the 3.5-, 7- and 14-Mc. bands from a 3.5-Mc. crystal. A 6L6 Tri-tet oscillator is used to drive a type 815 in a push-pull amplifier circuit. As shown in the wiring diagram, Fig. 1212, the oscillator and amplifier stages are coupled inductively, while the tuning condenser is connected in the grid circuit of the amplifier. Since the 815 is a screened tube, no neutralization is necessary at the frequencies at which the transmitter is designed to operate.

The 815 operates at all times as a straight amplifier. Excitation at 14 Mc. is obtained by tuning the plate circuit of the oscillator to the fourth harmonic of the crystal frequency. The 60-ma. dial lamp, B, connected in series with the crystal, serves to indicate relative crystal r.f. current.

Tuning — This transmitter is designed to operate from a single plate supply delivering up to 500 volts at 200 milliamperes or more. The unit shown in Fig. 1214 will be satisfactory for this purpose, and will also furnish the 6.3-

volt supply required for the heaters. A 45-volt "B" battery is also required for biasing the 815, to limit the plate current to a low value when the key is open.

Fig. 1212 shows how external meters may be connected for tuning the transmitter. Setting up for any one of the three bands is merely a matter of plugging in the coils for the band desired, as indicated in Fig. 1213.

It is advisable to test the oscillator circuit first, and the plate and screen voltages should be removed from the 815 during this period. With voltage applied to the oscillator, the 815 grid circuit, C_1L_3 , should be brought to resonance as indicated by maximum reading on a milliammeter connected in the amplifier grid-bias lead. The dropping resistor, R_4 , should be set at its full value of 6000 ohms during the preliminary testing; to secure proper plate voltage, a final setting may be made when the power supply is completely loaded by the entire transmitter. The grid current should be in the neighborhood of 10 milliamperes on all three bands. This may be adjusted by changing turns on L_2 , or by detuning C_1 if grid current is excessive. The oscillator plate current will re-

Fig. 1212 — Circuit diagram of the inexpensive three-band transmitter using a type 815 dual-tetrode output tube.

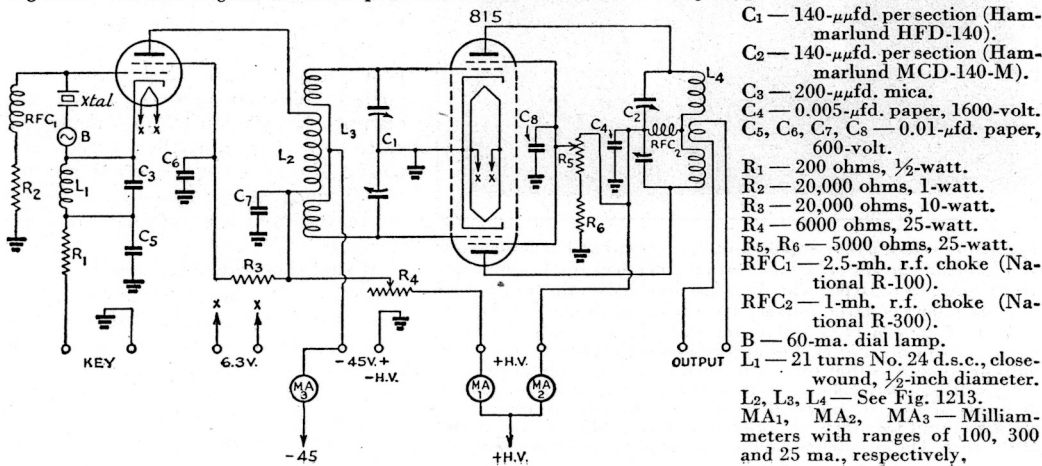
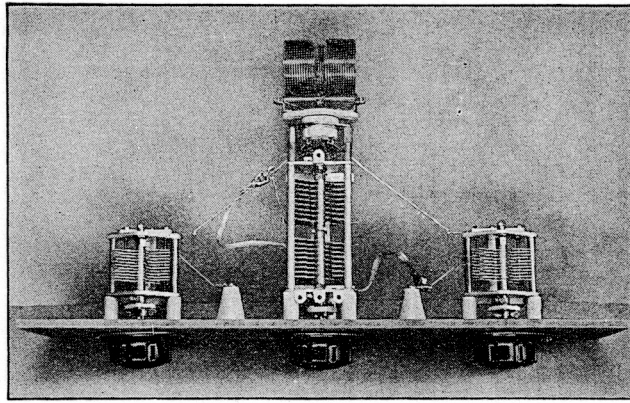


Fig. 1216—A rack-mounting antenna tuner for low-power transmitters. C_1 is in the center, with C_2 and C_3 on either side. All of the components are mounted directly on the $5\frac{1}{4}$ -inch panel. The variable condensers are mounted on the assembly rods on National type GS-1 insulating pillars which are fastened to the condenser end plates with machine screws from which the heads have been removed. Small Isolantite shaft couplings are used to insulate the controls. The coil socket is fastened to the rear end plate of the parallel condenser, C_1 , with spacers to clear the prongs. Clips with flexible leads are provided for the split-stator parallel condenser, C_1 , so that its sections may be connected either in parallel or in series to form either a high- or low-capacity tank circuit as required.



screen voltage when the load is greatly reduced. However, the plate current should drop to only a few milliamperes so long as the screen voltage does not reach a value which exceeds the normal voltage by more than 50 or 75 volts.

The amplifier plate coils are complete with links which permit working directly into a low-impedance line. This means that the amplifier may be fed into a concentric (73-ohm) or twisted-pair line, or that it may be link-coupled to an amplifier operating at higher input or to an antenna tuner for coupling to an antenna with tuned feeders. If desired, the oscillator circuit may be arranged for optional crystal or v.f.o. input as shown in Fig. 1260.

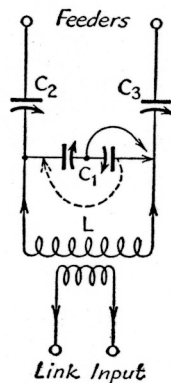


Fig. 1217—Circuit of the rack-mounting antenna tuner for use with transmitters having final amplifiers which are operated at less than 1000 volts on the plate.

C_1 —100 $\mu\text{fd.}$ per section, 0.045-inch spacing (National TMK-100-D) for higher voltages; receiving-type for lower voltages (Hammarlund MCD-100).

C_2, C_3 —250 $\mu\text{fd.}$, 0.026-inch spacing (National TMS-250) for higher voltages; receiving-type for lower voltages (Hammarlund MC250).

L —B&W JVL series coils. Approximate dimensions for parallel tuning for each band are as follows:

1.75-Mc. band—56 turns No. 24.

3.5-Mc. band—40 turns No. 20.

7-Mc. band—24 turns No. 16.

14-Mc. band—14 turns No. 16.

28-Mc. band—8 turns No. 16.

All coils are $1\frac{1}{8}$ inches in diameter and $2\frac{1}{4}$ inches long, with the variable link located at the center. For series tuning, use of the coil specified for the next-higher frequency band will be approximately correct.

◀ A Low-Power Antenna Tuner for Rack Mounting

In the rack-mounted low-power antenna tuner shown in Fig. 1216, separate series and parallel condensers are used. This arrangement, while requiring three variable condensers, has the advantage that no switching is necessary when changing over from series to parallel tuning. It also makes it possible to cover a wider range of antenna and transmission-line conditions, because the series condensers can be adjusted in conjunction with the parallel condenser to shorten the electrical length of the feeders whenever this is required to make parallel tuning effective. In addition, the series condensers provide a measure of control over the amplifier loading when parallel tuning is used.

Clips with flexible leads attached are provided for the parallel condenser, C_1 , so that the sections may be connected either in parallel or in series to form either a high- or low-capacity tank circuit, as required. When the high-C parallel tank is desired, the two stators are clipped together, as shown by the dotted lines in the circuit diagram of Fig. 1217, and the rotor is connected to the opposite feeder. When the two sections are connected in series, for low-C operation, the break-down voltage is increased.

Under the circuit diagram, Fig. 1217, two sets of variable condensers are suggested. The smaller condensers should be satisfactory for low-power transmitters operating at plate voltages of 400 to 450 volts, while the condensers with larger spacing will be required for transmitters using higher voltages up to about 750 or 1000 volts.

◀ Complete Two-Stage 70-Watt 3-Band Transmitter

The units shown in Figs. 1210, 1214 and 1216, with the addition of a 45-volt battery for bias, may be combined to form a complete transmitter. The smaller condensers listed for the antenna tuner may be used. If the transmitter is mounted on an $8\frac{3}{4}$ -inch panel and $3\frac{1}{2}$ inches is allowed for a meter panel, the complete transmitter will occupy a height of $26\frac{1}{4}$ inches.

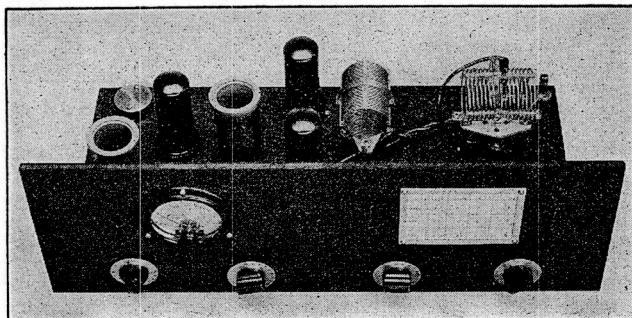


Fig. 1218 — A 90-watt c.w. transmitter using a 6L6 Tri-tet oscillator and a push-pull 6L6 amplifier. The rack-width panel of the transmitter is 7 inches high. The single milliammeter is switched from the oscillator to the amplifier by the rotary switch at the lower left. The three remaining controls are for tuning the oscillator plate, amplifier plate and antenna tank circuits. All sockets, except those for the amplifier- and antenna-tank coils are sub-mounted. The three insulated terminals just visible at the right rear behind the antenna coil, L_4 , are the binding-post output connections for the antenna tuner.

◀ A 90-Watt C.W. Transmitter Using Push-Pull 6L6s

In the 90-watt c.w. transmitter shown in Figs. 1218 and 1219, a 6L6 Tri-tet oscillator drives a pair of 6L6s in a push-pull inverted amplifier circuit. The circuit diagram appears in Fig. 1220.

The sockets for the crystal and the cathode coil are wired as shown in Fig. 1260, to permit feeding with a v.f.o. unit if desired. The plate circuit of the oscillator is parallel-fed to permit grounding of the rotor of C_2 in mounting. A high-capacity tank condenser is used so that two bands may be covered with one coil, reducing coil-changing when shifting from one band to another. The cathode coil, L_5 , by which the oscillator and amplifier are coupled, is center-tapped to provide push-pull input to the amplifier stage.

While neutralization is not required, a certain amount is introduced through the fixed condensers C_9 and C_{10} from plates to cathodes partially to nullify the effects of degeneration inherent in this type of circuit and thereby reduce excitation requirements. Neutralization is not carried to the point where there is danger of instability. All r.f.-wiring leads in the amplifier should be made as short and direct as possible. The individual grid condensers, C_7 and C_8 , should be connected directly at each socket.

The output of the amplifier is link-coupled to an antenna tuner. The lower stator of C_4 is fitted with a flexible lead terminated in an in-

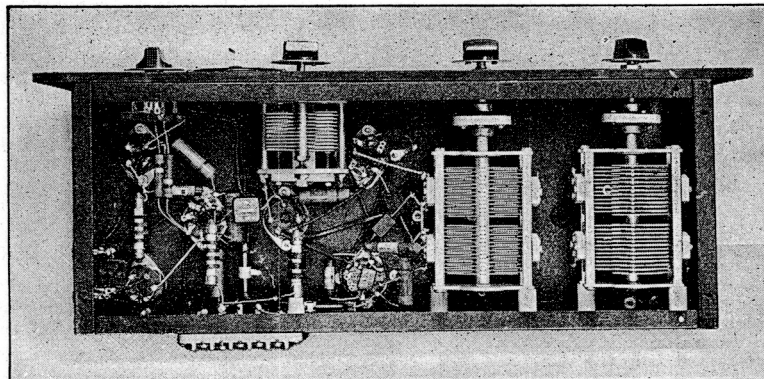
sulated banana plug which may be plugged into any one of the antenna terminals, which are jack-top binding posts. These posts are insulated from the chassis by mounting them in National polystyrene button-type insulators which have been drilled out. Series tuning with high capacity is obtained by placing the plug in terminal No. 1 and connecting the feeders to terminals Nos. 2 and 3, and series tuning with low capacity by leaving the plug free and connecting the feeders to terminals Nos. 2 and 3. High-capacity parallel tuning is obtained by placing the plug in terminal 1, shorting terminals 2 and 3, and connecting the feeders between 1 and 3, while parallel tuning with low capacity is obtained by placing the plug in terminal 3 and connecting to 1 and 3.

Both stages are keyed simultaneously in the cathode return leads. The milliammeter, MA , can be switched from the oscillator-cathode circuit to that of the amplifier. Switching of the meter is simplified by inclusion of the shunting resistances, R_6 and R_7 , which are sufficiently high in value to have negligible effect upon the reading of the meter.

The transmitter can be operated at maximum input from the 450-volt 200-ma. power supply shown in Fig. 1214.

Tuning — Tuning of the transmitter is quite simple. It should be borne in mind that output from the oscillator may be obtained at either the fundamental frequency of the crystal or at the second harmonic of that frequency, and that the selection of the proper coil for L_1 depends upon the crystal frequency and not

Fig. 1219 — The three tank condensers are mounted underneath the chassis of the 90-watt transmitter. The two split-stator condensers are mounted from the rear edge with insulating pillars, and their shafts are fitted with insulating couplings and panel bearings. They must be mounted so their shafts come level with that of C_2 to the left, which is mounted directly on the chassis. Heavy bare-wire leads through grommets connect the amplifier and antenna tank condensers and coils.



the output frequency of the oscillator. Using the oscillator plate coils listed under Fig. 1220, the lowest-frequency band will be found near the maximum-capacity end on the dial of C_2 , while the higher-frequency bands will be found near the minimum capacity end of its tuning range.

With the milliammeter switched to the oscillator circuit the plate-current reading should be about 60 ma. when the key is closed, if the full 350 volts is used on the plate. As C_2 is tuned to resonance, the oscillator plate current will dip to about 25 ma. at the lower frequencies and to about 50 ma. at the higher frequencies.

When the meter is switched to the amplifier stage, a plate-current reading of about 260 ma. should be obtained with the key closed. A plate-current dip to 50 ma. or less should be obtained when C_3 is tuned to resonance.

Once these adjustments have been completed, the antenna may be coupled and tuned. When the plate current of the amplifier increases to 200 ma. at resonance, this represents about optimum loading. Using a plate voltage of 450 and with proper adjustment of the amplifier, it should be possible to obtain a power output of 50 to 60 watts on all bands.

As with the single-tube inverted amplifier previously discussed, this transmitter is recommended for c.w. work only.

Complete 90-Watt C.W. Transmitter

The 90-watt 6L6 r.f. unit of Fig. 1218 may be combined with the power-supply unit showing Fig. 1214 (with the 6.3-volt filament transformer included) to form a complete c.w. transmitter. The two units will have a combined height of $15\frac{3}{4}$ inches when mounted in a standard relay rack or cabinet.

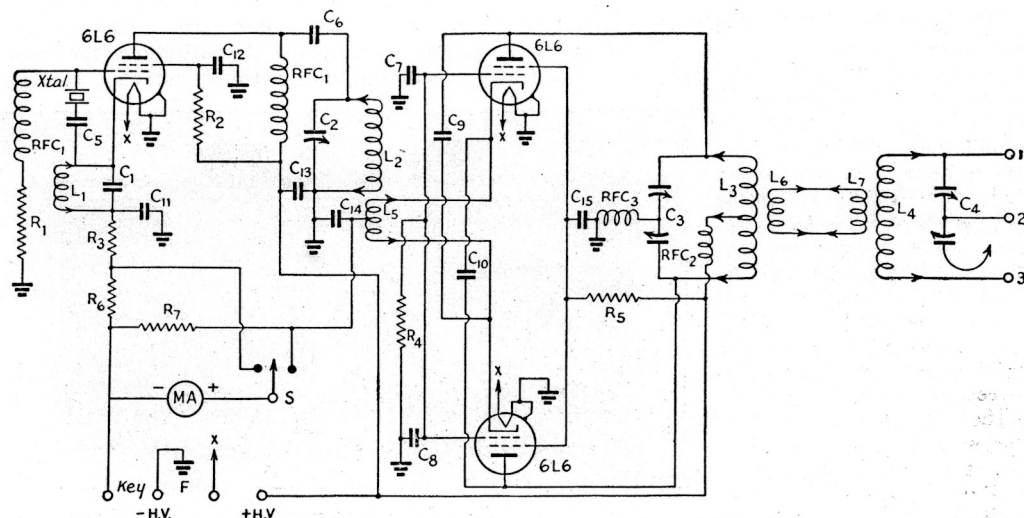


Fig. 1220 — Circuit diagram of the 90-watt push-pull 6L6 transmitter with a built-in antenna coupler.

- | | | |
|---|--|---|
| C_1 — 100- μ fd. mica. | C_9, C_{10} — 10- μ fd. mica. | R_6, R_7 — 25 ohms, 1-watt. |
| C_2 — 250- μ fd. variable (National TMS-250). | $C_{11}, C_{12}, C_{13}, C_{14}, C_{15}$ — 0.01 μ fd. paper. | MA — 0-300 milliammeter. |
| C_3, C_4 — 250 μ fd. per section (Hammarlund MTCD-250-C). | R_1 — 0.1 megohm, $\frac{1}{2}$ -watt. | S — S.p.d.t. switch. |
| C_5, C_6 — 0.001- μ fd. mica. | R_2 — 50,000 ohms, 2-watt. | RFC1 — 2.5-mh. r.f. choke, 100-ma. |
| C_7, C_8 — 50- μ fd. mica. | R_3 — 500 ohms, 1-watt. | RFC2 — 1-mh. r.f. choke, 300-ma. (National R300). |
| | R_4 — 25,000 ohms, 1-watt. | RFC3 — V.h.f. parasitic choke (Ohmite Z-1). |
| | R_5 — 12,000 ohms, 10-watt. | |
| L_1 * — For 1.75-Mc. crystals: 32 turns No. 24 d.s.c., close-wound. | | |
| For 3.5-Mc. crystals: 10 turns No. 22, 1 inch long; 100- μ fd. mica condenser mounted in form, connected across winding. | | |
| For 7-Mc. crystals: 6 turns No. 22, $\frac{5}{8}$ -inch long. | | |
| L_2 * — For 1.75- and 3.5-Mc. bands — 38 turns No. 18 d.c.c. close-wound. | | |
| For 3.5- and 7-Mc. bands — 20 turns No. 18, $1\frac{1}{8}$ inches long. | | |
| For 7- and 14-Mc. bands — 9 turns No. 18, $1\frac{1}{2}$ inches long. | | |
| L_3 ** — B & W JCL series coils, dimensions as follows: | | |
| 1.75 Mc. — 60 turns No. 24, $2\frac{1}{8}$ inches long. | | |
| 3.5 Mc. — 44 turns No. 20, $2\frac{1}{8}$ inches long. | | |
| 7 Mc. — 26 turns No. 16, $2\frac{1}{8}$ inches long. | | |
| 14 Mc. — 16 turns No. 16, $1\frac{1}{8}$ inches long. | | |
| L_4 *** — B & W JVL series coils, dimensions as follows: | | |
| 1.75 Mc. — 56 turns No. 24. | | |
| 3.5 Mc. — 40 turns No. 20. | | |
| 7 Mc. — 24 turns No. 16. | | |
| 14 Mc. — 14 turns No. 16. | | |
| 14 Mc. (series) — 8 turns No. 16. | | |
| L_5 — 1.75- and 3.5-Mc. bands — 20 turns, centertapped, No. 24 e., close-wound, wound close to bottom of L_2 on same form. | | |
| 3.5- and 7-Mc. bands — 14 turns, centertapped, No. 22 e., close-wound, wound $\frac{1}{8}$ -inch from bottom of L_2 on same form. | | |
| 7- and 14-Mc. bands — 8 turns, centertapped, No. 20 e., close-wound, wound $\frac{1}{8}$ -inch from bottom of L_2 on same form. | | |
| L_6, L_7 — 3 turns at center of L_3 and L_4 . | | |

* All wound on Hammarlund $1\frac{1}{2}$ -inch diameter 4-prong forms.

** All $1\frac{1}{2}$ inches in diameter.

*** All $1\frac{7}{8}$ -inch diameter, $2\frac{1}{4}$ inches long. Dimensions are approximate for parallel tuning for the band indicated. For series tuning, the coil for the next-higher frequency band is approximately correct.

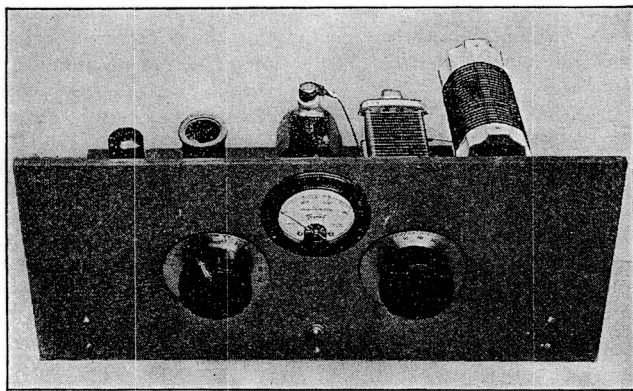


Fig. 1221—Front view of the 200-watt beam-tube transmitter.

A Two-Stage 200-Watt Beam-Tube Transmitter

The simplicity of the 200-watt transmitter shown in Figs. 1221, 1222 and 1223 will appeal to many amateurs. As the circuit of Fig. 1224 shows, a 6L6 Tri-tet oscillator supplies excitation at either the crystal fundamental frequency or its second harmonic for the HY67 in the output stage. Since the latter is a screened tube, no neutralizing is required. Parallel feed in the oscillator circuit permits mounting C_2 on the chassis without insulation. The milliammeter may be switched to read either oscillator or amplifier cathode current. R_5 in series with the screen prevents parasitic oscillation.

Power supply — A 300-volt supply is required for the plate of the oscillator and the screen of the amplifier. This voltage, as well as fixed biasing voltage for the amplifier, may be obtained from the combination unit in Fig. 1236, using the components shown for 300-volt output. The supply shown in Fig. 1225 will furnish plate voltage for the amplifier.

Tuning — The simplicity of the circuit makes tuning easy. With a cathode coil, L_1 , appropriate for the crystal in use, and an oscillator plate coil, L_2 , which covers the crystal frequency with C_2 near maximum, the oscillator is tuned either to the fundamental frequency, near the maximum of C_2 , or to the second harmonic, near the minimum capacity of C_2 , by the customary plate-current dips. The key should not be kept closed for prolonged periods during this adjustment unless the 300-volt lead to the screen of the amplifier is disconnected. If the plate-current dips indicating both fundamental and harmonic are not

found, it may be necessary to add or subtract a turn or two from L_2 .

The amplifier is simply tuned to resonance with the proper coil for the desired output frequency in place by switching the meter to read amplifier cathode current. The am-

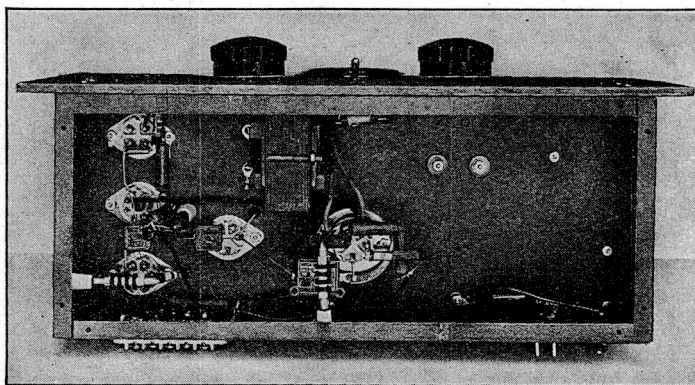


Fig. 1222 — Underneath the 3 × 7 × 17-inch chassis of the two-stage 200-watt beam-tube transmitter.

plifier may then be link-coupled to an antenna tuner, such as the one shown in Fig. 1226, and loaded in the usual way. As a matter of fact, it is preferable to tune the amplifier with the load connected, after one has become

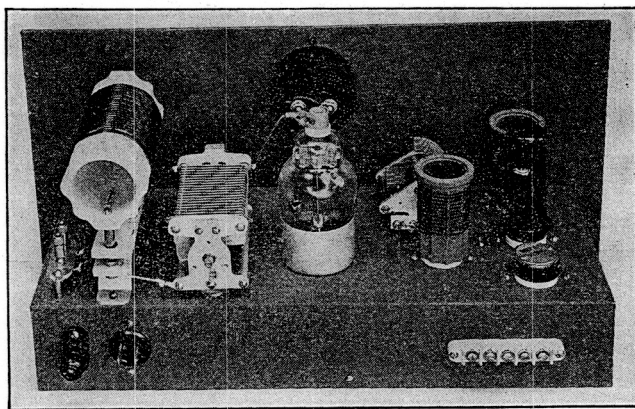


Fig. 1223 — The cathode coil, oscillator tube and crystal sockets of the 200-watt beam-tube transmitter are mounted in a row at the right. The socket for the HY67 is sunk an inch below the chassis level to shorten the plate lead, and the bottom portion of the tube is shielded with a section from a Hammarlund PTS tube shield. The amplifier plate tank condenser is insulated from the chassis by means of National polystyrene button-type insulators placed at the three mounting feet. The filament transformer and other small components are underneath the chassis, as may be seen in Fig. 1222. Power output of 130 to 150 watts on c.w. can be obtained on any of the bands covered. If the amplifier is to be plate-and-screen modulated, the input should be reduced to 1000 volts at 150 ma.

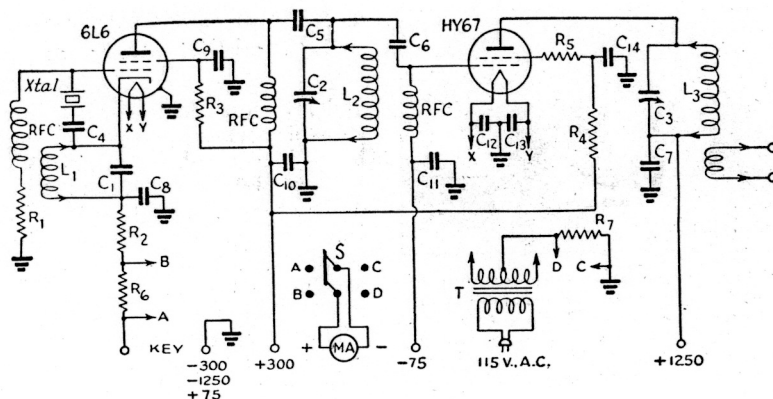


Fig. 1224 — Circuit diagram of the two-stage 200-watt beam-tube transmitter.

- C₁ — 100- μ fd. mica.
 C₂ — 300- μ fd. variable (National TMS-300).
 C₃ — 250- μ fd. variable, 0.045-inch spacing (National TMK-250).
 C₄, C₅ — 0.001- μ fd. mica.
 C₆ — 100- μ fd. mica.
 C₇ — 0.001- μ fd. mica, 5000-volt rating.
 C₈, C₉, C₁₀, C₁₁, C₁₂, C₁₃, C₁₄ — 0.01- μ fd. paper.
 MA — D.c. milliammeter, 0-300-ma. scale.
 R₁ — 0.1 megohm, $\frac{1}{2}$ -watt.
 R₂ — 500 ohms, 1-watt.
 R₃ — 50,000 ohms, 10-watt.
 R₄ — 2000 ohms, 10-watt.
 R₅ — 50 ohms, 1-watt.
 R₆ — 25 ohms, 1-watt.
 R₇ — 25 ohms, 10-watt.
 RFC — 2.5-mh. r.f. choke.
 S — Double-pole double-throw toggle switch.
 T — Filament transformer, 6.3 volts, 6 amperes (Thor-darson T-19F98).
 L₁ — For 1.75-Mc. crystals — 32 turns No. 24 d.s.c., close-wound.
 For 3.5-Mc. crystals — 10 turns No. 22, 1-inch

- long; C₁ is mounted in form, connected across winding.
 7-Mc. crystals — 6 turns No. 22, $\frac{5}{8}$ -inch long.
 L₂ — 1.75- and 3.5-Mc. bands — 30 turns No. 20 e., $1\frac{1}{2}$ inches long.
 3.5- and 7-Mc. bands — 15 turns No. 18 e., $1\frac{1}{2}$ inches long.
 7- and 14-Mc. bands — 6 turns No. 18 e., $\frac{7}{8}$ -inch long.
 All above coils wound on Hammarlund $1\frac{1}{2}$ -inch diameter coil forms.
 L₃ — 1.75-Mc. band — 32 turns No. 18 d.c.c., $3\frac{1}{2}$ inches long.
 3.5-Mc. band — 20 turns No. 12, 3 inches long, turns wound in successive grooves.
 7-Mc. band — 9 turns No. 12, $1\frac{3}{8}$ inches long, turns wound in successive grooves.
 14-Mc. band — 6 turns No. 12, $1\frac{1}{4}$ inches long, turns wound in alternate grooves.
 All above wound on National XB-10A $2\frac{1}{2}$ -inch diameter coil forms. The form for the 1.75-Mc. coil is covered with a sheet of cardboard before winding. Number of link turns is adjusted for proper loading.

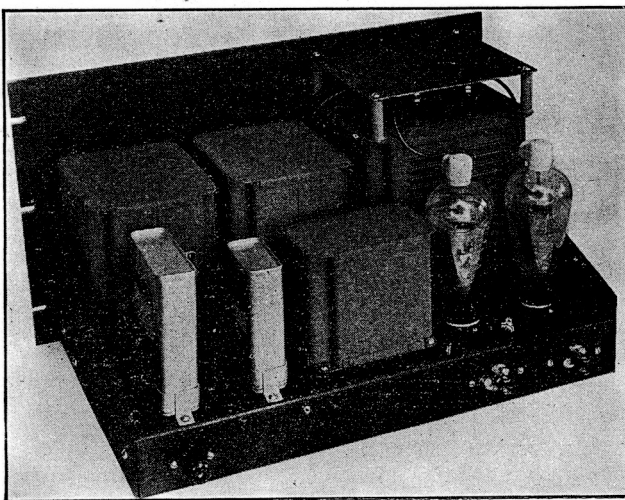
accustomed to the tuning procedure, so as to limit screen heating.

Under normal conditions, the oscillator cathode current will run between 35 and 40 ma. when tuned to resonance in any band, while the cathode current of the amplifier should be about 225 ma. when fully loaded. This total cathode current will include screen

current of about 30 ma. and grid current of about 20 ma. The oscillator screen voltage should be between 175 and 200 volts, while the amplifier screen voltage will run about 240 volts with the amplifier tuned and loaded.

If desired, the oscillator circuit may be arranged for v.f.o. input as shown in Fig. 1260.

Fig. 1225 — This power supply unit delivers 830, 1060 or 1250 volts at 250 ma. Voltages are selected by taps on the secondary. Ripple is reduced to 0.25 per cent and the regulation is about 10 per cent. The transformer terminal board is covered with a panel mounted on pillars at the four corners. Insulating caps are provided for the tube plate terminals. A Millen safety terminal protects the high-voltage connection. The chassis measures $11 \times 17 \times 2$ inches and the panel size is $10\frac{1}{2} \times 19$ inches. The circuit is the same as that shown in Fig. 1245, the following values being used:
 C₁ — 2- μ fd. 1500-volt (Aerovox Hyvol).
 C₂ — 4- μ fd. 1500-volt (Aerovox Hyvol).
 L₁ — Input choke, 5.25 henrys, 300 ma., 90 ohms (UTC S34).
 L₂ — Smoothing choke, 15 henrys, 300 ma., 90 ohms (UTC S33).
 R — 25,000 ohms, 100-watt.
 T₁ — 1500-1250-1000 volts r.m.s. each side, 300-ma. d.c. (UTC S47).
 T₂ — 2.5 volts, 10 amperes, 10,000-volt insulation (UTC S57).



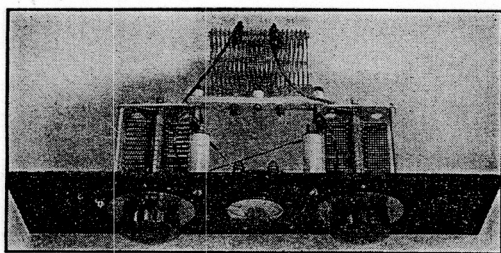


Fig. 1226 — A link-coupled antenna-tuning unit for use with resonant feed systems and medium-power amplifiers. The inductance, with variable link, is mounted on the condenser frames. Clips are provided for changing the number of turns and for switching the condensers from series to parallel. The panel is $5\frac{1}{4} \times 19$ inches.

Antenna Tuner for Medium Power

The antenna tuner shown in Fig. 1226 will usually be satisfactory for amplifiers operating at plate voltages not in excess of 1250 volts.

The two condensers are mounted from the panel by means of insulating pillars taken from National GS-1 insulators, which are fastened to the end plates with small sections of machine screws from which the heads have been cut. The variable link coil is mounted between the two rear end plates. The size of the coil is varied by short-circuiting turns, using clips which are attached to the condensers with flexible leads. As shown by the circuit diagram, Fig. 1227, the condensers are connected in parallel when the second pair of clips connects each rotor to the stator of the opposite condenser. The feeders are connected to the two large stand-off insulators mounted on the panel.

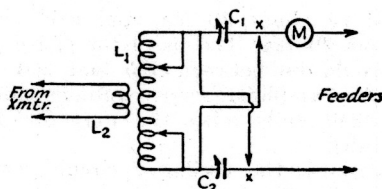


Fig. 1227 — Circuit diagram of the link-coupled antenna-tuning unit for use with medium-power transmitters. C_1 , C_2 — 100- μ fd. variable, 0.07-inch spacing (National TMC-100).

L_1 — 22 turns No. 14, diameter $2\frac{3}{4}$ inches, length 4 inches (Coto with variable link).

L_2 — 4 turns, rotating inside L_1 .

M — R.f. ammeter, 0-2.5-ampere range for medium-power transmitters.

Complete 200-Watt Beam-Tube Transmitter

The units of Figs. 1221, 1225 and 1226 may be combined with that of Fig. 1236 to form a complete transmitter which will occupy a total height in a relay rack of $31\frac{1}{2}$ inches. Plate voltage for the oscillator and screen and bias supply for the HY67 are obtained from the unit of Fig. 1236 (values for 300-volt output), which may be mounted on a 7-inch panel. Plate voltage of 1250 for the HY67 is obtained from the power-supply unit shown in Fig. 1225.

A Simple 200-Watt Transmitter for the 1.75- and 3.5-Mc. Bands

The transmitter shown in Figs. 1229, 1230 and 1231 illustrates how construction may be simplified when operation on only one or two bands is required. In the circuit, shown in Fig. 1228, a 6L6 Tri-tet oscillator is employed to drive a pair of 809s in pushpull. While the circuit is designed primarily for 1.75- and 3.5-Mc. output using 1.75-Mc. crystals, 3.5-Mc. crystals may be used for 3.5-Mc. output by closing S_1 which short-circuits the cathode tank coil.

The two stages are coupled capacitively, and, since no coil changing is required, all coils are permanently mounted. In the oscillator circuit, changing from one band to the other is by the main tank condenser, C_2 , which has sufficient range to cover both bands with the same coil.

Parallel plate feed is used in the oscillator so that the amplifier grids may be series fed to eliminate the possibility of low-frequency parasitic oscillations which might be caused by r.f. chokes in both grid and plate circuits. The fixed condenser, C_9 , is for the purpose of compensating for the output capacity of the 6L6, to equalize excitation to the grids of the 809s.

To permit easy reading of the low currents in the oscillator plate and amplifier grid circuits, a meter with a scale of 100 ma. is used. When the switch is turned to read amplifier plate current, a shunt, R_7 , is connected across the meter to multiply the scale reading by four times. This shunt is wound with No. 24 wire.

Power supply — The oscillator requires a plate voltage of 450, while the amplifier operates from a 1000-volt supply for full c.w. output. A $22\frac{1}{2}$ -volt "B" battery is required for fixed bias for the amplifier. The 450-volt unit shown in Fig. 1203 is suitable for the oscillator, while the supply pictured in Fig. 1225 will furnish power for the amplifier. The 1000-volt secondary taps should be used.

Tuning — Plate voltage should not be applied to the amplifier until the oscillator has been tuned and the amplifier neutralized. An active 1.75-Mc. crystal will oscillate with C_2 set at any position. Off resonance, the oscillator plate current should run in the neighborhood of 100 ma. Two dips in plate current will be found over the range of the condenser. The one near maximum capacity indicates resonance at the crystal fundamental and the one near minimum capacity indicates the second harmonic of the crystal frequency. At minimum dip the plate current should run between 80 and 90 ma. By switching the meter to the second position, it will be found that grid current indications are obtained at each of these points.

If a 3.5-Mc. crystal is used, S_1 should be closed and only the one point of resonance will be found, near minimum capacity. It will also be noticed that the circuit will oscillate only when the tank circuit is tuned near resonance and that a slight detuning toward the low-capacity side of C_2 will be required for reliable keying.

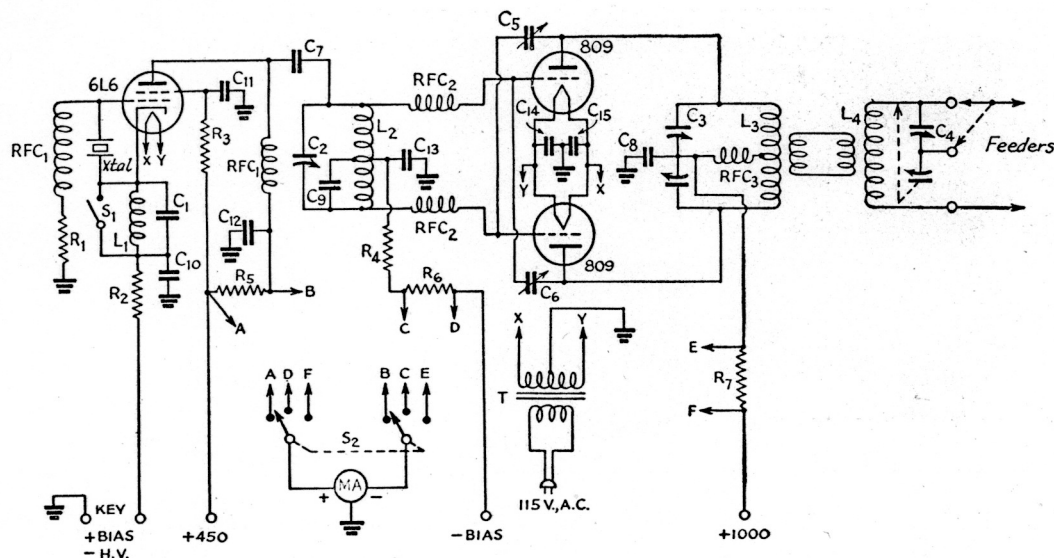


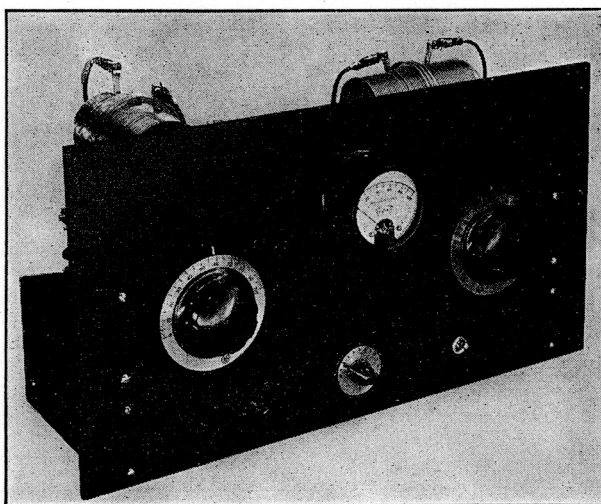
Fig. 1228 — Circuit diagram of the simple 200-watt push-pull 809 transmitter for the 1.75 and 3.5-Mc. bands.

- | | | |
|---|---|--|
| C ₁ — 100- μ fd. mica. | C ₁₀ , C ₁₁ , C ₁₂ , C ₁₃ , C ₁₄ , C ₁₅ — 0.01- μ fd. paper. | RFC ₁ — 2.5-mh. r.f. choke. |
| C ₂ — 250- μ fd. variable (National STH-250). | MA — Projection-type milliammeter, 0-100-ma. scale (Triplet Model 324). | RFC ₂ — V.h.f. parasitic choke, 20 turns No. 20, $\frac{1}{4}$ -inch diameter, close-wound. |
| C ₃ , C ₄ — 200 μ fd. per section, 0.07-inch spacing (Cardwell XT-210 PD). | R ₁ — 50,000 ohms, 1-watt. | RFC ₃ — 1-mh. r.f. choke, 300-ma., (National R-300). |
| C ₅ , C ₆ — Neutralizing condensers (Millen 15003). | R ₂ — 200 ohms, 2-watt. | S ₁ — S.p.s.t. toggle switch. |
| C ₇ — 500- μ fd. mica. | R ₃ — 25,000 ohms, 10-watt. | S ₂ — 2-gang 3-circuit high-voltage switch (Mallory 162C). |
| C ₈ — 0.001- μ fd. mica, 5000-volt rating. | R ₄ — 800 ohms, 10-watt. | T — Filament transformer, 6.3 volts, 6 amperes (Kenyon T387). |
| C ₉ — 50- μ fd. mica (see text). | R ₅ , R ₆ — 25 ohms, 1-watt. | |
| L ₁ — 40 turns No. 24 d.s.c., 1-inch diameter, close-wound. | R ₇ — Meter-shunting resistance (see text). | |
| L ₂ — 50 turns, $1\frac{1}{4}$ -inch diameter, $1\frac{5}{8}$ in. long (National AR-80-C, unmounted, no link, 2 turns removed from each end), 50 μ hy. inductance. | | |
| | L ₃ — 54 turns No. 16, $2\frac{1}{2}$ -inch diameter, $4\frac{1}{2}$ inches long, tapped 10 turns from each end for 3.5 Mc. (B & W) 160TA, unmounted, 80 μ hy. | |
| | L ₄ — Same as L ₃ , taps adjusted as required. | |

With C_2 adjusted for maximum grid current at the fundamental, the amplifier should be neutralized by adjusting both neutralizing condensers in small steps, keeping their capacities equal at all times. A check on the neutralizing adjustment may be made by any of the usual methods. One suitable test is with a neon bulb touched to one end of the plate tank coil,

which should not glow at any point in the range of the amplifier tank condenser except possibly at minimum capacity. Another test is that of observing the grid-current reading. When the amplifier is completely neutralized, swinging the amplifier tank condenser through its range should cause no change in grid current. When not neutralized, the grid current will show a

Fig. 1229 — A simple 200-watt transmitter for use on the 160 and 80 meter bands. The two large dials are used for tuning the amplifier and antenna tank circuits. The milliammeter is switched to read plate and grid currents in all circuits. The small control at the lower center is for the oscillator tank circuit, with the meter and cathode-circuit switches at either side. The panel measures $10\frac{1}{2} \times 19$ inches. An antenna tuner is included in the unit. If parallel tuning is required, the free stator of C_4 should be clipped to the free end of L_4 and the feeders connected one to each of the condenser stators. If series tuning is desired, the two stators are clipped together and one feeder clipped to the rotor and one to the coil, as indicated in the circuit diagram. The normal power output on c.w. will be approximately 150 watts. With the plate voltage reduced to 750 for plate modulation, the output will be about 100 watts. The oscillator circuit may be arranged for v.f.o. input, as shown in Fig. 1260.



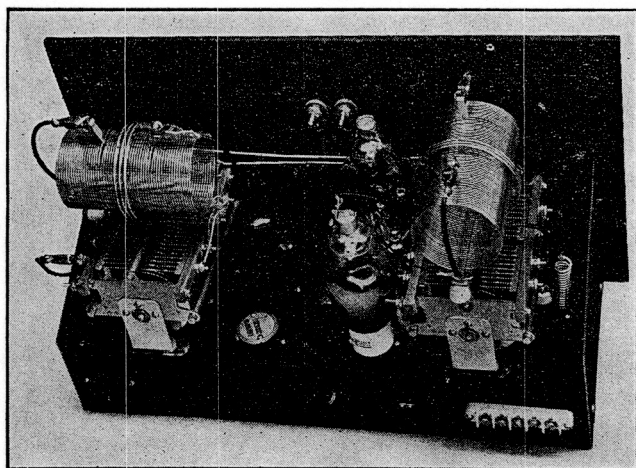


Fig. 1230 — Rear view of the 200-watt two-band transmitter. The antenna tank condenser at the left and the amplifier tank condenser at the right are mounted on metal brackets which are insulated from the chassis with pairs of National FWB polystyrene terminal strips placed at front and back. Strips of the same type are cut in half to form insulating bushings for the meter, which is mounted by its terminal studs. The neutralizing condensers are located between the 809s. The power plug at the lower left is for the filament transformer underneath. The chassis measures $7 \times 3 \times 17$ inches. When shifting to the 3.5-Mc. band, inductance in the amplifier and antenna tank circuits is changed by short-circuiting turns at each end of each coil. Johnson clamp-type coil clips are used at the shorting points as markers and to provide contacts for attaching the shorting clips.

sharp dip when the plate tank condenser is tuned through resonance.

Plate voltage may now be applied to the amplifier. It is advisable to make preliminary adjustments at reduced plate voltage. The voltage may be reduced by connecting a 150- or 200-watt lamp in series with the primary winding of the plate transformer. Minimum amplifier plate current (with the meter in the third position) as the plate tank circuit is tuned will indicate resonance. The value of plate current at the minimum point will depend somewhat upon the setting of the antenna tank condenser. However, by keeping the antenna circuit tuned well away from resonance a minimum reading of somewhat less than 50 ma. should be obtained.

Tests should next be made to make certain that the oscillator will key satisfactorily. If the crystal does not pick up readily, a slight re-tuning of C_2 should remedy the trouble.

Tuning the transmitter for 80-meter output is then a simple matter of tuning the oscillator to the resonance dip near the minimum of C_2 , placing the short-circuiting clips on L_3 , and tuning C_3 for resonance. The shift from one band to another should take but a few seconds.

The amplifier may be loaded until the total plate current reaches 200 ma. When loaded, the grid current should not fall below 60 ma.

If the plate of one amplifier tube shows color while the other remains cool, it is an indication that the excitation is unbalanced and calls for adjustment of C_9 . If the plate of the tube whose grid is connected to the same end of L_2 as the plate of the 6L6 shows color, the capacity of C_9 should be increased, while color in the other tube would require a reduction in capacity. In any case the value will not be critical within 10 or 20 $\mu\text{fd.}$, and the value of C_9 specified should be satisfactory in most cases.

Complete Two-Stage 200-Watt Transmitter for the 1.75- and 3.5-Mc. Bands

The transmitter of Fig. 1229 may be combined with the power-supply units of Figs. 1203 and 1225 in a complete unit with the addition of a 22.5-volt battery for bias. If the unit of Fig. 1203 and the bias battery are mounted behind a 7-inch panel, the total rack height required will be 28 inches. The unit of Fig. 1203 supplies power to the oscillator, while plate voltage for the amplifier is obtained from the power supply shown in Fig. 1225.

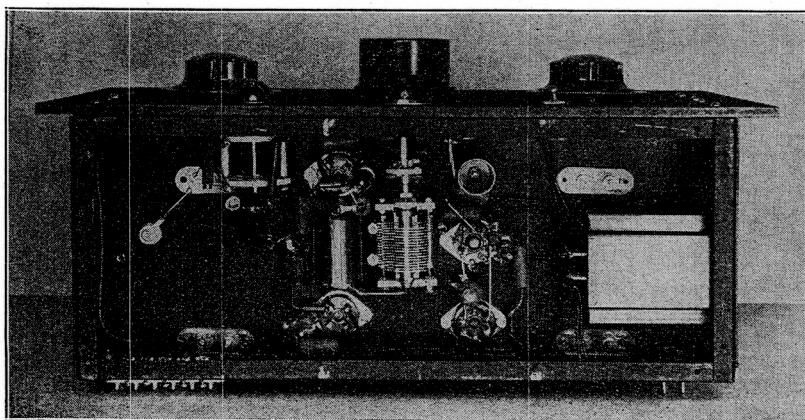
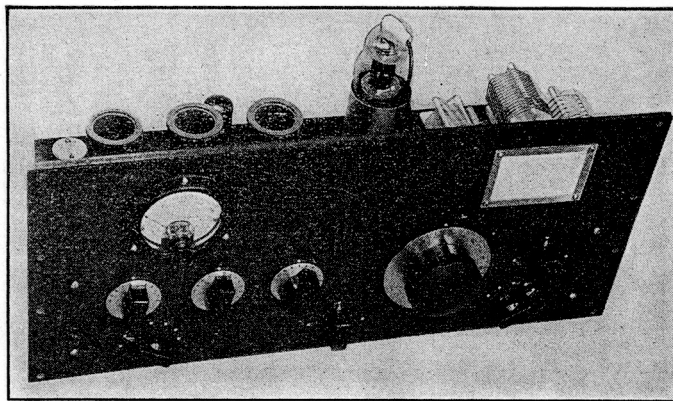


Fig. 1231 — The oscillator tank of the 200-watt two-band transmitter is underneath the chassis, well shielded from the amplifier. The tank coil, L_2 , is mounted on a pair of $\frac{1}{2}$ -inch stand-off insulators between the 809 sockets. Sufficient space is left between the 6L6 and crystal sockets to allow the oscillator tank condenser, C_2 , to be mounted at the center of the chassis on a pair of National FWB terminal strips serving as insulators. L_1 is just above the 6L6 socket.

Fig. 1232—An 807 exciter or low-power transmitter combining the flexibility of plug-in coils with the convenience of band-switching. A band-switching plug-in coil assembly changes tank coils in the 807 plate circuit. Crystal switching and meter switching also are provided. Plate currents for all tubes and screen current for the 807 are read on a 200-ma. meter which can be switched to any circuit. Keying is in the oscillator cathode circuit, for break-in operation. The panel is $8\frac{3}{4}$ inches high and of standard rack width. The chassis measures 8 x 17 x 2 inches. The unit requires two power supplies, one delivering 250 volts at approximately 75 ma. and the other 750 volts at 100 ma.



A Band-Switching Exciter with 807 Output

The exciter or low-power transmitter pictured in Figs. 1232, 1234 and 1235 is designed for flexibility, being adaptable for use on all bands from 1.75 to 28 Mc., with crystals cut for different bands, and also for quick band changing over three bands. It consists of a 6C5 triode oscillator followed by two triode doubler stages in one tube, a 6N7; by means of a switch, S_2 , the output of any of the three stages can be connected to the grid of the final tube, which is an 807 beam tetrode. The circuit diagram is given in Fig. 1233.

The oscillator, first and second doubler plate coils, L_1 , L_2 and L_3 respectively, need not be changed for crystals ground for a given band. The switching circuit is so arranged that the grids of unused stages are automatically disconnected from the preceding stage and grounded, so that excitation is not applied to the idle doubler tubes.

Capacity coupling between stages is used throughout. The plates of the first three stages are parallel-fed so that the plate tuning condensers can be mounted directly on the metal chassis. The 6C5, 6N7, and the 807 screen all operate from a 250-volt supply. Series feed is used in the 807 plate circuit, the tank con-

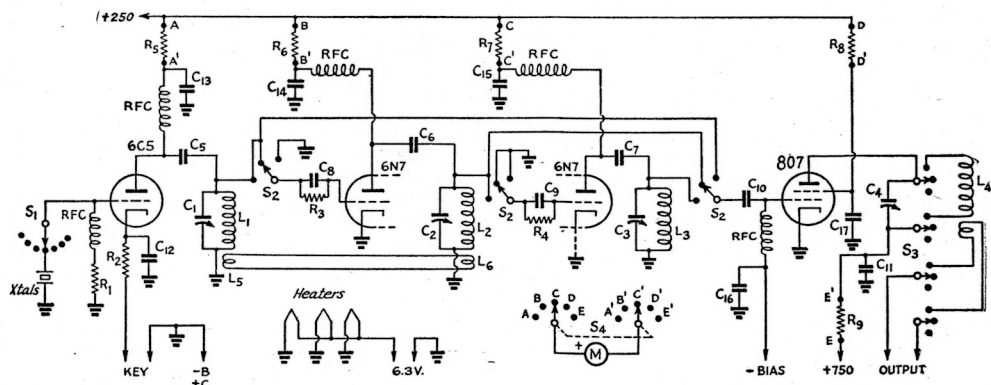


Fig. 1233—Circuit diagram of the crystal-controlled 807 band-switching exciter or low-power transmitter.

- C_1 , C_2 , C_3 —100- μ fd. variable (National ST-100).
- C_4 —150- μ fd. variable, 0.05-inch plate spacing (Hammarlund HFB-150-C).
- C_5 , C_6 , C_7 —0.002- μ fd. 500-volt mica.
- C_8 , C_9 , C_{10} —100- μ fd. 500-volt mica.
- C_{11} —0.002- μ fd. 2500-volt mica.
- C_{12} - C_{17} , inc.—0.01- μ fd. 600-volt paper.
- R_1 —10,000 ohms, $\frac{1}{2}$ -watt.
- R_2 —300 ohms, 1-watt.
- R_3 , R_4 —25,000 ohms, $\frac{1}{2}$ -watt.
- R_5 - R_9 , inc.—25 ohms, $\frac{1}{2}$ -watt.
- RFC—2.5-mh. r.f. choke.
- S_1 —Ceramic wafer switch, 6 or more positions.
- S_2 —Three-gang three-position ceramic wafer switch (Yaxley 163C).
- S_3 —Band-switch in coil assembly (Coto type 700).
- S_4 —Two-gang 6-position (5 used) ceramic wafer switch.
- M—0-200 d.c. milliammeter, bakelite case.

- L_1 , L_2 , L_3 —1.75 Mc.: 50 turns No. 22 d.s.c. close-wound.
- 3.5 Mc.: 26 turns No. 18, length $1\frac{1}{2}$ inches.
- 7 Mc.: 17 turns No. 18, length $1\frac{1}{2}$ inches.
- 14 Mc.: 8 turns No. 18, length $1\frac{1}{2}$ inches.
- 28 Mc.: 3 turns No. 18, length 1 inch.
- All wound on $1\frac{1}{2}$ -inch diameter forms (Hammarlund SWF-4); turns spaced evenly to fill specified winding length.
- L_4 —1.75 Mc.—50 turns, $1\frac{1}{2}$ -inch diameter, $2\frac{3}{8}$ inches long, 52 μ hys. (Coto CI6160E).
- 3.5 Mc.—25 turns, $1\frac{1}{2}$ -inch diameter, $1\frac{5}{8}$ inches long, 16 μ hys. (Coto CI680E).
- 7 Mc.—16 turns, $1\frac{1}{2}$ -inch diameter, $1\frac{1}{8}$ inches long, 5.7 μ hys. (Coto CI640E).
- 14 Mc.—8 turns, $1\frac{1}{2}$ -inch diameter, $1\frac{5}{8}$ inches long, 1.5 μ hys. (Coto CI620E).
- 28 Mc.—4 turns, $1\frac{1}{2}$ -inch diameter, $1\frac{1}{2}$ inches long, 0.7 μ hys. (Coto CI610E).
- L_5 , L_6 —One turn at bottom of L_1 and L_2 . See text.

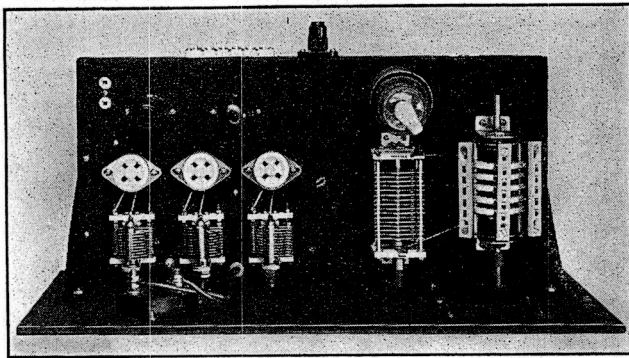


Fig. 1234—Top view of the band-switching exciter with coils removed. At the left rear are the spare crystal socket, the 6C5 and the 6N7. Directly in front of these are the tuning condensers (mounted directly on the chassis) and the coil sockets (mounted on pillars) for the oscillator and doubler stages. Grouped to the right are the 807, the amplifier tank condenser (which must be insulated from the chassis) and the switch assembly. The "hot" leads from the coils are brought through grommets in the chassis. The amplifier switch assembly should be mounted far enough back from the panel so that the coils will clear the side of the relay rack or cabinet. Leads between the switch and C_4 should be kept as short as possible.

denser being of the type which is insulated from the chassis. Fixed bias of about 75 volts is used on the 807 grid.

Plate currents for all tubes are read by a 200-ma. meter which can be switched to any circuit by means of S_4 . Keying is in the oscillator cathode circuit for break-in operation.

Since in normal operation the crystal tank circuit, C_1L_1 , is tuned well on the high-frequency side of resonance, there is a tendency for the first doubler section to break into a "tuned-grid tuned-plate" type of oscillation when the key is up; this is prevented by a small amount of inductive neutralization provided by the single-turn coils, L_5 and L_6 , wound as closely as possible to the ground end of each tank coil. The 28-Mc. coil does not need such a neutralizing winding, since it is used only in the second doubler stage. L_5 and L_6 should be so connected as to prevent self-oscillation of the first 6N7 section when the key is open; the proper connections should be found by trial.

In the bottom view, Fig. 1235, the meter switch with its shunting resistors is at the left, with the 807 plate by-pass condenser, C_{11} , just above it. The stage switch, S_2 , is in the center. R.f. leads to this switch should be kept separated as much as the layout will permit. R.f. junction points are insulated by small ceramic pillars. In this view, the right-hand section of the 6N7 is the first doubler. The rotor contact of the section of S_2 nearest the panel goes to the grid of the first doubler, the middle section to the second-doubler grid, and the third section to the 807 grid.

Figs. 1236 and 1238 show suitable 250- and 750-volt power-supply units for this transmitter. Heater voltage and grid bias are obtained from the 250-volt supply. If desired, both these power units may be assembled on one large chassis.

Tuning—To operate the exciter, coils for consecutively higher-frequency bands are plugged in at L_1 , L_2 and L_3 ; only five are necessary for operation with any crystal from 1.75 to 7 Mc. and for output from 1.75 to 28 Mc. For example, with 3.5-Mc. crystals, the 3.5-, 7- and 14-Mc. coils would be plugged in at L_1 , L_2 and L_3 respectively. For 1.75-Mc. crystals, the 1.75-, 3.5- and 7-Mc. coils would be used, and so on. The plate coils for the 807 should cover the same bands as the low-level coils.

Preliminary tuning should be done with the plate voltage for the 807 disconnected. Set S_2 so that all tubes are in use. Switch the milliammeter to the oscillator circuit and close the key. Rotate C_1 for the dip in plate current which indicates oscillation. The non-oscillating plate current should be between 20 and 25 ma., dropping to 15 or 20 when oscillating. Switch the meter to the doubler plate and adjust C_2 to minimum plate current, or resonance. The off-resonance plate current should be about 30 ma. or more and the reading should be between 10 and 15 at resonance. Check the second-doubler plate current and tuning similarly; the off-resonance plate current should again be around 30 ma., dropping to 15 or 20 at resonance. At this point the 807 screen current should be measured; with too much excitation it will be considerably higher than the rated

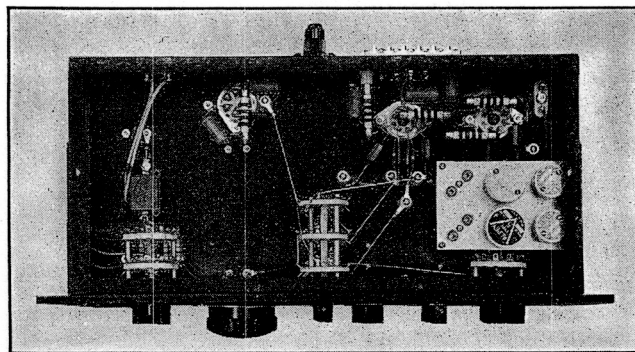


Fig. 1235—Bottom view of the band-switching exciter, showing the meter switch at the left, the band-switch in the center and the crystal switch at the right. The multiple crystal mounting, which holds six crystals, is made of a $3 \times 4\frac{1}{2}$ -inch aluminum plate fitted with Amphenol crystal sockets, the assembly being elevated from the chassis by metal pillars. A seventh socket is provided on top of the chassis for a spare crystal or for e.c.o. input. The 750-volt lead is brought through a Millen safety terminal, and all other power connections come to a terminal strip at the rear which has barriers between the terminals to prevent accidental contact. All grounds are made directly to the $8 \times 17 \times 2$ -inch chassis.

value (about 12 ma.) and the excitation should not be kept on for more than a second or two.

Next, the plate voltage may be applied to the 807. The amplifier should not be operated without load for more than a few moments at a time, because under these conditions the screen dissipation is excessive. Use a 70-ohm dummy antenna or a 60-watt lamp connected to the output link. The three bands may be checked in order by appropriate switching of S_2 and S_3 . With the 807 fully loaded, check the screen current to make sure it does not exceed 10 or 12 ma. If it is too high, reduce the excitation by detuning the crystal oscillator until it reaches the proper value. The 807 grid current may be measured with a lower-range milliammeter connected in series with the bias source, if desired. Maximum output will be secured with a grid current of about 3 or 4 milliamperes, a value which also will give about rated screen current. The screen current is, in fact, a very good indicator of excitation. The 807 should show no tendency to oscillate by itself when the key is open.

The current to each section of the 6N7 should be 20 ma. with the key open (no excitation). If the two currents are not the same or show changes when C_2 and C_1 are tuned with key open, the first doubler may be acting as a t.p.t.g. oscillator, as previously mentioned, and the neutralizing circuit should be checked. Do not use more than 250 volts for the low-voltage supply, as higher values will cause excessive 807 screen dissipation. Care also should be taken to avoid excessive excitation, for the same reason. In normal operation, with C_1 detuned to reduce excitation to the proper value, the doubler plate currents will show little change between resonance and off-resonance tuning.

With maximum input to the 807 plate (75 watts) the output is approximately 50 watts on all bands except 28 Mc., where greater circuit losses decrease it to about 40 watts. The excitation is more than ample on all bands.

The oscillator circuit may be arranged for v.f.o. input as in Fig. 1259.

Fig. 1237 — Circuit diagram of the combination plate, screen and grid-bias power supply pictured in Fig. 1236.

- C_1, C_2 — Sections of 8- μ fd. 450-volt dual electrolytic.
 C_3 — 8- μ fd. 450-volt paper.
 C_4 — Same as C_3 (used only for 300-volt output).
 L_1, L_2 — 6 henry, 80 ma., 138 ohms (Thorndarson T-57C51).
 R_1 — 20,000 ohms, 10-watt.
 R_2 — 20,000 ohms, 2-watt.
 R_3 — 25,000 ohms, 2-watt.
 R_4 — 15,000 ohms, 2-watt.
 T — 300 volts r.m.s., each side of center-tap, 90 ma.; 5 volts, 3 amperes; 6.3 volts, 3.5 amperes (Thorndarson T-13R13).

If desired, the bias branch may be omitted as shown at B. All values remain as above.

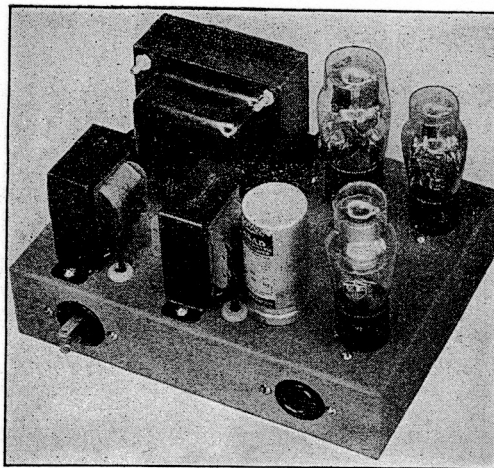
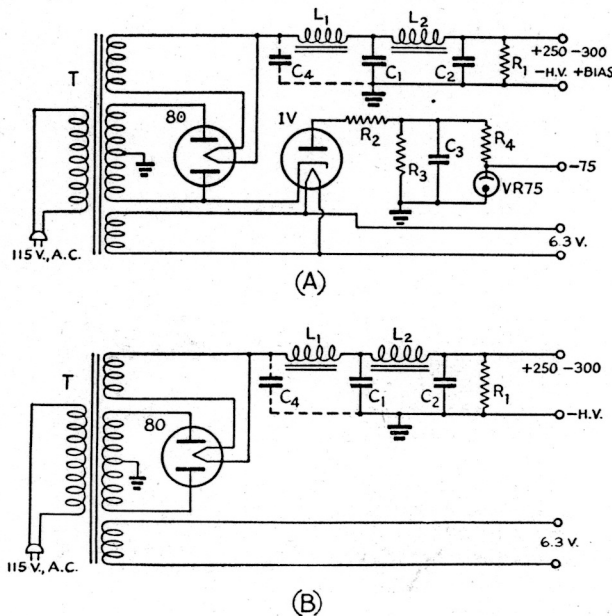


Fig. 1236 — A combination power-supply unit delivering 250 or 300 volts for exciter plate-supply and 75 volts of fixed bias. The unit is designed especially to work with the band-switching exciter of Fig. 1232 or the transmitter of Fig. 1221. If desired, the components may be combined with the components for a high-voltage plate-supply on a single chassis. The circuit diagram of the combination unit is shown in Fig. 1237.

◀ A Combination Low-Voltage Plate or Screen Supply and Fixed-Bias Pack

Fig. 1236 illustrates a combination pack which will deliver 250 or 300 volts, 75 ma., for supplying plate voltage for receiving-tube exciter stages as well as screen and fixed-bias voltage for a beam-tube driver stage.

The circuit diagram is shown in Fig. 1237-A. In addition to the usual full-wave rectifier circuit employing a type 80 tube, a 1V half-wave rectifier is also connected across one-half of the transformer secondary in reverse direction to provide a negative biasing voltage which



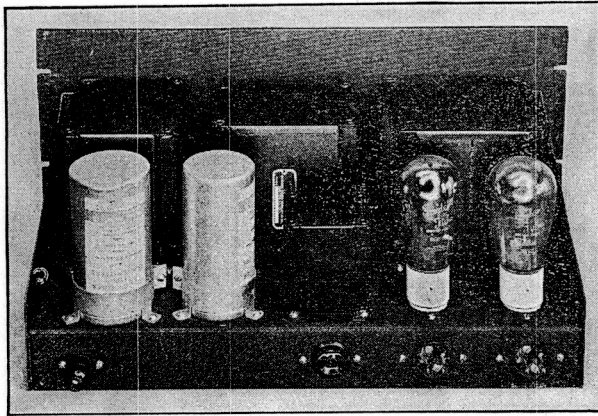


Fig. 1239 — This power-supply unit delivers either 620 or 780 volts at a full-load current of 260 ma. with 0.4 per cent ripple and regulation of 22 per cent. Voltage is changed by a tap on the plate-transformer primary winding. The filter chokes are at the left and the plate power transformer at the right on the panel side of the chassis. The can-type 1000-volt filter condensers are at the left in front and the rectifier tubes at the right, with the rectifier filament transformer in between. All exposed component terminals are underneath the chassis. The panel is $8\frac{3}{4} \times 19 \times 3$ inches. The 2.5-volt 10-ampere rectifier filament transformer should have 10,000-volt insulation. A 6.3-volt filament transformer is included for heating the filaments of r.f. tubes. This transformer is mounted underneath the chassis; its output terminals are brought out to a standard a.c. receptacle in the rear. The circuit diagram is shown in Fig. 1238.

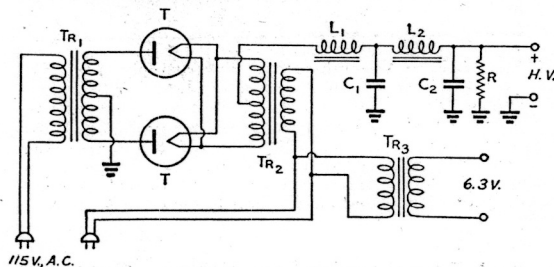


Fig. 1238 — Circuit of the power supply in Fig. 1239.

- C₁ — 2-μfd. 1000-volt paper (Sprague OT21).
- C₂ — 4-μfd. 1000-volt paper (Sprague OT41).
- L₁ — Input choke, 6-19 henrys, 300 ma., 125 ohms (Kenyon T-510).
- L₂ — Smoothing choke, 11 henrys, 300 ma., 125 ohms (Kenyon T-166).
- R — 20,000 ohms, 50-watt.
- T — Type 866 Jr. rectifier.
- Tr₁ — 925 or 740 volts r.m.s. each side of center-tap, 300 ma. d.c. (Kenyon T-656).
- Tr₂ — 2.5 volts, 10 amperes, 2000-volt insulation (Kenyon T-352).
- Tr₃ — 6.3-volt 3-ampere filament transformer.

is held constant at 75 volts by the VR75-30 regulator tube. With the dropping resistor shown, the regulator tube will pass a grid current of 25 ma. without overload. The 1V rectifier is indirectly heated, so that it may be operated from the same 6.3-volt winding provided to supply the r.f. tubes in the transmitter.

The output voltage at a normal load current of about 75 ma. can be increased from 250 to about 300 by the addition of the input condenser, C₄, the connections for which are shown in dotted lines.

If the bias section is not needed, plate or screen voltage may be obtained with the simplified circuit shown in Fig. 1237-B, eliminating the bias section.

Complete 75-Watt Multi-Band Transmitter

If it is desired to use the band-switching 807 exciter unit shown in Fig. 1232 as a complete transmitter feeding the antenna, it may be combined with the power-supply units of Figs. 1236 and 1239 and the antenna tuner of Fig. 1216 (using the large condensers) to make a complete unit. The combination power supply of Fig. 1236 will supply plate voltage for the oscillator and doubler stages, as well as screen and bias voltages for the 807. Filament supply also is obtainable from this unit. Plate voltage for the 807 is furnished by the power supply unit of Fig. 1239. The combined height of all units (assuming the unit of Fig. 1236 to be mounted on a 7-inch panel) will be $29\frac{3}{4}$ inches. The filament transformer shown in the diagram of Fig. 1238 will not be required.

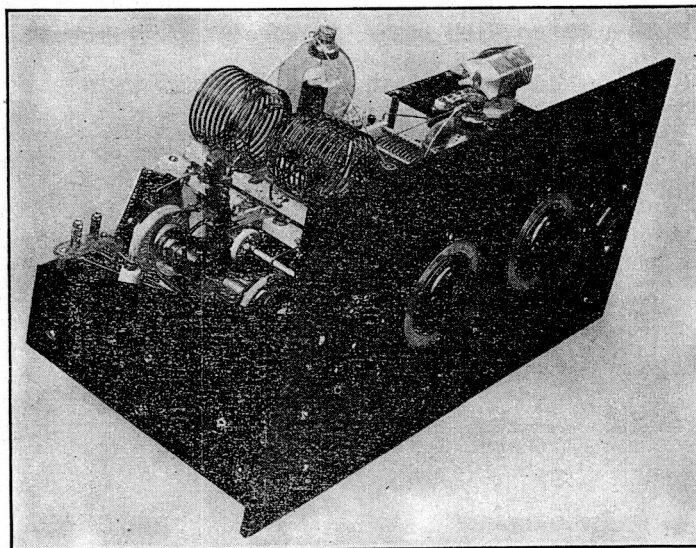
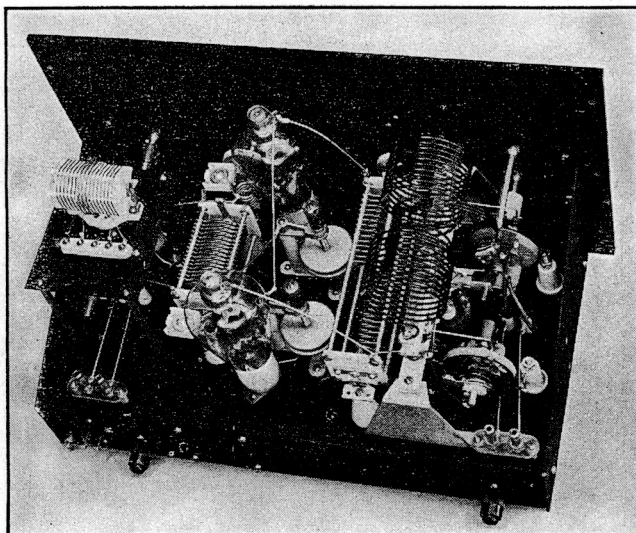


Fig. 1240 — A 450-watt band-switching amplifier. The panel size is $10\frac{1}{2} \times 19$ inches. The large dials on the panel control the plate and grid tank condensers. The uppermost of the two small knobs to the left is for adjusting the variable-link output coupling, while the lower knob is for the plate band-switch. The grid band-switch knob is to the right. All controls should be well insulated.

Fig. 1241 — Rear view of the 450-watt amplifier. The plate tank-coil jack bar at the right is mounted on brackets $2\frac{7}{8}$ inches high so that the variable-link shaft will clear the switches. These are mounted on 1-inch cone insulators after their brackets have been revamped to bring the shafts $1\frac{1}{2}$ inches above the chassis. The units are spaced so as to be central with the jack-bar terminals. The shafts are coupled with a section of $\frac{3}{8}$ -inch bakelite shaft fitted with brass reducing couplings at each end. The two feed-through insulators are for connections to the padder-condenser jack base underneath. The tank condenser is mounted on $1\frac{1}{2}$ -inch cone insulators. The plate r.f. choke and a feed-through insulator for high-voltage line are placed beneath the jack bar. The grid tank condenser is mounted to bring its shaft even with that of the plate condenser. The grid switch is mounted on insulators to balance the plate switch. The grid coil mounting is elevated over the switch. The tubes and neutralizing condensers are placed symmetrically between the two tank circuits.



□ A 450-Watt Band-Switching Amplifier

The photographs of Figs. 1240, 1241, 1243 and 1244 illustrate a 450-watt push-pull band-switching amplifier capable of handling a power input of 450 watts at 1500 volts for c.w. operation or 375 watts with plate modulation.

While the type T55 is shown, any of the triodes in the 1000- or 1500-volt class, such as the 809, T40, HY40, RK35, UH50, 808, 812, RK51 or 35T, may be used in a similar arrangement.

The circuit is shown in Fig. 1242. Band-switching is accomplished by short-circuiting

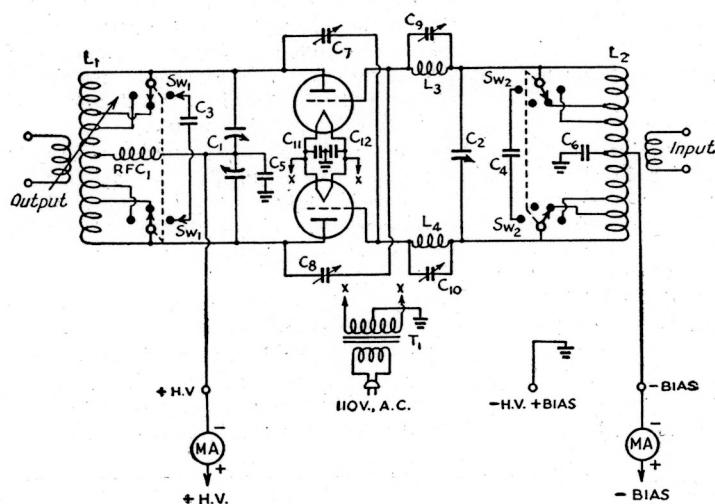


Fig. 1242 — Circuit diagram of the 450-watt amplifier.

- C₁ — 100 μ fd. per section, 0.07-inch plate spacing (Hammarlund HFB-100-E).
- C₂ — 150 μ fd., 0.05-inch plate spacing (Hammarlund HFB-150-C).
- C₃ — 50- μ fd. fixed air padder for 1.75 Mc., spacing 0.17 inch or greater (Cardwell JCO-50-OS).
- C₄ — 15- μ fd. padder for 1.75 Mc., 0.05-inch spacing (see text) (Hammarlund HFA-15-E).
- C₅ — 0.001- μ fd. 7500-volt mica (Aerovox 1623).
- C₆ — 0.01- μ fd. paper.
- C₇, C₈ — Neutralizing condenser (National NC800).
- C₉, C₁₀ — Isolantite mica trimmer, 20–100- μ fd. (Mallory CTX954).
- C₁₁, C₁₂ — 0.01- μ fd. paper.
- RFC₁ — 1-mh. r.f. choke, 600-ma. (National R154).
- SW₁ — Ganged sections of Ohmite ham-band switch (3-position).
- SW₂ — Ganged sections of Mallory ham-band switch (4-position) (type 162C).

T₁ — 7.5-volt 6-ampere filament transformer (Thordarson T-19F94).

L₁ — For 1.75-, 3.5- and 7-Mc. bands — 60 turns No. 16, $5\frac{3}{8}$ inches long, $2\frac{1}{2}$ -inch diameter, tapped at the 7th and 16th turn each side of center (B & W TVH-160) (90 μ hy., tapped each side of center at 7/30 and 8/15 of total turns in each half).
For 3.5-, 7- and 14-Mc. bands — 38 turns No. 14, $5\frac{1}{4}$ inches long, $2\frac{1}{2}$ -inch diameter, tapped at the 4th and 9th turn each side of center (B & W TVH-80) (35 μ hy., tapped each side of center at 2/19 and 9/38 of total turns in each half).
For 7-, 14- and 28-Mc. bands — 24 turns No. 12, $5\frac{1}{4}$ inches long, $2\frac{1}{2}$ -inch diameter, tapped at 2nd and 5th turns each side of center (see text for alterations) B & W TVH-40) 13 μ hy., tapped each side of center at approximately $\frac{1}{6}$ and $5\frac{1}{2}$ of total turns in each half.

- L₂ — For 1.57-, 3.5- and 7-Mc. bands — 52 turns, 2 inches long, $1\frac{1}{2}$ inch diameter, tapped at 9th and 17th turns each side of center. (Coto CS-160C) (56 μ hy. tapped each side of center at 9/26 and 17/26 of total turns in each half).
For 3.5-, 7- and 14-Mc. bands — 26 turns, $1\frac{1}{2}$ inches long, $1\frac{1}{2}$ -inch diameter, tapped at 5th and 9th turns from each side of center. (Coto CS80C) (17 μ hy., tapped each side of center at 5/13 and 9/13 of total turns in each half).
For 7-, 14- and 28-Mc. bands — 16 turns $1\frac{1}{8}$ inches long, $1\frac{1}{2}$ -inch diameter, tapped at 1st and 3rd turns each side of center. (Coto CS40C) (5 μ hy., tapped each side of center at $\frac{1}{8}$ and $\frac{3}{8}$ of total turns in each half).
- L₃, L₄ — 8 turns No. 12, $\frac{1}{2}$ -inch inside diameter, $1\frac{1}{8}$ inches long.

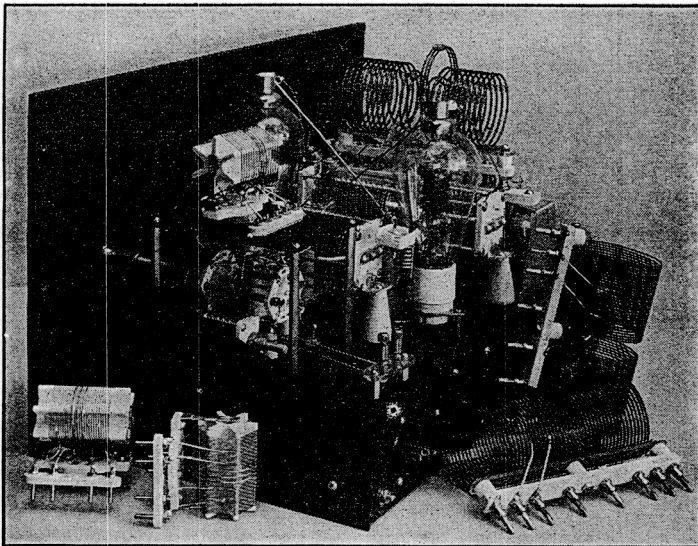


Fig. 1243 — A view of the grid-circuit end of the band-switching push-pull amplifier showing the coil-switching arrangement and the 1.75-Mc. paddler.

turns of both plate and grid coils by means of tap switches. Any three adjacent bands may be covered in this manner. By plugging in another pair of coils, a second set of three adjacent bands may be covered. Thus the 1.75-, 3.5- and 7-Mc. bands may be covered with one pair of coils, the 3.5-, 7- and 14-Mc. bands with another pair, and the 7-, 14- and 28-Mc. bands with a third pair.

A plug-in fixed air condenser is required for the plate circuit for the 1.75-Mc. band. The plug-in jack base is mounted under the chassis and is wired to the lowest-frequency switch points, so that the condenser is automatically connected across the coil when the switch is turned for the 1.75-Mc. band. When the coil covering this band is not used, the fixed condenser should be removed; it may be omitted entirely if operation in this band is not desired. The grid circuit likewise requires padding at 1.75 Mc., but here a 15- μ fd. condenser may be connected permanently across the fourth

set of switch contacts, which are not used for other bands. C_9L_3 and $C_{10}L_4$ are parasitic traps to eliminate v.h.f. parasitic oscillations. Fixed-link coupling is used at the input, with variable-link output coupling.

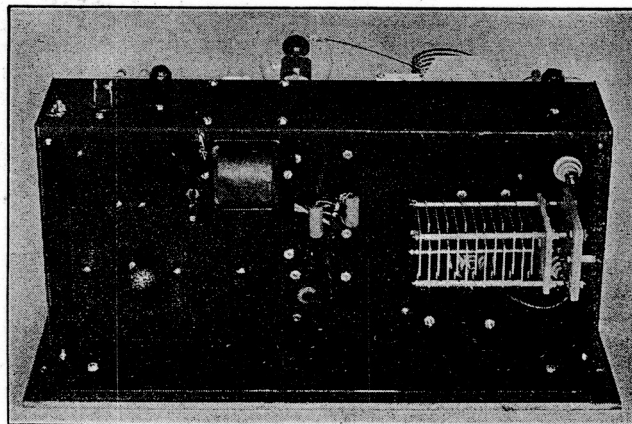
Coils — The plate-tank coils listed under the circuit diagram are of a special series designed primarily for use with a multi-section tank condenser. They are provided with four extra plugs which are used, in this case, for the short-circuiting taps. The coil covering 7, 14 and 28 Mc. requires slight alteration, however. Two turns on each side of center are cut free from the supporting strips and left self-supporting; otherwise, the coil heating which usually

occurs at 28 Mc. may be sufficient to ruin the base strip. At the same time, these two turns on each side should be reduced in diameter to $1\frac{1}{8}$ inches. This may be done quite readily by unsoldering the central ends, twisting the turns to the smaller diameter, and cutting off the excess wire. While the lower-frequency taps may be soldered, it is advisable to use clamps on the wire for the 28-Mc. taps. Johnson coil clips are suitable for this purpose.

Since grid coils are unobtainable with sufficient pins in the mounting, the taps for the grid coils are brought out to a five-prong Millen coil-mounting bar (Type 40205). A plug-in socket for the bar is sub-mounted in back of the coil socket.

Wiring — All of the wiring, excepting the power wiring underneath the chassis, is done with No. 14 tinned bus wire. Wherever possible, connections are made with short, straight pieces of wire running directly from point to point. Of most importance are the leads to the

Fig. 1244 — Bottom view of the 450-watt band-switching amplifier. The chassis measures $10 \times 17 \times 3$ inches. The plug-in air padding condenser for 1.75 Mc. is mounted so that it is an equal distance between top and bottom of the chassis. Filament by-pass condensers are soldered to the terminals of a fiber lug strip to which the filament transformer terminals are anchored. Millen safety terminals are used for bias and high-voltage output connections. A suitable 1500-volt plate-power unit for use with this amplifier is shown in Fig. 1246, the circuit diagram for which appears in Fig. 1245. The circuit diagram of a simple bias pack is shown in Fig. 1248. If this bias pack is used, the VR75-30 and the resistance R_1 should be omitted and R_2 and R_3 made approximately 4000 ohms each for T55s. The two power-supply units may be combined on a single chassis.



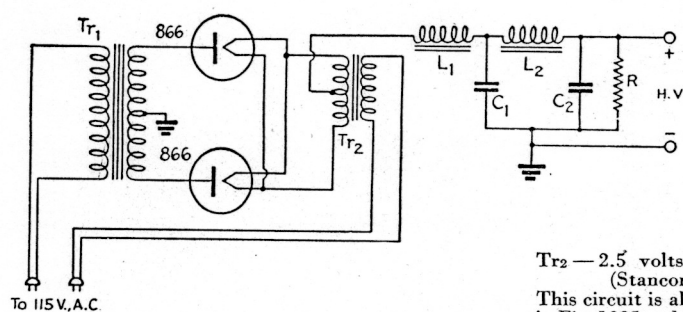


Fig. 1245 — Circuit diagram of the 1500-volt 425-ma. plate power supply for the band-switching amplifier. C_1, C_2 — 4- μ fd. 2000-volt paper (C-D TJU20040).

L_1 — 5-20 henrys, 500 ma., 75 ohms (Stancor C1405).
 L_2 — 8 henrys, 500 ma., 75 ohms (Stancor C1415).

R — 20,000 ohms, 150-watt.
 Tr_1 — 1820-1520-volts r.m.s. each side of center-tap, 500-ma. d.c. (Stancor type P6157).

Tr_2 — 2.5 volts, 10 amperes, 10,000-volt insulation (Stancor type P3025).

This circuit is also used for the 1250-volt supply shown in Fig. 1225 and the 2500-volt supply shown in Fig. 1285.

tube grids and plates. The leads to the tank condensers and those to the neutralizing condensers must be kept entirely separate; at no point should these leads be common. This practice helps in the prevention of parasitic oscillations. The grid by-pass condenser is mounted close to the grid-coil socket.

Fig. 1242 shows how d.c. milliammeters of suitable ranges may be connected for reading the grid and plate currents. These are not included in the unit, but may be mounted in a separate meter panel constructed as shown in Fig. 1294. The grid-current meter should have a 100 ma. scale, while the plate-current meter should have a range of 500 ma.

Tuning — Any one of the r.f. units shown in Figs. 1232, 1265 or 1276 will furnish sufficient excitation for this amplifier, the band-switching exciter of Fig. 1232 being an excellent companion unit.

Before excitation is applied, the two parasitic-trap condensers, C_9 and C_{10} , should be set at maximum capacity. With excitation applied and plate voltage off, grid current to the amplifier should run between 60 and 90 ma. Make certain that the coil switches are set at the appropriate points.

As the next step the amplifier may be neutralized, using the grid-current meter as a neutralizing indicator.

The amplifier should now be tested for parasitic oscillation. The bias should be reduced to a point which will allow a plate current of 100 ma. or so to flow without excitation. This may be done by moving the biasing tap of the amplifier down toward the positive terminal of the bias supply. It is advisable to lower the plate voltage for this test, either by inserting a resistance of about 2500 ohms in series with the plate-voltage source or by inserting a 200-watt lamp in series with the primary winding of the plate transformer. The grid tank condensers should be set at various points while the plate tank condenser is swung through its range. The plate current should remain perfectly stationary while this is done. If a point is found where a sudden change in plate current

takes place, C_9 and C_{10} should be adjusted, bit by bit, until the variation in plate current disappears. C_9 and C_{10} should be as close to maximum capacity as it is possible to set them and yet eliminate the parasitic oscillation.

Normal biasing voltage may now be replaced and the amplifier tuned up and loaded. For c.w. operation, the output should exceed 300 watts when operated at the maximum rated input of 1500 volts, 300 ma. With plate modulation, the plate current should be reduced to 250 ma. and the output should exceed 250 watts. The amplifier will operate satisfactorily when the grid current is 40 to 70 ma. with the plate circuit loaded. The maximum rating of 80 ma. for the two tubes should not be exceeded.

Reference should be made to the vacuum-tube tables of Chapter Twenty-One for data on the operation of other type of tubes.

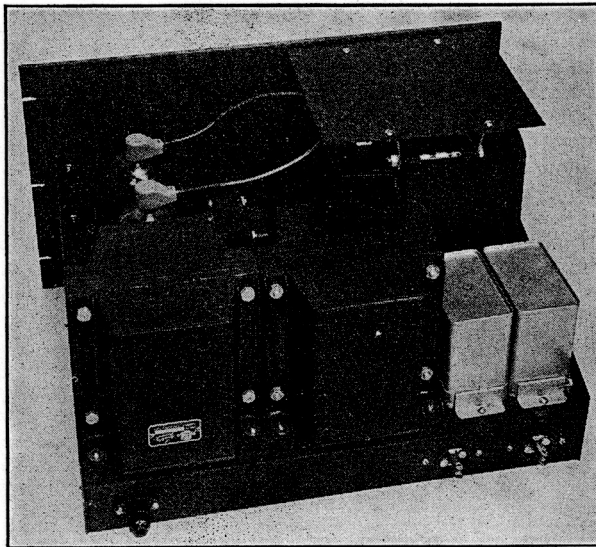


Fig. 1246 — This power supply delivers 1500 or 1250 volts at a full-load current of 425 ma., with 0.25 per cent ripple and regulation of 10 per cent. Voltages are selected by taps on the transformer secondary. The secondary terminal board is covered with a section of steel panel supported by brackets fastened underneath the core clamps and insulating caps are provided for the tube plate terminals. A special safety terminal (Millen) is used for the positive high-voltage connection. The panel is $10\frac{1}{2} \times 19$ inches and the chassis size is $13 \times 17 \times 2$ inches. The circuit is shown in Fig. 1245.

⌚ A Simple Combination Bias Supply

Fig. 1248 shows the circuit diagram of the simple transformerless bias unit, pictured in Fig. 1247, which may be used to supply cut-off bias voltages up to 100 volts or so. Through grid-leak action it will also provide the additional operating bias voltage required, if the resistor values are correctly proportioned. The circuit also includes a second branch, consisting of R_1 and a VR75-30 voltage-regulator tube. This branch may not be required in all cases, but will be found convenient in many applications for providing fixed cut-off or protective bias for a low-power stage independent of the main output voltage.

Adjustment — The voltage-divider resistances, R_2 and R_3 , are combined in a single resistor with two sliding taps. One of these taps alters the total resistance by short-circuiting a portion of the resistance at the negative end, while the other adjusts the cut-off voltage. The method of determining the values of resistance in each section is as follows:

The section R_2 is adjusted to equal the recommended grid-leak resistance for the tube or tubes in use. The value of resistance between the biasing tap and the short-circuiting tap is determined by the following formula:

$$R_3 = \frac{160 - E_{co}}{E_{co}} \times R_2,$$

where E_{co} is the voltage required for plate-current cut-off. This value may be determined to a close approximation for triodes by dividing the plate voltage by the amplification factor of the tube. No extra grid leak should be used in the stage being supplied by the pack.

The resistance in each section should be first set at the values determined by the formula. The biased amplifier should then be turned on, without excitation. If the plate current is not cut off, or reduced to a safe value, the biasing tap should be moved upward in the negative direction. With the amplifier in operation with rated grid current, the biasing voltage should be measured. If it is higher than that recommended in the tube operating tables, both the biasing tap and the short-circuiting tap on the upper section should be moved bit by bit toward the positive end until the correct operating bias is obtained. A final adjustment may now be necessary to again arrive at a cut-off voltage without excitation.

Fig. 1247 shows the components assembled separately on a small chassis. They may, however, be combined with plate-supply compo-

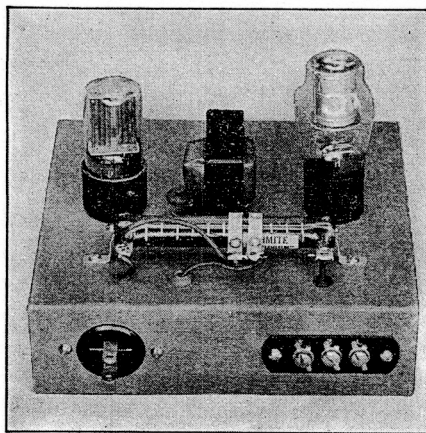


Fig. 1247 — A transformerless combination bias supply suitable for supplying bias for r.f. stages requiring 125 volts or less for cut off. A second branch, controlled by a VR75-30 regulator tube, provides 75 volts fixed bias for a second stage whose grid current does not exceed 20 ma. The unit above is constructed on a 7 × 7-inch chassis, although the components may easily be fitted into any spare space on another power-supply chassis. The regulated VR-tube branch may be omitted if not required. The circuit diagram is shown in Fig. 1248.

nents on a single chassis, since little additional space will be required.

It will be noticed in the circuit diagram that only one wire is shown connected to the power plug. The return connection for circuit is made through an actual ground connection to the chassis, to prevent possible short-circuit of the 115-volt line should the power plug happen to be incorrectly polarized when inserted.

⌚ A Wide-Range Antenna Coupler

The photograph of Fig. 1249 shows the construction of a wide-range antenna coupler. Diagrams of the various circuit combinations are given in Fig. 1250.

A separate coil is used for each band, and the desired connections for series or parallel tuning with high or low C , or for low-impedance output with high or low C , are automatically made when the coil is plugged in. Coil connections to the pins for various circuit arrangements are shown in Fig. 1250.

The tuning condenser specified, using a set of standard plug-in transmitting coils, should cover practically all coupling conditions likely to be encountered.

Because the switching connections require the use of the central pin, a slight alteration in the B & W unit is required. The link mounting

Fig. 1248 — Circuit diagram of the transformerless combination grid-bias supply with voltage-regulated output shown in Fig. 1247. C_1, C_2 — 16- μ fd. 450-volt electrolytic. L — 60-ma. replacement filter choke. R_1 — 7500 ohms, 10-watt. $R_2 + R_3$ — 15,000-ohm 50-watt wire-wound, with two sliders. See text for details of adjustment and operation.

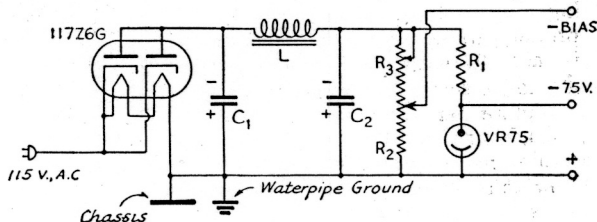
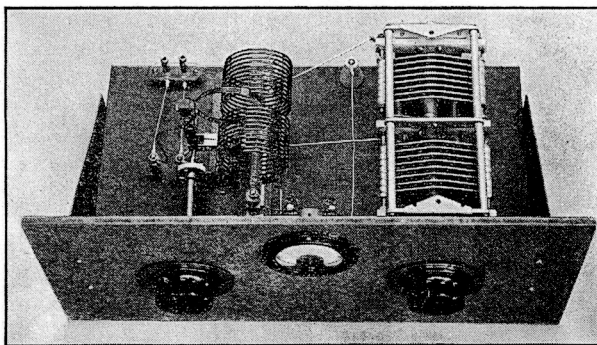


Fig. 1249 — Wide-range antenna coupler. The unit is assembled on a metal chassis measuring $10 \times 17 \times 2$ inches, with a panel $8\frac{3}{4} \times 19$ inches in size. The variable condenser is a split-stator unit having a capacity of $200 \mu\text{fd.}$ per section and 0.07-inch plate spacing (Johnson 200ED30). The plug-in coils are the B & W TVL series. The r.f. ammeter has a 4-ampere scale. If desired, the coils may be wound with fixed links on standard transmitting ceramic forms. The links will have to be provided with flexible leads which can be plugged into a pair of jack-top insulators mounted near the coil jack strip, unless a special mounting is made providing for the seven plug-in connections required.



should be removed from the jack bar and an extra jack placed in the central hole thus provided. The link assembly should then be mounted on a 2-inch cone insulator to one side of the jack bar. On each coil, the central nut must be removed and a Johnson tapped plug, similar to those furnished with the coils, substituted. An extension shaft may then be fitted on the link shaft and a control brought out to a knob on the panel.

The split-stator tank condenser is mounted with angle brackets on four 1-inch cone-type insulators, and an insulated flexible coupling is provided for the shaft.

If desired, the coils may be wound with fixed links on transmitting ceramic forms. The links should be provided with flexible leads which can be plugged into a pair of jack-top insulators mounted near the coil jack strip, unless a special mounting is made providing for seven connections.

The unit as described should be satisfactory for transmitters operating at a plate voltage of not more than 1500 with modulation. For higher voltages, a tank condenser with larger spacing should be used.

Complete 450-Watt Band-Switching Transmitter

The various units shown in Figs. 1232 through 1250, assembled together, form a complete high-power band-switching transmitter.

Heater, low-voltage plate and the 807 screen-voltage supply for the exciter may be obtained from the simplified 250-volt pack of Fig. 1237-B, while plate voltage for the 807 is furnished by the unit of Fig. 1239. Bias voltages for both amplifier and exciter are obtainable from the unit of Fig. 1247, while amplifier plate voltage is furnished by the unit of Fig. 1246. The units of Figs. 1237-B and 1247 may be combined in a single unit with a 7-inch panel. The addition of a $5\frac{1}{4}$ -inch panel for the amplifier grid and plate meters and the antenna tuner of Fig. 1249 completes the transmitter.

The most logical arrangement for the units, from top to bottom, is as follows: (1) antenna tuner, (2) final amplifier, (3) meter panel, (4) exciter, (5) low-voltage and bias supplies, (6) 750-volt supply, (7) high-voltage supply. The combined height of these units is $59\frac{1}{2}$ inches.

Information on a control circuit for such a transmitter will be found in Fig. 1296.

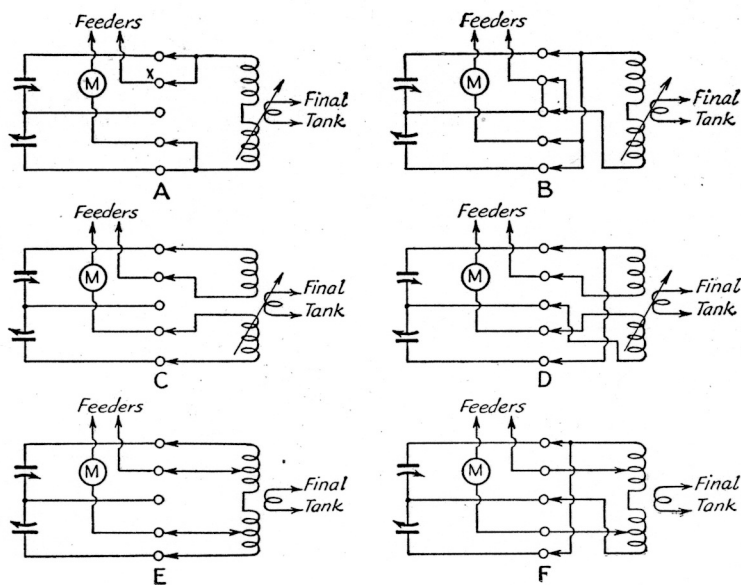


Fig. 1250 — Circuit diagram of the wide-range antenna coupler for use with the band-switching amplifier. A — Parallel tuning, low C. B — Parallel tuning, high C. C — Series tuning, low C. D — Series tuning, high C. E — Parallel tank, low-impedance output, low C. F — Parallel tank, low-impedance output, high C. For single-wire matched-impedance feeders, the arrangements of E or F would be used with a single tap instead of the double tap shown. For simple voltage-fed antennas, the arrangement of A would be used with the end of the antenna connected at "X." After the inductance required for each of the various bands has been determined experimentally, the connections to the coils can be made permanent. Then it will be necessary merely to plug in the right coil for each band, tune the condenser for resonance, and adjust the link for loading.

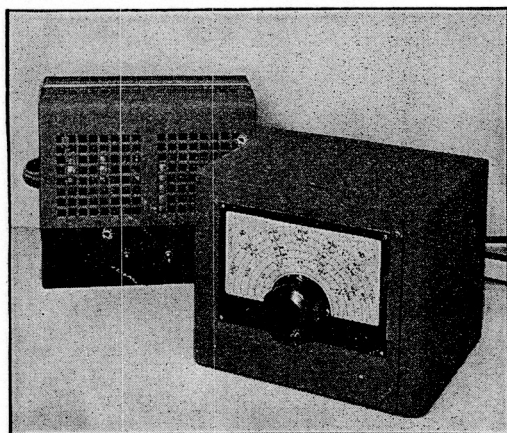


Fig. 1251—The variable-frequency exciter is enclosed in an 8 × 8 × 10-inch Parmetal cabinet. The dial is the National type ACN, suitable for calibrating. The voltage-regulated power supply is mounted in an amplifier-foundation case with a 5 × 3 × 10-inch chassis.

◄ A Variable-Frequency Exciter

The photographs of Figs. 1251, 1254 and 1256 illustrate the construction of a variable-frequency unit which is designed to take the place of the crystal as a frequency control in most of the common forms of crystal-oscillator circuits. The power output of the unit is approximately one and one-half watts, which is sufficient for this purpose, or for driving an 807. By means of plug-in coils, output at any frequency in the 1.75-, 3.5-, or 7-Mc. bands may be obtained.

Referring to the circuit diagram of Fig. 1252, a 6F6 is used in the e.c.o. circuit. Since the buffer stage provides adequate isolation, the use of a well-screened tube in the oscillator circuit is not a requirement. The cathode is connected to a feed-back winding, L_2 , rather than to a direct tap on L_1 , to make adjustment of feed-back less difficult. A high- C tank circuit is obtained by the fixed padders, C_1 and C_2 , which are of the zero-drift type. Bandspread tuning is obtained by the split-stator condenser, C_3 .

Fig. 1252—Circuit diagram of the v.f.o. exciter unit. C_1 , C_2 —300 μfd . each, zero-drift type (Centralab 816Z).

C_3 —140 μfd . per section (Hammarlund MCD-140-S).

C_4 —100- μfd . mica.

C_5 —250- μfd . mica.

C_6 —45-260- μfd . mica trimmer (Hammarlund CTS-160).

C_7 —Approximately 65 μfd . (Hammarlund MC-100-S with two stator and two rotor plates removed).

C_8 , C_9 , C_{10} , C_{11} , C_{12} —0.01- μfd . paper.

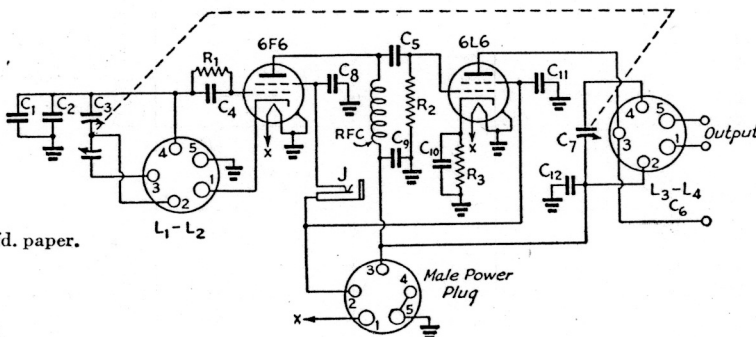
J—Closed-circuit jack.

R_1 —0.1 megohm, $\frac{1}{2}$ -watt.

R_2 —0.1 megohm, $\frac{1}{2}$ -watt.

R_3 —500 ohms, 1-watt.

L_1 , L_2 , L_3 , L_4 —See Fig. 1253.



When coils 1 and 1A (see coil charts) are plugged in, the two sections of C_3 are connected in parallel and the output-frequency spread is 1750 to 2050 kc. to cover the 1.75-Mc. band or, through a doubler, the 3.5-Mc. band. Similarly, with coils 2 and 2A, the two sections of C_3 are in parallel and the output-frequency spread is 3500 to 4000 kc. to cover the 3.5-Mc. band.

When coils 1B and 1AB are plugged in, the sections of C_3 are in series and the output-frequency range is 1750 to 1825 kc. for obtaining, through doublers, the frequency ranges of 7000 to 7300 and 14,000 to 14,400 kc. Similarly, when coils 2B and 2AB are plugged in, the output-frequency range is 3500 to 3650 kc. for obtaining, through doublers, the same frequency ranges of 7000 to 7300 and 14,000 to 14,400 kc. The sections of C_3 are also in series when coils 3 and 3A are plugged in and the output-frequency range is 7000 to 7300 kc. for covering the 7-Mc. band and, through a doubler, the 14-Mc. band.

When coils 3B and 3AB are plugged in, only one section of C_3 is in use and the output-frequency range of 7000 to 7500 kc. is useful in obtaining, through doublers, the range of 28,000 to 30,000 kc.

Proper connections to C_3 are made automatically when each oscillator coil is plugged in, as shown in Fig. 1253.

Choke coupling is used between the oscillator and the 6L6 isolating stage. This stage is operated very close to Class-A conditions and is tuned to the second harmonic of the oscillator frequency. Thus, the oscillator operates at half the desired output frequency. The type 6L6 tube is used to take care of the unusually high dissipation resulting from this type of operation. The tuning of the output tank circuit is ganged with that of the oscillator. Tracking taps on the output coil, L_3 , are required only for spreading the higher-frequency bands. Adjustable mica trimmers, C_6 , are mounted in each coil form.

To solve some of the difficulties often encountered in key-filtering an oscillator of this type, the oscillator stage is keyed in the screen circuit. This means that both sides of the key are at a potential of 150 volts above ground po-

COIL-SELECTION TABLE FOR VARIABLE-FREQUENCY UNIT *					
Transmitter Output Freq.	1.75 Mc.	3.5 Mc.	7 Mc.	14 Mc.	28 Mc.
Crystal Freq. 1.75 Mc.	1 & 1A	1 & 1A	1B & 1AB	1B & 1AB	—
3.5 Mc.	—	2 & 2A	2B & 2AB	2B & 2AB	—
7 Mc.	—	—	3 & 3A	3 & 3A	3B & 3AB

* Numbers refer to coils in coil-dimension table.

tential. It is, therefore, preferable to use a relay to isolate the key contacts from this voltage. Otherwise, due caution should be exercised. If preferred, cathode keying may be used as shown in Fig. 1253-F, but it is more difficult to obtain soft keying without introducing chirp with this system. With cathode keying, the screen connection will go directly to pin No. 2 on the power plug, eliminating the jack in the screen circuit.

A link winding, L_4 , is provided for coupling the output of the exciter unit to the input of the amplifier stage which it is to drive.

Coils—Coil dimensions for several oscillator ranges are given in the coil table under Fig. 1253. Only those which suit the conditions under which the unit is to be operated need be constructed. This will depend upon the type of transmitter with which the unit is to be used. To begin with, only coils need be provided giving output in bands for which crystals, formerly used, are ground. For instance, if the oscillator stage to be driven is designed for 1.75-Mc. crystals only, coils need be wound for this band only. If the transmitter operates only in the 1.75-Mc. band, or, by doubling, in

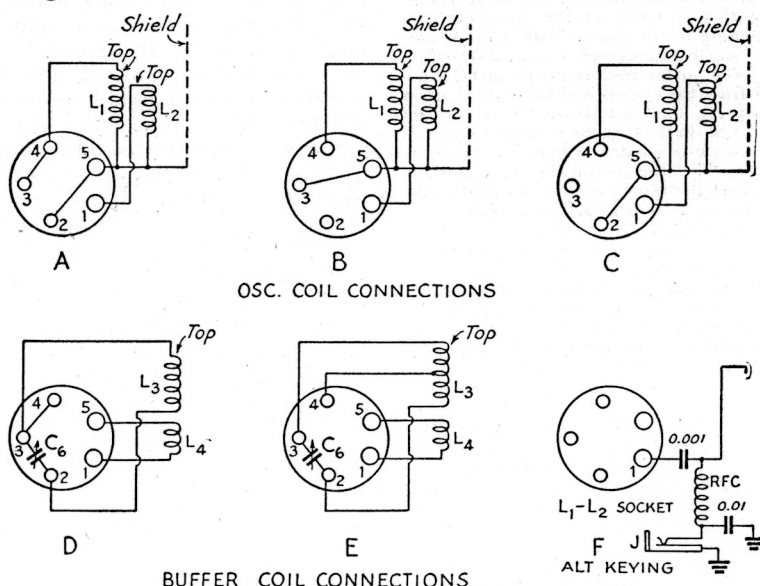


Fig. 1253—Coil-form connections for the v.f.o. circuit of Fig. 1252. Connections shown at A are for coils 1 and 2. Those shown at B are for coils 3, 1B and 2B. Connections shown at C are for coil No. 3B. Buffer coils 1A and 2A should be connected as shown at D, while coils 3A, 1AB, 2AB and 3AB should be connected as shown at E. F shows the circuit for optional cathode keying instead of screen keying, as mentioned in text. RFC is an ordinary 2.5-mh. r.f. choke. Coil dimensions are as follows:

Oscillator (L_1 and L_2)*

- Coil No. 1—(875 to 1025 kc.)—47 turns No. 26 d.s.c., $\frac{7}{8}$ -inch long; 6 turns for L_2 .
- Coil No. 2—(1750 to 2000 kc.)—23 turns No. 20 d.s.c., $1\frac{1}{4}$ inches long; 2 turns for L_2 .
- Coil No. 3—(3500 to 3650 kc.)—14 turns No. 20 d.s.c., $1\frac{1}{4}$ inches long; 2 turns for L_2 .
- Coil No. 1B—(875 to 912.5 kc.)—57 turns No. 26 d.s.c., $1\frac{1}{8}$ inches long; 5 turns for L_2 .
- Coil No. 2B—(1750 to 1825 kc.)—28 turns No. 20 d.s.c., 1 inch long; 2 turns for L_2 .
- Coil No. 3B—(3500 to 3750 kc.)— $13\frac{1}{2}$ turns No. 20 d.s.c., 1-inch long; 2 turns for L_2 .

* Wound on Millen 1-inch diameter forms, L_2 wound turn-for-turn over bottom end of L_1 in same direction.

** Wound on Hammarlund $1\frac{1}{2}$ -inch diameter forms, L_4 close-wound below L_3 .

Buffer Coils (L_3 and L_4)**

- Coil No. 1A—(1750 to 2050 kc.)—41 turns No. 24, $1\frac{3}{4}$ inches long; approximately 12 turns for L_4 .
- Coil No. 2A—(3500 to 4000 kc.)—21 turns No. 18, $1\frac{1}{2}$ inches long; approximately 6 turns for L_4 .
- Coil Co. 3A—(7000 to 7300 kc.)—14 turns No. 18, $1\frac{1}{2}$ inches long, tapped at 3 turns from bottom; approximately 4 turns for L_4 .
- Coil No. 1AB—(1750 to 1825 kc.)—46 turns No. 24, $1\frac{3}{4}$ inches long, tapped at 19 turns from bottom; approximately 12 turns for L_4 .
- Coil No. 2AB—(3500 to 3650 kc.)—24 turns No. 18, $1\frac{1}{2}$ inches long, tapped at $9\frac{1}{2}$ turns from bottom; approximately 6 turns for L_4 .
- Coil No. 3AB—(7000 to 7500 kc.)—14 turns No. 18, $1\frac{1}{2}$ inches long, tapped at 5 turns from bottom; approximately 4 turns for L_4 .

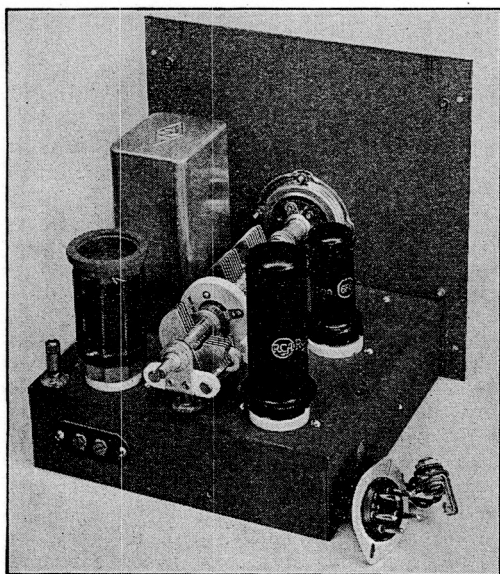


Fig. 1254 — Components for the v.f.o. exciter are assembled on a 7 × 7 × 2-inch chassis. The dual-section condenser is mounted by removing the shield between sections and fastening to the chassis with a single machine screw. The smaller condenser, C_7 , is mounted on National polystyrene button insulators and metal spacers to insulate it from the chassis and bring its shaft in line with that of the dual condenser. It is reverse-mounted, with its tail shaft extension coupled to the tail shaft extension of the dual condenser to reduce the overall mounting space. The stop pin on the shaft must be removed. Leads from the tuning condensers to the sub-mounted coil sockets pass through the chassis via $\frac{1}{2}$ -inch holes lined with rubber grommets. The jack for the key, which must be insulated, and the male power connector mount in the side of the cabinet. The chassis is fastened firmly in place with long machine screws running through the chassis and the bottom of the cabinet. The terminals at the rear are for link-output connections, the binding post for capacity coupling.

the 1.75- and 3.5-Mc. bands exclusively, only the 1.75-Mc. coils for the first bandspread range will be required. If, however, the transmitter is designed to cover the 7-Mc. band, as well as the lower-frequency bands, from a 1.75-Mc. crystal, coils for the second bandspread range will also be necessary to get full bandspread at 7 Mc. An examination of the coil-selection table will show what coils are required, depending upon the crystal frequency normally used to secure output in the desired band. If full bandspread at 7-Mc. and higher frequencies is not deemed necessary, the wide-bandspread coils for these frequencies need not be constructed.

The oscillator coils are wound on Millen one-inch diameter coil forms which are mounted in National PB-10 five-prong shielded plug-in bases. The feed-back coils, L_2 , are wound over the bottom turns of L_1 ,

and in the same direction. Connections to the base pins are given in Fig. 1253-A, B and C.

The buffer coils are wound on Hammarlund $1\frac{1}{2}$ -inch diameter five-prong forms. The padding condensers, C_6 , are mounted inside the coil forms, fastened in place with a 4-36 machine screw. Buffer coils for the higher-frequency ranges must be tapped as directed. One satisfactory way of making this tap is to drill a hole near the bottom of the form for a wire which may be brought outside from the pin to which the tap must be connected. The turn which is being tapped, as indicated in the table of coil dimensions, may be scraped and the tap wire soldered to this turn. Pin connections are shown in Fig. 1253-D and E.

Tuning — Before an attempt is made to tune the circuits, the dropping resistor, R_2 , in the power supply should be adjusted. This is done with any pair of coils plugged in and the key closed. Starting with maximum resistance, the slider should be adjusted, bit by bit, until the VR tubes ignite. As much resistance as possible should be left in the circuit consistent with the maintenance of reliable operation of the VR tubes. If the tubes ignite with maximum resistance in the circuit further adjustment will not be required, unless the output voltage of the pack used happens to be unusually high. If this is the case, the dropping resistance should be increased until the VR tubes no longer ignite and then decreased to the point where they just ignite.

The first step in tuning the unit is to check the frequency range of the oscillator. It is probable that differences in wiring inductances and capacities will make it necessary to make slight alterations in the oscillator coil dimensions given in the table. Unless these differ widely from those of the original model, however, nothing more than an adjustment of the spacing of a few turns at the top of L_1 should be required.

If close calibration is desired, a 100-kc. oscillator checked against WWV, or other frequency-checking means, should be provided.

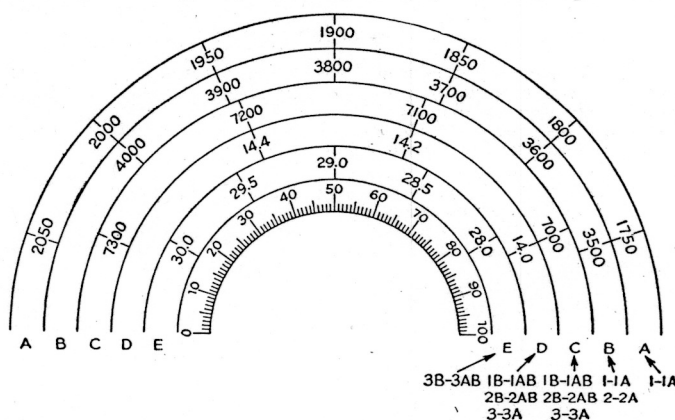


Fig. 1255 — Typical dial calibration for the v.f.o. unit. Notations at lower right indicate the calibrated ranges of the coil sets listed under Fig. 1253 and in the coil-selection table. Details of calibration are given in the text.

The approximate range of the oscillator coil under adjustment may be determined by listening on a receiver. The 1.75-Mc. range of the receiver should be used for checking coil No. 1. The ranges of other coils may be checked with the receiver tuned to the 3.5-Mc. band, since the harmonics of 2000 to 2050 kc. are the only usable frequencies to fall outside this band.

If the signal from the oscillator is not picked up at any point in the band with any setting of the v.f.o. dial, a wire should be run from the receiver antenna post to a point near the oscillator coil. If it is still impossible to pick up the signal, it is possible that the oscillator may not be functioning. One turn should then be added to the feedback winding. More than the single additional turn should not be required. If the winding is larger than that required to maintain reliable operation with the key closed, the circuit may oscillate weakly even with the key open. This condition is to be avoided, of course, if break-in operation is contemplated.

When the oscillator is functioning satisfactorily, the spacing of the top turn or two of L_1 should be adjusted until the desired band is centered on the dial of the unit. This can be done by spreading a turn or two, as mentioned previously. The shield can should be replaced each time a check is made. When the adjustment is final, the turns should be fastened permanently in place with Duco cement. The v.f.o. unit should be warmed up thoroughly before making a permanent calibration.

The National ACN dial has space for calibrating five ranges. Since the bandspread ratio is the same for the two lowest-frequency sets of coils, the oscillator coils for each of these ranges may be adjusted so that the 3.5-Mc. harmonics of the 1.75-Mc. range (1 and 1A) will coincide with the fundamental frequencies of the 3.5-Mc. range (2 and 2A) and one scale on the dial will serve for both calibrations. It is only necessary to adjust the oscillator coil of the 3.5-Mc. range so that the low-frequency end of the band falls at the same point as the second harmonic of 1750 of the 1.75-Mc. range falls when the 1.75-Mc. coils are plugged in. With similar adjustments, the 7-Mc. and 14-Mc. ranges of the coils 1B and 1AB, 2B and 2AB and 3 and 3A may be made to coincide. In the end there will be a single calibration on the dial for each band, and only five calibrations will be required for the complete set of coils listed in the coil table. A typical dial calibration is shown in Fig. 1255. Intermediate points may be marked in as desired. While the 14-Mc. band does not cover as much of the dial as do the other bands, nevertheless the bandspread is entirely adequate to enable accurate setting to zero-beat in this band.



Fig. 1256 — High-frequency connections underneath the chassis of the v.f. exciter unit are made with short, straight sections of heavy wire. The two zero-temperature padding condensers are soldered directly to the oscillator-coil socket. All components are mounted firmly with no opportunity to support mechanical vibration. Washers $\frac{1}{16}$ -inch thick are placed between the panel and the chassis to provide space for the lower lip of the cabinet opening.

With the oscillator ranges adjusted, the next step is to adjust the tracking of the buffer stage. A 6.3-volt (150-ma.) dial lamp with one or two turns of wire should be coupled to the output tank coil to act as an indicator. With the condenser gang set at minimum capacity, the padder, C_6 , in the coil form should be adjusted for maximum brilliance of the lamp. The gang should now be turned to maximum capacity. If the lamp decreases in brilliance, readjust C_6 , noting carefully whether an increase or decrease in capacity of C_6 is required to bring the lamp up to its original brilliance. (If the padders suggested in the parts table are used, and if they are mounted in the coil forms with their terminals downward, clockwise rotation of the adjusting screw will decrease capacity, while counter-clockwise rotation will increase capacity. If mounted with the terminals upward, the action will be reversed.) If an increase in the capacity of C_6 is required with coils having no bandspread tap, C_7 is not tuning fast enough and a turn should be added to L_3 . If a decrease in the capacity of C_6 is required, a turn should be removed from L_3 . With the tapped coils, the tap should be moved a turn toward the top of L_3 , if an increase in C_6 is required, or moved a turn toward the bottom of the coil, if a decrease is required.

After each adjustment of the coil, tracking should again be checked by adjusting C_6 for maximum brilliance with the condenser gang at minimum capacity and then checking at

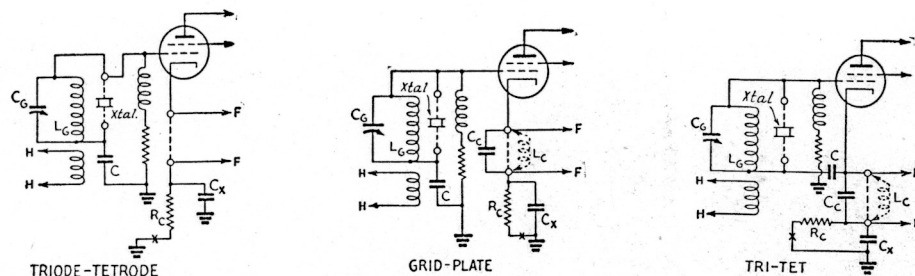


Fig. 1259 — Methods of coupling the output of the v.f.o. to crystal-oscillator stages of various types. See text for details. C is a mica condenser of $0.001 \mu\text{fd.}$ to prevent short-circuit of the grid leak. R_c and C_x are the usual oscillator cathode resistor and by-pass. C_c and L_c are the usual cathode-circuit tanks in the grid-plate and Tri-tet circuits. The v.f.o. link output is connected at H-H for harmonic operation and to F-F for fundamental operation. C_c is $100 \mu\text{fd.}$ for the 1.75-Mc. band and $50 \mu\text{fd.}$ for the 3.5- and 7-Mc. bands. Dimensions for L_c are as follows:
 1.75-Mc. input — 64 turns No. 24 d.s.c., close-wound, $1\frac{1}{2}$ -inch diameter.
 3.5-Mc. input — 40 turns No. 24, $1\frac{1}{2}$ -inch diameter, $1\frac{1}{2}$ -inches long.
 7-Mc. input — 20 turns No. 18, $1\frac{1}{2}$ -inch diameter, $1\frac{1}{2}$ -inches long.
 Link windings consist of 8, 6 and 5 turns respectively for the 1.75-, 3.5- and 7-Mc. bands, close-wound below L_c .

When the crystal stage is to be operated as a straight amplifier, the grid tank is removed, leaving the crystal position open. The link line from the v.f.o. is shifted to the points marked F-F and the cathode shorts indicated by the dotted lines removed. In Tri-tet or grid-plate oscillators, the cathode inductances and preferably the cathode tuning condensers also must be removed. If a cathode resistor is used, the excitation should be introduced between the cathode and the junction of the cathode resistor and its by-pass condenser.

If the v.f.o. is to be keyed, the key terminals of the crystal stage must be shorted. A small amount of fixed bias may have to be connected between grid leak and ground to prevent excessive plate current when the key in the v.f.o. circuit is open. If break-in keying is not desired, the v.f.o. may be operated continuously and the crystal stage keyed as usual.

Values for the substitute grid tank coil are given in Fig. 1259. A fairly-high L/C ratio has been chosen and, in most cases, any one band may be covered without retuning of the grid tank, if it is set to resonance in the middle of the band. The remainder of the transmitter will be tuned in the usual manner.

The details of a convenient plug-in system which takes care of all connections in shifting from Tri-tet crystal operation (used in most of the transmitters described in this chapter) to either fundamental or doubler operation when using the v.f.o. unit are shown in Fig. 1260. The grid tank for doubler operation is plugged into the same six-prong tube socket used for the crystal. Link connections to the v.f.o. are made through pin jacks H-H. A short-circuiting wire connects pin jacks F-F into the cathode circuit. The leads from the cathode-coil socket to these jacks and the shorting wire should be kept short. The cathode coil should be removed from its socket.

For fundamental operation with the v.f.o. unit, the tank is removed from the grid-circuit socket and the shorting wire removed from F-F, to which the link line from the v.f.o. is then shifted.

For crystal operation, the crystal is plugged into the grid circuit between prongs 6 and 3, or between 5 and 2, and the cathode coil is plugged into its socket, automatically connecting in the cathode condenser, C_c . The v.f.o. link line must be disconnected. Similar combinations may be worked out for other oscillator circuits.

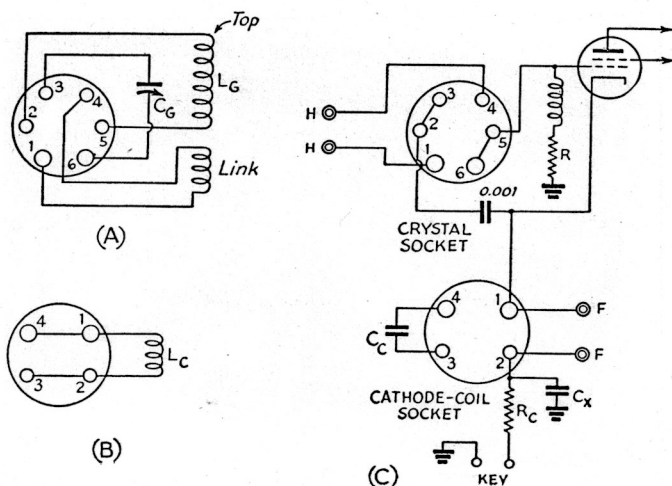


Fig. 1260 — Plug-in coil system for conveniently making connections in a Tri-tet oscillator circuit for optional crystal or v.f.o. operation. The grid tank for doubler operation is plugged into the same six-prong tube socket used by the crystal. A shows the connections of the plug-in grid tank for doubler operation of the crystal stage with v.f.o. input. Values for L_c , C_c , and link coils are given under Fig. 1259. B shows connections for the plug-in cathode coil, L_c , which is the usual Tri-tet cathode winding. C shows the circuit complete with all socket connections. C_c is the usual Tri-tet cathode-tank capacity and R_c and C_x are the usual cathode resistor and by-pass condenser.

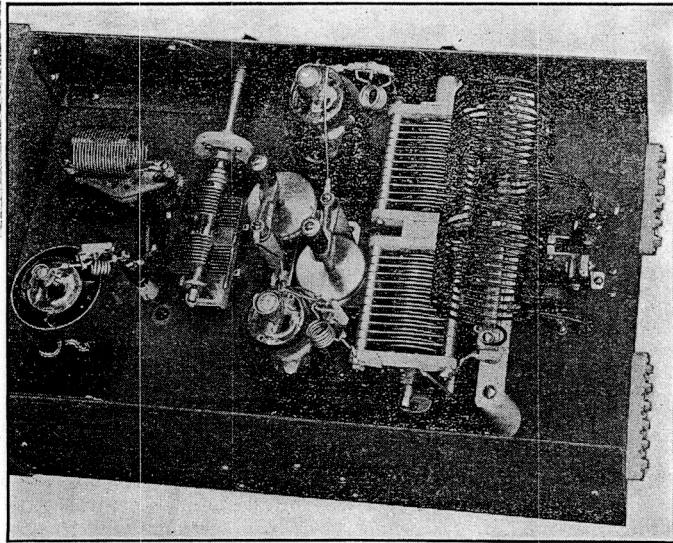


Fig. 1261 — Top view of the gang-tuned driver and push-pull amplifier designed to work with the v.f.o. unit of Fig. 1251. The chassis is elevated by 17 × 8-inch panels on each side. The 807 socket, which is mounted an inch below the chassis top on spacers, and the socket for the coupling transformer, L_1L_2 , at the left-hand end of the chassis, are on either side of the bandspread condenser, C_2 , underneath. The 807 padding condenser, C_1 , is next to the right with an insulating coupling on its shaft which is $5\frac{1}{2}$ inches from the left-hand end of the chassis. The shaft of the final-amplifier padding condenser, $5\frac{1}{2}$ inches from the right-hand end of the chassis, is also fitted with an insulating coupling. The condenser is mounted on National polystyrene button insulators to bring its shaft level with that of C_1 . The sockets for the 812s are at either end of C_3 , with the neutralizing condensers between to make neutralizing leads short. The jack bar for the tank coil, L_3 , is mounted on 2-inch cone insulators.

❑ A Gang-Tuned 450-Watt Push-Pull Amplifier and Driver

Figs. 1261, 1262 and 1264 show a gang-tuned unit which may be added to the v.f.o. unit of Fig. 1251. As shown in Fig. 1263, it consists of a push-pull amplifier and a driver stage, the tuning controls of which are coupled to the tuning shaft of the v.f.o. unit. Once adjusted for any given band, the entire transmitter can be tuned with the single dial of the v.f.o. unit.

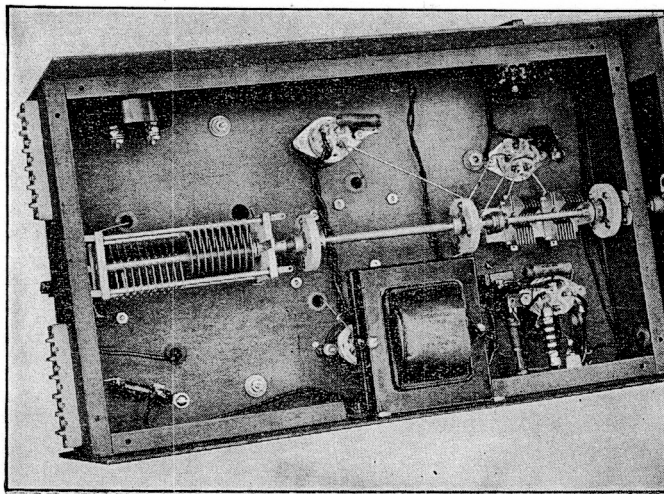
The two stages are coupled inductively with the tuning condensers connected across the grid winding. The use of inductive coupling solves the problem of balanced excitation to the amplifier without the dual tuning controls required with link coupling. C_1 and C_3 are the tank condensers, used for setting the circuits to the desired band. C_2 and C_4 are the band-tuning condensers. The two stages are adjusted for tracking by varying the portion of the coils across which C_2 and C_4 are connected.

Fig. 1262 — Bottom view of the gang-tuned unit. The final amplifier bandspread condenser, C_4 , is mounted as far to the left as possible, on National polystyrene button insulators stacked to bring the shaft level with that of the driver bandspread condenser, C_2 , to the right. The shafts of the two condensers are connected with flexible ceramic insulating couplings and also to the tail shaft of C_7 in the v.f.o. unit through a hole cut in the rear of the v.f.o. cabinet. C_2 is turned around so that its tail shaft couples to the shaft of the v.f.o. unit. The mounting hole of the condenser should come $2\frac{1}{2}$ inches from the left-hand edge of the chassis. The shaft stop pin should be removed. The remaining below-chassis wiring is simple and direct. Heavy tinned wire is used for all r.f. leads. The filament transformer is mounted below the chassis at the center rear. Insulated or protected terminals are used for all external power supply connections.

The trap circuits, L_4C_5 , L_5C_6 and L_6C_7 , are for the suppression of v.h.f. parasites.

The milliammeter may be switched to read 807 cathode or screen current, amplifier grid current, or amplifier cathode current.

Coils — While homemade coils of equivalent dimensions may be substituted, it may be found more convenient to alter manufactured coils. The National coils suggested for L_1 should be obtained minus the links and mountings. Stripped, it will be found that these coils fit snugly inside the B & W coils used for L_2 , and that the plastic strips on each coil hold them central to prevent short circuits between L_1 and L_2 . The link winding should be removed from L_2 . The free base-pins thus provided will serve for the connections to C_2 . The tubular rivets at each end of the bottom spacing strip of the coil should be drilled or filed out, and $\frac{3}{4}$ -inch 6-32 machine screws substituted. A Johnson banana plug is fastened at each end and the ends of L_1 are connected to these plugs.



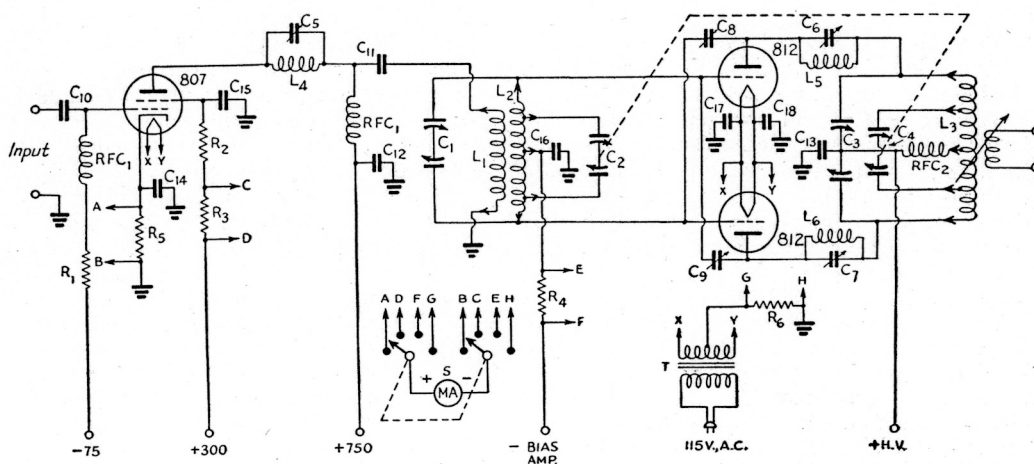


Fig. 1263 — Circuit diagram of the 450-watt gang-tuned driver and push-pull amplifier unit.

C₁ — 140 μ fd. per section (Hammarlund MCD-140-S).
 C₂ — 100 μ fd. per section (Hammarlund MCD-100-S).
 C₃ — 150 μ fd. per section, 0.07-inch spacing (Johnson 150ED30).
 C₄ — 65 μ fd. per section, 0.07-inch spacing (Hammarlund HFBD-65-E).
 C₅, C₆, C₇ — 3–30- μ fd. mica trimmer (National M-30).
 C₈, C₉ — Neutralizing condensers (National NC-800).
 C₁₀ — 100- μ fd. mica.
 C₁₁, C₁₂ — 0.001- μ fd. mica, 1000-volt rating.
 C₁₃ — 0.001- μ fd. mica, 7500-volt (Aerovox 1623).
 C₁₄, C₁₅, C₁₆, C₁₇, C₁₈ — 0.01- μ fd. mica.
 MA — Milliammeter, 100-ma. scale.
 R₁ — 25,000 ohms, 1-watt.
 R₂ — 20,000 ohms, 10-watt variable.
 R₃, R₄ — 25 ohms, 1-watt.
 R₅ — Meter multiplier resistance, 2 times, wound with No. 26 wire.
 R₆ — Meter multiplier resistance, 5 times, wound with No. 24 wire.
 RFC₁ — 2.5-mh. r.f. choke.
 RFC₂ — 500-ma. r.f. choke (Hammarlund CH500).
 S — Two circuit, 4-contact switch (Mallory 3234J).
 T — 6.3 volts, 10 amperes (Thordarson T-19F99).
 L₁ — Mounted inside L₂:
 1.75 Mc. — 45 turns No. 24, 1 $\frac{1}{4}$ -inch diameter, 1 $\frac{3}{8}$ inches long (National AR80, unmounted, 11 turns removed).

3.5 Mc. — 22 turns No. 22, 1 $\frac{1}{4}$ -inch diameter, 1 $\frac{1}{4}$ inches long (National AR40, unmounted, 6 turns removed).
 7 Mc. — 14 turns No. 20, 1 $\frac{1}{4}$ -inch diameter, 1 $\frac{1}{4}$ inches long (National AR20, unmounted).
 L₂ — 1.75 Mc. — 58 turns No. 24, 1 $\frac{5}{8}$ -inch diameter, 2 $\frac{1}{4}$ inches long, taps at ends of coil (B & W JCL-160, no link).
 3.5 Mc. — 28 turns No. 22, 1 $\frac{5}{8}$ -inch diameter, 1 $\frac{1}{2}$ inches long, taps at 3 turns from each end (B & W JCL-80, no link, 8 turns removed from each end).
 7 Mc. — 18 turns No. 16, 1 $\frac{5}{8}$ -inch diameter, 1 $\frac{1}{2}$ inches long, taps at 6 turns from each end (B & W JCL-40, no link, 5 turns removed from each end).
 L₃ — 1.75 Mc. — 60 turns No. 16, 5 $\frac{1}{2}$ inches long, 2 $\frac{1}{2}$ -inch diameter, $\frac{5}{8}$ -inch space at center for link, taps at ends of coil (B & W TVH-160).
 3.5 Mc. — 38 turns No. 14, 5 $\frac{1}{4}$ inches long, 2 $\frac{1}{2}$ -inch diameter, $\frac{3}{4}$ -inch space at center for link, taps at 3 $\frac{3}{4}$ turns from each end (B & W TVH-80).
 7 Mc. — 24 turns No. 12, 5 $\frac{1}{4}$ inches long, 2 $\frac{1}{2}$ -inch diameter, $\frac{3}{4}$ -inch space at center for link, taps at 7 $\frac{3}{4}$ turns from each end (B & W TVH-40).
 L₄ — 5 turns No. 14, $\frac{3}{8}$ -inch diameter, 1 inch long.
 L₅, L₆ — 4 turns No. 14, $\frac{5}{8}$ -inch diameter.

In the chassis, on either side of the coil socket and directly below the banana plugs, a hole should be drilled. The one on the right-hand side should be $\frac{1}{4}$ -inch in diameter, while the one on the left-hand side should be $\frac{1}{2}$ -inch in diameter. A jack to fit the banana plug should be placed in a National polystyrene button-type insulator with the shoulder filed off and the hole drilled out to fit the jack. This jack, mounted in the $\frac{1}{4}$ -inch hole with the insulator as a spacer, then serves to make the ground connection for L₁. The $\frac{1}{2}$ -inch hole is for a second jack insulated from the chassis by a pair of button insulators which serves as the connection for the other end of L₁.

The B & W type TVH coils are supplied with extra plugs which may be used for the ganging taps for C₄.

Both L₂ and L₃ require no bandspread taps for the 1.75-Mc. band; the plugs for the taps and those for the ends of the coils are simply tied together, connecting the bandspread and padding condensers in parallel for this band.

Combining Units

Fig. 1264 shows how the two units are joined together. The output of the v.f.o. and the input of the 807 driver stage are coupled capacitively, a short wire connecting the binding post in the v.f.o. unit with the coupling condenser, C₁₀, in the ganged unit. Large holes are made in the rear of the v.f.o. cabinet and the end of the chassis to clear a small National rigid shaft coupling. The height of the chassis should be adjusted so that the shafts of the two units line up perfectly. If the condenser

COIL-SELECTION TABLE FOR GANGED UNIT

Band	Osc.	Buffer	Driver	Final
1.75 Mc.	No. 1	No. 1A	1.75 Mc.	1.75 Mc.
3.5 Mc.	No. 2	No. 2A	3.5 Mc.	3.5 Mc.
7 Mc.	No. 3	No. 3A	7 Mc.	7 Mc.
14 Mc.	No. 3	No. 3A	14 Mc.	14 Mc.

gangs in each unit have been mounted as described, the shafts will be lined up when the bottom edge of the chassis is $2\frac{1}{4}$ inches above the bottom edges of the supporting panels.

Tuning — If coil dimensions have been followed carefully, there should be little difficulty in lining up the various stages. The shaft couplings must be adjusted so that all condensers of the gang arrive at maximum or minimum capacity simultaneously. Coils should be plugged in the various stages for the desired band, using the coil-selection table as a guide.

With the tuning control set for the high-frequency edge of the band, the voltage-regulated supply and the bias supply should be turned on simultaneously. This will apply plate voltage to the v.f.o. unit and screen voltage to the 807. Using the 807 screen current as an indicator, the trimmer of the buffer stage in the v.f.o. unit should be lined up. Maximum screen current indicates resonance. The key should not be held closed for excessively long periods, to limit screen heating. Tuning to the low-frequency end of the band should show negligible change in screen current. Should there be evidence of poor tracking, the buffer stage can be brought into line as discussed in describing the tuning of the v.f.o. unit.

Plate voltage may now be applied to the 807 and the stage tuned to resonance with C_1 . A check should be made for parasitic oscillation, with a lamp of sufficient size to reduce the plate voltage to about half in series with the primary of the 750-volt transformer. At several settings of the v.f.o. unit C_1 should be varied throughout its range, carefully noting any change in cathode current which would indicate oscillation. An additional check may be made by touching a neon bulb to the plate of the 807. Should oscillation occur, C_5 should be adjusted until the oscillation is suppressed.

Turning now to the tracking of the driver stage, tuning C_1 to resonance should result in a show-

ing of amplifier grid current. Again starting at the h.f. end of the band, C_1 should be adjusted for maximum grid current. If there is a serious falling off of grid current at the l.f. end, determine if readjusting C_1 will bring the grid current back up. If it does not, the size of L_1 must be increased by one or two turns. If, however, retuning of C_1 shows the tuning to be off resonance at the l.f. end of the band, it should be carefully noted whether an increase or a decrease in the capacity of C_1 is necessary to restore resonance. If an increase in C_1 is required, the taps of C_2 should be spread slightly farther apart; if a decrease is required, they should be brought closer together. After each check the tuning of the unit should be returned to the h.f. end and realigned, before again checking the l.f. end.

However, should the first check at the l.f. end of the band show an increase in grid current over that obtained at the h.f. end a turn or two should be removed from L_1 , after which the tracking should again be checked.

With substantially constant grid current over the band, the amplifier may be neutralized in the usual manner. With the amplifier operating at reduced plate voltage, a check similar to that described for the 807 stage should be made to eliminate any tendency toward parasitic oscillation. For several settings of the ganged control, C_3 should be varied throughout its range. If oscillation occurs, C_6 and C_7 should be adjusted in equal steps until it ceases.

Still operating at reduced plate voltage, the amplifier should be loaded with a lamp bulb of 150 to 200 watts connected to the output link. C_3 should be adjusted for resonance at the h.f. end of the band. Tuning across the band should now show no appreciable change in power input or output. If a check, by retuning C_3 at the l.f. end of the band, shows the stage to be off resonance, a note should be made as to whether an increase in the capacity of C_3 or a decrease is necessary to restore reso-

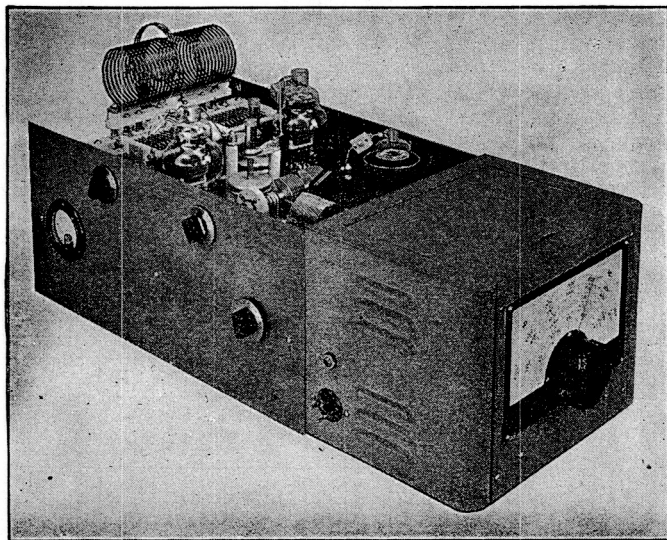


Fig. 1264 — The v.f.o. unit of Fig. 1251 combined with the gang-tuned driver and push-pull final amplifier. The two units are fastened together with 7-inch triangular brackets, the tops of which have been cut off to fit, on each side of the chassis. The excitation lead to the grid of the 807 passes through a grommet-lined hole in the back of the v.f.o. cabinet. The milliammeter and the meter switch are placed on the panel to balance each other at opposite ends of the chassis. Holes for these components must be cut in the chassis edge. The control at the left is for setting the final-amplifier padder or band-setting condenser, C_3 , while the control to the right is for the driver padder, C_1 . The $10 \times 17 \times 3$ -inch chassis is elevated approximately $2\frac{1}{4}$ inches by supporting it on panels 8 inches high running the length of the chassis. The clearance and assembly holes through the panel and chassis should be made slightly oversize to permit accurate adjustment of the chassis height for lining up the tuning-condenser shafts.

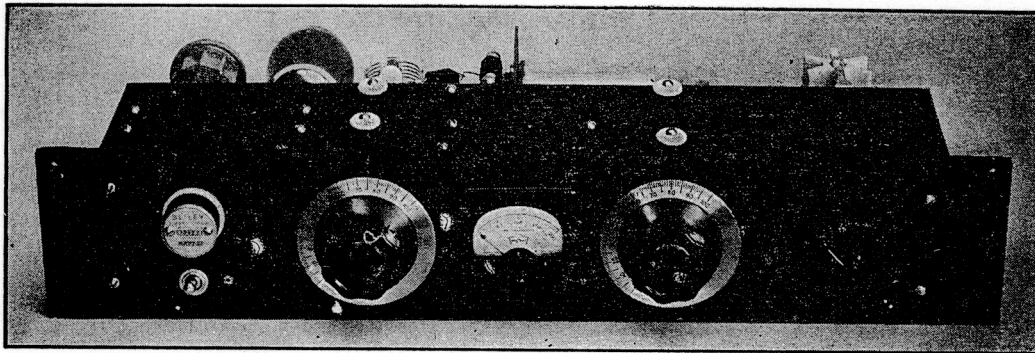


Fig. 1265 — The two-tube plug-in coil exciter is built to conserve space in the relay rack. The panel is $3\frac{1}{2} \times 19$ inches. A clearance hole is cut in the left end of the panel for the crystal socket, which is mounted in the chassis directly above the cathode-circuit switch. The left-hand dial controls the tuning of the oscillator plate-tank circuit; the dial to the right tunes the output tank circuit. The switch at the right-hand end is for the 200-ma. milliammeter.

nance. If it increases, the taps of C_4 should be spread slightly, while a decrease in C_3 indicates that the taps of C_4 should be brought slightly closer together. Again, each adjustment of tracking should be followed by realigning at the h.f. end of the band before making a check on the new adjustment at the l.f. end.

If coil dimensions have been followed carefully these tracking adjustments should not be required. They are described to take care of cases in which the constructor may have gone astray at some point, or in which the design has been changed to suit other requirements. Naturally, the adjustments for the higher-frequency bands must be made in smaller steps than for the lower-frequency bands.

At the plate voltages recommended, the screen current, when lining up the v.f.o. output stage, should run between 5 and 10 ma. Cathode current to the driver stage when tuned and loaded should be between 70 and 100 ma., while grid current to the final amplifier should exceed 50 ma. with the amplifier loaded to the rated plate current of 300 ma. at 1500 volts. The driver screen voltage should run close to 250 volts. When correctly adjusted, the output across any of the three bands should remain constant at 300 watts.

The tables of Chapter Twenty-One should be consulted if other tubes are used in the final.

Complete Variable-Frequency Gang-Tuned Transmitter

Fig. 1264 shows the two units of Figs. 1251 and 1261 combined for gang tuning. The voltage-regulated supply of Fig. 1257 may be used to furnish screen voltage for the 807 by bringing out a tap from the junction of resistors R_1 and R_2 . The unit of Fig. 1247 will furnish biasing voltages for both 807 and final amplifier. The voltage-divider resistance of the bias unit should be adjusted with 4000 ohms in the R_2 portion and 4000 ohms in the R_3 portion. Plate voltage for the 807 may be obtained from the unit of Fig. 1238, while the unit of Fig. 1246 will furnish plate voltage for the amplifier. A suitable antenna tuner is shown in Fig. 1249.

A Two-Tube Plug-In Coil Exciter

In the two-tube exciter or low-power transmitter shown in Figs. 1265, 1266 and 1268, a 6L6 oscillator is used to drive an 807 as an amplifier-doubler. As shown in Fig. 1267, a Tri-tet circuit, used to obtain harmonic output, is reduced to a simple tetrode circuit for oscillator output at the crystal fundamental by short-circuiting the cathode tank circuit. Sufficient oscillator output at the fourth harmonic of the crystal frequency is obtainable to drive the 807, which may be operated as either a straight amplifier or frequency doubler, providing output of 25 to 50 watts or more in four bands from a single crystal.

The entire unit is designed to operate from a single 250-ma. power supply delivering up to 750 volts (see Fig. 1239), the maximum rating for the 807. Fixed bias of 45 volts, which may be obtained from a dry battery, is required for the 807. In the system shown, both oscillator and amplifier are keyed simultaneously in the common cathode lead. A single 200-ma. milliammeter may be switched to read the plate current of either stage.

Tuning — Because it is possible to double or quadruple frequency in the plate circuit of the oscillator and to double in the plate circuit of the 807, as well, there are several possible combinations of coils and crystals which will produce the same output frequency. Since much better efficiencies are obtainable, it is advisable to operate the 807 as a straight amplifier rather than as a doubler. This is possible in all cases except where it is necessary to obtain output at the eighth harmonic of the crystal frequency — 14-Mc. output from a 1.75-Mc. crystal, or 28-Mc. output from a 3.5-Mc. crystal. The accompanying chart shows the combination required for the desired output from any given crystal. This chart also indicates the position for SW_1 . Be sure that the harmonics of the crystal frequency fall in the band in which operation is to occur.

With the proper coils and crystal in place, SW_1 in the correct position and both con-

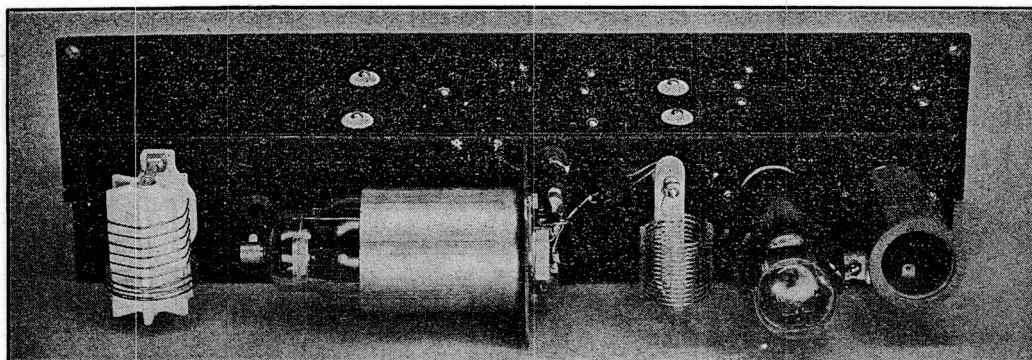


Fig. 1266 — The four-prong socket for the cathode coil, the octal socket for the 6L6 oscillator and the five-prong socket for the Coto coils used in the output tank circuit are sub-mounted along the rear of the chassis. The mounting for the National AR coils used in the oscillator plate circuit is fastened on short cone insulators, while the socket for the 807 is sub-mounted in the small steel partition. The grid r.f. choke and screen and cathode by-pass condensers are fastened directly to the socket. Large clearance holes lined with grommets are provided for passing the connections through the chassis from the oscillator plate coil to the tank condenser and for the 807 plate lead. A pair of pin jacks serves as the link output terminals. Power-supply connections are made to a terminal strip at the right.

densers set at minimum capacity (100 on the dial), the plate voltage should be applied with the meter reading plate current to the 807. If all resistances are correct and the plate voltage is 750, the plate current should run approximately 25 ma. With the key closed, tune the oscillator tank condenser for maximum amplifier plate current. (Do not hold the key closed for long periods under this high-current condi-

tion.) As soon as the peak has been obtained, tune the amplifier plate tank condenser for resonance as indicated by a pronounced dip in plate current. Should the points of response on either condenser be found at points on the scale differing appreciably from those given in the accompanying table, each circuit should be checked with an absorption frequency meter to make sure that it is tuned to the correct fre-

Fig. 1267—Circuit diagram of the two-tube plug-in coil exciter.

C₁ — 140- μ fd. variable (Hammarlund MC-14M).

C₂ — 150- μ fd. variable (Cardwell MR150BS).

C₃ — 100- μ fd. mica.

C₄ — 20- μ fd. mica.

C₅, C₆, C₇, C₈, C₉, C₁₀ — 0.01- μ fd., 600-volt paper.

C₁₁ — 0.01- μ fd. 1000-volt paper.

C_x — 100- μ fd. mica (used only on 3.5 Mc.)

MA — Milliammeter, 0-200-ma.

R₁ — 20,000 ohms, 1-watt.

R₂ — 25,000 ohms, 2-watt.

R₃ — 200 ohms, 2-watt.

R₄ — 10,000 ohms, 25-watt.

R₅ — 3500 ohms, 25-watt.

R₆, R₇ — 15,000 ohms, 25-watt.

R₈, R₉ — 1250 ohms, 50-watt.

R₁₀, R₁₁ — 10 ohms, 1-watt.

RFC — 2.5-mh. r.f. choke.

SW₁ — S.p.s.t. toggle switch.

SW₂ — D.p.d.t. rotary switch (Mallory 3222J).

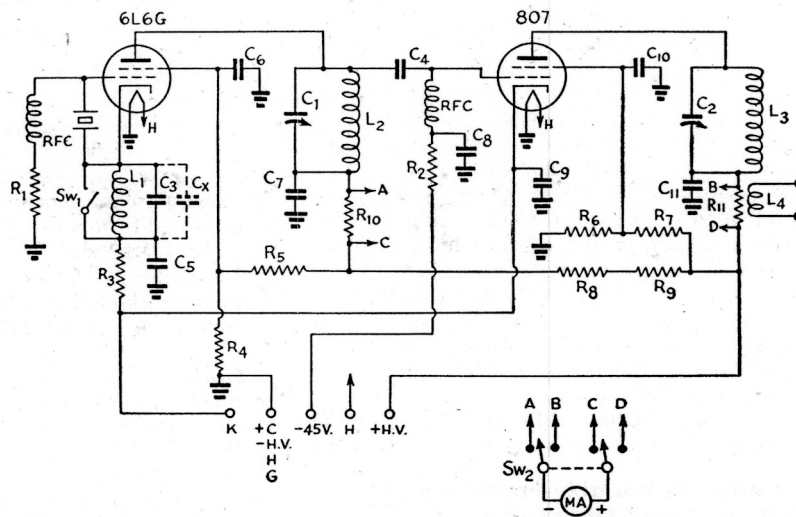
L₁ — 1.75-Mc. crystals — 32 turns No. 22 d.s.c., close-wound.

3.5-Mc. crystals — 10 turns No. 22 d.s.c., 1 inch long.

Note: C_x mounted in form.

7-Mc. crystals — 6½ turns No. 22 d.s.c., ¾-inch long.

All wound on Hammarlund 1½-inch diam. 4-pin forms.



L₂ — 1.75 Mc. — 56 turns, 1¼-inch diameter, 1¾ inches long, 54 μ hys. (National AR80 — no link).

3.5 Mc. — 28 turns, 1¼-inch diameter, 1½ inches long, 15 μ hys. (National AR40 — no link).

7-Mc. — 14 turns, 1¼-inch diameter, 1¼ inches long, 4.2 μ hys. (National AR20 — no link).

14 Mc. — 8 turns, 1¼-inch diameter, 1½ inches long, 1.25 μ hys. (National AR10 — no link).

28 Mc. — 4 turns, 1¼-inch diameter, ¾-inch long, 0.5

μ hy. (National AR10, 4 turns removed — no link).

L₃ — 1.75 Mc. — 50 turns, 1½-inch diameter, 2½ inches long, 52 μ hys. (Coto CS6160E).

3.5 Mc. — 25 turns, 1½-inch diameter, 1½ inches long, 16 μ hys. (Coto CS630E).

7 Mc. — 16 turns, 1½-inch diameter, 1½ inches long, 5.7 μ hys. (Coto CS640E).

14 Mc. — 8 turns, 1½-inch diameter, 1½ inches long, 1.5 μ hys. (Coto CS620E).

28 Mc. — 4 turns, 1½-inch diameter, 1½ inches long, 0.7 μ hy. (Coto CS610E).

COIL AND TUNING TABLE FOR TWO-TUBE PLUG-IN COIL EXCITER							
Xtal Band Mc.	Output Band Mc.	SW ₁	L ₁ Band Mc.	C ₁ L ₂ Band Mc.	C ₂ L ₃ Band Mc.	C ₁ *	C ₁ *
1.75	1.75	Closed	1.75	1.75	1.75	10	10
1.75	3.5	Open	1.75	3.5	3.5	10	30
3.5	3.5	Closed	3.5	3.5	3.5	10	30
1.75	7	Open	1.75	7	7	20	50
3.5	7	Open	3.5	7	7	20	50
7	7	Closed	7	7	7	20	50
1.75	14	Open	1.75	7	14	20	70
3.5	14	Open	3.5	14	14	35	70
7	14	Open	7	14	14	35	70
3.5	28	Open	3.5	14	28	35	80
7	28	Open	7	28	28	75	80

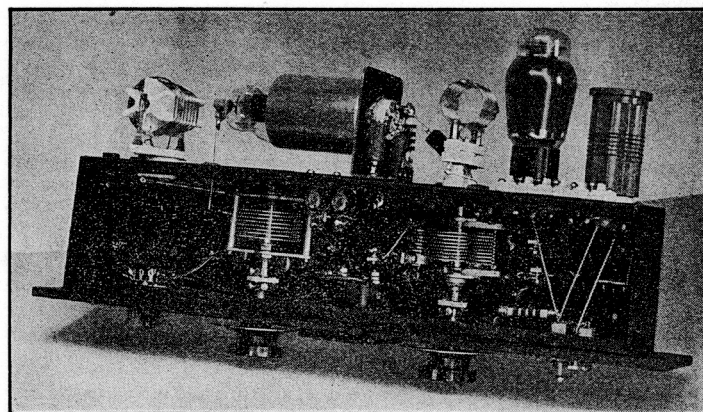
* Approximate settings for low-frequency ends of bands with dial reading zero at full capacity of condenser.

quency, since the ranges covered by some of the coils include odd harmonics falling outside the amateur bands. Once checked, the dial settings can be logged for quick resetting.

When the amplifier has been tuned, the meter switch may be set to read oscillator plate current and the oscillator tank circuit tuned for minimum plate current consistent with satisfactory keying. Active crystals usually will oscillate continuously in the Tri-tet circuit, regardless of the setting of the tank condenser. With the tetrode circuit, however, the circuit will oscillate only within relatively narrow limits. SW₁ must be closed when the oscillator plate circuit is tuned to the crystal frequency. The oscillator plate current will vary widely, depending upon whether output is taken at the fundamental, second harmonic or fourth harmonic. At the specified plate voltage, it should run between 40 and 50 ma. with the plate circuit tuned to the crystal fundamental or second harmonic. When tuned to the fourth harmonic, the plate current will normally run between 85 and 95 ma.

Because the plate and screen of the 6L6 are operated from a voltage divider, their voltages vary with tuning. Plate voltage varies between 400 and 450, except at the fourth harmonic when it falls to 340 volts or so. The screen voltage varies from 280 to 210 volts.

Fig. 1268 — Bottom view of the plug-in exciter. Space inside the 4 × 17 × 3-inch chassis has been utilized to the greatest extent possible while preserving accessibility. Voltage divider resistors R₈ and R₉ are to the right of the oscillator tank condenser, while R₄, R₅, R₆ and R₇ are mounted to the rear of the meter. The oscillator r.f. choke and grid leak are fastened to the crystal socket. Connections between the crystal socket and cathode switch are made directly and kept well spaced. The oscillator circuit may be arranged for v.f.o. input as shown in Fig. 1260. Meter-shunting resistances are fastened to the meter switch. Both tank-condenser shafts must be fitted with insulated couplings and panel bearings.



The plate current should be limited to 70 ma. at 28 Mc. and 80 ma. at 14 Mc. when doubling frequency in the output stage, and to 90 ma. when operating the 807 as a straight amplifier at 28 Mc. Power output under these conditions should average 40 to 55 watts on all bands. When doubling frequency in the output circuit to 14 and 28 Mc., the output will be reduced to about 27 and 18 watts respectively.

If the exciter is operated from a power supply of lower voltage, the values of resistance specified for the voltage dividers may be altered to increase the voltages on the oscillator plate and screen and also the screen of the 807. With a 600-volt supply, R₈ and R₉ should be 1000 ohms each, R₄, 20,000 ohms, and R₅, 10,000 ohms. Power output will average 30 to 35 watts from the 807 as a straight amplifier.

Complete 75-Watt All-Band Transmitter with Plug-in Coils

If it is desired to feed the unit of Fig. 1265 into an antenna as a complete transmitter, it may be combined with the power-supply unit of Fig. 1238, which will furnish heater and plate voltages, and the antenna-tuning unit of Fig. 1215 using the large condensers. A 45-volt dry battery will be required for bias. The three units may be placed in a small table rack with a total height of only 17½ inches.

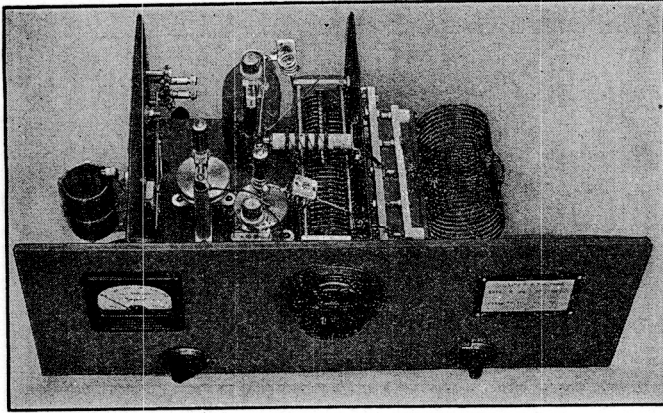


Fig. 1269 — A general view of the compact 450-watt push-pull amplifier, showing the front panel and top-of-chassis arrangement. Mounted on a standard relay rack, the height is only 7 inches and the depth 9 inches. Grid and plate tank circuits are isolated from each other by the double shielding partitions. On the panel are the 0-100 ma. milliammeter, which is switched to read current in all circuits, the plate-tank tuning dial, and a chart giving coil and tuning data. The small knob at the left below is the grid-circuit tuning control, while the one to the right is for the meter switch. The tube sockets are mounted adjacent to the stator terminals of the plate-tank condenser, C_2 , in the center with the neutralizing condensers between them, providing short leads.

Ⓐ Push-Pull Amplifier for 200 to 500 Watts Input

Figs. 1269, 1270 and 1272 show various views of a compact push-pull amplifier for tubes of the 1500-volt 150-ma. class, although the design is also suitable for use with tubes of the 1000-volt 100-ma. class. With the lower plate voltages, a plate tank condenser with a spacing between plates of 0.05 inch and smaller tank coils may be used.

The circuit, shown in Fig. 1271, is quite conventional, with link coupling at both input and output. C_{11} and C_{12} are plug-in fixed air capacitors for the 1.75-Mc. band, to eliminate the necessity for an unduly large variable tank condenser to cover this one band. The tuned circuits, L_3C_6 and L_4C_5 , are traps important for the prevention of v.h.f. parasitic oscillations. The 100-ma. meter may be shifted between the grid and cathode circuits for reading either grid current or cathode current. When shifted to read cathode current, the meter is shunted by a resistor, R_2 , which multiplies the scale reading by five. This resistance is wound experimentally with No. 26 copper wire to give the desired scale multiplication.

Construction — The mechanical arrangement shown in the photographs results in a compact unit requiring a minimum of panel space. The tank condenser is mounted on the left-hand partition (Fig. 1270) at a height which brings its shaft down $2\frac{5}{8}$ inches from the top of the panel. The plate tank-coil jack bar is mounted centrally with the condenser on spacers which give a $\frac{1}{2}$ -inch clearance between the strip and the partition. The socket for the plate padder, C_{12} , is mounted in the lower rear corner of the left-hand partition. C_{10} is mounted with a small angle on the partition under the center of C_2 . Leads from both ends of the rotor shaft are brought to one side of C_{10} for symmetry.

The two tube sockets are mounted in a line through the center of the chassis and at opposite ends of the plate tank condenser. They are spaced about one inch below the chassis on long machine screws. The neutralizing con-

densers are placed between the two tubes, so that the leads from the plate of one tube to the grid of the other are short. The r.f. choke is mounted just above the tank condenser.

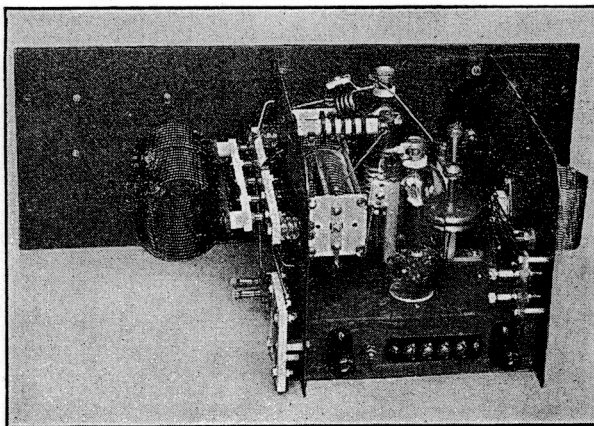
The right-hand partition is cut out at the forward edge to clear the meter. This cut-out can be readily made with a socket punch and a hacksaw. The socket for the grid tank coil is mounted $4\frac{1}{2}$ inches behind the panel, just above the chassis line. The grid-circuit padder, C_{11} , is fitted with banana plugs which mount in jacks set in the right-hand partition just behind the grid coil. The jacks are insulated from the metal by being mounted in National polystyrene button insulators which have been drilled out to fit.

The grid tank condenser, C_1 , is mounted under the chassis without insulation. Large clearance holes, lined with rubber grommets, are drilled for connecting wires which must be run through the chassis or partitions. The parasitic traps are made self-supporting in the plate leads from the tank condensers to the tube caps. The panel is placed so that the plate tank-condenser shaft comes at the center. The meter switch is mounted to balance the knob controlling C_1 .

Power supply and excitation — The T40 tubes shown in the photographs operate at a maximum plate voltage of 1500 for c.w. work. For this, the unit shown in Fig. 1246 is suitable. The supply shown in Fig. 1248, minus the VR-tube branch, will provide the biasing voltage required for plate-current cut-off. R_2 should have a resistance of 2500 ohms and R_3 of 1500 ohms. A filament transformer delivering 7.5 volts at 5 amperes also will be required; it may be mounted on the bias-supply chassis, if desired. The exciters of Figs. 1232 or 1265 will furnish adequate excitation.

Tuning — After the amplifier has been neutralized, a test should be made for parasitic oscillation. The bias should be reduced until the amplifier draws a plate current of about 100 ma. without excitation. With C_1 adjusted to various settings, C_2 should be varied through its range and the plate current watched closely for any abrupt change. Any change will indicate

Fig 1270 — All components of the 450-watt push-pull amplifier are assembled around a small metal chassis $7 \times 2 \times 9$ inches deep. The partitions are standard $6\frac{1}{2} \times 10$ -inch interstage shields. The plate tank condenser is mounted on the left-hand partition. The plate tank-coil jack-bar is mounted centrally, opposite the condenser, on spacers which give $\frac{1}{2}$ -inch clearance between the strip and the partition. The socket for C_{12} is mounted in the lower rear corner of the left-hand partition. C_{10} is mounted with a small angle bracket on the partition under the center of C_2 . The socket for the grid tank coil is mounted just above the chassis line. The grid-circuit padder, C_{11} , is fitted with banana plugs which mount in jacks set in the partition behind the grid coil. The jacks are insulated from the metal partition by polystyrene button-type insulators. Millen safety terminals are used for the external high-voltage plate and bias connections.



oscillation, and condensers C_5 and C_6 should be adjusted in slight steps simultaneously until the oscillation disappears. Unless the wiring differs appreciably from that shown, complete suppression will be obtained with the two condensers at full capacity. Changing bands should have no effect upon this adjustment.

With normal bias replaced, the amplifier should now be tuned up and the excitation adjusted so that a grid current of 60 ma. is obtained with the amplifier fully loaded. Full loading will be indicated when the cathode-current meter registers 360 ma., which includes the 60-ma. grid current. Under these conditions the biasing voltage should rise to 150 volts, drop-

ping to about 70 volts without excitation when the plate current will fall to almost zero.

If the amplifier is to be plate-modulated, the plate voltage should be reduced to 1250 and the loading decreased to reduce the plate current to 250 ma. The same bias-supply adjustment will be satisfactory for this type of operation but excitation may be reduced to give a grid current of 40 ma., bringing the total cathode current to 290 ma. The antenna tuner shown in Fig. 1227 or the pi-section network of Fig. 1274 may be used.

Reference should be made to the tube tables in Chapter Twenty-One for operating conditions for tubes of different characteristics.

Fig. 1271 — Circuit diagram of the 450-watt push-pull amplifier.

C_1 — 100- μ fd. per section, 0.03-inch spacing (Hammarlund HFAD-100-B).

C_2 — 100- μ fd. per section, 0.07-inch spacing (Hammarlund HFBD-100-E).

C_3, C_4 — Neutralizing condensers (National NC-800).

C_5, C_6 — 3-30- μ fd. mica trimmers (National M-30)

C_7, C_8, C_9 — 0.01- μ fd. mica.

C_{10} — 0.001- μ fd. mica, 7500-volt rating (Aerovox 1653).

C_{11} — 50- μ fd. air padder (for 1.75 Mc.), 0.05-inch spacing (Cardwell EO-50-FS).

C_{12} — 50- μ fd. air padder (for 1.75 Mc.), 0.125-inch spacing (Cardwell JD-50-OS).

R_1 — 25 ohms, 1-watt.

R_2 — Meter-multiplier resistance for 5-times multiplication, wound with No. 26 wire.

RFC — 1-mh. r.f. choke (National R-154U).

MA — Milliammeter, 100-ma.

L_1 — B & W JCL series, dimensions as follows: *

1.75 Mc. — 60 turns No. 24, $2\frac{1}{8}$ inches long.

3.5 Mc. — 44 turns No. 20, $2\frac{1}{8}$ inches long.

7 Mc. — 26 turns No. 16, $2\frac{1}{8}$ inches long.

14 Mc. — 14 turns No. 16, $1\frac{1}{8}$ inches long (remove 2 turns from B & W coil).

28 Mc. — 6 turns No. 16, $1\frac{1}{8}$ inches long (remove 2 turns from B & W coil).

L_2 — B & W TCL series, dimensions as follows: **

1.75 Mc. — 28 turns No. 12, $4\frac{3}{4}$ -inch diameter, $4\frac{1}{4}$ inches long.

3.5 Mc. — 26 turns No. 12, $3\frac{1}{2}$ -inch diameter, $4\frac{1}{2}$ inches long.

7 Mc. — 22 turns No. 12, $2\frac{1}{2}$ -inch diameter, $4\frac{1}{2}$ inches long.

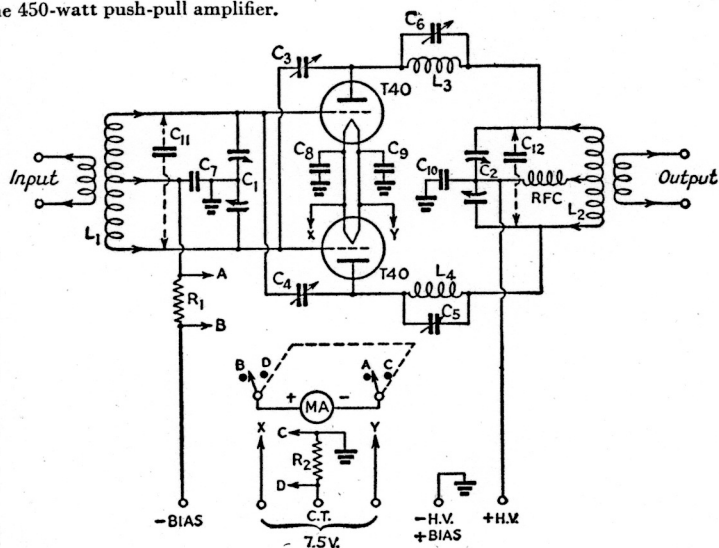
14 Mc. — 10 turns No. 12, $2\frac{1}{2}$ -inch diameter, $4\frac{1}{4}$ inches long, remove one turn from each end.

28 Mc. — 4 turns $\frac{1}{8}$ -inch copper tubing, $2\frac{1}{2}$ -inch diameter, $4\frac{1}{2}$ inches long. Remove one turn from each end.

L_3, L_4 — 4 turns No. 14, $\frac{1}{2}$ -inch diameter, $\frac{3}{4}$ -inch long.

* All $1\frac{1}{2}$ -inch diameter, 3-turn links.

** All coils fitted with 2-turn links.



7 Mc. — 22 turns No. 12, $2\frac{1}{2}$ -inch diameter, $4\frac{1}{2}$ inches long.

14 Mc. — 10 turns No. 12, $2\frac{1}{2}$ -inch diameter, $4\frac{1}{4}$ inches long, remove one turn from each end.

28 Mc. — 4 turns $\frac{1}{8}$ -inch copper tubing, $2\frac{1}{2}$ -inch diameter, $4\frac{1}{2}$ inches long. Remove one turn from each end.

L_3, L_4 — 4 turns No. 14, $\frac{1}{2}$ -inch diameter, $\frac{3}{4}$ -inch long.

* All $1\frac{1}{2}$ -inch diameter, 3-turn links.

** All coils fitted with 2-turn links.

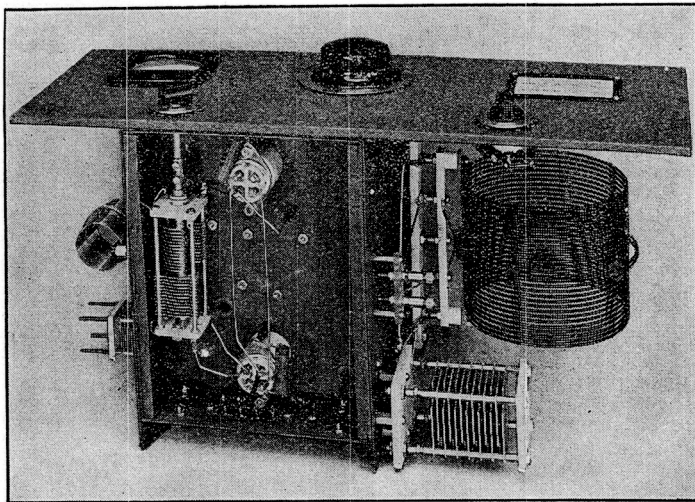


Fig. 1272 — Bottom view of the 450-watt push-pull amplifier, showing the position of the grid tank condenser between the two submounted tube sockets. The two air padding condensers, C_{11} and C_{12} , are in place for 1.75-Mc. operation.

❏ A Pi-Section Antenna Coupler

The photograph of Fig. 1274 shows the constructional details of a pi-section type antenna coupler. The wiring diagram appears in Fig. 1273. All parts are mounted directly on the panel using flathead machine screws. The condensers each are supported on three ceramic pillars from National type GS-1 stand-off insulators. A $\frac{3}{4}$ -inch 6-32 machine screw is in-

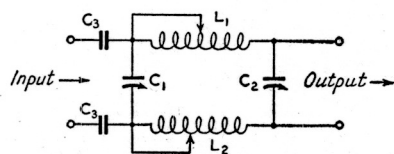


Fig. 1273 — Diagram of the pi-section antenna coupler. C_1 — C_2 —300- μ fd. variable, 0.07-inch spacing (National TMC-300).

C_3 —0.01- μ fd. mica., 5000-volt rating.

L_1, L_2 —26 turns No. 14, $2\frac{1}{2}$ -inch diameter, $3\frac{1}{2}$ inches long (National XR10A form wound full).

serted in one end of each pillar and turned tight. The head of the screw is then cut off with a hacksaw and the protruding quarter-inch or so is threaded into the mounting holes in the end plate of the condenser. The shaft is cut off about $\frac{1}{4}$ inch from the frame and fitted with a Johnson rigid insulated shaft coupling (No. 252). Since the coupling will extend beyond the stand-off insulators, a $\frac{3}{4}$ -inch clearance hole should be cut in the panel for each shaft. Alternatively, metal washers could be used between the panel and each pillar to extend the mounting.

Each coil form is supported on $1\frac{1}{2}$ -inch cone insulators. The two high-voltage blocking condensers,

C_3 , also are mounted on pillars from GS-1 stand-offs. A copper clip on a flexible lead connected permanently to one end of each coil serves to adjust the coil inductance by short-circuiting turns.

Output connections are made to the two terminal insulators at the right, while input connections are made to the terminals of the two voltage-blocking condensers. When single-wire output is desired, the output terminal connected to the condenser rotors is grounded and the coil in that side short-circuited by the clip and lead.

Under most circumstances the components specified will work satisfactorily with transmitters of 400 or 500 watts input, operating at plate voltages up to 1500. For higher power, the condensers should have greater spacing and the coils should be wound with No. 12 or larger wire. Couplers for lower power may be made using smaller components of equal values.

❏ Complete 300- to 400-Watt Compact Plug-In Coil Transmitter

The compact exciter and amplifier units of Figs. 1265 and 1269 may be combined as a complete transmitter. Plate and filament supply for the exciter may be obtained from the unit of Fig. 1238. Plate voltage for the amplifier may be obtained either from the unit of Fig. 1225 or that of Fig. 1246. A 7.5-volt 5-ampere filament transformer may be combined on a $5\frac{1}{4}$ -inch panel with the unit of Fig. 1247 (minus the VR75-30 branch), which will furnish bias for the amplifier. A 45-volt dry battery will be required for biasing the 807.

Suitable antenna tuners are those of Figs. 1227, 1249 or 1274. The height of all units, including a $5\frac{1}{4}$ -inch meter panel is 49 inches.

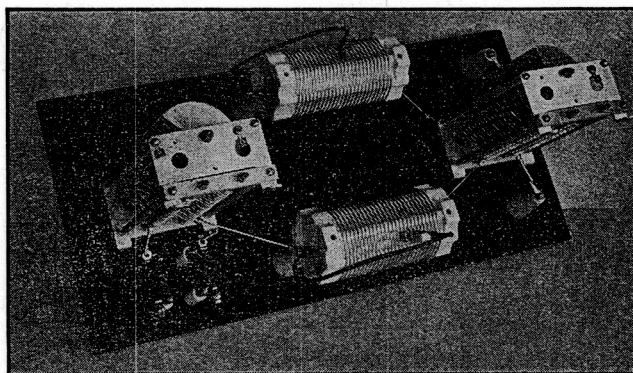


Fig. 1274 — Pi-section type antenna coupler. All parts are mounted on a Presdwood panel 8×19 inches. The circuit is given in Fig. 1273.

■ A Three-Stage 100-Watt Transmitter for Five Bands

The three-stage transmitter shown in Figs. 1275, 1277 and 1278 is designed to use a single 1000-volt 100-ma. tube such as the 1623, 809, HY40, or higher-voltage tubes at reduced ratings, in the output stage.

Referring to the circuit diagram of Fig. 1276, a 6L6, operating at a plate voltage of 400 but at reduced input, is used in the Tri-tet oscillator circuit. A potentiometer in the screen circuit provides a means of varying the screen voltage and, ultimately, the excitation to the final amplifier. The HY65 buffer-doubler circuit is capacitively

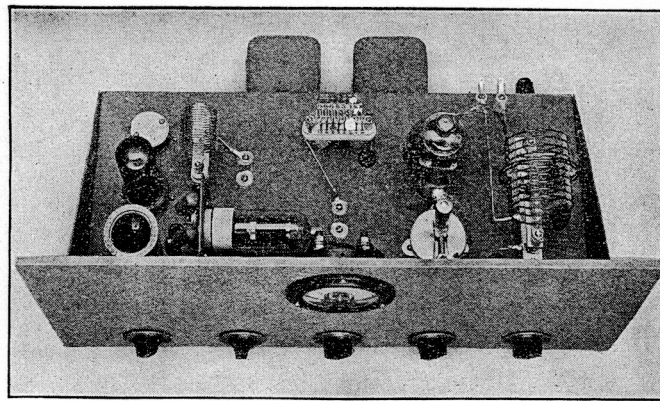


Fig. 1275 — All controls for the 100-watt five-band transmitter are below the chassis level. From left to right they are on the oscillator screen-voltage potentiometer, the oscillator plate-tank condenser, the buffer-doubler plate-tank condenser, the meter switch and the final-amplifier plate-tank condenser. The panel is of standard rack width and 8¾ inches high.

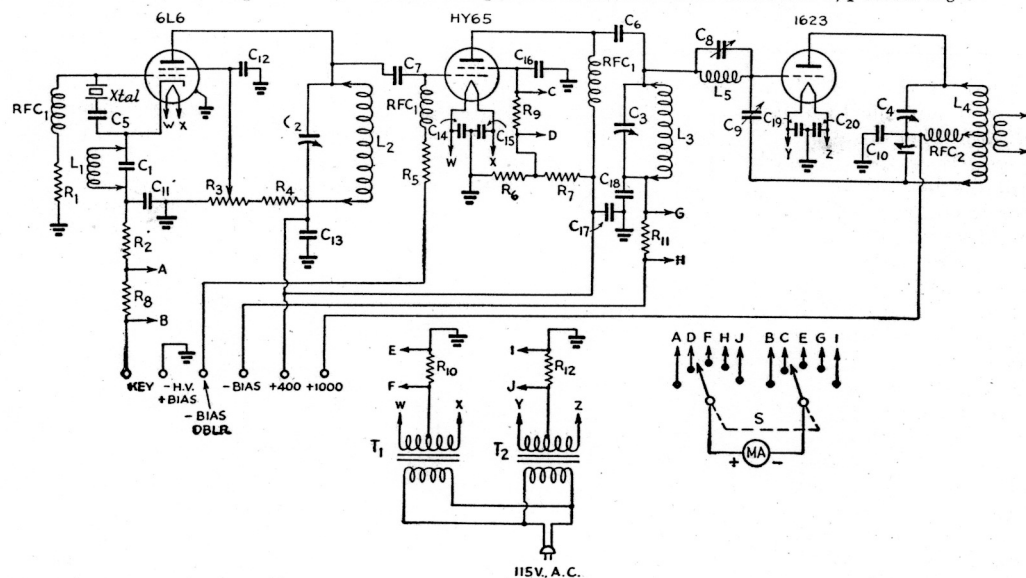


Fig. 1276 — Wiring diagram of the three-stage five-band 100-watt transmitter for 1000-volt power supply.

C₁ — 100- μ fd. mica.
 C₂, C₃ — 150- μ fd. variable (National ST-150).
 C₄ — 100 μ fd. per section, 0.05-inch spacing (Hammarlund HFBD-100-C).
 C₅, C₆ — 0.001- μ fd. mica.
 C₇ — 100- μ fd. mica.
 C₈ — 6-60- μ fd. mica trimmer (two National M-30 in parallel).
 L₁ — 1.75-Mc. crystals — 32 turns No. 24 d.s.c., close-wound.
 3.5-Mc. crystals — 9 turns No. 22, 1 inch long; 100- μ fd. mica in form, connected across winding.
 7-Mc. crystals — 6 turns No. 22, 5/8-inch long. All on Hammarlund 1½-inch diameter forms.
 L₂, L₃ — 1.75 Mc. — 56 turns, 1¼-inch diameter, 1¾ inches long, 54 μ hy. (National AR80, no link).
 3.5 Mc. — 28 turns, 1¼-inch diameter, 1½ inches long, 15 μ hy. (National AR40, no link).
 7 Mc. — 14 turns, 1¼-inch diameter, 1¼ inches long, 4.2 μ hy. (National AR20, no link).
 14 Mc. — 8 turns, 1¼-inch diameter, 1½ inches long, 1.25 μ hy. (National AR10, no link).
 28 Mc. — 4 turns, 1-inch diameter, ¾-inch long, 0.5 μ hy. (National AR5, turns close, no link).
 C₉ — Neutralizing condenser (National NC-800).
 C₁₀ — 0.001- μ fd., 5000 volts test.
 C₁₁, C₁₂, C₁₃, C₁₄, C₁₅, C₁₆, C₁₇, C₁₈, C₁₉, C₂₀ — 0.01- μ fd. mica.
 R₁ — 0.1 megohm, ½-watt.
 R₂ — 300 ohms, 1-watt.
 R₃ — 20,000-ohm 10-watt potentiometer (Mallory E2OMP).
 R₄ — 25,000 ohms, 10-watt.
 R₅ — 50,000 ohms, 1-watt.
 R₆ — 20,000 ohms, 10-watt.
 R₇ — 10,000 ohms, 10-watt.
 R₈, R₉, R₁₀, R₁₁, R₁₂ — 25 ohms, 1-watt.
 RFC₁ — 2.5-mh. r.f. choke.
 RFC₂ — 1-mh., 300-ma. r.f. choke (National R-300U).
 S — Double-gang, 5-circuit switch (Mallory 3226J).
 T₁, T₂ — Filament transformer, 6.3-volt, 3 amperes (UTCS-55).
 L₄ — 1.75 Mc. — 40 turns No. 18, 2½-inch diameter, 2½ inches long, 78 μ hy. (B & W 160 BCL). An 80- μ fd. fixed air padder (Cardwell JD-80-OS) is placed in right-rear corner of chassis and attached to coil with flexible leads and clips.
 3.5 Mc. — 32 turns No. 16, 2½-inch diameter, 2¾ inches long, 39 μ hy. (B & W 80 BCL).
 7 Mc. — 20 turns No. 14, 2-inch diameter, 2½ inches long, 12 μ hy. (B & W 40 BCL).
 14 Mc. — 8 turns No. 14, 2-inch diameter, 2 inches long, 2.5 μ hy. (B & W 20 BCL). One removed turn from each end.
 28 Mc. — 4 turns No. 12, 2-inch diameter, 1¾ inches long, 0.7 μ hy. (B & W 10 BCL). One turn removed from each end.
 L₅ — 5 turns No. 14, ½-inch diameter, ½-inch long.

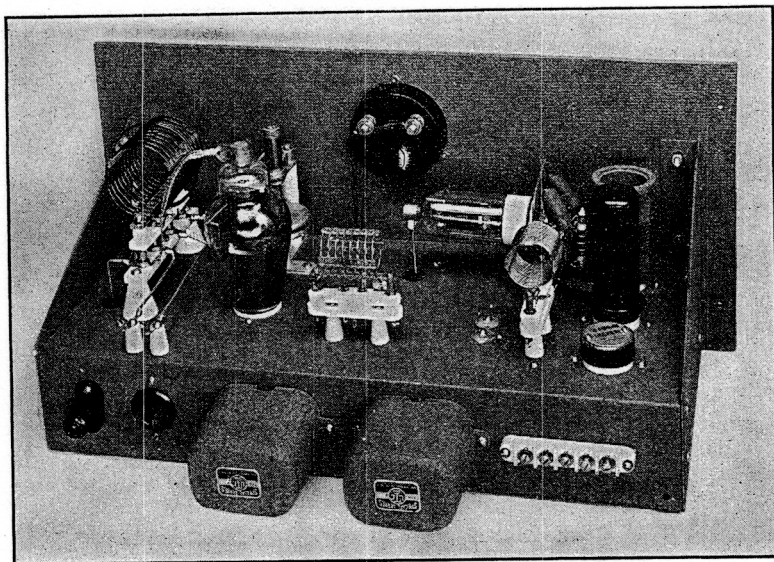


Fig. 1277 — On top of the chassis of the 100-watt transmitter, the cathode coil, L_1 , the 6L6 and the crystal are in line at the right-hand end. The HY65 is mounted horizontally on a small panel which also provides mounting space for the filament and screen by-pass condensers, the coupling condenser, C_7 , the grid leak, R_5 , and the grid choke. L_2 is just to the left of the 6L6 and to the right of C_2 underneath. L_3 is in the center at right angles to L_2 and L_4 and just to the rear of C_3 underneath. The 1623 socket is submounted to lower the plate terminal. The neutralizing condenser, C_9 , is directly in front of the tube. RFCs is just to the left of L_4 . The two filament transformers are mounted on the rear edge.

coupled to the oscillator. This second stage makes it possible to obtain excitation for the final amplifier in a third band from a single crystal, operation in the second band being available by doubling frequency in the oscillator itself. Parallel plate feed is used in the second stage to permit series grid feed to the final amplifier, thereby avoiding the probability of low-frequency parasitic oscillations.

The neutralized final amplifier is directly coupled to the driver stage. C_3 and L_5 form a trap for v.h.f. parasitic oscillations.

The meter switch, S , shifts the milliammeter to read oscillator cathode current, driver screen current, driver cathode current, final-amplifier grid current and final-amplifier cathode current. The individual filament transformers permit independent metering of the cathode currents of the last two stages.

Power supply — This transmitter is designed to operate from the combination 1000-volt and 400-volt plate supply shown in Fig.

1280. Both fixed bias of 75 volts for the HY65 and cut-off bias for the final amplifier may be obtained from the unit shown in Fig. 1247. For the type 1623, resistors R_2 and R_3 should be 6000 ohms and 7000 ohms, respectively.

Tuning — Coils for the desired output frequency, consistent with the crystal frequency, should be plugged in the various stages, bearing in mind that frequency may be doubled in the plate circuit of the oscillator and again in the second stage, if desired. It should also be remembered that the selection of the cathode coil, L_1 , depends upon the crystal frequency and not necessarily the output frequency of the oscillator, the same cathode coil being used for both fundamental and second-harmonic output from the crystal stage. Since much better efficiencies can be obtained with the HY65 operating as a straight amplifier, it is advisable to avoid doubling in this stage.

The first two stages should be tested first, with all voltages applied except the plate

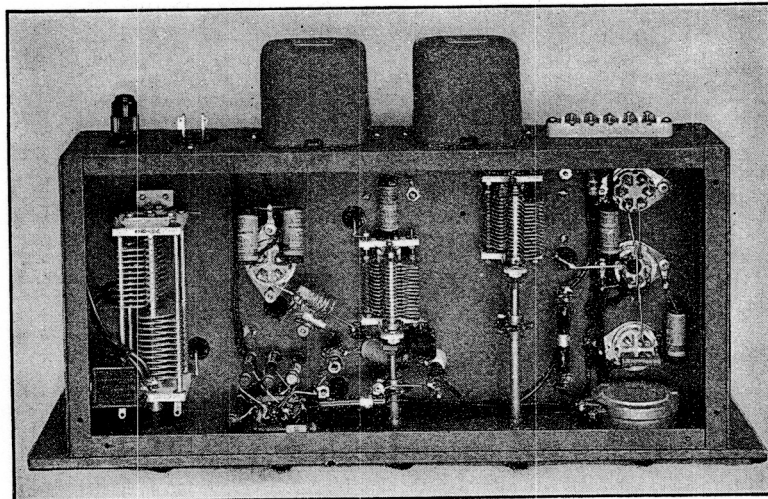


Fig. 1278 — Underneath the $8 \times 17 \times 3$ -inch chassis of the 100-watt transmitter. C_2 to the right and C_3 in the center are insulated from the chassis by polystyrene button insulators. C_4 to the left also is insulated and is spaced from the chassis to bring all shafts at the same level. Leads to the coils immediately above the tank condensers pass through large grommeted clearance holes. Meter-shunt resistances are soldered directly to the switch terminals. R_3 at the right is insulated from the chassis by extruded bakelite washers. The v.h.f. parasitic trap is suspended in the amplifier grid lead to the left of C_3 . Insulating couplings are required for C_2 and C_3 .

voltage for the final amplifier. Tuning the oscillator to resonance, with the key closed, should cause a slight dip in cathode current accompanied by an abrupt rise in the screen and cathode current of the second stage. Tuning the HY65 plate circuit to resonance should produce a good dip in cathode current, with a simultaneous reading of maximum grid current to the final amplifier.

The amplifier should then be neutralized and tested for parasitic oscillation. The latter is done by shifting the final-amplifier plate-voltage lead to the 400-volt tap and turning off the bias supply. No plate voltage should be applied to the exciter stages. C_4 is then varied through its entire range for several settings of C_3 . If at any point a change in the final-amplifier cathode current is observed, C_3 should be adjusted to eliminate it. During this process, plate voltage should not be applied long enough to cause appreciable heating of the tube.

Normal operating voltages may now be replaced and the final amplifier tuned up in the usual manner. A plate current of 100 ma. will indicate normal loading of the final amplifier. (Plate current will be the difference between grid and cathode currents under operating conditions.) With all stages tuned and the amplifier loaded normally, the oscillator cathode current should run between 16 and 30 ma., HY65 screen current between 6 and 11 ma., HY65 cathode current between 45 and 70 ma.,

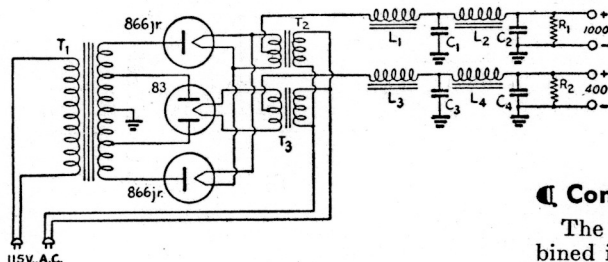


Fig. 1279 — Circuit diagram of the combination 1000- and 400-volt power supply for the 100-watt transmitter. C_1, C_2 — 2- μ fd. 1000-volt paper (Mallory TX805). C_3 — 4- μ fd. 600-volt electrolytic. (C-D 604). C_4 — 8- μ fd. 600-volt electrolytic. (C-D 608). L_1, L_3 — 5/20-henry swinging choke, 150-ma. (Thordarson T-19C39). L_2, L_4 — 12-henry smoothing choke, 150-ma. (Thordarson T-19C46). R_1 — 20,000 ohms, 75-watt. R_2 — 20,000 ohms, 25-watt. T_1 — High-voltage transformer, 1075 and 500 volts r.m.s. each side, 125- and 150-ma. simultaneous current rating (Thordarson T-19P57). T_2 — 2.5 volts, 5 amperes (Thordarson T-19F88). T_3 — 5 volts, 4 amperes (Thordarson T-63F99).

denser, white three type 65-1 insulators are used for the grid tuning condenser. Insulated flexible couplings and panel bearings are used on each shaft to insulate the controls. One of high break-down voltage rating should be used

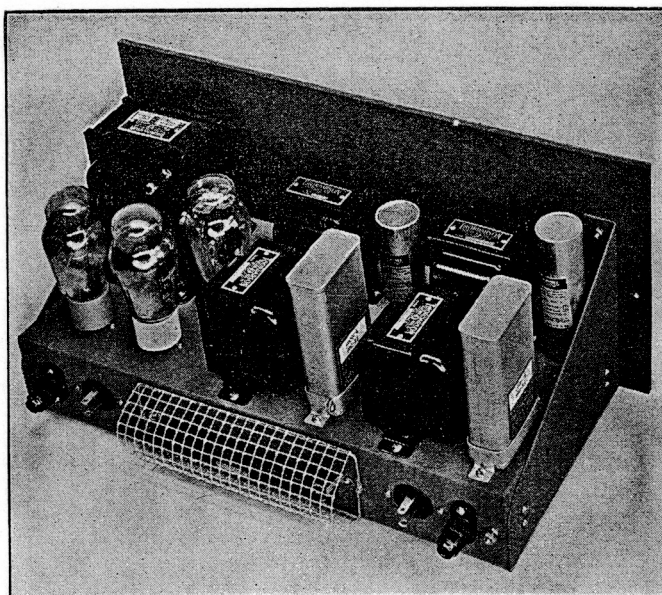


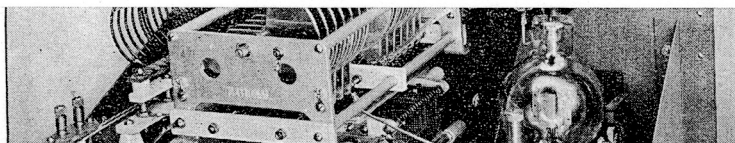
Fig. 1280 — This power supply makes use of a combination transformer and dual filter system delivering 1000 volts at 125 ma. and 400 volts at 150 ma., simultaneously. The circuit diagram is given in Fig. 1279. The 1000-volt bleeder resistance is mounted on the rear edge of the chassis, with a protective guard made of a piece of galvanized fencing material to provide ventilation. Millen safety terminals are used for the two high-voltage terminals. Ceramic sockets should be used for the 866 Jrs. The chassis measures 8 × 17 × 3 inches and the standard rack panel is 8 3/4 inches high.

HY65 grid voltage between 125 and 260 volts, oscillator screen voltage between 100 and 250 volts, and HY65 screen voltage between 210 and 250 volts, exact values depending upon whether the stage is operating at the fundamental or doubling frequency. Excitation should be adjusted to keep the amplifier grid current between 20 and 25 ma., when the grid voltage should measure 130 to 150 volts. Power output of 65 to 75 watts should be obtainable on all bands. The oscillator circuit may be arranged for optional v.f.o. input as shown in Fig. 1260, if desired.

If the output stage is to be plate-modulated, the plate voltage should be reduced to 750. Operating data for tubes of other types will be found in the tables of Chapter Twenty-One.

Complete 100-Watt 5-Band Transmitter

The transmitter of Fig. 1275 may be combined in a standard rack with other units to form a complete transmitter. Plate voltage for oscillator and driver as well as for the final-amplifier stage may be obtained from the duplex power supply shown in Fig. 1280. Bias voltage for both driver and final-amplifier stages may be obtained from the combination unit shown in Fig. 1247, with fixed bias for the HY65 being taken from the VR75-30 branch. A suitable antenna tuner is the one shown in Fig. 1216. The larger variable condensers should be used. The total height of the various units combined is 29 3/4 inches, allowing a 7-inch panel for the bias-supply unit.



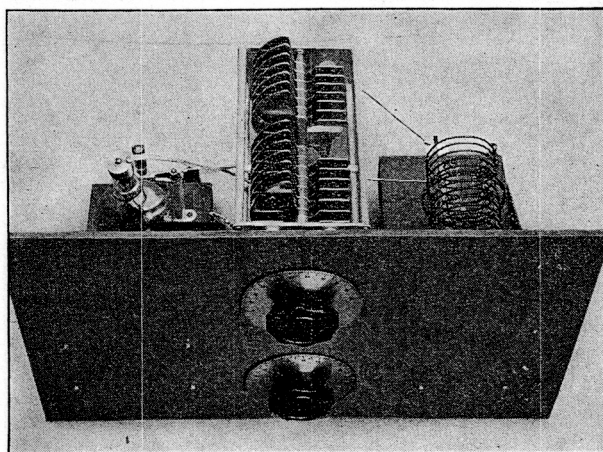


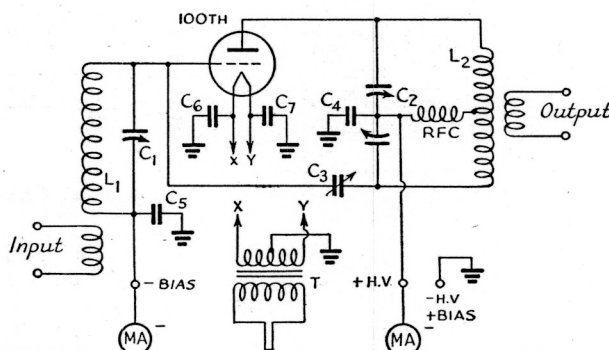
Fig. 1281 — A single-tube high-power amplifier for high-voltage inputs up to 500 watts. The standard rack panel is $12\frac{1}{4}$ inches high.

□ A Single-Tube 500-Watt Amplifier

A single-tube amplifier which may be operated at inputs up to 500 watts at voltages as high as 3000 is shown in Figs. 1281, 1283 and 1284. The circuit, shown in Fig. 1282, is strictly conventional, with link coupling for both input and output circuits. While a type 100TH is shown in the photographs, other tubes of similar physical size and shape designed to operate at plate voltages of 3000 or less may be used in a similar arrangement.

Power supply and tuning—The plate power supply shown in Fig. 1285 may be used with this unit. Bias may be obtained from the unit shown in Fig. 1247. For this purpose, the VR75-30 branch may be omitted and a single resistor of 5000 ohms connected across the output of the pack, with the bias lead connected to the extreme negative end of the resistor.

Fig. 1282 — Circuit diagram of the high-power 500-watt input single-tube amplifier.
 C_1 — 250- μ fd. variable, 0.047-inch spacing (National TMK-250).
 C_2 — 100 μ fd. per section, 0.171-inch spacing (National TMA-100-DA).
 C_3 — Neutralizing condenser (National NC-800).
 C_4 — High-voltage insulating condenser, 0.001- μ fd. mica, 12,500-volt rating (Cornell-Dubilier 21A-86).
 C_5, C_6, C_7 — 0.01- μ fd. mica.
RFC — 1-mh. r.f. choke, 300-ma. (National R-300U mounted on GS-1 insulator).
 MA_1 — Grid milliammeter, 100 ma.
 MA_2 — Plate milliammeter, 300 ma.
T — Filament transformer — 5 volts, 8 amperes (Thordarson T-10F24).



The transmitter shown in Fig. 1275 should provide sufficient excitation. Fig. 1282 shows milliammeters connected in grid and plate leads. These meters are not included in the unit. They should be mounted on a separate well-insulated panel protected with a glass cover (see Fig. 1294).

An amplifier operating at high voltage should always, after neutralizing, be tuned up at reduced plate voltage. This may be obtained by connecting a lamp bulb in series with the primary of the plate transformer. Coupling between the exciter and the amplifier should be adjusted so that the grid current does not exceed 40 to 50 ma. with the amplifier tuned and loaded to the rated plate current of 167 ma. Power output of 225 to 300 watts should be obtainable on all bands at

plate voltages from 2000 to 3000.

The tube tables of Chapter Twenty-One should be consulted for data on the operation of tubes of other types.

□ A Push-Pull 1-Kilowatt Amplifier

The push-pull amplifier shown in the photographs of Figs. 1287, 1288 and 1289 is capable of handling a power input of 1000 watts for c.w. operation or 900 watts with plate modulation.

The circuit is shown in Fig. 1286. Plug-in coils with fixed links are used in the grid circuit, while the output-coil mounting is provided with variable link coupling. L_3C_3 and L_4C_4 form traps against v.h.f. parasitic oscillation. A multi-section plate tank condenser provides a low minimum capacity for operation at the higher frequencies and a high maximum capacity for the lower frequencies.

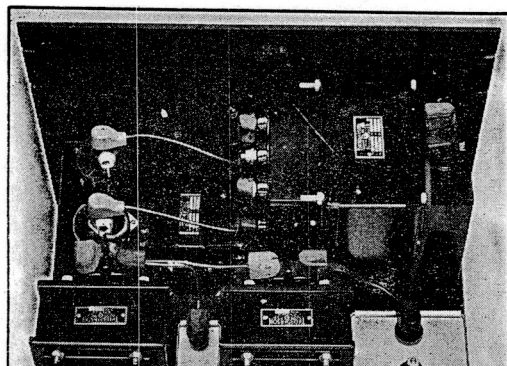


Fig. 1285 — This power supply unit delivers 2025 and 2480 volts at full-load current of 450 ma. with ripple of 0.5 per cent and regulation of 19 per cent. Voltages are selected by taps on the secondary. All exposed high-voltage terminals are covered with Sprague rubber safety caps and the tube plate terminals with moulded caps. The rectifier tubes are placed away from the plate transformer to avoid induction troubles. The panel is 14×19 inches and the chassis $13 \times 17 \times 2$ inches. The exposed high-voltage terminal should be covered with a rubber-tubing sleeve. The circuit is the same as that shown in Fig. 1245, the values being as follows:

- C_1 — 1- μ fd. 2500-volt oil-filled (G.E. Pyranol).
- C_2 — 4- μ fd. 2500-volt oil-filled (G.E. Pyranol).
- L_1 — Input choke, 5-20 henrys, 500 ma., 75 ohms (Thordarson T-19C38).
- L_2 — Smoothing choke, 12 henrys, 500 ma., 75 ohms (Thordarson T-19C45).

Fig. 1287 — The panel for the 1-kilowatt push-pull amplifier is 14 inches high and 19 inches wide. The chassis size is 13 × 17 inches.

Tuning — The only departure from ordinary procedure in tuning is that of adjusting the parasitic traps. The trap condensers, C_3 and C_4 , should be set near maximum capacity, but not screwed up tight. After the amplifier has been neutralized, a bias voltage of about $22\frac{1}{2}$ volts should be applied to the grid and the plate voltage applied through a 2500-ohm series resistance. With a pair of coils for any band plugged in, the plate current should not vary with any setting of the grid or plate condensers. If the plate current changes suddenly at any point, the trap condensers should be adjusted equally until the change disappears. The trap condensers should

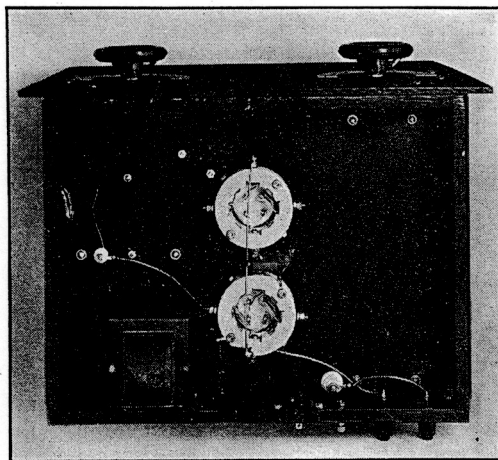
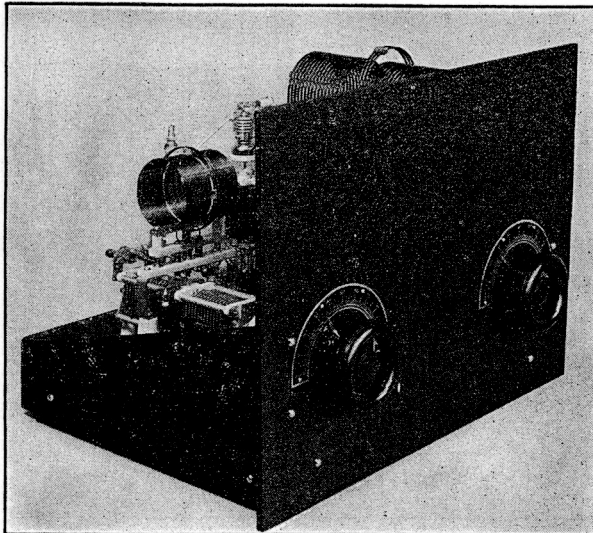


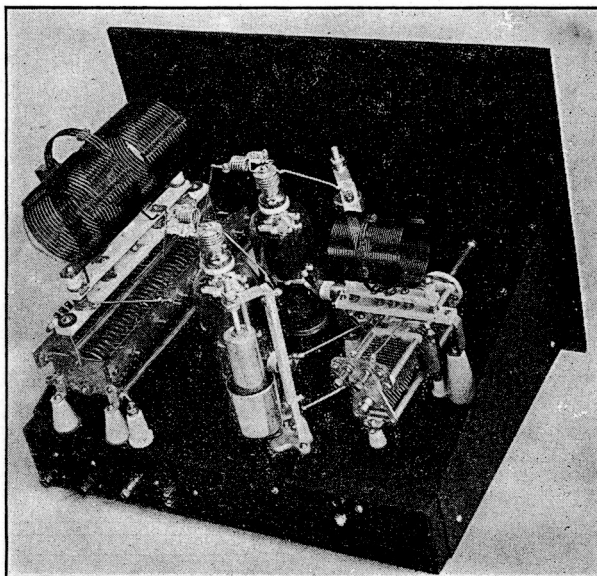
Fig. 1288 — The tube sockets in the 1-kilowatt amplifier are sub-mounted. The filament transformer is mounted close to the sockets.

be set as near to maximum capacity as is possible consistent with parasitic suppression. If the r.f. wiring has been carefully duplicated, the initial adjustment of the parasitic traps as described above should be sufficient.

After the above adjustment is complete, excitation may be applied and the amplifier loaded. The high-capacity sections of the plate tank condensers are required only for the 3.5-Mc. band.

Grid current should run about 100 ma. on all bands, and the amplifier may be loaded until the plate current increases to 500 ma. The power output at 2000 volts on the plates should be approximately 750 watts.

Fig. 1289 — Rear view of the 1-kw. amplifier, showing wiring and the placement of parts.



Complete High-Power Transmitters

The 100-watt transmitter of Fig. 1275 may be used as a driver for either of the high-power amplifiers in Figs. 1281 and 1287. In addition to the power-supply units of Figs. 1247 and 1280 required for the exciter, a bias supply for the high-power amplifier will be necessary. A second unit similar to that of Fig. 1247, minus the VR-tube branch, will be satisfactory. Plate voltage for either amplifier may be obtained from the unit shown in Fig. 1285. The antenna tuner may be the one shown in Fig. 1249, with a condenser of 0.1-inch plate spacing and coils of higher power rating.

Using the amplifier of Fig. 1281, the combined heights of all units will be $66\frac{1}{2}$ inches. If the push-pull amplifier of Fig. 1286 is used, the total height will be $68\frac{1}{4}$ inches.

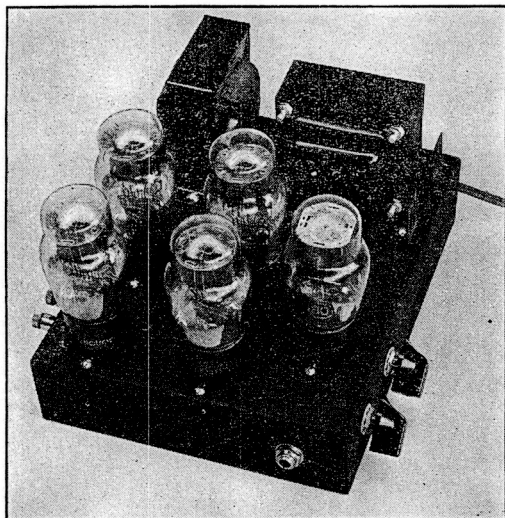


Fig. 1290 — A vacuum-tube keyer, built up on a 7 × 9 × 2-inch chassis with space for four or more keyer tubes and the power-supply rectifier. The resistors and condensers which produce the lag are mounted underneath, controlled by the knobs at the right. The jack is for the key, while terminals at left are for the keyed circuit.

A Practical Vacuum-Tube Keyer

Fig. 1290 shows a practical vacuum-tube keyer unit. The circuit diagram is shown in Fig. 1291. T_1 , the rectifier, with C_1 and R_1 form the power-supply section for producing the blocking voltage necessary for cutting off the keyer tubes. With only R_2 in the circuit and Sw_2 in the open position, there will be no lag. As Sw_2 is turned to introduce more capacity in the circuit, the keying characteristic is "softened" at both make and break. Adding resistance by turning Sw_1 to the right affects the "break" only. The use of high resistances and small capacities results in small demand on the power supply and makes the key safe to handle.

As many 45s may be added in parallel as desired. The voltage drop through a single tube varies from 90 volts at 50 ma. to 52 volts at 20 ma. Tubes in parallel will reduce the drop in proportion to the number of tubes. If rated voltage is important in the operation of the keyed circuit, the drop through the keyer tubes must be taken into account and the transmitter voltage boosted to compensate for the drop.

If desired, more degrees of lag can be obtained by using a rotary switch with more points and additional resistors and condensers.

Suggested values of capacity, in addition to C_2 and C_3 , are 0.001 and 0.002 μ fd. From R_2 , resistors of 2, 3 and 5 megohms may be added.

When connecting the output terminals of the keyer to the circuit to be keyed, care must be used to connect the grounded output terminal to the negative side of the keyed circuit.

Rack Construction

Most of the units described in the constructional chapters of this *Handbook* are designed for standard rack mounting. The assembly of a selected group of units to form a complete transmitter is, therefore, a relatively simple matter. While standard metal racks are available on the market, many amateurs prefer to build their own less expensively from wood. With care, an excellent substitute can be made.

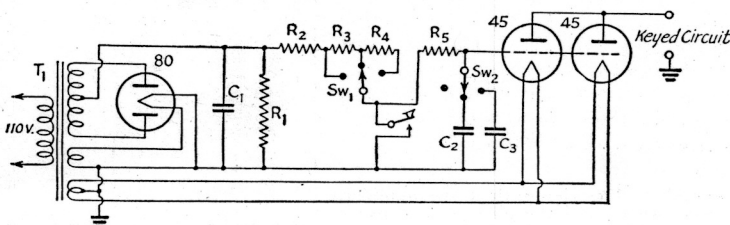
The plan of a rack of standard dimensions is shown in Fig. 1292. The rack is constructed entirely of 1 × 2-inch stock of smooth pine, spruce or redwood, with the exception of the trimming strips, M , N , O and P . Since the actual size of standard 1 × 2-inch stock runs appreciably below these dimensions, a much sturdier job will result if pieces are obtained cut to the full dimensions.

The two main vertical supporting members are each comprised of two pieces (A and B , and I and J) fastened together at right angles. Each pair of pieces is fastened together by No. 8 flathead screws, counter-sunk.

Before fastening these pairs together, pieces A and J should be made exactly the same length and drilled in the proper places for the mounting screws, using a No. 30 drill. The length of pieces A , J , B and I should equal the total height of all panels required for the transmitter plus *twice* the sum of the thickness and width of the material used. If the dimensions of the stock are exactly 1 × 2 inches, then 6 inches must be added to the sum of the panel heights. An inspection of the top and bottom of the rack in the drawing will reveal the reason for this. The first mounting hole should come at a distance of $\frac{1}{4}$ inch plus the sum of the thickness and width of the material from either end of pieces A and J . This distance will be $3\frac{1}{4}$ inches for stock exactly 1 × 2 inches. The second hole will come $1\frac{1}{4}$ inches from the first, the third $\frac{1}{2}$ inch from the second, the fourth $1\frac{1}{4}$ inches from the third and so on, alternating spacings between $\frac{1}{2}$ inch and $1\frac{1}{4}$ inch (see detail drawing D, Fig. 1292). All holes should

Fig. 1291 — Wiring diagram of the practical vacuum-tube keyer unit and power supply shown in Fig. 1290.

- C_1 — 2- μ fd. 600-volt paper.
- C_2 — 0.003- μ fd. mica
- C_3 — 0.005- μ fd. mica.
- R_1 — 0.25 megohm, 1-watt.
- R_2 — 50,000 ohms, 10-watt.
- R_3, R_4 — 5 megohms, 1-watt.
- R_5 — 0.5 megohm, 1-watt.
- Sw_1, Sw_2 — 3-position 1-circuit rotary switch.
- T_1 — 325-0-325 volts, 5 volts and 2.5-volts (Thor-darson T-13R01).



be placed $\frac{3}{8}$ inch from the inside edges of the vertical members.

The two vertical members are fastened together by cross-member *K* at the top and *L* at the bottom. These should be of such a length that the inside edges of *A* and *J* are exactly $17\frac{1}{2}$ inches apart at all points. This will bring the lines of mounting holes $18\frac{1}{4}$ inches center to center. Extending back from the bottoms of the vertical members are pieces *G* and *D* connected together by cross-members *L*, *Q* and *E*, forming the base. The length of the pieces *D* and *G* will depend upon space requirements of the largest power supply unit which will rest upon it. The vertical members are braced against the base by diagonal members *C* and *H*. Rear support for heavy units placed above the base may be provided by mounting angles on the insides of *C* and *H*, or by connecting them with cross-members at suitable heights as shown at *F*.

To finish off the front of the rack pieces of $\frac{1}{4}$ -inch oak strip (*M*, *N*, *O*, *P*) are fastened around the edges with small-head finishing nails. The heads are set below the surface and the holes plugged with putty or plastic wood. The top and bottom edges of *O* and *P* respectively should be $\frac{1}{4}$ inch from the first mounting holes and the distance between the inside edges of the vertical strips, *N* and *P*, $19\frac{1}{16}$ inches.

To prevent the screw holes from wearing out when panels are changed frequently, $\frac{1}{2} \times \frac{1}{16}$ or $\frac{1}{32}$ -inch iron or brass strip may be used to back up the vertical members of the frame.

The outside surfaces should be sandpapered thoroughly and given one or two coats of flat black, sandpapering between coats. A finishing surface of two coats of glossy black "Duco" is then applied, again sandpapering between coats. It is important to allow each coat to dry thoroughly before applying the next, or sandpapering.

Since the combined weights of power supplies, modulator equipment, etc., may total to a surprising figure, the rack should be provided with rollers or wheels so that it may be

moved about when necessary after the transmitter has been assembled. Ball bearing roller-skate wheels are excellent for the purpose.

Standard chassis are 17 inches wide. Standard panels are 19 inches wide and multiples of $1\frac{3}{4}$ inches high. Panel mounting holes start with the first one $\frac{1}{4}$ inch from the edge of the panel, the second $1\frac{1}{4}$ inches from the first, the third $\frac{1}{2}$ inch from the second, the fourth $1\frac{1}{4}$ inches from the third, and the distances between holes from there on alternated between $\frac{1}{2}$ inch and $1\frac{1}{4}$ inches. (See detail D, Fig. 1292.) In a panel higher than two or three rack units ($1\frac{3}{4}$ inch), it is common practice to drill only sufficient holes to provide a secure mounting. All panel holes come $\frac{3}{8}$ inch from either edge.

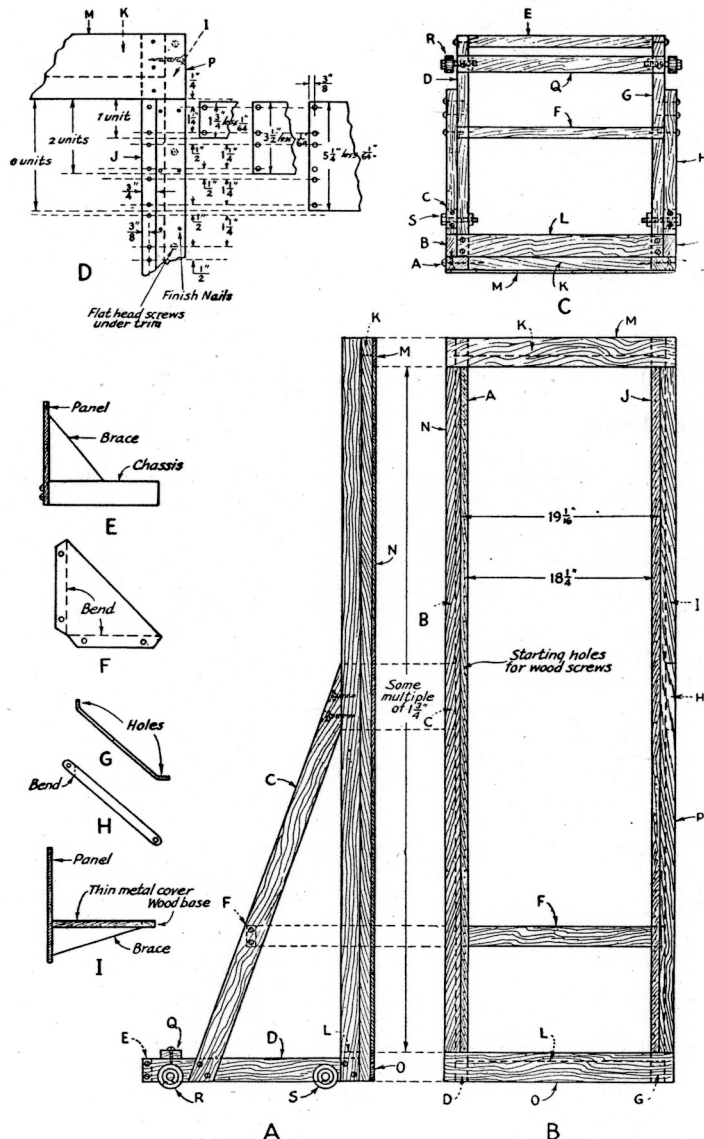


Fig. 1292 — The standard rack. A — Side view. B — Front view. C — Top view. D — Upper right hand corner detail. E — Panel and chassis assembly. F, G, H — Various types of panel brackets. I — Substitute for metal chassis.

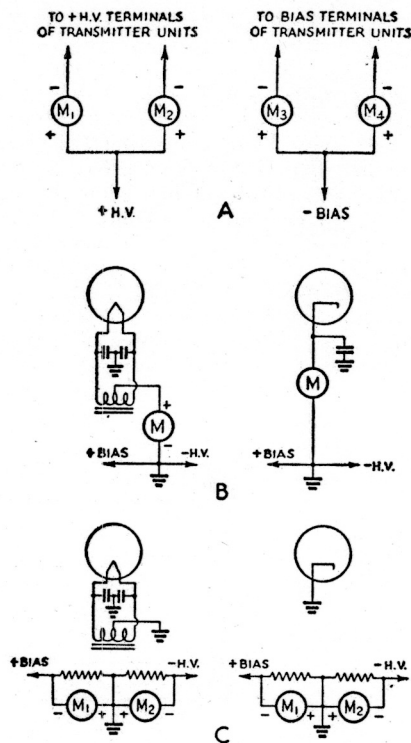


Fig. 1293 — Various methods of connecting milliammeters in grid and plate currents. A — High-voltage metering. B — Cathode metering. C — Shunt metering.

Ⓐ Metering

Various methods of metering are shown in Fig. 1293. A shows the meters placed in the high-voltage plate and bias circuits. M_1 and M_2 are for plate current and M_3 and M_4 for grid current. When more than one stage operates from the same plate-voltage or bias-voltage supply, each stage may be metered as shown. If this system of metering is used, the meters should be mounted so that the meter dials are not accessible to accidental contact with the adjusting screw. One method of mounting is shown in Fig. 1294, where the meters are mounted behind a glass panel.

When plate milliammeters are to be mounted on metal panels, care must be taken to see that

the insulation is sufficient to withstand the plate voltage. Metal-case instruments should not be mounted on a grounded metal panel if the difference in potential between the meter and the panel is to be more than 300 volts; bakelite-case instruments can be used under similar circumstances at voltages up to 1000. At higher voltages than these an insulating panel should be used.

The placing of meters at high-voltage points in the circuit may be overcome by the use of the connections shown in Fig. 1293-B and -C. The disadvantage of the arrangements at B is that the meter reads total cathode current and the grid and plate currents cannot be metered individually. This disadvantage is overcome in C, where the meters are connected across low resistances in the grid and plate return circuits. M_1 reads grid current and M_2 plate current. The parallel resistors should have a value of not less than 10 to 20 times the resistance of the meter, and should be of sufficient power rating so that there will be no possibility of resistor burn-out. If desired, the resistance values may be adjusted to form a multiplier scale for the meter (see Chapter Nineteen). The same principle is used in the meter-switching system shown in Fig. 1295.

Meters may also be shifted from one stage to another by a plug-and-jack system, but this system should not be used unless it is possible to ground the frame of the jack or unless a suitable guard is provided around the meter jacks to make personal contact with high voltages impossible in normal use of the plug.

Ⓐ Control Circuits

Proper arrangement of controls is important if maximum convenience in operation is to be attained. If the transmitter is to be of fairly high power, it is desirable to provide a special service line leading directly from the public utility meter board to the operating room. This line should be run in conduit or BX cable, and the conductors should be of ample size to carry the maximum load without undue voltage drop. The line should be terminated with an enclosed entrance switch, properly fused.

Fig. 1296 shows the wiring diagram of a simple control system. It will be noticed that,

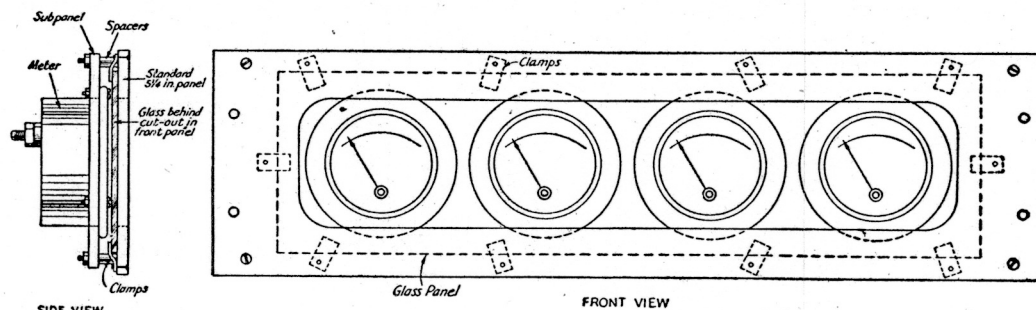


Fig. 1294 — Safety panel for meters. The meters are mounted in the usual manner on an insulating sub-panel spaced back of a glass-covered opening in the front panel. The glass is fastened in place with metal clamps or tabs, fastened to the front panel with small screws or pins. The front panel is of standard rack size, 19 × 5¼ inches.

because the control switches are connected in series, none of the high-voltage supplies can be turned on until the filament switch has been closed, and that the high-power plate supply cannot be turned on until the low-power plate supply switch has been closed. Furthermore, the modulator power cannot be applied until the final-amplifier plate voltage has been applied. SW_5 places a 100- to 300-watt lamp, L_p , in series with the primary winding of the high-voltage plate transformer for use during the process of preliminary tuning and for local c.w. work. The final amplifier should first be tuned to resonance at low voltage and SW_5 then closed, short-circuiting the lamp. Experience will determine what the low-voltage plate-current reading should be to have it increase to the full-power value when SW_5 is closed, so that the proper antenna-coupling and tuning adjustments may be made.

Preferably, SW_3 should be of the non-locking push-button type which remains closed only so long as pressure is applied. A switch of this type provides one of the simplest and most effective means of protection against accidents from high voltage. In the form which is usually considered most convenient, it consists of a switch, located underneath the operating table, which may be operated by pressure of the foot. When used in this manner the operator must be in the operating position, well removed from danger, before high voltage can be applied. If desired, SW_{3a} may be wired in parallel on the front of the transmitter panel, so that it can be used while tuning the transmitter. SW_{3a} also should be of the push-button type.

In more elaborate installations, and in remote control systems where the transmitter is located some distance from the operating position, similarly arranged switches may be used to control relays whose contacts serve to perform the actual switching at the transmitter.

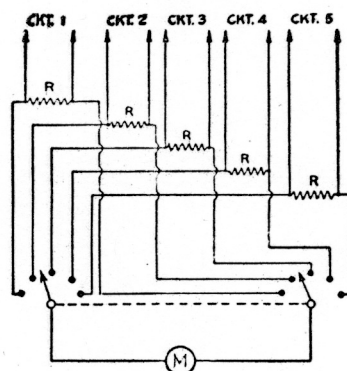


Fig. 1295 — Method of switching a single milliammeter to various circuits with a two-gang switch. The control shaft should be well insulated from the switch contacts, and should be grounded. The resistors, R , should have values of resistance ten to twenty times the internal resistance of the meter; 20 ohms will usually be satisfactory.

Two strings of utility outlets, one on each side of the entrance switch, are provided for operation of the receiver and such accessories as the monitor, lights, electric clock, soldering iron, etc. Closing the entrance switch should close those circuits which place the station in readiness for operation. SW_2 and SW_4 are normally closed and SW_3 is normally open. When SW_1 is closed upon entering the operating room, the transmitter filaments are turned on as also is the receiver, which should be plugged into line No. 2. With SW_4 closed (as well as SW_5 and SW_6), SW_3 performs the job of turning all plate supplies on and off during successive periods of transmission and reception.

All continuously operating accessories, such as the station clock, should be plugged into line No. 1. This is so that they will not be turned off when SW_1 is opened. Line No. 1 is of use also for supplying the soldering iron, lights, etc., when it is desired to remove all voltage from the transmitter by opening SW_1 .

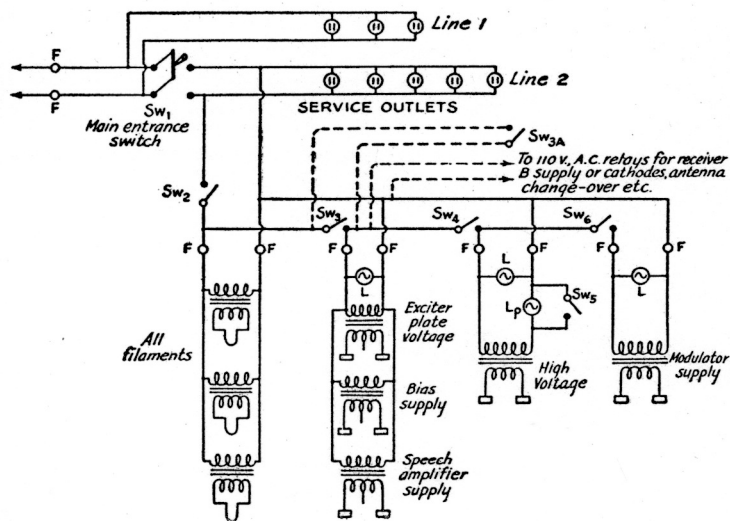


Fig. 1296 — A station control system. No high-voltage supply can be turned on until the filament switch has been closed; the high-power plate supply cannot be turned on until the low-power plate supply switch has been closed; and modulator power cannot be applied until the final-amplifier plate voltage has been applied. With all switches except SW_3 closed, SW_3 serves as the main control switch. SW_1 — Enclosed entrance switch. SW_2 — Filament switch. SW_3 — Low plate voltage and main control switch, preferably of the push-button type which remains closed only so long as pressure is applied. SW_4 — High plate-voltage switch. SW_5 — Low-power and tune-up switch short-circuiting L_p . SW_6 — Modulator plate-voltage switch. F — Fuse. L — Warning light. L_p — 100- to 300-watt voltage-reducing lamp.