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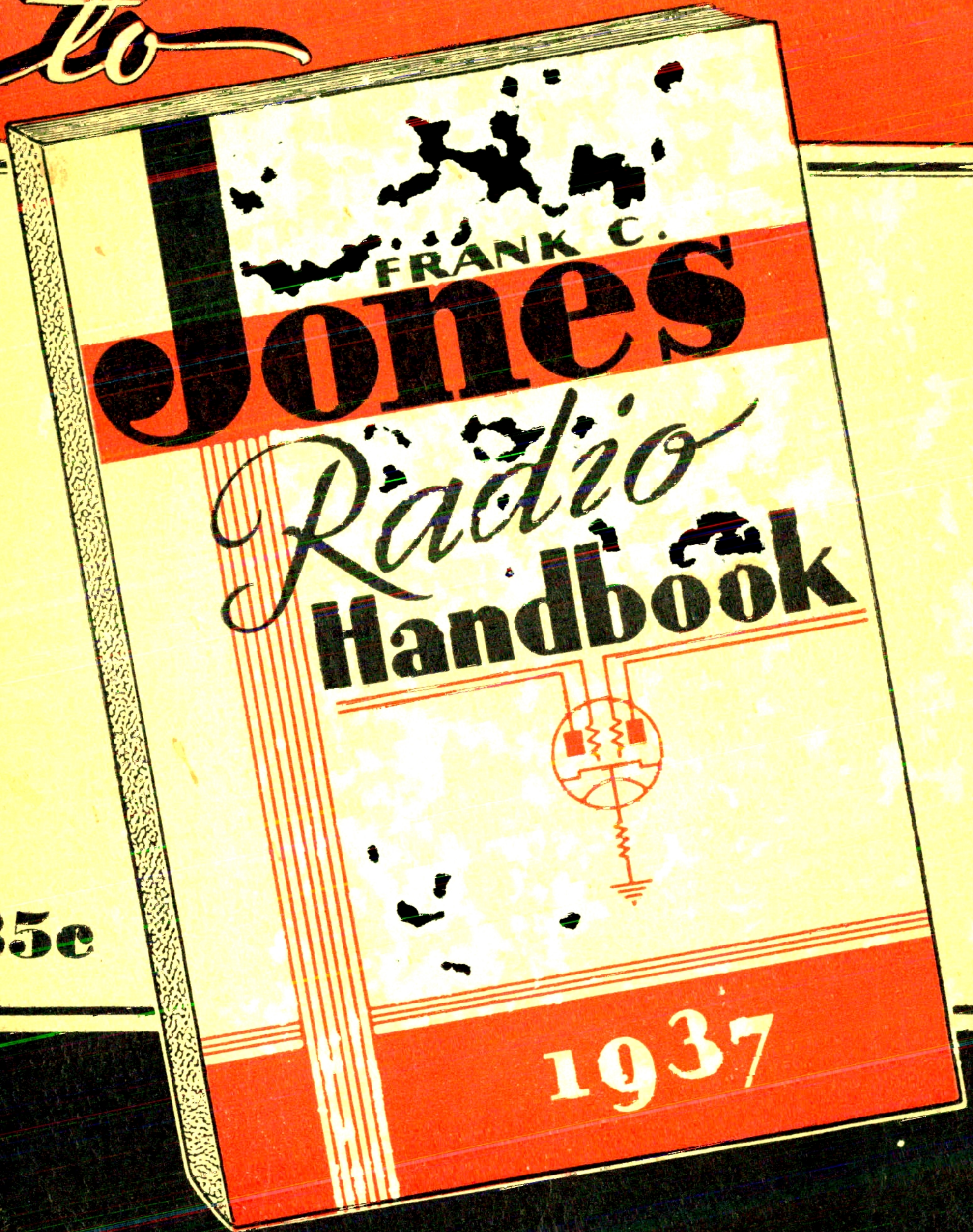

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Supplement to . . .

JONES RADIO HANDBOOK

1937 EDITION

By Frank C. Jones

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Contents

Notes on Transmitter Design

The newer tubes, such as the beam power tetrodes and low C triodes, call for certain important considerations in circuit design in order to realize the greatest possible efficiency.

A typical, modern transmitter circuit which accompanies this text is used to illustrate the newer features under discussion.

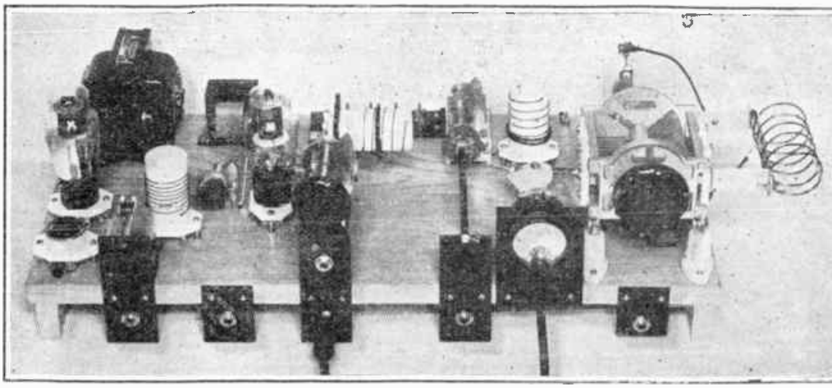
Crystal Oscillator

The crystal-controlled oscillator in this transmitter is of very modern design; it incorporates regeneration at the crystal frequency to reduce the r.f. current through the crystal itself. This feature improves the stability of the oscillator, and minimizes the danger of crystal fracture. This regenerative effect in the crystal oscillator is obtained by connecting the cathode circuit across a portion of the plate circuit in order to obtain feedback at the crystal frequency. The amount of feedback is very small and is controlled by the 3-to-30 μμfd. trimmer condenser connected between the plate and cathode. If the capacity of this condenser is set at 10 μμfd., for example, the cathode is, in effect, connected across 1/40th of the tuned plate circuit, since the .0004 μfd. (400 μμfd.) condenser is connected from cathode to ground. The adjustable 3-to-30 μμfd. condenser, assumed to be set at 10 μμfd. in this case, and the .0004 μfd. condenser are connected in series across the plate load impedance.

It has been found from experience that the 6L6 or 6L6G tube has such a high transconductance that an extremely small amount of feedback is required for the purpose of maintaining the crystal in a state of oscillation. In fact, the plate circuit can be tuned to frequencies other than that of the fundamental resonance, and still provide sufficient impedance across the condenser feedback circuit to keep an active quartz crystal in an oscillating condition. This makes an ideal crystal oscillator, because the plate circuit can be either tuned to the approximate fundamental frequency or to the exact harmonics of the crystal. For example, the output on the second harmonic is practically the same as that secured on the fundamental frequency. All that is necessary is to change the coil L_1 when operating the crystal oscillator on its fundamental or second harmonic frequencies. The oscillator can be made to cover two bands by using a larger tuning condenser, which would provide low C on the second harmonic and high C on the fundamental. In any case, this crystal oscillator will supply very nearly the same output on either the fundamental or second harmonic, and about 50% as much on the fourth harmonic. The third harmonic is intermediate between the second and fourth harmonics, from the standpoint of power output. When the oscillator is tuned to a harmonic, the circuit should be tuned to exact resonance as indicated by maximum dip in plate or cathode current. When operated on its fundamental frequency, the oscillator tuning condenser should be set at a capacity which is slightly less than that which would tune the plate circuit to exact resonance with the quartz crystal.

The r.f. choke in the cathode of the 6L6G crystal oscillator is a necessary adjunct in maintaining the cathode at an r.f. potential determined by the ratio of the semi-variable and fixed mica condensers connected across the plate circuit. Other types of receiving tubes can be made to operate in this same crystal oscillator circuit, but at lower output. A type 42 or 2A5 tube will supply approximately half as much output as a 6L6G. In the case of a metal 6L6 tube, the same circuit should be used, but with the metal shell of the tube connected to ground.

Some triodes, such as the 6C5 and 76, will function as low power crystal oscillators in this same circuit. The 6.3 volt pilot lamp in series with the grid of the 6L6G and the crystal requires less than 100 milliamperes in order to light, and it



The "ideal" transmitter as evolved from the data and considerations in this chapter. It has an output of 150 watts.

is therefore advisable to use such a lamp for the purpose of indicating the amount of r.f. current flowing through the crystal. If the lamp shows no indication of lighting-up, the r.f. current through the crystal is far below the maximum safe value.

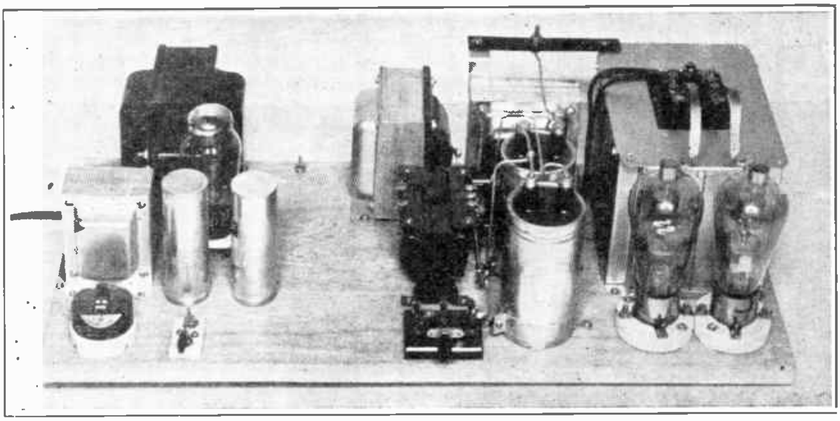
The value of grid-leak across the quartz crystal will depend upon the type of tube used and ranges from 50,000 to 250,000 ohms. This leak is necessary to provide a path for the d.c. return current flowing in the grid circuit. No cathode bias resistor is needed for 6L6 or 6L6G tubes in this particular circuit. The regenerative circuit keeps the r.f. crystal current at such a low value that ordinary grid-leak bias is entirely satisfactory.

The r.f. output from the crystal oscillator shown in the accompanying diagram can be adjusted to any value of from less than one watt up to as high as 15 or 20 watts. This variation is accomplished by adjusting the plate and screen voltages, particularly the latter. In the circuit shown, the crystal oscillator drives a 6L6G as a buffer or doubler stage, and to prevent overdriving this stage the screen voltage on the oscillator is reduced by means of a 10,000 ohm 2 watt resistor in series with the 275 volt supply. In addition, a 50 μμfd. variable coupling condenser is connected between the plate and grid circuits of the two stages. A 40 or 50 μμfd. mica fixed coupling condenser is usually employed at this point, but the variable condenser enables a more flexible adjustment of r.f. excitation to the buffer or doubler stage. This capacity can be as low as 20 μμfd., particularly when using a 40 meter crystal in the oscillator circuit, and when going down to 10 meters in the output stage of the 6L6G frequency multiplier circuit.

The Buffer-Doubler Circuit

Either a 6L6 type of tube or an 807 beam tetrode will perform equally well as a doubler. The advantage of an 807 lies in the screening between the control grid and plate, which is sufficient to eliminate the need of neutralization when the tube is used as a buffer. The 6L6G requires a very small neutralizing capacity when used as a straight buffer. For complete neutralization of this stage, a split-stator tuned plate circuit would be necessary due to the high transconductance of the 6L6G. The split-coil circuit illustrated in the circuit diagram is slightly regenerative; however, the tube is used only as a buffer or doubler stage and this effect is therefore negligible. The neutralizing condenser in this stage must have a very low minimum capacity. In this case there was used a pair of small parallel plates, approximately the size of a small postage stamp, with an adjustable gap between them.

The grid bias is obtained through a combination of grid-leak and cathode bias



The 1500 volt and 375 volt power supplies are mounted on a single board.

resistors. The values of resistors should be chosen so that the tube will supply approximately the same output as a doubler as when it serves as a buffer. If a 50,000 ohm grid-leak and a 400 ohm cathode resistor are used as shown, this condition is obtained. The value of grid-leak is not critical and 100,000 ohms is more often used when this stage is used only as a doubler.

The grid current to the buffer or doubler stage does not have to be greater than 2 milliamperes, and should *never* exceed 5 milliamperes, otherwise the tube will be over-excited. When higher values of grid-leak are used, grid currents as low as one milliampere are satisfactory to this type of tube. The 400 ohm cathode resistor (300 ohms would also be satisfactory) not only furnishes additional grid bias but also provides automatic bias to this stage when the crystal oscillator is keyed or when r.f. excitation is removed. A cathode resistor in this case also tends to keep the plate current from creeping should the grid excitation be a little too high.

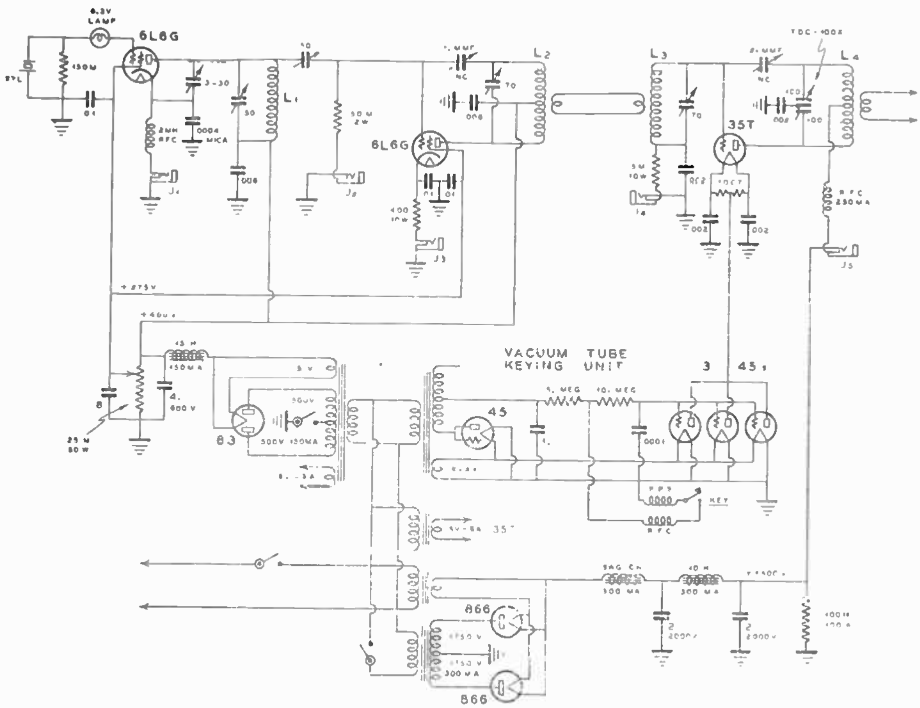
The buffer or doubler stage can be either capacitively or link coupled to the final amplifier. Link coupling will give more grid drive than ordinary capacitive coupling because of a better impedance match. The 35T is a high-μ tube with very low grid impedance. This makes it easier to match correctly the impedances with link coupling.

The Final R.F. Amplifier

The 6L6G buffer-doubler shown in the circuit diagram will satisfactorily drive several varieties of tubes in the final amplifier, such as the 35T, HF-100, T-55, HK-154, RCA-808, or RK-37. The modern design of low C tubes has progressed to a point where high-μ tubes are easier to drive than medium or low-μ tubes. Previously designed high-μ tubes required more grid excitation than the same type of medium or low-μ tube.

The great improvement came about as a result of improved grid structure design. Because some of the modern high-μ tubes can be so easily driven, their use in c.w. or plate modulated phone transmitter circuits is highly recommended.

If a high-μ and a low-μ tube have the same operating mutual conductance and plate dissipation, the high-μ tube is more easily driven at very high frequencies. This can be easily illustrated in the following example: A tube which requires 300 volts d.c. bias to operate in a class C modulated amplifier requires a peak r.f. grid voltage of more than 300 volts in order to drive grid current and cause a rectified grid d.c. current to flow. On the other hand, a high-μ tube which might require 100 volts of negative bias would require less than half as much peak r.f.



General wiring diagram of the r.f. section, keying unit, and power supplies.

voltage. The problem of obtaining a high r.f. voltage across the grid tank circuit is very evident for wavelengths below 20 meters. At 5 meters, it may be a major problem. The total capacity across the grid circuit of the driven tube may provide a reactance of only 200 or 300 ohms at very high frequencies, which would require a circulating grid tank current of several amperes in order to build-up the required r.f. voltage for a low-μ tube. The low C of modern tubes and the use of low C in the tuned circuit are a great aid in simplifying transmitter design in any of the high-frequency bands, especially 5 and 10 meters.

Many amateurs make the mistake of over-exciting their final amplifier tubes, without realizing that the tube life is a matter of a few hours, instead of the usual several thousand hours obtained under proper operating conditions. On the other hand, insufficient grid excitation will cause low efficiency in the plate circuit, which is undesirable from the standpoint of power output and plate dissipation.

The matter of grid dissipation is just as important as plate dissipation, and is usually overlooked by the amateur. When the grid is driven too hard, i.e., "over-excited", the grid wires must dissipate the r.f. energy in the form of heat, and since the grid is very close to the white-hot filament, its ability to dissipate energy in the form of heat is not very great. All tube manufacturers have had a great many transmitter tubes returned as defective, when an inspection revealed that the grid had been over-heated, which thus permanently destroyed the grid structure. When a tube is rated to operate at a d.c. grid current of 20 milliamperes in a class C amplifier, it is wise to adhere to this value. Too many amateurs forget the possibility of damaging the tube by over-driving it, and they are of the belief that they can obtain 5% or 10% more plate efficiency by increasing the grid current to more than the required or recommended

Coil Data for 6L6G-6L6G-35T Transmitter				
Band	*Oscillator 1½" Coil Forms*	*Buffer-Doubler Plate Coil 1½" Coil Forms*	*Final Amp. Grid Coil 1½" Coil Forms*	*Final Amp. Plate Coil "Air-Supported" Construction*
80	30 turns No. 20 d.s.c., slightly space wound to cover 1½".	35 turns No. 20 d.s.c., close wound. Center-tapped.	35 turns No. 20 d.s.c., close wound.	24 turns No. 14 enam., spaced 8 turns per inch. 2¾" diameter, center-tapped.
40	16 turns No. 20 d.s.c., spaced to cover 1½".	18 turns No. 20 d.s.c., spaced to cover 1½". Center-tapped.	18 turns No. 20 d.s.c., spaced to cover 1½".	18 turns No. 14 enam., spaced 5 turns per inch. 2¾" diameter, center-tapped.
20	Use 40 meter Oscillator coil.	11 turns No. 20 d.s.c., spaced to cover 1¾", center-tapped.	9 turns No. 20 d.s.c., spaced to cover 1¼".	10 turns No. 14 enam., spaced 2½ turns per inch. 2¾" diameter, center-tapped.
10	8 turns No. 20 d.s.c., spaced to cover 1½" ("20 meter coil").	5 turns No. 18 enam., spaced to cover 1¾", center-tapped.	5 turns No. 18 enam., spaced to cover 1¾".	6 turns No. 14 enam., spaced 1½ turns per inch. 2" diameter, center-tapped.

amount. If very high grid excitation is desired in order to obtain extremely high plate efficiency, the value of d.c. grid bias should be increased in the form of a higher value of grid-leak resistance. The d.c. grid current should not be run at a value higher than that shown in the transmitting tube tables for maximum d.c. rating.

The 35T has a maximum d.c. grid current rating of 25 milliamperes. The driver stage in the transmitter under discussion is capable of driving from 40 to 50 grid milliamperes from the 6L6G buffer doubler into the final amplifier. This is much more than required, and the grid excitation should be adjusted to not over 25 milliamperes by changing the link coupling positions around the plate and grid coils. If highest plate efficiency is desired and proper means are taken to eliminate the radiation of the stronger harmonics produced in the final amplifier, more grid excitation may be applied. This should be done by increasing the value of grid-leak resistance rather than by increasing the d.c. grid current. A 10,000 or 15,000 ohm grid-leak will prevent the grid current from being excessive, and at the same time it will increase the grid bias by two or three times for the same current. The r.f. voltage across the grid circuit can then be increased to a point which will cause normal grid current (20 to 25 milliamperes) to flow.

The plate efficiency depends upon the r.f. grid excitation, as well as the circuit "Q" of the final plate tuned tank circuit. The "Q" of the final tank circuit in a low-loss coil and condenser design is exceedingly high when no antenna load is connected across this circuit. The plate current will dip to very low values in an efficient circuit, and this dip to a value of 10% to 20% of the normal d.c. plate current has been used as a rough check for circuit efficiency. It is not a very satisfactory method of checking the circuit efficiency because the r.f. voltage built up across the tuned circuit under these conditions usually reaches excessive value and may cause flash-over between condenser plates and consequent damage to the r.f. tube or to some component in the power supply.

The circuit "Q" of the final amplifier is of importance in both phone and c.w. transmitter design. Its value should be about 10 for c.w. and 15 to 20 for phone, in order to provide a sufficient "fly-wheel effect" to the tuned circuit for class C amplifier operation.

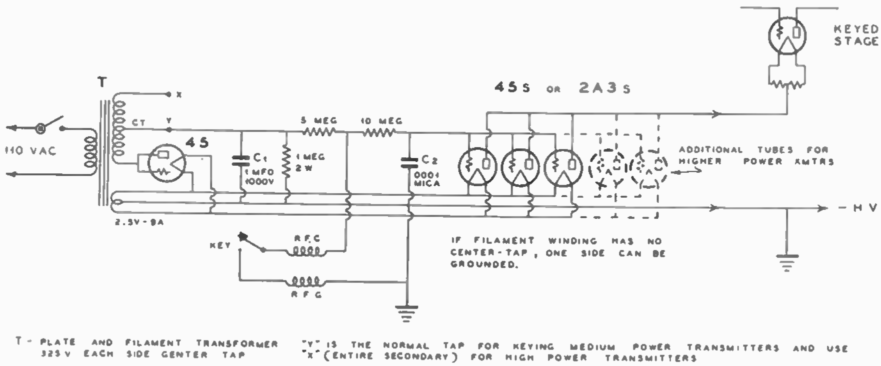
When the r.f. amplifier is loaded by an antenna circuit, the "Q" of the tuned circuit drops to a low value, due to the effective resistance coupled into this tuned circuit by the antenna. This "resistance" represents useful energy or power transfer from the tube to the antenna circuit. The introduction of an apparent resistance into the tuned circuit reduces the impedance of the circuit, so that the tuning condenser should have a reasonable amount of capacity in order to provide the necessary fly-wheel effect. The class C amplifier tube only supplies power to the tuned circuit during about 1/3 or ¼ of the r.f. cycle. During the remainder of the time the tube is inoperative and is cooling off. The tuned circuit must act like a fly-wheel and supply the energy during the remainder of the r.f. cycle. The antenna is coupled to the tuned circuit in order to absorb as much of this power as possible. The value of tuning condenser shown in the final amplifier in the accompanying circuit diagram is suitable for either phone or c.w. operation, for frequencies as low as those used for the 80 meter band.

Since the reactance of the tuning condenser varies with frequency, the capacity of the condenser depends upon the frequency band or wavelength to be used. A split-stator tuning condenser with a maximum capacity of 50 μμfd. per section would be suitable for this transmitter when c.w. transmission alone is contemplated. The plate spacing in this tuning condenser should be great enough that no flash-over will occur for peak voltages of at least four times the value of plate supply d.c. voltage.

The Keying Unit

Clickless keying of the final amplifier, at high speeds, can be accomplished by using the vacuum tube keyer unit shown in the circuit diagram. This unit is completely described elsewhere in these pages. Other keying methods could be used, such as oscillator keying with a fixed bias of at least 90 volts applied to the grid of the final tube. Primary keying in the power supply of the final amplifier is also satisfactory providing less filter is used than shown in the diagram. The power supply shown in the schematic diagram and in the photograph is designed to supply the requirements of a class B modulator in addition to the 35T r.f. amplifier. The amount of filter, as shown, is satisfactory for a plate modulated phone transmitter. The second section of filter, consisting of the 10 henry smoothing choke and 2 μfd. condenser, can be omitted for a c.w. transmitter without causing objectionable a.c. hum on the carrier output.

An Improved V. T. Keying Circuit



VACUUM - TUBE KEYING SYSTEM

The vacuum tube keying circuit in the unit illustrated here is a practical improvement over the one shown in the 1937 *Jones Radio Handbook*.

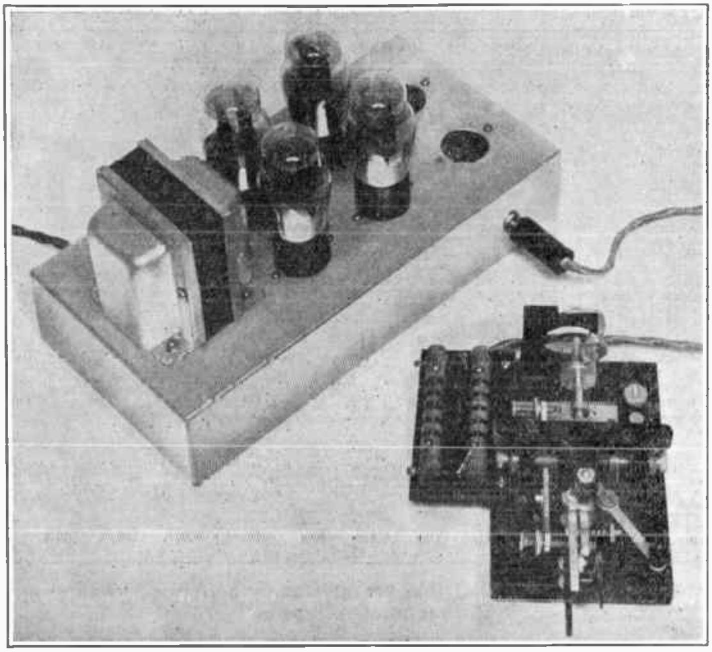
Vacuum tubes can be used for keying an r.f. amplifier for the purpose of eliminating key clicks. The vacuum tube system is not critical with respect to its constants, and invariably removes the key clicks. In spite of its numerous advantages, this type of keying has one disadvantage in that it reduces the power output from 5 to 15 per cent, because of a voltage drop of approximately 100 volts across the type 45 tubes which are used as keyers. The plate current of the keyed r.f. stage flows through the type 45 tubes when the c.w. key is closed, and with zero bias on the grids of the 45's the plate resistance of these tubes is sufficient to cause a voltage drop of approximately 100 volts when the plate current in each tube is 50 milliamperes. This value of 100 volts is constant for any number of paralleled keyer tubes, as long as the current is 50 milliamperes per tube, and 100 volts therefore must be subtracted from the actual plate voltage applied to the keyed amplifier stage.

The 100 volt drop also acts as an additional grid bias to the keyed stage, and must be taken into consideration when designing the type of grid bias supply, or the size of the grid-leak which is to be used.

The cost of the parts for the complete vacuum tube keyer unit will not exceed five dollars. The number of type 45 tubes to be used in parallel connection easily can be calculated for any transmitter by dividing the plate current of the keyed stage by 50. In other words, if the final amplifier is to be keyed, and if it draws 150 milliamperes, three type 45 tubes should be connected in parallel.

An additional type 45 tube is used as a half-wave rectifier with the grid and plate of the tube tied together, and the filament operating from the same winding which supplies the keyer tubes.

A small b.c.l. type power transformer is used to supply a negative bias to the grids of the keyer tubes, through a resistance filter. This negative bias of from 200 to 400 volts is short-circuited when the key is closed, as far as the grids of the keyer tubes are concerned. The actual current flow through the key contacts is extremely minute, due to the very high values of resistance in the circuit. For this reason it is possible actually to key the transmitter by moistening one's fingers and holding them across the key contacts, without fear of electrical shock.

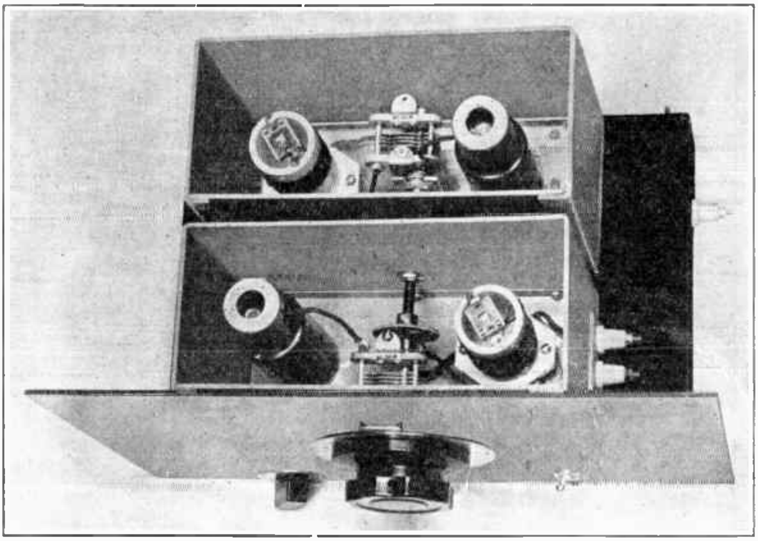


The vacuum tube keying system, using four 45's. Sockets for two additional (optional for higher power) tubes are provided. It is advantageous to mount the b.c.l. chokes directly at the key terminals as shown.

The small power supply must furnish sufficient negative bias to the grids of the keyer tubes to cut-off completely the flow of plate current when the key is open. This, of course, reduces the r.f. stage plate current to zero. When the key is closed the negative bias is short-circuited and the grids are at ground potential. The plate circuits of the type 45 tubes then act as a low resistance in series with the center-tap lead of the keyed r.f. stage. Clicks are completely eliminated on the signal frequency by means of the RC filter of 10 megohms and a .0001 µfd. mica condenser in the grid circuit of the keyer tubes. The time constant of this circuit is sufficient to prevent a sudden application of plate current to the r.f. stage when the key is closed and, similarly, the plate current is prevented from being too sharply cut off. A large value for the mica condenser will provide a greater lag, but will not allow a keying speed as high as is obtained with the constants shown in the circuit diagram. These constants will allow clean, sharp keying at speeds up to 70 words per minute without clicks.

Two small r.f. chokes of the b.c.l. variety can be connected directly at the key terminals in order to prevent the very slight spark at the key contacts from radiating into a nearby b.c.l. receiver. It is important that no condenser be connected across the key contacts. This would prevent even a slow keying, in view of the high values of resistance in the circuit.

All Purpose, Two-Stage Preselector



Without regeneration this preselector outperforms one-tube regenerative types.

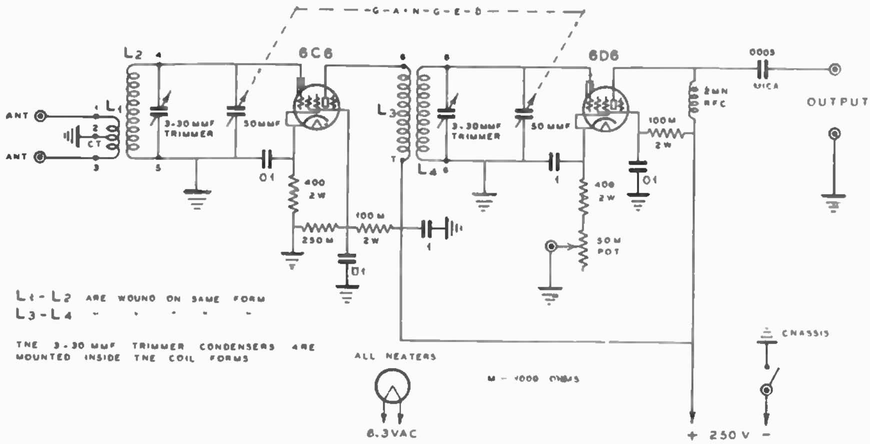
It has been customary for the author to describe only the single-tube regenerative types of pre-selectors in previous *Handbooks.* A two-stage pre-selector can provide more image selectivity and r.f. gain than a single-tube regenerative pre-selector. In addition, provided that care is taken in the design of the first r.f. stage, the tube noise level will be lower in the former than in the latter. Lower tube noise means better sensitivity for weak-signal reception.

The two-stage pre-selector described here consists of a 6C6 and 6D6 in the tube line-up. The 6C6 is operated with low grid bias and at maximum gain at all times to obtain a high signal-to-noise ratio in the high-frequency bands. The second stage with its 6D6 variable μ tube has a 50,000 ohm variable resistor in series with the cathode for the purpose of controlling the gain. The two 50 μμfd. tuning condensers are ganged together for tuning with a single vernier dial. Small 3-to-30 μμfd. mica trimmer condensers are connected across each plug-in coil in order to align exactly each tuned circuit.

Type 57 and 58 tubes can be substituted for the 6C6 and 6D6 tubes, by changing the filament supply from 6.3 volts to 2.5 volts. Also, a metal type 6J7 and a 6K7 tube could be used in place of the 6C6 and 6D6 tubes. The only change would be the type of sockets employed. The pre-selector is designed to operate from the 250 volt plate supply and heater supply of the receiver to which it is to be connected.

The two r.f. stages are built into separate aluminum shield compartments, each 3¾ inches wide, 8 inches long, and 5½ inches high. These compartments are spaced ½ inch apart to isolate better the two r.f. stages. The compartments are then mounted on a standard 8 in. x 12 in. x 2½ in. chassis pan. The metal front panel is proportioned to match the particular receiver with which the pre-selector is to be used.

If the power supply in the receiver is inadequate to supply the additional load of approximately 20 milliamperes of plate



General wiring diagram of the non-regenerative preselector. For coil schematic see page 14.

Coil Data

All coils are wound on standard 1½ in. diameter plug-in coil forms. Isolantite forms are used on the higher frequencies.

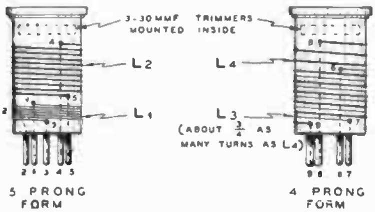
Band in Meters	*First R.F. Stage*	*Second R.F. Stage*
160	1½ inch winding of No. 24 enameled, close wound. Antenna coil: 12 turns No. 24 enameled.	1½ inches of No. 24 enameled, close wound. Plate winding 40 turns No. 32 d.s.c., wound over secondary with insulation between windings.
80	30 turns No. 20 d.s.c., close wound. Antenna coil: 12 turns No. 20 d.s.c., center-tapped.	30 turns No. 20 d.s.c., close wound. Plate winding: 20 turns, wound over secondary.
40	16 turns No. 20, d.s.c., 1⅛ in. long. Antenna coil: 8 turns No. 20 d.s.c., center-tapped.	16 turns No. 20 d.s.c., 1⅛ in. long. Plate coil: 12 turns No. 32 d.s.c., interwound with secondary.
20	9 turns No. 20 d.s.c., 1¼ in. long. Antenna coil: 8 turns No. 20 d.s.c., center-tapped.	9 turns No. 20 d.s.c., 1¼ in. long. Plate winding: 7 turns No. 32 d.s.c., interwound with secondary.
10	4 turns No. 20 d.s.c., 1 inch long. Antenna coil: 6 turns No. 20 d.s.c., center-tapped.	4 turns No. 20 d.s.c., 1 inch long. Plate winding: 3 turns No. 32 d.s.c., interwound with secondary.

All antenna windings are spaced ½ inch below the secondary windings, and are center-tapped. The plate windings in the second r.f. coil are interwound with the secondary winding, wound in the same direction, and begun at the lower (ground) end of the winding. The connections are made as shown in the supplementary sketch which accompanies the circuit diagram.
The 3-30 μμfd. trimmer condensers are soldered to the terminals of each coil by means of heavy wire so that the condensers are self-supporting.

current and 0.6 ampere at 6.3 volts for the heaters of the pre-selector tubes, a separate power supply will be needed.

Lining-up Procedure

The coils are wound in such a manner that the tuning condenser strikes the desired band toward the center point of the tuning dial. The small trimmer con-



densers are then adjusted until maximum sensitivity is obtained from a weak signal, preferably toward the high-frequency end of a particular amateur band. The two circuits should track throughout any amateur band, providing the secondaries are similar. Slight variations in inductance can be compensated for by compressing or expanding the windings of one of the coils when it is tuned to the low-frequency end of that amateur band. The trimmer condensers would then have to be readjusted for the high-frequency end of the band. A resonant antenna, such as a doublet, may have a tendency to throw the first tuned circuit out of alignment; however, this effect has been minimized by using quite loose coupling between the secondary and antenna winding on each coil.

The pre-selector output should normally be connected to the antenna and ground post of the receiver with a short lead, preferably shielded. The r.f. gain of the second stage will depend upon the impedance of its plate circuit, consequently a very small coupling coil in a receiver may not provide a suitable plate load for the 6D6 tube. In such cases, the "hot" lead from the pre-selector can generally be twisted around the grid lead of the first tube in the radio receiver, and the trimmer condenser across that circuit readjusted to make the circuit track. Only about two or three twists of insulated wire should be wound around the aforementioned grid lead.

Automatic Frequency Control

A superheterodyne radio receiver can be more easily tuned by the average person when automatic frequency control is incorporated. Its function is to tune automatically the receiver to the correct frequency after it has been roughly adjusted to the desired station by manual operation. It is an electrical device for swinging the frequency of the high-frequency oscillator to the value which will heterodyne the desired signal into the i.f. amplifier at precisely the correct frequency.

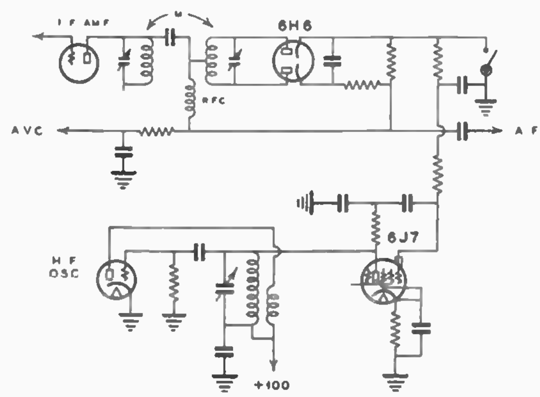
The circuit diagram shows how this is accomplished by means of vacuum tubes. The listener can adjust his receiver to within a few kilocycles of a desired signal and if the signal is strong enough the receiver will swing into exact tune with the carrier signal. This effect eliminates poor tone quality due to incorrect tuning in the broadcast band; it also has the effect of spreading out the tuning adjustment in the short wave broadcast bands. It has one disadvantage, in that a fading signal may cause the receiver to stop operating on the desired signal, or it may swing from one station to another if both signals are of the same intensity and fairly close together on the tuning dial.

Present circuit designs do not provide the same width of frequency band control for the short wave bands as for the broadcast band. The circuits at present are not as sharp on the short-wave bands unless the circuit constants are changed.

Automatic frequency control is obtained by using a vacuum tube as a variable impedance, having either capacitive or inductive reactance, depending upon the voltage applied to its grid circuit. A sharp cut-off tube, such as 6C6 or 6J7, is suitable for this purpose. The grid and plate circuits are connected across the high-frequency oscillator tuned circuit and the change of grid voltage changes the equivalent tuning capacity of the h.f. oscillator circuit. This grid circuit is connected through a resistance filter circuit to a 6H6 double-diode cathode circuit, as shown in the circuit diagram. The 6H6 has its plate circuits connected across a tuned coil which is coupled to the i.f. amplifier, both inductively and by direct coupling to the center-tap of the coil.

This circuit arrangement provides control voltages and currents which are applied to the 6H6 tube in such a manner that the phase relations are correct for proper frequency control. When the applied i.f. signal is not that resulting from the receiver being tuned to the center of the carrier signal, the voltages applied to the two diodes produce effects which tend to swing the corrector-6J7-tube. This change, or swinging effect, changed the tuning of the high-frequency oscillator so that the receiver becomes automatically tuned to the desired signal. The circuit constants must be chosen for the particular receiver. The r.f. and first detector pre-selector circuits should be of the band-pass type, or at least not sharply tuned, since these circuits may be detuned several kilocycles in normal operation.

Automatic frequency control produces a peculiar effect in reception of phone signals in the crowded amateur bands; very often the interfering heterodyne squeals are greatly attenuated.



AUTOMATIC FREQUENCY CONTROL

RCA Radio Tube Characteristics Chart

TYPE	NAME	BASE	SOCKET CONNECTIONS	DIMENSIONS MAXIMUM OVERALL LENGTH x DIAMETER	CATHODE TYPE ■	RATING: FILAMENT OR HEATER VOLTS	RATING: FILAMENT OR HEATER AMPERES	RATING: PLATE MAX. VOLTS	RATING: SCREEN MAX. VOLTS
00-A	DETECTOR TRIODE	MEDIUM 4-PIN Bayonet	4D	4 11/16" x 1 13/16"	D-C FILAMENT	5.0	0.25	45	—
01-A	DETECTOR★ AMPLIFIER	MEDIUM 4-PIN Bayonet	4D	4 11/16" x 1 13/16"	D-C FILAMENT	5.0	0.25	135	—
1A4	SUPER-CONTROL R-F AMPLIFIER PENTODE	SMALL 4-PIN	4M	4 17/32" x 1 9/16"	D-C FILAMENT	2.0	0.06	180	67.5
1A6	PENTAGRID CONVERTER ■	SMALL 6-PIN	6L	4 17/32" x 1 9/16"	D-C FILAMENT	2.0	0.06	180	67.5
1B4	R-F AMPLIFIER PENTODE	SMALL 4-PIN	4M	4 17/32" x 1 9/16"	D-C FILAMENT	2.0	0.06	180	67.5
1B5/25S	DUPLEX-DIODE TRIODE	SMALL 6-PIN	6M	4 1/4" x 1 9/16"	D-C FILAMENT	2.0	0.06	135	—
1C6	PENTAGRID CONVERTER ■	SMALL 6-PIN	6L	4 17/32" x 1 9/16"	D-C FILAMENT	2.0	0.12	180	67.5
1F4	POWER AMPLIFIER PENTODE	MEDIUM 5-PIN	5K	4 11/16" x 1 13/16"	D-C FILAMENT	2.0	0.12	135	135
1F6	DUPLEX-DIODE PENTODE	SMALL 6-PIN	6W	4 17/32" x 1 9/16"	D-C FILAMENT	2.0	0.06	180	67.5
1-V	HALF-WAVE RECTIFIER	SMALL 4-PIN	4G	4 1/4" x 1 9/16"	HEATER	6.3	0.3	—	—
2A3	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN	4D	5 3/8" x 2 1/16"	FILAMENT	2.5	2.5	250 300	— —
2A5	POWER AMPLIFIER PENTODE	MEDIUM 6-PIN	6B	4 11/16" x 1 13/16"	HEATER	2.5	1.75	—	—
2A6	DUPLEX-DIODE HIGH-MU TRIODE	SMALL 6-PIN	6G	4 17/32" x 1 9/16"	HEATER	2.5	0.8	250	—
2A7	PENTAGRID CONVERTER ■	SMALL 7-PIN	7C	4 17/32" x 1 9/16"	HEATER	2.5	0.8	250	100
2B7	DUPLEX-DIODE PENTODE	SMALL 7-PIN	7D	4 17/32" x 1 9/16"	HEATER	2.5	0.8	250	125
‖ 5W4	FULL-WAVE RECTIFIER	SMALL OCTAL 5-PIN	5T	3 1/4" x 1 5/16"	FILAMENT	5.0	1.5	—	—
5Z3	FULL-WAVE RECTIFIER	MEDIUM 4-PIN	4C	5 3/8" x 2 1/16"	FILAMENT	5.0	3.0	—	—
‖ 5Z4	FULL-WAVE RECTIFIER	SMALL OCTAL 5-PIN	5L	3 1/4" x 1 5/16"	HEATER	5.0	2.0	—	—
6A4/LA	POWER AMPLIFIER PENTODE	MEDIUM 5-PIN	5B	4 11/16" x 1 13/16"	FILAMENT	6.3	0.3	180	180
6A6	TWIN-TRIODE AMPLIFIER	MEDIUM 7-PIN #	7B	4 11/16" x 1 13/16"	HEATER	6.3	0.8	300	—
6A7	PENTAGRID CONVERTER ■	SMALL 7-PIN	7C	4 17/32" x 1 9/16"	HEATER	6.3	0.3	250	100
‖ 6A8	PENTAGRID CONVERTER ■	SMALL OCTAL 8-PIN	8A	3 1/8" x 1 5/16"	HEATER	6.3	0.3	250	100
6B7	DUPLEX-DIODE PENTODE	SMALL 7-PIN	7D	4 17/32" x 1 9/16"	HEATER	6.3	0.3	250	125
‖ 6B8	DUPLEX-DIODE PENTODE	SMALL OCTAL 8-PIN	8E	3 1/8" x 1 5/16"	HEATER	6.3	0.3	250	125
‖ 6C5	DETECTOR★ AMPLIFIER TRIODE	SMALL OCTAL 6-PIN	6Q	2 5/8" x 1 5/16"	HEATER	6.3	0.3	250	—
6C6	TRIPLE-GRID DETECTOR AMPLIFIER	SMALL 6-PIN	6F	4 15/16" x 1 9/16"	HEATER	6.3	0.3	250	100

RCA Radio Tube Characteristics Chart

USE Values to right give operating conditions and characteristics for indicated typical use	PLATE SUPPLY VOLTS	GRID BIAS ■ VOLTS	SCREEN SUPPLY VOLTS	SCREEN CURRENT MA.	PLATE CURRENT MA.	A-C PLATE RESISTANCE OHMS	TRANSCONDUCTANCE (GRID-PLATE) µMHOS	AMPLIFICATION FACTOR	LOAD FOR STATED POWER OUTPUT OHMS	POWER OUTPUT WATTS	TYPE
GRID-LEAK DETECTOR	45	Grid Return to (−) Filament			1.5	30000	666	20	——	——	00-A
CLASS A AMPLIFIER	90 135	− 4.5 − 9.0	——	——	2.5 3.0	11000 10000	725 800	8.0 8.0	——	——	01-A
CLASS A AMPLIFIER	90 180	{− 3.0 min.}	67.5 67.5	0.9 0.8	2.2 2.3	600000 1000000	720 750	425 750	——	——	1A4
CONVERTER	135 180	{− 3.0 min.}	67.5 67.5	2.5 2.4	1.2 1.3	400000 500000	Anode-Grid (#2): 180 ▲ max. volts, 2.3 ma. Oscillator-Grid (#1) Resistor ●. Conversion Conductance, 300 micromhos.				1A6
CLASS A AMPLIFIER	90 180	− 3.0 − 3.0	67.5 67.5	0.7 0.6	1.6 1.7	1000000 1500000	600 650	550 1000	——	——	1B4
CLASS A AMPLIFIER	135	− 3.0	——	——	0.8	35000	575	20	——	——	1B5/25S
CONVERTER	135 180	{− 3.0 min.}	67.5 67.5	2.0 2.0	1.3 1.5	550000 750000	Anode-Grid (#2): 180 ▲ max. volts, 3.3 ma. Oscillator-Grid (#1) Resistor ●. Conversion Conductance, 325 micromhos.				1C6
CLASS A AMPLIFIER	135	− 4.5	135	2.6	8.0	200000	1700	340	16000	0.34	1F4
PENTODE UNIT AS R-F AMPLIFIER	180	− 1.5	67.5	0.6	2.0	1000000	650	650	——	——	1F6
PENTODE UNIT AS A-F AMPLIFIER	135 ⌘	− 2.0	Screen Supply, 135 volts applied through 0.8-megohm resistor. Grid Resistor,** 1.0 megohm. Voltage Gain, 46.								1F6
Maximum A-C Plate Voltage....350 Volts, RMS Maximum D-C Output Current.... 50 Milliamperes											1-v
CLASS A AMPLIFIER	250	−45.0	——	——	60.0	800	5250	4.2	2500	3.5	2A3
PUSH-PULL CLASS AB_1 AMPLIFIER	300 300	Self-bias, 780 ohms −62 volts, fixed bias			80.0 80.0	——	——	——	5000 3000	10.0† 15.0†	2A3
AMPLIFIER	For other ratings and characteristics, refer to Type 42.										2A5
TRIODE UNIT AS AMPLIFIER	For other characteristics, refer to Type 75.										2A6
CONVERTER	For other characteristics, refer to Type 6A7.										2A7
AMPLIFIER	For other characteristics, refer to Type 6B7.										2B7
Maximum A-C Voltage per Plate....350 Volts, RMS Maximum D-C Output Current....110 Milliamperes											5W4
Maximum A-C Voltage per Plate....500 Volts, RMS Maximum D-C Output Current....250 Milliamperes											5Z3
Maximum A-C Voltage per Plate....400 Volts, RMS Maximum D-C Output Current....125 Milliamperes											5Z4
CLASS A AMPLIFIER	100 180	− 6.5 −12.0	100 180	1.6 3.9	9.0 22.0	83250 45500	1200 2200	100 100	11000 8000	0.31 1.40	6A4/LA
AMPLIFIER	For other characteristics, refer to Type 6N7.										6A6
CONVERTER	100 250	{− 3.0 min.}	50 100	2.5 2.2	1.3 3.5	600000 360000	Anode-Grid (#2): 250 ▲ max. volts, 4.0 ma. Oscillator-Grid (#1) Resistor ●. Conversion Conductance, 520 micromhos.				6A7
CONVERTER	100 250	{− 3.0 min.}	50 100	1.5 3.2	1.2 3.3	600000 360000	Anode-Grid (#2): 250 ▲ max. volts, 4.0 ma. Oscillator-Grid (#1) Resistor ●. Conversion Conductance, 500 micromhos.				6A8
PENTODE UNIT AS R-F AMPLIFIER	100 250	− 3.0 − 3.0	100 125	1.7 2.3	5.8 9.0	300000 650000	950 1125	285 730	——	——	6B7
PENTODE UNIT AS A-F AMPLIFIER	90 ⌘ 300 ⌘	Self-bias, 3500 ohms. Screen Resistor = 1.1 meg. Self-bias, 1600 ohms. Screen Resistor = 1.2 meg.					Grid Resistor,** 0.5 megohm.		{Gain per stage = 55 Gain per stage = 79}		6B7
PENTODE UNIT AS R-F AMPLIFIER	250	− 3.0	125	2.3	10.0	600000	1325	800	——	——	6B8
PENTODE UNIT AS A-F AMPLIFIER	90 ⌘ 300 ⌘	Self-bias, 3500 ohms. Screen Resistor = 1.1 meg. Self-bias, 1600 ohms. Screen Resistor = 1.2 meg.					Grid Resistor,** 0.5 megohm.		{Gain per stage = 55 Gain per stage = 79}		6B8
CLASS A AMPLIFIER	250 250♥	− 8.0 − 5.0	——	——	8.0 1.0	10000 Gain per stage = 14	2000	20	——	——	6C5
BIAS DETECTOR	250	{−17.0 approx.}	——	——	Plate current to be adjusted to 0.2 milliampere with no signal.						6C5
AMPLIFIER DETECTOR	For other characteristics, refer to Type 6J7.										6C6

RADIO RCA TUBES

TYPE	NAME	BASE	SOCKET CONNECTIONS	DIMENSIONS MAXIMUM OVERALL LENGTH x DIAMETER	CATHODE TYPE ■	RATING: FILAMENT OR HEATER VOLTS	RATING: FILAMENT OR HEATER AMPERES	RATING: PLATE MAX. VOLTS	RATING: SCREEN MAX. VOLTS
6D6	TRIPLE-GRID SUPER-CONTROL AMPLIFIER	SMALL 6-PIN	6F	4 15/16″ x 1 9/16″	HEATER	6.3	0.3	250	100
6E5	ELECTRON-RAY TUBE	SMALL 6-PIN	6R	4 1/4″ x 1 9/16″	HEATER	6.3	0.3	250†	—
6F5	HIGH-MU TRIODE	SMALL OCTAL 5-PIN	5M	3 1/8″ x 1 5/16″	HEATER	6.3	0.3	250	—
6F6	POWER AMPLIFIER PENTODE	SMALL OCTAL 7-PIN	7S	3 1/4″ x 1 5/16″	HEATER	6.3	0.7	315	315
								250	—
								375	250
								350	—
6F7	TRIODE-PENTODE	SMALL 7-PIN	7E	4 17/32″ x 1 9/16″	HEATER	6.3	0.3	100	—
								250	100
								250	100
6G5	ELECTRON-RAY TUBE	SMALL 6-PIN	6R	4 1/4″ x 1 9/16″	HEATER	6.3	0.3	250†	—
6H6	TWIN DIODE	SMALL OCTAL 7-PIN	7Q	1 5/8″ x 1 5/16″	HEATER	6.3	0.3	—	—
6J7	TRIPLE-GRID DETECTOR AMPLIFIER	SMALL OCTAL 7-PIN	7R	3 1/8″ x 1 5/16″	HEATER	6.3	0.3	250	125
6K7	TRIPLE-GRID SUPER-CONTROL AMPLIFIER	SMALL OCTAL 7-PIN	7R	3 1/8″ x 1 5/16″	HEATER	6.3	0.3	250	125
6L6	BEAM POWER AMPLIFIER	SMALL OCTAL 7-PIN	7AC	4 5/16″ x 1 5/8″	HEATER	6.3	0.9	375	250
								375	250
								400	300
								400	300
6L7	PENTAGRID MIXER & AMPLIFIER	SMALL OCTAL 7-PIN	7T	3 1/8″ x 1 5/16″	HEATER	6.3	0.3	250	150
								250	100
6N7	TWIN-TRIODE AMPLIFIER	SMALL OCTAL 8-PIN	8B	3 1/4″ x 1 5/16″	HEATER	6.3	0.8	300	—
6Q7	DUPLEX-DIODE HIGH-MU TRIODE	SMALL OCTAL 7-PIN	7V	3 1/8″ x 1 5/16″	HEATER	6.3	0.3	250	—
6R7	DUPLEX-DIODE TRIODE	SMALL OCTAL 7-PIN	7V	3 1/8″ x 1 5/16″	HEATER	6.3	0.3	250	—
6X5	FULL-WAVE RECTIFIER	SMALL OCTAL 6-PIN	6S	3 1/4″ x 1 5/16″	HEATER	6.3	0.6	—	—
10	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN Bayonet	4D	5 5/8″ x 2 3/16″	FILAMENT	7.5	1.25	425	—

RADIO (RCA) TUBES

USE (Values to right give operating conditions and characteristics for indicated typical use)	PLATE SUPPLY (VOLTS)	GRID BIAS ■ (VOLTS)	SCREEN SUPPLY (VOLTS)	SCREEN CURRENT (MA.)	PLATE CURRENT (MA.)	A-C PLATE RESISTANCE (OHMS)	TRANS-CONDUCTANCE (GRID-PLATE) (μMHOS)	AMPLIFICATION FACTOR	LOAD FOR STATED POWER OUTPUT (OHMS)	POWER OUTPUT (WATTS)	TYPE
SCREEN-GRID R-F AMPLIFIER	100 250	−3.0 min.	100 100	2.2 2.0	8.0 8.2	250000 800000	1500 1600	375 1280	—	—	6D6
MIXER IN SUPERHETERODYNE	100 250	−10.0 −10.0	100 100	—	—	Oscillator Peak Volts = 7.0					6D6
VISUAL INDICATOR	Plate & Target Supply = 100 volts. Triode Plate Resistor = 0.5 meg. Target Current = 4.5 ma. Grid Bias, −3.3 volts; Shadow Angle, 0°. Bias, 0 volts; Angle, 90°; Plate Current, 0.19 ma.										6E5
VISUAL INDICATOR	Plate & Target Supply = 250 volts. Triode Plate Resistor = 1.0 meg. Target Current = 4.5 ma. Grid Bias, −8.0 volts; Shadow Angle, 0°. Bias, 0 volts; Angle, 90°; Plate Current, 0.24 ma.										6E5
CLASS A AMPLIFIER	250	−2.0	—	—	0.9	66000	1500	100	—	—	6F5
CLASS A AMPLIFIER	250 ✕	−0.3	—	—	0.4	Grid Resistor, 0.25 meg.** Gain per stage = 52					6F5
PENTODE CLASS A AMPLIFIER	250 315	−16.5 −22.0	250 315	6.5 8.0	34.0 42.0	80000 75000	2500 2650	200 200	7000 7000	3.0 5.0	6F6
TRIODE □ CLASS A AMPLIFIER	250	−20.0	—	—	31.0	2600	2700	7	4000	0.85	6F6
PENTODE PUSH-PULL CLASS AB_2 AMPLIFIER	375	Self-bias	250	8.0	54.0	Self-Bias Resistor, 340 ohms			10000	19.0†	6F6
	375	−26.0	250	5.0	34.0	—	—	—	10000	19.0†	6F6
TRIODE PUSH-PULL □ CLASS AB_2 AMPLIFIER	350	Self-bias	—	—	50.0	Self-Bias Resistor, 730 ohms			10000	14.0†	6F6
	350	−38.0	—	—	45.0	—	—	—	6000	18.0†	6F6
TRIODE UNIT AS CLASS A AMPLIFIER	100	−3.0	—	—	3.5	16000	500	8	—	—	6F7
PENTODE UNIT AS CLASS A AMPLIFIER	100 250	−3.0 min.	100 100	1.6 1.5	6.3 6.5	290000 850000	1050 1100	300 900	—	—	6F7
PENTODE UNIT AS MIXER	250	−10.0	100	0.6	2.8	Oscillator Peak Volts = 7.0. Conversion Conductance = 300 micromhos.					6F7
VISUAL INDICATOR	Plate & Target Supply = 100 volts. Triode Plate Resistor = 0.5 meg. Target Current = 4.5 ma. Grid Bias, −8 volts; Shadow Angle, 0°. Bias, 0 volts; Angle, 90°; Plate Current, 0.19 ma.										6G5
VISUAL INDICATOR	Plate & Target Supply = 250 volts. Triode Plate Resistor = 1.0 meg. Target Current = 4.5 ma. Grid Bias, −22 volts; Shadow Angle, 0°. Bias, 0 volts; Angle, 90°; Plate Current, 0.24 ma.										6G5
TWIN-DIODE DETECTOR RECTIFIER	Maximum A-C Voltage per Plate.........100 Volts, RMS Maximum D-C Output Current......... 4 Milliamperes										6H6
SCREEN-GRID R-F AMPLIFIER	100 250	−3.0 −3.0	100 100	0.5 0.5	2.0 2.0	1000000 1.5 +‡	1185 1225	1185 1500+	—	—	6J7
SCREEN-GRID A-F AMPLIFIER	90 ✕ 300 ✕	Self-bias, 2600 ohms. Screen Resistor = 1.2 meg. Self-bias, 1200 ohms. Screen Resistor = 1.2 meg.					Grid Resistor,** 0.5 megohm.	Gain per stage = 85 Gain per stage = 140			6J7
BIAS DETECTOR	250	−4.3	100	Cathode current 0.43 ma.		—	Plate Resistor, 500000 ohms. Grid Resistor,** 250000 ohms.				6J7
SCREEN-GRID R-F AMPLIFIER	90 250	−3.0 min.	90 125	1.3 2.6	5.4 10.5	315000 600000	1275 1650	400 990	—	—	6K7
MIXER IN SUPERHETERODYNE	250	−10.0	100	—	—	Oscillator Peak Volts = 7.0					6K7
SINGLE-TUBE CLASS A_1 AMPLIFIER	250	−14.0	250	5.0	72.0	—	—	—	2500	6.5	6L6
	250	Self-bias	250	5.4	75.0	Self-Bias Resistor, 170 ohms.			2500	6.5	6L6
PUSH-PULL CLASS A_1 AMPLIFIER	250	−16.0	250	10.0	120.0	—	—	—	5000	14.5†	6L6
	250	Self-bias	250	10.0	120.0	Self-Bias Resistor, 125 ohms.			5000	13.8†	6L6
PUSH-PULL CLASS AB_1 AMPLIFIER	400	−25.0	300	6.0	102.0	—	—	—	6600	34.0†	6L6
	400	Self-bias	300	7.0	112.0	Self-Bias Resistor, 200 ohms.			6600	32.0†	6L6
PUSH-PULL CLASS AB_2 AMPLIFIER	400 400	−20.0 −25.0	250 300	4.0 6.0	88.0 102.0	—	—	—	6000 3800	40.0† 60.0†	6L6
MIXER IN SUPERHETERODYNE	250	−3.0	100	6.2	2.4	Oscillator-Grid (#3) Bias, −10 volts. Grid #3 Peak Swing, 12 volts min. Conversion Conductance, 350 micromhos.					6L7
CLASS A AMPLIFIER	250	−3.0 min.◄	100	5.5	5.3	800000	1100	880	—	—	6L7
CLASS A AMPLIFIER (As Driver)⊕	250 294	−5.0 −6.0	—	—	6.0 7.0	11300 11000	3100 3200	35 35	20000 or more	exceeds 0.4	6N7
CLASS B AMPLIFIER	250 300	0 0	—	—	Power Output is for one tube at stated plate-to-plate load.				8000 10000	8.0 10.0	6N7
TRIODE UNIT AS CLASS A AMPLIFIER	100 250	−1.5 −3.0	—	—	0.35 1.1	87500 58000	800 1200	70 70	—	—	6Q7
	100◎◎ 250■	−1.1 −2.0	—	—	0.25 0.5	Grid Resistor,** 0.5 megohm		Gain per stage = 35 Gain per stage = 43			6Q7
TRIODE UNIT AS CLASS A AMPLIFIER	250	−9.0	—	—	9.5	8500	1900	16	10000	0.28	6R7
	250♥	−6.0	—	—	1.3	Grid Resistor,** 0.5 meg. Gain per stage = 12					6R7
	Maximum A-C Voltage per Plate.........350 Volts, RMS Maximum D-C Output Current.........75 Milliamperes										6X5
CLASS A AMPLIFIER	350 425	−32.0 −40.0	—	—	16.0 18.0	5150 5000	1550 1600	8.0 8.0	11000 10200	0.9 1.6	10

RADIO RCA TUBES

TYPE	NAME	BASE	SOCKET CONNECTIONS	DIMENSIONS MAXIMUM OVERALL — LENGTH X DIAMETER	CATHODE TYPE ■	RATING — FILAMENT OR HEATER — VOLTS	RATING — FILAMENT OR HEATER — AMPERES	RATING — PLATE — MAX. VOLTS	RATING — SCREEN — MAX. VOLTS
11 12	DETECTOR★ AMPLIFIER TRIODE	WD 4-PIN MEDIUM 4-PIN Bayonet	4F 4D	$4\frac{1}{8}''$ x $1\frac{3}{16}''$ $4\frac{11}{16}''$ x $1\frac{7}{16}''$	D-C FILAMENT	1.1	0.25	135	—
12Z3	HALF-WAVE RECTIFIER	SMALL 4-PIN	4G	$4\frac{1}{4}''$ x $1\frac{9}{16}''$	HEATER	12.6	0.3	—	—
15	R-F AMPLIFIER PENTODE	SMALL 5-PIN	5F	$4\frac{17}{32}''$ x $1\frac{9}{16}''$	HEATER	2.0	0.22	135	67.5
19	TWIN-TRIODE AMPLIFIER	SMALL 6-PIN	6C	$4\frac{1}{4}''$ x $1\frac{9}{16}''$	D-C FILAMENT	2.0	0.26	135	—
20	POWER AMPLIFIER TRIODE	SMALL 4-PIN	4D	$4\frac{1}{8}''$ x $1\frac{3}{16}''$	D-C FILAMENT	3.3	0.132	135	—
22	R-F AMPLIFIER TETRODE	MEDIUM 4-PIN	4K	$5\frac{1}{32}''$ x $1\frac{13}{16}''$	D-C FILAMENT	3.3	0.132	135	67.5
24-A	R-F AMPLIFIER TETRODE	MEDIUM 5-PIN	5E	$5\frac{1}{32}''$ x $1\frac{13}{16}''$	HEATER	2.5	1.75	275	90
25A6	POWER AMPLIFIER PENTODE	SMALL OCTAL 7-PIN	7S	$3\frac{1}{4}''$ x $1\frac{5}{16}''$	HEATER	25.0	0.3	180	135
25Z5	RECTIFIER-DOUBLER	SMALL 6-PIN	6E	$4\frac{1}{4}''$ x $1\frac{9}{16}''$	HEATER	25.0	0.3	—	—
25Z6	RECTIFIER-DOUBLER	SMALL OCTAL 7-PIN	7Q	$3\frac{1}{4}''$ x $1\frac{5}{16}''$	HEATER	25.0	0.3	—	—
26	AMPLIFIER TRIODE	MEDIUM 4-PIN	4D	$4\frac{11}{16}''$ x $1\frac{13}{16}''$	FILAMENT	1.5	1.05	180	—
27	DETECTOR★ AMPLIFIER TRIODE	MEDIUM 5-PIN	5A	$4\frac{1}{4}''$ x $1\frac{9}{16}''$	HEATER	2.5	1.75	275	—
30	DETECTOR★ AMPLIFIER TRIODE	SMALL 4-PIN	4D	$4\frac{1}{4}''$ x $1\frac{9}{16}''$	D-C FILAMENT	2.0	0.06	180	—
31	POWER AMPLIFIER TRIODE	SMALL 4-PIN	4D	$4\frac{1}{4}''$ x $1\frac{9}{16}''$	D-C FILAMENT	2.0	0.13	180	—
32	R-F AMPLIFIER TETRODE	MEDIUM 4-PIN	4K	$5\frac{1}{32}''$ x $1\frac{13}{16}''$	D-C FILAMENT	2.0	0.06	180	67.5
33	POWER AMPLIFIER PENTODE	MEDIUM 5-PIN	5K	$4\frac{11}{16}''$ x $1\frac{13}{16}''$	D-C FILAMENT	2.0	0.26	180	180
34	SUPER-CONTROL R-F AMPLIFIER PENTODE	MEDIUM 4-PIN	4M	$5\frac{1}{32}''$ x $1\frac{13}{16}''$	D-C FILAMENT	2.0	0.06	180	67.5
35	SUPER-CONTROL R-F AMPLIFIER TETRODE	MEDIUM 5-PIN	5E	$5\frac{1}{32}''$ x $1\frac{13}{16}''$	HEATER	2.5	1.75	275	90
36	R-F AMPLIFIER TETRODE	SMALL 5-PIN	5E	$4\frac{17}{32}''$ x $1\frac{9}{16}''$	HEATER	6.3	0.3	250	90
37	DETECTOR★ AMPLIFIER TRIODE	SMALL 5-PIN	5A	$4\frac{1}{4}''$ x $1\frac{9}{16}''$	HEATER	6.3	0.3	250	—
38	POWER AMPLIFIER PENTODE	SMALL 5-PIN	5F	$4\frac{17}{32}''$ x $1\frac{9}{16}''$	HEATER	6.3	0.3	250	250
39/44	SUPER-CONTROL R-F AMPLIFIER PENTODE	SMALL 5-PIN	5F	$4\frac{17}{32}''$ x $1\frac{9}{16}''$	HEATER	6.3	0.3	250	90
40	VOLTAGE AMPLIFIER TRIODE	MEDIUM 4-PIN Bayonet	4D	$4\frac{11}{16}''$ x $1\frac{13}{16}''$	D-C FILAMENT	5.0	0.25	180	—
41	POWER AMPLIFIER PENTODE	SMALL 6-PIN	6B	$4\frac{1}{4}''$ x $1\frac{9}{16}''$	HEATER	6.3	0.4	250	250

RADIO RCA TUBES

USE Values to right give operating conditions and characteristics for indicated typical use	PLATE SUP-PLY VOLTS	GRID BIAS ■ VOLTS	SCREEN SUPPLY VOLTS	SCREEN CUR-RENT MA.	PLATE CUR-RENT MA.	A-C PLATE RESIS-TANCE OHMS	TRANS-CONDUC-TANCE (GRID-PLATE) μMHOS	AMPLIFI-CATION FACTOR	LOAD FOR STATED POWER OUTPUT OHMS	POWER OUT-PUT WATTS	TYPE
CLASS A AMPLIFIER	90 135	− 4.5 −10.5	—	—	2.5 3.0	15500 15000	425 440	6.6 6.6	—	—	11 12
Maximum A-C Plate Voltage ....250 Velts, RMS Maximum D-C Output Current .... 60 Milliamperes											12Z3
CLASS A AMPLIFIER	67.5 135	− 1.5 − 1.5	67.5 67.5	0.3 0.3	1.85 1.85	630000 800000	710 750	450 600	—	—	15
CLASS B AMPLIFIER	135 135	0 − 3.0	—	—	Power Output is for one tube at stated plate-to-plate load.				10000 10000	2.1 1.9	19
CLASS A AMPLIFIER	90 135	−16.5 −22.5	—	—	3.0 6.5	8000 6300	415 525	3.3 3.3	9600 6500	0.045 0.110	20
SCREEN-GRID R-F AMPLIFIER	135 135	− 1.5 − 1.5	45 67.5	0.6* 1.3*	1.7 3.7	725000 325000	375 500	270 160	—	—	22
SCREEN-GRID R-F AMPLIFIER	180 250	− 3.0 − 3.0	90 90	1.7* 1.7*	4.0 4.0	400000 600000	1000 1050	400 630	—	—	24-A
BIAS DETECTOR	250●	−5.0 approx.	20 to 45	—	Plate current to be adjusted to 0.1 milliampere with no signal.						24-A
CLASS A AMPLIFIER	95 180	−15.0 −20.0	95 135	4.0 7.5	20.0 38.0	45000 40000	2000 2500	90 100	4500 5000	0.9 2.75	25A6
VOLTAGE DOUBLER	Maximum A-C Voltage per Plate .... 125 Volts, RMS Maximum D-C Output Current ....100 Milliamperes										25Z5
HALF-WAVE RECTIFIER	Maximum A-C Voltage per Plate♦ ....250 Volts, RMS Maximum D-C Output Current per Plate ... 85 Milliamperes										25Z5
VOLTAGE DOUBLER	Maximum A-C Voltage per Plate .... 125 Volts, RMS Maximum D-C Output Current .... 85 Milliamperes										25Z6
HALF-WAVE RECTIFIER	Maximum A-C Voltage per Plate♦ .... 250 Volts, RMS Maximum D-C Output Current per Plate .... 85 Milliamperes										25Z6
CLASS A AMPLIFIER	90 180	− 7.0 −14.5	—	—	2.9 6.2	8900 7300	935 1150	8.3 8.3	—	—	26
CLASS A AMPLIFIER	135 250	− 9.0 −21.0	—	—	4.5 5.2	9000 9250	1000 975	9.0 9.0	—	—	27
BIAS DETECTOR	250	−30.0 approx.	—	—	Plate current to be adjusted to 0.2 milliampere with no signal.						27
CLASS A AMPLIFIER	90 135 180	− 4.5 − 9.0 −13.5	—	—	2.5 3.0 3.1	11000 10300 10300	850 900 900	9.3 9.3 9.3	—	—	30
CLASS B AMPLIFIER	157.5	−15.0	—	—	1.0	—	—	—	8000	2.1†	30
CLASS A AMPLIFIER	135 180	−22.5 −30.0	—	—	8.0 12.3	4100 3600	925 1050	3.8 3.8	7000 5700	0.185 0.375	31
SCREEN-GRID R-F AMPLIFIER	135 180	− 3.0 − 3.0	67.5 67.5	0.4* 0.4*	1.7 1.7	950000 1200000	640 650	610 780	—	—	32
BIAS DETECTOR	180♥	− 6.0 approx.	67.5	—	Plate current to be adjusted to 0.2 milliampere with no signal.						32
CLASS A AMPLIFIER	180	−18.0	180	5.0	22.0	55000	1700	90	6000	1.4	33
SCREEN-GRID R-F AMPLIFIER	135 180	− 3.0 min.	67.5 67.5	1.0 1.0	2.8 2.8	600000 1000000	600 620	360 620	—	—	34
SCREEN-GRID R-F AMPLIFIER	180 250	− 3.0 min.	90 90	2.5* 2.5*	6.3 6.5	300000 400000	1020 1050	305 420	—	—	35
SCREEN-GRID R-F AMPLIFIER	100 250	− 1.5 − 3.0	55 90	— 1.7*	1.8 3.2	550000 550000	850 1080	470 595	—	—	36
BIAS DETECTOR	100● 250●	− 5.0 − 8.0	55 90	—	Grid-bias values are approximate. Plate current to be adjusted to 0.1 milliampere with no signal.						36
CLASS A AMPLIFIER	90 250	− 6.0 −18.0	—	—	2.5 7.5	11500 8400	800 1100	9.2 9.2	—	—	37
BIAS DETECTOR	90 250	−10.0 −28.0	—	—	Grid-bias values are approximate. Plate current to be adjusted to 0.2 milliampere with no signal.						37
CLASS A AMPLIFIER	100 250	− 9.0 −25.0	100 250	1.2 3.8	7.0 22.0	140000 100000	875 1200	120 120	15000 10000	0.27 2.50	38
SCREEN-GRID R-F AMPLIFIER	90 250	− 3.0 min.	90 90	1.6 1.4	5.6 5.8	375000 1000000	960 1050	360 1050	—	—	39/44
CLASS A AMPLIFIER	135✖ 180✖	− 1.5 − 3.0	—	—	0.2 0.2	150000 150000	200 200	30 30	—	—	40
CLASS A AMPLIFIER	100 250	− 7.0 −18.0	100 250	1.6 5.5	9.0 32.0	103500 68000	1450 2200	150 150	12000 7600	0.33 3.40	41

RADIO RCA TUBES

TYPE	NAME	BASE	SOCKET CONNECTIONS	DIMENSIONS MAXIMUM OVERALL (LENGTH x DIAMETER)	CATHODE TYPE ■	RATING: FILAMENT OR HEATER VOLTS	RATING: FILAMENT OR HEATER AMPERES	RATING: PLATE MAX. VOLTS	RATING: SCREEN MAX. VOLTS
42	POWER AMPLIFIER PENTODE	MEDIUM 6-PIN	6B	4 11/16" x 1 13/16"	HEATER	6.3	0.7	315	315
								315	—
								375	250
								350	—
43	POWER AMPLIFIER PENTODE	MEDIUM 6-PIN	6B	4 11/16" x 1 13/16"	HEATER	25.0	0.3	180	135
45	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN	4D	4 11/16" x 1 13/16"	FILAMENT	2.5	1.5	275	—
46	DUAL-GRID POWER AMPLIFIER	MEDIUM 5-PIN	5C	5 5/8" x 2 3/16"	FILAMENT	2.5	1.75	250	—
								400	—
47	POWER AMPLIFIER PENTODE	MEDIUM 5-PIN	5B	5 3/8" x 2 1/16"	FILAMENT	2.5	1.75	250	250
48	POWER AMPLIFIER TETRODE	MEDIUM 6-PIN	6A	5 3/8" x 2 1/16"	D-C HEATER	30.0	0.4	125	100
49	DUAL-GRID POWER AMPLIFIER	MEDIUM 5-PIN	5C	4 11/16" x 1 13/16"	D-C FILAMENT	2.0	0.12	135	—
								180	—
50	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN Bayonet	4D	6 1/4" x 2 7/16"	FILAMENT	7.5	1.25	450	—
53	TWIN-TRIODE AMPLIFIER	MEDIUM 7-PIN#	7B	4 11/16" x 1 13/16"	HEATER	2.5	2.0	300	—
55	DUPLEX-DIODE TRIODE	SMALL 6-PIN	6G	4 17/32" x 1 9/16"	HEATER	2.5	1.0	250	—
56	SUPER-TRIODE AMPLIFIER DETECTOR★	SMALL 5-PIN	5A	4 1/4" x 1 9/16"	HEATER	2.5	1.0	250	—
57	TRIPLE-GRID DETECTOR AMPLIFIER	SMALL 6-PIN	6F	4 15/16" x 1 9/16"	HEATER	2.5	1.0	250	100
58	TRIPLE-GRID SUPER-CONTROL AMPLIFIER	SMALL 6-PIN	6F	4 15/16" x 1 9/16"	HEATER	2.5	1.0	250	100
59	TRIPLE-GRID POWER AMPLIFIER	MEDIUM 7-PIN#	7A	5 3/8" x 2 1/16"	HEATER	2.5	2.0	250	—
								250	250
								400	—
71-A	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN Bayonet	4D	4 11/16" x 1 13/16"	FILAMENT	5.0	0.25	180	—
75	DUPLEX-DIODE HIGH-MU TRIODE	SMALL 6-PIN	6G	4 17/32" x 1 9/16"	HEATER	6.3	0.3	250	—
76	SUPER-TRIODE AMPLIFIER DETECTOR★	SMALL 5-PIN	5A	4 1/4" x 1 9/16"	HEATER	6.3	0.3	250	—
77	TRIPLE-GRID DETECTOR AMPLIFIER	SMALL 6-PIN	6F	4 17/32" x 1 9/16"	HEATER	6.3	0.3	250	100
78	TRIPLE-GRID SUPER-CONTROL AMPLIFIER	SMALL 6-PIN	6F	4 17/32" x 1 9/16"	HEATER	6.3	0.3	250	125

RADIO RCA TUBES

USE Values to right give operating conditions and characteristics for indicated typical use	PLATE SUPPLY VOLTS	GRID BIAS ■ VOLTS	SCREEN SUPPLY VOLTS	SCREEN CURRENT MA.	PLATE CURRENT MA.	A-C PLATE RESISTANCE OHMS	TRANSCONDUCTANCE (GRID-PLATE) μMHOS	AMPLIFICATION FACTOR	LOAD FOR STATED POWER OUTPUT OHMS	POWER OUTPUT WATTS	TYPE
PENTODE CLASS A AMPLIFIER	250 315	−16.5 −22.0	250 315	6.5 8.0	34.0 42.0	80000 100000	2350 2600	190 260	7000 7000	3.0 5.0	42
TRIODE □ CLASS A AMPLIFIER	250	−20.0	——	——	31.0	2700	2300	6.2	3000	0.65	
PENTODE PUSH-PULL CLASS AB_2 AMPLIFIER	375 375	Self-bias −26.0	250 250	8.0 5.0	54.0 34.0	Self-Bias Resistor, 340 ohms ——	——	——	10000 10000	19.0† 19.0†	
TRIODE PUSH-PULL □ CLASS AB_2 AMPLIFIER	350 350	Self-bias, 730 ohms −38.0 volts, fixed bias			50.0 45.0	——	——	——	10000 6000	14.0† 18.0†	
CLASS A AMPLIFIER	95 180	−15.0 −20.0	95 135	4.0 7.5	20.0 38.0	45000 40000	2000 2500	90 100	4500 5000	0.90 2.75	43
CLASS A AMPLIFIER	180 275	−31.5 −56.0	——	——	31.0 36.0	1650 1700	2125 2050	3.5 3.5	2700 4600	0.82 2.00	45
CLASS AB_2 AMPLIFIER	275 275	Self-bias, 775 ohms −68.0 volts, fixed bias			72.0 28.0	——	——	——	5060 3200	12.0† 18.0†	
CLASS A AMPLIFIER □	250	−33.0	——	——	22.0	2380	2350	5.6	6400	1.25	46
CLASS B AMPLIFIER ◆	300 400	0 0	——	——	8.0 12.0	——	——	——	5200 5800	16.0† 20.0†	
CLASS A AMPLIFIER	250	−16.5	250	6.0	31.0	60000	2500	150	7000	2.7	47
TETRODE CLASS A AMPLIFIER	96 125	−19.0 −20.0	96 100	9.0 9.5	52.0 56.0	—— ——	3800 3900	—— ——	1500 1500	2.0 2.5	48
TETRODE PUSH PULL CLASS A AMPLIFIER	125	−20.0	100	——	100.0	——	——	——	3000	5.0†	
CLASS A AMPLIFIER □	135	−20.0	——	——	6.0	4175	1125	4.7	11000	0.17	49
CLASS B AMPLIFIER ◆	180	0	——	——	4.0	——	——	——	12000	3.5†	
CLASS A AMPLIFIER	300 400 450	−54.0 −70.0 −84.0	——	——	35.0 55.0 55.0	2000 1800 1800	1900 2100 2100	3.8 3.8 3.8	4600 3670 4350	1.6 3.4 4.6	50
AMPLIFIER	For other characteristics, refer to Type 6N7.										53
TRIODE UNIT AS AMPLIFIER	For other characteristics, refer to Type 85.										55
AMPLIFIER DETECTOR	For other characteristics, refer to Type 76.										56
AMPLIFIER DETECTOR	For other characteristics, refer to Type 6J7.										57
AMPLIFIER MIXER	For other characteristics, refer to Type 6D6.										58
TRIODE * CLASS A AMPLIFIER	250	−28.0	——	——	26.0	2300	2600	6.0	5000	1.25	59
PENTODE** CLASS A AMPLIFIER	250	−18.0	250	9.0	35.0	40000	2500	100	6000	3.0	
TRIODE● CLASS B AMPLIFIER	300 400	0 0	——	——	20.0 26.0	——	——	——	4600 6000	15.0† 20.0†	
CLASS A AMPLIFIER	90 180	−19.0 −43.0	——	——	10.0 20.0	2170 1750	1400 1700	3.0 3.0	3000 4800	0.125 0.790	71-A
TRIODE UNIT AS CLASS A AMPLIFIER	250✖	− 1.35	——	——	0.4	——	——	Gain per stage = 50-60			75
CLASS A AMPLIFIER	100 250 250♥	− 5.0 −13.5 − 9.0	——	——	2.5 5.0 1.0	12000 9500 ——	1150 1450 ——	13.8 13.8 ——	——	——	76
BIAS DETECTOR	250	{−20.0 approx.}	——	——	Plate current to be adjusted to 0.2 milliampere with no signal.						
SCREEN-GRID R-F AMPLIFIER	100 250	− 1.5 − 3.0	60 100	0.4 0.5	1.7 2.3	650000 1500000	1100 1250	715 1500	——	——	77
BIAS DETECTOR	250	− 1.95	50	Cathode current 0.65 ma.		——	Plate Resistor, 250000 ohms. Grid Resistor,** 250000 ohms.				
AMPLIFIER MIXER	For other characteristics, refer to Type 6K7.										78

RADIO RCA TUBES

TYPE	NAME	BASE	SOCKET CONNEC-TIONS	DIMENSIONS MAXIMUM OVERALL LENGTH X DIAMETER	CATHODE TYPE ■	RATING: FILAMENT OR HEATER VOLTS	RATING: FILAMENT OR HEATER AMPERES	RATING: PLATE MAX. VOLTS	RATING: SCREEN MAX. VOLTS
79	TWIN-TRIODE AMPLIFIER	SMALL 6-PIN	6H	$4\frac{17}{32}''$ x $1\frac{9}{16}''$	HEATER	6.3	0.6	250	—
80	FULL-WAVE RECTIFIER	MEDIUM 4-PIN	4C	$4\frac{11}{16}''$ x $1\frac{13}{16}''$	FILAMENT	5.0	2.0	—	—
81	HALF-WAVE RECTIFIER	MEDIUM 4-PIN Bayonet	4B	$6\frac{1}{4}''$ x $2\frac{7}{16}''$	FILAMENT	7.5	1.25	—	—
82	FULL-WAVE ➤ RECTIFIER	MEDIUM 4-PIN	4C	$4\frac{11}{16}''$ x $1\frac{13}{16}''$	FILAMENT	2.5	3.0	—	—
83	FULL-WAVE ➤ RECTIFIER	MEDIUM 4-PIN	4C	$5\frac{3}{8}''$ x $2\frac{1}{16}''$	FILAMENT	5.0	3.0	—	—
83-v	FULL-WAVE RECTIFIER	MEDIUM 4-PIN	4L	$4\frac{11}{16}''$ x $1\frac{13}{16}''$	HEATER	5.0	2.0	—	—
84/6Z4	FULL-WAVE RECTIFIER	SMALL 5-PIN	5D	$4\frac{1}{4}''$ x $1\frac{9}{16}''$	HEATER	6.3	0.5	—	—
85	DUPLEX-DIODE TRIODE	SMALL 6-PIN	6G	$4\frac{17}{32}''$ x $1\frac{9}{16}''$	HEATER	6.3	0.3	250	—
89	TRIPLE-GRID POWER AMPLIFIER	SMALL 6-PIN	6F	$4\frac{17}{32}''$ x $1\frac{9}{16}''$	HEATER	6.3	0.4	250	—
								250	250
								250	—
V-99 X-99	DETECTOR★ AMPLIFIER TRIODE	SMALL 4-NUB SMALL 4-PIN	4E 4D	$3\frac{1}{2}''$ x $1\frac{1}{16}''$ $4''$ x $1\frac{3}{16}''$	D-C FILAMENT	3.3	0.063	90	—
112-A	DETECTOR★ AMPLIFIER TRIODE	MEDIUM 4-PIN Bayonet	4D	$4\frac{11}{16}''$ x $1\frac{13}{16}''$	D-C FILAMENT	5.0	0.25	180	—
874	VOLTAGE REGULATOR	MEDIUM 4-PIN Bayonet	4S	$5\frac{5}{8}''$ x $2\frac{3}{16}''$	——	—	—	—	—
876	CURRENT REGULATOR	MOGUL SCREW	—	$8''$ x $2\frac{1}{16}''$	FILAMENT	—	—	—	—
886	CURRENT REGULATOR	MOGUL SCREW	—	$8''$ x $2\frac{1}{16}''$	FILAMENT	—	—	—	—

★For Grid-leak Detection—plate volts 45, grid return to + filament or to cathode.

■Either A. C. or D. C. may be used on filament or heater, except as specifically noted. For use of D.C. on A-C filament types, decrease stated grid volts by ½ (approx.) of filament voltage.

⚡Supply voltage applied through 20000-ohm voltage-dropping resistor.

➤Mercury-Vapor Type.

▪▪Grid #1 is control grid. Grid #2 is screen. Grid #3 tied to cathode.

¶Grid #1 is control grid. Grids #2 and #3 tied to plate.

●Grids #1 and #2 connected together. Grid #3 tied to plate.

◘Grids #3 and #5 are screen. Grid #4 is signal-input control grid.

▲Grids #2 and #4 are screen. Grid #1 is signal-input control grid.

✢Triode Plate-Supply Voltage and Max. Target Voltage; Min. Target Voltage = 90 volts.

°Both grids connected together; likewise, both plates.

†Power output is for two tubes at stated plate-to-plate load.

RADIO RCA TUBES

USE Values to right give operating conditions and characteristics for indicated typical use	PLATE SUPPLY VOLTS	GRID BIAS ■ VOLTS	SCREEN SUPPLY VOLTS	SCREEN CURRENT MA.	PLATE CURRENT MA.	A-C PLATE RESISTANCE OHMS	TRANSCONDUCTANCE (GRID-PLATE) μMHOS	AMPLIFICATION FACTOR	LOAD FOR STATED POWER OUTPUT OHMS	POWER OUTPUT WATTS	TYPE
CLASS B AMPLIFIER	180 250	0 0	—	—	Power Output is for one tube at stated plate-to-plate load.				7000 14000	5.5 8.0	79
A-C Voltage per Plate (Volts RMS) ...... 350 400 550 D-C Output Current (Maximum MA.) 125 110 135					The 550-volt rating applies to filter circuits having an input choke of at least 20 henries.						80
Maximum A-C Plate Voltage ....700 Volts, RMS Maximum D-C Output Current .... 85 Milliamperes											81
Maximum A-C Voltage per Plate ... 500 Volts, RMS Maximum D-C Output Current ......125 Milliamperes					Maximum Peak Inverse Voltage......1400 Volts Maximum Peak Plate Current .... 400 Milliamperes						82
Maximum A-C Voltage per Plate ... 500 Volts, RMS Maximum D-C Output Current ......250 Milliamperes					Maximum Peak Inverse Voltage......1400 Volts Maximum Peak Plate Current .... 800 Milliamperes						83
Maximum A-C Voltage per Plate..........400 Volts, RMS Maximum D-C Output Current..........200 Milliamperes											83-V
Maximum A-C Voltage per Plate..........350 Volts, RMS Maximum D-C Output Current.......... 60 Milliamperes											84/6Z4
TRIODE UNIT AS CLASS A AMPLIFIER	135 250	−10.5 −20.0	—	—	3.7 8.0	11000 7500	750 1100	8.3 8.3	25000 20000	0.075 0.350	85
AS TRIODE ¶ CLASS A AMPLIFIER	160 250	−20.0 −31.0	—	—	17.0 32.0	3300 2600	1425 1800	4.7 4.7	7000 5500	0.30 0.90	
AS PENTODE ●● CLASS A AMPLIFIER	100 250	−10.0 −25.0	100 250	1.6 5.5	9.5 32.0	104000 7000	1200 1800	125 125	10700 6750	0.33 3.40	89
AS TRIODE ♦ CLASS B AMPLIFIER	180	0	—	—	6.0	—	—	—	13600 9400	2.50† 3.50†	
CLASS A AMPLIFIER	90	− 4.5	—	—	2.5	15500	425	6.6	—	—	V-99 X-99
CLASS A AMPLIFIER	90 180	− 4.5 −13.5	—	—	5.0 7.7	5400 4700	1575 1800	8.5 8.5	—	—	112-A
Minimum D-C Starting Supply Voltage......125 Volts D-C Operating Voltage.......... 90 Volts					D-C Operating Current..........10-50 Ma. Maximum Current (Continuous)..........50 Ma.						874
Voltage Range..........40 to 60 Volts					Operating Current..........1.7 Amperes						876
Voltage Range..........40 to 60 Volts					Operating Current..........2.05 Amperes						886

● Applied through plate resistor of 250000 ohms or 500-henry choke shunted by 0.25-megohm resistor.
♥ Applied through plate resistor of 100000 ohms.
⌘ Applied through plate resistor of 250000 ohms.
■ 50000 ohms.
* Requires different socket from small 7-pin.
□ Grid #2 tied to plate.
♦ Grids #1 and #2 tied together.
●● For grid of following tube.
¶ Plate voltages greater than 125 volts RMS require 100-ohm series-plate resistor.
○○ Applied through plate resistor of 150000 ohms.
◀ For signal-input control-grid (#1); control-grid #3 bias, −3 volts.
■ Applied through 200000-ohm plate resistor.
* Maximum.
§ Megohms.

Note 1: Types with octal bases have *Miniature Metal Cap;* all others have *Small Metal Cap.*

Note 2: Subscript 1 on class of amplifier service (as AB_1) indicates that grid current does not flow during any part of input cycle.
Subscript 2 on class of amplifier service (as AB_2) indicates that grid current flows during some part of the input cycle.

RADIO RCA TUBES

INDEX OF TYPES BY USE AND BY CATHODE VOLTAGE

Tubes of All-Metal construction are shown in BOLD FACE

CATHODE VOLTS	RECTIFIERS	VOLTAGE AMPLIFIERS *Including Duplex-Diode Types*	POWER AMPLIFIERS
1.1	—	11, 12	—
1.5	—	26	—
2.0	—	1A4, 1A6, 1B4, 1B5/25S, 1F6, 15, 30, 32, 34	1F4, 19, 31, 33, 49
2.5.	82	2A6, 2B7, 24-A, 27, 35. 55, 56, 57, 58	2A3, 2A5, 45, 46, 47, 53, 59
3.3	—	22, 99	20
5.0	**5W4**, 5Z3, **5Z4**, 80, 83, 83-v	01-A, 40, 112-A	71-A, 112-A
6.3	**6H6, 6X5**, 1-v, 84/6Z4	6B7, **6B8, 6C5**, 6C6, 6D6, **6F5**, 6F7, **6J7, 6K7, 6L7, 6Q7, 6R7**, 36, 37, 39/44, 75, 76, 77, 78, 85	6A4, 6A6, **6F6, 6L6, 6N7**, 38, 41, 42, 79, 89
7.5	81	—	10, 50
12.6	12Z3	—	—
25.0	25Z5, **25Z6**	—	**25A6**, 43
30.0	—	—	48

CATHODE VOLTS	CONVERTERS IN SUPERHETERODYNES	DETECTORS	MIXER TUBES IN SUPERHETERODYNES	INDICATORS (Visual)
1.1	—	11, 12	—	—
1.5	—	—	—	—
2.0	1A6, 1C6	1A6, 1B5/25S, 1F6, 30, 32	1A6, 1C6, 34	—
2.5	2A7	2A6, 2B7, 24-A, 27, 55, 56, 57	2A7, 35, 58	—
3.3	—	99	—	—
5.0	—	00-A, 01-A, 40, 112-A	—	—
6.3	6A7, **6A8**	6B7, **6B8, 6C5**, 6C6, 6F7, **6J7, 6H6, 6Q7, 6R7**, 36, 37, 75, 76, 77, 85	6A7, **6A8**, 6D6, **6K7, 6L7**, 39/44, 78	6E5, 6G5
7.5	—	—	—	—
12.6	—	—	—	—
25.0	—	—	—	—
30.0	—	—	—	—

* * * * * *

Concluded from page 15.

RCA-25B6-G:

Characteristics:

Heater Voltage	25.0 a-c or d-c	Volts
Heater Current	0.3	Ampere
Plate Voltage	95	Volts
Screen Voltage	95	Volts
Grid Voltage	-15	Volts
Plate Current	45	Milliamperes
Screen Current	4	Milliamperes
Plate Resistance	Subject to considerable variation	
Transconductance	4000	Micromhos
Load Resistance	2000	Ohms
Power Output (10% Distortion)	1.75	Watts

* * * * * *

KEY TO TERMINAL DESIGNATIONS OF SOCKETS

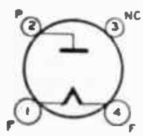
Alphabetical subscripts D, P, and T indicate, respectively, diode unit, pentode unit, and triode unit in multi-unit types.

Numerical subscripts are used (1) in multi-grid types to indicate relative position of grids to cathode or filament, and (2) in multi-unit types to differentiate between two identical electrodes which would otherwise have the same designation.

BP = **Bayonet Pin**
F = **Filament**
G = **Grid**
H = **Heater**
K = **Cathode**
NC = **No Connection**
P = **Plate**
P_{BF} = **Beam-Forming Plates**
TA = **Target**

RADIO TUBES

SOCKET CONNECTIONS
BOTTOM VIEWS



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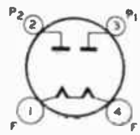

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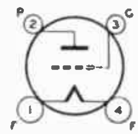

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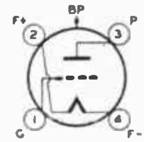

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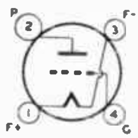

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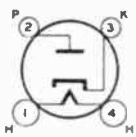

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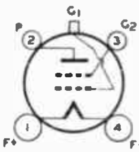

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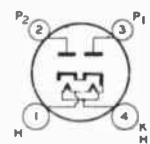

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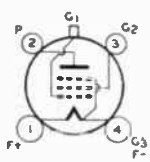

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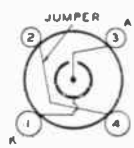

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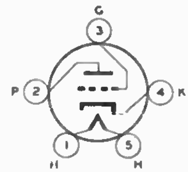

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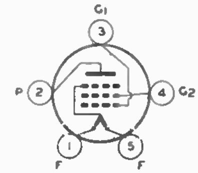

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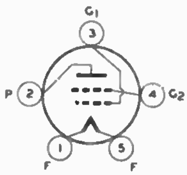

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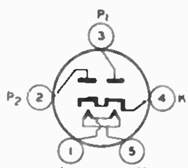

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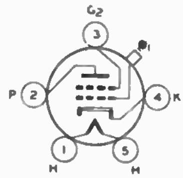

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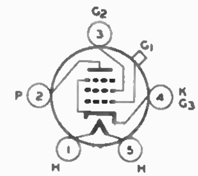

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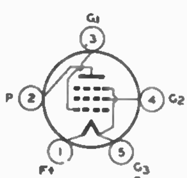

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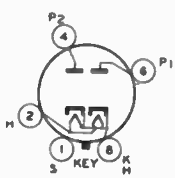

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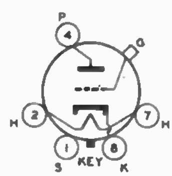

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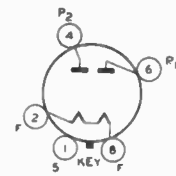

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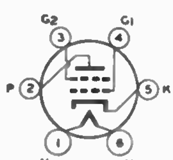

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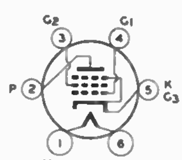

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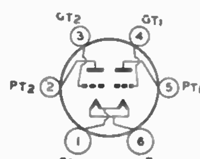

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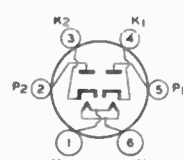
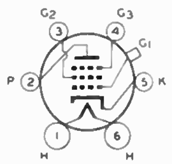


6E

RADIO RCA TUBES

SOCKET CONNECTIONS
BOTTOM VIEWS



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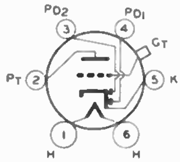

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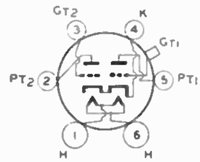

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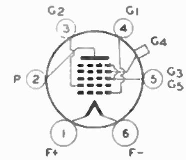

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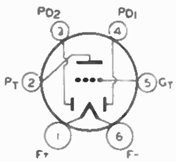

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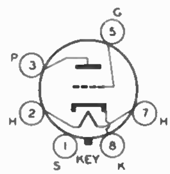

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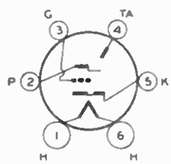

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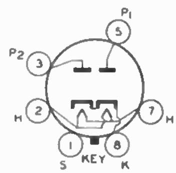

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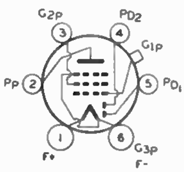

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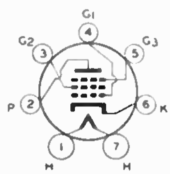

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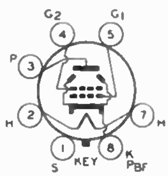

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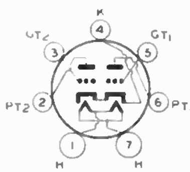

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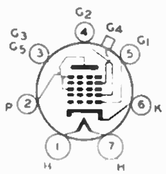

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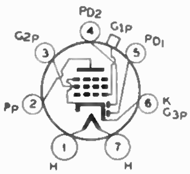

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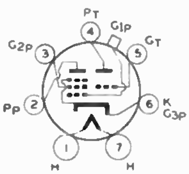

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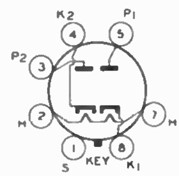

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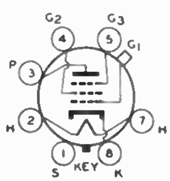

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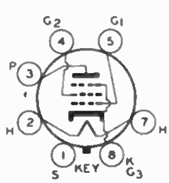

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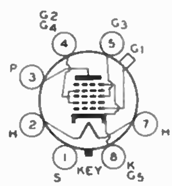

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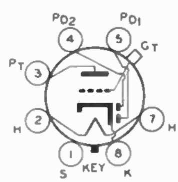

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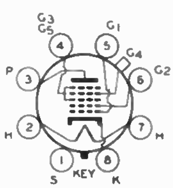

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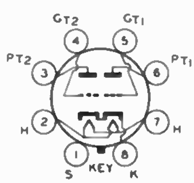

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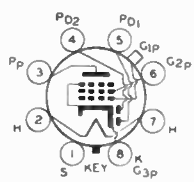


8E

RADIO RCA TUBES

RCA G-TYPE RADIO TUBES

(OCTAL-BASE, GLASS-BULB TYPES)

In addition to the types of tubes shown on the preceding pages, the following octal-base, glass-bulb types are also available. These types are identified by the letter "G" following the type number. For each of these types, the corresponding glass or metal types are indicated below, together with socket connections and overall dimensions. Characteristics data for the G-types, except for some differences in capacity values, are the same as those for the corresponding types.

G-Series Type	Corresponding Glass Type	Corresponding Metal Type	Socket Connections	Max. Overall Dimensions Length x Diam.
1C7-G	1C6	—	G-7Z	4 15/32" x 1 9/16"
1D5-G	1A4	—	G-5Y	4 15/32" x 1 9/16"
1D7-G	1A6	—	G-7Z	4 15/32" x 1 9/16"
1E7-G	§	—	G-8C	4 1/8" x 1 9/16"
1F5-G	1F4	—	G-6X	4 5/8" x 1 13/16"
1F7-G	1F6	—	G-7AD	4 15/32" x 1 9/16"
1H4-G	30	—	G-5S	4 1/8" x 1 9/16"
1H6-G	1B5/25S	—	G-7AA	4 1/8" x 1 9/16"
1J6-G	19*	—	G-7AB	4 1/8" x 1 9/16"
5V4-G	83-v	—	G-5L	4 5/8" x 1 13/16"
5X4-G	5Z3	—	G-5Q	5 5/16" x 2 1/16"
5Y3-G	80	—	G-5T	4 5/8" x 1 13/16"
5Y4-G	80	—	G-5Q	4 5/8" x 1 13/16"
6A8-G	—	6A8	G-8A	4 15/32" x 1 9/16"
6C5-G	—	6C5	G-6Q	4 1/8" x 1 9/16"
6F5-G	—	6F5	G-5M	4 15/32" x 1 9/16"
6F6-G	—	6F6	G-7S	4 5/8" x 1 13/16"
6H6-G	—	6H6	G-7Q	4 1/8" x 1 9/16"
6J7-G	—	6J7	G-7R (6J7-G)	4 15/32" x 1 9/16"
6K5-C	See data below		G-5U	4 15/32" x 1 9/16"
6K6-G	41	—	G-7S	4 1/8" x 1 9/16"
6K7-G	—	6K7	G-7R (6K7-G)	4 15/32" x 1 9/16"
6L6-G	—	6L6	G-7AC	5 5/16" x 2 1/16"
6L7-G	—	6L7	G-7T	4 15/32" x 1 9/16"
6N7-G	—	6N7	G-8B	4 5/8" x 1 13/16"
6Q7-G	—	6Q7	G-7V	4 15/32" x 1 9/16"
6R7-G	—	6R7	G-7V	4 15/32" x 1 9/16"
6X5-G	—	6X5	G-6S	4 1/8" x 1 9/16"
25A6-G	—	25A6	G-7S	4 5/8" x 1 13/16"
25B6-G	See data on page 12		G-7S	4 5/8" x 1 13/16"
25Z6-G	—	25Z6	G-7Q	4 1/8" x 1 9/16"

* Except that filament current is 0.24 ampere. § Two 1F4's in the same bulb.

NOTE: Certain G-types have an internal shield which is brought out to Pin No. 1. Socket connections for such types designate Pin No. 1 as SHIELD. For G-types without SHIELD connections, Pin No. 1 is marked NC. Other symbols on socket diagrams are explained in the KEY TO TERMINAL DESIGNATIONS OF SOCKET CONNECTIONS on page 12.

RCA-6K5-G: Similar to triode section of 6Q7.

Characteristics:

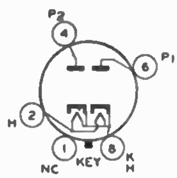
Heater Voltage	6.3	6.3 a-c or d-c	Volts
Heater Current	0.3	0.3	Ampere
Plate Voltage	100	250	Volts
Grid Voltage	−1.5	−3	Volts
Amplification Factor	70	70 approx.	
Plate Resistance	78000	50000 approx.	Ohms
Transconductance	900	1400	Micromhos
Plate Current	0.35	1.1	Milliamperes

SOCKET CONNECTION DIAGRAMS ARE SHOWN ON THE NEXT PAGE.

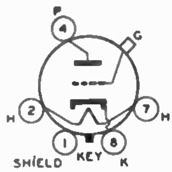
RADIO RCA TUBES

SOCKET CONNECTIONS FOR G-TYPES

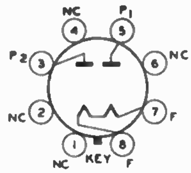
BOTTOM VIEWS



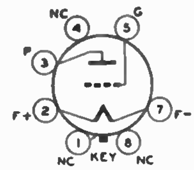
G-5L



G-5M



G-5Q



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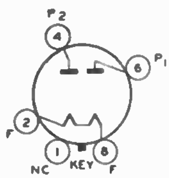

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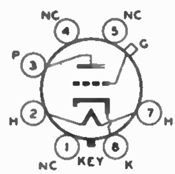

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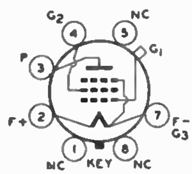

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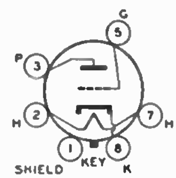

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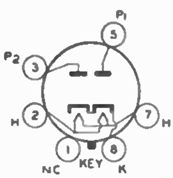

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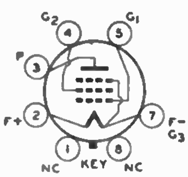

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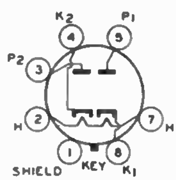

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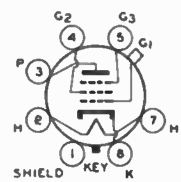

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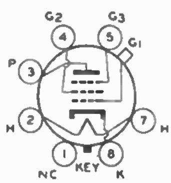

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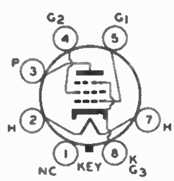

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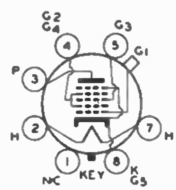

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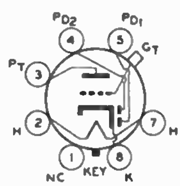

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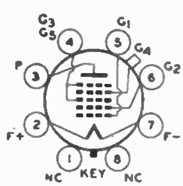

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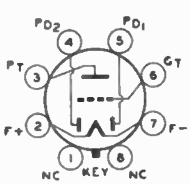

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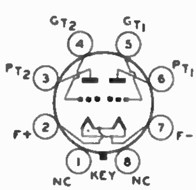

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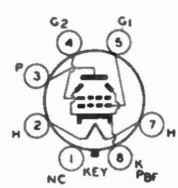

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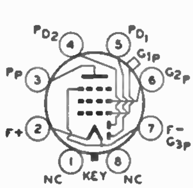

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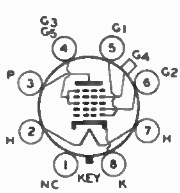
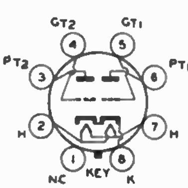
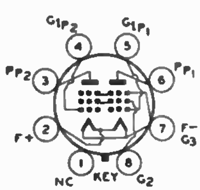


G-8A



G-8B



G-8C

Antenna Directivity

If the experimenter is in possession of the correct theoretical data before he actually constructs an antenna, it is a simple matter to know in advance exactly what *any* antenna will do, when operated on any frequency. The relative height above ground, the direction in which the antenna is pointed, the angle of tilt, and the length of the wire or wires can all be calculated from charts and curves, such as the specimens shown in these pages. The use of these curves and charts makes it unnecessary to spend days, or even weeks, of cut-and-try antenna experiments.

The useful radiation for nearly any form of antenna can be shown in curves, such as those which accompany this text. By useful radiation is meant that portion which is most effective for long-distance transmission or reception for the particular amateur band under consideration. The relative amount of radiation from the sides or ends, and all other intermediate points of any antenna, can be read directly from these curves. The useful radiation is that portion which starts out at an angle above the surface of the earth (or horizon) which will produce the strongest signal at the receiving point. For example, low-angle radiation is necessary for the high-frequency bands, such as 10 and 20 meters, as has been found by experiment through the years, by both commercial and amateur tests.

It has also been found that the radiation of an angle of about 10 degrees above the surface of the earth is most effective for 10 meter operation; the radiation at lower angles is reflected upward by the surface of the earth and is not very effective. Angles much greater than 10 degrees represent wasted radiation, because the radio waves are not reflected back to the distant receiving points, to any great extent.

The optimum vertical angle of radiation for the 20 meter band is apparently in the vicinity of 15 degrees above the surface of the earth; higher angle radiation is lost in the *Heaviside Layer* and is not usually returned to earth. The radiation at lower angles tends to be attenuated by ground losses and reflection.

Lower frequencies (longer wave lengths), such as 40 and 80 meters, are most effective for long-distance communication when the angle of radiation above the earth is in the vicinity of 30 degrees. This is relatively high-angle radiation. Very short distances require very low angle radiation or extremely high angle radiation, but for all practical purposes the major portion of the transmitted energy should be directed upward at an angle of 30 degrees above earth for the 40 and 80 meter bands. Slightly higher angles are more likely to be best for the 80-meter band for short and medium distances.

The important point to remember is to use an antenna system which will transmit *most* of its energy outwardly at a vertical angle of 10 degrees for 10 meter operation, 15 degrees for 20 meter operation, and 30 degrees for 40 and 80 meter operation. Certain types of antennas accomplish this purpose, while others are apt to waste most of the energy in radiation at undesired angles. A simple type of antenna, such as a half wave horizontal wire, has a relatively broad coverage in vertical angle radiation. The amount of radiation at various angles above the earth depends upon the height of the antenna above earth or other conductors.

In this discussion, up to this point, only those radiation angles with respect to the earth have been considered. No attempt has so far been made to discuss the radiation in various horizontal angles, such as North, South, East and West. When it is desired to choose an antenna which will transmit or receive signals to or from a given area, such as European coverage for American amateur stations, the horizontal and vertical angles of radiation must both be taken into consideration. If 20-meter band operation is wanted, a vertical angle of 15 degrees above the surface of the earth should be chosen as the angle of the greatest amount of radiation from the antenna system. At the same time, the horizontal angle should be chosen so that the energy is most efficiently transmitted or received along the *great circle* route between the desired points. Use can be made of horizontal directivity to increase the gain of an antenna in the desired horizontal direction at the expense of a loss in other directions.

Most theoretical curves which have previously been published have neglected to take into consideration the effect of the earth near the antenna, and no effort was made to show the horizontal directivity of an antenna at various vertical angles above the earth. The curves which accompany this text show only the relative radiation of angles of 15 degrees above the horizon, such as are most effective for 20-meter band operation. However, the forthcoming 1938 edition of our large *Handbook* will show the radiation patterns for the same antennas at higher and lower angles above the earth. These curves are now in preparation and several dozen will be shown.

With the aid of the complete set of curves which will be in the new *Handbook,* the proper antenna can be chosen in advance for general coverage, or for transmission and reception in only certain desired directions.

The curves also indicate which antennas are most suitable for operation in several bands, and the relative gain of the antenna in all horizontal directions for the proper vertical angle of radiation. The effect of height above ground can be seen at a glance from these curves.

While the curves were calculated on the basis of a "perfect ground," in actual practice they are not greatly different. The presence of objects near the antenna will often distort the radiation pattern, however.

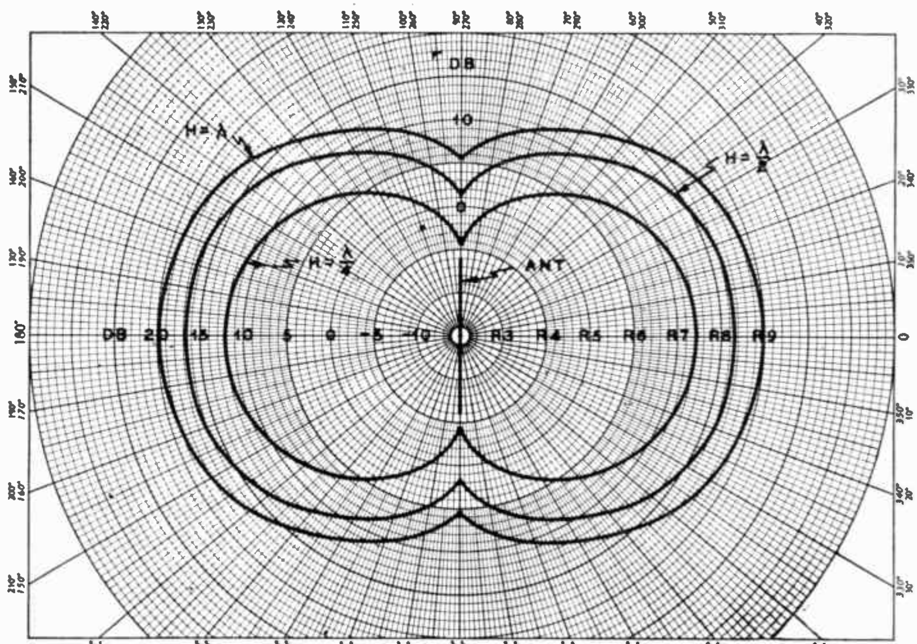
Vertical half wave antennas transmit energy uniformly in all horizontal directions. This type of antenna transmits the major portion of its energy at a low vertical angle, if the antenna is high above the earth. When one end of the vertical half wave antenna is close to the ground, the earth prevents the transmission of energy at right-angles to the wire, so that the major portion of the radiation is at a vertical angle of approximately 16 degrees. There is zero radiation directly off the top of the vertical antenna, and it gradually increases to a maximum at the relatively low vertical angle of approximately 16 degrees, and then is zero again at zero angle or in a direction parallel to the horizon. As the height of a vertical antenna is increased above earth the maximum radiation is at a lower angle, which makes these antennas quite effective for ultra-high-frequency operation and often very efficient for 10 and 20 meter communication.

A horizontal half wave antenna often makes more effective use of the presence of the earth; in the horizontal directions of maximum radiation (broadside) the horizontal antenna *may* produce more signal than a vertical antenna which has the same height above ground as the center of the antenna.

The horizontal antenna receives horizontally polarized radio waves most efficiently, so that this type of antenna is seldom used for *ultra-*high-frequency operation.

A radio signal may be transmitted from a vertical antenna with vertical polarization, but due to the reflection from the *Heaviside Layer* and from the earth it is largely horizontally polarized by the time it reaches the distant receiving point. For this reason, horizontal antennas are very satisfactory for receiving any of the amateur bands *above 5 meters* in wave length. The horizontal antennas are less subject to pickup of man-made noise and automobile ignition than the vertical types of antennas, so that their use is highly recommended.

Horizontal antennas are usually superior to vertical antennas for long-distance transmission or reception *in the 40 and 80 meter bands*, since a larger proportion of the radia-



RADIATION PATTERN AT 15° ANGLE ABOVE HORIZON

H = HEIGHT ABOVE GROUND HORIZONTAL $\frac{\lambda}{2}$ ANTENNA.

tion angle can be confined to vertical angles in the vicinity of 30 degrees. A horizontal, half wave antenna is very nearly non-directional in a horizontal direction *for high angles of radiation.* There is more and more signal gain in the horizontal directions at right angles to the antenna wire (broadside) as the frequency is increased and high angle radiation becomes less and less effective.

The polar diagram here shown gives the horizontal directivity of a half wave horizontal antenna for various heights above ground. This diagram enables the reader to determine the transmission or reception efficiency of this horizontal antenna in any direction, and at three different heights above ground. The effect of the ground is to change the amplitude of radiation, or gain, and does not change the relative horizontal directivity. This curve is especially useful for 20-meter band operation, since it shows the energy radiated at a vertical angle of 15 degrees above earth.

The curves are plotted in db units of relative power gain or loss. The "zero db" circle is an arbitrary point and does not indicate zero radiation, since the 20 db circle, or points, could have been called 40 db, if desired, which would make the zero points 20 db. Db units were used because they provide the most practical curve for amateur use. The operator is interested in the relative amount of power which he can transmit in a given direction.

When the received signal is increased 3 db, this represents twice as much power output from the loudspeaker or headphones; however, this 3 db increase in signal strength is barely perceptible to the human ear. The amateur is usually more familiar with signal strength when expressed in "R" points, such as R6 or R9. A difference of one R point, such as from R6 to R7, has been arbitrarily chosen by many engineers to be equal to a 5 db gain. The polar diagrams are plotted both in points and in db units, for convenience.

The direction of the horizontal antenna wire is indicated in the polar diagram. This antenna, for 20 meter operation, would be approximately 33 feet long and can be fed with any type of feeder without affecting the radiation pattern, providing the feeders are of a non-radiating type. From these curves it can be seen that the radiation in the direction of the antenna wire is 16 db down from that at right angles to the antenna wire. This amount of loss varies with the vertical angle above earth, and is shown in this diagram for an angle of 15 degrees. The value of 16 db represents a gain or loss of slightly more than 3 R points, so that the half wave horizontal antenna should *not* be used for transmission or reception in the direction of the antenna wire, *in the 20 meter band.*

This antenna is very effective over a wide horizontal range; the gain is a maximum at right angles to the wire, as the polar diagram shows; however, it drops off less than 5 db, or one R point, in the horizontal directions 45 degrees to the wire. Thus it can be said that this antenna transmits or receives with practically equal efficiency over two horizontal angles of about 90 degrees. The efficiency, or gain, drops off considerably over the remaining portions of the 360 degree arc.

The polar diagram shows three complete patterns, for various antenna heights above a perfect ground. The inner pattern is for an antenna height of a quarter wave length, which would be about 17 feet above the earth; the center pattern is for a height of a half wave, which would be about 34 feet above the earth, and the outer or larger pattern is for a full wave length, which would be approximately 67 feet. These figures are for a 20 meter antenna.

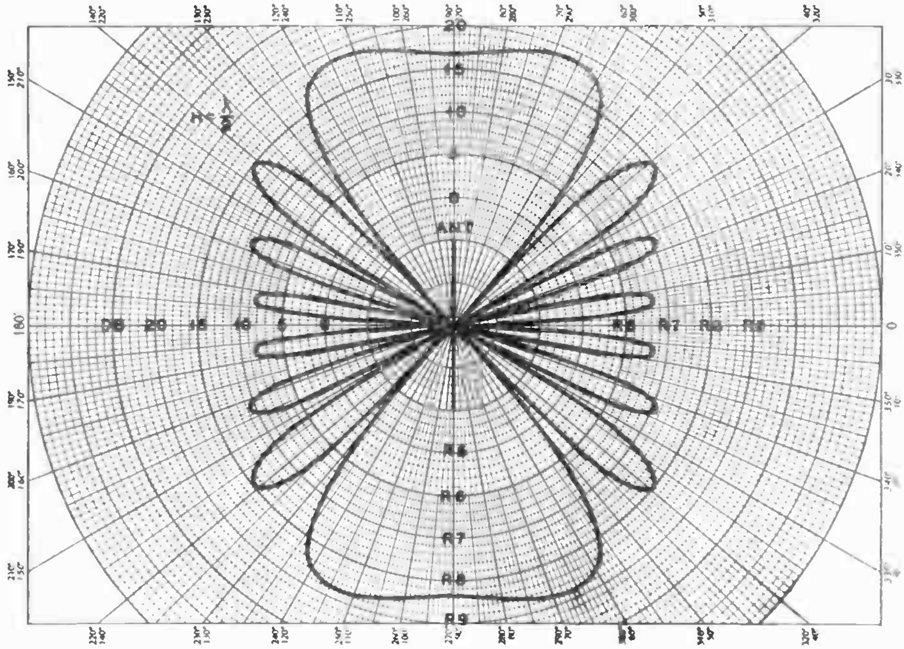
When the height of the antenna is increased from a quarter wave to a half wave above ground, the power gain is increased approximately 5 db, which is greater than that which can be obtained by adding a reflector wire to the antenna. A parasitic reflector wire will only add a gain of 3 db. A further increase in height of the antenna to a full wave adds another 3 db gain. The reason for the great difference in gain with respect to antenna heights is the relatively low angle of radiation. Lower antenna heights tend to confine most of the radiation to higher angles; these angles are of no value in most cases for 20 meter communciation. *Occasionally,* high angle radiation is desirable for long-distance communciation on 20 meters under "freak" conditions, but as a general rule the low angle is far more satisfactory.

It can be seen that height is a very important factor when the operator is mainly concerned with low angle radiation.

The radiation pattern of a very long wire resonant antenna is shown in the accompanying polar diagram. This antenna has a wire length of nearly four full waves for the desired band of operation, which makes it approximately eight times as long as a half wave antenna.

This antenna is often used for 20 meter operation, in which case the antenna wire should be about 275 feet long. The polar diagram shows the radiation pattern at a 15 degree angle above the horizon, since this is the optimum angle for 20 meter operation.

The radiation pattern is quite different from that of a half wave antenna, as shown in the preceding polar diagram. The antenna is a very good "end-fire" radiator, i.e., it is most efficient in the directions of the wire. The antenna has additional minor lobes of radiation off



RADIATION PATTERN AT 15° ANGLE ABOVE HORIZON

H = $\frac{\lambda}{2}$ ABOVE GROUND HORIZONTAL FOUR-WAVE ANTENNA

the sides of the wire; these lobes radiate more power in numerous broadside directions than previous theory would indicate. There are numerous directions of no radiation, or zero signal reception; however, these are confined to very narrow angles and may not be very noticeable to the average operator. The two heart-shaped large lobes of radiation are in reality the four major lobes of a long wire antenna.

If the antenna is very high above earth the radiation directly in line with the wire would be zero, and the pattern would show four major lobes instead of only two. In the practical case of an antenna a half wave above ground, for the angle radiation of 15 degrees, the four lobes merge into two lobes, as shown in the accompanying polar diagram.

The horizontal angle of these lobes can be taken from the polar diagram and a globe or *Great Circle* map can be used as an aid to determine the exact coverage of such an antenna. When the antenna wire is put into position, so that it will transmit or receive best in the desired directions, *true north* should be used, and *not* magnetic north. *True north* may be as much as 20 degrees east or west of *magnetic north* for locations in the United States.

A four wave antenna gives nearly 4 db more gain in the optimum horizontal direction than can be obtained from a horizontal antenna a half wave above ground. This antenna is slightly more effective at an angle of about 25 degrees with respect to the wire than in a direction in line with the antenna wire. The four next largest lobes of radiation are down about a db at their point of maximum intensity, which is about 51 degrees from the direction of the antenna wire. The remaining eight minor lobes, four on each side of the long wire, form a reasonably complete coverage, but with reduced signal strength in the direction of these minor lobes.

A typical antenna for 20 meter operation would be 275 feet long and approximately 34 feet above the ground. This same antenna would correspond to a two wave antenna for 40 meter operation, a quarter wave above ground,—or a full wave antenna at 80 meters. It would be a half wave antenna for the 160 meter band. The resonant frequency of each harmonic of the antenna is not an exact multiple, due to the end effects; however, it can be operated on even harmonics if the antenna is *end-fed*.

On 160 meters, the radiation pattern would be of the shape shown in the polar diagram for a half wave antenna. For intermediate bands, the shape of the radiation pattern changes to other forms.

150 Watt Grid Modulated Phone

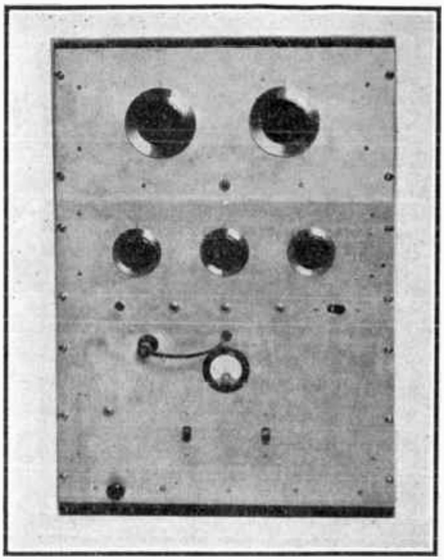
A grid modulated phone transmitter with a single HK-154 triode was described in *"Amateur Radiotelephony"*. The interest which this description created has resulted in a large number of requests for a transmitter of somewhat similar design, but with greater power output. For this reason, the push-pull HK-154 grid modulated phone transmitter described here was developed.

A *properly* designed and operated grid modulated phone transmitter always has good quality of voice transmission. Many of the grid modulated phones on the air today sound "sour", due to incorrect design of the modulator circuit, insufficient antenna load, or excessive grid excitation in the final amplifier. Insufficient antenna loading is one serious cause of non-linearity, usually resulting in audible distortion. Excessive r.f. grid excitation prevents high-percentage modulation and good quality. The problem of maintaining proper adjustment is no more difficult than with a good plate modulated phone transmitter, providing the operator is content to leave the adjustments alone once they have been made.

Medium or low μ tubes are particularly adaptable for grid modulation. The type HK-154 tube is excellent for this purpose because it can be operated at somewhat above rated plate dissipation and is less critical than most tubes with respect to any of the usual adjustments of a grid modulated stage.

The transmitter described here has been in use for several months at W6AJF, and during all of this time it was not necessary to make any readjustments whatsoever. Amateurs who have heard this phone on the air have stated that it sounds above-the-average from the standpoint of voice quality.

This grid modulated phone transmitter is not strictly an efficiency-type of modulation device. The resting efficiency runs between 50% and 60%; obviously this efficiency cannot be doubled during 100% peak modulation. The efficiency apparently increases as usual for low level modulation, and the remaining power represented by a modulated wave is obtained from additional plate supply power release. This transmitter can be modulated up to 90% or 95% without noticeable distortion.

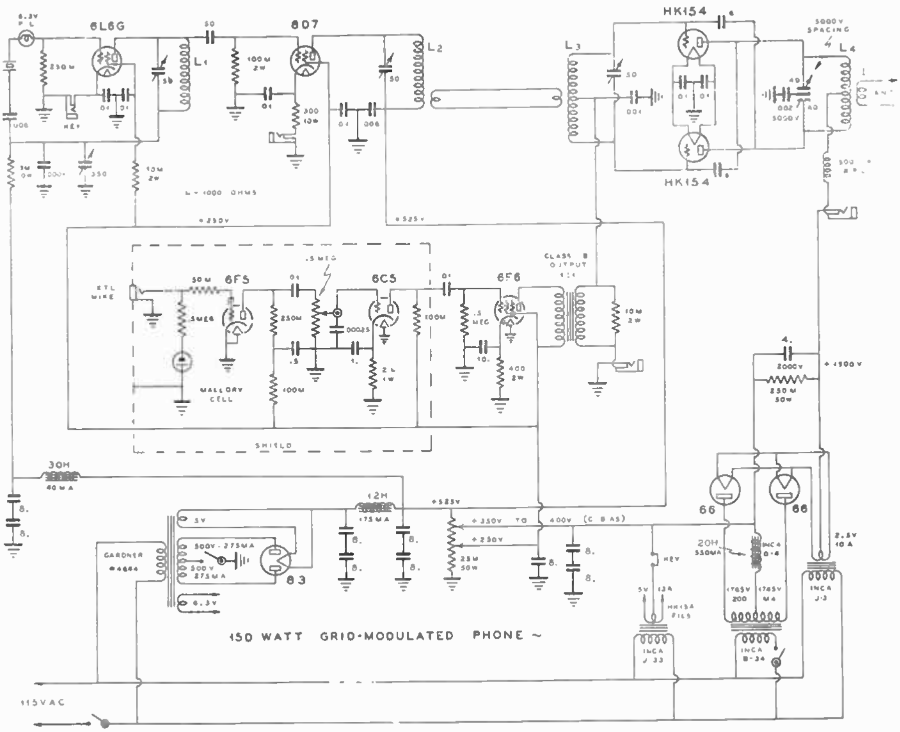


The Entire Transmitter Is Contained in a Single Rack.

The modulator required for the 150 watt carrier from the phone transmitter shown here is a small amplifier tube which supplies not more than 3 watts of audio power. The audio requirement is about 1/40th of that needed for a plate modulated phone transmitter of similar power output. The high voltage power supply filter is smaller than that required for plate modulation for the same degree of hum in the carrier output. This tends to counteract the increased cost of the high voltage power supply.

Circuit Analysis

A 6L6G-807 exciter is used to drive the final amplifier for operation on any band from 75 to 10 meters. This same



exciter has been used to operate the final amplifier on 5 meters at reduced output. The exciter itself is suitable for 160 meter operation, but the final plate tuning condenser, in this case, would require greater capacity than the one shown in the circuit diagram.

The 6L6G crystal oscillator furnishes output on the fundamental, second harmonic, or fourth harmonic of the quartz crystal. The plate circuit is tuned to the desired harmonic. When operated on the fundamental frequency, the plate circuit of the oscillator must be slightly detuned in order not to overload the grid circuit of the 807.

The 6L6G is operated with relatively low screen voltage in order to limit the power output from the tube; the plate circuit is connected to the 525 volt supply through a 3,000 ohm 10-watt resistor which not only reduces the plate voltage to the oscillator but also acts as an r.f. choke. The crystal oscillator is regenerative, as can be seen from the circuit diagram, and a 350 μμfd. variable condenser shunted by a .0001 μfd. (100 μμfd.) mica condenser serves as a control of regeneration when the oscillator is furnishing output on its harmonic. The grid circuit is connected back to the r.f. plate circuit instead of to ground, in order to obtain regeneration. The 6L6G tube always oscillates at the fundamental frequency of the crystal, even when the plate circuit is tuned to a harmonic.

Many amateurs already have a particular type of oscillator or exciter available which will be satisfactory for driving the grid modulated final amplifier. Any exciter which is capable of supplying approximately 25 watts of output is suitable for driving the HK-154's, even on 5 or 10 meters.

The RCA-807 tetrode tube in the exciter of the transmitter shown here, is used either as a buffer or doubler. The tube is operated at normal screen voltage but somewhat above normal plate voltage, in order to obtain at least 20 watts of r.f.

output. Not all of the 525 volts from the plate supply is consumed between the plate and cathode of the RCA-807, since there is about 20 volts drop across the cathode resistor. If the RCA-807 is moderately shielded there is no need for neutralization. The output of this tube when used as a doubler is very nearly as great as when used as a buffer, since the crystal oscillator supplies ample excitation for operation as either.

Approximately 15 watts of r.f. output is obtained from the RCA-807 as a doubler to 5 meters; this is sufficient power to drive the final amplifier with a plate voltage of 1000, and a grid bias of 300 volts. The low reactance in the grid circuit of the final amplifier makes it difficult to build-up an r.f. potential much greater than 300 volts on 5 meters. The r.f. voltage across each grid circuit must have a peak value slightly greater than the d.c. grid bias, which, incidentally, is obtained from the low voltage supply. The same holds true to a lesser degree on 10 meters.

The output from the RCA-807 must be reduced by using rather loose link coupling between the exciter and final amplifier when the transmitter is operated in the 75 meter phone band. This is due to the ease of building-up the required r.f. voltage across the capacitive reactance in the grid circuits of the final amplifier at the lower frequency. The capacitive reactance varies inversely with the frequency, and is therefore one-fifteenth as great on 5 meters as on 75 meters for the same setting of grid tuning condenser.

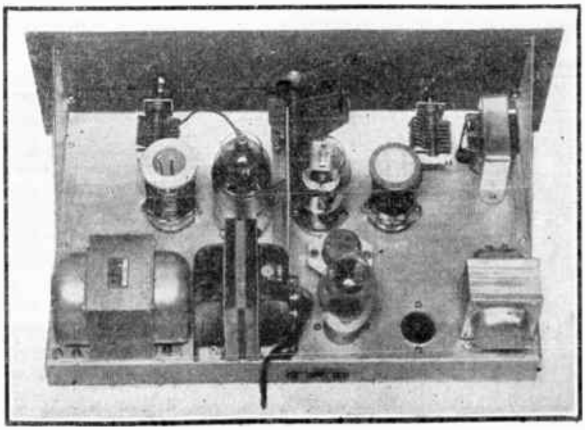
The final amplifier is link coupled to the exciter with a one-turn loop at each end of the link for all bands. The link over the RCA-807 plate coil is varied in position along the coil form as an additional control of r.f. grid excitation to the 154's. The final amplifier is a standard, neutralized push-pull r.f. amplifier with fixed bias equal to approximately 1½ times cutoff. This bias is obtained by connecting the grid return circuit through the modulation transformer to ground and the filament center-tap of the HK-154 tubes, and the negative voltage lead to a positive point on the low voltage bleeder resistor.

The antenna should be link coupled to the final amplifier through an additional tuned circuit unless a twisted-pair feeder is used.

The Audio Channel

The speech amplifier and modulator consists of three metal tubes. A 6F5 high μ triode amplifies the output of a standard diaphragm crystal microphone. This tube is resistance coupled to a 6C5 which, in turn, is resistance coupled to a 6F6 modulator tube. This tube line-up provides sufficient amplification for close talking into the microphone. A 6J7 pentode audio amplifier could be substituted for the 6F5 if greater speech amplification is desired. The 6F6 tube is connected through a small class B output transformer which has a ratio of approximately one-to-one. The grids of the HK-154 tubes and the 10,000 ohm resistor across the output winding of the modulation transformer serve as the load for the modulator. The 10,000 ohm resistor tends to stabilize the load on the 6F6.

Two power supplies furnish all of the



Exciter and 807 Buffer, with Low Voltage Power Supply.

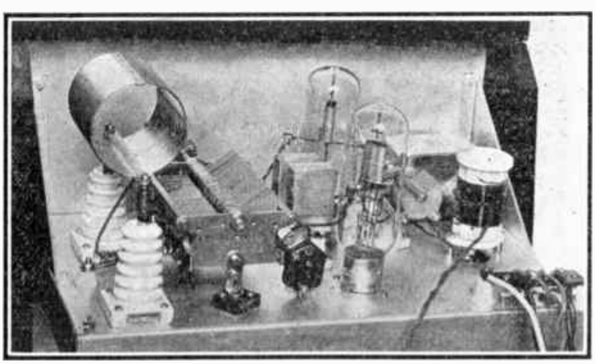
voltages required for the complete transmitter. A type 83 rectifier is in the low voltage unit, and a pair of 866 tubes serve as rectifiers for the high voltage supply. A 1000 volt center-tapped transformer, rated to supply a 275 milliampere load (through a choke input filter) is connected to a condenser input filter system. This type of filter reduces the allowable current drain to 180 milliamperes for this same transformer, yet this is more than ample to supply the exciter and audio voltages. The high voltage power supply uses a transformer which is rated at 3530 volts center-tapped. This transformer, with choke input to the filter, furnishes between 1500 and 1600 volts depending upon the primary line voltage. The high voltage filter consists of a single 20 henry 350 milliampere choke in the center-tap lead, and a 4 μfd., 2000 volt filter condenser. This filter is sufficient to prevent any noticeable a.c. hum in the carrier of the grid modulated stage.

The negative high voltage and center-tap of the final amplifier leads connect to a slider on the 50 watt, 25,000 ohm bleeder across the low voltage power supply. This point can be adjusted to 400 volts and left in that position for operation on any band from 10 to 75 meters. Another tap at between 250 and 275 volts on the same resistor supplies the screen voltage for the exciter and plate voltage for the audio channel. The r.f. output from the complete exciter, particularly the crystal oscillator, must be entirely free from a.c. hum, since a very small amount of hum will produce audio modulation in the grid circuit of the final amplifier. The output must be more pure from the exciter than in the case of a plate modulated phone; however, the ripple in the plate supply to the final amplifier can be greater in the grid modulated stage than in a plate modulated phone.

The crystal oscillator has an additional section of filter in its plate supply; this consists of a small 30 henry, 80 milliampere choke. The taps on the low voltage power supply bleeder resistor must be adjusted while testing the transmitter in order to obtain the correct voltages under normal load conditions.

Mechanical Considerations

The transmitter illustrated is very compact and has overall dimensions of 27 inches high, 19 inches wide and 10 inches deep. It consists of three separate decks mounted behind standard relay-rack panels. The top deck holds the final amplifier and the modulation transformer. The latter can be seen in the photograph (behind the grid tuning circuit) close to the front panel. The reason for locating the transformer on this top deck is to keep it as far as possible from the high voltage power supply which is on the bottom deck. The three speech amplifier tubes are mounted in a small metal can on the main power supply (bottom) deck. Since these tubes are resistance coupled they are not subject to magnetic a.c. hum pick-up. Capacitive coupling is avoided by suitable shields.



The Grid Modulated Final Amplifier.

The middle deck mounts the exciter and low voltage power supply, including the 5-volt filament supply for the final amplifier tubes. The 6L6 oscillator has an aluminum baffle shield between it and the 807 stage. The regeneration condenser is at the center of the panel and is a well-spaced b.c.l. type variable tuning con-

Coil Table for HK-154 Push-Pull Grid Modulated Phone

Band in Meters	*Osc.-Buffer Coil*	*Final Grid Coil*	*Final Amp. Plate Coil*
80	33 turns No. 24 d.s.c., 1½" diameter, 1½" long.	32 turns No. 18 enam., 1¾" diameter, 1¾" long, center-tapped.	36 turns No. 14, 2¾" diameter, 3½" long, center-tapped.
40	16 turns No. 16 enam., 1½" diameter, 1½" long.	20 turns No. 16 enam., 1½" diameter, 1½" long, center-tapped.	22 turns No. 14, 2¾" diameter, 4" long, center-tapped.
20	8 turns No. 16 enam., 1½" diameter, 1½" long.	10 turns No. 16 enam., 1½" diameter, 1½" long, center-tapped.	9 turns No. 14, 2¾" diameter, 2" long, center-tapped.
10	4½ turns No. 16 enam., 1½" diameter, 1¼" long.	5 turns No. 16 enam., 1½" diameter, 1½" long, center-tapped.	7 turns No. 10, 2" diameter, 3½" long, center-tapped.

denser of 350 μμfd. maximum capacity. The two 50 μμfd. tuning condensers in the exciter are mounted on insulated brackets with insulated extension shafts to the front dials. These condensers are double-spaced "Star" midgets. The 807 tube has an aluminum shield extending up around the base of the tube and is made by sawing off parts of a standard large-size aluminum shield can. All of the low voltage power supply leads between decks are run through cables and terminate in five-prong plugs and sockets.

The chassis are each 10 inches by 17 inches by 1¾ inches, made from no. 20 gauge cadmium plated steel. These are rigidly supported by the front panels by means of triangular end-brackets. The front panels are no. 10 gauge aluminum, finished on a wire-wheel brush in order to secure a silver-frosted appearance. A single 0-500 d.c. milliammeter measures the plate and cathode currents in all stages by means of jacks, some of which are insulated from the front panels. A separate 0-10 or 0-25 ma. d.c. milliammeter is a necessary accessory for adjusting the final amplifier for phone operation and should preferably remain permanently in the grid circuit.

Tuning and Operation

The 6L6G oscillator is tuned for maximum dip in cathode current; since the plate and screen voltages on this tube are relatively low, this current is in the vicinity of 20 to 30 milliamperes. The 807 plate circuit is also tuned for maximum dip. This tube will normally be loaded to from 40 to 60 milliamperes of cathode current when driving the final amplifier for grid modulation on any of the bands from 10 to 75 meters. The link coupling and tuning of the final grid circuit, after neutralization, is adjusted to a value which provides less than one milliampere of d.c. grid current. The grid current may kick up to several milliamperes during modulation.

The neutralizing condensers in the final amplifier are adjusted by pushing the plates so that they mesh either more or less, as the case may be. These two neutralizing condensers are made of U-shaped pieces of metal, approximately 2 inches square. The spacing between adjacent plates is about 1/3rd inch. Two of these U-shaped pieces are fastened directly to the respective rotors of the final tank tuning condenser by means of small brackets. The other two sets of plates in the neutralizing condenser are mounted on small standoff insulators; the leads cross-over to opposite grids of the HK-154 tubes. The resulting neutralizing leads and tuned circuit leads are so short that 10 meter operation is very effective and full output can be obtained on this band.

Approximately 90 to 100 watts of carrier output was obtained on the 5 meter band by winding an experimental set of coils, terminating in small plugs which fit tightly into the isolantite coil sockets. The 807 5 meter coil consists of two turns of no. 12 wire, approximately 1 inch in diameter, which plugs into the proper socket holes. The plugs are made by stripping the springs from standard small banana-type plugs. A similar coil with 3 turns, center-tapped, is used for the final grid coil for 5 meter operation. The final amplifier plate coil for this band is made by winding three turns of no. 10 wire, fastened directly between the two rotors of the final tank condenser, rather than being plugged into the large coil support insulators used for the other coils.

Operation on 5 meters will necessitate a reduction in plate potential to 1000 volts. This is accomplished by changing the taps on the high voltage transformer. The bias tap is varied (on the resistor) to a point where approximately 300 volts will be secured. The 5 meter band is the only one in which any special care is required in connecting the coils to the condensers, or in operating with lower modulated stage voltages. Standard coils and fixed values of voltages are used on all of the other bands.

The final amplifier can be keyed in the center-tap for c.w. operation or the crystal can be keyed in its cathode circuit, since fixed—or self—bias is used throughout the entire transmitter. The d.c. grid current to the final amplifier should be run as high as can be obtained from the 807 when c.w. operation is wanted. This varies from about 15 or 20 milliamperes on 20 meters, up to approximately 30 milliamperes on 80 meters. This transmitter was primarily designed for grid modulated phone operation with the result that the exciter is inadequate for greatest output as a c.w. transmitter. The screen voltage on the exciter, particularly on the crystal oscillator, can be somewhat increased to obtain greater output if c.w. operation is to be an important factor.

Antenna Coupling

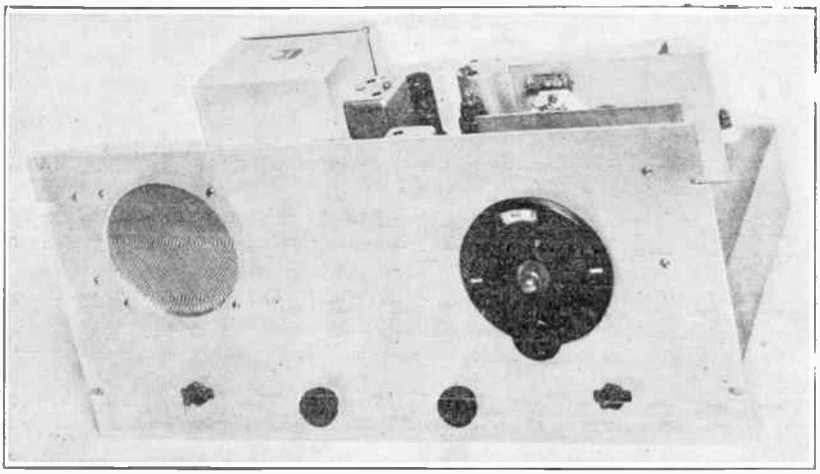
The antenna should be coupled to the final amplifier more tightly than is normally the practice for c.w. or for plate modulated phone transmitters. The coupling should be increased until the plate current is 200 milliamperes for the two HK-154 tubes, at the point of greatest dip in tuning the plate tank condenser. This value of 200 milliamperes should occur when the r.f. grid excitation is set so that only *one-half-of-one-milliampere of grid current is flowing*. Less plate current indicates insufficient antenna loading, providing that the grid excitation is correct, and will result in inferior voice quality.

The plates of the HK-154 tubes operate with a dull cherry-red color; this indicates a dissipation of between 60 and 70 watts per plate.

The peak value of audio voltage required across the output of the modulation transformer for modulation of more than 90% was measured and found to be approximately 120 volts. This represents a total requirement of less than 2 watts of audio power for full modulation.

The plate current in the final amplifier will normally increase 10 to 20 milliamperes when the final amplifier is fully modulated with a steady tone. Peaks of speech input will slightly increase the plate current, but due to the inertia of the meter this increase will not be as noticeable as the application of a steady tone. This increase in plate current represents the release of power into the final amplifier plate circuit necessary for complete modulation. The effect of combined "efficiency" and "power" modulation is to provide a modulated waveform which is relatively free from distortion and at the same time to permit high "resting" efficiency. The theoretical distortion factors apparently tend to cancel, and the final result is a grid modulated amplifier having a resting efficiency of more than 50%, instead of the usual 30%.

A 5 and 10 Meter Superheterodyne

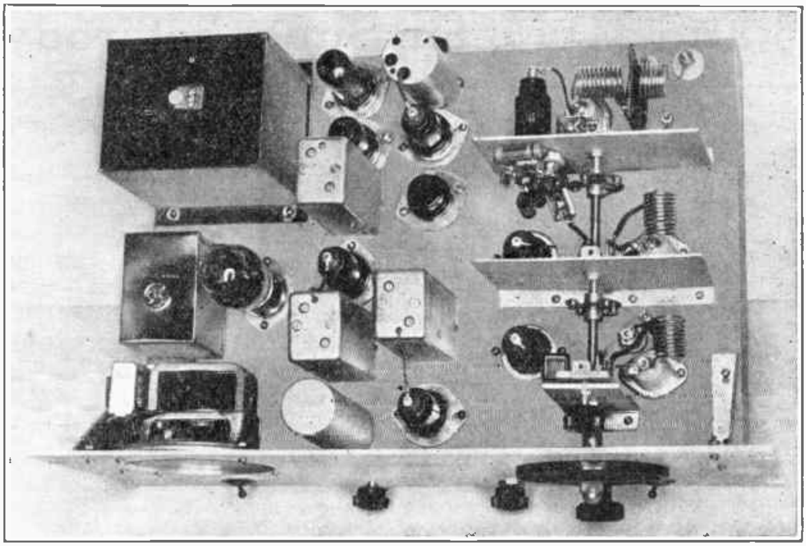


Front Panel View of the Special "5 and 10" Receiver.

An increasingly large number of experimenters are finding that their receiver requirements are not fulfilled with the usual simple 5 and 10 meter receivers. There is also a growing interest in long-distance 5 meter c.w., i.c.w. and phone communication, both for transcontinental and transoceanic testing. It is believed possible that new records may soon be made in the u.h.f. spectrum by means of c.w. transmission, rather than by voice. Super-regenerative receivers are not suitable for c.w. reception because of the impossibility of obtaining beat-note reception. A good ultra-high-frequency superheterodyne can be made more sensitive than a super-regenerative receiver, more stable in operation, and as free from ignition noise pickup as the super-regenerative receiver. A considerable number of amateurs in all parts of the world are now engaged in tests with several hundred watts of crystal-controlled power in the amateur 5 meter band, and it is hoped that this band may at certain times of the year prove to be suitable for dx communication.

Other uses for a combination 5 and 10 meter superheterodyne, such as the one described here, are for police and commercial services where dependability and absence of background hiss are essential requirements. The Dickert noise silencer circuit, as described in *All Wave Radio* magazine, has proven to be very satisfactory for limiting automobile ignition interference, which is extremely bothersome in the u.h.f. range. The receiver herein described employs a modified noise limiting circuit of this type. It is very effective and enables reception of fairly weak signals even in very noisy locations.

A Faraday screen is used to prevent capacitive coupling between the antenna feeders and the first tuned circuit in the receiver. The high-frequency oscillator and mixing circuit were especially designed for u.h.f. operation as a result of numerous tests with all kinds and forms of first-detector circuits. Grid-leak and space-charge detectors were tested and found to be quite sensitive but unsuitable for operation into an i.f. amplifier of more than 500 kc. The amplifier in this receiver uses 1600 kc. air-tuned i.f. transformers and the frequency of the i.f. amplifier can be made any value between 1600 kc. and 5000 kc. by changing the



Top View, Showing Layout of Parts.

i.f. transformers and slightly altering the high-frequency oscillator coils. The choice of i.f. frequency depends upon the service required of the receiver. For 5 meter voice reception, the higher i.f. frequency such as 3000 or 5000 kc. would provide a more broadly tuned i.f. amplifier. The selectivity of the 1600 kc. i.f. amplifier is rather great for reception of signals from an ordinary 5 meter transceiver, but is excellent for reception of m.o.p.a. or crystal-controlled 5 meter voice or c.w. signals. The high-frequency oscillator in this receiver could be crystal-controlled for police communication service where single-frequency reception is desired.

This receiver is tuned with a single dial. The r.f. stage is not of the regenerative type, thus simplifying the problem of ganging this tuned circuit with the first detector and oscillator circuits. The r.f. amplifier, however, has appreciable gain even on 5 meters due to careful circuit design. Very short r.f. leads, low C tuned circuits, and a 6J7 sharp cutoff tube are used to accomplish this purpose.

The 6J7 r.f. tube is operated at very low bias and high screen voltage, and at somewhat more than normal plate current. Under these conditions, the tube has about the same plate current as a 6K7 variable μ tube operating under normal conditions, but produces about twice as much amplification. The increased gain available from a sharp cutoff tube, such as 6J7 or 6C6, gives a better signal-to-noise ratio in the front-end of a superheterodyne. The sharp cutoff tube will provide at least as much r.f. gain-to-noise ratio as can be obtained from a variable μ tube connected in a regenerative r.f. amplifier.

The 6J7 metal tube has nearly twice as much output capacitance as a 6C6 glass tube, if the latter is not shielded. The difference in output capacitance is not very great when the 6C6 tube has a metal shield around it, such as is necessary for any r.f. amplifier. The shell of the metal tube serves as the shield and the small physical size of this tube allows shorter r.f. leads.

The disadvantage of a possible effective higher output capacitance in the r.f. tube can be overcome by using capacitive coupling between the r.f. and first detector tubes. As long as this tube capacity is not too great, it does not lower the L/C ratio in the following tuned circuit, and simply becomes a part of the tuning condenser capacity. The r.f. coupling circuit shown in the schematic diagram is very effective for high-frequency r.f. amplifiers. The variable plate coupling condenser allows exact alignment of the detector tuned circuit if the oscillator and r.f. trimmer condensers have previously been adjusted to the correct values. This method of circuit alignment can only be applied over a very narrow range, since the variation of coupling capacity changes the r.f. gain.

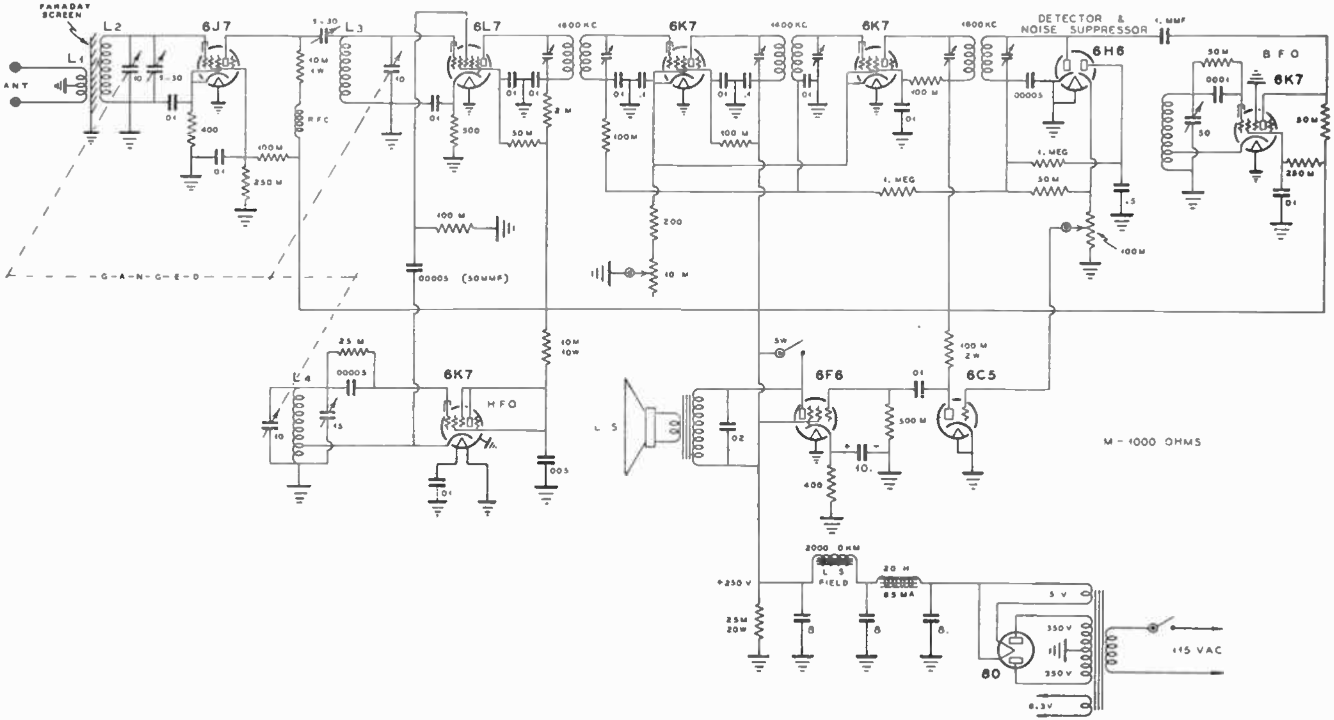
The r.f. amplifier plate can be connected to the positive B through a small r.f. choke of 75 turns of no. 34 d.s.c. wire, closewound on a 3/8 in. diameter bakelite rod. This choke coil is suitable for 5 to 10 meter operation but will not have enough inductance for use on 20 meters. The receiver can be operated on 20 and 40 meters by winding additional coils on small plug-in forms. The 10,000 ohm resistor in series with the r.f. choke in the plate circuit allows operation on 20 or 40 meters (in spite of the too small r.f. choke) and the resistor does no harm when the set is used in the 5 or 10 meter bands.

The 1600 kc. i.f. transformers are tuned by means of air dielectric trimmer condensers. Type G-1601, G-1600 and G-1604 Aladdin iron-core i.f. transformers are used in the amplifier in the order given.

Grid-leak and space-charge first detectors depend upon grid rectification for their operation and the tube itself acts as an additional i.f. amplifier. For audio frequencies or very low i.f. frequencies, grid detection is very effective because the grid impedance can be made high for such low frequencies. The grid coupling condenser by-passes the r.f. frequency to the grid of the detector in these circuits and is supposed to act as a very high impedance to the demodulated or new frequency of the plate circuit. This new frequency is formed in the grid circuit by the process of detection, or mixing, and part of it is lost due to the by-passing action of the grid condenser. If the i.f. frequency is very high, such as 1600 kc., the usual value of .0001 μfd. grid condenser provides quite a low impedance to this frequency; as a result, the tube itself may produce a loss instead of a gain. If the grid condenser is made smaller in order to minimize this loss, its reactance soon becomes too great to apply the major portion of the r.f. signal across the grid-to-cathode capacitance of the tube. Space-charge detectors, such as a type 24-A or 36 tube, act as triodes which have a very low plate impedance and very high mutual conductance. The low plate impedance loads the first i.f. transformer to an excessive degree and tends to reduce both the i.f. amplification and selectivity. A grid-leak detector tends to have a low grid impedance as well as low plate impedance, resulting in a non-desirable load on both the r.f. tuned circuit and the first i.f. tuned circuit. Bias detection eliminates these faults at the expense of a drop in detection efficiency. The final result is a compromise in either case when a 465 kc. i.f. amplifier is used. Tests conducted with this receiver with its 1600 kc. i.f. amplifier indicated the superiority of *bias detection* for weak signal reception.

Several different tubes were tested for use as first detectors, with various forms of oscillator injection. The 6L7 was a great deal more effective for weak signal reception than the 6A8, 6J7, or 6K7 tube. This only holds true, however, for a proper degree of oscillator voltage injection. If the high-frequency oscillator is not able to supply sufficient r.f. voltage, the sensitivity of the 6L7 drops very rapidly and is not as good as that obtained from a 6A8 or 6J7 tube. The oscillator circuit shown is the final result after numerous circuits and tubes had been experimented with.

This oscillator has a 6K7 connected as a triode with the cathode tapped into the tuned grid circuit. The injection grid of the 6L7 is capacitively coupled to the



General Wiring Diagram of the U.H.F. Superheterodyne cathode of the 6K7 oscillator. This arrangement provides sufficient mixing voltage and loads the oscillator tuned circuit to a lesser degree than when the injection grid of the 6L7 is connected to the oscillator grid. The 6K7, connected as a triode, is better than a 6C5 triode from the standpoint of input capacitance. The grid of the 6K7 comes out through the top of the tube and has less capacitance to ground than the grid of the 6C5, which comes out through a prong in the base.

Two stages of i.f. amplification give good selectivity and sufficient gain to operate effectively the second detector and noise limiter circuit. A.v.c. voltage is applied to the i.f. amplifier in order to minimize fading of signals. The a.v.c. voltage, fed-back to the two grid circuits, is not as high as in an ordinary broadcast receiver due to the type of second detector circuit, which combines detection and noise-limiting functions in one tube. A 10,000 ohm variable cathode-bias resistor serves as a control of sensitivity for c.w. reception. As the value of this bias reresistor is increased, the a.v.c. effect becomes less, so that it is not necessary to cut out the a.v.c. for c.w. reception.

A 6H6 double-diode tube serves a dual function; one diode unit acts as a second detector and also supplies a.v.c. voltage to the i.f. amplifier. The second diode in the 6H6 tube provides a noise-limiting or silencing action. This diode acts as a variable resistor shunted across the audio amplifier. When the noise impulses, due to automobile ignition, are of a value greater than the average modulated signal, this diode acts as a short-circuit across the audio output. A noise pulse of very short duration, such as that from automobile ignition interference, causes the receiver to become inoperative for a correspondingly short interval. This interval of silence is so short that it is inaudible to the ear, and it only takes place on noise impulses in which the amplitude is much greater than that of the carrier signal. The 1 megohm resistor and ½ µfd. condenser in the plate circuit of the noise diode have a slow time constant, so that the tube follows the a.v.c. voltage (which is proportional to the carrier signal). This makes the noise limiter entirely automatic in its action, and by choosing those values of resistors in the noise limiter cathode circuit as are shown in the diagram, the noise limiting action can be made to start only for noise pulses of an amplitude greater than the modulated component of the desired signal. Any noise impulse of high amplitude makes the noise diode cathode circuit negative with respect to its plate, and therefore reduces the diode impedance to a few hundred ohms. This portion of the diode is connected across the audio amplifier volume control (100,000 ohm potentiometer) and thereby tends to short-circuit the audio amplifier during the noise impulse interval. This circuit does not eliminate automobile ignition of low or medium amplitude; however, it does improve reception of readable signals through strong ignition interference.

A beat-frequency oscillator is coupled to the second detector diode plate through a small capacitance consisting of a short length of hookup wire twisted twice around the plate lead of the diode. The b.f.o. consists of a standard electron-coupled oscillator tuned to produce a beat note with the 1600 kc. signal for c.w. reception. The value of screen-grid resistor shown in the circuit diagram depends upon the type of grid tuned coil and location of cathode tap.

This b.f.o. coil is made by scramble-winding 150 turns of no. 30 d.s.c. wire on a ½ inch diameter dowel rod, with a winding length of one inch. The cathode tap is made ¼ of the total number of turns up from the grounded end. This dowel rod is then forced into a ½ inch diameter hole in the chassis, and this coil, grid-leak and condenser, are then shielded by covering them with a aluminum shield can. The 50 µµfd. tuning condenser is mounted on the rear of the chassis directly below the b.f.o. coil and the b.f.o. switch is mounted on the front panel for the sake of convenience. Excessive b.f.o. injection into the second detector produces an objectionable amount of hiss and a consequent loss of sensitivity on weak signals. If the injection voltage is too low, the beat note on c.w. reception will be weak and strong signals can not be heterodyned. The amount of injection voltage can be varied by changing the coupling capacity between the two plate circuits, and by changing the value of the screen-grid resistor.

The power supply and loudspeaker are built into the chassis. The presence of the loudspeaker produces an audio howl on signals having a strong carrier if the volume control is advanced too far. If high audio volume is desired, the loudspeaker should be mounted in a separate cabinet. The howling effect is an acoustic feedback from the loudspeaker to the tuning condenser plates and is not easily remedied. Broadcast receivers can be made with the tuning condenser, or complete chassis, mounted on soft rubber. This practice is undesirable for u.h.f. receivers because short, rigid r.f. leads are necessary.

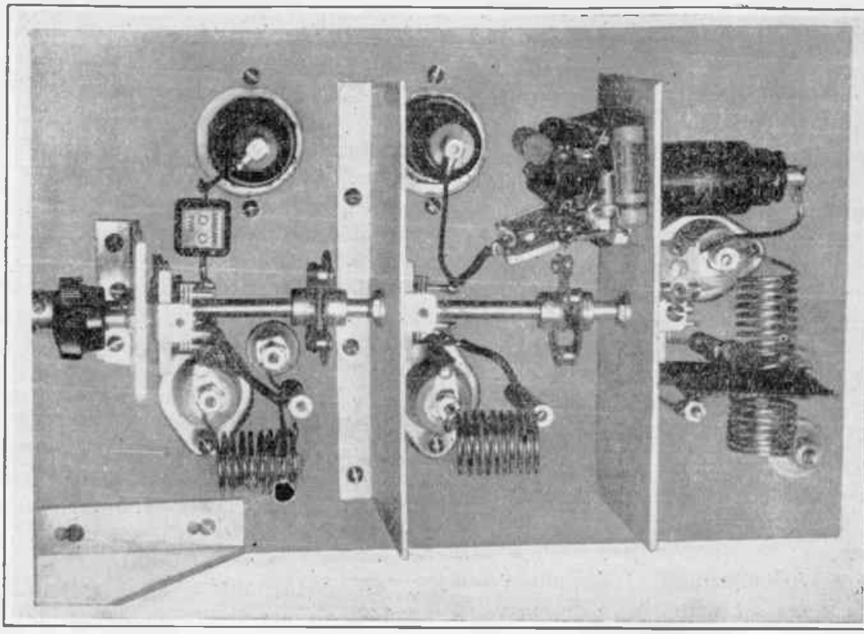
The audio amplifier consists of a 6C5 triode, resistance coupled into a 6F6 pentode. The 6C5 obtains its grid bias from the diode voltage; this bias voltage depends upon the signal strength and position of the arm on the volume control potentiometer. The bias is automatically increased when receiving strong signals, or when the volume control is advanced for a high audio level. This arrangement is desirable in preference to fixed bias because of the noise limiter circuit. The disadvantage lies in obtaining a quiet volume control, since there is a small flow of d.c. current through the resistor, and most types of volume controls tend eventually to become noisy under these conditions.

Mechanical Considerations

The receiver is mounted on a cast aluminum chassis, 12" x 17" x 2½". The front panel is 8¾" x 19", 10 gauge dural. There are three tuning condensers, of the Hammarlund u.h.f. type, originally having a capacity of 35 μμfd. each and then reduced in capacity by removing plates until only two rotors and two stators remain in each condenser. These condensers are very efficient for u.h.f. operation because very short r.f. leads can be made; however, they are difficult to gang together for single-dial tuning. Extension shafts, two in number, each 1¾ in. long, are cut from ¼ inch round brass tubing having an *inside* diameter of ⅛ in. These are forced-fit over the ⅛ inch shafts on the tuning condensers and then soldered in place. This is accomplished by drilling a ¼ in. hole in a block of wood which is clamped to the base plate of a drill press. The tuning condenser's front shaft is then slipped into the ¼ inch hole and the brass extension shaft is fastened into the chuck of the drill press. The chuck is then brought down until the brass tube slips over the ⅛ inch condenser shaft and the two are then sweated together with a hot soldering iron and solder. This alignment procedure results in a reasonably straight extension shaft which rotates on the shaft axis without wobbling. Each tuning condenser is then mounted on an aluminum subpanel, with flexible couplings linking the shafts. The mounting holes for the condensers are made a little large so that the condensers can be lined up with the front section and tuning dial without binding when the dial is rotated. The aluminum panels which hold the condensers (three required) are spaced 3¼ inches apart; and they also serve as r.f. shields between stages. The two larger aluminum shield brackets are 6 in. long and 4 in. high. The smaller bracket is used for the oscillator tuning condenser and padding condenser; this bracket is 2 in. wide and 4 in. high.

Even when great care was exercised in lining up the condenser, the friction developed, plus the friction of each condenser itself, required a vernier tuning dial with a powerful driving action. If care is taken to gang the condensers properly, and if a good dial is chosen, it is easy to tune without backlash, even on 5 meter c.w. reception.

The oscillator components are mounted in the compartment closest to the front



Showing Ganged High Frequency Stages in Detail.

of the receiver in order to minimize backlash, which is inherent even in a solid 1/4 inch brass rod. The detector is mounted in the center compartment and the r.f. tube is mounted in a horizontal position in the third compartment at the rear of the chassis. The horizontal mounting makes it possible to run a very short plate lead, so that the efficiency even on 4 meters is relatively high. Plug-in coils, "air supported", are used for the 5 and 10 meter bands. Brass standoff supports are made by drilling a 1/8 inch hole in one end of a 5/16 in. round brass rod for receiving the banana-type plug on the coil. The other end of each brass standoff (1 1/2 in. long) is drilled and tapped to take a 6/32 machine screw, so that the standoff can be supported to the chassis. Small porcelain standoff insulators, 1 1/2 in. high, support the grid end of each coil by means of a banana-type plug and jack. The cathode of the oscillator feeds up through the chassis into a through-type insulator which has a plug in its end. The oscillator coil has three of the small banana-type plugs, whereas the detector and r.f. coils have only two. The antenna coupling coil is mounted on standoff insulators and the coupling remains fixed for all bands. This coil consists of 7 turns of no. 14 bare wire, 7/8 in .diameter, 3/4 in. long. This coil can be center-tapped to ground for connection to a transposed two-wire feeder, or connected to ground at one end for connection to a concentric line feeder or simple antenna and ground.

A "Faraday screen" is mounted between the antenna coil and r.f. tuned circuit. This screen consists of parallel insulated wires, spaced one diameter of the wire, cemented to a flat sheet of celluloid. One end of all of these wires is soldered to a no. 12 "bus" wire which serves as a common support for the screen. This end is grounded. The remaining ends of all the wires are insulated from each other. The physical size of this screen is 2 1/4" wide and 2 3/4" high.

The 5 meter detector and r.f. grid coils are both identical in size; each has 7 turns of no. 14 wire, 5/8 in. diameter and spaced to occupy a length of 1 1/2 in. The 5 meter oscillator coil consists of 6 turns of no.

14 wire, 5/8 in. diameter, space-wound to occupy a length of 1 1/8 in. The cathode tap is soldered to a point on the coil which is slightly more than one turn from the ground end.

The 10 meter r.f. and detector coils each have 10 turns of no. 14 wire, "air wound", 7/8 in. diameter, 1 1/4 in. long. The 10 meter oscillator coil has 9 turns of no. 14 wire, "air wound", 7/8 in. diameter, 1 1/8 in. long, with a cathode tap taken two turns from the ground end. All coils are fitted with banana-type plugs.

The oscillator padding condenser (15 μμfd. maximum capacity) is mounted directly above its tuning condenser in the compartment closest to the front of the panel, and its capacity is set so that the plates are about one-third enmeshed. The r.f. grid trimmer and r.f. coupling condensers are set with the plates between one-third and one-half enmeshed. The coil turns are then compressed or expanded until the circuits track over the 5 and 10 meter bands. This is a rather tedious procedure and can be accomplished most easily by means of the 5 or 10 meter harmonics from a test oscillator or signal generator.

The first detector connects to the i.f. transformer nearest to it and the high-frequency oscillator tube. The first i.f. tube is mounted close to the front panel and it feeds into the second i.f. transformer, which is directly behind the round electrolytic condenser can. The second i.f. amplifier tube and third i.f. transformer are in a line with the 6C5 and 6F6 audio tubes.

The 6H6 detector and 6K7 b.f.o. tube and coil are mounted near the last i.f. transformer and audio tubes. The power supply components are mounted far to the left on the chassis. The knob on the rear side of the chassis is the b.f.o. adjuster.

All of the .00005 μfd. (50 μμfd.) condensers are of the mica type; the remaining condensers are of the 600 volt tubular paper type, except for the 1/2 μfd. noise filter condenser, which has a rating of 400 volts.

250 Watt 20 Meter C.W. Transmitter

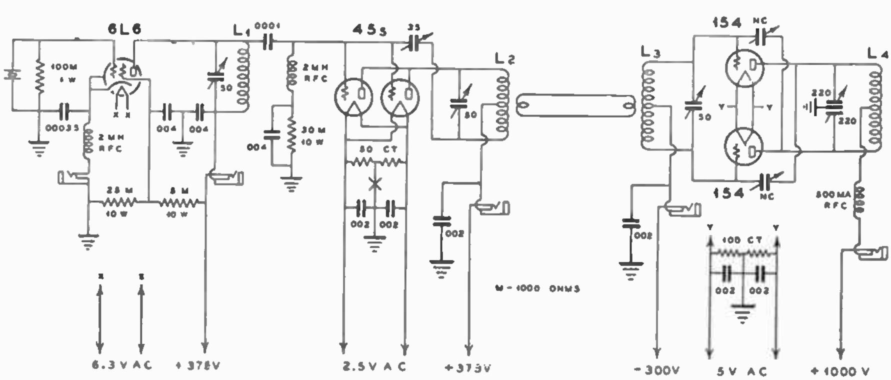
A c.w. transmitter primarily designed for full efficiency on 20 meters would obviously be ideal for 40 meter operation, thus giving the amateur a two-band transmitter which can be operated on either of these most popular dx bands when conditions so warrant.

The transmitter described here will deliver an output of 250 watts without overloading any stage. It consists of a standard 6L6 regenerative crystal oscillator capacitively coupled to a pair of neutralized type 45 tubes in parallel. These are then link coupled to a pair of HK-154 tubes in push-pull in the final amplifier.

A metal tube 6L6 crystal oscillator is used with a 40 meter crystal for operation either on 40 or 20 meters by tuning the plate circuit of the oscillator to either the fundamental frequency or the second harmonic. The crystal oscillator is regenerative, due to the feedback between the plate of the 6L6 tube to its cathode through the capacity of the metal shell of the tube. The metal shell is connected to the cathode at the tube socket terminals. The remaining portion of the regenerative circuit is the cathode by-pass condenser of .00035 μfd. The latter can have a value as low as .00025 μfd. in most cases, without self-oscillation taking place in the crystal oscillator when the transmitter is operated on 20 meters. The 6L6 is capacitively coupled to two type 45 tubes in parallel through a .0001 μfd. mica condenser. The type 45 tubes are neutralized with a split-coil circuit which is tuned with a single-section double-spaced 50 μμfd. variable condenser. This circuit is link coupled to the final grid circuit. A one-turn loop is used at each end of the link so that the coupling to the 45 plate coil can be made very loose.

Fixed bias is used on the final amplifier to allow keying in the center-tap lead of the type 45 tubes.

The transmitter is mounted on a breadboard which is covered with a sheet of aluminum tacked into position on the under-side of the board. This aluminum sheet acts as a common ground. All the parts are mounted on bakelite subpanels or on standoff insulators. The grid coil

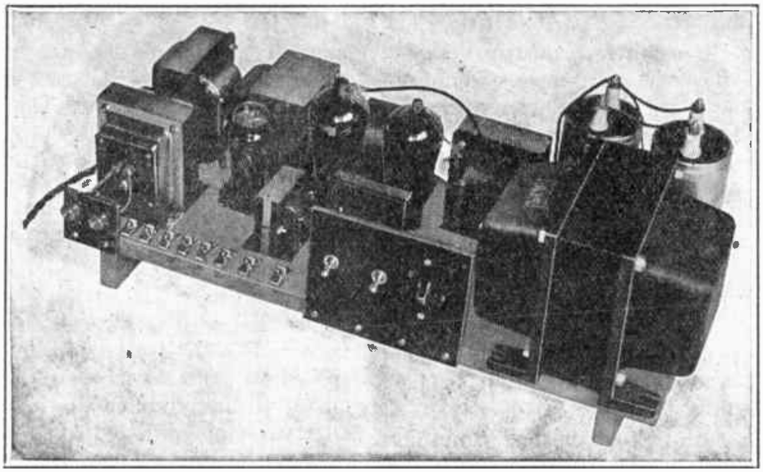


NC - NEUTRALIZING CONDENSERS MADE OF 2" DIAM DISCS SPACED 3/16" TO 1/4"

— FOR 14 MC. OPERATION —

L1 - 6 TURNS Nº 18 1½" DIAM. 1½" LONG
L2 - 10 TURNS Nº 18 1½" DIAM. 1½" LONG
L3 - 12 TURNS Nº 18 1½" DIAM. 1½" LONG
L4 - 7 TURNS Nº 14 2½" DIAM. 2" LONG

7 MC CRYSTAL



The 375 Volt and 1000 Volt Power Supplies.

for the final amplifier is raised about 2 inches above the baseboard to keep the grid leads short. The two neutralizing condensers are mounted one on either side of the final amplifier tubes, as shown in the photograph, and the tube plate leads are cross-connected to opposite stators of the plate tuning condenser.

The neutralizing condensers have two aluminum discs each, 2 in. in diameter, spaced about 1/4 inch apart. The capacity is varied by means of a threaded-rod adjustment.

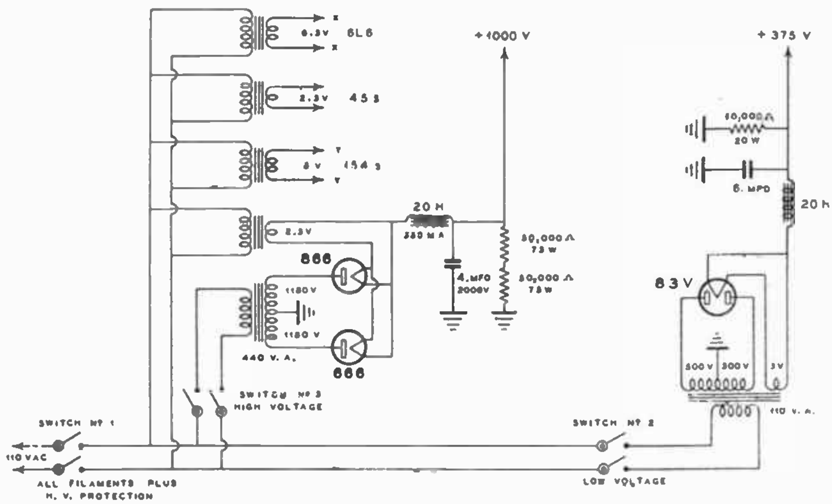
Double-spaced midget tuning condensers are used for tuning the type 45 tube plate circuit, final grid circuit, and for neutralizing the type 45 tubes. The oscillator tuning condenser is a single-spaced midget variable. The final tank condenser has a maximum capacity of 220 μμfd. per section, which is much larger than required for 20 or 40 meter operation. Only a small portion of the available capacity of this final tank condenser is used for tuning. A condenser with a rating of 3,000 volts breakdown per section, 50 μμfd. capacity in each section, would be entirely suitable for this transmitter.

All coils are wound on isolantite forms. The oscillator coil for 20 meter operation has 6 turns of no. 18 wire, on a 1½" diameter form, and covers a winding length of 1⅛" in. An oscillator coil suitable for 40 meter operation would have 14 turns of no. 18 wire on a 1½" diameter form, wound to cover 1½ inches.

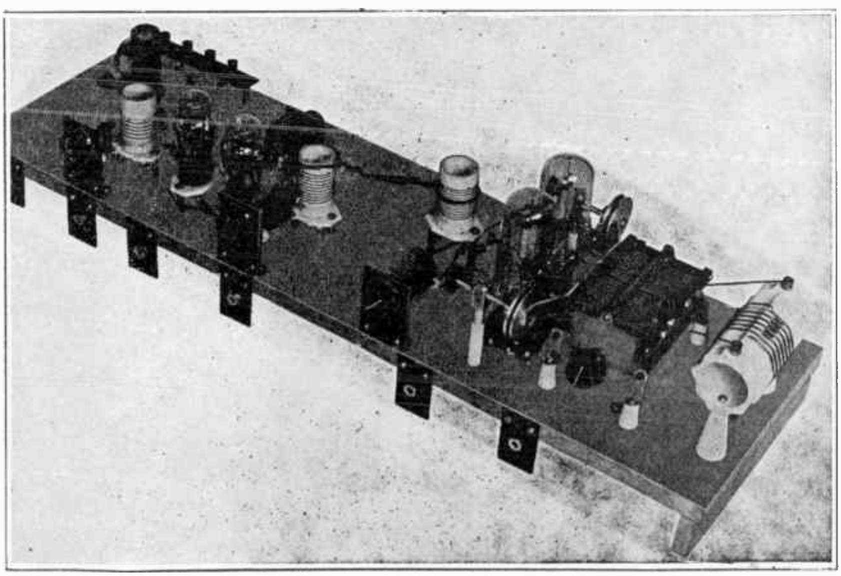
The 20 meter plate coil for the 45 stage consists of 10 turns of no. 18 wire, center-tapped, on a 1½ inch diameter form, with a winding length of 1½ inches. A 40 meter coil for this same stage would have 20 turns of no. 18 wire, on a 1½ inch diameter form, wound to cover a space of 1½ inches.

The final amplifier grid coil for 20 meter operation has 12 turns of no. 18 wire, on a 1½ in. diameter form, with a winding length of 1½ inches, and is center-tapped. A 40 meter coil for this stage would have 22 turns of No. 18 wire, on a 1½ in. diameter form, wound to cover 1½ inches, and would be center-tapped.

The final amplifier plate coil for 20 meter operation has 7 turns of no. 14 wire on a 2½ in. diameter form, spaced



General Wiring Diagram of the Two Power Supplies.



The R.F. Section of the Transmitter Is Also Built Breadboard Fashion.

to cover 2 inches, and is center-tapped. A coil suitable for 40 meters would have 14 turns on a 2½ in. diameter form, 7 turns per inch, with a center-tap.

The final tank coil should be mounted on standoff insulators fitted with plugs and jacks for convenience in changing coils.

Power Supply

Two separate power supplies are needed for operating this transmitter. The low voltage supply has a 1000 volt center-tapped transformer which delivers approximately 375 volts across the output of the filter. This transformer should be rated to carry a d.c. load of 150 milliamperes. The high voltage power supply delivers 1000 volts at 350 milliamperes. The power transformer delivers approximately 1200 volts each side of center and is rated at 440 watts. Two type 866 tubes serve as rectifiers in this power supply, which has a single-section choke input filter.

The filters shown in the circuit diagram and in the photographs provide pure d.c. for c.w. operation, but would not be satisfactory for phone communication. The 5 volt filament transformer for the HK-154 tubes must be capable of supplying 16 amperes and should have taps on the primary winding to adjust the voltage at the filament of the tubes to 5 volts.

The plate current in the final amplifier should read between 300 and 350 milliamperes under load; the grid current will run between 30 and 40 milliamperes.

Transmitting Tube Characteristics

● **The following tube data is new and supplementary to that in the JONES RADIO HANDBOOK. Some of the data are in the form of corrections; some represent manufacturers' new ratings.**

HK-354D

Heinz & Kaufman Triode. Ultra-high-frequency amplifier, doubler and class B audio amplifier. Similar to HK-354C except for amplification constant.

Characteristics:

Filament voltage	5.0 volts
Filament current	10.0 amps.
Amplification constant	22
Normal plate dissipation	150 watts
Maximum d.c. plate voltage	4000 volts
Maximum d.c. plate current	300 m.a.
Maximum d.c. grid current	50 m.a.

Base: Standard 50 watt. Plate through top, grid through side of envelope.

Class C R.F. Amplifier:

D.C. plate voltage	1500	2000	2500	3000	3500	volts
D.C. grid voltage	—236	312	—317	—424	—490	volts
D.C. plate current	300	297	274	255	240	m.a.
D.C. grid current	50	50	50	50	50	m.a.
Grid driving power	24	26	30	35	38	watts
Grid-bias loss	12	12	16	21	25	watts
Approximate power output	316	445	535	614	690	watts

R.F. Doubler:

D.C. plate voltage	1000	1500	2000	volts
D.C. grid voltage	—361	—458	—619	volts
D.C. plate current	250	200	175	m.a.
D.C. grid current	50	50	50	m.a.
Grid driving power	32	36	44	watts
Grid-bias loss	16	22	32	watts
Approximate power output	100	150	200	m.a.

Class B Audio Amplifier (Two Tubes):

D.C. plate voltage	1500	2000	2500	3000	volts
D.C. grid voltage	—60	—87	—112	—135	volts
Zero signal d.c. plate current	50	50	50	50	m.a.
Maximum signal d.c. plate current	277	362	290	327	m.a.
Plate to-plate load resistance	12000	20000	20000	21000	ohms
Power output	302	469	519	692	watts

Suggested Driver: Four type 2A5 or 42 tubes, triode connected, with fixed bias and 350 volts plate supply.

HK-354E

Heintz & Kaufman triode for U.H.F. service. Tantalum late and grid. Similar to HK-354 in physical size, but with grid out of side of envelope. Principal difference lies in amplification constant. Suitable for class C r.f. amplifiers, class B audio and r.f. frequency doubling.

Characteristics:

Filament voltage	5 volts
Filament current	10 amps.
Amplification constant	35
Maximum d.c. plate voltage	4000 volts
Maximum d.c. plate current	300 m.a.
Normal plate dissipation	150 watts

Base: Standard 50 watt. Plate through top, grid through side of envelope.

Class C R.F. Amplifier:

D.C. plate voltage	1500	2000	2500	3000	3500	volts
D.C. plate current	300	297	275	255	240	m.a.
D.C. grid bias	—287	—295	—392	—437	—448	volts
D.C. grid current	60	60	60	60	60	m.a.
Grid driving power	35	36	42	45	45	watts
Grid bias loss	17	18	24	26	27	watts
Power output, approximate	315	445	525	615	690	watts

R.F. Doubler:

D.C. plate voltage	1000	1500	2000	volts
D.C. plate current	250	200	175	m.a.
D.C. grid bias	—238	—379	—474	volts
D.C. grid current	60	60	60	m.a.
Grid driving power	31	38	44	watts
Grid bias loss	14	23	29	watts
Power output, approximate	100	150	200	watts

Class B Audio (2 Tubes):

D.C. plate voltage	1500	2000	2500	3000	volts
D.C. grid bias	—25	—37.5	—50	—67	volts
No signal d.c. plate current	50	50	50	50	m.a.
Maximum signal D.C. plate current	325	372	343	335	m.a.
Load resistance, plate-to-plate	10000	11000	16000	20000	ohms
Power output	320	470	600	700	watts

HK-354F

Heintz & Kaufman triode. Ultra-high-frequency. Class C r.f. frequency doubling and class B audio amplification. Similar to HK-354 in size.

Characteristics:

Filament voltage ... 5.0 volts
Filament current ... 10.0 amps.
Amplification factor ... 50
Normal plate dissipation ... 150 watts
Maximum d.c. plate voltage ... 4000 volts
Maximum d.c. plate current ... 300 m.a.
Maximum d.c. grid current ... 75 m.a.
Base: Standard 50 watt. Plate through top, grid through side of envelope.

Class C R.F. Amplifier:

D.C. plate voltage	1500	2000	2500	3000	3500	volts
D.C. grid voltage	—85	—135	—225	—312	—368	volts
D.C. plate current	300	295	260	255	250	m.a.
D.C. grid current	75	75	75	75	75	m.a.
Grid driving power	28	31	38	45	50	watts
Grid-bias loss	6.5	10	17	23.5	27.5	watts
Power output, approximate	300	435	500	615	720	watts

R.F. Doubler:

D.C. plate voltage	1000	1500	2000	volts
D.C. grid voltage	—243	—395	—425	volts
D.C. plate current	250	200	175	m.a.
D.C. grid current	75	75	75	m.a.
Grid driving power	38	49	50	watts
Grid-bias loss	18	30	32	watts
Power output, approximate	100	150	200	watts

Class B Audio Amplifier (Two Tubes):

D.C. plate voltage	1500	2000	2500	3000	volts
D.C. grid voltage	—15	—22.5	—35	—45	volts
Zero signal plate current	50	50	50	50	m.a.
Maximum signal d.c. plate current	280	347	300	344	m.a.
Plate-to-plate load resistance	12000	12000	20000	20000	ohms
Power output	290	445	550	725	watts

HK-354C

Heintz & Kaufman Triode. Ultra-high-frequency amplifier, tantalum plate and grid. Suitable for use as class B modulator and class C amplifier. All characteristics are the same as those for HK-354, except for lower grid-to-filament capacity. The grid comes out through the side of the glass envelope, rather than through the base of the tube as in the HK-354, which makes the tube more suitable for high-frequency operation. Refer to HK-354 for characteristics and operating data.

●

TAYLOR

203-B

Taylor High-mu Triode. Redesigned primarily for class B audio amplifiers.

Driver:
2A3s in push-pull with Primary / ½ sec. = 1.6 ratio input transformer

Characteristics:

Filament voltage ... 10 volts
Filament current ... 3.85 Amps.
Amplification factor ... 25
Maximum plate dissipation ... 55 watts
Maximum d.c. plate voltage ... 1250 volts
Maximum d.c. plate current ... 150 m.a. (in R-F circuits)
Grid to plate capacity ... 14 μμfd.
Grid to filament capacity ... 6 μμfd.
Plate to filament capacity ... 5 μμfd.
Base ... Standard 4 pin. 50 watt

Class B Audio Amplifier (2 tubes):

D.C. plate voltage	1000	1250 volts
D.C. grid voltage (approx.)	—35	—45 volts
Zero signal d.c. late current (per tube)	20	20 m.a.
Maximum signal d.c. plate current (2 tubes)	330	350 m.a.
Load impedance (plate to plate)	6800	7900 ohms
Power output	200	300 watts
Driving power	10	12 watts

203-Z

Taylor Tube Co. zero-bias class B audio amplifier or modulator. Standard 50-watt base, metal plate, plate lead through top of envelope. Suitable for r.f. operation at frequencies below 15 Mc.

Characteristics:

Filament voltage ... 10.0 volts
Filament current ... 3.85 amps.
Amplification factor ... 85
Mutual conductance ... 5900 μmhos
Average plate resistance ... 16,700 ohms

Class B Audio Amplifier or Modulator:

D.C. plate voltage	1250 (max.)	1000 volts
Grid bias voltage	0	0 volts
Zero-signal plate current	45	35 m.a.
Max.-signal plate current	175	153 m.a.
Load res., plate-to-plate	7900	6900 ohms
Power output, two tubes	300	200 watts

Radio Frequency Amplifier Service:

Maximum plate voltage ... 1250 volts
Maximum plate current ... 175 m.a.
Maximum grid current ... 60 m.a.
Grid bias resistor (class C service) ... 2500 ohms
Maximum frequency for full ratings ... 15 Mc.

T20

Taylor Tube Co. H.F. Triode. General purpose high μ; suitable for high-frequencies up to 56 Mc. Suitable for class B audio service, or as an r.f. frequency-doubler or r.f. amplifier. Isolantite-based tube with plate through top of envelope. 4-pin base. Molybdenum plate. Greater plate dissipation than type 10 or 841 triode.

Characteristics:

Filament voltage ... 7.5 volts
Filament current ... 1.75 amps.
Amplification factor ... 20
Grid-to-plate capacity ... 4 μμfd.
Maximum plate dissipation ... 20 watts
Maximum d.c. plate voltage ... 750 volts
Maximum d.c. plate current ... 75 m.a.
Maximum d.c. grid current ... 25 m.a.

Class B Modulator or A.F. Amplifier (2 Tubes)

D.C. plate voltage	800	600 volts
D.C. grid voltage	—40	—30 volts

Zero signal late current (per tube)	10	10 m.a.
Maximum signal plate current (per tube)	68	70 m.a.
Load resistance (plate-to-plate)	12000	8100 ohms
Power output	70	50 watts

Class C Amplifier:

D.C. plate voltage....750 volts
D.C. grid voltage....—100 volts
D.C. plate current....75 m.a.
D.C. grid current....20 m.a.
Grid driving power (approx.)....3 watts
Grid bias loss....2 watts
Power output (approx.)....40 watts

TZ-20

Taylor Tube Co. H.F. triode. Primarily designed for zero-bias class B audio use. Also suitable for all r.f. uses for which the T-20 is suitable. Operating conditions for r.f. use of the TZ-20 will be similar to those of the T-20; the grid bias, however, will be somewhat lower in each case. An improved doubler over the T-20. Isolantite base, metal plate, plate lead through top.

Characteristics:

Filament voltage....7.5 volts
Filament current....1.75 amps.
Amplification factor....62
Average plate resistance....26,700 ohms
Mutual conductance....2320 μmhos

Class B Audio Amplifier or Modulator:

D.C. plate voltage	800	600 volts
Grid bias voltage	0	0 volts
Zero-signal plate current	20	14 m.a.
Max.-signal plate current	69	70 m.a.
Load res., plate-to-plate	12,000	8100 ohms
Power output, two tubes	70	50 watts

Radio Frequency Amplifier Service:
See operating conditions for T-20.

866 Jr.

Taylor Tube Co. Mercury vapor half wave rectifier for operation in full wave or bridge rectifier systems. Intermediate in load capability between the type 866 and 83 rectifiers.

Characteristics:

Filament voltage....2.5 volts
Filament current....2.5 amps.
Maximum RMS a.c. voltage....1250 volts
Maximum d.c. load current (choke input)..250 m.a.
Base: Standard 4 pin, UX, Isolantite.

●

WESTINGHOUSE

WL461

Westinghouse ultra-high-frequency triode for medium and high power service. Special design of terminals for elements enables direct connection to elements, thus providing a very low inductance path to the tube electrodes. This construction, together with low interelectrode capacities, gives 5 megacycle performance at 50 megacycles and useful output up to 150 megacycles.

Characteristics:

Filament voltage....5.0 volts
Filament current....11.5 amps.
Amplification constant....28
Maximum d.c. plate voltage....2000 volts
Maximum a.c. plate voltage (RMS)....2500 volts
Maximum d.c. plate current....250 m.a.
Maximum plate dissipation....160 watts
Dimensions....7½" long, 3¾" diameter
Tantalum plate, all leads out thru base in special short leads for diathermy operation.
Approximate power output on 50 Mc....400 watts

EIMAC

Data To Replace 100 T:

100TL

Eimac UHF Triode with medium amplification constant. Designed primarily for diathermy service and as replacement for original Eimac 50 T.

Characteristics:

Filament voltage....5 to 5.1 volts
Filament current....6.5 amps.
Grid-to-plate capacity....2.3 μμfd.
Grid to-filament capacity....2.0 μμfd.
Plate-to-filament capacity....0.4 μμfd.
Normal plate dissipation....100 watts
Maximum d.c. plate voltage....3000 volts
Maximum d.c. plate current....225 m.a.
Maximum d.c. grid current....35 m.a.
Amplification factor....12
Base: Standard UX 4-pin. Plate thru top, grid thru side of envelope.

Class C R.F. Amplifier:

D.C. plate voltage	1000	2000	3000 volts
D.C. plate current	200	150	135 m.a.
D.C. grid current	30	30	30 m.a.
D.C. grid bias	—200	—400	—600 volts
Approximate power output	120	225	300 watts
Approximate grid driving power	7.5	13.5	21 watts
Grid bias loss	6	12	18 watts

Class B Audio Amplifier:

D.C. plate voltage	1000	2000	3000 volts
Load impedance, plate-to-plate	5200	16000	30000 ohms
Power output, 2 tubes	170	350	465 watts

100TH

Eimac. High-mu U.H.F. triode. Especially suitable for class C r.f. amplification and class B audio service. Replaces Eimac 100 T in Tube Tables, page 263 JONES RADIO HANDBOOK, 1937 edition.

Filament voltage....5 to 5.1 volts
Filament current....6.5 amps.
Amplification factor....30
Grid-to-plate capacity....2 μμfd.
Grid-to-filament capacity....2.2 μμfd.
Plate-to-filament capacity....0.3 μμfd.
Maximum d.c. plate voltage....3000 volts
Maximum d.c. plate current....225 m.a.
Maximum d.c. grid current....50 m.a.
Normal plate dissipation....100 watts
Base: Standard UX 4-pin, Isolantite. Plate thru top, grid thru side of envelope.

Class C R.F. Amplifier:

D.C. plate voltage	1000	2000	3000 volts
D.C. plate current	200	150	135 m.a.
D.C. grid current	45	45	45 m.a.
D.C. grid bias	—70	—140	—210 volts
Approximate grid driving power	4.5	8	10 watts
Grid bias loss	3.2	6.3	9.5 watts
Approximate power output	120	225	300 watts

Class B Audio Amplifier:

D.C. plate voltage	1000	2000	3000 volts
Load impedance, plate-to-plate	5200	16000	30000 ohms
Power output, 2 tubes	210	380	500 watts

250TL

Eimac. U.H.F. Triode with medium amplification factor. Designed for diathermy service and for replacement of older type 150 T Eimac.

Characteristics:

Filament voltage....5 to 5.1 volts
Filament current....10.5 amps.
Amplification factor....13
Grid-to-plate capacity....3.5 μμfd.
Grid-to-filament capacity....3.0 μμfd.
Plate-to-filament capacity....0.5 μμfd.

Maximum d.c. plate voltage....................3000 volts
Maximum d.c. plate current........................350 m.a.
Maximum d.c. grid current............................50 m.a.
Normal plate dissipation.............................250 watts
Base: Standard 50-watt. Plate through top, grid through side of envelope.

Class C R.F. Amplifier:

D.C. plate voltage......	1000	2000	3000 volts
D.C. plate current......	300	350	330 m.a.
D.C. grid current........	45	45	45 m.a.
D.C. grid bias..............	—200	—400	—600 volts
Approximate grid driving power................	11	22	33 watts
Grid bias loss...........	9	18	27 watts
Approximate power output	200	500	750 watts

Class B Audio Amplifier:

D.C. plate voltage......	1250	2000	3000 volts
Load impedance, plate-to-plate	3280	6000	12400 ohms
Power output, 2 tubes	540	900	1180 watts

250TH

Eimac. High-mu U.H.F. Triode. Designed primarily for r.f. amplification and class B audio service.

Characteristics:
Filament voltage....................................5 to 5.1 volts
Filament current ....10.5 amps.
Amplification factor..32
Grid-to-plate capacity ....3.3 μμfd.
Grid-to-filament capacity.............................3.5 μμfd.
Plate-to-filament capacity ....0.3 μμfd.
Maximum d.c. plate voltage.....................3000 volts
Maximum d.c. plate current.........................350 m.a.
Maximum d.c. grid current.............................65 m.a.
Normal plate dissipation..............................250 watts
Base: Standard 50-watt. Grid through side, plate through top of envelope.

Class C R.F. Amplifier:

D.C. plate voltage.........	1000	2000	3000 volts
D.C. plate current........	300	350	330 mi.a.
D.C. grid current........	55	55	55 m.a.
D.C. grid bias................	—70	—140	—210 volts
Approximate grid driving power	8	16	25 watts
Grid bias loss..............	3.9	7.7	11.6 watts
Approximate power output	200	500	750 watts

Class B Audio Amplifier:

D.C. plate voltage.........	1000	1500	3000 volts
Load impedance, plate-to-plate	2360	4200	12400 ohms
Power output, 2 tubes	350	630	1180 watts

Grid Bias: Zero for plate potentials up to 1400 volts.

450TH
450TL

Eimac high power triodes. The 450TH has an amplification factor of 32, the 450TL has an amplification factor of 16. These tubes are especially designed for broadcast and commercial transmitters. Tantalum plates and grids.

Filament voltage...7.5 volts
Filament current..12 amps.
Maximum d.c. plate current.........................500 m.a.
D.C. plate voltage..4000 volts
Normal plate dissipation..............................450 watts
Grid to plate capacity..................................4.5 μμfd.
Base: Standard 50 watt type. Plate out thru top and grid thru side of glass envelope.

●

RAYTHEON

RK-39

Raytheon beam power tetrode, designed for frequency-doubler, amplifier, or crystal oscillator service. Frequency range: full voltage ratings up to 30 Mc. Maximum plate voltage at 60 Mc., 400 volts.

Characteristics:
Heater voltage..6.3 volts
Heater current..0.9 amps.
Grid-to-plate capacity...............................0.15 μμfd.
Input capacity...13 μμfd.
Output capacity...10.5 μμfd.
Maximum plate dissipation...........................21 watts
Maximum screen dissipation.....................3.5 watts
Maximum d.c. plate voltage........................500 volts
Maximum d.c. screen voltage.......................300 volts
Maximum d.c. screen current.........................20 m.a.
Maximum d.c. plate current.........................100 m.a.
Maximum d.c. control grid current................5 m.a.
Base...............................Standard 5-Pin (Isolantite.)
Plate Through Top of Envelope.

R.F. Service

	Class B R.F.	Class C
D.C. plate voltage......................	500	500 volts
D.C. plate current.......................	75	95 m.a.
D.C. screen voltage.....................	250	250 volts
D.C. screen current.....................	3	12 m.a.
D.C. control grid current...........	0.3	3 m.a.
Carrier power input.....................	11	35 watts

●

AMPEREX

ZB120

Amperex. Zero-bias Triode. Especially designed for class B audio amplification. Can be used as linear r.f. power amplifier. Is capable of delivering up to 150 watts in class C r.f. service. Its high amplification factor makes it an efficient frequency doubler.

Characteristics:
Filament voltage...10 volts
Filament current..2 amps.
Amplification factor...90
Maximum plate dissipation...........................74 watts
Maximum d.c. plate voltage....................1250 volts
Maximum a.f. power output (2 tubes)......300 watts
Transconductance at 100 m.a. plate current ....5000 μmhos
Base: Standard 50-watt. Plate: Carbon.

●

R.C.A.

806

RCA U.H.F. power triode for general use in either r.f. or audio service. Frequency range: 100% of rating up to 56 Mc.

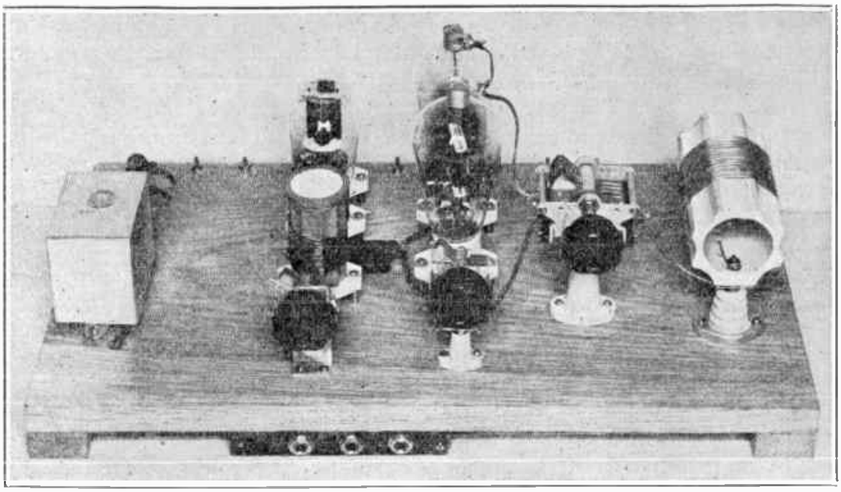
Characteristics:
Filament voltage..5.0 volts
Filament current ....10.0 amps.
Amplification factor...12.6
Grid-to-plate capacity ....3.4 μμfd.
Grid-to-filament capacity.............................6.1 μμfd.
Plate-to-filament capacity.............................1.1 μμfd.
Maximum d.c. plate voltage.....................3000 volts
Maximum d.c. plate current.........................200 m.a.
Maximum d.c. grid current..............................50 m.a.
Normal plate dissipation.............................150 watts
Base: Standard 50-watt; grid through side, plate through top of envelope.

Class B Audio Amplifier (two tubes):

D.C. plate voltage.....................	2000	3000 volts
D.C. grid voltage.......................	—150	—240 volts
Zero signal plate current.........	20	20 m.a.
Max. signal plate current.........	390	330 m.a.
Load res. (plate to plate).........	11500	21500 ohms
Max. signal driving power......	14	10 watt
Power output............................	500	660 watts

Class C R.F. Amplifier:
Maximum d.c. plate voltage.....................3000 volts
Maximum d.c. plate current.........................200 m.a.
Maximum d.c. grid voltage...................—1000 volts
Maximum plate input.................................600 watts

A 100 Watt C. W. Transmitter



The Transmitter Is Simplicity Itself, Utilizing a 6L6-G Into Paralleled T-20's.

One economical method for securing medium power output from a transmitter is by the use of a multi-band harmonic crystal oscillator driving a pair of the new Taylor T-20 triodes. The average amateur's pocketbook restricts his transmitter to a financial outlay of modest proportions; the transmitter described here can be built for approximately $25.00, including tubes and crystal (but not including the power supply).

The popular type 210 tube, long favored by the amateur, has certain disadvantages which have been overcome in the design of the newer type T-20 tube. The standard type 210 has a bakelite base with the grid and plate leads brought through the base; this causes losses at the higher frequencies and rather high grid-to-plate capacity. The losses in the base often cause blistering of the bakelite and, consequently, power output and efficiency are reduced. The type T-20 tube has an isolantite base, and the plate lead is brought through the top of the envelope. In addition, the interelectrode capacities are lower than those of the type 210, another feature that makes the tube much more effective for high-frequency operation. The cost of the T-20 is slightly more than that of the type 210; however, the plate dissipation of the T-20 is greater and a pair of these tubes can be operated at 100 watts input without exceeding the manufacturer's ratings. The T-20 can, *with care,* undoubtedly be operated at greater outputs than in the transmitter shown, without appreciably shortening the useful life.

The amplification constant of the T-20 is more than twice as high as that of the type 210. This higher μ makes the tube more satisfactory for class B audio amplification. The high amplification constant, together with high mutual conductance, results in a tube that is easy to drive for r.f. service.

The ease with which the type T-20 can be driven makes it possible to use a medium power multi-band crystal oscillator and still have ample grid drive for a pair of type T-20 tubes connected in parallel (for c.w. operation). Between 10 and 15 watts of grid drive is desirable for high efficiency. This amount of drive can be furnished very nicely by a 6L6G crystal oscillator in the circuit shown. This crystal oscillator supplies sufficient output so that capacitive coupling can be used for coupling into the grid circuit of the T-20 tubes. Nearly twice as much grid drive can be obtained with link coupling through an additional tuned circuit; however, this is not necessary for c.w. operation with split-coil neutralization. A split-stator tuning condenser in the final amplifier would be less "regenerative", and this would require more grid drive under antenna loaded conditions. Link coupling would be desirable if a split-stator is to be used.

The Crystal Oscillator

The crystal oscillator used in this transmitter is a modified form of the Multi-Band Oscillator described in the *Jones Radio Handbook*. It is a more satisfactory circuit in that the constants are of such values that the degree of regeneration is very nearly the same for 160, 80 or 40 meter crystals. This crystal oscillator can be used on either the fundamental or second harmonic of the crystal by merely changing the plate coil, or by using a 140 μμfd. tuning condenser which will cover both the fundamental frequency and the second harmonic. This particular oscillator gives more output at 350 to 400 volts of plate supply than is obtainable from any other common type of crystal oscillator.

The regenerative circuit used in this oscillator consists of a small semi-variable condenser connected between plate and cathode of the 6L6G tube and a .0004 μfd. mica condenser connected from cathode to ground. This circuit is somewhat comparable to a modified *Colpitts*. Once it is correctly adjusted it is possible to use 160, 80, or 40 meter crystals without further change except in the plate tuning circuit.

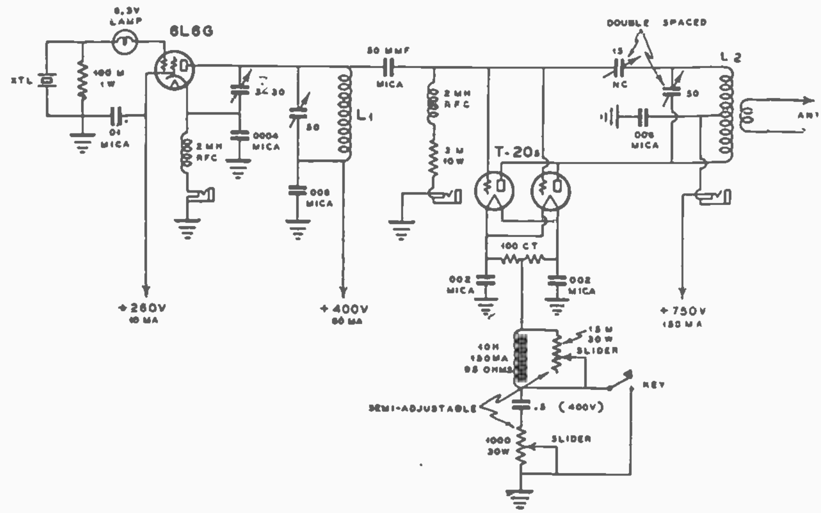
The regeneration condenser is adjusted (with the aid of an insulated-handle screwdriver) to a point below self-oscillation in the crystal oscillator. This adjustment is correct when the plate circuit can be tuned to the second harmonic of the crystal and only one dip can be found. Only one beat-note should be heard in the monitor when the circuit is properly adjusted. Too much capacity in the regeneration condenser will produce self-excited oscillations with a rough note, and it will not be possible to tune the circuit to a single dip.

A flashlight globe and loop of wire can be used to indicate proper operation. If the oscillator is acting in a self-excited manner, the lamp will light to nearly the same brilliancy over the entire tuning range of the oscillator plate condenser.

Insufficient capacity in the regeneration condenser will not permit the oscillator to have a good dip in cathode or plate current when tuned to the second harmonic of the crystal in use. Also, the oscillator will not supply sufficient output to drive the final amplifier when it is operating on the second harmonic.

The correct adjustment for the regeneration condenser is suitable for either fundamental or second harmonic operation. Inactive quartz crystals are not suitable for second harmonic operation. The 6.3 volt pilot lamp which is in series with the crystal and grid of the 6L6G oscillator tube should *not* light up in operation because the crystal r.f. current is very low when the oscillator is operating properly. This lamp is used as an indicating device to show whether or not the crystal current is low enough to safeguard the crystal; when the light does not glow it is an indication that crystal heating and frequency drift will be negligible. If the 6.3 volt light shows color, it indicates lack of neutralization in the final amplifier with feedback from its plate circuit, excessive screen-grid voltage in the crystal oscillator, an inactive crystal, or incorrect setting of the regeneration condenser.

The r.f. choke which is in series with the cathode of the 6L6G tube confines the r.f. return circuit to the cathode through the .0004 μfd. condenser. This cathode condenser is larger than the values shown in the *Jones Radio Handbook* because it has been found that the original value of .00025 μfd. sometimes allows excessive regeneration even when small values of regeneration condenser capacity are used.



This was especially true in the case of the metal type 6L6 tube in which the shell is connected to the cathode. In this case the shell-to-plate capacity served as the regeneration feedback condenser.

A metal 6L6 tube can be used in the place of the 6L6G that is indicated by connecting the shell of the metal tube to ground, and by using the circuit constants shown in the accompanying diagram.

The setting of the regeneration condenser depends upon the value of applied screen-grid voltage and also to some extent upon the load placed upon the plate circuit of the crystal oscillator. The oscillator should be tested by first opening the regeneration condenser to minimum capacity, then tuning the plate circuit to the fundamental frequency of the crystal. The grid current to the final amplifier should be in the neighborhood of 30 milliamperes. The oscillator plate coil can then be exchanged for one for second harmonic operation, such as a 40 meter plate coil with an 80 meter crystal. The regeneration condenser and oscillator plate tuning condenser should be adjusted simultaneously for maximum grid current into the final amplifier. A dip of from 10 to 20 milliamperes in oscillator cathode current should take place when there is sufficient capacity in the regeneration condenser. Too much capacity in the regeneration condenser will cause the grid current in the final amplifier to remain nearly constant, regardless of the setting of the oscillator plate tuning condenser, indicating non-crystal oscillation. There should only be one point of maximum grid current, except in the case where the oscillator plate tuning condenser is large enough and the coil of such inductance to cover both the third and second harmonics of the crystal frequency. The grid current into the final amplifier will be at least 30 milliamperes. Values as high as 40 milliamperes were obtained in the transmitter shown here, when operated under load.

The final amplifier is capacitively coupled to the crystal oscillator through a small (50 μμfd.) mica condenser in order to prevent excessive loading of the oscillator. The grid circuit impedance of a high μ tube is relatively low and with two of these tubes in parallel the load impedance across the crystal oscillator would be too low if a large value of coupling condenser were used.

The final amplifier uses grid-leak bias in the form of a 3,000 ohm 10 watt grid-leak. This stage is neutralized by a double-spaced 15 μμfd. midget variable condenser. The one shown in the photograph is a 35 μμfd. double-spaced "Star" midget variable with about half of the plates removed. The final amplifier circuit is neutralized in the usual manner before plate voltage is applied. As the plate tuning condenser is varied through resonance there will be a sharp change in grid current for all settings of the neutralizing condenser except that setting which is correct for perfect neutralization. The c.w. telegraph key must remain closed while the amplifier is being neutralized. Once neutralized, plate voltage can be applied to the final amplifier and the antenna may be coupled to the final plate coil. The antenna coupling should be "tight" enough to load the final amplifier to approximately 150 milliamperes when the plate tuning condenser is tuned to minimum plate current. Most antennas can be coupled to this transmitter by using an additional tuned circuit similar to the plate tuned circuit with link coupling between these two circuits. Complete tuning procedure for this type of coupling is in your copy of the *Jones Radio Handbook*.

The Keying Circuit

The final amplifier is keyed in the filament center-tap lead for c.w. operation. Key clicks are eliminated in the transmitter shown here through the use of a simple key-click filter in the center-tap circuit. The 10-henry choke coil should be capable of carrying at least 150 milliamperes and should have a low d.c. resistance to prevent loss in plate voltage.

The choke coil used in this transmitter is mounted on the baseboard near the crystal oscillator, as the picture shows. The amount of inductance required in this circuit to slow down the application of plate current to the tube will range between one and ten henrys, depending upon the type of power supply filter and the adjustment of the r.f. circuits. The inductance must be adjusted for each individual transmitter under actual operating conditions. This is accomplished by using an adjustable 15,000 ohm resistor shunted across the choke coil. The resistor has a slider adjustment, such as the one shown on the baseboard in the illustration. This resistor was set to about 5,000 ohms for the best click suppression in the transmitter under discussion when it was connected to a 750 volt power supply for the final amplifier in which condenser input to the filter was used. Choke input to the high voltage power supply would probably require a different setting of the resistor across the key-click choke coil.

The power supply used for testing this transmitter consisted of a pair of 5Z3 tubes, each connected as a half-wave rectifier, across a center-tapped 1400 volt 225 milliampere power transformer. With condenser input, this power supply delivered between 750 and 800 volts at the output of the filter under normal load. A heavy-duty bleeder was necessary across the filter because of the poor voltage regulation while keying the transmitter. Choke input to the filter gives much better voltage regulation—less key-click difficulty—but requires a power transformer having at least 25% to 30% more voltage across its secondary. A power supply with relatively poor voltage regulation will give rise to greater key-click difficulties; however, by careful adjustment of the two semi-adjustable resistors in the key-click filter circuit the key-clicks will be effectively eliminated.

The 1,000 ohm resistor in series with the condenser directly across the c.w. telegraph key contacts should be adjusted to a point which will minimize sparking at the key contacts. This value will usually be in the neighborhood of 400 ohms when used with a ½ μfd. condenser. This condenser and resistor should be mounted very close to the key. Two small r.f. chokes with an inductance of several millihenrys each, rated to carry at least 150 milliamperes, can be connected in series with the two key leads, directly at the key, in order to prevent the key leads from radiating the slight spark interference from the make-and-break of the key contacts.

The oscillator should preferably have a separate power supply which should put out a well-filtered 400 volts. The screen-grid voltage should be obtained from a slider-contact on a 25,000 ohm 50 watt bleeder resistor.

Band of Operation (in Meters)	*Oscillator Coil*	*Final Amplifier Plate Coil*
80	30 turns no. 18 enameled, 1½" long.	28 turns no. 14 enameled wire, space wound to cover 3½ inches and center-tapped. (See note*.)
40	15 turns no. 18 enameled, 1½" long.	14 turns no. 14 bare wire, 7 turns per inch, and center-tapped.
20	7 turns no. 18 enameled, 1½" long.	8 turns no. 14 bare wire, 3½ turns per inch, and center-tapped.

*NOTE: The 80 meter final amplifier plate coil can be a standard "air supported" coil, such as Merrill, Coto-Coil, etc.

Coil Data

The oscillator coils are wound on standard 1½ inch diameter composition plug-in coil forms. The final amplifier plate coils are wound on 2½ inch diameter plug-in isolantite ribbed forms.

Mechanical Construction

The transmitter is mounted on an oak baseboard, 11 inches wide, 20 inches long, ¾ inch thick, with cleats at both ends to elevate the board to a sufficient height to permit mounting the small components under the board. The base can be 5 inches shorter in length if the key-click filter choke coil is mounted in the power supply unit.

By-pass condensers, center-tap resistors, r.f. chokes and the 3,000 ohm grid-leak resistor are mounted under the board. Leads are brought to three closed-circuit jacks for meter measurements. The jacks are supported on a small strip of insulating material which is secured to the board by means of angle bracket. The center-tap filament resistor can be eliminated if the 7.5 volt filament supply has a center-tap connection.

The ACT-20 Amateur Transmitter

This low power amateur transmitter has several interesting circuit features which will appeal to many amateurs. The transmitter is completely housed in a cabinet similar to that used for a radio receiver, and will supply 16 watts of carrier output in any band from 10 to 160 meters. The c.w. output is 20 watts on any band.

A tetrode crystal oscillator is employed, using an RCA-807 with a small external capacity between the control-grid and plate for feedback at the crystal frequency. The plate circuit includes a split-coil arrangement, with the plate of the crystal oscillator connected to one end of the coil, and the grid of the RCA-802 connected to the other end through a blocking condenser. This arrangement tends to balance the capacities across the two halves of the split plate coil and, in effect, is the same as connecting the grid circuit of the buffer stage across half of the tuned plate coil. An 802 serves as a buffer or doubler stage which does not require neutralization. The final amplifier is neutralized because the 807 is not perfectly screened and would be regenerative without the neutralizing circuit. This stage must not be regenerative because it is modulated for phone operation. Combined plate and screen-grid modulation is applied to the final amplifier from a 6L6 class AB modulator.

The transmitter can be keyed for c.w. in nearly any portion of the circuit, such as in the oscillator and amplifier stages simultaneously, or in the buffer and amplifier stages.

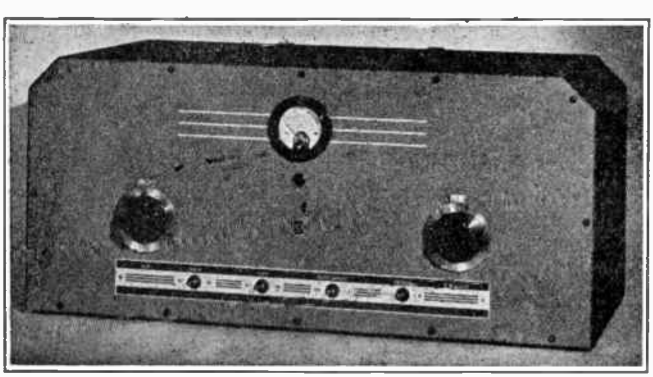
The grid circuit of the final amplifier is connected across a small portion of the 802 plate coil. The r.f. ground potential point of this plate coil is not at the usual low end of the tank circuit, but is tapped part of the way up on the coil.

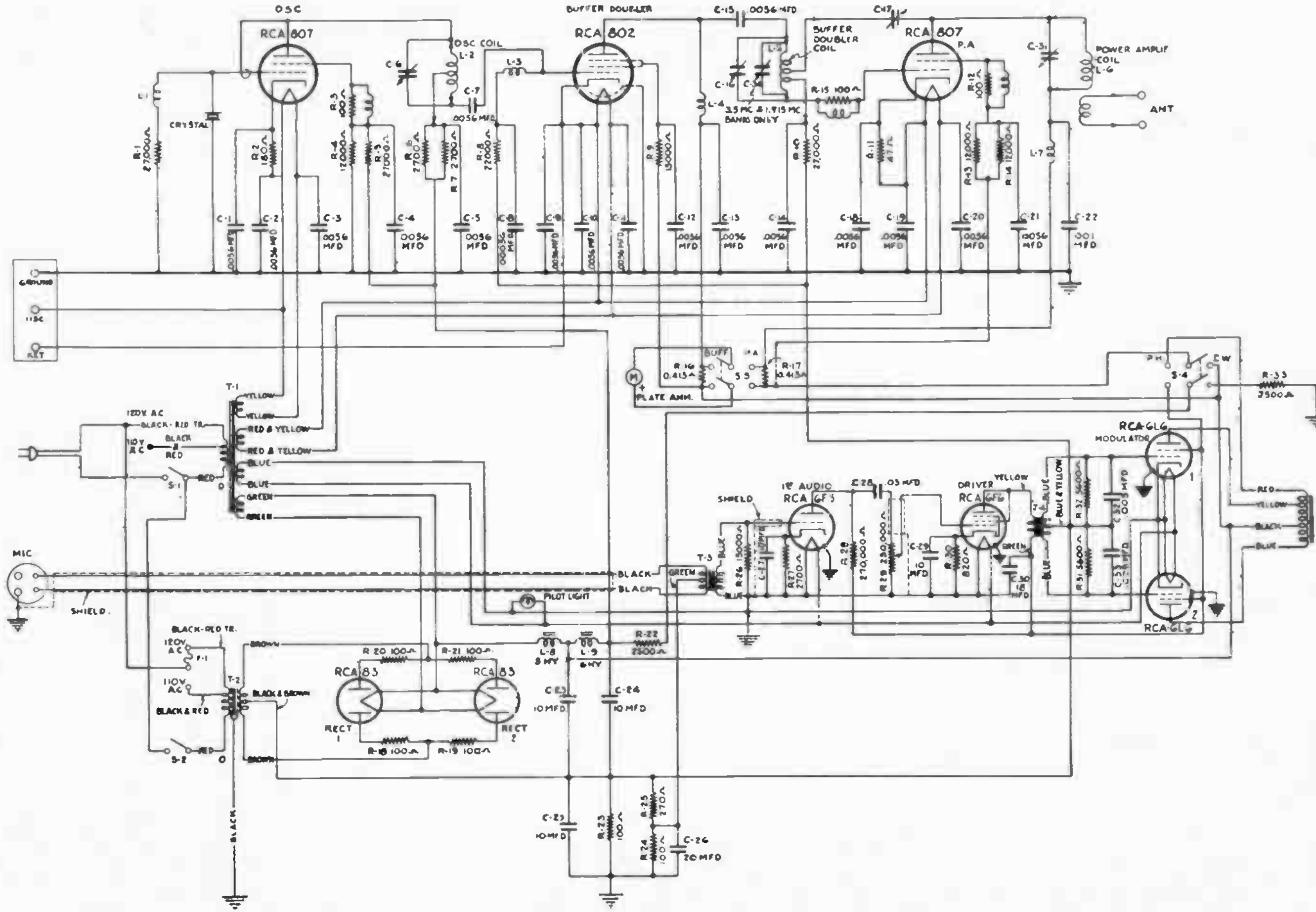
The neutralizing condenser is tapped farther up on the same tank coil so as to provide an out-of-phase voltage for grid neutralization of the 807 stage. A parasitic suppressor, consisting of a 100 ohm resistor and a small r.f. choke, is connected in series with the control grid of the power amplifier. Similar parasitic suppressors are connected in the screen-grid leads of both 807 stages.

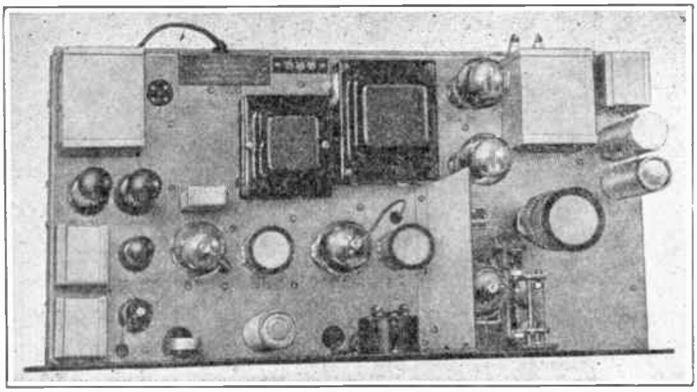
The method of connecting the heaters to the cathode circuits is interesting in that it will prevent voltage breakdown between the heater and cathode when the circuit is keyed in the cathode lead.

A double-button carbon microphone can be connected to the input transformer of the speech amplifier. The circuit is arranged so that the transmitter supplies current to the carbon microphone, which should be capable of a level of —35 db.

The speech amplifier consists of a 6F5 high μ triode, resistance coupled to a 6F6 triode-connected driver stage. This tube drives a pair of 6L6's as modulators. The c.w. switch removes the plate voltage from the speech amplifier, and from the screen of the modulator, in addition to connecting another bleeder across the power supply to maintain good voltage regulation under keying. A single power supply furnishes plate voltage for the entire transmitter. This requires a heavy duty




OSC
RCA 807
BUFFER DOUBLER
RCA 802
RCA 807
P.A
OSC COIL
L-2
BUFFER DOUBLER COIL
POWER AMPLIF COIL L-6
ANT
CRYSTAL
3.5 MC & 1.975 MC BANDS ONLY
GROUND
PLATE AMM.
PH
CW
R-33 2500Ω
RCA 6L6
MODULATOR
RCA 6L6
1ST AUDIO
RCA 6F5
DRIVER
RCA 6F6
SHIELD
MIC
PILOT LIGHT
120V AC
110V AC
BLACK-RED TR.
RCA 83
RECT 1
RCA 83
RECT 2
R-22 2500Ω
C-24 10 MFD
C-26 20 MFD



Looking Down on the Transmitter with the Cover Removed.

power transformer and two type 83 rectifier tubes which are effectively in parallel. A 100 ohm resister is placed in each plate lead of the 83 tubes in order to equalize the current load. Choke input is used to the filter, which consists of two filter chokes and several 10 µfd. condensers.

The crystal oscillator should be adjusted for the highest frequency crystal in the desired band of operation, after which the crystals can be changed for operation in the same band without retuning, except when 20 meter crystals are used.

Resistance Coupled Amplifiers

Resistance coupled amplifiers are used for many purposes, such as radio receivers, speech amplifiers, public address systems and phonograph amplifiers. This form of amplifier utilizes condensers and resistors, rather than transformers or inductances, for coupling between stages. The resistors are used for the purpose of supplying d.c. voltage or current to the grids and plates of the tubes. The resistor values are chosen so as to have as little effect as possible on the signal which is being amplified by the vacuum tube. In some cases the resistor and condenser values purposely are chosen to provide amplification only over certain bands of frequencies. The constants shown in the accompanying circuit diagrams are values suitable for speech amplifier and radio receiver operation in which the desired band is from approximately 100 cycles up to 5000 cycles per second.

The values of coupling condensers between the plate and grid circuits can be chosen so that a resistance coupled amplifier will pass very low audio frequencies. When using the values shown, cut-off occurs at approximately 100 cycles per second when the grid resistors also indicated in the circuits are inserted for connection across the grids of the following amplifier tubes. The relative values of the plate and grid resistors with respect to the tube input and output capacities (in addition to the values of coupling condensers) determine the high-frequency cut-off. Lower values of resistance provide less gain per stage over the desired frequency range; the range, however, is extended upward for higher frequencies. By using lower values of plate resistors the amplifier can be made to pass frequencies of several hundred thousand cycles per second, such as for television requirements.

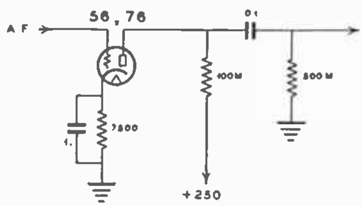
Resistance coupled amplifiers are used only for voltage amplification and not for power amplification. The relatively high value of the resistance in the plate circuit limits the amount of d.c. plate current, which makes these amplifiers unsuitable for delivering high power output. The resistance coupled amplifier has a decided advantage over other forms of amplifiers in that it is less subject to a.c. hum pickup from nearby magnetic fields. For this reason it generally is used for circuits in which the input audio signal is very small, such as low-level microphone amplifiers.

Audio transformers tend to pick up an excessive amount of a.c. hum in low-level circuits, no matter how carefully the transformers are oriented or shielded. More voltage gain can be obtained from a resistance coupled amplifier with the proper choice of tubes than can be obtained from a transformer coupled amplifier having an equivalent audio frequency characteristic.

Motor-boating difficulties in multi-stage amplifiers generally are more pronounced with resistance coupling than with transformer coupling. This is due to the better low-frequency amplifying characteristic of most resistance coupled amplifiers; motor-boating occurs at very low audio frequencies, so that an amplifier which does not amplify low audio frequencies will seldom prove troublesome. RC filters, which consist of additional resistors and condensers as shown in the plate circuits of some of the amplifiers illustrated, will greatly reduce any tendency toward motor-boating. Normally, no trouble will be had from this source unless at least three stages of amplification are connected to the same plate supply. The phase relationship is correct for regenerative feed-back from the last stage to the first in a three stage amplifier. The common coupling occurs across the impedance of the plate supply because this impedance cannot be made equal to zero. This impedance usually is in the neighborhood of 1,000 ohms even in a well designed power supply, and at very low audio frequencies it may well exceed this value. The feedback between adjacent circuits, such as would occur in a two stage resistance coupled amplifier, is of the wrong phase relationship to produce oscillation or motor-boating.

Triode Resistance Coupled Amplifiers

Several circuits are shown with suitable constants for high and low μ triodes. A high μ triode will always provide more voltage amplification per stage than can be obtained from a low μ resistance coupled amplifier. Low μ triodes, however, often are used with resistance coupling to simplify the circuit design and also for reasons of economy.

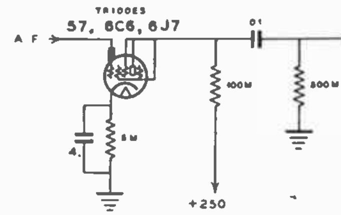


VOLTAGE GAIN OF 10

Figure 1

A type 76 or 56 triode, which has a medium amplification constant, can be used in the circuit shown in figure 1, where a voltage amplification of approximately 10 is desired. These tubes are more suitable for resistance coupled amplification than the older type 27 or 201A tubes, whose amplification constants are lower than those of a 76 or a 56. This type of amplifier is suitable for connection to the grid of a class A 45 tube, or a pentode such as the 2A5 or the 42.

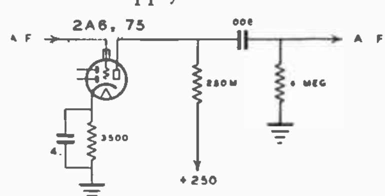
Pentode tubes, such as the 6C6, 6J7, or 57 may be used as triodes by connecting the suppressor and screen grids to the plate of the tube. This connection generally produces about 10% as much voltage amplification as could be obtained with the same tube in a pentode resistance coupled amplifier. However, the circuit design may call for a stage having an amplification of 10 or 12 in order to obtain the desired overall gain in a multi-stage amplifier.



VOLTAGE GAIN OF 12

Figure 2

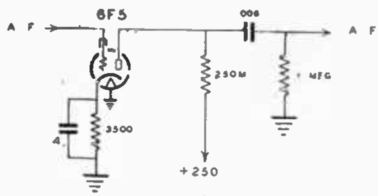
With the circuit constants shown in figure 2, a voltage amplification of approximately 12 can be obtained and this amplifier can be used in any circuit which ordinarily uses a 56 or 76 amplifier. The value of the cathode resistor is somewhat different, due to the difference in amplification constant. The value of the cathode by-pass condenser is determined by the low-frequency characteristic desired. In these circuits the values indicated are suitable for amplifiers which operate down to somewhat less than 100 cycles per second. The condenser value shown across the cathode resistor is nearly twice as high as would be needed in order to obtain the desired frequency characteristic, because of the difficulties from a.c. hum which will be introduced in the amplifier when an a.c. supply is used for the heater of the tube. A large value of cathode by-pass capacity always tends to reduce a.c. hum in the amplifier when the latter is due to the use of an a.c. 2.5 or 6.3 filament supply.



VOLTAGE GAIN OF 50

Figure 3

A high μ triode, such as a 2A6 or 75, will provide a gain of approximately 50 in the circuit shown in figure 3. The diode plates in these tubes are normally connected to the cathode at the tube



VOLTAGE GAIN OF 65

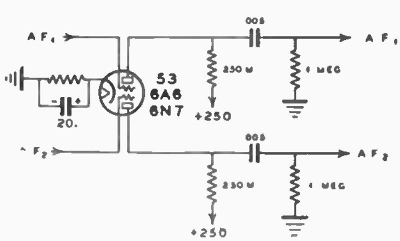
Figure 4

socket since the diode portion of the tube is not used unless the tube is functioning in a radio receiver circuit.

Another high μ tube circuit is shown in figure 4.

The 6F5 is a high μ metal tube triode which will give a voltage gain of about 65 in this circuit. The type 6F5 tube should have an RC filter in the plate supply lead when it is connected in the usual speech amplifier which has three or more stages of amplification operating from the same power supply. A typical RC filter is shown in figure 7 and consists of a 0.5 μfd. condenser and a 50,000 ohm resistor connected in the plate supply lead. This same filter is suitable for use in any pentode or high μ triode resistance coupled amplifier.

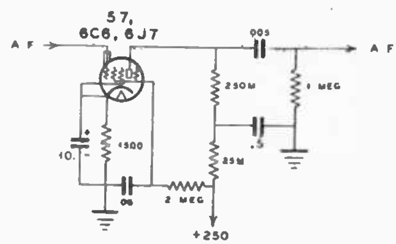
In some public address and phonograph amplifiers, a dual-triode tube, such as a 53, 6A6 or 6N7 can be used to reduce the total number of tubes required. Each triode unit can be connected to a



VOLTAGE GAIN OF 24 IN EACH TRIODE

Figure 5

separate input, such as a microphone and a phonograph unit, and the outputs can be connected to separate amplifiers, as shown in figure 5; it is also possible that the plates be connected in parallel by reducing the value of the plate resistor to approximately half that shown in the accompanying diagram. In this case (parallel plate connection) the voltage amplification will be less than the value of 24 shown in the circuit diagram, because of the lower value plate resistor. These dual-triodes can be connected in series, if the grid and plate return circuits are properly decoupled with RC filters. Fixed grid-bias, obtained from C batteries or Mallory cells in series connection, is often more desirable than self-bias obtained from a cathode resistor. Fixed bias of this type reduces the tendency of feedback in the grid circuits and often eliminates a.c. hum difficulties which can



VOLTAGE GAIN OF 175

Figure 6

be traced to a cathode resistance in this type of circuit. When fixed bias is used in series with the grid resistor to ground, the cathode is connected directly to ground and negative B.

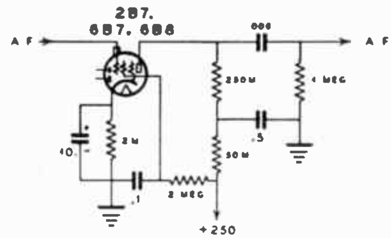
Pentode Resistance Coupled Amplifiers

A typical high gain pentode resistance coupled amplifier is shown in figure 6. The pentode tube operates in a manner similar to that of a high μ triode, but provides considerably more voltage gain per stage. A 6C6, 57 or 6J7 will give a gain of approximately 175 when used in the circuit shown in figure 6.

The resistor and plate supply voltage values can be altered in order to obtain amplifications of any value from 2 or 3, up to well over 200 times in this same general type of circuit. The value of plate supply voltage determines the cathode, screen-grid and plate resistor values for a given amount of voltage amplification. The grid coupling condenser and screen-grid and cathode by-pass condensers determine the low-frequency audio amplification characteristic. The pentode tube is especially desirable in resistance coupled amplifiers which must amplify the higher audio frequencies (8000 to 20,000 cycles per second). The pentode is a screen-grid tube in which there is very little capacity between the control grid and plate. This extremely small capacity prevents the reaction of the plate circuit on the grid circuit with respect to input capacity. The dynamic input capacity of any amplifier depends upon the amplification of the stage and the value of grid-to-plate capacity of the tube, with the result that it is always a great deal more than the static value of grid-to-cathode, or input capacity. A triode has a grid-to-plate capacity of a great many times that of the screen-grid tubes, so that the effective input capacity in a resistance coupled amplifier is a great deal higher than in a pentode amplifier, in spite of the much higher amplification of the latter.

A type 2B7, 6B7 or 6B8 duplex-pentode can be used in a resistance coupled amplifier in order to obtain a voltage gain of 100 times in the circuit shown in figure 7.

The diode plates of any of these tubes



VOLTAGE GAIN OF 100

Figure 7

can be used for the purpose of detection or a.v.c. in a radio receiver, or they can be connected to the cathode in case the tube is to be used only as an audio amplifier, such as in a speech amplifier.

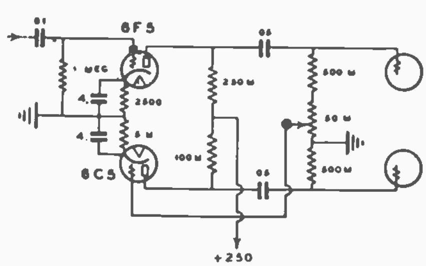
If frequencies much below 100 cycles per second are to be amplified, the .006 μfd. grid coupling condenser can be increased in value to .03 μfd. Fixed bias in the form of a 1.5 volt C battery or a single Mallory cell, can be connected in series with the control grid of the tube shown in figure 6 or 7 in order to eliminate the cathode resistor and bypass condenser. The usual 1 or 2 megohm grid-leak used in nearly all amplifiers from grid-to-ground is not indicated in any of these circuit diagrams. This grid-leak would be necessary in order to provide a d.c. grid-bias to the amplifier tube.

Phase Inverters

A push-pull audio amplifier requires voltages across the two grid circuits which are 180 degrees out-of-phase. This can be accomplished in a transformer-coupled amplifier by means of a center-tapped secondary coil with the two grids connected to the outside terminals of the winding. Sometimes it is desirable to eliminate an audio transformer, yet still make use of push-pull amplification; this can be accomplished by means of any of the three circuits shown here.

The out-of-phase voltage (180 degrees out-of-phase) can be obtained by means of a vacuum tube as well as through a split-coil in an audio transformer. The plate voltage in a resistance coupled amplifier is 180 degrees out-of-phase with that of the grid circuit; this allows an extra tube to be connected so that its plate circuit is connected to one side of the desired push-pull amplifier and its grid circuit connected across a portion of the other side of the push-pull input stage.

In figure 1, the 6C5 tube acts as a phase inverter having a gain of one. It is used simply for the purpose of driving one side of the push-pull amplifier grid circuit in the proper phase relationship. The input signal is connected to the high μ 6F5 tube and is then amplified and applied to the grid of the upper push-pull tube. A small portion of this amplified signal is connected to the 6C5 phase inverter grid and amplified through it to drive the remaining push-pull grid. The amount of amplification in the 6C5 tube determines the point of connection of its grid circuit to the driver stage. If this tube gives an amplification of 10 times, its grid would be connected across 1/10th of the driver stage output signal voltage. For practical purposes, the grid is connected to the moving arm of a 50,000 ohm potentiometer in series with the ½ megohm grid-leak, shown in figure 1. The correct setting for this potentiometer can easily be determined by ear because very noticeable audio distortion will result when this potentiometer is incorrectly set. The 6F5-6C5 two-tube phase inverter may be connected to a pair of 6L6 or 6F6 power amplifier tubes; outputs of from 6 to 15 watts can be obtained in the conventional arrangements.

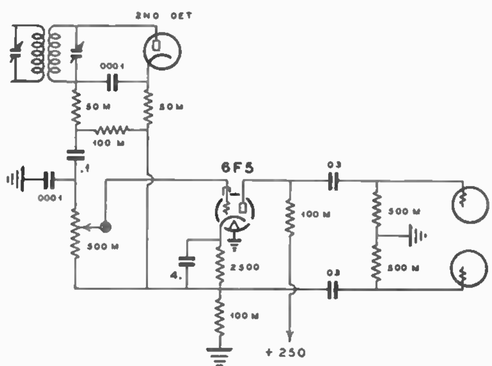


6F5-6C5 TWO TUBE PHASE INVERTER

Figure 1

A single tube can be connected as a phase inverter, as shown in figure 2, provided that the input signal can be isolated from the common ground bus connection. A diode detector, connected as shown, allows the input signal to be applied across the grid and cathode through the 4 mfd. condenser and 2,500 ohm resistor.

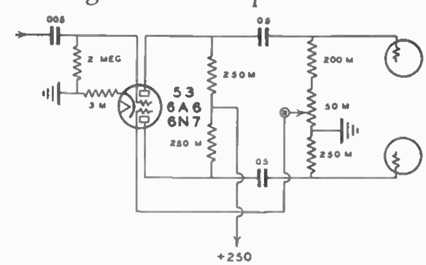
The 6F5 amplifies this signal and divides it equally between the plate and cathode circuits when equal resistors are used, such as the value of 100,000 ohms shown in the diagram. One push-pull grid circuit is connected to the 6F5 plate circuit, and the other to the 6F5 cathode circuit. The audio signal applied to the push-pull grids is equal and 180 degrees out-of-phase. A pair of 6F6 or 6L6 tubes are suitable for power amplifiers connected to the 6F5 phase inverter. This circuit requires no variable adjustment, such as that shown in figure 1, but requires an input circuit which is completely isolated from common ground connection. A ½-megohm volume control can be connected as shown in the grid cir-



SINGLE 6F5 TUBE PHASE INVERTER

Figure 2

cuit, making sure that the lower end is connected back to the cathode circuit at the point indicated in the diagram. An audio transformer secondary could be connected across the volume control for connection into any type of circuit. The capacity of the secondary winding to ground should be made as low as possible in order to prevent circuit unbalance at the higher audio frequencies.



DUAL TRIODE PHASE INVERTER – GAIN APPROX 20

Figure 3

A dual-triode is often used as a phase inverter, as shown in figure 3. The phase inverting action is exactly the same as that described for figure 1. One triode serves as a resistance coupled amplifier driver stage, the other triode of a 53, 6A6, or 6N7 acts as a phase inverter. The grid of one triode is connected to a 50,000 ohm potentiometer in order to obtain the correct adjustment for distortionless operation. This adjustment can be made for any given tube and need not be changed over long periods of time. This control can be located at the rear of an amplifier or receiver chassis.

If a cathode ray oscilloscope is available, the proper setting for the 50,000 ohm grid potentiometer can be determined more accurately. In this case the potentiometer is varied until the voltage being applied to each grid of the push-pull output stage is exactly equal; this can be determined when the deflection produced on the screen of the oscilloscope is the same as measured on either of the output grids.

Phase inverters are often used in television receivers in order to amplify the outputs of scanning oscillators for connection into the four deflection plates of a cathode-ray tube. In some cathode-ray tubes the deflection plates are not grounded, and require a balanced circuit with respect to ground for proper operation.

CAPACITIVE REACTANCE TABLE

● This *Table* is useful in that it shows how effective a certain size condenser will be for a few of the commonly used audio and radio frequencies. The capacitive reactance listed indicates how effective the particular condenser capacity will be when the condenser is used for coupling or by-passing. A by-pass condenser should have very low reactance to the frequencies which must be by-passed. For example, a 0.1 μfd. condenser would be suitable for by-passing a frequency of one megacycle, but would present over 26,000 ohms reactance to an audio frequency of 60 cycles per second. The reactance of an 8 μfd. condenser is several hundred ohms at 60 cycles per second, which shows why cathode by-pass condensers in power amplifiers are often made as high as 50 μfd.

A 0.1 μfd. condenser would be suitable for a coupling condenser between resistance coupled audio amplifier stages, since its reactance at 60 cycles (26,540 ohms) is only a small percent of the grid-leak resistance, which would normally be a ¼ or ½ megohm (250,000 or 500,000 ohms). The low-frequency amplification of the amplifier would be reduced only slightly from that obtained at 1,000 cycles per second, at which point the 0.1 μfd. condenser would have a reactance of 1,592 ohms.

Other uses for and applications of the table will be apparent.

Capacity in Micro-farads	CAPACITIVE REACTANCE IN OHMS					
	Xc for 60 Cycles Per Second	*Xc for 180 Cycles Per Second*	*Xc for 1000 Cycles Per Second*	*Xc for 5000 Cycles Per Second*	*Xc for 1 Mega-cycle*	*Xc for 15 Mega-cycles*
.00005	53,078,000	17,690,000	3,185,000	637,000	3,185	212
.0001	26,540,000	8,840,000	1,592,000	318,500	1,592	106
.00025	10,616,000	3,540,000	636,900	127,400	637	42.5
.0005	5,308,000	1,769,000	318,500	63,700	319	21.2
.001	2,654,000	884,000	159,200	31,850	159	10.6
.005	530,800	176,900	31,850	6,370	32	2.1
.01	265,400	88,400	15,920	3,185	16	1.06
.05	53,080	17,690	3,185	637	3.2	0.21
0.1	26,540	8,840	1,592	319	1.6	0.11
0.5	5,308	1,769	319	64	0.32	0.02
1.0	2,654	884	159	32	0.16	0.01
2.0	1,327	442	79	16	0.08	0.005
4.0	664	221	39	8	0.04	0.003
8.0	332	111	20	4	0.02	0.001

Tank Circuit Capacities

The theory of tank circuit capacities is fully covered in the *Jones Radio Handbook.* The accompanying Tables were compiled, however, in order to simplify further the problem of choosing the correct tuning condenser capacities. In the tabulated values will be found the optimum magnitudes from which to select the total tuning capacity in the final amplifier of any short-wave transmitter.

These values provide an approximate Q equal to 20 for normal antenna loading. Values of tuning capacities are shown for the commonly used phone bands of 2, 4, and 28 megacycles. Each general type of final amplifier plate circuit requires a different value of tuning capacity. For example, a single-ended final amplifier with grid neutralization would require four times as much capacity as would be required for a plate neutralized class C amplifier. (See Tables.)

A push-pull amplifier is similar to a plate neutralized circuit; the L/C circuit, however, receives twice as many impulses from the power tubes as it would in the case of a single tube. For this reason a Q value of 10 under normal load conditions should be satisfactory. On this basis the value of tuning capacity across the entire circuit would be half as much as for a single-ended plate neutralized circuit. The empirical formula used in calculating this table is:

$$C = \frac{800{,}000}{fR_p}$$

where C is the capacity in micro-micro-farads,
f is the frequency in megacycles,
R_p is the d.c. plate resistance in ohms.

$$R_p = \frac{E_{dc}}{I_{dc}}$$

where E_{dc} is the plate voltage,
I_{dc} is the total d.c. value of plate current in amperes.

The value of R_p always is equal to the d.c. plate voltage divided by the d.c. plate current, regardless of the number of tubes in the circuit. The total current either to push-pull or to paralleled tubes is used for the value of I_{dc}.

In these tabulations, listings are made against d.c. plate resistance, rather than against typical plate voltage and plate current values, in order to avoid duplication of listed capacity values. For example, an amplifier operating at 150 ma. with 3,000 volts of plate supply would require the same tuning capacity as an amplifier operating with 75 ma. at 1,500 volts. In either case, the d.c. plate resistance is 20,000 ohms. Typical values of d.c. plate resistance are given in the following examples:

A pair of type 211 tubes operating at 1,200 volts plate supply and 300 ma. would have a resistance of 4,000 ohms, which would be the value used in the tables to locate the desired tuning capacity. An HK-354 with a 3,000 volt plate supply operating at 250 ma. of plate current would have a d.c. plate resistance of 12,000 ohms. From the tables the tuning capacity would fall between the values

Push-Pull Class C Modulated Amplifier Plate Tuning Capacity

DC Plate Resist. $\frac{E_{dc}}{I_{dc}}$	2 Mega-cycles (Capac. n µµfd.)	4 Mega-cycles (Capac. in µµfd.)	14 Mega-cycles (Capac. in µµfd.)	28 Mega-cycles (Capac. in µµfd.)
2,000	200	100	29	14
3,000	133	66	19	9
4,000	100	50	14	7
5,000	80	40	11	6
6,000	67	33	10	5
7,500	53	27	8	4
10,000	40	20	6	3
15,000	27	13	4	2
20,000	20	10	3	1.5

Plate Neutralized Circuit Class C Modulated Amplifier Tuning Capacity				
DC Plate Resist. $\frac{E_{dc}}{I_{dc}}$	2 Mega-cycles (Capac. in μμfd.)	4 Mega-cycles (Capac. in μμfd.)	14 Mega-cycles (Capac. in μμfd.)	28 Mega-cycles (Capac. in μμfd.)
2,000	400	200	57	28
3,000	267	133	38	19
4,000	200	100	28	14
5,000	160	80	23	11
6,000	133	66	19	10
7,500	107	53	15	8
10,000	80	40	11	6
15,000	53	27	8	4
20,000	40	20	6	3
25,000	32	16	5	2
30,000	27	13	4	2

shown for 10,000 and 15,000 ohms. A pair of type '10 tubes in push-pull with a 600 volt plate supply at 150 ma. would have a d.c. plate resistance of 4,000 ohms, which would require a tuning capacity of 100 μμfd. in the 160 meter band, or 50 μμfd. in the 75 meter band, as shown in the tables for a push-pull amplifier. If these same type '10 tubes are used in parallel with plate neutralization, (split-stator or split-coil tuned plate circuit), the capacity would be 200 μμfd. for 160 meter operation. Grid neutralization would not be very practicable for this particular parallel tube arrangement, since the desired value would be 800 μμfd.

A type 35T or T55 with a 1500 volt plate supply at 150 ma. would have a plate impedance of 10,000 ohms.

A pair of type T200 tubes operating at 1500 volts and 600 ma would have a plate impedance of 2,500 ohms, which is half-way between the values of 2,000 and 3,000 shown in the tables.

Practically any combination of plate voltage and plate current, no matter what type of tubes are employed, will result in a d.c. plate resistance which will fall near to the values listed in the tables.

All of the values for tuning capacities shown in the various tables may be divided by 2 for c.w. operation. For example, a tuning condenser capacity of 35 μμfd. for c.w. operation would be satisfactory, where a 70 μμfd. condenser would be required for phone operation. The size of the tuning coil, of course, would be different in the two cases.

The values shown for phone operation are quite suitable for c.w. operation, since very little loss in efficiency will result, and the values shown will reduce the amount of illegal harmonic radiation.

A single screen-grid tube amplifier in which the plate circuit is connected across the entire tuned circuit should use tuning capacities listed in the table for grid neutralized amplifiers.

Grid Neutralized Circuit Modulated Class C Amplifier Plate Tuning Capacity				
DC Plate Resist. $\frac{E_{dc}}{I_{dc}}$	2 Mega-cycles (Capac. in μμfd.)	4 Mega-cycles (Capac. in μμfd.)	14 Mega-cycles (Capac. in μμfd.)	28 Mega-cycles (Capac. in μμfd.)
2,000	1600	800	228	114
3,000	1064	532	152	76
4,000	800	400	114	56
5,000	640	320	92	46
6,000	533	266	76	38
7,500	427	213	60	30
10,000	320	160	46	22
15,000	217	108	30	15
20,000	160	80	23	11
25,000	128	64	18	8
30,000	106	53	15	7

Coil Calculations

The physical dimensions and the number of turns of wire for short-wave receiver or transmitter coils can be calculated to within an accuracy of 1 or 2% with the aid of the information given here.

The effective capacity across the tuned circuit usually is known; this value includes that of the variable tuning condenser, together with the few micro-microfarads of miscellaneous tube and wiring capacities. The frequency to which the coil must be tuned is known, so that the inductance of the coil can be calculated by means of the following formula:

$$(1) \qquad L = \frac{1}{(2\pi f)^2 C}$$

where L is the inductance in microhenrys,
f is the frequency in megacycles,
C is the capacity in microfarads,

The number of turns of wire required to obtain the value of inductance calculated from the above formula may be determined by means of the following equation:

$$(2) \qquad n = \frac{\sqrt{a L}}{\sqrt{.01 \; d^2 K}}$$

where n is the total number of turns,
d is the diameter of the coil,
a is the length of the coil in the same units,
L is the inductance in microhenrys,
K is a constant taken from the accompanying table.

The value of K depends upon the ratio of the coil diameter to the coil length. For example, a coil 1 inch long and 2 inches in diameter would have a ratio of 2.00, and from the table the value of K would be 1.32. As another example, assume a coil to be 4 inches long and 2 inches in diameter; this coil would have a ratio of $\frac{d}{a} = 0.50$, which in the tables is seen to give a value of K equal to 2.05. The value of $\frac{d}{a}$ can be obtained from the size of the coil forms available for use in the desired short-wave band. The number of turns can be chosen from the *Wire Table*, so that the coil can be close-wound or space-wound. A simplified *Wire Table* is shown for the most commonly used sizes of wire with the various kinds of insulation. From this *Table* it is seen that no. 18 double-cotton-covered wire can be wound 20 turns to the inch when close wound. The coil could be wound with no. 18 double-cotton-covered wire and be space wound, so that it would have only one-half or one-third as many turns as it would have if close wound. The total number of turns of wire on the coil for close-wound coils can be obtained by multiplying the number of turns per inch, as shown in the *Wire Table*, by the length of the coil, a, in inches.

Formula (2), previously given for the number of turns, is derived from the relationship:

$$(3) \qquad L = \frac{.01 \, d^2 n^2 K}{a}$$

This formula has an error of less than 2% for single-layer-wound solenoid coils.

A typical coil calculation for the amateur 80 meter band is given in the following example of a coil used in a crystal oscillator or low power buffer stage:

The circuit is assumed to be tuned with a 100 μμfd. condenser. It can be safely assumed that the total circuit capacity at resonance is 80 μμfd. with the condenser plates partially enmeshed. The tube capacities add from 15 to 30 μμfd. if capacitive coupling is used between stages. The frequency corresponding to about 85 meters is 3.5 megacycles. By substituting these values in formula (1), the required value for the inductance

can be calculated:
(Remembering that 80 μμfd. = .00008 μfd.)

$$L = \frac{1}{(2\pi\, 3.5)^2 \times .00008}$$

from which, L = 26 microhenrys.

If a standard plug-in coil form is used, with a diameter of 1½ inches, the winding can be made any convenient length, such as 2 inches. This gives d and a the values 1½ and 2 respectively. The value for K corresponding to their ratio is 1.87. The number of turns then can be calculated from formula (2):

$$\text{thus}\quad n = \frac{\sqrt{a\,L}}{\sqrt{.01\,d^2\,K}}$$

$$= \frac{\sqrt{2 \times 26}}{\sqrt{.01 \times 1.5 \times 1.5 \times 1.87}}$$

$$= 35 \text{ turns.}$$

The value for K (1.87) is found from the *Table*, corresponding to

$$\frac{d}{a} = \frac{1.5}{2} = .75$$

The 35 turns obtained in the preceding calculation are to be wound into a space of 2 inches, which corresponds to 17½ turns per inch. Any wire of a size which will fit into this space of 17½ turns per inch can be used for the coil winding. No. 18 wire could be slightly space-wound, or no. 16 single-cotton-covered wire could be close-wound, as shown in the *Copper Wire Table*.

Inductance Formula Constants

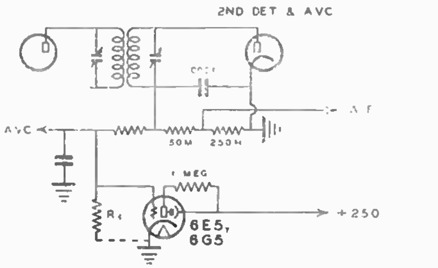
Diam. to Length Ratio $\frac{d}{a}$	Constant K
.01	2.50
.1	2.40
.5	2.05
.75	1.87
1.0	1.72
2	1.32
3	1.08
10	.51

Copper Wire Table (Turns Per Inch)

Wire Gauge No.	DCC	SCC	DSC	SSC	Enam.
34	68.5	87.5	97	120	145
32	60	75	84	101	130
30	51	64.5	71	83	92
28	45.5	54.5	60	68	74
26	40	45	50	56	59
24	33.5	37.5	41.5	45	47
22	28.5	32	34	36.5	37.5
20	24	26.5	28	29.5	30
18	20	21	22.5	23.5	24
16	16.5	17	18	19	19
14	13	13.5	14.5	15	15
12	10.6	10.8	11.8	12.1	12.1

Tuning Indicators

Several types of electron-ray tubes, of which the 6E5 is typical, are specifically intended for use as tuning indicators in radio receivers. Three commonly used circuits are shown here for various circuit applications. These tubes provide a visual indication of the carrier signal strength, and in this way afford an excellent aid toward the proper tuning of a receiver, or in conjunction with a potentiometer control, as an indicator of signal strength.



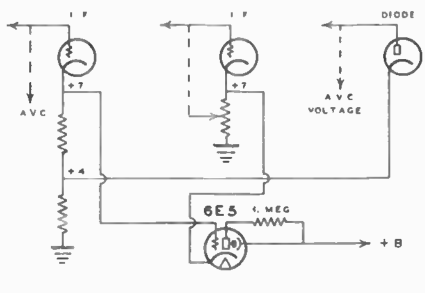
ELECTRON RAY TUNING INDICATOR CIRCUIT

Figure 1

The tube types 6E5 and 6G5 produce a brilliant fluorescent arc segment which opens and closes, depending upon the variance of signal strength. The maximum signal closes the arc. The indication of carrier signal strength obtained in this way is more sensitive than a meter to variations of low magnitude and short duration. It can be seen more easily than a variation in the reading of a d.c. milliammeter, or a tuning indicator meter.

The electron ray tubes are voltage operated and the control grid is connected across a portion of the a.v.c. voltage in most radio receiver applications. A typical circuit of this type is shown in figure 1. The selection of a 6E5 or 6G5 in this circuit depends upon the maximum value of a.v.c. voltage developed in the radio receiver. In a multi-stage set the automatic volume control voltage is applied to the grid circuits of several amplifying stages so that the required a.v.c. voltage is relatively low, even on very strong signals. The 6E5 cuts off with a grid potential of approximately 7 volts (i.e., the arc is completely closed) and is suitable for such multi-stage receivers. The tube type 6G5 has a more remote cut-off, approximately 22 volts, and hence is preferable in radio receivers having only a few tubes and requiring an a.v.c. voltage of greater magnitude.

When a.v.c. voltage is applied only to one or two stages of a radio receiver the maximum voltage obtained from a very strong carrier signal, such as that of a local broadcasting station, may reach a value even greater than 22 volts. In this case, the grid of the electron ray tube should be connected across only a portion of the total a.v.c. voltage. For circuits in which the maximum a.v.c. voltage only slightly exceeds the cut-off value of the particular electron-ray tube, a fixed resistor of the proper value, R_1, can be connected as shown in figure 1, in order to prevent any overlapping effect of the tuning-eye segment. If the radio receiver employs delayed a.v.c., the tuning indicator tube should be connected through an RC filter to the audio-diode circuit. The audio frequency component must be filtered out in order to prevent flickering of the tuning indicator "eye".



CIRCUIT FOR GREATER SIGNAL RANGE FOR A CATHODE RAY TUNING INDICATOR

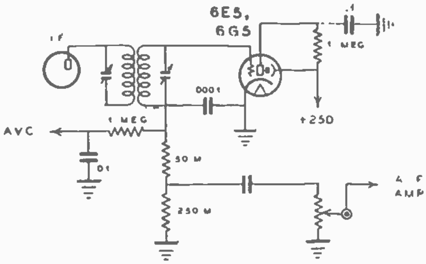
Figure 2

A fading signal will cause a change in the width of the center arc segment. These indicator tubes may be used for direct "R" strength measurements, by calibrating the receiver sensitivity control against a constant value of fluorescent deflection.

The 6E5 tube can be connected into a superheterodyne receiver circuit as shown in figure 2. This arrangement provides a wider range than can be obtained in the more common circuits, such as figure 1.

The tuning indicator deflection depends upon the a.v.c. voltage in most circuits, with the result that when provision is made to prevent overload of the indicator tube the sensitivity to a low signal strength of relatively few microvolts input is imperceptible to the eye. The circuit shown in figure 2 overcomes this defect and a more nearly constant variation of deflection is obtained over the complete range from strong local signals to very weak distant signals. The control grid of the 6E5 tube is connected to the cathode of one of the amplifying tubes which is controlled by the a.v.c. voltage. The cathode is made to operate at a positive potential of 7 volts with no signal input by the use of a high value of cathode resistor, which may be tapped as shown in figure 2.

The cathode of the 6E5 tube is connected to an i.f. amplifier which has its return grid circuit connected to its cathode resistor, rather than to the a.v.c. bus. This cathode must also be operated at 7 volts positive and the control grid circuit can be tapped across part of the cathode resistor in order to obtain the normal value of (negative) 3 volts grid-bias. The control grid varies over a range of not more than 7 volts regardless of the a.v.c. voltage applied to the grid of that particular i.f. tube. The cathode bias in this i.f. tube decreases from the positive 7 volt value practically to zero for very strong signals which bias the control grid to a high negative value by means of the a.v.c. voltage. The plate and target of the 6E5 tube are connected through a 1 megohm resistor to positive B, as in any tuning indicator circuit arrangement.



ELECTRON RAY DETECTOR TUBE CIRCUIT

Figure 3

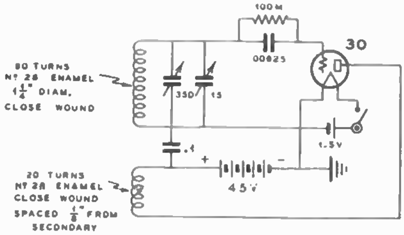
The circuit shown in figure 3 eliminates one tube in a radio receiver. The tone quality obtained, however, is not quite as good as when a separate detector tube is used.

The grid and cathode of the 6E5 or 6G5 tube are connected together as a diode in order to obtain a.v.c. voltage and second detector action, as shown in figure 3. It is necessary to by-pass the plate circuit of the tube in this arrangement, since the control grid has r.f. or i.f. voltage applied to it.

The fluorescent deflection of the tube in the circuit of figure 3 depends upon the applied carrier signal which is rectified in the grid circuit of the tube. The tuning indicator tube serves a multiple purpose, in that it acts as a second detector supplying an audio signal, furnishing a.v.c. voltage to the i.f. and r.f. amplifiers, and as a tuning indicator for tuning the receiver to resonance with the desired signal.

Calibration Oscillators

Broadcast stations are capable of maintaining their respective frequencies with extremely high accuracy. Many of the stations in the 550 to 1500 k.c. broadcast range maintain their carrier frequencies to within 5 or 10 cycles per second. The

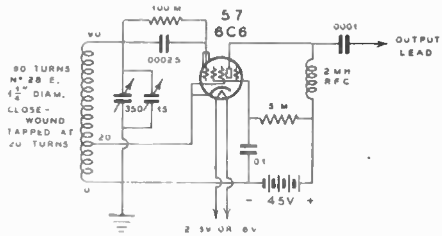


Calibration Oscillator for Battery Operation.

signals from these stations may be used for calibration purposes in the short-wave range. The method is to zero-beat a small oscillator with the incoming broadcast carrier signal and pick-up the harmonics of the local oscillator in the short-wave receiver. The short-wave receiver may be calibrated by using several points, or a frequency meter may be calibrated by zero-beating it against the harmonics of the local oscillator.

The necessary equipment includes a roughly calibrated short-wave receiver, either with a beat-frequency oscillator or one of the autodyne detector type, a calibration oscillator, and a broadcast receiver of any type. The calibration oscillator should be capable of tuning over the broadcast band and can be of either type shown in the accompanying circuit diagrams. Any oscillator or signal generator may be used for this purpose. Harmonics of the local oscillator, up to the 10th or 15th, generally can be picked-up by the short-wave receiver.

The local oscillator should be tuned so that it produces zero-beat against the desired broadcast station signal as heard in the broadcast receiver. A small 15 μμfd. midget variable condenser connected across the main tuning condenser of the calibration oscillator simplifies the adjustment to zero-beat. This oscillator will usually supply enough signal to the broadcast receiver for heterodyne purposes if it is within a few feet of the receiver. If the broadcast station signal is very strong, the calibration oscillator sometimes must be coupled loosely to the antenna lead-in of the broadcast receiver. If the signal is weak, a mutual coupling will suffice. After the calibration oscillator is tuned to zero-beat, the harmonics will be exact multiples of the broadcast station frequency. For example, a 700 k.c. signal will result in harmonics on 1400, 2100, 2800, 3500, 4200, 4900, 5600, 6300, 7000, 7700,



With Heater Type Tubes, Battery Plate Supply Is Still Used for Stability.

8400 k.c., etc. Normally, certain broadcast stations in any locality will have carrier frequencies which will provide harmonic calibration for those frequencies lying within the amateur bands. A frequency meter or receiver can be very accurately calibrated by means of this method.

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