THE RADIO Handbook

1936

CHAPTERS COVERING

SHORTWAVE RECEIVER CONSTRUCTION

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THE RADIO *Handbook*

1936

FOR AMATEURS AND EXPERIMENTERS

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receiver construction
chapters from

Frank C. Jones's
1936 Radio Handbook

RECEIVERS

Elements of Tuning Inductances

Resonant circuits are the major electrical tuning units in all amateur, communication, and broadcast receivers. The importance attached to the tuning circuit and other associated elements requires a detailed analysis; however, the following considerations are all that are necessary.

Electro-magnetic and Electro-static Coupling

When an electro-magnetic wave is intercepted by an antenna, a small radio-frequency voltage is induced in the conductor, which surges to-and-fro in an oscillatory manner. Tapping the antenna at a suitable point by a **lead-in** or **feeder** and causing the voltage to pass through an inductance will produce a current in the coil in proportion to its reactance.

Assuming that the inductance in the antenna circuit is untuned; that is, an inductance without any shunt capacity, the voltage induced across the coil will be equal to the current times the inductive resistance. Hence, anything done to increase the voltage developed across the coil will also increase its magnetic flux; and furthermore, when a secondary winding is coupled to the antenna coil a greater voltage will be induced on account of the increased flux density cutting the secondary inductors. Anything to cause the antenna voltage to increase, before being applied to the grid of the detector tube, will augment the overall amplification of the signal strength.

Now, by changing the untuned antenna coil to a tuned parallel resonant circuit by the simple expedient of adding a variable capacity across the inductance, the voltage will no longer equal the current times the inductive reactance; but, instead, will equal the current times the ratio of the reactance and resistance. The impedance of such a circuit drops off rather rapidly at either side of resonance; the voltage, and consequently the signal diminishes proportionately. In other words, a circuit that is tuned exactly to the signal frequency will give considerably more gain than one that is untuned or that may differ in some respects from the resonant frequency by an appreciable amount.

The energy from the antenna can be connected directly across a coil and induced into another coil without being physically connected to the former; this is known as **inductive coupling.** On the other hand, if the energy is connected across the plates of a condenser, then fed to the grid side of the coupling coil, the connection is known as **electro-static coupling.** From the foregoing explanations it will be apparent that this type of coupling has no voltage gain in itself, and is therefore inferior, though possibly more convenient to use than inductive coupling.

. Whenever an antenna circuit is coupled closely to the grid circuit, some electrostatic coupling is bound to exist, due to the capacity between the metals in the respective coils. A combination of coupling is undesirable in most cases, since electrostatic coupling permits steep wave-front voltages, such as static and noise, to have greater paralyzing effect on the grid. Pure inductive coupling is only practicable if the separation between the two coils is made large, or through the use of an electrostatic shield, commonly known as a "Faraday screen."

In inductively coupled circuits, the amplitude of the induced voltage will depend upon the strength of the magnetic field set up, the proximity of the two "coils" and the impedance of the grid circuit to the particular frequency.

The impedance of the grid will follow the same rules set forth for the antenna circuit, since they are both parallel resonant circuits and are both maintained at resonance with the incoming frequency. At this point it is necessary to take into consideration another property of resonant circuits known as the "Q."

"Q" of Resonant Circuits

"Q" may be defined as the inductive reactance divided by the resistance. The Q of a coil is the factor of merit; the higher the Q, the better the coil. Authorities differ quite widely on the ideal shape for a coil, but, in general, agree that very long, or very short coils are to be avoided. A coil whose length is approximately equal to its diameter is often considered best.

The diameter of the wire used to form the coil also has a definite influence on the Q. Hence the wire size should be as large as possible to get into a given winding space. NOTE: Practically all the resistance in a parallel resonant circuit is contributed by the inductance; the condenser, if well designed, has negligible resistance. But nearly all the resistance in the inductance is contributed by the "skin effect." This effect increases almost directly with frequency and is introduced at high-frequencies because the current is not equally distributed throughout the conductor, but travels only on the outermost surface. Thus, in order to provide ample surface for the current to pass along, it is necessary to use a much larger size conductor than would be the case if the current was equally distributed throughout the conductor.

Round conductors are always better than flat strips because, even if the flat strip has more surface area, the fact remains that the current does not distribute evenly over the entire surface but has a maximum density at the edges, with low density on the sides.

Distributed capacity, or the capacity existing between successive turns and also between these turns and the ends, is to be avoided in any receiver coil, since this capacity has the effect of lowering the Q. Space winding is one means of lessening this effect. Where the conductor is large in diameter, "space winding" reduces the skin-effect, due to currents set up in adjacent turns. Dielectric loss due to poor insulating material in coil forms also has the bad effect of lowering the Q.

Summarizing: The ideal inductance would be one having the following properties:

1—A shape such as to make the length approximate the diameter.

2—Entirely air-supported. Since this condition is practically impossible, a compromise must be adopted taking the form of a coil support of a low-loss dielectric, such as Isolantite.

3—A wire size of ample proportions. This must also be a compromise, since with excessive wire diameters the skin-effect and distributed capacity more than offset the gain due to increased surface. For all practical purposes a wire size larger than No. 16 need not be used in receiver coil design.

4—A space type of winding. The spacing will be more or less governed by the length-to-diameter rule. In general, the spacing ought not to exceed twice the diameter of the coil.

Considering the coil and condenser as a unit (a parallel resonant circuit), it is required in good design to adhere to the following:

1—In order for the circuit Q to be as high as possible, the inductance-to-capacity ratio should be very high.

2—The tuning condenser should have excellent mechanical and electrical properties and be preferably insulated with Isolanite, or similar material. Some type of pig-tail connection or positive wiping contact must be included in the assembly for contacting the rotor; this reduces high-resistance during rotation.

Selecting a Receiver

The selection of the proper type of receiver best suited to one's needs is a problem that confronts every beginner. Incidentally, there are practically as many types of receivers as there are kinds of amateurs. No perfect receiver exists for all-around operation under all operating conditions; hence, it is largely the personal choice of the operator that governs the receiver type. All receivers represent a compromise between such factors as cost, size, accessibility, convenience, dependability, versatility, output desired and the purpose for which it is to be used.

If a receiver is to be built, instead of being purchased, and if the constructor has had no experience in receiver construction, it is advisable to first build the more simple types of receivers, using from one to three tubes, instead of the more complicated multi-tube superheterodyne receivers, which may have from six to twelve or more tubes.

The constructor who chooses the regenerative autodyne receiver must weigh the compromises involved in its design. If the receiver is located in a metropolitan area, where power lines, street cars, oil furnaces and other sources of man-made static interference are prevalent, the receiver must be particularly well shielded. If the set is battery-operated, the noise pick-up will be minimized, as no interference will be introduced through AC power lines feeding a mains-operated plate or filament supply. If the receiver is used in the country, remote from man-made static, shielding is a matter of lesser importance, and thus a somewhat simpler receiver will give entirely satisfactory results.

If a receiver is located in the neighborhood of a powerful radio transmitter, the strong radiations may block or paralyze the RF or detector circuits, making it necessary to provide a tuned stage of radio-frequency amplification or some other form of volume control to obtain satisfactory selectivity. At the same time it may also be necessary to choose a somewhat less sensitive detector circuit in order to make the detector less susceptible to overload.

One of the salient points of receiver construction is that of cost. The actual design of a receiver is a simple problem. Of course, the design may become complex if all late engineering refinements are incorporated into the construction. In general, the most elaborately designed receiver is actually more modest in cost than might otherwise be expected. Although every set builder will desire the most expensive coil forms, tuning condensers and vernier dials, it is essential to strive for a happy medium when selecting a receiver circuit which makes the best use of the parts available.

A receiver which is to operate on one band is much easier to build than one which must operate satisfactorily in the entire range of from 160 meters to 10 meters. A band-spread arrangement of condenser combinations which give excellent results on 20 meters will not be satisfactory when used to cover the 160-meter band. Thus, if the constructor desires to operate on two such widely different frequencies, a sacrifice must be made of both convenience and efficiency on one or both of these bands.

Methods of Band-Spreading

Band-spreading is an electrical means of obtaining tremendous gear reduction on the tuning condenser dial of a receiver. High-frequency receivers must cover a very wide range of frequencies and therefore it is difficult to design a dial and drive mechanism which will cover the desired ranges, yet still provide sufficient "vernier" (geared down) drive so that weak signals will not be passed over without hearing them. In newer all-wave broadcast receivers this problem is solved by the use of a two-speed dial arrangement, the low reduction being provided for rough tuning and the high reduction for fine tuning. This is usually accomplished mechanically by means of planetary gear. The system is quite satisfactory, but rather difficult to manufacture by the average amateur or experimenter. Practically the same effect can be obtained by means of electrical band-spread. Almost all receiver circuits use a variation in the capacity of the tuned circuit for tuning purposes. In order to obtain a small variation in tuning it is essential that the capacity be increased or decreased by a small amount. However, difficulty is encountered in varying the capacity of a large condenser by small increments or decrements, but in an electrical band-spreading system utilizing two tuning condensers—one large condenser to give rough tuning, the other, a very small condenser (two or three plates) may be connected in a wide variety of combinations to give the electrical effect of "fine" or "vernier" tuning. The first system is shown in Figure 1a. It is the most common system and consists of a small condenser C_2, connected directly in parallel with the large condenser C_1. In most high-frequency receivers the capacity of C_1 will be chosen so that the coil and the condenser combination will cover a frequency range of between 2-and-3-to-1. The condenser C_2 is much smaller than C_1 and will often be chosen so as to cover a band of approximately 1000KC.

Figure 1b shows a band-spread condenser in series with the main tuning condenser. Because the capacity of two condensers in series is always smaller than the capacity of the smaller of the two condensers, it will be seen that both condensers in Figure 1b must be considerably larger in capacity than the corresponding condensers in Figure 1a in order to cover the same frequency ranges. Both of the systems shown in Figures 1a and 1b have the disadvantage in that the degree of band-spread varies with the tuning of C_1, and thus if a given coil covered both 40 and 20 meters, the system may provide too much band-spread for 40 meters and not enough band-spread for 20 meters. In Figure 1c the band-spread effect can be kept constant over a wide range of frequencies by tapping the band-spread condenser across part of a coil, instead of being tapped across the entire coil, as in Figure 1a. The position of the tap varies with frequency. On the larger low-frequency coils, the tap will be placed near the top of the coil. On small high-frequency coils, the tap will be placed proportionately farther down on the coil in order to maintain an approximately constant degree of band-spread. This system has the disadvantage in that some selectivity is lost in the tuned circuit. Figure 1d shows another means of equalizing the degree of band-spread over a wide range of frequencies. C_1 is the conventional large tuning condenser of between 140 and 350 mmfd. C_2 and C_3 are both band-spread condensers. C_2 has approximately 50 mmfds. for band-spreading the 80 and 160 meter bands; C_3, from 15 to 20 mmfd., is best for use on the 40 and 20 meter bands. The proper condenser is chosen by means of switches, as shown in the accompanying figure. A disadvantage of switching is that rather long leads are required, as well as a possibility of losses in the switch contact.

METHODS OF BAND SPREADING

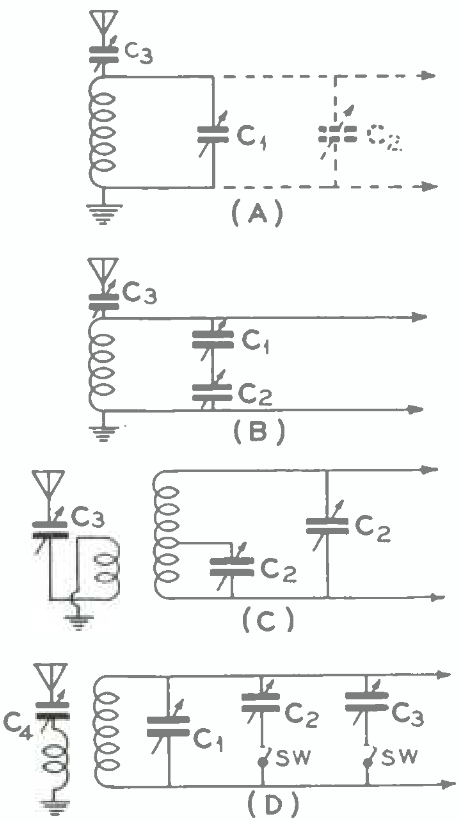


FIG. 1

Plug-in Coils

Practically all regenerative receivers use plug-in coils. This is also true of some of the highest-priced amateur receivers and commercial superheterodynes. The advantages of plug-in coils are only obtained when low-loss materials and low-loss design are featured as a complement. The very best low-loss coil form is "dry-air," or self-supported coil winding. Next best are the ceramic forms which use Isolantite, Mycalex, or their equivalents. Then follow the special mica compounds, such as the XP-53 and R-39 compounds. Whereas celluloid is a more inferior dielectric than the aforementioned materials, its advantage is that a very thin form will serve as an excellent coil support. In addition, because losses are a function of the volume of dielectric material in an electric field, the thin celluloid makes possible the construction of an extremely low-loss coil form.

Wire for Coil Winding

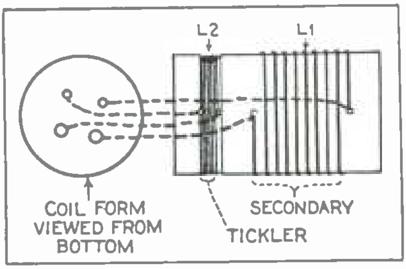
Bare wire, having as large a diameter as possible, is better than insulated wire in winding coils, because the larger the wire diameter, the lower will be the radio-frequency resistance. In coil winding, the space-wound method is superior to others, while grooved coil forms are undesirable on account of increasing distributed capacity. It is essential that all coils be placed as far away as possible from metallic shields or other metal bodies, such as the chassis.

Coil Winding Data for Simple Receivers

Coil winding tables vary with the size of the coil form used. The standard form is 1½ inches outside diameter. A table is given below for the number of turns required on a coil form to cover the four popular amateur bands. If forms larger than 1½ inches in diameter are on hand, obviously fewer turns will be required. Conversely, a smaller form will require a greater number of turns per coil. It is a simple matter to use the "cut and try" method when winding coils; however, the accompanying table will greatly simplify matters. It is assumed that the coils are to be wound on standard forms and tuned with a 100 uufd. midget variable condenser.

Wave-length	L1, Secondary Winding	L2, Tickler Winding
20 M	7 turns, No. 18 DCC, spaced two diameters.	4 turns, No. 22 DSC, close wound.
40 M	18 turns, No. 22 DSC wire, spaced one diameter.	Ditto.
80 M	36 turns, No. 22 DSC wire, close wound.	6 turns, No. 22 DSC, close wound.
160 M	72 turns, No. 32 DSC or SCC wire, close wound.	11 turns, No. 22 DSC or SCC, close wound.

Spacing between secondary and tickler coils to be ⅛-inch. The wire should be tightly wound on the coil forms. Insulating varnishes should be used sparingly, if at all. The most common form of coil "dope" is known as Collodion, made by diluting small pieces of celluloid in a vessel containing about an ounce of Acetone.



Reading from Right to Left, the coil connections are as follows: Antenna (and grid condenser), Ground, Plate, B Plus.

Tickler Winding

If the detector does not regenerate, reverse the tickler connections or add one or two turns of wire to the tickler coil, until smoothest regeneration is obtained.

The Detector in a Regenerative Autodyne

The detector is the heart of the regenerative autodyne receiver, and a wide variety of tubes may be used for this purpose, each having certain advantages and disadvantages. The four most commonly used detector tubes are the 76 and 6C6, for operation from house lighting current, and the 30 and 32 types for battery-operated sets. The 76 and 30 are triodes, while the 6C6 and 32 are screen-grid types. Screen-grid detectors are somewhat more sensitive than triodes, although are more susceptible to overload and more difficult to get going. In place of the 6C6 or 32, it is often desirable to utilize a tube with a variable mu, such as the 6D6 or 34. This type of tube is slightly less susceptible to overload than the sharp cut-off detectors, such as the 6C6 and 32. Variable mu tubes afford a smoother control of regeneration but necessitate a sacrifice in sensitivity.

The 24, 36 and 57 tubes are very similar to the 6C6. By the same token, the 39 and 58 are similar to the 6D6. Likewise the 27, 37 and 56 will act exactly like the 76 in most circuits. In the battery-operated field there is less choice, although the 99, 201A and 12A are quite similar in characteristics to the 30, and type 22 can be used in a circuit designed for a 32.

Audio Coupling

The detector can be coupled to an audio amplifier in three different ways, which are known as resistance coupling, impedance coupling, and transformer coupling.

In general, resistance coupling is the least desirable of the three methods when working out of a regenerative detector, because the question of fidelity is relatively unimportant and fidelity is the principal advantage of a resistance coupled amplifier. Resistance coupling can be used out of either triode or screen-grid detectors.

Impedance coupling (or choke coupling) is particularly recommended when working out of a screen-grid detector because it enables the full plate voltage to be applied to the detector and also has enough distributed capacity so that any radio-frequency present is easily by-passed to ground. The only disadvantage of impedance coupling is that it affords no voltage step-up, as does transformer coupling. An impedance to work out of a triode detector should be approximately 30 henrys at 15 to 20 milliamperes. An impedance designed to give best results out of a screen-grid or pentode detector should be rated at more than 250 henrys at 5 milliamperes.

Transformer coupling is unsuited when using a screen-grid or pentode detector, although it is recommended when working out of a triode detector. A step-up ratio of approximately three-to-one gives the best all-around results.

Impedance or transformer coupling sometimes gives trouble, due to fringe audio howl in a regenerative receiver. A 50,000 to 250,000 ohm resistor shunted across the impedance coil or transformer secondary will usually cure this trouble.

Audio Tubes

The choice of the audio output tube is largely dictated by the amount of audio power required. If loudspeaker operation is desired, two stages of audio amplification will ordinarily suffice; for example, a triode type 76, in the first stage, and a pentode, such as a 41, in the second stage.

If headphone operation is desired, the second stage may be eliminated and the phones connected in the plate circuit of the first amplifier stage. For loudspeaker use, pentodes are recommended, such as types 38, 41, 42, 47, 59, 89, 33, or 43. Triodes may also be used, but will require somewhat more amplification; they are the 12A, 71A, 45, 46, 2A3, 31, 120, and others.

Any of the following tubes are entirely satisfactory for headphone reception in the audio stage: 99, 30, 201A, 112A, 27, 37, 56, 76 and either of the following pentodes when connected as triodes (screen and suppressor grids tied to plate): 57 and 6C6.

Notes for Set Builders

SOCKETS: The socket material is as important as the material from which the coil forms are made, because the socket is in the direct field of the coil. In receiver construction it is essential that only the very best material is used in socket assemblies; thus, ceramic, Isolantite and other good insulators will suffice.

LEADS AND CONNECTIONS: Leads to the tube socket and tuning condenser must be short and direct, sharp bends being avoided whenever possible. All joints must be carefully soldered with rosin-core solder, and a clean, hot iron should be used for all soldering operations. Make all connecting wires mechanically secure to all connecting points and keep all wiring well remote from metal shielding and chassis.

CALCULATING FILAMENT DROPPING RESISTOR VALUES: It is important that the filaments of all tubes, either in a transmitter or receiver, be operated at the rated filament voltage. If the voltage is too low or too high, tube life is materially reduced. When in doubt, it is advisable to operate the filament at a slightly higher than normal voltage, rather than at lower voltage. The value of a filament resistor can be calculated by means of Ohm's Law, a very simple formula which indicates the relationship between voltage, current and resistance. If any two are known, the third can be determined. The three forms of this equation are:

$$E = IR \qquad R = \frac{E}{I} \qquad I = \frac{E}{R}$$

Where E = the voltage; I, current (amperes); R, resistance (ohms).

For example, assume the two type 30 tubes are being operated with their filaments in parallel and a 3 volt battery is to supply the filament power. But, since 3 volts is too high, it must be dropped to 2 volts through a series dropping resistor, which will give the normal operating voltage. To calculate the value of the series resistor, it is first necessary to determine the current drawn by the two tubes. The current in this case is 120 milliamperes, or .12 amperes. From the equation R = E/I, the resistance is computed by dividing the desired voltage drop by one volt (which is "I" in this case) by 12/100, which is the same as multiplying 100/12. The equation then is 1/1 × 100/12, which equals 8.3 ohms. Therefore, 8 ohms is the proper value of resistor to use, because fractional value resistors are not obtainable. When connecting two tubes in series, it becomes necessary to provide twice as much heating voltage as when only one tube is used; however, there is no increase in heating current. When the filaments of two type 30 tubes are connected in series, it is necessary to provide 4 volts at 60 milliamperes (0.06 amperes). Either a 4½ volt "C" battery or three 1½ volt dry cells connected in series provide a convenient means for operating the two tubes in series. The dropping resistor should be 8 ohms, which is determined by dividing the voltage drop of ½ volt by the total filament current of .06 amperes. Care should be taken to see that tubes which draw different values of filament current are not connected in series unless special precautions are taken, as shown in Figure 2. A shunt resistor must be connected across the filament of the tube drawing the least current, so that the sum of the current through the resistor, plus the current through the filament which it shunts, is equal to the current drawn by the other tube.

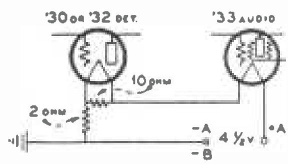


Fig. 2. Series connection for dissimilar filament currents.

CALCULATING VALUE OF SELF-BIASING RESISTORS: In practically all receivers utilizing either radio or audio frequency amplifying stages, some method of self-biasing the grids is employed. This bias is obtained by inserting a resistor in the cathode lead return wire and taking the necessary voltage drop across the resistor. The value of self-biasing resistors can be calculated by the formula:

$$\text{Ohms} = \frac{\text{grid bias} \times 1000}{\text{plate current}}$$

Thus, for a 45 tube which has a plate current of 34 ma. for which a grid bias of 50 volts is needed:

$$\frac{50 \text{ Volts} \times 1000}{34} = 1{,}470 \text{ Ohms}$$

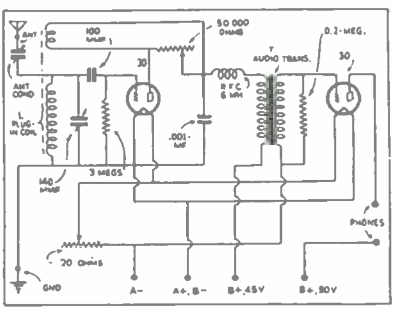
The wattage or power consumed in the resistor equals E × I or .034 × 50 or 1.7 watts. For push-pull amplifiers combine the plate currents of each tube. For screen-grid and pentodes use the sum of the plate and screen currents.

Simple Receivers
2-Tube "DX-ER"

This receiver does not in any sense represent a new development in the short-wave construction field. Instead, it is one in which the designer combined well-known and accepted principles to produce a set that is simple and inexpensive to build.

From a casual examination of the schematic diagram it will be seen that the receiver is of the single-circuit regenerative type, with tickler feed-back. The placement of the parts is extremely important for effective results. As in all receiver designs where the maximum efficiency is desired, only the highest quality of parts should be used. Equipment of inferior design, carelessly assembled, will not bring the desired results.

For economical operation, two type 30 low-drain two-volt tubes are used. The first serves as a regenerative detector; the second as an audio amplifier. The tuning range of the receiver is 15 to 200 meters, covered by a set of four plug-in coils. Regular broadcast reception is optional, by adding a set of two plug-in coils to cover 200-500 meters.



Simple 2-Tube Regenerative Receiver.

Only two dry-cells and two 45 volt "B" batteries are required for complete operation.

Regeneration is controlled by a 50,000 ohm variable resistor connected across the tickler leads. The output of the detector is transformer-coupled to the audio tube by a shielded transformer having a ratio of 1 to 5. A load resistor of 200,000 ohms is connected across the secondary of the audio-transformer to eliminate any possibility of "fringe howl."

The antenna is coupled to the tuning coil by a semi-variable "postage stamp" condenser having a maximum capacity of 80 uufds.

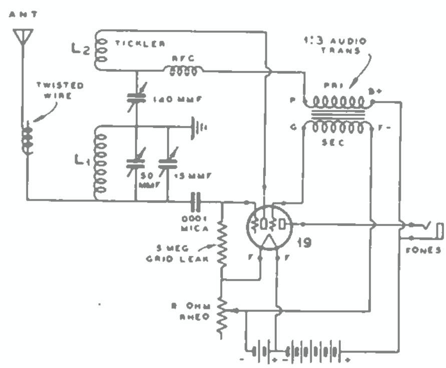
Tuning is accomplished by a 140 uufd. midget variable condenser mounted on the front panel. A smooth vernier-type dial is used to insure proper tuning.

OPERATING NOTES: Phone signals are loudest just below the oscillation point, and CW signals just above the oscillation point. When tuning the "DX-ER," set the regeneration control to the point where the detector just starts to oscillate; then the tuning dial should be carefully turned until a "whistle" is heard. Careful tuning at this point and further adjustment of the regeneration control will bring in the intelligible signal.

Simple Receiver With One Type 19 Tube

This receiver gives surprisingly good volume on DX signals; it is especially recommended for the beginner who is contemplating the design of a simple and inexpensive set.

The circuit diagram is self-explanatory; however, there are some details that need explanation. The grid and plate connections must be properly made, as shown in the circuit diagram. The grid bias is secured by means of the rheostat in the filament circuit. The constructor, therefore, is cautioned to connect the movable arm of the rheostat to the negative A, and also to the negative F on the audio transformer. Best results are secured with a 5 megohm gridleak; smaller values may cause the detector to regenerate with an unpleasant roar. Smoother regeneration is sometimes secured by connecting a 250,000 ohm ½ watt resistor across the secondary (GF) terminals of the audio transformer.



Schematic circuit diagram of the one-tube receiver. L1 is the secondary, or grid coil. L2 is the "tickler," or regeneration coil.

The band-spread tuning condenser is a 3-plate midget variable; the tank tuning condenser is a 50 uufd (or 100 uufd) midget variable. A 140 uufd. midget variable condenser is used for the regeneration control. The secondary and tickler coils are both wound on the same form, and both coils **must** be wound in the same direction; otherwise the detector will not oscillate.

General Construction: The front panel is made of a piece of No. 12 or No. 14 gauge aluminum, 7 in. x 9 in. The wood baseboard is 9 in. x 11 in. The band-spread, tank condenser and regeneration condenser are mounted directly on the panel and the rotors of these condensers are grounded to the panel. The rotors may be connected together, and the connecting wire bonded to the ground or panel. An inexpensive airplane dial enhances the symmetry of the front panel. This dial controls the 3-plate band-spread tuning condenser.

Ordinary Fahnestock battery connection-clips can be used for headphone connections in place of the phone jack; these connectors can be secured to the baseboard in any convenient location, preferably near the audio frequency transformer.

An on-off switch can be added, or the dry cells can be disconnected from the receiver when not in use. Two 1½-volt dry cells are required. These will give excellent service for a long period of time. The B-battery voltage may be as low as 22 volts, but at a sacrifice in audio volume; 45 to 90 volts is more suitable for normal operation, except when the receiver is used as a portable. With 22 volts the tickler coil must be placed very close to the secondary coil.

Antenna Connection: The antenna is coupled to the "high potential end" of the secondary coil by a few turns of lead-in wire twisted around the grid-lead of coil L1; a single turn loop wound around the top of L1 will give the same results. The small midget condenser shown in rear-view photograph of the receiver is connected in series with the antenna lead and the top lead of L1. It can be used as a substitute for the twisted-wire coupling arrangement.

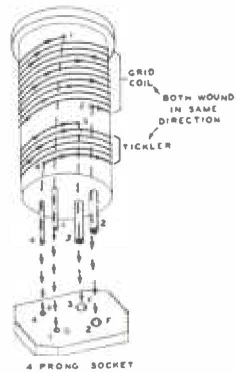
Noise-Free Two-Tube Autodyne

The circuit of this receiver is conventional in every respect. It utilizes a 57 detector in an electron-coupled "Hartley" circuit which has proven so simple to make oscillate at high frequencies. Regeneration is controlled by varying the screen-grid voltage by a potentiometer across the power supply. A RF filter is incorporated in the plate lead from the detector as a precaution against spurious RF currents flowing through the audio impedance. The audio stage uses a 56 type vacuum tube, although a 27 may be substituted. In general, the circuit includes all refinements commonly found in standard practice, except for the filtering of the phone and power leads, and the link coupling to the antenna.

The receiver housing is made of aluminum, approximately 7½ inches deep. The actual panel dimensions are left to the discretion of the builder. Inside the housing is an aluminum sub-panel formed by making two rectangular, or flat "U," bends two inches deep. Another piece of aluminum is closely fitted and fastened to the bottom of the housing by tapping holes in ¼-inch "dural" corner posts which hold the assembly together. The top is fitted in the same manner as the bottom, with the exception that no drilling is necessary—the top merely rests on the corner posts.

RECEIVER ASSEMBLY: The tuning condenser is mounted on an aluminum bracket which rigidly supports it; the bracket also serves to shield the audio

COIL DATA



The upper coil is the grid (secondary) coil. Start the winding at point 1, make the connection to prong 1. The bottom of the grid coil (2) connects to prong 2. The top of the tickler coil (3) connects to prong 3; the bottom of the tickler (4) connects to prong 4. Mark the coil prongs and the coil socket contacts to correspond with these numbers. See the pictorial layout to show how the connections are made to the coil socket. Make certain that Connection No. 1 goes to the stators of both tuning condensers, and also to one side of the .0001 mfd. grid condenser. Likewise, take care to see that Connection No. 4 goes to the plate of the detector portion (P2) of the type 19 tube. If these connections are not properly made, the receiver will not function. The antenna lead-in wire can be looped around the No. 1 connecting lead.

COIL FORM LEGEND

Terminal No. 1 connects to one side of the .0001 mfd. mica fixed condenser and to the stator of the 100 mmf. (or 50 mmf.) condenser, as well as to the stator of the 3-plate midget variable tuning condenser. Likewise, the insulated antenna lead-in wire is twisted around the lead which connects to Terminal No. 1.

Terminal No. 2 connects to the rotors of all three variable condensers, and at the point where the three are connected together another lead is run to the "ground" terminal of the receiver.

Terminal No. 3 connects to the stator of the 140 mmf. variable condenser which is used for regeneration, and the same terminal also connects to one end of the 2.5 mh. RF choke.

Terminal No. 4 connects to the P2 terminal on the type '19 tube.

COIL WINDING DATA

The secondary coil and the tickler coil are both wound in the same direction.

20-Meter Coil: Secondary winding—7 turns of No. 22 DSC wire, space-wound to cover a winding space of 1-in.

Tickler Winding—5 turns of No. 22 DSC wire, close-wound, and spaced about ⅛-in. from the secondary winding.

40-Meter Coil: Secondary Winding—14 turns of No. 22 DSC wire, space-wound to cover a winding space of 1-in.

Tickler Winding—11 turns of No. 22 DSC wire, close-wound, and spaced ⅛-in. from secondary winding.

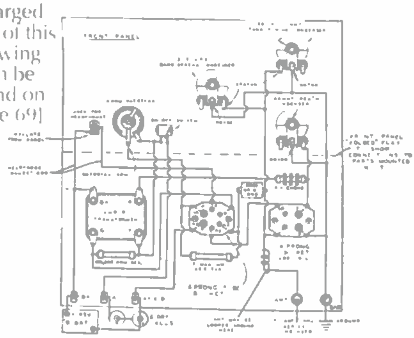
80-Meter Coil: Secondary Winding—27 turns of No. 22 DSC wire, close wound.

Tickler Winding—11 turns of No. 22 DSC wire, close wound, and spaced ⅛-in. from secondary winding.

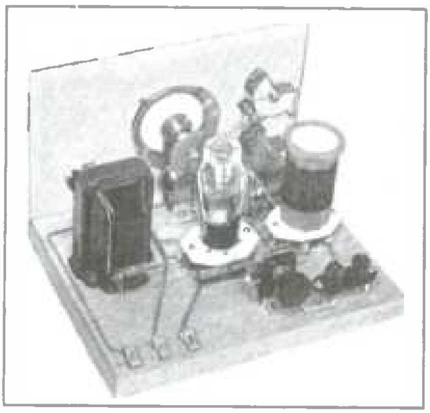
160-Meter Coil: Secondary Winding—60 turns of No. 22 DSC wire, close-wound.

Tickler Winding—17 turns of No. 32 Enameled wire, close-wound, and spaced ⅛-in. from secondary winding.

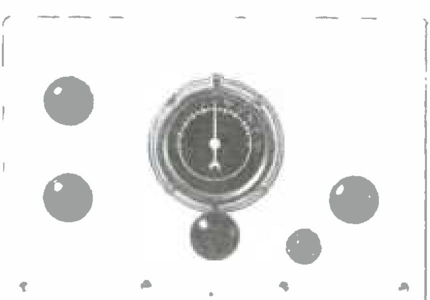
[An enlarged copy of this drawing can be found on page 69]



Pictorial layout of parts for 1-tube receiver. This arrangement should be closely adhered to.



Rear View of the Completed Receiver.

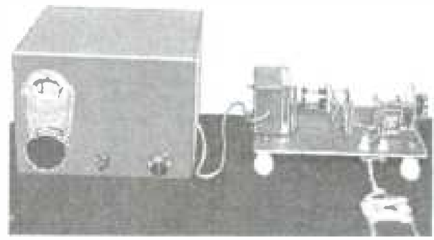


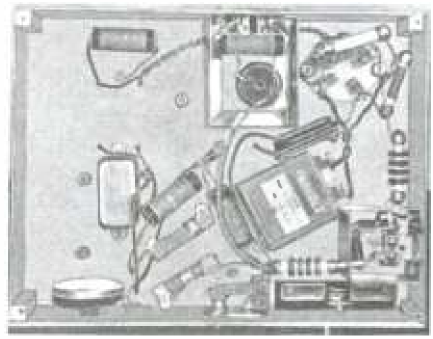
Front Panel Layout.

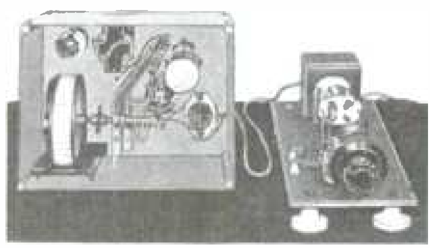
The Controls on the Front Panel Are:

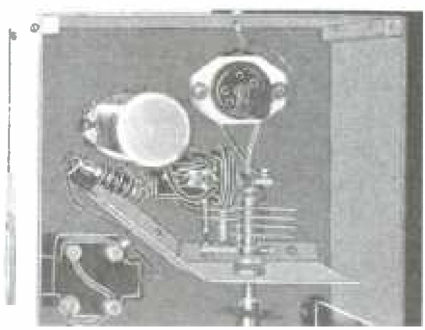
Top, left—"Tank" tuning condenser.
Bottom, left—Regeneration condenser.
Center—Airplane tuning dial.
Extreme right—Rheostat control.

The headphone jack is mounted between the airplane dial and the rheostat control. This jack MUST be insulated from the metal front panel and a hole at least ⅛-inch larger in diameter than the outside diameter of the screw thread on the jack should be drilled in the panel.



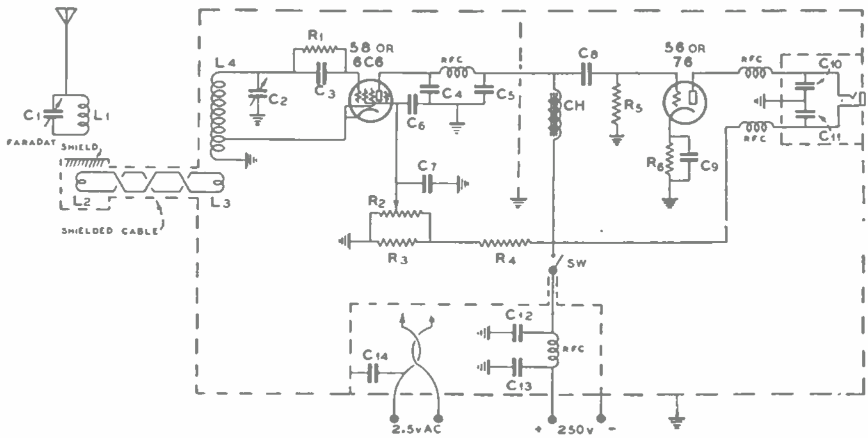






Four views of the Noise-Free Autodyne. The center picture shows how the small shield compartments are arranged under the chassis.

impedance (choke) from affecting the detector stage, thus eliminating possibility of "fringe howl." The grid leak and condenser are fastened to the tuning condenser, thereby making the leads very short to the detector tube. Only short and direct leads make



LEGEND FOR THE NOISE-FREE AUTODYNE

L1—Similar to L4, but with fewer turns, depending on type of antenna used. L2-L3—See coil table. L4—Described in Text. C1—100 mmf. midget variable. C2—20 mmf. National SEU-20. C3—100 mmf. Sangamo, with grid clip. C4, C5, C10, C11—250 mmf. mica Aerovox postage stamp type. C6, C12, C13—.01 mfd. mica condensers. C7—½ mfd. 400 volt non-inductive condenser. C8—.01 mica, Sangamo. C9—1 mfd. 200 volt paper condenser. C14—.01 mfd. non-inductive. R1—2 to 5 megohm grid leak (experiment for noiseless one). R2—50,000 ohm Centralab variable resistor. R3—4,000 ohm 10 watt. R4—15,000 ohm 10 watt. R5—½ megohm 1 watt. R6—3000 ohm 1 watt. RFC—Good short-wave choke. CH—Old A.F. Transformer or high inductance choke.

possible the ease by which this set oscillates on 28 MC; this, coupled to the fact that more coil turns are required in the circuit than is common in ordinary practice, make for a high LC ratio—a prerequisite for high sensitivity. The plate filter is mounted above the sub-panel to keep leads short and the RF from under the chassis.

Under the sub-panel, the wiring arrangement is completely conventional, with the exception of the RF filters and the number of by-pass condensers. Note, for example, that the screen-grid of the detector tube is by-passed twice—once at the socket of the 6C6, and again by a .05 ufd. condenser across the regeneration control. This latter condenser eliminates any noises that may be injected into the circuit by the sliding contact on the potentiometer. A simple output filter consists of two .00025 ufd. condensers and two RF chokes; the condensers and phone jack are included in a special shielded can, as may be seen in

COIL DATA FOR L4

3.5 MC—46 turns No. 30 enameled, close wound, tapped 1½ turns up.

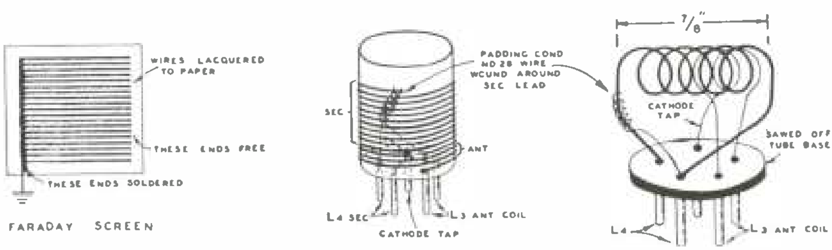
7 MC—23 turns No. 18 enameled, spaced diameter of wire, tapped ⅞ turns up.

14 MC—11 turns No. 18 enameled, spaced 1½ diameters, tapped 2/3 turns up.

(Above coils wound on 1½-inch five-prong coil forms).

28 MC—9 turns No. 14 enameled wound ¾-in. diameter on air, tapped 1⅛ turns up. Turns spaced about ½ diameter.

Each link coupling loop consists of two turns interwound between the two bottom turns of each coil.



Showing how to make the Faraday Screen, 3.5, 7 and 14 MC coil, and (right) the special 28 MC coil.

the photographs. Another shield can encloses the power supply RF filter; a configuration made from a pi section filter of two .01 ufd. condensers shunted across an RF choke inserted in series with the positive terminal of the "B" battery or power supply. The two shields are made from small pieces of aluminum bent to form three sides of a box, and another piece, to serve as top, is made by bending the edges to fit snugly over the cans.

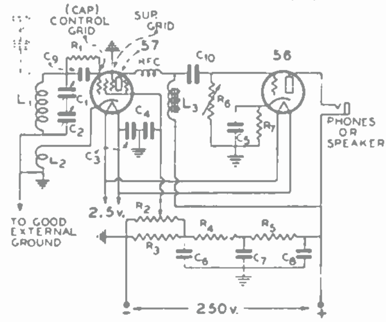
Proper band-spreading is achieved by placing padding condensers across the tuning condenser. These condensers are not shown in the photographs or wiring diagrams. Each coil contains its own padding condenser. A piece of No. 28 enameled wire is soldered to the ground side of the coil, right in the coil itself, and this is wrapped around the lead that goes up to the grid end of the coil. This permits accurate spotting of each coil right into the band, and the more turns, the more capacity; consequently the more band-spread. When the coil has once been adjusted, the extra wire is cut off and the connections made permanent. NOTE: If the coil does not cover the band for which it has been designed, it is only necessary to repeat the spotting adjustments by either lengthening or shortening the wire wrapped around the grid lead; only by experimentation can the best setting be found.

A-C Operated Gainer
An Ideal Amateur Receiver

Of the many two-tube circuits developed for amateur reception, the improved circuit shown in the accompanying diagram will be found superior to others of similar design. Although series band-spread tuning is shown, the constructor can substitute parallel band-spread tuning, the latter being a more simple method for the beginner to use. If the constructor embodies the parallel band-spread system in the circuit design, the variable condenser C_1 should have a capacity of 100 mmfds.; this condenser is shunted across coil L_1. The band-spread condenser C_2 may be a 3 plate midget, 15-25 mmfds., shunted across C_1, the tank condenser.

The receiver may be mounted on a metal chassis, 9x7 inches, with a "U" supporting bend 2 inches high. The space under the chassis is used for mounting resistors R3, R4, R5, R7 and condensers C3, C4, C5, C6, C7, and C8. The regeneration control is brought out to the front of the panel, as are controls R6 (gain) and the band-spread tuning dial for condenser C_2. The tank tuning condenser knob C_1 should also be on front of the panel. The grid condenser C9 and grid leak R1 are air-supported above the chassis, close to the grid cap of the 57 detector. The lead from R2 to the screen of the 57, and the lead from R5 to the phone jack are run through shielded braid. Plug-in coils are used in this receiver. L1 is the secondary coil; L2, the cathode regeneration coil. Both of these coils are wound on ordinary 4-prong tube bases or on standard plug-in coil forms, 1¼ or 1½ inches in diameter. The coils are wound as shown in the table under the List of Parts.

[An enlarged copy of this schematic can be found on page 69]



AC "Gainer" Circuit Diagram

L1—Secondary winding. L2—Tickler winding. C1, C2—Band-spread condensers, each 100 mmf., for series-band-spread tuning. C3—.01 mfd. C4—.5 mfd. C5—.1 mfd. C6, C7, C8—Each .5 mfd. C9—.0001 or .00025 mfd. C10—.002 mfd. R1—2 megs. R2—50,000 ohm potentiometer. R3, R4—Each 10,000 ohms, 10 watt. R5—5,000 ohms, 10 watt. R6—500,000 ohm potentiometer. R7—2500 ohms, 1 watt. L3—Iron-core choke (or impedance) 100 henry, or larger. An ordinary audio transformer, with primary and secondary windings connected in series, can also be used at L3. If parallel band-spread is to be used, C1 and C2 are connected in parallel, instead of in series, as shown above, and C1 should then be a 100 mmf. variable condenser, C2 a 3-plate (approx. 15 mmf.) band-spread condenser of the midget type.

L1—20 meters— 8 turns of No. 22 DCC.
40 meters—16 turns of No. 22 DCC.
80 meters—32 turns of No. 22 DCC.

L2—(Wound on the same form as L1, spaced about 3/16 inch away from L1) 4 turns of No. 22 DCC. (L2 is the same for all coils.)

The AC "Gainer" with front panel removed to show correct arrangement of parts.

Superheterodyne Receivers

The highest grade receiver for general amateur use is the superheterodyne. The circuit design is more complex than a regenerative autodyne. One of the salient points about a superheterodyne is that it has a remarkable ability to reject undesired signals, and is less susceptible to overload from powerful local transmitters.

In general, superheterodynes may be classified according to their uses, because the ideal superheterodyne for CW reception differs in many respects from the type used for phone reception. For both classes of work a superheterodyne must necessarily be a compromise between the two ideals.

In a superheterodyne exclusively used for CW reception, the two most important points are: (1) extreme selectivity; (2), freedom from noise. To date no superheterodyne has been designed which is too selective or too free from noise. A superheterodyne for CW must also have particular attention given to the high-frequency and beat-frequency oscillators, because a frequency drift in either oscillator of only a few cycles, can make the received signal entirely disappear. This point is less important in a receiver used for phone on account of the signal being considerably broader than a CW signal, and the oscillator drift, if any, is of little importance.

Conventional automatic volume control systems have no place in a CW receiver, which is primarily designed to operate from the variations in a continuous carrier. Hence, the variations in sensitivity caused by a CW signal merely make the signal difficult to read. Likewise, high-fidelity has no place in a CW receiver. In fact, many of the best CW superheterodynes utilize intentionally-poor audio fidelity by means of a peaked audio filter which passes the audio-beat note being received, and suppresses all others.

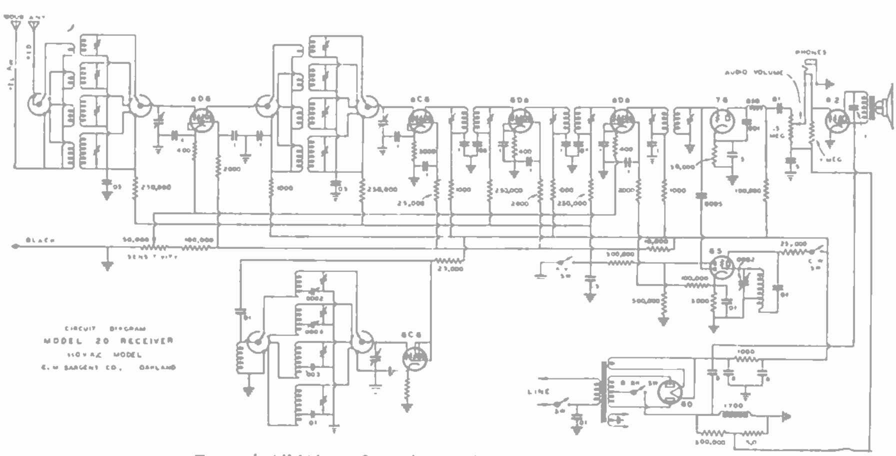
Automatic volume control belongs in a receiver for phone use, as does good fidelity in the audio channel. A receiver for phone generally has more audio amplification than a receiver for strict CW reception, in order to satisfactorily drive a loudspeaker. This is because the majority of phone operators prefer loud-speaker reception, while most of the CW men prefer the use of headphones. A receiver designed exclusively for phone reception probably would not require a beat-frequency oscillator, while in a CW receiver it is an essential device in order to produce an audible beat tone in the headphones.

A superheterodyne designed for phone use need not have the extreme selectivity required for CW as the modulation sidebands as well as the carrier coming from the transmitter must be passed through the receiver for detection. Thus, the conventional type of "series crystal filter" (explained later) is undesirable in a "phone" receiver on account of its extreme selectivity impairing the intelligibility of the received voice signal.

Circuit Pre-selection

The question of pre-selection arises in the design of both CW and phone superheterodynes. Pre-selection ahead of the first detector minimizes "image interference." An explanation of image interference requires a brief outline of how a superheterodyne operates.

In superheterodynes, it is important to note that instead of tuning the major receiver elements to the incoming signal, it remains fixed on one frequency and the received signal is then changed in frequency to the frequency of the intermediate amplifier, which is the real heart of the superheterodyne. This portion of the receiver provides 90 per cent of the selectivity and amplification achieved. The undesired image response is a characteristic of the frequency-changer in the front end, which consists of the first detector and high-frequency oscillator. An incoming signal from



Typical All-Wave Superheterodyne with Coil Switching.

the antenna is applied to the first detector or mixing tube, then a second signal, locally generated by a high-frequency oscillator, is likewise applied to the mixing tube. The presence of the two signals combine in the tube and cause the generation of sum and difference beat notes to appear in the mixing tube plate circuit. For example: Suppose the signal coming from the antenna is exactly 7,000 kilocycles, and the signal coming from the local oscillator is 7,460 KC. In the plate circuit of the mixing tube there will be, therefore, the sum and difference of these two frequencies, namely 14,460 KC and 460 KC. It is the 460 KC frequency that is wanted in this particular case, on account of the intermediate frequency amplifier being tuned to this frequency. The sum frequency (14,460 KC) would be by-passed to ground in the first intermediate amplifier transformer, while the difference frequency is the one usually chosen for amplification.

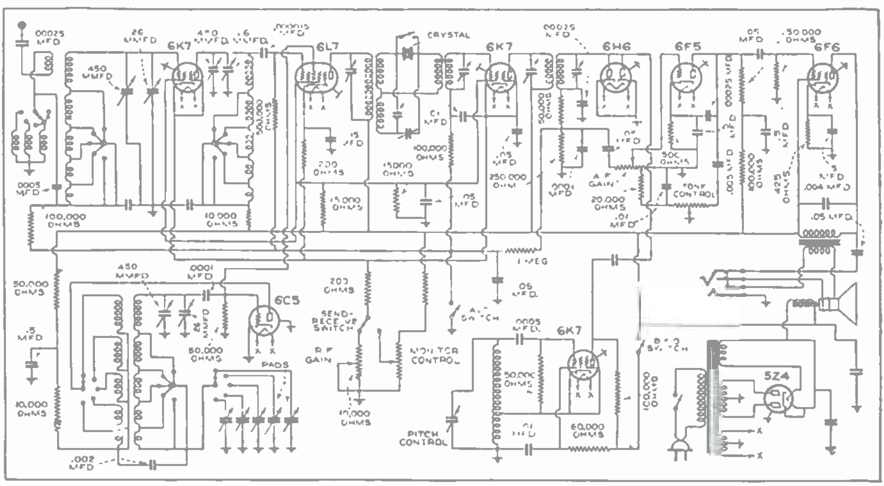
While the desired signal was 7,000 KC, and the local oscillator frequency was 7,460 KC, it will be seen that if there is a signal of 7920 KC present in the antenna and the first detector circuits, this 7920 KC frequency will also "heterodyne" or "beat" with the local oscillator frequency to produce a difference frequency of 460 KC. Because one of 460 KC signal is just like any other 460 KC signal, the intermediate frequency amplifier has no way of rejecting the undesired beat produced by the 7920 KC interfering signal. It is this interfering signal that has been termed the "image," and the frequency of the image signal is almost always two times the intermediate amplifier frequency higher in frequency than the signal which the operator is trying to receive. Therefore, the only method by which the image response can be minimized is to provide enough tuned circuits, or selectivity, AHEAD of the first detector in order to pre-select the desired signal and at the same time to reject the image.

Image interference is not always present. It only occurs when there is a powerful transmitter in operation on a frequency twice the intermediate frequency away from the desired signal being received. Because the intermediate frequencies chosen in most amateur work are in the neighborhood of 450 KC, the image interference is largely from stations approximately 900 KC higher in frequency than the signal being received. This means that the image cannot be produced by other amateur stations, because none of the commonly-used amateur bands are 900 KC wide. Thus the interference most often heard originates from either commercial or government stations. A selective pre-selector interposed between the antenna and first detector will eliminate, or at least minimize, this form of interference.

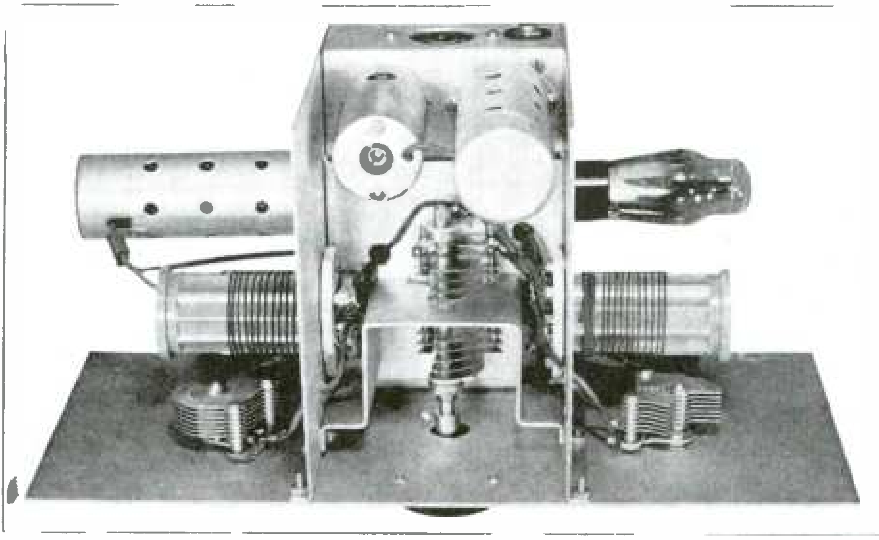
The Super-Gainer

This three tube superheterodyne circuit has a regenerative first and second detector, no intermediate-frequency stage, and is selective and sensitive; it answers the problem which has long confronted the experimenter of limited means. It does not "block" on strong, undesired signals.

Technical Details: By employing detector regeneration at two frequencies, three tubes do the work of six, as shown in the unique circuit accompanying this description. On account of regeneration, a separate '76 tube oscillator is necessary to prevent interlock or reaction between the first detector and oscillator. The front-end of this receiver is smiliar to the "222" described elsewhere in this section.



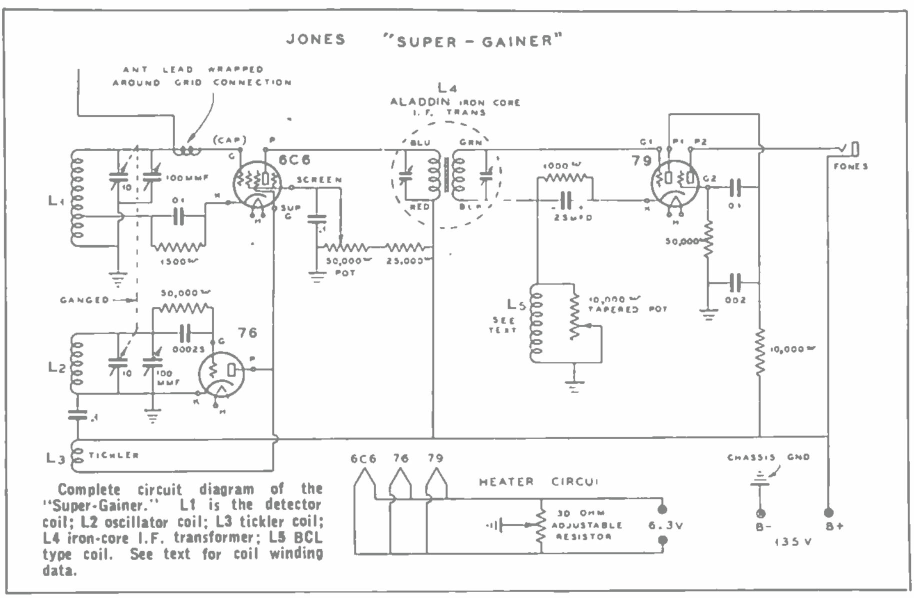
All-Wave Metal Tube Superheterodyne, Hallicrafter's Super-Skyrider. Illustration courtesy "Radio News."



Professional construction characterizes this model of the Jones "Super-Gainer." Note the short, direct leads. The antenna is coupled to the grid by twisting a few turns of the antenna lead around the grid lead.

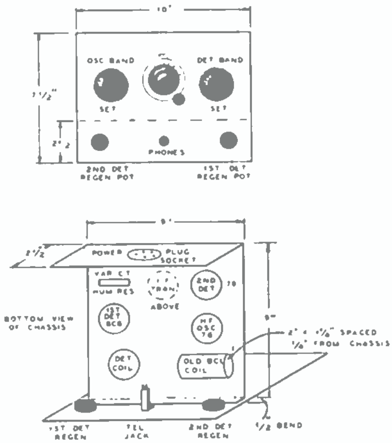
The second detector, a '79 twin-triode, is the most important component in this new receiver. The tube functions as a regenerative second detector, beat-frequency oscillator, and as an additional stage of audio amplification. Regeneration in the second detector, even when oscillating for CW reception, eliminates the need of an IF stage. By the same token, a separate BFO tube is eliminated. The second triode only functions as a stage of resistance coupled audio amplification.

Cathode regeneration is used in the first section of the 79 tube. The cathode coil consists of an old BCL receiver coil of about 90 turns of No. 30 wire, wound on a 1¼-inch diameter form. The regeneration is controlled by means of a tapered



Complete circuit diagram of the "Super-Gainer." L1 is the detector coil; L2 oscillator coil; L3 tickler coil; L4 iron-core I.F. transformer; L5 BCL type coil. See text for coil winding data.

Front view of the Jones "Super-Gainer."



Front panel view and under-chassis layout of alternate design using standard front panel and "U"-bend chassis.

10,000 ohm variable resistor shunted across the BCL coil. This latter component is not directly a part of the 456 KC tuned circuit, and therefore no trouble is encountered from a detuning effect on CW for various settings of the regeneration or oscillation control. A 1000 ohm control may give smoother control.

A single Aladdin iron-core IF transformer (465 KC) provides sufficient selectivity for this receiver. This unit has a screw adjustment on the side of the shield-can which varies the coupling between the two tuned coils. When the second detector is made to regenerate it is necessary that very loose coupling between the circuits be maintained. For this reason only such types of IF transformers should be used which will allow adjustment of coupling.

The main tuning is accomplished by means of a two-gang double-spaced condenser, originally having 35 mmfd. max. capacity per section. To prevent interlock effect on 20 meters, an aluminum shield is placed around the oscillator section of the condenser. By removing one stator plate from each of the inside ends of the stators, space is made available for the ground shield. The oscillator section of the condenser also has its front plate removed; thus, this section has 7 dielectric spaces between rotor and stator, while the detector has eight spaces. The detector band-setting condenser is adjusted for maximum signal or noise pick-up by advancing the first detector regeneration control; that is, increasing the screen-grid voltage. The cathode-tap on the first detector coil allows regeneration at the signal frequency; variation of screen-voltage provides a convenient adjustment of regeneration. The tube should never be permitted to oscillate; otherwise it will bring in undesired stations which will differ in frequency from the desired station by the value of the intermediate frequency.

The antenna is capacitively coupled to the grid of the 6C6 by twisting a few turns of the lead-in wire around the grid lead of the first detector. If the antenna is inductively coupled to the receiver, too much coupling, as when using a resonant antenna, will prevent sufficient regeneration.

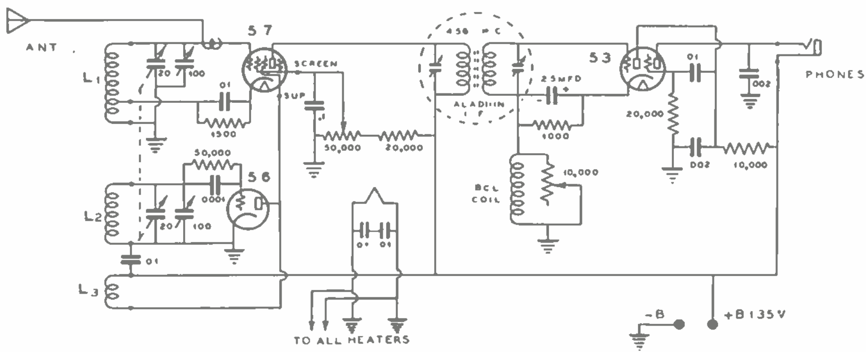
Receiver Adjustments: The second detector must oscillate when its regeneration control is adjusted. The IF transformer tuning can then be adjusted to resonance with the secondary by noting the spot at which it tends to pull this detector out of oscillation.

After the second detector is operating properly, the 76 oscillator can be aligned on some strong signal, or by a calibrated modulated oscillator. The first detector

RECEIVER COIL DATA

All in 1½" Diameter Forms

Wavelength	L_1	L_2	L_3
160 Meters	1¾" winding of #24E. Tapped at 1½ turns. Close wound.	1¼" winding of #24E. Close wound. Grid on top end.	12t #24E. Close wound ⅛" from L2. Same direction as L2 with plate on far end.
80 Meters	40t #20 DSC, spaced to cover 1¾". Tap at ¾ turn.	33t #20DSC, spaced to cover 1¾".	8t #24E. Close wound ⅛" from L2.
40 Meters	12t #20DSC, spaced to cover 1½". Tap at ½ turn.	11t #20DSC, spaced to cover 1¼".	5t #24E, spaced ¼" from L2.
20 Meters	5t #20DSC, spaced to cover ⅞". Tap at ½ turn.	5t #20DSC, spaced to cover ⅞".	2½t #20DSC, spaced ¼" from L2.
10 Meters	3½t #20DSC, spaced to cover 1". Tap at ⅓ turn.	3½t #20DSC, spaced to cover 1".	2½t #20 DSC ¾" from L2, and 1/16" between turns.



3-tube "Super-Gainer" with 2.5 volt heater tubes.

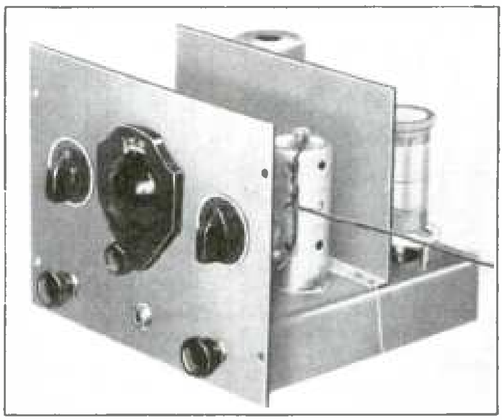
control must not be advanced to the point of actual oscillation. The antenna coupling can be adjusted so that it will allow the first detector to actually oscillate. All tests can be made by listening with a headset plugged into the telephone jack. The audio volume is not sufficient for operating a loudspeaker.

by means of a two-gang 20-mmfd. condenser.

Selectivity is obtained from regeneration in the iron-core intermediate-frequency transformer. In general, the circuit is a simplified superheterodyne. The triode portion of the 6F7 is the H.F. oscillator, tuned to about 456KC higher in frequency than

IMPORTANT DATA:

When more than 135 volts plate supply is used, the H-F oscillator voltage must be reduced by means of a 25,000 or 50,000 ohm, 1 watt resistor, then by-passed to ground with a 0.1 mfd. condenser. The value of the second detector cathode resistor should be reduced to approximately 250 ohms. Smoother second detector regeneration can be obtained by using either a 400 ohm or 1,000 ohm variable wire-wound resistor instead of the 10,000 ohm resistor across the BCL coil. Sometimes a few turns must be added to the BCL coil when a lower value of variable resistor is used.



Front view of the 2-tube "Super-Gainer," showing shield partition and antenna "condenser" (twisted lead around grid connection).

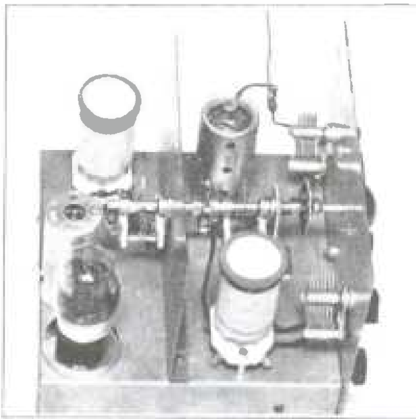
Two - Tube Super - Gainer: Multi-purpose tubes are used in this receiver producing results comparable to 6- or 7-tube superheterodynes. The inherent selectivity of this set is greater than that of a tuned RF receiver and the sensitivity is comparative.

Technical Considerations: A 6F7 dual-purpose tube serves as a regenerative first detector and separate oscillator. A 6A6 double triode performs the functions of regenerative second detector, beat-oscillator and audio amplifier. The receiver sensitivity is apparently higher than the three-tube super-gainer, but has a slight interlock effect which is encountered on 10 and 20 meters. This effect is practically unnoticeable after the two band-setting 100-mmfd. condensers have been properly adjusted for any given band. Turning over any portion of the communication spectrum between 10 and 160 meters is accomplished

the first detector input. The pentode portion of the 6F7 is a regenerative first detector with cathode-tap for regeneration and H.F. oscillator coupling. Screen-grid voltage variation serves for both volume and regeneration control.

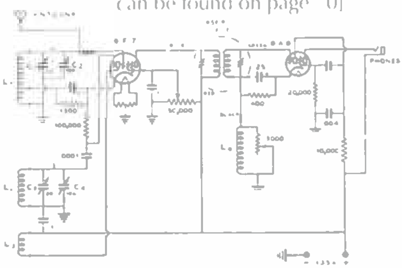
The I.F. transformer coupling is set to a value which will allow regeneration and oscillation within the range of the tapered variable resistor control. This control shunts the 6A6 cathode-coil which consists of 100 turns of No. 32 DSC wire "jumble-wound" on a ½-in. diameter rod. The second detector is by-passed with a .004 mfd. by-pass condenser to ground while the grid and cathode are above ground poten-

2-Tube "Super-Gainer" Layout

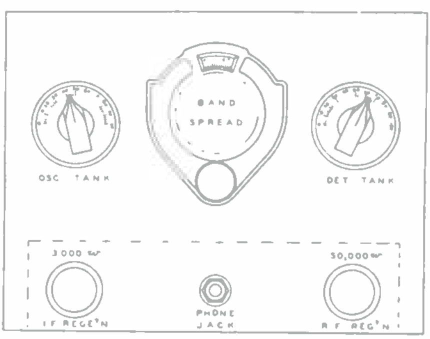


2-tube "Super-Gainer" Layout, 6A6 tube shield removed.

[An enlarged copy of this schematic can be found on page 70]

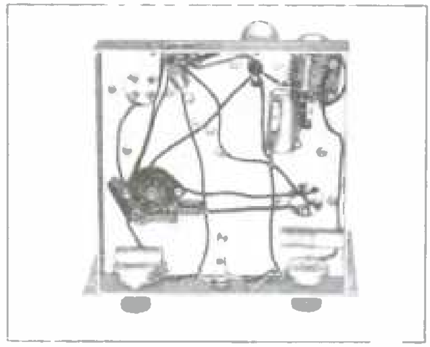


The circuit diagram. See table on page 42 for coil winding data.

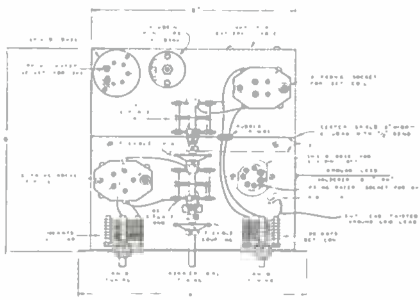


FRONT PANEL LAYOUT FOR 2-TUBE SUPER-GAINER
METAL PANEL 9" WIDE, 7" HIGH

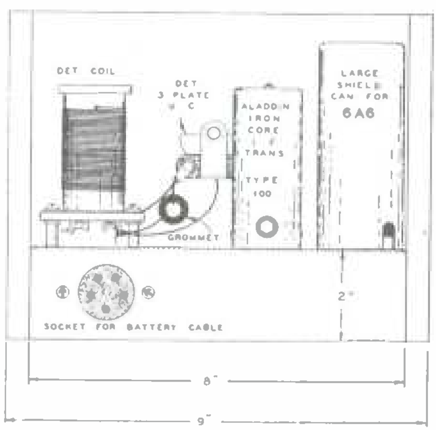
The front panel is 9" wide, aluminum or steel.



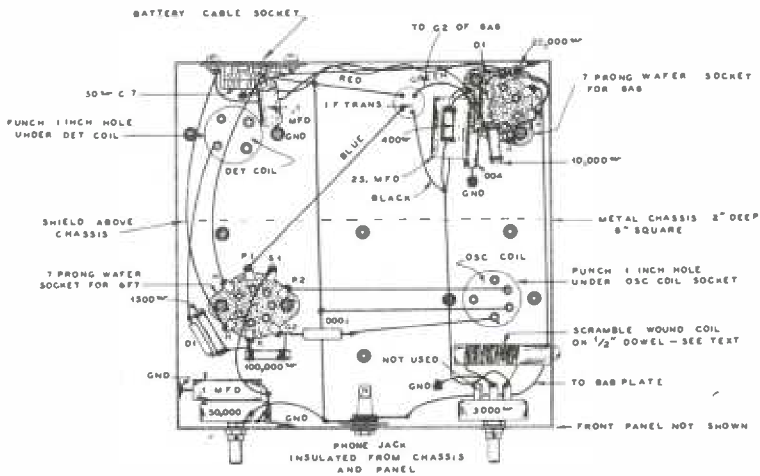
Under-chassis view, showing the BCL coil, L4.



Pictorial arrangement for correct parts placement.



Rear view showing shield can for 6A6 tube, iron-core I. F. transformer, detector coil and detector condenser.



Construction of the 2-tube "Super-Gainer" is simple, if this under-chassis pictorial wiring plan is carefully followed.

tial for RF, or rather I.F. This forms a regenerative or oscillating circuit controlled by the 3000-ohm variable resistor. The value of the tapered resistor may have a maximum as high as 5000 or 10,000 ohms; control, however, taking place in the region between 0 and 2000 ohms.

The 400-ohm cathode-resistor must be by-passed with a large low-voltage, electrolytic condenser in order to prevent degenerative amplification (motor-boating). The detector is resistively coupled into the audio amplifier part of the 6A6 by low ohmic resistors.

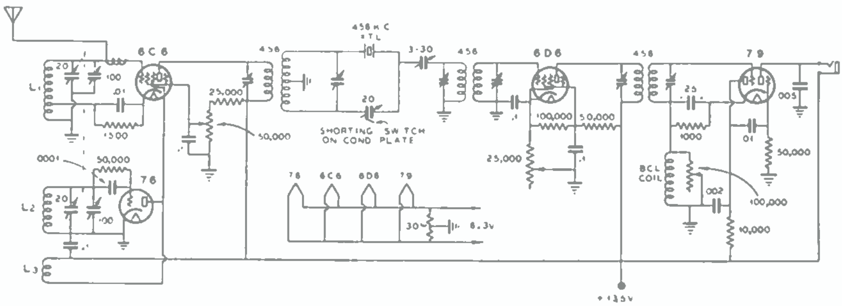
Antenna coupling is varied by twisting more or less insulated hook-up wire around the 6F7 detector grid-lead until smooth regeneration is obtained up to the point of oscillation. Note: A modulated test oscillator will simplify all preliminary adjustments.

The chassis is about 8 x 8 x 1¾th inches with a front panel 8 x 7 inches. A shield 5 inches high separates the first detector and the H.F. oscillator coils and tuning condensers. The latter are ganged by means of a flexible shaft coupling, and tuned by a vernier dial. The two 100-mmfd. band-setting condensers should be controlled from the front panel in order to accurately resonate the detector circuit when using regeneration. The coil turns may be compressed or expanded before cementing in place, so as to obtain circuit tracking across each amateur band. Both tubes should be shielded.

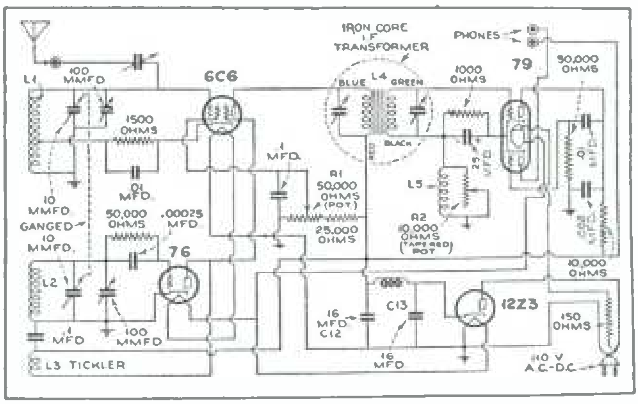
2 TUBE SUPER-GAINER COIL DATA

All Coils Wound on 1½" Diameter Forms

Wavelength	L_1 Detector	L_2 Oscillator	L_3 Tickler
160 Meters	1¾" of #24 E. Tapped at 4 turns. Closewound.	1¼" of #24 E. Closewound. Grid on top end.	20t #24 E. Closewound ⅛" from L2. Same direction as L2 with plate on far end.
80 Meters	40t #20 DSC., Spaced to cover 1¾". Tap at 2 turns.	33t #20 DSC., Spaced to cover 1¾".	10t #28 DSC. Closewound 1/16" from L2.
40 Meters	12t #20 DSC., Spaced to cover 1½". Tap at 1½ turn.	11t #20 DSC., Spaced to cover 1¼".	7t #24 E. Spaced ⅛" from L2.
20 Meters	7t #20 DSC., Spaced to cover 1⅛". Tapped at one turn.	7t #20 DSC., Spaced to cover 1⅛".	4t #20 DSC., Spaced ⅛" from L2.
10 Meters	3½t #20 DSC., Spaced to cover 1". Tap at ½ turn.	3½t #20 DSC., Spaced to cover 1".	3t #20 DSC., ⅛" from L2 and 1/16" between turns.



Experimental "Super-Gainer" with Crystal Filter.



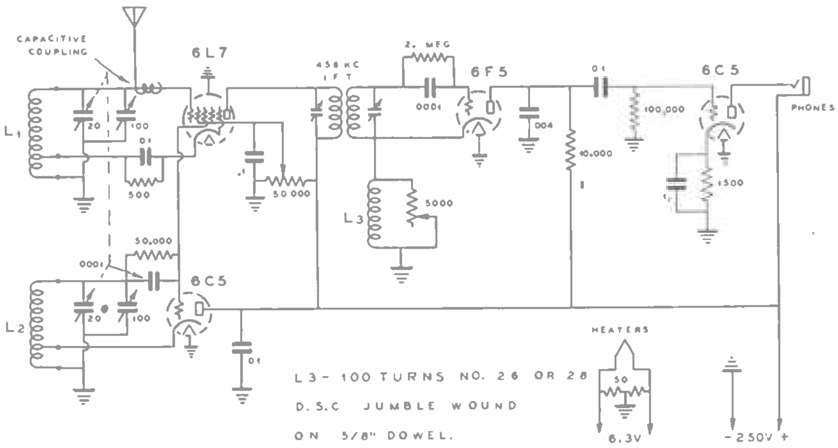
A-C operated "Super-Gainer" with 12Z3 rectifier tube in the power supply. This is a diagram of the McMurdo-Silver factory-built "Super-Gainer."

Metal Tube Super-Gainer: This receiver has four of the new metal tubes in the Super-Gainer circuit, the characteristics of which are similar to the receiver previously described except that with the inclusion of the 6L7, special mixer tube, the receiver has a higher degree of sensitivity. The 6L7 tube has a higher plate impedance as a first detector so that I.F. gain is as high with a small Aladdin iron-core I.F. unit as with a larger unit and 6C6 tube. The 6L7 also makes a very effective regenerative first detector with variable screen-voltage control. A cathode-tap on the detector grid coil serves as a means of obtaining regeneration at the signal frequency.

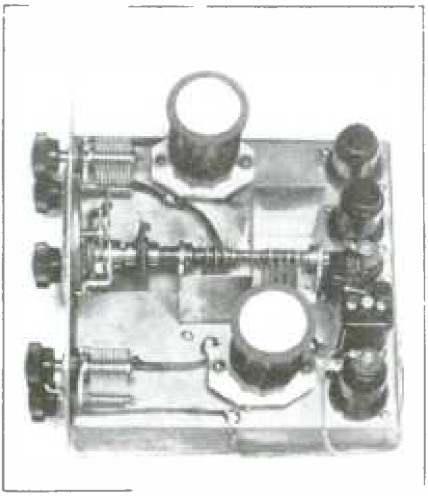
Miscellaneous Notes: Second detector regeneration and oscillation is controlled by a 5000-ohm tapered variable resistor shunted across a cathode coil. The latter is made of 100 turns of No. 26 or No. 28 DSC wire "scramble-wound" on a short section of ⅝th-inch diameter dowel rod. There is no magnetic coupling between this coil and the second detector grid coil. A 6F5 high-mu tube functions as the detector of the grid-leak or bias type. Grid-leak detection is shown, but generally cathode-bias detection will allow the circuit to regenerate smoother.

A 6C5 tube similar to a 76 serves as an audio amplifier, resistance-coupled to the detector circuit. Another 6C5 tube functions as a H.F. oscillator with cathode-tap for oscillation. The grid-leak and condenser bias this tube as well as the special injection grid of the 6L7 tube.

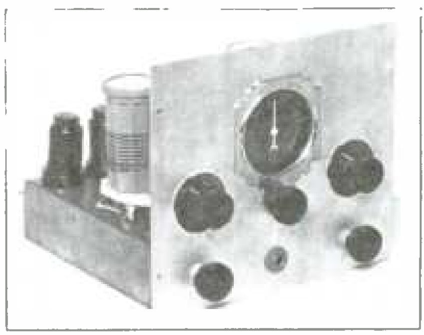
The set is assembled on a 7 x 7 x 1¾-inch metal chassis with a small shield placed between the coils and ganged-condenser sections. The sections are made from 35-35 mmfd. midget condenser having only four stator plates per section (the others being removed). The 100 mmfd. condensers are band-setting controls which are manipulated by small dials on the front panel, the latter is of aluminum 7 x 8 inches 12-gauge. The vernier dial is insulated from the tuning condenser shaft in order to eliminate multiple ground leads and resulting noise when tuning. A power-plug and socket are mounted at the rear of the chassis for connection to a 6.3 volt filament transformer and 135-volts of B-battery, or to similar values of voltage from



METAL TUBE SUPER-GAINER



Looking into the Metal-Tube "Super-Gainer."



The airplane tuning dial adds beauty and convenience.

an AC power supply. With a power-pack, the DC voltage should not be over 180-volts and an 8mfd. condenser must be connected across the voltage divider at this point.

The coils are similar to those listed under the three tube Super-Gainer except that no tickler is needed on the oscillator coils. The cathode-tap in this case is from ¼th to ⅓rd of the total turns up from the grounded end of each oscillator coil. The antenna coupling should be semi-variable because of the effects of antenna resonance on the first detector regeneration.

METAL TUBE SUPER-GAINER COIL TABLE

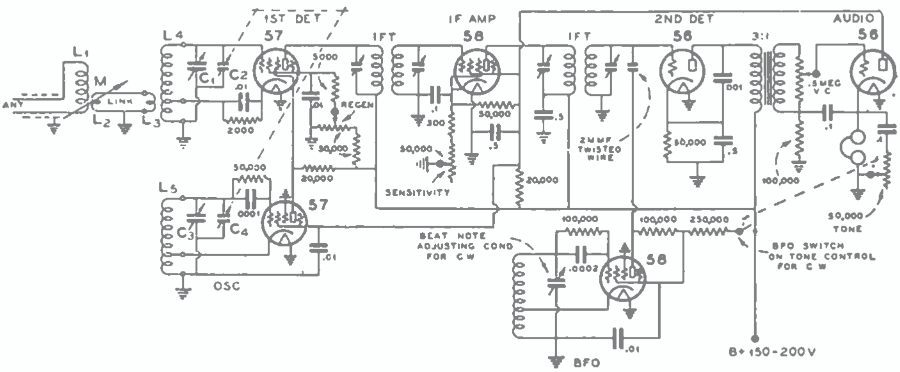
All Coils Wound on 1½" Diameter Forms

Wavelength	Detector Coil	Oscillator Coil
160 Meters	1¾" of #24 E., closewound. Tap at 1¼ turns.	1¼" of #24 E., closewound. Tap at 1/3 of total turns.
80 Meters	38t #22 DSC., 1¾" long. Tap at ¾ turn.	32t 22 DSC., 1¾" long. Tap at 10 turns.
40 Meters	12t #22 DSC., 1½" long. Tap at ½ turn.	11t #22 DSC., 1¼" long. Tap at 3½ turns.
20 Meters	6t #22 DSC., 1" long. Tap at ¼ turn.	6t #22 DSC., 1" long. Tap at 1½ turns.
10 Meters	3½t #22 DSC., 1" long. Tap at ¼ turn.	3½t #22 DSC., 1" long. Tap at 1 turn.

Amateur Superheterodyne Receivers The "222" Radio Series

A splendid ultra-sensitive amateur communications receiver featuring the superheterodyne principle together with many engineering refinements is given herewith. The receiver will cover both the 20 and 40 meter wave bands without coil changing; for 80 meter operation a separate set of coils are required.

In describing the circuit complement, reference should be made to the circuit diagram from which the more salient points can be taken into consideration.



6-Tube Jones "222" Superheterodyne, ideal for amateur operation.

Antenna and Coupling: Regeneration is used and a variable antenna coupling allows maximum effect from the regeneration. The antenna coupling is the same as shown for the "pre-selector" on page 50. The antenna and first detector coils are connected by link coupling; one of the link coils sliding backward or forward to vary the degree of coupling. The advantage of link coupling minimizes capacity coupling to the antenna without using a Faraday electro-static screen, and at the same time minimizes man-made static.

First Detector: Note that the regenerative effect is obtained by means of a cathode tap on the detector coil which gives a more uniform effect to the regeneration for certain sets of coils. In addition, the detector conversion gain is increased many fold due to regeneration and to the method of oscillator coupling. A careful study of the circuit will show that the suppressor-grid is connected directly to the plate of the oscillator; this connection practically eliminates oscillator radiation into the antenna due to the screen-grid being by-passed to ground which electrostatically shields the suppressor-grid from the control-grid circuit. The positive potential placed on the suppressor-grid augments the sensitivity of the first detector.

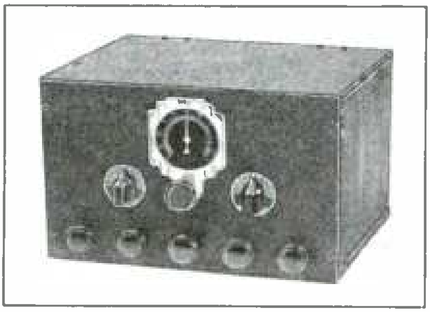
Electron-coupled Oscillators: The first oscillator is made to oscillate strongly for good conversion gain, while the second oscillates weakly to minimize harmonics which would cause steady beat-note whistles in certain band-settings in the short-wave range. The oscillator strength is adjusted by simply twisting the wire-coupling capacity to the second detector. This type of coupling allows maximum signal to BFO noise ratio. The high value given to the plate and screen resistors limit the harmonic output, in addition, simplifies the shielding problem for the BFO.

IF Amplifier: The IF amplifier has only one stage, as two stages complicate the set and tends to increase the noise to signal ratio. With one high-gain IF stage operating in the neighborhood of 500 KC, no isolating condensers and resistors are needed in the plate, screen-grid and cathode circuits. Flexibility of control is provided by an IF and volume control, each operating independently of the other.

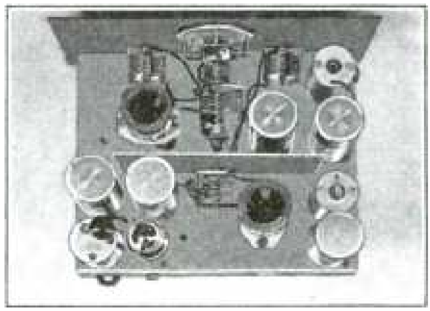
Detector and Audio Circuits: The detector circuit is conventional, while the audio amplifier has an interesting modification which utilizes the telephone headset as a bias resistor for the tube with the tone control across the phones. This connection allows the telephone jack to be grounded to the aluminum chassis or panel. The grid circuit is confined to the grid and cathode by means of a 1 megohm resistor and a 0.1 mfd. by-pass from the audio transformer to the cathode. This scheme prevents audio degeneration and the loss of signal; the output, therefore, is the same as if the cathode resistor and a large by-pass condenser were used and the headset placed in the plate circuit.

Power Supply: The power supply is isolated to keep stray capacity, hum and other sources of spurious noises at a distance. If "A" and "B" batteries supply the necessary power, it will be necessary to provide some means of cutting off both A and B leads by a switch when disconnecting the power supply from the receiver.

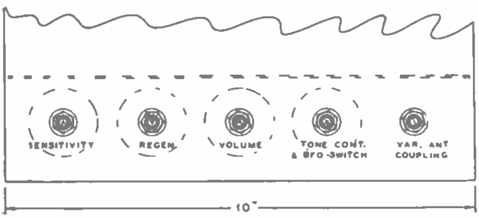
CONSTRUCTION: In the original design, a pair of Aladdin iron-core IF transformers were used as they had better selectivity and higher gain than ordinary air-core IF transformers. If these transformers are



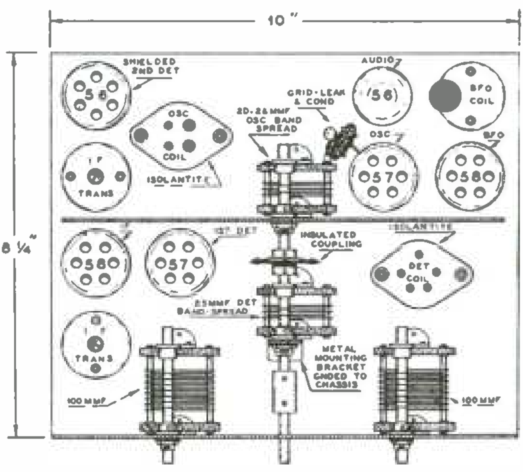
Front view of the "222" Super.



Looking into the "222."



Front Panel Control Arrangement for the "222."



The constructor is advised to use the exact layout of parts, as shown above. All tubes are shielded, other than the type 56 audio tube. Isolantite sockets should be used for the Detector and Oscillator coils.

not available, air-core transformers may be substituted with entire satisfaction. In most all IF units, the coupling has been adjusted at the factory for best broadcast reception gain and band-width. This is generally to close for best short-wave practice where greatest selectivity and good gain are desirable. The two coils should be at least 1¼ inches apart for most all air-core types. Some makes can be adjusted by warming the supporting tube with a soldering iron tip until the wax softens, then sliding the coils apart. The iron-core transformers have a pair of coils mounted at right angles to each other on short molded straight cores. Coupling is adjusted by a screw adjustment on the lower coil which slowly moves it along its axis.

As previously stated, a single stage of IF will give ample gain if the front-end of a "super" is functioning properly. A stage of RF ahead of the first detector is sometimes desirable, but it does not compare with a "super" having a regenerative first detector unless regeneration is used in the RF stage.

The oscillator tuning condenser consists of a double-spaced midget condenser of eight plates, while the detector condenser has nine plates double-spaced. These condensers are made from "Cardwell 100 mmfd. Trim-Air" normally spaced midget condensers, similar to those used for band-setting. By winding the oscillator coil to cover a greater winding space of 1¼ inches as against 1⅛ inches for the detector coil, the oscillator and detector will track throughout the narrow amateur bands. With the number of plates left in these double-spaced condensers, the 20 meter band covers approximately 15 divisions on the airplane type of dial, and the 40-meter band about 60. Greater band-spread may be had by removing plates from each of these condensers. A flexible coupling must be used to gang the oscillator condenser to the front detector condenser to eliminate torsion detuning effects on the beat-note of a CW station. This effect always occurs with all types of dial and condenser mountings.

A pair of shielded lead-in wires are connected directly from the antenna system to the fixed antenna coil underneath the chassis. (See photo of under-chassis view.) The antenna coil consists of 12 turns of No. 24 DSC wire closely wound on a 1¼ inch diameter bakelite tube, approximately 1¼ inches long. The sliding coil is made by closely winding 4 turns of No. 24 DSC on a 1 inch diameter tube. Flexible leads form the remainder of the link coupling device to the isolantite coil-socket above the chassis. Four turns of this same wire were wound on the detector coil about one-eighth inch from the ground end. This 1 inch bakelite tube is controlled from the front panel by means of a plunger action knob over a distance of approximately 1 inch. The knob is fitted with a ¼ inch diameter brass rod extending through the front panel and fastened to the one-inch tubing with two machine screws. The bearing, retaining and pressure spring is simplicity itself, being an ordinary telephone jack. The rear tip connection acts as a pressure spring against the brass rod, making it remain in whatever position it is adjusted to by merely manipulating the knob.

The antenna coupling device allows adjustment of the resonant antenna coupling to obtain optimum value of first detector regeneration. This scheme is applicable to any type of antenna system, the latter being externally adjusted or tuned to resonance until the optimum coupling is found. The results are very gratifying. The image interference on 40 meters measures 60 DB units down in level from the desired signal, using a signal generator for these measurements. 60DB means an image rejectivity of 1000-to-1 which is extremely good for sets using a well designed stage of RF. The image measures 50 DB down on 20 meters, which is more than most superheterodyne receivers can even approach at that wave length. The receiver has practically no image whistles of "phantom" commercial signals in the amateur bands, unless the commercial signal is of very high field intensity. The signal generator gives an audible signal in the headset with an input of 130 DB down from 1 volt, which is less than 1 micro-volt input. This is ample sensitivity, with low internal noise level, to reach down into the atmospheric noise level in any locality.

The receiver is built into a metal cabinet measuring 8½ inches deep, 7 inches high, and 11 inches long. The front panel is 7x11 inches and is made of No. 12 gauge aluminum. The chassis is also made from the same gauge aluminum, bent in the form of a U, two inches deep and 8¼ inches wide by 10 inches long. All of the necessary tube socket and dial holes can be punched, or cut out with a circle cutter and drill press. The shield partition between the oscillator and first detector is also made from No. 12 gauge aluminum, 7 inches long, 4¾ inches high with a ½ inch lip along the bottom for fastening to the chassis with three machine screws.

In building this set, it is a good plan to take all the largest parts and set them on the chassis so as to get the proper chassis

COIL WINDING TABLE FOR "222" COMMUNICATIONS RECEIVER

Coils L1, L2 and L3 are the same for 20, 40 and 80 meter operation. L1—12 turns No. 24 DSC wire, close wound, on 1¼-in. dia. tubing.

L2—4 turns No. 24 DSC wire, close wound, on 1-in. dia. tubing. This coil slides into coil L1; the coupling is made variable by sliding L2 into and out of L1.

L3—4 turns, No. 24 DSC wire, wound on 1½-in. dia. tubing, separated ⅛ in. from L4.

For 20 and 40 meters: (same coils used for both bands).

L4—11 turns, No. 18 DCC wire, space-wound on 1½-in. dia. tubing, to cover a winding space of 1⅛ in. long, and tapped at one and one-third turns from bottom.

L5—11 turns, No. 18 DCC wire, space wound on 1½-in. dia. tubing, to cover a winding space of 1¼ inches, and tapped at 2½ turns from bottom.

C1-C3—100 uufd. midget variable condenser.

C2—9-plate double-spaced midget condenser to give approx. 25 uufd.

C4—7-plate double-spaced midget condenser to give approx. 20 uufd.

(Use 8 plates for C2 and 6 plates for C4 if more band-spread is desired.)

Condensers C2 and C4 are standard Cardwell 100 uufd. "Trim-Air" midgets, with alternate plates removed so as to double-space the plates.

L1, L2, L3 same as for 20 and 40 meter operation.

L4—30 turns, No. 24 DSC wire, wound to cover a space of 1½ in. on a 1½-in. dia. form, with cathode tap taken at one turn from bottom.

L5—26 turns, No. 24 DSC wire, wound to cover a space of 1⅜ in. on a 1½-in. dia. form, with cathode tap taken at 4¼ turns from bottom.

NOTE—The cathode tap on the oscillator coil must not be too high, otherwise image interference will become serious.

TUBES—Instead of using type 56, 57 and 58 tubes, this receiver will give equal satisfaction if the types 6C6, 6D6 and 76 are used for 6.3 volt operation.

160-METER BAND—This receiver will not operate successfully on the 160-meter band unless large variable condensers are used in place of the small midgets. The receiver was primarily designed for 20, 40 and 80 meter operation.

CONDENSER SETTINGS

Band	Oscillator Band-Setting Condenser	Detector Band-Setting Condenser	Coverage on Main Tuning Dial
20 Meters	8°	10°	12° to 15°
40 Meters	80°	95°	50° to 60°
75 Meter Phone Band	45°	50°	25°
80 Meter C.W. Band	50°	55°	100°

layout before drilling. The accompanying pictures and the plan drawing should enable anyone to duplicate the design without trouble. The lower knobs on the front panels, from left to right, are sensitivity, regeneration, audio volume, tone control and BFO switch combination, and antenna coupling. The upper row: Oscillator band-setting adjustment with knob and small 0-100 metal escutcheon plate, main tuning control, and last, the detector band-setting control and a 0-100 division plate. The antenna leads, power-pack cable plug, and telephone jack are at the rear of the chassis with large holes drilled around them through the metal cabinet. The cabinet has a metal hinged lid.

The "222" Receiver with Improved Crystal-Filter and BFO

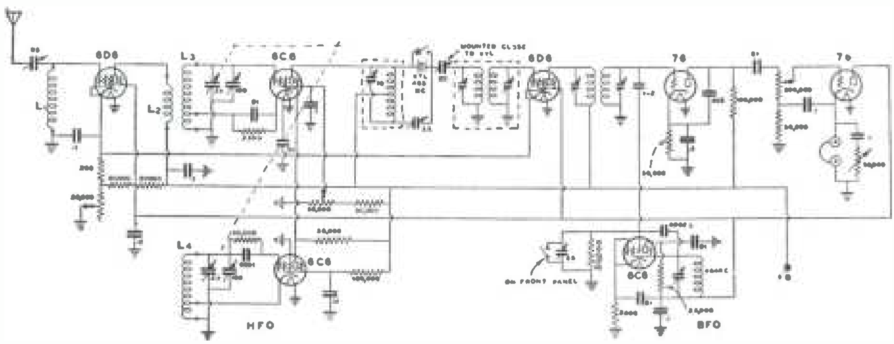
This receiver is exceptionally sensitive and selective, and is capable of remarkable signal-to-noise ratio. The receiver incorporates a new crystal-filter arrangement. One of the features of the new unit are that no loss in sensitivity occurs when switching from the "off" to the "series" position, because the impedances remain matched whether the crystal is "in" or "out." Another interesting feature of the improved crystal-filter is that it can be put into any existing superheterodyne receiver without disturbing the IF amplifier in any way, except to disconnect the detector plate leads.

Circuit Data: The circuit of this receiver is similar in many respects to the "222" receiver previously described. The circuit modifications in this design are new, and have only been incorporated after having proved meritable in laboratory and field tests.

The receiver consists of a stage of semi-tuned RF using plug-in resonant chokes, a regenerative first detector, a single stage of IF, second detector, audio and BFO. The HF oscillator, detector and RF are exactly the same as the original "222" with only minor deviations. Here, it was found that tuning condensers using bakelite instead of isolantite insulation require about ¼ more coil turn in the first detector cathode-tap. It was also found desirable to use a separate set of coils for 20 meters to obtain more bandspread. Five turns one-inch long on the 1½ inch diameter plug-in coils, are satisfactory for this band. All other coil data are given in the coil table for the "222" receiver with RF (see preceding descriptive articles).

The plate circuit of the first detector must be tuned for maximum signal gain so that the plate tuning condenser acts as an effective RF by-pass to increase detector efficiency. The center-tapped coil and neutralizing or phasing condenser form a Wheatstone bridge to balance out the crystal holder capacity. At resonance the succeeding tuned IF circuit would be over-coupled to the first detector tuned-plate circuit, because effectively there is only a resistance of a few thousand ohms between the "live" ends of the tuned circuits. To prevent any bad effects caused by over-coupling, a small 3-30 mmfd. condenser is placed in series with the crystal. This allows the use of tuned circuits between the crystal and first IF amplifier grid without loss in signal. By this matching device there is no appreciable loss in the crystal filter when it is cut into the circuit. The noise level decreases because of the very narrow band passed through the IF amplifier.

With an efficient circuit of this type, only one stage of high-gain IF is necessary. In general, superheterodyne circuits should have high gain in the front end, but should not depend too much upon the IF amplifier for gain. The main function of the IF amplifier is to increase selectivity.



"222" Superheterodyne with Jones Crystal Filter and Improved B.F.O.

Crystal Filter: The crystal filter is made by removing the center universal wound coil of a Hammarlund 2.1 mh. RF choke, thereby providing a center-tapped plate coil which is tuned by a 7-70 mmfd. trimmer condenser. A 25 mmfd. variable condenser is employed for phasing; the value of the condenser depends upon the plate-to-plate capacity of the crystal holder. The condenser is mounted on the front panel with insulating bushings; by resorting to plugging, the crystal may be placed "in" or "out" of the circuit. The stator plate of the phasing condenser is bent to cause a short-circuit in the condenser at minimum capacity setting for phone operation. The idea may also be included to turn the BFO "on" or "off" for CW or "phone" reception.

Beat-Frequency Oscillator: The oscillator is of the relaxation type. The advantages are in simplicity, since no tickler or cathode-tap are necessary in the tuned circuit; in addition, the circuit is highly stable, and the harmonic content is less than in an electron-coupled circuit. Unless the oscillator is **completely** shielded, harmonics will be heard in the form of steady carrier signals at various points throughout the short-wave spectrum.

The function of the circuit depends upon feedback in phase to the suppressor-grid through condenser C_4 of the BFO circuit diagram. The screen is more positive than the plate. The plate voltage is adjusted to approximately +22½ volts, the screen from +75 to +100, the usual control grid at zero potential, and the suppressor-grid at about 6 to 10 volts negative with respect to the cathode. The various potentials are reduced to the proper value by means of resistors.

The BFO coil L_1 and condenser C_1 must tune to the IF; the combination can be made from an old IF coil unit by simply removing coil turns until it resonates at the desired frequency by manipulating the shunt condenser and the trimmer condenser mounted on the front panel. As an alternative the combination can be made from a "jumble wound" coil with a fixed .001 mfd. and a semi-variable 70 mmfd. condenser. Front panel control of the BFO frequency can be obtained by C_2 which acts as a vernier adjustment for C_1. On account of the rotor plates C_1 being grounded, the condenser can be mounted on the metal front panel. Output from the BFO is taken from the suppressor-grid in the form of a short length of hookup wire with its free end twisted once or twice around the second detector grid lead.

Operating Notes: Lack of good single-signal effect can usually be traced to extraneous capacity coupling, lack of proper setting of neutralizing or BFO condensers, or insufficient circuit isolation. In the receiver shown, it was found necessary to shield the grid lead to the IF amplifier to prevent direct capacity coupling past the crystal-filter. This decreases the undesired signal from R9 to R5 ratio up to R9 to R3 ratio. Even better ratio could probably be obtained by better cathode, screen and plate return-lead isolation resistors and condensers.

To properly line-up this receiver, reference should be made to the sub-topic "Receiver Adjustments."

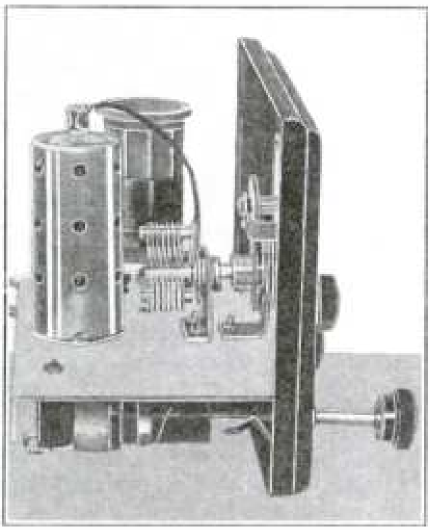
Coil Winding Table for Frank C. Jones' 222 Communications Receiver With R.F. Stage

	L1 (R. F. Grid Coil)	L2 (Plate Winding)	L3 (Detector Coil)	L4 (Oscillator Coil)
For 10 Meters	20 Turns No. 18 DCC Wire. Winding space 1 inch long on a 7/16 inch dia. tube.	3 Turns No. 36 DSC Wire, interwound with L3.	4¼ Turns No. 22 DSC Wire, space wound to cover a winding space 1 inch long on a 1½ inch dia. coil form. Tapped at ⅓ turn.	4 Turns No. 22 DSC wire, space wound to cover a winding space 1 inch long on a 1½ inch dia. coil form. Tapped at 1¼ turns.
For 20 Meters	35 Turns No. 22 DSC Wire. Winding space 1 inch long on a 7/16 inch dia. tube.	7 Turns No. 36 DSC Wire, interwound with L3.	10 Turns No. 22 DSC Wire, space wound to cover a winding space 1 inch long on a 1½ inch dia. coil form. Tapped at ½ turn.	8¾ Turns No. 22 DSC wire, space wound over a winding space 1 inch long on a 1½ inch dia. coil form. Tapped at 2¼ turns.
For 40 Meters	60 Turns No. 26 Enameled Wire. Winding space 1 inch long on a 7/16 inch dia. tube.	7 Turns No. 36 DSC Wire, interwound with L3.	10 Turns No. 22 DSC Wire, space wound to cover a winding space of 2 inches long on a 1½ inch dia. coil form. Tapped at ½ turn.	8¾ Turns No. 22 DSC Wire, space wound to cover a winding space 1 inch long on a 1½ inch dia. coil form. Tapped at 2¼ turns.
For 80 Meters	160 Turns No. 36 DSC Wire. Scramble wound on a 7/16 inch dia. tube, 1 in. long.	16 Turns No. 36 DSC Wire. Interwound with L3.	30 Turns No. 22 DSC Wire over a winding space of 1⅜ inches long on a 1½ inch dia. coil form. Tapped at ¾ turn.	26¾ Turns No. 22 DSC wire over a winding space of 1⅜ inches long on a 1½ inch dia. coil form. Tapped at 4¼ turns.
For 160 Meters	300 Turns No. 36 DSC Wire. Scramble wound on a 7/16 inch dia. tube, 1 in. long.	30 Turns No. 36 DSC Wire, interwound with L3.	60 Turns No. 28 DSC Wire over a winding space of 1½ inches long on a 1½ inch dia. coil form. Tapped at 1¼ turns.	53 Turns No. 28 DSC wire over a winding space of 1½ inches long on a 1½ inch dia. coil form. Tapped at 7 turns.

Regenerative Pre-selector With Variable Antenna Coupling

This pre-selector consists of a single RF amplifier stage placed ahead of any short-wave superheterodyne receiver. By the use of variable antenna coupling and cathode regeneration, this single stage can be made equivalent to the usual two stage RF pre-selector. The function of this class of apparatus is to increase the signal-to-noise ratio and to reduce image interference.

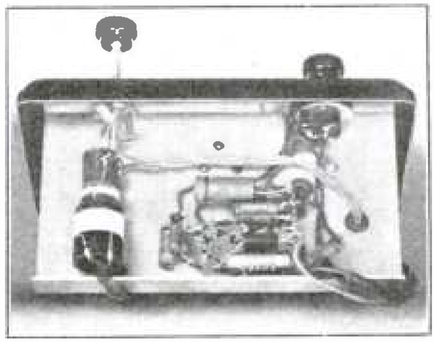
The variable antenna coupling is obtained by means of a sliding coil whose electrical constants need not be changed for different amateur bands. An efficient plug-in coil is used in the tuned circuit inductance to insure the correct placement of the cathode tap for each band. Regeneration is controlled by means of 50,000 ohm potentiometer which varies the screen voltage. The screen-grid series resistor of 5,000 ohms tends to prevent the regeneration control from introducing noise as the latter is varied. The plate voltage is fed through a small Hammarlund multi-section RF choke which is effective over all the amateur bands.



Side view of Jones Regenerative Pre-Selector.

The plate circuit is connected through a coupling condenser to the receiver so this can connect to the antenna post on the main receiver, or this lead can be twisted around the first detector grid lead a few times to obtain capacity coupling. In the latter case the trimmer condenser must be re-set for best results.

The regeneration is slightly affected by the plate circuit load, requiring in some cases, a trial adjustment of the cathode-tap or changes in coupling to the receiver. The RF tube will smoothly slide into oscillation when the pre-selector is functioning properly. The point just below oscillation gives the greatest gain and selectivity.

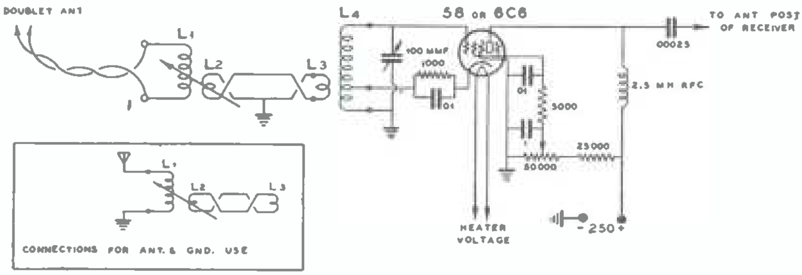


Under-chassis assembly, showing variable antenna coupler.

The antenna coupler is made of two pieces of bakelite tubing, each 1½ inches long. The larger one is 1⅛ inch outside diameter, and the smaller one ⅞ inch diameter, so that the latter with its winding of 8 turns will slide readily inside the other tube. The large tube has 20 turns of No. 28 DSC wire, close wound which is connected to a doublet antenna for maximum outside noise reduction. The link coupling system employed here is similar to that used in the "222" receiver.

The tuning condenser is of the midget type, well insulated and having a maximum capacity of about 100 mmfd. A small aluminum bracket supports the condenser (see photo) at the proper level for the dial shaft connecting bushing. All parts are mounted on a piece of 12-gauge aluminum bent in the shape of an inverted U. The original piece should be 8½ inches long and 7 inches wide, 1½ inches on the front edge and ¾ inch on the rear edge are bent down, so the top of the chassis is 8½x4¾ inches. The antenna coupler mounts underneath on one side and the regeneratioa

Shield housing for Jones Pre-Selector.



Regenerative Pre-Selector Circuit.

control on the other; the entire unit mounts in a can which comes equipped with a dial. The approximate dimensions of this can are 9½ inches long, 5 inches deep, and 6 inches high. The front and back are removable so the coil can be changed by snapping off the rear cover or by means of an opening in the rear. The dial is fastened to the chassis by a right-angle bend in the dial-mounting strap, the latter being fastened down by a machine screw. The chassis is fitted to the front cover or panel.

It is desirable to twist the antenna leads together for the two leads into the pre-selector. The plate coupling lead should come out at the other side of the rear cover and be as short as possible in its connection to the radio receiver. Coupling between this plate lead and the antenna would cause undesirable effects. Power for the tube can be obtained from the receiver. If a doublet antenna is not used, one of the antenna leads must be grounded.

Coil winding table for Pre-Selector.

L1—Same for all bands. 20 turns, No. 28 DSC, close wound on 1⅛-in. dia. tubing.

L2—Same for all bands. 8 turns, No. 28 DSC, close wound on ⅞-in. dia. tubing.

Coupling between L1 and L2 variable. L2 slides into and out of L1.

RF COIL FOR 160 METERS

L3—10 turns, No. 22 DSC, close wound on 1½-in. dia. low-loss coil form.

L4—60 turns, No. 22 DSC, close wound, and tapped 1¼ turns up from ground end. L4 is wound on same coil form as L3, and is spaced ⅛ in. from L3.

RF COIL FOR 80 METERS

L3—7 turns, No. 22 DSC, close wound, on 1½-in. dia. form.

L4—35 turns, No. 22 DSC, close wound, and tapped ½ turn up from ground end.

Spacing between L3 and L4 to be ⅛ in.

RF COIL FOR 40 AND 20 METERS

L3—5 turns No. 22 DSC, close wound, on 1½-in. dia. form.

L4—12 turns, No. 18 DSC, space-wound over a winding space of 1¼ in., and tapped ¼ turn from ground end.

NOTE—The ground end of the L4 is the bottom of the coil. The top end of L4 connects to the grid of the 58 or 6C6 tube in the Pre-Selector.

Dual Band 20-40 Meter Receiver

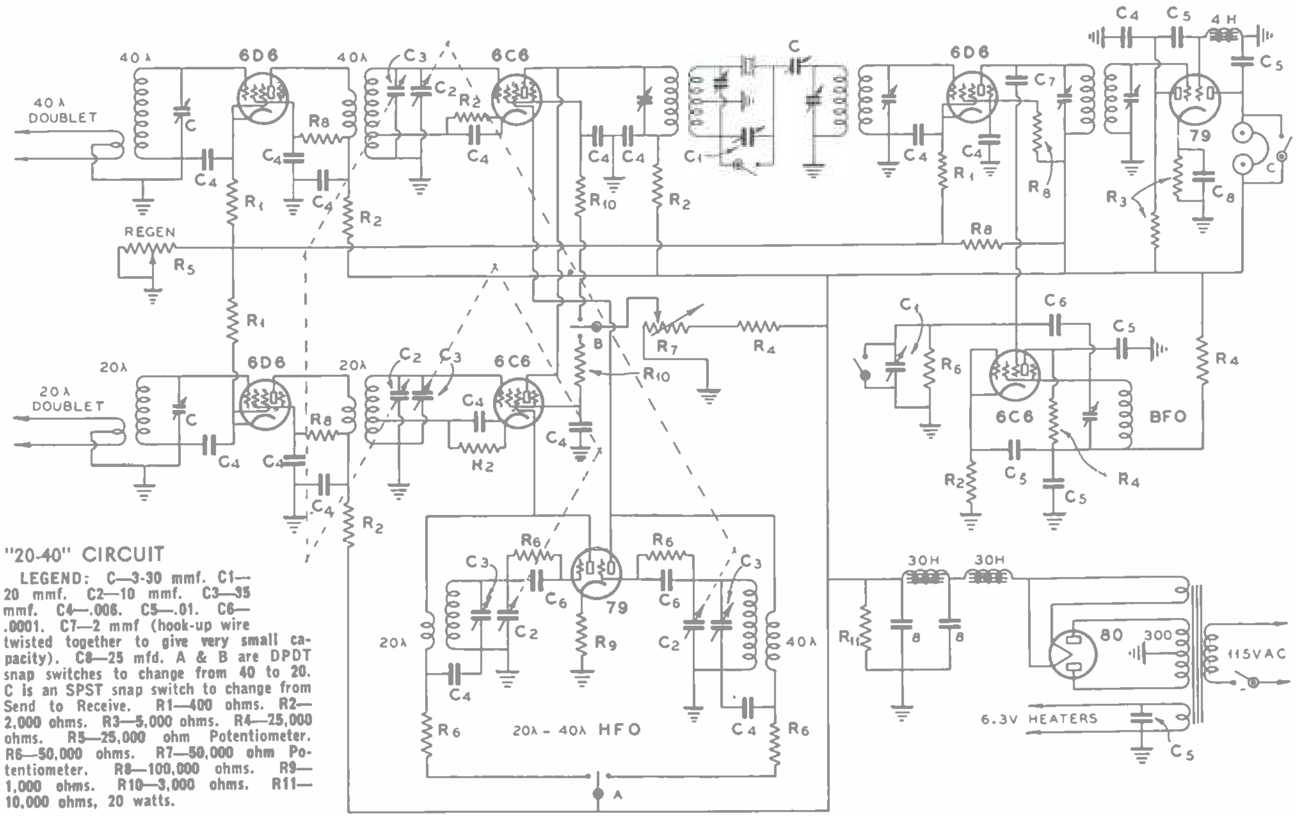
This is a receiver for the DX operator who devotes the greater portion of his time between the 20 and 40 meter wavebands. The circuit, as will be seen in the accompanying figure, has two front ends, one for 20 meters and the other for 40 meters, with a common IF amplifier, crystal filter circuit, detector and 800 cycle audio amplifier. The circuit is quite similar to that used in the "222 Receiver" in that a fixed tuned RF stage is placed ahead of the regenerative first detector.

Circuit Details: The HF oscillator employs a twin-triode type 79; one portion oscillating for the 20 meter band and the other for 40 meters. The oscillator circuits are stabilized with a combination grid-leak and cathode bias polarizing the grids. The cathode resistor is not by-passed; consequently it forms part of the oscillating circuit with an automatic regulating effect. The result is a high degree of frequency stability for changes in plate and filament voltages comparable to an electron-coupled oscillator.

The second detector employs a twin-triode, type 79; one portion acts as a bias detector and the other as an audio amplifier. The audio amplifier is tuned to series resonance at 800 cycles. The resonant reactor consists of a 4 henry audio choke-coil made from an old 250 mh RF choke with an "A metal" core from a small audio frequency transformer. The audio amplifier is tuned to the desired AF by adjusting the air-gap in the core. The coil of a small filter choke, with a few straight pieces of iron-core inserted in the coil form, will provide a 4 henry choke suitable for this purpose.

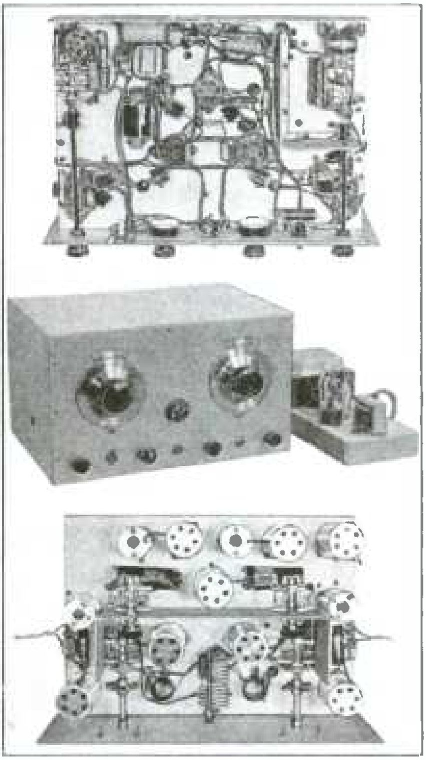
The first detector 2-plate main tuning condensers are ganged with flexible couplings to their respective 2-plate oscillator tuning condensers. A 2-gang 35 mmfd. per section condenser provides a tank condenser capacity, plus front panel trimmer adjustment, which is neded when using regeneration.

Coil Data: The RF coils are wound on ½-inch tubing to minimize the external field. The 20-meter coil consists of 40 turns of No. 22 DSC wire, with a primary of No. 36 DSC of 8 turns center-tapped. These primaries are wound over the



"20-40" CIRCUIT

LEGEND: C—3-30 mmf. C1—20 mmf. C2—10 mmf. C3—35 mmf. C4—.006. C5—.01. C6—.0001. C7—2 mmf (hook-up wire twisted together to give very small capacity). C8—25 mfd. A & B are DPDT snap switches to change from 40 to 20. C is an SPST snap switch to change from Send to Receive. R1—400 ohms. R2—2,000 ohms. R3—5,000 ohms. R4—25,000 ohms. R5—25,000 ohm Potentiometer. R6—50,000 ohms. R7—50,000 ohm Potentiometer. R8—100,000 ohms. R9—1,000 ohms. R10—3,000 ohms. R11—10,000 ohms, 20 watts.



Three views of the "20-40" receiver. See page 52 for complete circuit diagram.

grounded end of the secondary in a small bunch winding with center grounded. The 40-meter RF coil has 66 turns of No. 26 enameled wire with a center-tapped 10-turn primary of No. 36 DSC wire.

The 20-meter detector coil consists of 10 turns of No. 22 DSC, 1-in. diameter, ¾ in. long, wound on celluloid strips. The wire is cemented to the strips with Duco cement. The primary consists of 7 turns of No. 36 DSC interwound with the secondary with the RF PLUS "B" connection to the "ground" end of the coil. The cathode tap is made of ¼ turn from the ground end. This tap should only be high enough to allow the first detector to spill into oscillation with the regeneration control well advanced.

The 40-meter detector coil is made in the same manner as the 20-meter coil, but with 24 turns, wound on a form one inch long and one inch in diameter. The cathode tap is made one-third of a turn up from ground and the primary is interwound for 14 turns; No. 36 DSC wire is used. For mechanical rigidity, the ends of the celluloid strips are cemented to bakelite tubing which is fastened to the chassis with a machine screw.

The oscillator coils are wound on one-inch bakelite tubing to provide great rigidity to the coil. The 20-meter coil has 10 turns of No. 22 wire wound on a form ¾ inch long, with a three-turn tickler interwound at the ground end of the secondary. The 40-meter oscillator coil has 22 turns of No. 22 DSC, wound on a form one inch long, one inch in diameter, with a 6 turn tickler of No. 36 DSC interwound. Duco cement is applied to the coils at various points to firmly secure the wires in place. All coils are mounted at right angles to each other, and an aluminum shield of No. 12 gauge is used between them. The RF coils are tuned by means of small compression-type 3-30 mfd. condenser soldered across the ends of the RF coils.

The change from 20 to 40 meters is accomplished by switching the detector screen-grids and oscillator plate-returns through a small DPDT snapswitch. There is no RF on these leads.

Antenna Connection: A 20 and separate 40 meter doublet with twisted-pair lead-ins should be used with this receiver in order to minimize auto ignition and power line noise pick-up. There is practically no antenna coupling capacity to the RF grid coil because a balanced primary is used. This prevents pick-up from the antenna feeders nearly as effectively as a very elaborate Faraday screen system.

The Perrine Superheterodyne

An amateur receiver setting up new standards and unexcelled for DX reception is here shown. The parts have been arranged so that no lead in the entire receiver is over one inch in length. A very high degree of shielding separates all the major electrical components. A minute study of the details will reveal a number of unique features. Some of these are: (a) the double by-passing of heater circuits; (b) coupling the oscillator plate to the detector suppressor; (c) the crystal filter circuit with a split-stator condenser which places twice as much capacity between the first detector plate and ground, thus by-passing more effectively the high-frequency components in the first detector plate circuit; (d) the air-tuned beat frequency

Acorn Tube R-F Plug-In Unit for Perrine Super.

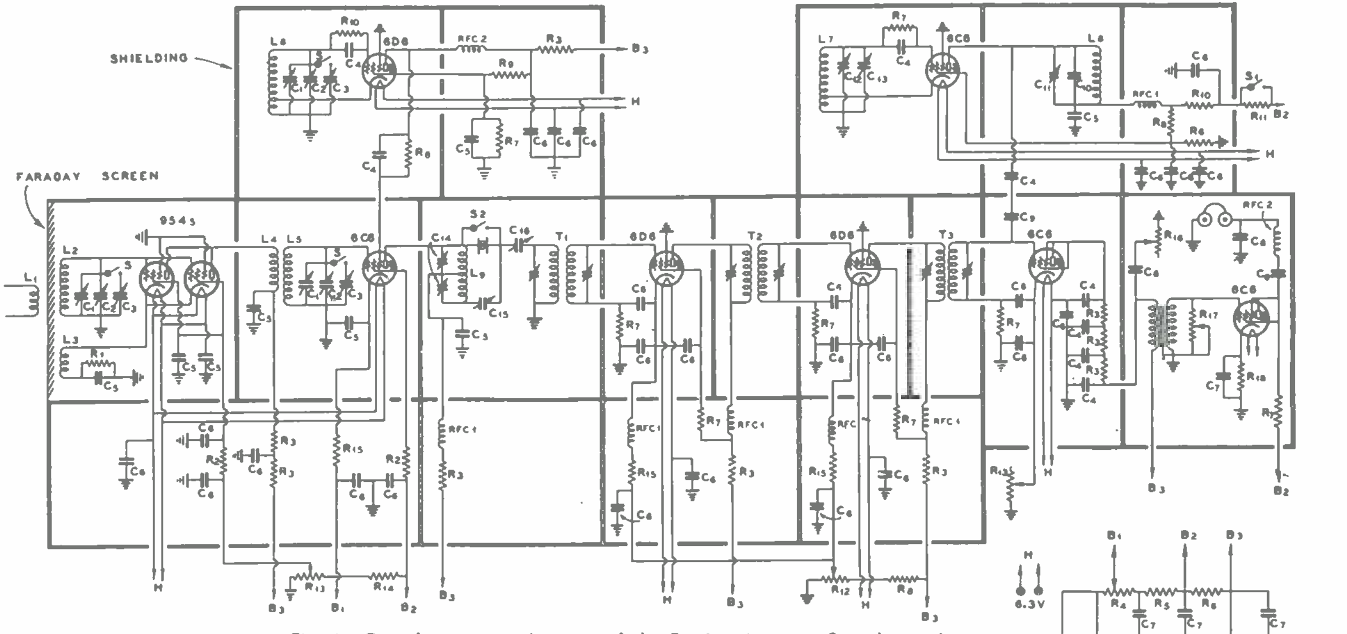


Fig. 1—Complete circuit diagram of the Perrine Amateur Superheterodyne.

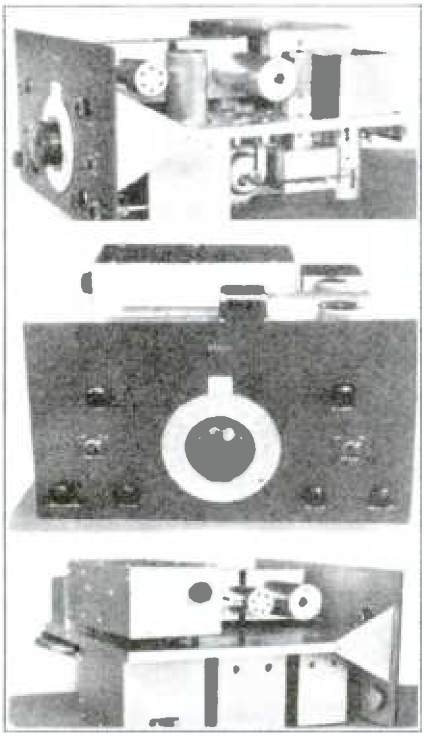
LEGEND

L1—5 turns, 1-in. dia., No. 28 enameled.
L2—13 turns, 1-in. dia., No. 20 bare.
L3—2 turns, 1-in. dia., No. 32 SSC.
L4—9 turns, 1-in. dia., interwound with L5—No. 30 DSC.
L5—13 turns, 1-in. dia., No. 20 bare.
L6—12 turns, 1-in. dia., No. 20 bare tapped 4 turns from ground.
L7—95 turns, 1-in. dia., tapped at 30 turns, No. 32 DSC.
L8—30 turns, 1-in. dia., No. 32 DSC.
L9—Hammarlund choke with center pie removed.

C1—Approx. 20 mmf.—Hammarlund 50 mmf. with two stator plates removed.
C2—20 mmf. Cardwell Trimair.
C3—100 mmf. Cardwell Trimair.
C4—.0001 mica.
C5—.01 mica.
C6—.1 non-inductive paper (500 V.).
C7—1 mfd. paper (500 V.).
C8—.04 paper.
C9—3 mmf.—See text.
C10—.004 mica fixed.
C11—.001 mica variable (trimmer).
C12—.001 air variable.
C13—50 mmf. air midget (Hammarlund).

C14—140 mmf. per section (Hammarlund) midget.
C15—Phasing control—10 mmf.
C16—30 mmf. midget.
R1—400 ohm, 1 W.
R2—10,000 ohm, 1 W.
R3—1,000 ohm, 2 W.
R4—1,000 ohm, var. pot.
R5, R6—CT 30,000 ohm, 50 W. voltage divider.
R7—100,000 ohm, 1 W.
R8—50,000 ohm, 3W.
R9—40,000 ohm, 3 W.
R10—50,000 ohm, 3 W.
R11—500,000 ohm, 3 W.

R12—15,000 ohm, var. tapered
R13—50,000 ohm, var. pot.
R14—10,000 ohm, 3 W.
R15—200 ohm, 3 W.
R16—10,000 ohm, tone control.
R17—500,000 ohm, AF Gain.
R18—5,000 ohm, 3 W.
T1, T2, T3—Hammarlund 465 KC IF trans.
T4—UV712 RCA audio trans.—1,000 ohm peaked type.
RFC1—85 mh.
RFC2—2 mh.
S—Band changers.
S1—BFO strength control.
S2—Xtal shorting SW.



The beautiful Perrine Superheterodyne. Note placement of tube shields and individual shield housings.

oscillator which assures freedom from frequency drift and, in addition, has a high-C tuned-plate circuit which definitely reduces any strong harmonics in the output and thus reduces oscillation hiss—a switch is also provided to reduce the BFO plate voltage so that more readable signals are delivered to the output at low microvolt inputs.

A legend of the various parts is given on page 54. In constructing this receiver all coils should be rigidly mounted to prevent frequency changes due to vibration externally transmitted to the receiver chassis. The design is otherwise conventional in all respects.

Receiver Measurements

Satisfactory results can only be obtained from a radio receiver when it is properly aligned and adjusted. The most practical technique for making these adjustments is given in the following discussion.

The simplest type of regenerative receiver requires little adjustment other than those necessary to insure correct tuning and smooth regeneration over some desired range. Receivers of the tuned radio-frequency type and superheterodynes require almost precision alignment to obtain the highest possible degree of selectivity and sensitivity.

Testing Instruments: Only a very small number of instruments are necessary to check and align any multi-tube receiver. The most important of these testing units being a modulated oscillator and a DC and AC voltmeter. The meters are essential in checking the voltages applied at each circuit point from the power supply. NOTE: If the AC voltmeter is of the oxide-rectifier type, it can be used, in addition, as an output meter when connected across the receiver output when tuning to a modulated signal. If the signal is a steady tone, such as from a test oscillator, the output meter will indicate the value of the detected signal. In this manner line-up adjustments may be visually noted on the meter rather than by increases or decreases of sound intensity as detected by ear.

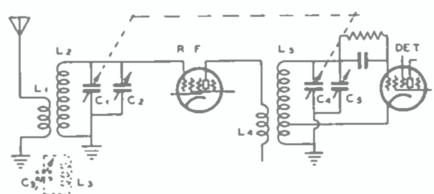


FIG. 1

R-F stage and regenerative detector.

Tuned RF and Regenerative Detector: In Figure 1 is shown a single stage of tuned RF and a regenerative detector. For proper performance, these two tuned circuits must resonate to the same frequency throughout the desired tuning range. It is required, therefore, that L_2 and L_5 have equal values of inductance and equal values of effective shunt capacity at each point on the tuning dial. The inductances may be closely matched by using similar coil forms and windings. If one coil is closer to some metal object, such as the chassis or shield, it will be difficult to obtain a good match unless coil turns are removed or shifted along the coil-form to change the effective coil length. A resonant antenna will unbalance the RF stage unless L_1 is loosely coupled to L_2.

Circuit Capacities: The shunt capacities are due to coil distributed capacity, wiring capacity, shunt condensers and tube capacity. Usually trimmer condensers C_2 and C_5 are needed to equalize the fixed circuit capacities. These should be adjusted for maximum signal sensitivity towards the high-frequency end of the tuning dial, that is, minimum capacity position for C_1 and C_4. After making this adjustment (usually with a screw driver) the alignment can be checked throughout the tuning range by bending "in" or "out" one of the outside rotor plates of tuning condenser C_1. Some receivers have condensers with slotted end-plates to facilitate bending to correct circuit alignment over the whole tuning range after C_2 and C_5 have been correctly set. The RF tube and primary L_4 reflect a capacity across L_5 which can be exactly balanced by having a duplicate primary winding L_6 on the RF grid coil. A small trimmer condenser simulates the RF tube plate circuit—this refinement is seldom used in receivers, but is well merited.

Multi-Stage Tuned RF Receivers: The alignment procedure in a multi-stage RF receiver is exactly the same as aligning a single stage. If the detector is regenerative, each preceding stage is successively aligned while keeping the detector circuit tuned to the test signal, the latter being a station signal or one locally generated by a test oscillator loosely coupled to the antenna lead. During these adjustments the RF amplifier gain control is adjusted for maximum sensitivity, assuming that the RF amplifier is stable and does not oscillate. Oscillation is indicative of improper by-passing or shielding. Often a sensitive receiver can be roughly aligned by tuning for maximum noise-pick-up, such as parasitic oscillations originating from static or electrical machinery.

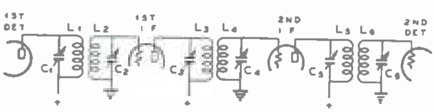


FIG. 2

I. F. Amplifier.

Superheterodynes: A superheterodyne presents an involved alignment procedure since it is necessary to align both the oscillator and first detector as well as the intermediate frequency amplifier. In this case, the latter should be aligned first. METHOD: A calibrated modulated oscillator is set to the frequency of the IF amplifier; this is usually between 175 KC and 500 KC. A lead from the oscillator is connected to the grid of the last IF stage, and C_5 and C_6 of Figure 2, varied until maximum signal strength is obtained in the output of the 2nd detector or audio amplifier. The adjustment can be simplified if the receiver has AVC, the tuning meter being used to indicate the maximum signal strength. Since the coupling inductances L_5 and L_6 are generally fixed, the only possible adjustment will be by varying the trimmer condensers. After C_5 and C_6 are properly set, the oscillator power is decreased, then coupled to the grid of the first IF amplifier tube. C_3 and C_4 may then be adjusted for maximum signal strength. The RF input to the receiver must be kept at an optimum value to insure signal readability. The procedure is repeated to align C_1 and C_2, providing the receiver has two IF stages. Sometimes it is necessary to disconnect the first detector grid lead from the coil, it then being grounded in series with a 1000 or 5000 ohm grid leak, and the test oscillator coupled through a small capacity to the grid. The oscillator should have some form of attenuator; however, the coupling may be varied by moving the oscillator lead further away from the tube grid into which it is coupled. For test purposes, the 1000 ohm resistor prevents the RF coil from short-circuiting the IF of the test oscillator so the first detector acts as an amplifier. After the IF is aligned, the first detector grid lead is connected back to its RF coil.

The technique of lining-up the first detector and RF stages, if any, is precisely the same as that described in aligning a tuned RF receiver. However, the line-up with the RF oscillator is slightly modified. METHOD: The HF oscillator is used to provide a signal in the first detector which will beat with the desired signal to form a new signal at the frequency to which the IF amplifier is tuned. If this is 450 KC, the HF oscillator should tune to 450 KC higher frequency than that of the first detector and RF stage. Figure 3 illustrates this circuit. In general, coil L_2 must have less inductance than L_1. and C_4 must have less tuning range than C_1. These requirements necessitate that L_2 have less turns than L_1, and less capacity in C_4 than in C_1. If C_1 and C_4 are of the same capacity and are coupled in tandem, a fixed or variable condenser C_3 is placed in series with C_4 to reduce its maximum capacity. C_2 and C_5 may be either trimmer or band-setting condensers. C_3 is required at longer wavelengths where the ratio of the oscillator to detector frequency is not approaching unity of equality. For example: at 14,000 KC with the oscillator at 14,450 KC no series condenser is necessary, but one would be required at frequencies of 2,000 KC and 2,450 KC if the tuning condensers C_1 and C_4 were very large.

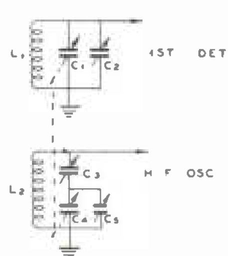


FIG. 3

Front-End of Superheterodyne.

Alignment Procedure: Actual alignment of the front end of a "superhet," such as shown in Figure 3, follows: The test oscillator is set at the highest frequency which can be tuned-in with a given set of coils.

This may require a little manipulation, but if the tuning range is known or can be estimated, an approximate frequency setting of the test oscillator can be made. The test signal is increased in value until it is heard or can be measured at the output of the receiver. C_2 is then adjusted to bring the dial reading to the desired point for a given frequency, that is, providing the dial is calibrated. C_1 and C_4, of course, being tuned simultaneously; afterwards, C_2 is adjusted for maximum sensitivity. Next, the tuning dial is rotated through to nearly full capacity setting of C_1 and C_4, of Figure 3, and the oscillator set for this lower frequency. These circuits can be aligned by moving the tuning dial while adjusting C_3 with a screwdriver or plate bending of C_1. A middle dial setting can be checked by means of a third setting of the test oscillator and plate bending of C_1. If alignment cannot be obtained by plate bending adjustments, a new value of trimmer condenser settings of C_5 and C_2 will have to be used and the whole procedure repeated. Sometimes L_2 has to have considerably less turns than L_1, and a few turns added or subtracted to allow the HF oscillator to tune through the whole range at precisely 450 KC higher in frequency than the detector and RF stages.

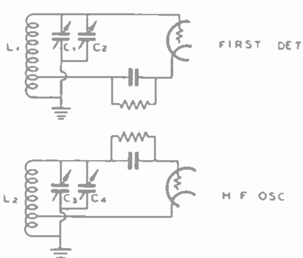


FIG. 4

Another type of front-end.

Multi-band Receivers: Individual coils in multi-band receivers with coil switching arrangements must have small trimmer condensers shunted across the inductive circuits, as shown in Figure 5. This allows fairly accurate alignment in each band by following the procedure previously outlined. In assembling a superheterodyne, the labor of checking is rather long and tedious since each coil must have exactly the correct number of turns because bending the main tuning condenser plates would unbalance or misalign all other coils. Unfortunately in receivers incorporating coil switching arrangements, it is impossible to obtain accurate circuit alignment. Many commercially built receivers use two stages of RF ahead of the first detector, tuned rather broadly to overcome this defect and obtain better signal-to-noise and image ratios.

If either the circuits of the RF stage are regenerative, they must track exactly with the HF oscillator. This type of circuit is shown in Figure 4, where C_1 and C_3 are

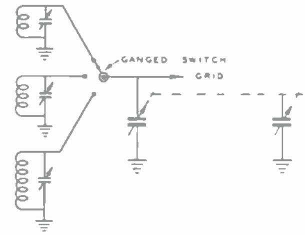


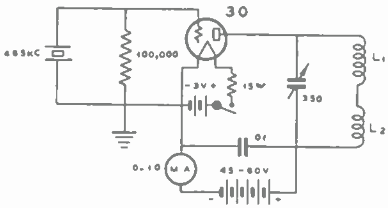
FIG. 5

Tuned circuits for coil switching.

approximately 20 to 30 mmfds. ganged tuning condensers on the main tuning dial, and C_2 and C_4 are band setting condensers of 100 to 140 mmfds. In this instance, C_2 can be used as a panel operated trimmer condenser to hold the circuits exactly in line at high degrees of regeneration. The series condensers C_5 of Figure 3 are not required in this class of receiver due to the very narrow band tuning-range of C_1 and C_3. The coil turns on L_1 and L_2 can be adjusted so that at random settings of C_2 and C_4 they will give practically perfect alignment. In practice, the adjustment occurs at slightly greater capacity settings of C_2 than for C_4, together with a small increase in inductance L_1. Varying the coil turns and spacing between turns will insure good tracking throughout all the amateur bands with the possible exception of the 160 meter band. This form of receiver invariably uses plug-in coils which must be adjusted properly, the turns being cemented in place with celluloidal cement.

Beat-frequency Oscillator: A beat-frequency oscillator, BFO, is lined up by tuning it so that its hiss is loudest in the receiver output; later, a signal is impressed to give a 1000 or 800 cycle beat-note. For example: If the IF amplifier is lined up to 450 KC, the BFO must be tuned to either 499 or 451 KC. If a crystal filter forms part of the IF amplifier complement, a vernier adjustment for the BFO should be available on the front panel in order to exactly set the beat-note for best results. The BFO input to the second detector need only be sufficient to give a good beat-note on a fairly strong signal. Too much coupling to the second detector will mean excessive hiss level with loss of very weak signals in the noise background. The BFO must be well shielded to prevent harmonics of the circuit from radiating and setting up unwanted signals. The oscillating circuit must have a high C to L ratio in order to generate oscillatory currents of high stability.

Crystal Filters: In lining up the IF amplifier for use with a crystal-filter, it is necessary to employ the crystal itself as an oscillator, providing a calibrated test oscillator is unavailable and the exact frequency of the crystal unknown. When the crystal itself functions as the oscillating medium, the circuit shown in Figure 6 should be used. In the diagram, the crystal is connected as a conventional crystal-oscillator in a transmitter, with the exception that a



TEST OSCILLATOR CIRCUIT
FIG. 6

Crystal Filter Aligning.

small air-gap is used and the grid-leak and choke combination eliminated. A winding from an IF transformer for the plate inductance with the trimmer attached are all that are required for tuning. For lining-up purposes, a type 30 tube with 2 volts AC on the filament will suffice; the AC modulates the signal and simplifies the adjusting procedure. Plate voltage (180 volts) is secured from a tap on the voltage divider. A milliammeter inserted in the plate circuit will indicate oscillation, the plate current dipping as the trimmer condenser tunes the inductance to the resonant frequency of the crystal. A piece of insulated wire is brought near the inductance and the far end of the wire hooked over the grid input to the first IF. Tuning the IF to exact resonance with the crystal then becomes a simple matter. Unless the IF amplifier is lined up to the exact crystal frequency, the crystal will introduce a very decided loss in sensitivity when it is switched into operation.

In adjusting the crystal filter, the phasing condenser and input tuning condenser should be adjusted simultaneously for maximum signal response, then a slight readjustment of the phasing condenser will allow elimination of the other sideband.

Notes: In lining up a receiver which has automatic volume control (AVC), it is considered good practice to keep the test-oscillator signal near the threshold sensitivity at all times to give the effect of a very weak signal relative to the audio amplifier output with the audio gain control on maximum setting.

In checking over a receiver certain troubles are often difficult to locate. In general, by making voltage or continuity tests, blown-out condensers, or burned-out resistors, coils or transformers may be easily located. Oscillators are usually checked by means of a DC voltmeter connected from ground to screen or plate-return circuits. Short-circuiting the tuning condenser plates should usually produce a change in voltmeter reading. A vacuum-tube voltmeter is also very handy for the purpose of measuring the correct amount of oscillator RF voltage supplied to the first detector circuit. The value of the RF voltage is approximately one volt less than the fixed grid bias on the first detector when the voltage is introduced into either the grid or the cathode circuit.

Incorrect voltages, poor resistors or leaky bypass or blocking condensers will ruin the audio tone of the receiver. Defective tubes can be checked in a tube tester. Loudspeaker rattle is not always the defect in the voice coil or spider support, or metallic filings in its air-gap; more often the distortion is caused by overloading the audio amplifier. An IF amplifier can also impair splendid tone due to a defective tube or overloading the final IF tube. In some AVC circuits, the last IF tuhe will easily overload if too much bias is fed back on strong carrier signals. Diode detectors give best fidelity when operated at fairly high input levels which means that there must be ample voltage swing delivered to the output of the last IF tube.

Quartz Crystal Filters: The subject of quartz-crystals is confusing to many users, which may be attributed to the complexities underlying the technical nature of the device.

Briefly, a quartz-crystal cut on certain axes and with parallel faces, has the property of mechanically oscillating in alternating-current electric fields of certain frequency. In addition, it has the very unique property of functioning as a resonator. In CW reception, the self-resonant feature is utilized in a filter circuit to limit the received signal to a band of approximately 100 cycles wide, such an electrical combination improves the signal-to-noise ratio as well as assures the highest selectivity obtainable for CW radio telegraphic reception.

General Details: To generally illustrate the function of the crystal and filter circuit, assume that the latter is replaced with its electrical equivalent in inductance and capacity. A crystal of 451.5 has an equivalent inductance of 3.5 henries and a capacity of less than 0.1 micromicrofarad. The effective "Q" of such a circuit ranges from 1000 to 10,000. Since the "Q" is the property which governs the shape of the resonance curve, the circuit would have a very narrow shoulder with a sharply peaked characteristic. Apparently no combination of inductance and capacity could eclipse these effects. Similarly, to an electrical equivalent circuit, the crystal has also properties of a series-resonant circuit. A circuit of this type offers very low impedance to the resonant frequency (that frequency where the inductive reactance and capacitive reactance are equal), while at the same time presents very high impedance to all other frequencies. A series-resonant circuit will pass the resonant frequency (in this case the frequency to which the receiver is tuned) and reject all other adjacent signals. In general, resonance curves do not have vertical sides, they slope. The "steepness" of the slope is dependent, among other things, upon the "Q" of the circuit. With a circuit having a resonance curve with gradual sloping sides, an interfering signal removing 10 KC from the desired signal may only be ten points down in strength from the desired signal at the output of the receiver. In contrast, a quartz-filter circuit with extremely steep sides can cause interfering signals to be cut down from the unwanted signal 10,000 times. These figures are merely illustrative of the effect of the extreme discrimination of such circuits as compared with ordinary tuned-parallel resonant circuits used in an IF amplifier.

Technical Discussion: The impedance of a quartz-crystal oscillator to an AC electrical current is exceptionally low and it can therefore be used as a series element of an electrical filter for CW reception. The quartz-crystal may be compared to the electrical equivalent circuit shown in Figure 1, where C1 is the capacity across the quartz plate when not vibrating; R, the resistance equivalent to the frictional effects of the vibrating crystal; L, the inductance corresponding to inertia; and C, the capacity corresponding to the elasticity. One side of resonance the circuit has capacitive reactance due to the elastic forces which control the crystal virbrations, while on the other side of resonance the reactance is inductive on account of the inertia effects. At resonance, the crystal vibrates freely, its amplitude being limited by the frictional

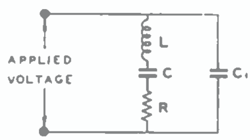


FIG. 1

Equivalent circuit of a quartz crystal.

effects; in the resonating state, L and C are equal in reactance and the resonant frequency is the same as the mechanical vibratory mode.

If the impressed voltage is at the resonant frequency, the current through it will be large, limited only by the resistance R. There is also a leading component due to C1 which can be balanced out by means of a "phasing" condenser. (Note: A phasing condenser is used in all single-signal receiver circuits to eliminate the by-passing effect of C1, of Figure 1, or to use it as a means of eliminating one sideband.) C1 combined with L and C have a sufficient inductive effect to provide a parallel circuit at a frequency slightly different from series resonance.

By placing the phasing condenser in the circuit so that the voltage across it is out of phase with that across the crystal, the parallel resonance can be shifted above or below crystal-resonance. Thus, the phasing condenser can be adjusted so that the parallel resonance causes a sharp dip in the response curve at some desired point, such as 2 KC away from the desired signal peak. This means that the other sideband 1 KC away from zero-beat can be practically eliminated with a beat-frequency oscillator. The series-resonant effect is used to pass the desired signal through an IF amplifier for further amplification.

Quartz-Filter Circuits: In reception, it is required that the noise-to-signal ratio be kept at a very low value; to obtain the optimum noise ratio requires circuits having selective and highly-peaked response curves. Thus, it is desirable to have a band-width only about 100 cycles wide, down to a point at where the gain of the receiver will discriminate against undesired signals audible in the output. A well-designed crystal filter will provide an attenuation of about 60 DB to signals more than 5 KC off resonance with, of course, that much more attenuation of the opposite sideband, 1 KC from zero-beat on the opposite side from the peak response.

Quartz-crystals have a greater "Q" at lower frequencies. For this reason most filters are designed for operation at 500 to 450 KC, and used in an IF amplifier resonating at the crystal frequency. From a selectivity standpoint, frequencies lower than 450 KC would be desirable because the crystal "Q" would be greater; however, in the lower ranges image interference becomes a problem.

In quartz-crystal filter circuits, the R value ranges between 2,500 and 10,000 ohms which requires that the circuit be designed to minimize its loading effect on any tuned circuits, otherwise the impedance irregularity will cause an excessive loss at the desired signal frequency. This latter condition occurs in the popular circuit shown in Figure 2.

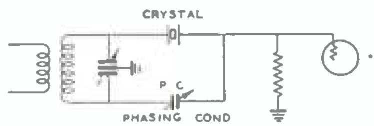


FIG. 2

Lamb's crystal filter circuit.

Some of the undesirable effects of the circuit shown in Figure 2 are eliminated in the circuit of Figure 3. Here, the grid-leak is replaced by a tapped resonant RF choke. The resonant effect, plus the mid-point connection, gives a step-up in impedance from the series element (the quartz-crystal) with only a slight loss in signal strength. To realize the full possibilities of this system requires that the resonant choke be properly designed; unfortunately, the design is difficult.

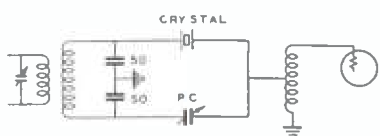


FIG. 3

McMurdo Silver's crystal filter.

The difference between the circuits of Figures 2 and 3 is in the manner of obtaining an out-of-phase voltage across the crystal. The coil can be center-tapped to ground, or the center point of the two condensers may be used. In either case, the crystal-input circuit tuning condenser and phasing condenser are simultaneously adjusted for maximum signal response and greatest single signal effect.

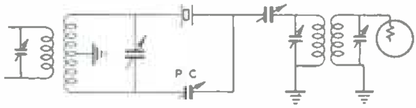


FIG. 4

Frank C. Jones' crystal filter.

In the circuit of Figure 4 the crystal is used as a series element, connecting two parallel resonant circuits together in a band-pass circuit. The small condenser C of 20 to 30 uufds. is necessary to prevent over-coupling between the tuned IF transformers, because at series resonance, only a few thousand ohms is offered as impedance. The small condenser C does not appreciably decrease the signal strength, its function is that of coupling the two tuned circuit together. The extra tuned circuits, which cause only an effective loss, eliminate the usual spurious side-band responses of most quartz crystals. The side-band responses are a few kilocycles away from resonance, but by careful tuning of the IF transformers, these effects can be attenuated to practically zero value.

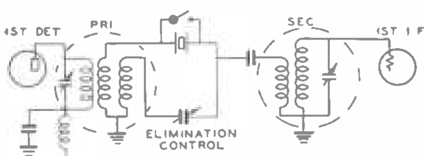
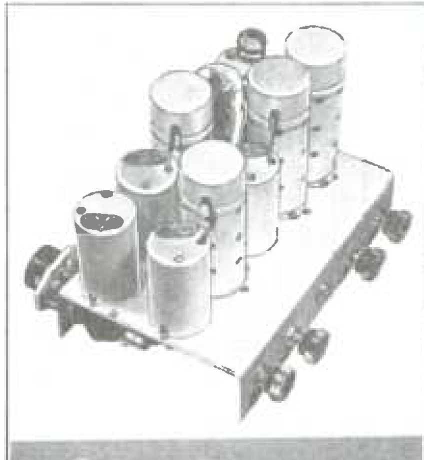


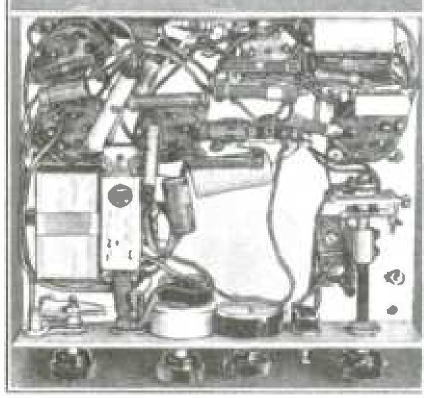
FIG. 5

Comet "Pro" crystal filter

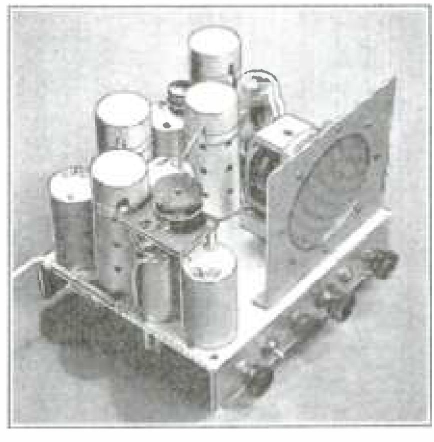
Another method for matching impedances is shown in Figure 5. Here the low impedance of the crystal at resonance does not over-couple the two parallel tuned circuits. A 30-1 step-down ratio of impedance works into the crystal, and a similar step-up ratio couples it into the tuned-grid circuit. In this circuit, as well as in the one above, a small series condenser prevents over-coupling. Laboratory and field tests show that very little, if anything, is gained by the step-down transformers as compared with the system shown in Figure 4. The circuits shown in Figures 3, 4 and 5 are better than that of Figure 2.

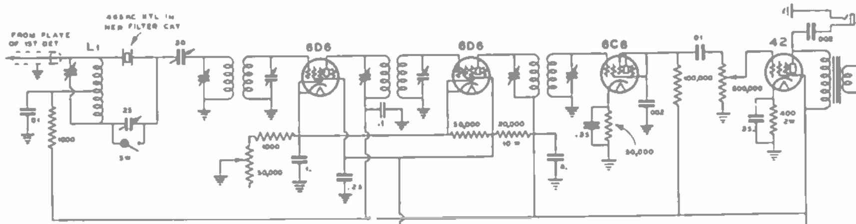
The illustrations to the right show modern designs for home-built crystal filter I-F amplifier and B.F.O. circuits.



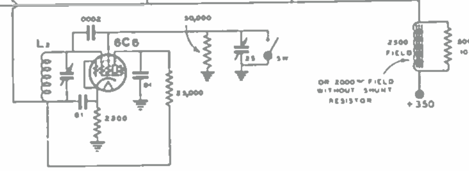


The under-chassis view shows the placement of the crystal phasing condenser, which has one of its rotor plates bent over slightly so that the condenser will be short-circuited when it is in the full "in" position.

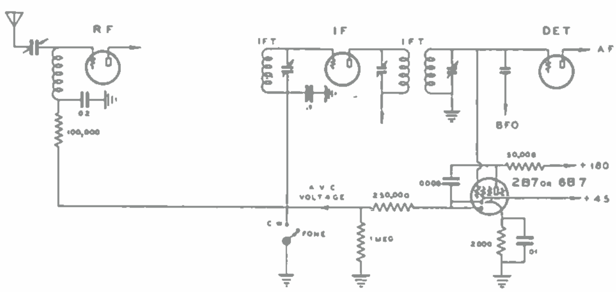




Intermediate frequency amplifier with Jones crystal filter and R.C.A. BFO circuit. The photographs on the preceding page show two types of units in which these modern circuits are incorporated. They can be used for converting a regenerative detector and R-F into a superheterodyne.

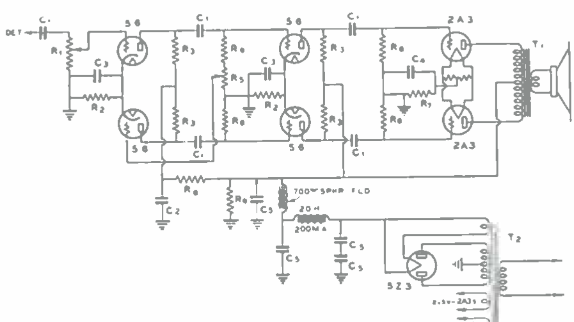


IMPROVED BFO CIRCUIT



AMPLIFIED A V C FOR 222 RECEIVER OR ANY OTHER SHORT WAVE SUPERHET

Automatic volume control is a distinct advantage when the receiver is used for phone reception. It automatically compensates for signal fading. Briefly, its action depends upon the carrier signal strength which causes a control voltage to vary in proportion to the actual carrier intensity.

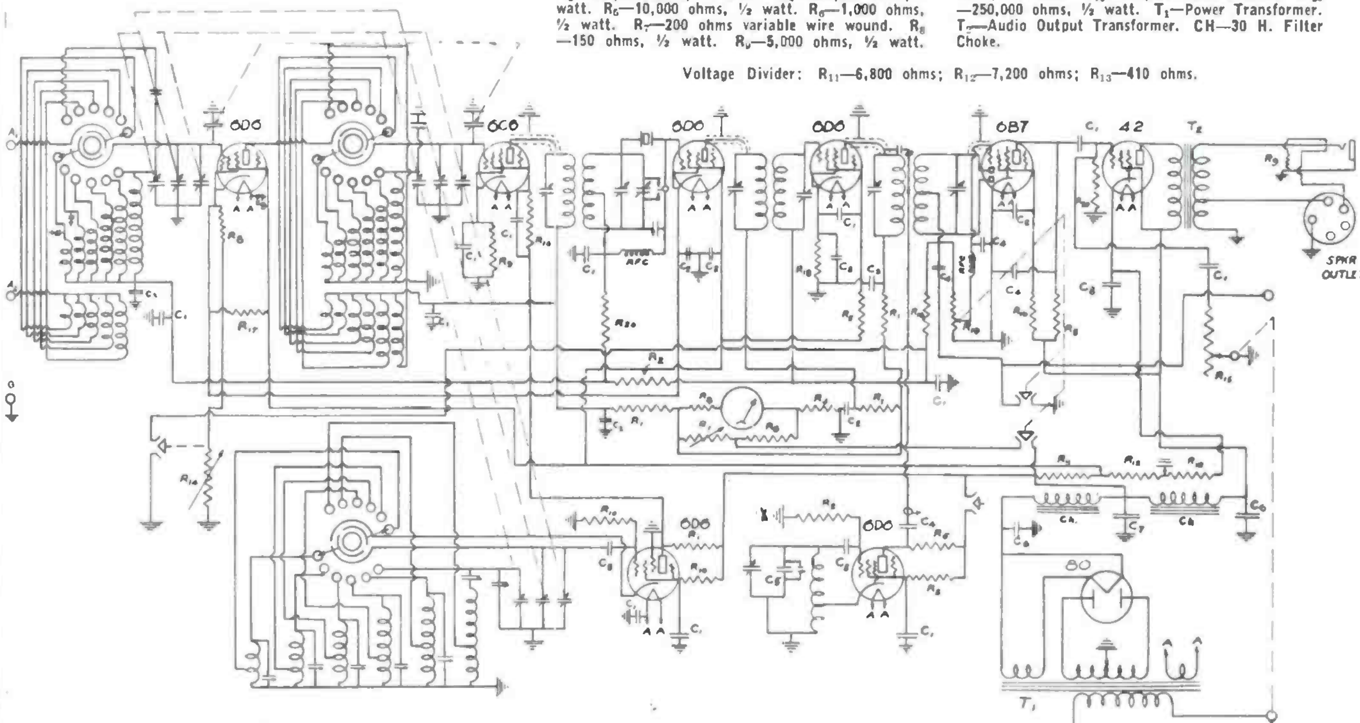


High quality audio amplifier with a maximum output of 15 watts. Legend—

C1—0.1. C2—4 mfd. C3—4 mfd. C4—10 mfd. C5—8 mfd. R1—500,000 ohm Potentiometer. R2—1250 ohms, 1 watt. R3—100,000 ohms, 1 watt. R4—250,000 ohms, 1 watt. R5—250,000 ohm Potentiometer. R6—500,000 ohms, 1 watt. R7—750 ohms, 10 watts. R8—20,000 ohms, 1 watt. R9—25,000 ohms, 20 watts. T1—Output Transformer from 2A3s Push-Pull to Dynamic Speaker. T2—Power Transformer, 300 volts each side of center-tap at 150 MA.

C_1—.01. C_2—.1. C_3—.0001. C_4—.00025. C_5—.00025. C_6—8. C_7—12. C_8—25. C_9—.002. R_1—2,000 ohms, ½ watt. R_2—100,000 ohms, ½ watt. R_3—100,000 ohms, ½ watt. R_4—100,000 ohms, 1 watt. R_5—10,000 ohms, ½ watt. R_6—1,000 ohms, ½ watt. R_7—200 ohms variable wire wound. R_8—150 ohms, ½ watt. R_9—5,000 ohms, ½ watt. R_{10}—50,000 ohms, ½ watt. R_{14}—30,000 ohms variable. R_{15}—1 megohm variable. R_{16}—1 megohm, ½ watt. R_{17}—20,000 ohms, 1 watt. R_{18}—500 ohms, ½ watt. R_{19}—250,000 ohms variable. R_{20}—250,000 ohms, ½ watt. T_1—Power Transformer. T_2—Audio Output Transformer. CH—30 H. Filter Choke.

Voltage Divider: R_{11}—6,800 ohms; R_{12}—7,200 ohms; R_{13}—410 ohms.



Circuit Diagram of RME-69 Crystal Filter Superheterodyne.

Band Pass Crystal Filters

An ideal characteristic for an I.F. amplifier in a c-w receiver would be a band width 500 cycles broad at the top, and practically straight-sided. The total attenuation would be down at least 120 D.B. at approximately 100 cycles either side of this band-pass. The attenuation should extend down to 120 D.B. in order to eliminate "slop-over" from very powerful local stations.

A multiple quartz crystal filter, combined with a number of tuned I.F. circuits, would approach this ideal condition for phone reception; on the other hand its use would not be desirable for c-w reception. Series crystal filter circuits as used in single signal superheterodynes give a very narrow width, but the shape of the curve resembles the outline of a volcano. It is too sharp

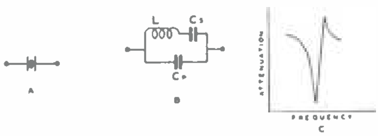


FIG. 1

for easy tuning on the peak, and altogether too wide at the base; therefore the strong local signals cannot be eliminated. The peak portion of the curve is too selective for phone reception, and for this reason the series crystal circuits will eventually be discarded.

The equivalent circuit of a quartz crystal is shown in Fig. 1, wherein both series and parallel resonance occur. Series resonance is due to the equivalent inductance and series capacity:

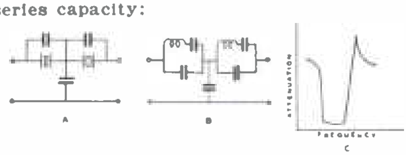


FIG. 2

$$F_s = \frac{1}{2\pi\sqrt{LC_s}}$$

The crystal holder introduces a shunt or parallel capacity C_p across the crystal, and parallel resonance occurs at:

$$F_p = \frac{1}{2\pi}\sqrt{\frac{C_s + C_p}{LC_sC_p}}$$

The parallel resonance effect can be varied by means of a "phasing" condenser in a single signal receiver in such a manner that it will nearly eliminate the second beat note of a c-w signal which is tuned-in on the peak of resonance. The parallel resonance is too sharp to make possible the elimination of the entire undesired beat note, except over a certain range, such as from 800 to 900 or 1,000 cycles. Thus a weak, undesired signal of higher or lower beat note can still be heard, especially if the lower beat note signal is of sufficient intensity.

Fig. 2 shows two crystals in a band-pass circuit. The crystals used in band-pass circuits are slightly different in frequency.

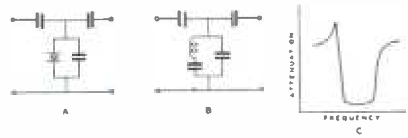


FIG. 3

In Fig. 2 the response curve is wider at the base, which is the point of least attenuation (the peak of response in a receiver) than for the single series crystal shown in Fig. 1c.

Fig. 3 shows a shunt single crystal filter circuit with series condensers. The circuit is similar to that of Fig. 2, except for the reversal in the point of greatest attenuation. The curve of (c) depends upon the proper impedance terminations, as well as the correct values of shunt and series condensers.

Fig. 4 shows a system with three crystals for better band-pass characteristic. The band-pass width is less than 0.4% of the series resonance frequency of the crystals; consequently for a 465 KC crystal the band width would not be greater than 1750 cycles.

These band-pass filters have a low impedance, depending upon their band widths. The narrower the band, the lower is the value of impedance to match. This impedance ranges from a few hundred ohms, downward. Impedance matching can be accomplished with tuned I.F. coils which have low inductance untuned secondary and primary windings.

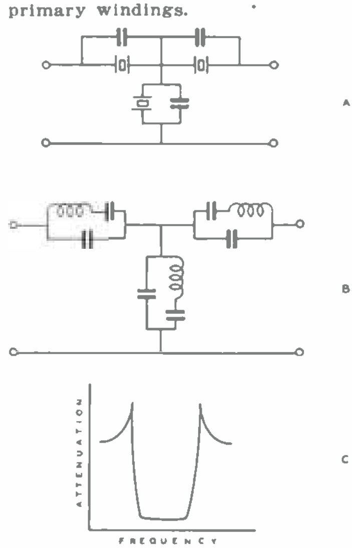
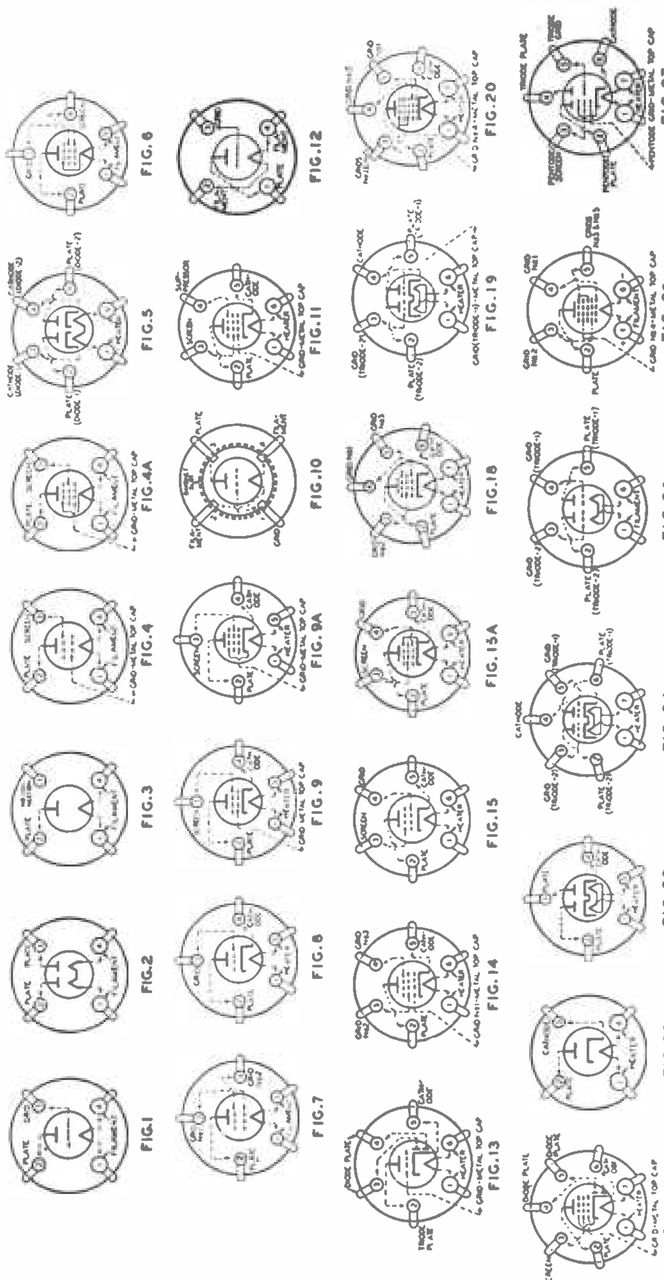


Fig. 4

The attenuation of these band-pass crystal filters is from 30 to 40 D.B., except at the points of highest attenuation, which may run from 60 to 100 D.B. This sliding-off effect on the sides beyond the parallel resonant cut-off points means that additional attenuation in the I.F. amplifier is required, or more than one section of crystal filter must be used between stages.

Tube Symbols and Bottom Views of Socket Connections



Tube Characteristics and Socket Connections courtesy RCA Cunningham Radiotron Co., Inc.

Characteristics of Receiving 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	USE Values to right give operating conditions and characteristics for indicated typical use	PLATE SUPPLY VOLTS	GRID VOLTS ■	SCREEN VOLTS	SCREEN MILLI-AMP.	PLATE MILLI-AMP.	A-C PLATE RESISTANCE OHMS	MUTUAL CONDUCTANCE MICROMHOS	VOLTAGE AMPLIFICATION FACTOR	LOAD FOR STATED POWER OUTPUT OHMS	POWER OUTPUT WATTS	TYPE
1A6	PENTAGRID CONVERTER ●	SMALL 6-PIN	FIG. 28	4 11/32" x 1 9/16"	D-C FILAMENT	2.0	0.06	180	67.5	CONVERTER	180	−3.0 min.	67.5	2.4	1.3	500000	Anode-Grid (● 2) 135 max. volts, 2.3 ma. Oscillator Grid (● 1) Resistor, 50000 ohms. Conversion conductance, 300 micromhos				1A6
1C6	PENTAGRID CONVERTER ●	SMALL 6-PIN	FIG. 28	4 11/32" x 1 9/16"	D-C FILAMENT	2.0	0.12	180	67.5	CONVERTER	180	−3.0 min.	67.5	2.0	1.5	750000	Anode Grid (● 2) 135 max. volts, 3.3 ma. Oscillator Grid (● 1) Resistor, 50000 ohms. Conversion conductance, 325 micromhos				1C6
2A3	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	5 5/8" x 2 1/16"	FILAMENT	2.5	2.5	250	—	CLASS A AMPLIFIER	250	−45	—	—	60.0	800	5250	4.2	2500	3.5	2A3
								300	—	PUSH-PULL AMPLIFIER	300 300	−62 −62	Self bias Fixed bias		40.0 40.0	Power Output is for 2 tubes at stated load, plate-to-plate			5000 3000	10.0 15.0	
2A5	POWER AMPLIFIER PENTODE	MEDIUM 6-PIN	FIG. 15A	4 11/16" x 1 13/16"	HEATER	2.5	1.75	250	250	CLASS A AMPLIFIER	250	−16.5	250	6.5	34.0	100000	2200	220	7000	3.0	2A5
2A6	DUPLEX-DIODE HIGH-MU TRIODE	SMALL 6-PIN	FIG. 13	4 11/32" x 1 9/16"	HEATER	2.5	0.8	250	—	TRIODE UNIT AS CLASS A AMPLIFIER	250 ■	−1.35	—	—	0.4	—	—	Gain per stage = 50-60			2A6
2A7	PENTAGRID CONVERTER ●	SMALL 7-PIN	FIG. 29	4 11/32" x 1 9/16"	HEATER	2.5	0.8	250	100	CONVERTER	250	−3.0 min.	100	2.2	3.5	360000	Anode Grid (● 2) 200 max. volts, 4.0 ma. Oscillator Grid (● 1) Resistor, 50000 ohms. Conversion conductance, 520 micromhos.				2A7
2B7	DUPLEX-DIODE PENTODE	SMALL 7-PIN	FIG. 21	4 11/32" x 1 9/16"	HEATER	2.5	0.8	250	125	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	—	—	2B7
										PENTODE UNIT AS A-F AMPLIFIER	250 †	−4.5	50	—	0.65	—	—	—	—	—	
6A4 also LA	POWER AMPLIFIER PENTODE	MEDIUM 5-PIN	FIG. 6	4 11/16" x 1 13/16"	FILAMENT	6.3	0.3	180	180	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 also LA
6A7	PENTAGRID CONVERTER ●	SMALL 7-PIN	FIG. 29	4 11/32" x 1 9/16"	HEATER	6.3	0.3	250	100	CONVERTER	250	−3.0 min.	100	2.2	3.5	360000	Anode Grid (● 2) 200 max. volts, 4.0 ma. Oscillator Grid (● 1) Resistor, 50000 ohms. Conversion conductance, 520 micromhos.				6A7
6B7	DUPLEX-DIODE PENTODE	SMALL 7-PIN	FIG. 21	4 11/32" x 1 9/16"	HEATER	6.3	0.3	250	125	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	250 †	−4.5	50	—	0.65	—	—	—	—	—	
6C6	TRIPLE-GRID DETECTOR AMPLIFIER	SMALL 6-PIN	FIG. 11	4 9/32" x 1 9/16"	HEATER	6.3	0.3	250	100	SCREEN GRID R-F AMPLIFIER	250	−3.0	100	0.5	2.0	exceeds 1.5 meg	1225	exceeds 1500	—	—	6C6
										BIAS DETECTOR	250	−1.95	50	Cathode current 0.65 ma		—	Plate coupling resistor 250000 ohms. Grid coupling resistor 250000 ohms **				
6D6	TRIPLE-GRID SUPER-CONTROL AMPLIFIER	SMALL 6-PIN	FIG. 11	4 9/32" x 1 9/16"	HEATER	6.3	0.3	250	100	SCREEN GRID R-F AMPLIFIER	250	−3.0 min.	100	2.0	8.2	800000	1600	1280	—	—	6D6
										MIXER IN SUPERHETERODYNE	250	−10.0	100	—	—		Oscillator peak volts = 7.0.				
6F7	TRIODE-PENTODE	SMALL 7-PIN	FIG. 27	4 11/32" x 1 9/16"	HEATER	6.3	0.3	100	—	TRIODE UNIT AS AMPLIFIER	100	−3.0	—	—	3.5	17800	450	8	—	—	6F7
								250	100	PENTODE UNIT AS AMPLIFIER	250	−3.0 min.	100	1.5	6.5	850000	1100	900	—	—	
								250	100	PENTODE UNIT AS MIXER	250	−10.0	100	0.6	2.8	Oscillator peak volts = 7.0. Conversion conductance = 300 micromhos.					
'00-A	DETECTOR TRIODE	MEDIUM 4-PIN	FIG. 1	4 11/16" x 1 13/16"	D-C FILAMENT	5.0	0.25	45	—	GRID LEAK DETECTOR	45	Grid Return to (−) Filament			1.5	30000	666	20	—	—	'00-A
01-A	DETECTOR & AMPLIFIER	MEDIUM 4-PIN	FIG. 1	4 11/16" x 1 13/16"	D-C FILAMENT	5.0	0.25	135	—	CLASS A AMPLIFIER	90 135	−4.5 −9.0	—	—	2.5 3.0	11000 10000	725 800	8.0 8.0	—	—	01-A
10	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	5 5/8" x 2 3/16"	FILAMENT	7.5	1.25	425	—	CLASS A AMPLIFIER	350 425	−31.0 −39.0	—	—	16.0 18.0	5150 5000	1550 1600	8.0 8.0	11000 10200	0.9 1.6	10
11 12	DETECTOR & AMPLIFIER TRIODE	WD 4-PIN MEDIUM 4-PIN	FIG. 12 FIG. 1	4 1/8" x 1 3/16" 4 11/16" x 1 3/16"	D-C FILAMENT	1.1	0.25	135	—	CLASS A AMPLIFIER	90 135	−4.5 −10.5	—	—	2.5 3.0	15500 15000	425 440	6.6 6.6	—	—	11 12
19	TWIN-TRIODE AMPLIFIER	SMALL 6-PIN	FIG. 25	4 1/4" x 1 9/16"	D-C FILAMENT	2.0	0.26	135	—	CLASS B AMPLIFIER	135 135	0 −3.0	—	—	Power output value is for one tube at stated load, plate-to-plate.				10000 10000	2.1 1.9	19
'20	POWER AMPLIFIER TRIODE	SMALL 4-PIN	FIG. 7	4 1/8" x 1 3/16"	D-C FILAMENT	3.3	0.132	135	—	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
22	R-F AMPLIFIER TETRODE	MEDIUM 4-PIN	FIG. 4	5 17/32" x 1 13/16"	D-C FILAMENT	3.3	0.132	135	67.5	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
24-A	R-F AMPLIFIER TETRODE	MEDIUM 5-PIN	FIG. 9	5 17/32" x 1 13/16"	HEATER	2.5	1.75	275	90	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.						
26	AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	4 11/16" x 1 13/16"	FILAMENT	1.5	1.05	180	—	CLASS A AMPLIFIER	90 180	−7.0 −14.5	—	—	2.9 6.2	8900 7300	935 1150	8.3 8.3	—	—	26
27	DETECTOR & AMPLIFIER TRIODE	MEDIUM 5-PIN	FIG. 8	4 1/4" x 1 9/16"	HEATER	2.5	1.75	275	—	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.						
30	DETECTOR & AMPLIFIER TRIODE	SMALL 4-PIN	FIG. 1	4 1/4" x 1 9/16"	D-C FILAMENT	2.0	0.06	180	—	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

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

† Applied through plate coupling resistor of 200000 ohms.
■ Applied through plate coupling resistor of 250000 ohms.
** For grid of following tube.

Characteristics of Receiving Tubes
(Continued)

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	USE (Values to right give operating conditions and characteristics for indicated typical use)	PLATE SUPPLY VOLTS	GRID VOLTS ■	SCREEN VOLTS	SCREEN MILLI-AMP.	PLATE MILLI-AMP.	A-C PLATE RESISTANCE OHMS	MUTUAL CONDUCTANCE MICROMHOS	VOLTAGE AMPLIFICATION FACTOR	LOAD FOR STATED POWER OUTPUT OHMS	POWER OUTPUT WATTS	TYPE
31	POWER AMPLIFIER TRIODE	SMALL 4-PIN	FIG. 1	4½" x 1 9/16"	D-C FILAMENT	2.0	0.13	180	—	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
32	R-F AMPLIFIER TETRODE	MEDIUM 4-PIN	FIG. 4	5 7/32" x 1 13/16"	D-C FILAMENT	2.0	0.06	180	67.5	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.						
33	POWER AMPLIFIER PENTODE	MEDIUM 5-PIN	FIG. 6	4 11/16" x 1 13/16"	D-C FILAMENT	2.0	0.26	180	180	CLASS A AMPLIFIER	180	−18.0	180	5.0	22.0	55000	1700	90	6000	1.4	33
34	SUPER-CONTROL R-F AMPLIFIER PENTODE	MEDIUM 4-PIN	FIG. 4A	5 7/32" x 1 13/16"	D-C FILAMENT	2.0	0.06	180	67.5	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
35	SUPER-CONTROL R-F AMPLIFIER TETRODE	MEDIUM 5-PIN	FIG. 9	5 7/32" x 1 13/16"	HEATER	2.5	1.75	275	90	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
36	R-F AMPLIFIER TETRODE	SMALL 5-PIN	FIG. 9	4 17/32" x 1 9/16"	HEATER	6.3	0.3	250	90	SCREEN GRID R-F AMPLIFIER	100 180 250	−1.5 −3.0 −3.0	55 90 90	— — 1.7*	1.8 3.1 3.2	550000 500000 550000	850 1050 1080	470 525 595	—	—	36
										BIAS DETECTOR	100● 250●	−5.0 −8.0	55 90	—	Plate current to be adjusted to 0.1 milliampere with no signal.						
37	DETECTOR★ AMPLIFIER TRIODE	SMALL 5-PIN	FIG. 9	4¼" x 1 9/16"	HEATER	6.3	0.3	250	—	CLASS A AMPLIFIER	90 180 250	−6.0 −13.5 −18.0	—	—	2.5 4.3 7.5	11500 10200 8400	800 900 1100	9.2 9.2 9.2	—	—	37
										BIAS DETECTOR	90 250	−10.0 −28.0	—	—	Plate current to be adjusted to 0.2 milliampere with no signal.						
38	POWER AMPLIFIER PENTODE	SMALL 5-PIN	FIG. 9A	4 17/32" x 1 9/16"	HEATER	6.3	0.3	250	250	CLASS A AMPLIFIER	100 180 250	−9.0 −18.0 −25.0	100 180 250	1.2 2.4 3.8	7.0 14.0 22.0	140000 115000 100000	875 1050 1200	120 120 120	15000 11600 10000	0.27 1.00 2.50	38
39-44	SUPER-CONTROL R-F AMPLIFIER PENTODE	SMALL 5-PIN	FIG. 9A	4 17/32" x 1 9/16"	HEATER	6.3	0.3	250	90	SCREEN GRID R-F AMPLIFIER	90 180 250	−3.0 min.	90 90 90	1.6 1.4 1.4	5.6 5.8 5.8	375000 750000 1000000	960 1000 1050	360 750 1050	—	—	39-44

★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.
●Applied through plate coupling resistor of 250000 ohms or 500-henry choke shunted by 0.25 megohm resistor.
♥Applied through plate coupling resistor of 100000 ohms.
*Maximum.

TYPE	NAME	BASE	SOCKET CONNECTIONS	DIMENSIONS	CATHODE TYPE	FIL. VOLTS	FIL. AMPERES	PLATE MAX. VOLTS	SCREEN MAX. VOLTS	USE	PLATE SUPPLY VOLTS	GRID VOLTS	SCREEN VOLTS	SCREEN MILLI-AMP.	PLATE MILLI-AMP.	A-C PLATE RESISTANCE OHMS	MUTUAL CONDUCTANCE MICROMHOS	VOLTAGE AMPLIFICATION FACTOR	LOAD FOR STATED POWER OUTPUT OHMS	POWER OUTPUT WATTS	TYPE
40	VOLTAGE AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	4 11/16" x 1 13/16"	D-C FILAMENT	5.0	0.25	180	—	CLASS A AMPLIFIER	135■ 180■	−1.5 −3.0	—	—	0.2 0.2	150000 150000	200 200	30 30	—	—	40
41	POWER AMPLIFIER PENTODE	SMALL 6-PIN	FIG. 15A	4¼" x 1 9/16"	HEATER	6.3	0.4	250	250	CLASS A AMPLIFIER	100 180 250	−7.0 −13.5 −18.0	100 180 250	1.6 3.0 5.5	9.0 18.5 32.0	103500 81000 68000	1450 1850 2200	150 150 150	12000 9000 7600	0.33 1.50 3.40	41
42	POWER AMPLIFIER PENTODE	MEDIUM 6-PIN	FIG. 15A	4 11/16" x 1 13/16"	HEATER	6.3	0.7	250	250	CLASS A AMPLIFIER	250	−16.5	250	6.5	34.0	100000	2200	220	7000	3.00	42
43	POWER AMPLIFIER PENTODE	MEDIUM 6-PIN	FIG. 15A	4 11/16" x 1 13/16"	HEATER	25.0	0.3	135	135	CLASS A AMPLIFIER	95 135	−15.0 −20.0	95 135	4.0 7.0	20.0 34.0	45000 35000	2000 2300	90 80	4500 4000	0.90 2.00	43
45	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	4 11/16" x 1 13/16"	FILAMENT	2.5	1.5	275	—	CLASS A AMPLIFIER	180 250 275	−31.5 −50.0 −56.0	180 250 275	—	31.0 34.0 36.0	1650 1610 1700	2125 2175 2050	3.5 3.5 3.5	2700 3900 4600	0.82 1.60 2.00	45
46	DUAL-GRID POWER AMPLIFIER	MEDIUM 5-PIN	FIG. 7	5⅜" x 2 1/16"	FILAMENT	2.5	1.75	250	—	CLASS A AMPLIFIER □	250	−33.0	—	—	22.0	2380	2350	5.6	6400	1.25	46
								400	—	CLASS B AMPLIFIER ◆	300 400	0 0	—	—	Power output values are for 2 tubes at indicated plate-to-plate load.				5200 5800	16.0 20.0	
47	POWER AMPLIFIER PENTODE	MEDIUM 5-PIN	FIG. 8	5⅜" x 2 1/16"	FILAMENT	2.5	1.75	250	250	CLASS A AMPLIFIER	250	−16.5	250	6.0	31.0	60000	2500	150	7000	2.7	47
48	POWER AMPLIFIER TETRODE	MEDIUM 6-PIN	FIG. 15	5⅜" x 2 1/16"	D-C HEATER	30.0	0.4	125	100	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
49	DUAL-GRID POWER AMPLIFIER	MEDIUM 5-PIN	FIG. 7	4 11/16" x 1 13/16"	D-C FILAMENT	2.0	0.12	135	—	CLASS A AMPLIFIER □	135	−20.0	—	—	6.0	4175	1125	4.7	11000	0.17	49
								180	—	CLASS B AMPLIFIER ◆	180	0	—	—	Power output values are for 2 tubes at indicated plate-to-plate load.				12000	3.5	
50	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	6¼" x 2 11/16"	FILAMENT	7.5	1.25	450	—	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
53	TWIN-TRIODE AMPLIFIER	MEDIUM 7-PIN#	FIG. 24	4 11/16" x 1 13/16"	HEATER	2.5	2.0	300	—	CLASS B AMPLIFIER	250 300	0 0	—	—	Power output value is for one tube at stated load, plate-to-plate.				8000 10000	8.0 10.0	53
55	DUPLEX-DIODE TRIODE	SMALL 6-PIN	FIG. 13	4 17/32" x 1 9/16"	HEATER	2.5	1.0	250	—	TRIODE UNIT AS CLASS A AMPLIFIER	135 180 250	−10.5 −13.5 −20.0	—	—	3.7 6.0 8.0	11000 8500 7500	750 975 1100	8.3 8.3 8.3	25000 20000 20000	0.075 0.160 0.350	55
56	SUPER-TRIODE AMPLIFIER DETECTOR★	SMALL 5-PIN	FIG. 8	4¼" x 1 9/16"	HEATER	2.5	1.0	250	—	CLASS A AMPLIFIER	250	−13.5	—	—	5.0	9500	1450	13.8	—	—	56
										BIAS DETECTOR	250	−20.0 approx.	—	—	Plate current to be adjusted to 0.2 milliampere with no signal.						
57	TRIPLE-GRID DETECTOR AMPLIFIER	SMALL 6-PIN	FIG. 11	4 11/16" x 1 9/16"	HEATER	2.5	1.0	250	100	SCREEN GRID R-F AMPLIFIER	250	−3.0	100	0.5	2.0	exceeds 1.5 meg.	1225	exceeds 1500	—	—	57
										BIAS DETECTOR	250	−1.95	50	Cathode current 0.65 ma.		—	Plate coupling resistor 250000 ohms. Grid coupling resistor 250000 ohms**				

★For Grid-leak Detection—plate volts 45, grid return to + filament or to cathode. ●Applied through plate coupling resistor of 250000 ohms or 500-henry choke shunted by 0.25 megohm resistor. *Maximum.

Characteristics of Receiving Tubes

(Continued)

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	USE Values to right give operating conditions and characteristics for indicated typical use	PLATE SUP-PLY VOLTS	GRID VOLTS ■	SCREEN VOLTS	SCREEN MILLI-AMP.	PLATE MILLI-AMP.	A-C PLATE RESIS-TANCE OHMS	MUTUAL CON-DUC-TANCE MICRO-MHOS	VOLT-AGE AMPLI-FICATION FACTOR	LOAD FOR STATED POWER OUTPUT OHMS	POWER OUT-PUT WATTS	TYPE
58	TRIPLE-GRID SUPER-CONTROL AMPLIFIER	SMALL 6-PIN	FIG. 11	4 11/16" x 1 9/16"	HEATER	2.5	1.0	250	100	SCREEN GRID R-F AMPLIFIER	250	(−3.0 min.)	100	2.0	8.2	800000	1600	1280	—	—	58
										MIXER IN SUPERHETERODYNE	250	−10.0	100	—	—	Oscillator peak volts = 7.0.					
59 ●	TRIPLE-GRID POWER AMPLIFIER	MEDIUM 7-PIN#	FIG. 18	5 3/8" x 2 1/16"	HEATER	2.5	2.0	250	—	AS TRIODE ¶ CLASS A AMPLIFIER	250	−28.0	—	—	26.0	2300	2600	6.0	5000	1.25	59
								250	250	AS PENTODE ** CLASS A AMPLIFIER	250	−18.0	250	9.0	35.0	40000	2500	100	6000	3.00	
								400	—	AS TRIODE ● CLASS B AMPLIFIER	300 400	0 0	—	—	Power output values are for 2 tubes at indicated plate-to-plate load.				4600 6000	15.0 20.0	
71-A	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	4 11/16" x 1 11/16"	FILAMENT	5.0	0.25	180	—	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
75	DUPLEX-DIODE HIGH-MU TRIODE	SMALL 6-PIN	FIG. 13	4 11/32" x 1 9/16"	HEATER	6.3	0.3	250	—	TRIODE UNIT AS CLASS A AMPLIFIER	250 ⌘	−1.35	—	—	0.4	—	—	Gain per stage = 50-60			75
76	SUPER-TRIODE AMPLIFIER DETECTOR★	SMALL 5-PIN	FIG. 8	4 1/4" x 1 9/16"	HEATER	6.3	0.3	250	—	CLASS A AMPLIFIER	250	−13.5	—	—	5.0	9500	1450	13.8	—	—	76
										BIAS DETECTOR	250	−20.0	—	—	Plate current to be adjusted to 0.2 milliampere with no signal.						
77	TRIPLE-GRID DETECTOR AMPLIFIER	SMALL 6-PIN	FIG. 11	4 11/32" x 1 9/16"	HEATER	6.3	0.3	250	100	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 coupling resistor 250000 ohms. Grid coupling resistor 250000 ohms**				
78	TRIPLE-GRID SUPER-CONTROL AMPLIFIER	SMALL 6-PIN	FIG. 11	4 11/32" x 1 9/16"	HEATER	6.3	0.3	250	125	SCREEN GRID R-F AMPLIFIER	90 180 250 250	(−3.0 min.)	90 75 100 125	1.3 1.0 1.7 2.6	5.4 4.0 7.0 10.5	315000 1000000 800000 600000	1275 1100 1450 1650	400 1100 1160 990	—	—	78
79	TWIN-TRIODE AMPLIFIER	SMALL 6-PIN	FIG. 19	4 11/16" x 1 9/16"	HEATER	6.3	0.6	250	—	CLASS B AMPLIFIER	180 250	0 0	—	—	Power output value is for one tube at stated load, plate-to-plate.				7000 14000	5.5 8.0	79
85	DUPLEX-DIODE TRIODE	SMALL 6-PIN	FIG. 13	4 11/32" x 1 9/16"	HEATER	6.3	0.3	250	—	TRIODE UNIT AS CLASS A AMPLIFIER	135 180 250	−10.5 −13.5 −20.0	—	—	3.7 6.0 8.0	11000 8500 7500	750 975 1100	8.3 8.3 8.3	25000 20000 20000	0.075 0.160 0.350	85
89	TRIPLE-GRID POWER AMPLIFIER	SMALL 6-PIN	FIG. 14	4 11/32" x 1 9/16"	HEATER	6.3	0.4	250	250	AS TRIODE ¶ CLASS A AMPLIFIER	160 180 250	−20.0 −22.5 −31.0	—	—	17.0 20.0 32.0	3300 3000 2600	1425 1550 1800	4.7 4.7 4.7	7000 6500 5500	0.300 0.400 0.900	89
										AS PENTODE ** CLASS A AMPLIFIER	100 180 250	−10.0 −18.0 −25.0	100 180 250	1.6 3.0 5.5	9.5 20.0 32.0	104000 80000 70000	1200 1550 1800	125 125 125	10700 8000 6750	0.33 1.50 3.40	
										AS TRIODE ● CLASS B AMPLIFIER	180	0	—	—	Power output values are for 2 tubes at indicated plate-to-plate load.				13600 9400	2.50 3.50	
V-'99 X-'99	DETECTOR★ AMPLIFIER TRIODE	SMALL 4-NUB SMALL 4-PIN	FIG. 10 FIG. 1	3 1/2" x 1 3/16" 4 1/8" x 1 3/16"	D-C FILAMENT	3.3	0.063	90	—	CLASS A AMPLIFIER	90	−4.5	—	—	2.5	15500	425	6.6	—	—	V-'99 X-'99
112-A	DETECTOR★ AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	4 11/16" x 1 11/16"	D-C FILAMENT	5.0	0.25	180	—	CLASS A AMPLIFIER	90 180	−4.5 −13.5	—	—	5.0 7.7	5400 4700	1575 1800	8.5 8.5	—	—	112-A

★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.
Requires different socket from small 7-pin.

** 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. ⌘ Applied through plate coupling resistor of 250000 ohms.
● Grids #1 and #2 connected together. Grid #3 tied to plate. **For grid of following tube.

RECTIFIERS

TYPE	NAME	BASE	SOCKET CONNEC-TIONS	DIMENSIONS	CATHODE TYPE	VOLTS	AMPERES	PLATE	SCREEN	RATINGS	TYPE
5Z3	FULL-WAVE RECTIFIER	MEDIUM 4-PIN	FIG. 2	5 3/8" x 2 1/16"	FILAMENT	5.0	3.0	—	—	Maximum A-C Voltage per Plate 500 Volts, RMS Maximum D-C Output Current 250 Milliamperes	5Z3
12Z3	HALF-WAVE RECTIFIER	SMALL 4-PIN	FIG. 22	4 1/4" x 1 9/16"	HEATER	12.6	0.3	—	—	Maximum A-C Plate Voltage 250 Volts, RMS Maximum D-C Output Current 60 Milliamperes	12Z3
25Z5	RECTIFIER-DOUBLER	SMALL 6-PIN	FIG. 5	4 1/4" x 1 9/16"	HEATER	25.0	0.3	—	—	Maximum A-C Voltage per Plate 125 Volts, RMS Maximum D-C Output Current 100 Milliamperes	25Z5
1-V°	HALF-WAVE RECTIFIER	SMALL 4-PIN	FIG. 22	4 1/4" x 1 9/16"	HEATER	6.3	0.3	—	—	Maximum A-C Plate Voltage 350 Volts, RMS Maximum D-C Output Current 50 Milliamperes	1-V°
80	FULL-WAVE RECTIFIER	MEDIUM 4-PIN	FIG. 2	4 11/16" x 1 13/16"	FILAMENT	5.0	2.0	—	—	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
'81	HALF-WAVE RECTIFIER	MEDIUM 4-PIN	FIG. 3	6 1/4" x 2 7/16"	FILAMENT	7.5	1.25	—	—	Maximum A-C Plate Voltage 700 Volts, RMS Maximum D-C Output Current 85 Milliamperes	'81
82	FULL-WAVE ▸ RECTIFIER	MEDIUM 4-PIN	FIG. 2	4 11/16" x 1 13/16"	FILAMENT	2.5	3.0	—	—	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
83	FULL-WAVE ▸ RECTIFIER	MEDIUM 4-PIN	FIG. 2	5 3/8" x 2 1/16"	FILAMENT	5.0	3.0	—	—	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
84 also 6Z4	FULL-WAVE RECTIFIER	SMALL 5-PIN	FIG. 23	4 1/4" x 1 9/16"	HEATER	6.3	0.5	—	—	Maximum A-C Voltage per Plate 350 Volts, RMS Maximum D-C Output Current 50 Milliamperes	84 also 6Z4

▸ Mercury Vapor Type. ° Interchangeable with Type 1.

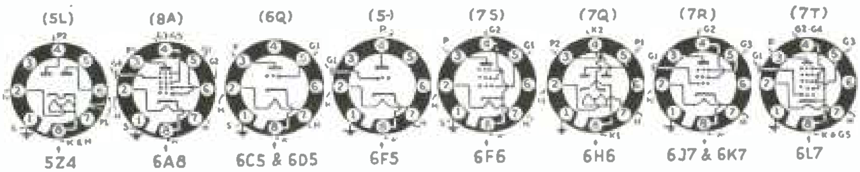
★For Grid-leak Detection—plate volts 45, grid return to + filament or to cathode. □ Grid next to plate tied to plate. ◇ Two grids tied together. ● Requires different socket from small 7-pin. ⁘ Applied through plate coupling resistor of 250000 ohms. ** For grid of following tube.

Characteristics of Metal Tubes

TUBE TYPE	Fil or Heater V.	Fil or Heater A	Max Pl V	Max S-G V.	Grid V Neg	Pl Ma	Cath Ma	Plate Resis	Mutual Cond	Amp Factor	Plate Load	Out-Put Watts*	Equiv Types	No of Pins	Function
6A8 *RA*	6.3	0.3	250	100	3.0	4.0	14	300M	520				6A7	8	Pent. Converter
6A8 *A*	6.3	0.3	250	100	3.0	2.6	12.8						6A7	8	Pent. Converter
6A8 *TNS*	6.3	0.3	250	100	3.0	3.3		360M					6A7	7	Pent. Converter
6C5 *RATNKS*	6.3	0.3	250		8.0	8.0		10M	2,000	20			76	6	Triode Amplif
6D5 *RATNKS*	6.3	0.7	275		40	31		2,250	2,100	4.7	7,200	1.4	45	6	Triode Amp., Class A
6D5 *NKA*	6.3	0.7	300		50	23					5,300	5.0	45	6	Triode Amp., Class AB
6F6 *RKS*	6.3	0.7	250	250	16.5	34		100M	2,300	200	7,000	3.0	42	7	Pentode Output, Class A
6F6 *TAN*	6.3	0.7	250	250	16.5	31	40.5	100M	2,200	220	7,000	3.0	42	7	Pentode Output, Class A
6F6 *KS*	6.3	0.7	250		20.0	31	31	2,600	2,700	7.0	4,000	.85	42	7	Triode Output, Class A
6F6 *K*	6.3	0.7	250	250	26.0	17	19.5				10,000	19.0	42	7	Pentode Output, Class AB
6F6 *K*	6.3	0.7	350		38.0	22.5					6,000	18.0	42	7	Triode Output, Class AB
6H6 *RATNKS*	6.3	0.3	100	Direct Current 2 Ma (max.)									none	7	Duodiode Detector
6J7 *RTKANS*	6.3	0.3	250	100	3.0	2.0	2.5	1.5 meg +	1,225	1,500+			6C6	7	Pentode Det.-Amp (Non-var Mu)
6K7 *RTANKS*	6.3	0.3	250	100	3.0	7.0	8.7	800M	1,450	1,160			6D6	7	Var Mu Amplifier
6L7 *RNKS*	6.3	0.3	250	150	6.0	3.5		2.0 meg +	325				none	7	Pentagrid Mixer-Amplifier
6L7-G *A*	6.3	0.3	250	100	3.0	5.3		800M	1,100				none	7	Pentagrid Mixer-Amplifier
5Z4 *RKNTS*	5.0	2.0	400			125 Max							5Z3	5	Full-wave—H.-V. Amplifier
6P7 *A (Pent. section)*	6.3	0.3	250	100	3.0	6.5	8.0	850M	1,100	900			6F7	8	Pentode and
(Triode sections)	2	....	100		3.0	3.5	3.5	17,800	450	8			6F7	8	Triode Amp. in one Bulb
43-MG *T*	25.0	0.3	135	135	20	34	41	35,000	2,300	80	4,000	2.0	43	7	AC-DC Power Amp. Pentode
6B6	6.3	0.3	250		2.0	0.8		91,000	1,100	100			75	7	Duodiode-Triode
6F5 *NATKS*	6.3	0.3	250		2.0	0.9	0.9	66,000	1,500	100			none	5	High-Mu Triode
25Z5-MG *T*	25.0	0.3	125	100									25Z5	7	Full-Wave Rectifier
5Y3 *A*	5.0	2.0	400	125									80	5	Full-Wave Rectifier
50A2-MG *T*	50 V total drop, 0.3-A;												none	4	Ballast tube
50B2-MG *T*	50 V total drop; 0.3-A.												none	4	Ballast tube

Courtesy "Radio Craft"

R-RCA and Raytheon; *K*-Ken-Rad; *A*-Arcturus; *T*-Triad; *N*-National Union; *S*-Sylvania. These letters appearing after the tube types above mean that data was available from the makers on these particular types. Some manufacturers do not as yet make all the types at present available. Arcturus tube designations are all terminated by "G," meaning glass-"metal"; the Triad termination is "MG", meaning metal-glass. Where manufacturers differ somewhat in their tube characteristics, the tube is listed twice, as is the case with the 6A8. The power tubes, 6D5 and 6F6 appear more than once because they are used under different operating conditions. The 6H6 is equivalent to the two diodes of a 75, while the 6F5 resembles the triode section of a 75. The Triad 50A2-MG and 50B2-MG are ballast tubes, both having a voltage drop of 50, the former for use with one Type No. 40 pilot lamp and the latter for use with two. They are to be used in A.C.-D.C. sets, in place of the usual series resistors.



Metal Tubes Released After Above Chart Was Compiled:

6X5—Full-wave rectifier for automobile service.

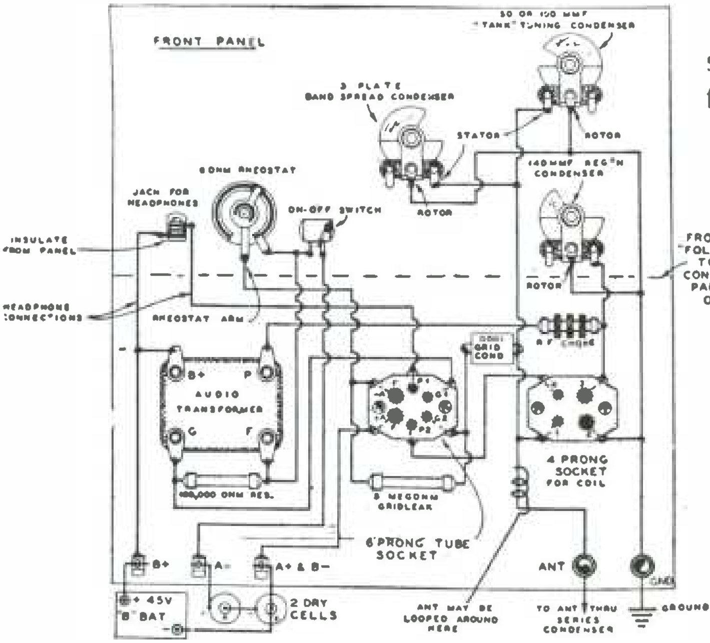
6Q7—Duplex Diode, high mu (70) triode. 6.3v heater.

25A6—Power-Amplifier-Pentode. 18v heater.

25Z6—Rectifier, voltage doubler. 85 m.a. Heater 0.3 amp.

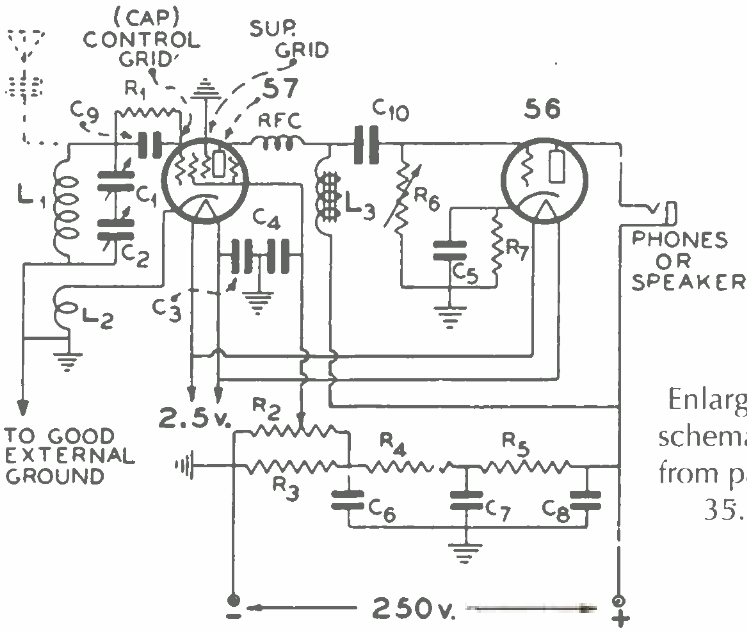
0Z4—Gas-filled filamentless rectifier (Raytheon).

Compact I-F Amplifier with metal tubes and Aladdin midget iron-core I-F transformers.



Enlarged schematic from page 33.

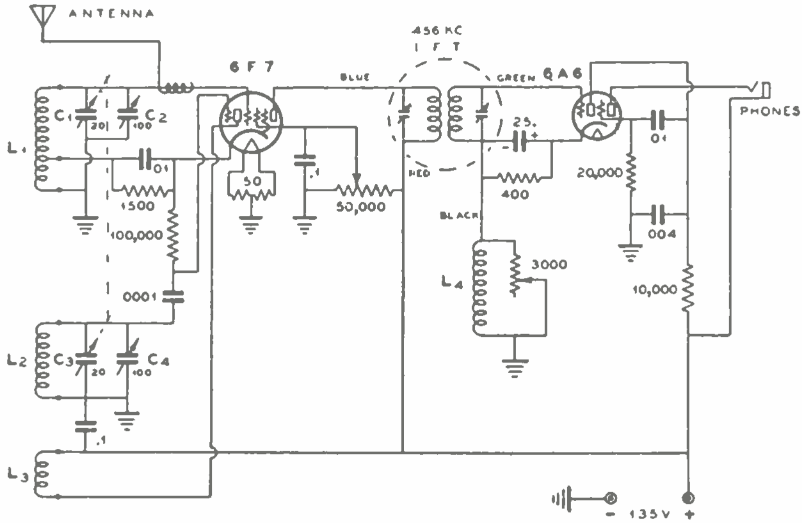
Pictorial layout of parts for 1-tube receiver. This arrangement should be closely adhered to.



Enlarged schematic from page 35.

AC "Gainer" Circuit Diagram

Enlarged schematic from page 41.



The circuit diagram. See table on page 42 for coil winding data.