

SIMPLIFIED
Radio Servicing
by
COMPARISON
METHOD

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SYMBOLS & ABBREVIATIONS

AIR-CORE INDUCTANCE COIL	ELECTROLYTIC CONDENSER	PILOT LAMP
AMMETER	FIXED CONDENSER	POTENTI OMETER
(ANT.) ANTENNA	FIXED RESISTOR	SINGLE CELL
BATTERY (BAT.)	FUSE	SINGLE-POLE SINGLE-THROW SWITCH (S P S T.)
BINDING POSTS	GROUND (GND.)	TRANS- FORMER
CONNECTED WIRES	IRON-CORE CAME COIL (CH)	VARIABLE CONDENSER
COUPLED S.P. COILS	MAGNETIC SPEAKER	VARIABLE RESISTOR
CRYSTAL DETECTOR	PHONES	VOLTMETER
DOUBLE BUTTON CARBON MICROPHONE	PHOTO- CELL	WIRES NOT CONNECTED
DYNAMIC SPEAKER		

Radio repairmen must have an understanding of the method used in inter-connecting the various parts employed. The plan that gives this information is called a schematic diagram or a circuit diagram. Such a plan could be made by tracing the various connections and making a picture drawing of the parts and wiring. It is difficult, however, to make the needed pictures of various radio parts. Further, when such a picture drawing is completed, it is almost as confusing as the maze of wires one sees by looking at the bottom of a chassis.

To simplify this task, radio engineers and servicemen have decided to use symbols to represent the different radio parts. The connecting wires are represented by straight lines.

This is a logical solution. We are experienced in using symbols in almost all fields. The fact that an animal with four legs and of a certain appearance is called a dog and is spelled d-o-g, shows an application of symbols.

The symbols of often used radio parts are shown above. These symbols should be carefully noted and you should practice making each of these on paper. As you continue with your studies (if you are a beginner), refer back to this page as new parts are mentioned in the text.

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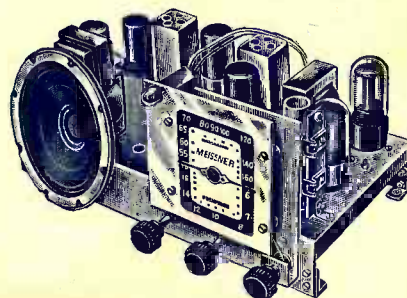
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A.C.	Alternating current
A.F.	Audio frequency, sound vibrations
A.F.C.	Automatic frequency control
A.V.C.	Automatic volume control
C	Capacity of condensers
db	Decibel, a unit for measuring sound
D.C.	Direct current
FM	Frequency modulation
E	Voltage, electromotive force, EMF
HF	High frequency, short wave
Hy.	Henry, a unit of inductance of coils
I	Symbol for current
I.F.	Intermediate frequency in superhets
Kilo	Prefix meaning one thousand
ma.	milliamperes, 1/1,000 of an ampere
Meg	Prefix meaning one million
Mfd.	Micro-farad (one millionth of a farad)
Mho	Unit of conductance
Micro	Prefix indicating one millionth part
Mil	Another prefix meaning 1/1,000 part
MU	Amplification factor of a radio tube
Ω	Ohms, measure of resistance
P.A.	Public Address, amplification system
R	Resistance, opposition to passage of current
RF	Radio frequency.
RMS	Root means square, used in A.C.
SG	Symbol for screen grid of a radio tube
Super	Superheterodyne, a type of radio circuit
SW	Short wave
TRF	Tuned radio frequency, a radio circuit
W	Watts, measure of electrical power
X	Symbol for reactance, opposition to A.C.
Z	Impedance, total opposition to A.C.

These abbreviations are often used by practical radio servicemen and appear in many places in this manual. As you come across new radio abbreviations in reading the text, refer to this page for an explanation. Soon you will remember the meaning of these important short-hand notations.



A radio receiver consists of a great many parts connected in a suitable manner to form required circuits.

PREFACE AND INTRODUCTION

You are now being introduced to a remarkably simplified technique of radio repairing. This new way of finding radio faults and repairing them is so revolutionary in scope, so different in application, and so effective in results, that one can hardly believe in its true possibilities. But this method will (in contrast to all other servicing methods) in 90% of all cases isolate the fault in minutes instead of hours and without instruments, permit checking of parts and circuits quickly without any special testers, and can be used to an advantage by beginners and experts.

The contents of this manual have been used for lectures in a number of practical radio shop classes and proved very successful in application. Only practical and required data for actual radio work is included. Theory is kept to a very low minimum.

Sufficient introductory material has been included to acquaint the beginner with essential radio facts. This same information will serve as an excellent review for all others. You only need to be mechanically inclined to be able to follow these simplified instructions and repair any radio set.

The *comparison* technique of radio servicing tells you what simple tests may be made to obtain electrical, visual, and other reactions from radio parts and circuits, and how to determine if the indications secured are what is to be expected from a properly functioning circuit, or what parts or stage to suspect. This method is a great simplification of radio servicing and calls for less knowledge, less time spent, and less instruments.

While the technique of *comparison* servicing is easy to learn and employ, read the explanations with care. There are no meaningless words in this manual and every sentence tells you of some important facts. Each time you use this new method, you will become more proficient and will refer to the comparison circuits and hints only once in a while.

You can learn this new method best by reading the entire manual carefully, making sure you understand every part. This will give you a good working knowledge of this new technique and permit you to try *comparison* method on the next job. To get specific help for any radio repair job refer to the index and to the parts of the manual dealing with the difficulty on hand. The comparison diagrams should be studied and all the tests suggested very carefully tried.

M. N. BEITMAN.

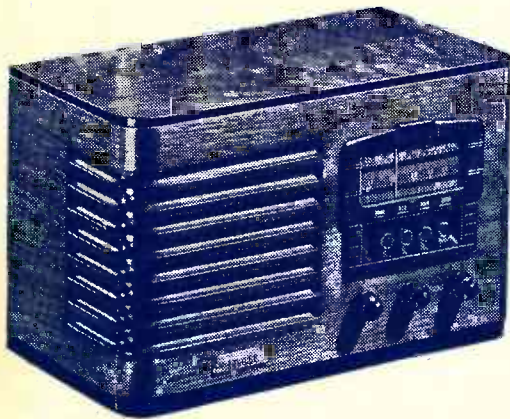
January, 1945
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WHAT IS ELECTRICITY?

Electricity plays an important part in making possible radio communication. In an ordinary house-radio, electric power is changed in form, increased and decreased in voltage, and made to conform exactly to the electrical radio waves picked up by the antenna.

We are able to control and use electricity to our advantage, but we have only workable theories regarding the exact nature of this force. According to this theory all matter is made up of 93 different atoms. These atoms, however, are in turn made up of identical negatively charged particles called electrons and heavier positive particles. We are primarily interested in the negative electrons since these make up the electric current.



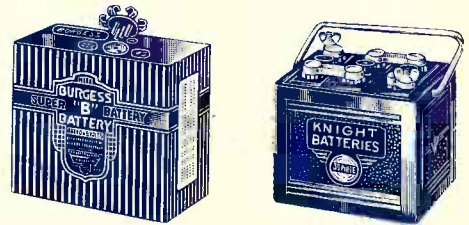
The operation of any radio depends on the behavior of electricity.

The electrons are very small and millions upon millions are required to make up the current to keep a radio tube in operation. These electrons not only make up the atoms of matter, but are present as free electrons ready to move to any positive body which attracts them. In nature, negative particles, small or large, are attracted by positive bodies and repelled by other similarly charged negative bodies.

These free electrons tend to be present in equal quantity everywhere. If a body has too many electrons, they will move to other bodies to equalize this distribution. And for the same reason, a body short of free electrons will attract free electrons. This movement of electrons constitutes actual electric current.

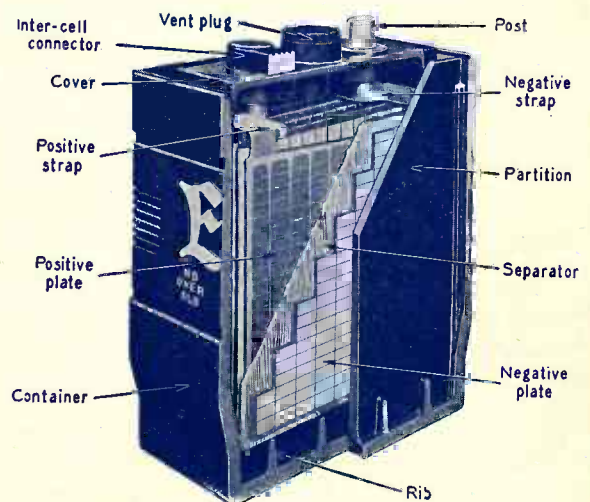
Material which acts as a conductor (copper wire, for example) will permit easy passage of these free electrons, but if two bodies have a large difference in the number of free electrons present, the movement will take place across an insulator, as in the case of a spark or lightning where air is the insulator.

Many of the present day radios used in homes away from power lines or employed for portable purposes still operate on battery power. Batteries are chemical machines which produce electrical power by means of a chemical reaction. Any battery is made up of a number of cells connected in some manner to give the required quantity of electricity. Flashlight cells produce $1\frac{1}{2}$ volts each. Many of these cells are connected to give the higher voltage of radio batteries.



In localities where power lines are not available and for portable use, dry batteries and storage batteries supply the needed electrical power.

These cells which produce electrical current of themselves are called primary cells. They may be used until discharged and then must be replaced. These batteries cannot be "charged" in any way.



Courtesy Electric Storage Battery Co.

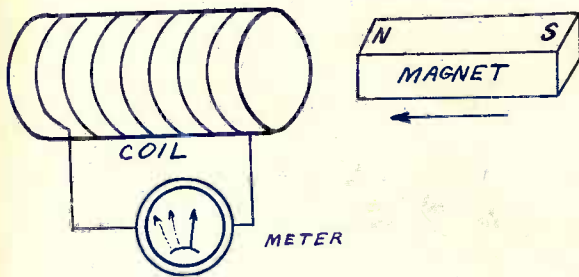
A cross-section view of one cell of a storage battery.

The storage battery used in automobiles and with many type radio sets does not produce any electrical power of itself. This battery acts only as a storage reservoir of electrical energy. The battery must be charged first of all. This is a process which permits placing the electric current into the cells of the battery. After this the current may be taken out in any quantity required until all the electrons, which were in excess, are removed.

PRACTICAL ELECTRICAL FACTS

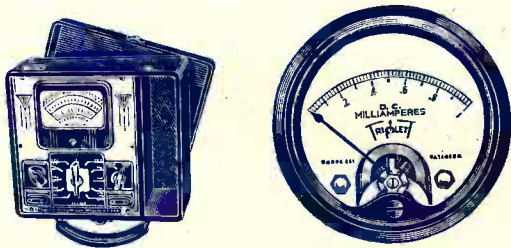
Magnetism is closely related to electricity and is also of importance to a radio serviceman. Transformers, relays, loudspeakers, and many other radio parts depend on magnetism for their operation.

Every magnet, no matter how small or large, has two opposite poles which we call *North* and *South*. In any group of magnets, the like poles will repel each other, while the unlike poles will attract each other.



A conductor has a voltage induced when it cuts magnetic lines of force. The meter indicates current. Either the coil or the magnet may be moved to produce effects.

When electric current flows in a wire, it produces a corresponding magnetic field. Also if a magnet is moved in relation to a coil of wire, electric current is produced in this coil. This principle is used in generators to produce electrical energy in large quantity.



Meters, used alone or in radio test equipment, depend on magnetic effects for their operation.

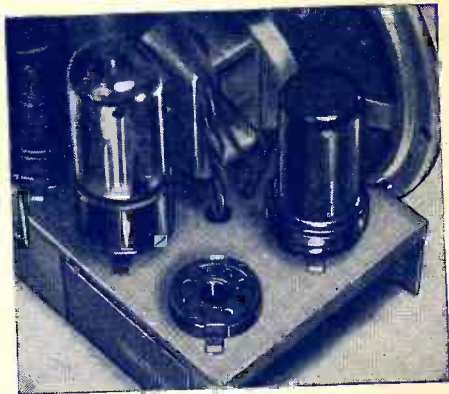
To measure electricity and magnetism indirect indicators are employed. Meters of service testers are used this way. Also special units are used to express the quantity of these forces since the unit of weight, the pound, or of length, the foot, are not adaptable.

Batteries or generators create a voltage or pressure. This is called the electromotive force (symbol *E*) and is measured in volts. The existing voltage forces (pushes) through a conductor a quantity of electricity measured in *amperes*. The symbol *I* is used for current. Amperes of electricity correspond to gallons of water in a plumbing system.

These quantities of electrical pressure and current are related together with the opposition to electrical current present and in a mathematical way are known as the *Ohm's Law*. This relationship states that the voltage is always equal to the current multiplied by the resistance (opposition). The formula is given below.

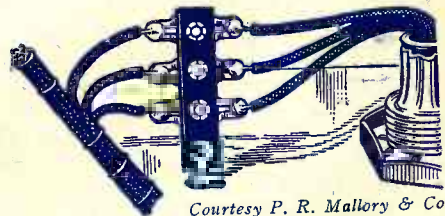
$$E = I \times R$$

In reference to magnetism it is important to understand that any passage of electric current creates an associated magnetic field. Also that the "power" or flux density of this field depends on (1) the current passing, (2) number of turns, and (3) material of the core.



A radio set has many materials used as insulators while others are employed as conductors. Copper wire inter-connects various parts.

Electric current, made up of electrons, may pass along certain substances known as conductors. Silver, copper, and other metals are considered conductors. Many materials pass very little electric current. Known as insulators these materials actually stop the current. Rubber, cloth, mica, slate and many other materials are used to insulate radio parts.

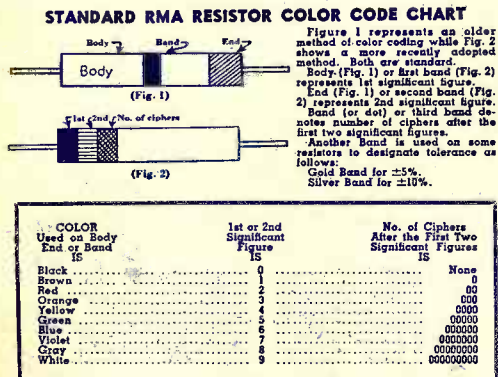


Courtesy P. R. Mallory & Co.
Wires conduct electric current. The path must be continuously made up of conducting materials.

If electric current is required to pass from one radio part to another, these must be connected by hook-up wire. On the other hand, if parts are not to be in electrical contact, they must be insulated. Separation is enough since air is a good insulator.

FACTS ABOUT RESISTORS

Opposition to the passage of electric current is known as resistance. Even the best conductor has some resistance, and insulators have very high resistance. Resistance is a property required in radio circuits and special parts to supply resistance are called *resistors*. The unit of resistance is the *ohm*. A million ohms is called a megohm. Small radio resistors are color coded as explained below.



EXAMPLE: Take the number 62,000. 6 is the first significant figure, 2 is the 2nd significant figure and the number of ciphers after the first two significant figures is 3.

The "watt" rating of a resistor indicates the power handling ability of the unit. Carbon resistors for replacements are supplied in $\frac{1}{2}$, 1, and 2 watts. ($\frac{1}{4}$ watts are not recommended). Always use the same or larger wattage for replacement. When larger than 5 watt units are needed, wire-wound resistors are used.



When large voltage divider resistors have several sections and a single section is defective, this one section may be replaced with a suitable unit. Various fixed resistors used in radio are illustrated above.

Variable resistors are constructed so that the amount of resistance may be changed by rotating a control shaft. These are known as *potentiometers* and *rheostats* and are used for volume and tone control purposes. Since these units receive much mechanical use in a radio set, they are a common source of trouble. The "on-off" switch used is mounted on the back of these units and is controlled by the first rotation. Very occasionally the volume control may be opened and repaired by bending back the rubbing prongs and cleaning the carbon element with alcohol and rubbing the resistance surface



Potentiometers are used as volume and tone controls. Usually there are three terminals, but a fourth *tap* may be found on some special units.

with graphite of a soft pencil. Usually it is best to replace the unit. Exact duplicates are listed in manufacturers' catalogs. The *old* switch plate, if used, cannot be employed with the new control and a new switch should be obtained at the same time. A potentiometer is illustrated above. Typical circuits are shown on page 41.

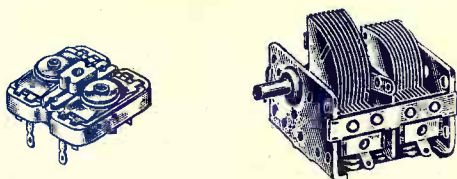
Since controls are used in many different types of circuits, they are of various resistance values and degree of resistance change with rotation. However, certain simple tests will tell you promptly if the fault lies in the volume control or tone control unit.

In almost every circuit *shorting* (touching terminals with a short piece of wire having its ends bare) the center terminal and one of the other terminals should increase the volume to a very loud quality or distort at high volume. Touching the center and the other terminal should reduce the volume.

Here are several important points for beginners. The switch is not connected electrically to the resistance element or the revolving arm. In a few units, the arm, having the center connection, is grounded to the shaft. But in the majority of the controls the shaft and the metal frame of the control are completely insulated from the resistance element and movable arm.

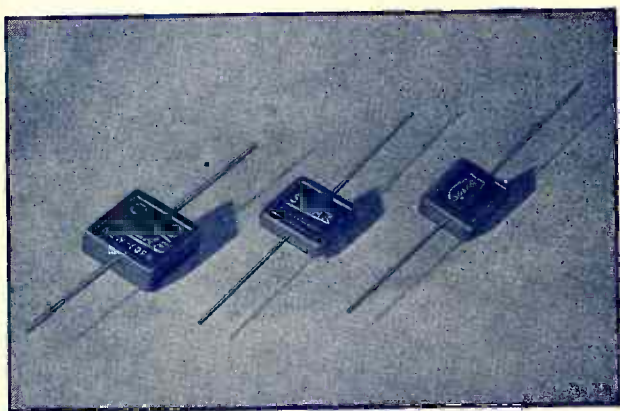
FACTS ABOUT CONDENSERS

First we will talk about condensers that have wax paper or mica as the insulating material between the plates. Such condensers have the appearance of those illustrated. In tuning (variable) condensers air is used as the insulator, or dielectric.



If a condenser is connected to source of voltage, such as a battery, the negative side will become charged with free electrons. The side of the condenser connected to the positive potential of the battery will lose any free electrons it had initially. Because of the inequality of electrons on the two plates of the condenser, the unit is said to be charged with electricity.

The condenser will remain charged for a period of time even after the battery is removed. The duration of the charge marks the quality of the condenser. Good condensers may keep the charge for hours. If the condenser is charged with a voltage above 50 volts, the source of voltage may be disconnected and, when the two connections of the condenser are brought almost in contact, a spark will jump.



Mica condensers are of small capacity and are usually enclosed in bakelite.

The unit of capacity is the *farad*. This unit is much too large for radio condensers and the microfarad (one-millionth part of a farad) is employed. Even this unit is too large and most paper condensers have capacities indicated by decimals, i.e. .01 mfd. Mica condensers are of even smaller capacity. For example, .00025 mfd.; this is the same as 250 micro-micro-farads, since this smaller unit abbreviated mmfd. is one millionth of a mfd. which in turn is one millionth of a farad of capacity.

Besides capacity, condensers are also rated as to the maximum voltage they can withstand. Any condenser may be used with any value of voltage up to the maximum of its rating. In fact, there is a safety advantage to use higher voltage condensers for replacement purposes.

The capacity required for replacement purposes is not critical in majority of applications. 100% variation



Courtesy Solar Mfg. Co.

Here are three types of commonly used radio receiving set condensers: a paper dielectric condenser in a metal can, a tubular paper dielectric condenser, and a metal-can electrolytic condenser.

in size is almost always acceptable, and in some circuits condensers 10 times the size of the original condenser or 1/10 the size will work just as well. Later on we will point out where the size of the condenser is important.

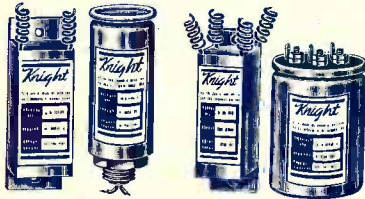
In making a replacement of a condenser, the physical size and appearance are not important—as long as they will fit the available space. Capacity may be somewhat greater or if need be a little smaller. The voltage rating must be high enough, but the actual value makes little difference.

Condensers do not permit the passage of direct current as supplied by batteries or radio power supply. However, alternating current which is found in sections of the circuit which handle the signal, does pass through a condenser. Amount of A.C. passing depends on the size of the condenser and the frequency (number of cycles per second) of the current. In this manner a condenser is used to “block” the D.C., and to by-pass the alternating current.

The higher the frequency of the current, the less reactance (opposition) the condenser offers. In certain applications a .00025 mfd. mica condenser may be used. For audio frequencies (up to 5,000 cycles) this capacity offers so much reactance that for practical purposes we may assume that no current of A.F. passes through. Radio frequency currents (above 540,000 cycles) pass through with little opposition. The condenser separates currents of two widely different frequencies.

ELECTROLYTIC CONDENSERS

Electrolytic condensers are illustrated on this page. These units are semi-dry and are of large capacity. They must be used with D.C. only. The pulsating or single direction changing D.C. found in radio power supplies may also be used with lower priced electrolytic condensers. These condensers are similar in action to paper units described, but do have a small leakage all

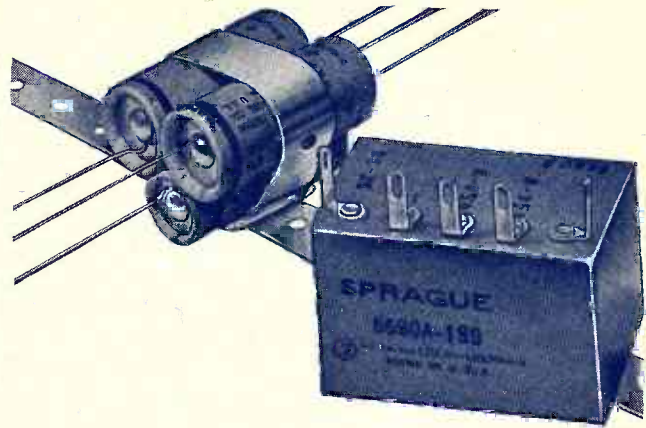


the time. This is not important since electrolytic condensers are usually used as filters in power supplies and a small additional drain is of no consequence. Please notice how different electrolytic condensers are mounted. Always select a replacement that is easy to place in the set.

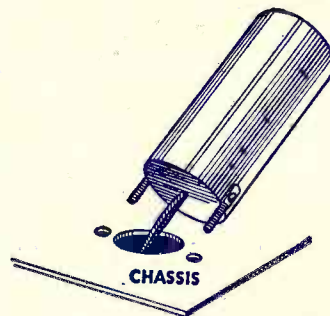


While special condenser testers may be used to detect faults in condensers, a simple ohmmeter will serve the purpose. A *small* capacity (under 1 mfd. paper type) condenser should test open with an ohmmeter, after the needle shows a slight movement. If the condenser has resistance under 100,000 ohms or is completely shorted, the unit must be replaced. A still simpler test, not requiring any equipment, is to connect the condenser momentarily to a source of D.C. voltage between 50 and 150 volts (the set's power supply will do). Quickly disconnect the condenser and bring the terminals together. A spark should be noticed at the point of contact if the condenser under test is in good condition.

Electrolytics can be quickly tested by the ohmmeter method. They will upon being connected first show a shorted condition, but the resistance will quickly in-



crease. The ohmmeter must be correctly connected, i.e. positive side of the meter to the positive side of the electrolytic condenser. The D.C. potential discharge test also may be used.

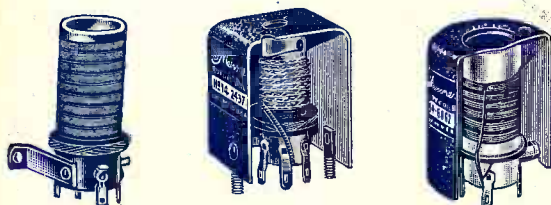


The condensers used originally in a radio set may be mounted in various ways. Mica and small capacity paper condensers are usually supported on their leads. Replacements should be mounted in this same way. Long bare leads should be covered with insulated sleeving or electrician's tape. Electrolytic condensers have been made in various containers and you will find all types in the radios you may be called on to repair. The replacement you may use need not be the same in physical appearance or size, but should have about the same electrical values, and shape and size to fit available space.

COILS USED IN RADIOS

Every radio receiver uses several coils. Coils are wound on cardboard tubing or wood dowel rod, treated with varnish or laquer against moisture, and usually enclosed in metal shields. You must learn to tell what coils are being used, how to test them, and how to make replacements.

At first we will talk about coils used in single band or broadcast receivers. Every radio (superhet or TRF) has an antenna coil. These coils have four terminals, but since two of these in some sets go to the chassis frame-work or ground, these two connections may be brought out to a single terminal and only three used in all. One of these, of course, is connected to the antenna lead or binding post.



Antenna coil can be identified by the bulky primary, by the fact that a connection is made to the antenna, and by the lack of any voltage on any terminal. Tests for this part will be given later.

R.F. coils are used in all TRF sets and in larger superhets with an R.F. stage. Some TRF sets have several R.F. type coils. These coils always have four connections, but if they are for multi-band sets they may have more. The secondary is the outside coil and, in some, the primary is a small coil placed at right angles inside the tubing.

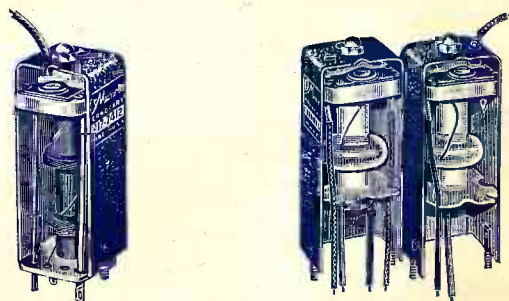
You will always find in these coils that one end of the secondary passes through an opening at the top of the tube and runs down, inside the tubing, to a lug. This is for the grid connection of the following tube. The other end of the secondary connects to ground or to the AVC if used in the set. The antenna coil primary connections for all sets go to the antenna post and ground. The antenna lug usually has an extra heavy wire running up on the outside and wound around the coil once. This is for the purpose of making the radio respond equally well to all frequencies.

R.F. coils, as illustrated, are similar to antenna coils, but are not interchangeable. Replacing but a single coil in radio, when the need comes up, is sufficient, but alignment will be required. Most coil replacements will track (tune together) with other coils in the set.

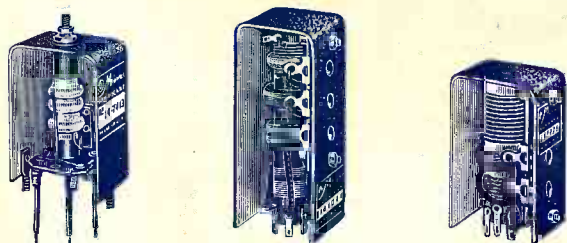
Oscillator coils are used only in superhets and do not give very much trouble. These coils are usually unshielded. They may appear to have but one coil, but in almost all cases two coils are used and are wound very close together. A replacement should be for the same I.F. frequency. If this frequency is not marked on the chassis, the author will be glad to look this information up for you. However, if the radio set uses a cut-section condenser for tuning (a condenser with the movable plates not all of the same size) than a suitable oscillator must be obtained from the factory.

Every simple and every complex superhet uses I.F. transformers. These are really coils enclosed in cans. Padders (semi-variable condensers adjusted with a set screw) are also included and permit the setting of the I.F. unit for best results for the I.F. frequency. These settings are made at the factory and should be left alone except in rare cases. Detailed alignment instructions are given in a later section.

Several I.F. transformers are pictured below. Here is what you must know about them. What is their frequency? This may be marked on the units, on the radio, or in the diagrams. Are they of the input or output type? They are always of the input type except if they connect into a diode tube (see section on tubes). Almost always these have four leads. Primary leads to plate and plate supply. Secondary leads go to the next tube's grid (this is an I.F. stage) and to AVC or ground.

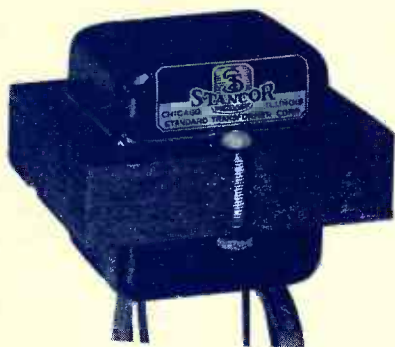


If a single I.F. stage is used in smaller superhets, two I.F. transformers will be employed. One of these will be in front of the tube of this stage, and one I.F. transformer will follow the tube. If two I.F. stages are used, as in larger sets, three I.F. transformers will be used. A few sets made have a single I.F. stage with but a single I.F. transformer in front of that stage.



TRANSFORMERS AND CHOKES

With the exception of a few AC-DC type radios, every A.C. operated set uses a power transformer. This transformer steps up the line voltage usually 110 volts for plate current requirements of the radio. It also steps the voltage down to values such as 5, 6.3 volts, for tube filament requirements. Other filament voltages are used in many sets.



A burned out power transformer can be detected by the appearance of the unit and the "burning" smell. To see if the transformer is getting 110 volt power, follow the power cord leads into the set. You will probably find one lead goes to the switch and the other to the power transformer terminal or wire. Connect an ordinary 110 volt house-bulb to this terminal, and to another terminal of the transformer which has a wire or lead going to a second terminal of the switch. The bulb will light if the power from the socket is getting to the transformer. If the tubes do not light up, although the transformer is receiving power, you may safely assume a winding of the transformer is burned out.



The illustration shows an upright type power transformer used in radio receiving sets. Wire connecting leads come out of the bottom. The transformer is bolted to the chassis and the wire leads go through an opening in the chassis under the transformer.

Replace a bad transformer with an electrical equivalent unit. Exact replacements are available for many sets and simplify the repair. They have exactly the same physical appearance and the leads are of the same color. However, they do cost a little more. Suitable replacement transformers are lower priced and are just as good.

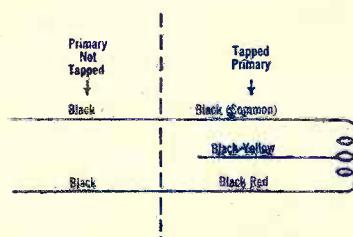
Chokes are not critical and should be replaced, when need arises, with units of suitable physical size and ample current carrying capacity. Four tube sets use about 40 ma. rating, six tube sets about 60 ma., higher current rating provides a safety factor. If you short (connect with a piece of wire) the two terminals or

leads of a choke in a radio set, the results mentioned are possible and indicate possible fault: (1) Set works, well or badly, *short choke*, loud hum will result. (2) Set dead, *short choke*; if distorted playing, choke bad; if no change—trouble in other section.

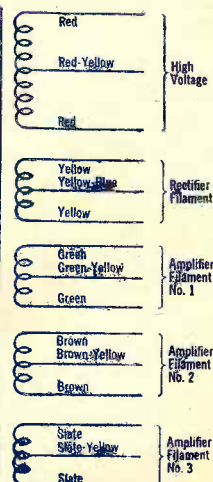
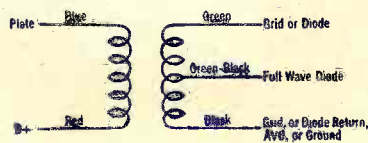


Output transformers match the final output tube to the loud-speaker and are usually mounted on the speaker frame. Probably never the cause of trouble, but primary sometimes burns out. To test, you will later be told how to see if plate voltage is present on the plate of the output tube, if lacking but present at other points, transformer at fault.

POWER TRANSFORMER LEADS



IF TRANSFORMER LEADS

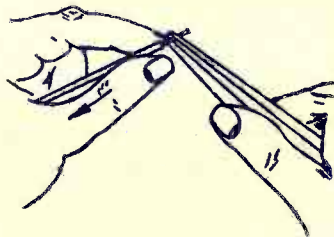
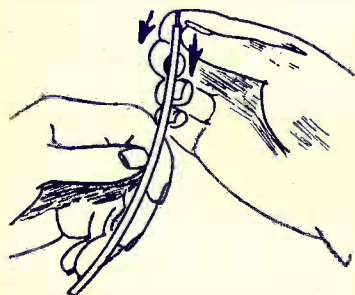


MECHANICS OF RADIO

We must learn how to mount replacement radio parts. Small parts, such as resistors, condensers, and R.F. chokes, are supported with their own leads. Tube sockets are fastened to the chassis with machine screws or rivets. Large condensers (used in the power supply of receivers) are mounted with bolts or with stud-nut over the threaded section of the metal container. Power transformers are bolted in place, using the screws, that



hold the frame to the laminations in the case of the half-shell type, or with machine bolts in case the transformer is of the upright type. Volume controls (potentiometers) are mounted behind the side of the metal chassis. The shaft comes through a threaded section which is attached to the case. This section is tightened



against the chassis. The shaft may be cut to the needed length. The switch, used with many volume controls, is mounted in place on the back plate of the volume control unit.

Radio parts are inter-connected with hook-up wire. The wire electrically joins the terminals to be connected. The hook-up wire should be insulated along its path, but is made bare and clean at the place where it comes in contact with the terminals. Push-back braided cotton covered wire is easiest to handle. Enough insulation is pushed back to make the needed connection, and then the insulation is pushed back over the wire up to the terminal. The illustration shows the proper method used for pushing back the insulation on both solid and stranded wire. When the insulation cannot be pushed back far enough with the fingers, it will be easier to

grasp the bare end of the wire with long-nose pliers. Then, holding the wire in this manner, it is a simple matter to push the insulation back with the fingers as much as required.

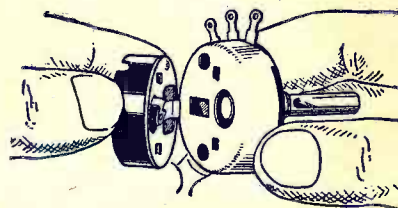
All electrical connections must be soldered to insure low resistance electrical contact under all conditions. Make it your rule to solder every connection you make, even if the equipment you are building is for temporary use.

To do a good soldering job, the tip of the soldering iron must be properly shaped and tinned. Tinning an iron is a process whereby a thin, uniform layer of solder is formed upon the tip of the iron. The transfer of



heat from the tip to the work occurs most easily if the surface is bright as the result of tinning. When the tip of the iron becomes "pitted" by the action of the rosin core in the solder, the iron must be filed and re-tinned. The iron can be kept clean for long periods of time by wiping the tip with a rag whenever corrosion accumulates.

The soldering iron must actually heat the joint to be soldered to a temperature that will readily melt solder. The solder will then run into each crack in the joint and form a good electrical bond. Hot smoothly flowing solder has a bright silver luster; as it cools, its

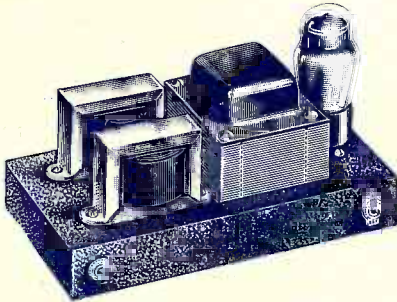


appearance changes to a duller gray, setting shortly after this change. If the joint cools with a rough surface, the soldering job is not well done; a dirty contact, improper heating, or movement of the wires may have been the cause.

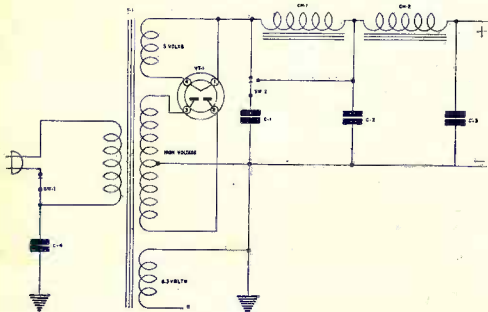
During the War, because of the shortage of certain types of vacuum tubes, a great deal of substitution of tubes was carried out by radio servicemen. Usually such tube substitution required changing the circuit slightly and at times the placement of a different socket. You should try to obtain exact tube which may be needed for the set you are repairing. You will find it pays to wait a week or two rather than attempt to change wiring, socket, and parts. Certain tubes may be substituted by means of inexpensive adapters which are available from your dealer.

POWER SUPPLY CIRCUITS

A radio set is made up of electrical circuits. The parts used control, direct, separate, and change in form the signal received in the antenna and reproduced in the loudspeaker of the radio. We will consider a simple power supply circuit to get a general idea how this is accomplished.



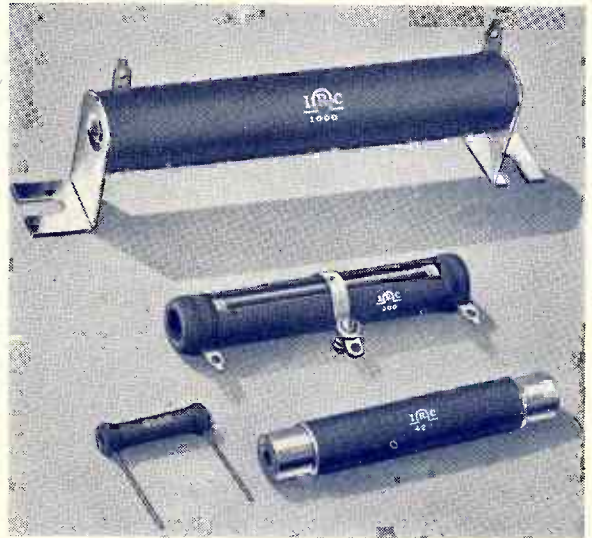
The symbol on the left of the diagram represent a power transformer with the primary winding connected to 110 volts, A.C. since D.C. cannot be used with any transformer. This transformer acts as a machine to step the voltage up or down. The voltage is stepped down to supply 5 volts for the filament of the rectifier tube. In another secondary winding this voltage is stepped up and supplies the plates of this same tube. The center tap of this high voltage winding serves as a negative connection — in many radio sets this negative connection is grounded to the chassis.



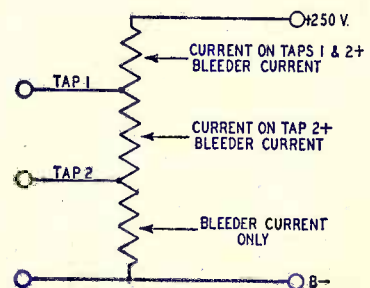
The rectifier tube changes the A.C. to pulsating or varying D.C. This current is not yet suitable for the tubes of the radio set since it will cause a loud hum. The pulsating D.C. must first of all be filtered.

This task of filtering is performed by the three condensers, marked C_1 , C_2 , and C_3 ; and the two filter chokes, CH-1 and CH-2. This is a very efficient filter and usually only a single choke and two condensers are needed. The chokes oppose the passage of the changing ripple voltage, but offer a path for the direct current. The condensers, on the contrary, pass to ground (minus potential) the variations which must be removed, but do not permit the D.C. to escape in this same fashion. In this way, the ripple is removed and pure direct current is present at the terminals marked — and +.

A power supply is designed to deliver a given maximum voltage. Most radio receivers require plate voltages of several different values to serve different tubes and a variety of circuits. It is possible to use a single resistor with sliding (adjustable) taps to serve as the bleeder and to permit an easy means for securing any required voltage between zero and the maximum voltage available.

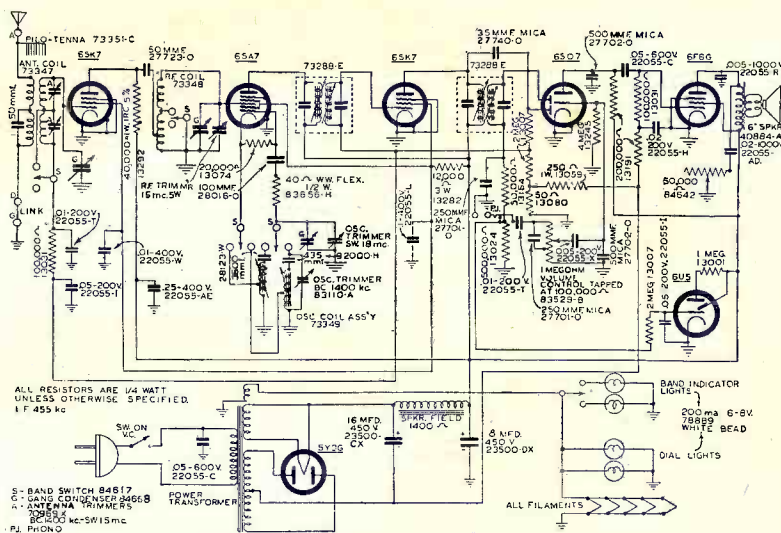


The two ends of the voltage divider will be at the maximum and zero voltage respectively. Taps between these two extremes will provide any desired voltage between these limits. Now, besides the bleeder current,



certain sections of the voltage divider will carry the current taken by some of the taps, the calculation of the exact setting of the taps is not too simple. You should guess the position for the different taps, connect the equipment, and make final adjustments of the taps while taking measurements with a voltmeter.

UNDERSTANDING DIAGRAMS

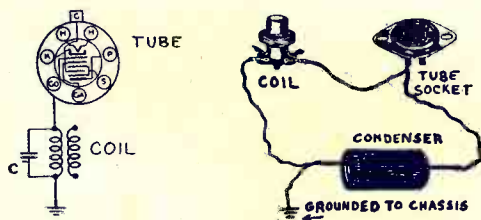


A correct electrical circuit of inter-connected parts, as illustrated diagrammatically, will accomplish the desired results. But these parts, without the proper electrical circuit will serve no useful purpose.

The comparison technique depends on the circuits used in radio receivers. You will be told what to look for in the circuit, and how to test to find out if the circuit is working properly. If the radio is not working, it must be a part or wire that is *spoiling* the correct circuit and prevents the proper operation.

Radio diagrams show how the different parts are interconnected to permit proper operation. The parts are shown as symbols (see page 2) and straight lines represent the way wires connect the parts. But these printed lines do not represent actual wires as they may appear to one examining the radio set. The parts may be wired in any fashion as long as exactly the same component parts are connected with the lines in the drawing and are also wired in the set to permit the passage of electric current.

Below you have an example of this. You will notice



that the lines of the diagram and the wires of the picture illustration connect the few parts in somewhat different manner, but *do* permit the current to pass in the same way. This is very important to understand

clearly and this knowledge will aid you to trace circuits in radio trouble-shooting.

A diagram above gives hundreds of valuable facts about the radio set and aids in making the repair. In the next paragraph you will find a description of the general information about this circuit. Please refer to the circuit and check each point.

This is a seven tube radio using a tuning eye and designed for A.C. operation. This set covers two bands since there are dual coils. A dynamic speaker is used as indicated by the 6" unit. This set is a superhet since it has an oscillator coil and an I.F. transformer. (See if you can locate these parts.)

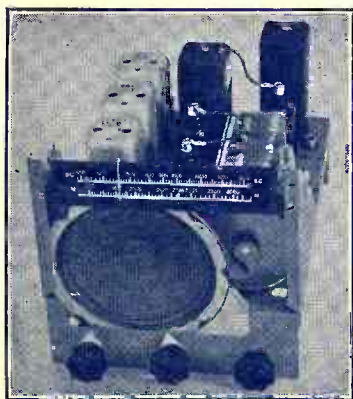
Now you may find this basic information about the audio output stage (the last tube next to the speaker). This stage employs a 6F6-G pentode (see page 16) and is resistance coupled to previous stage. The tube is connected to the voice coil of the speaker through an output transformer. From the tube data charts (pages 20 to 31) it is easy to find out that the power output is about three watts.

If we analyze this same stage with greater detail, we can obtain specific information on the value of each condenser and resistor used. Many of these parts are also listed with manufacturers part numbers. Circuit details also can be found. For example: a .005 mfd. condenser used as a tone compensator; the tone control consists of another condenser and variable resistor. Specific analysis will also indicate the novel method used to secure the bias for the output tube. You will be able to follow this circuit later.

Of course, specific information is given about many parts and will help you to secure replacements. For example, the plate coupling resistor of the 6SQ7 tube has a resistance value of 200,000 ohms, as marked.

OBTAINING REPLACEMENT PARTS

The comparison technique relies strongly on the use of diagrams. After you complete your study of essential fundamentals, you will be told how to examine the radio you are trying to repair and find a circuit which is similar to the one used in the radio. This comparison diagram and chart will tell you where to look for faults, what to check, and how to make the actual repair.



Although many of the faults which develop in radio sets do not require any replacement parts, in majority of cases you will find the trouble lies in some component which has to be replaced. Needed radio parts may be purchased from radio supply houses. If you live in a city, it probably has several radio parts dealers who cater to radio servicemen. If you live in a small town or on a farm, there are many mail order radio companies who will be glad to sell you needed parts. The author will be glad to tell you the names and addresses of dealers near your home, if you need this help.

How exacting must radio parts be? For almost all replacement requirements parts similar to the original, but not necessarily exact duplicates, will serve. Since in radio repair work you will be buying many replacement parts, the knowledge how to select such parts is of prime importance to you.

In the case of power transformers, you must be certain that the replacement will fit the available physical space and could be mounted in place. Electrically, the primary of the transformer must be rated at the supply voltage and frequency. Usually this is 110 volts, 60 cycles. The various secondaries which supply the filament voltages must correspond to the original unit. The voltages must be correct. The current rating of each filament secondary must be large enough to take care of the tubes connected to this winding. For example, a secondary of $2\frac{1}{2}$ volts serving five type 27 tubes must supply at least 8.75 (or about 9) amperes,

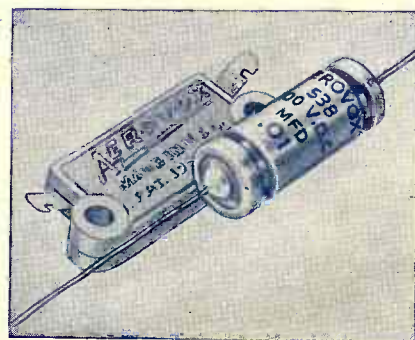
since each tube takes 1.75 amperes. Higher current rating is always in order. If a center-tap connection is needed and the replacement transformer you are using does not have one, use a 50 ohm center-tapped resistor across winding to solve this problem.

The high-voltage winding should supply approximately the same voltage as the original. The winding should be rated at least at 45 ma. for 4 tube sets, 55 ma. for 5 tube sets, and 70 ma. for larger sets with a single output tube, or 90 ma. for sets with push-pull output stage.

In most cases the resistance value of the choke used is not critical. If you do want to use the exact D.C. resistance value and it is not available, connect a choke of lower resistance value in series with a fixed 10 watt wire-wound resistor. The total resistance of choke and resistor should be made equal to the original choke.



As you have already learned, fixed resistors are accurate to within 10% of the marked values. However, in most applications resistors may be off even more than this. For example, a plate coupling resistor in the original circuit may have been 250,000 ohms. You may use a replacement between 100,000 and 700,000 with no noticeable difference in operation. Cathode bias resistors (usually between cathode and ground) should be of accurate value.

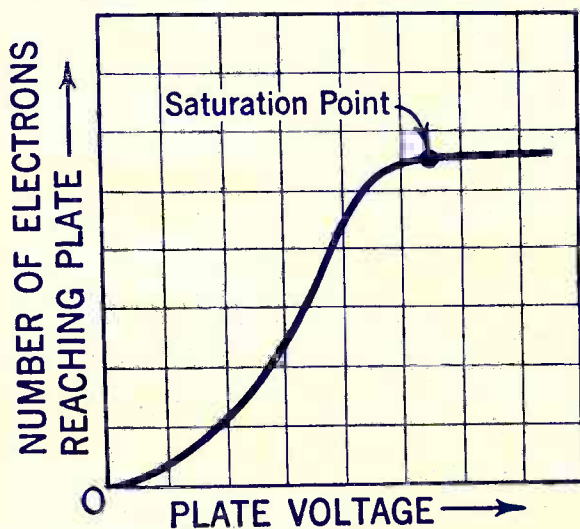


By-pass condensers may be off from the indicated value a great deal. For replacements values from 1/10 to 10 times the original size will serve. Voltage rating, however, should be as high or higher than the original.

FACTS ON VACUUM TUBES

The basis of all vacuum tubes operation, be they rectifiers, or multi-purpose tubes, in glass or metal envelopes, is electron emission. Electrons are emitted from an electrically heated filament or from a covering (cathode) placed over this filament and insulated from it. This later type of emission is called indirect. The element emitting the electrons is known as the *cathode*.

In 1883, Thomas Edison discovered that when an additional electrode was placed inside an incandescent lamp and this electrode connected to a positive potential with respect to the filament, a current passed through the circuit. This is actually a simple vacuum tube of the diode type. It contains but two elements, the cathode to emit and the *plate* (anode) to receive the electrons. Under the influence of a $+$ voltage applied to the plate, electrons will flow from the cathode to the positively charged plate. An increase in the plate potential will increase the plate current.

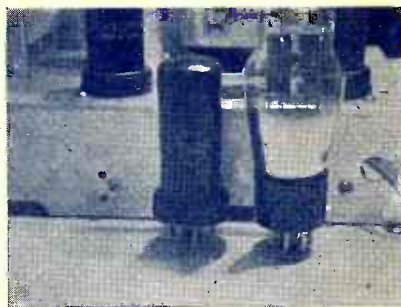


As the plate of a diode tube is made more positive, a greater number of electrons will be attracted across the space in the tube. Finally, the plate can be so positive that *all* electrons emitted by the cathode will be going to the plate. If the plate is made even more positive beyond this point, all the available electrons will continue to be received by the plate. There will not be any increase since there are no more electrons emitted. Now, you know that electric current is made up of electrons, and so a maximum current will be reached. Raising the plate potential (voltage) will no longer increase the current after this *saturation* point. Up to the saturation point, of course, an increase in plate voltage increases the plate current in the diode. Vacuum tubes are not operated near the saturation point and the plate voltage is kept at a value to prevent saturation current.

From a heated cathode many electrons venture out, forming a cloud around it. If a negative potential is

applied to the plate the electrons around the cathode will be repelled back into the cathode and no current will pass between these two elements. If, however, the plate becomes positive with respect to the cathode, the electrons around the cathode will be attracted to the plate, since unlike charges attract, and current will pass. In a rectifier, an alternating current is applied, during the positive cycle current will flow, but not during the negative. In this manner the alternating current will be rectified into pulsating direct current.

Of the electrons leaving the cathode not all, of course, reach the plate. Many return to the cathode while others remain for short periods of time between the cathode and the plate forming a space charge. Since this charge consists of electrons, it is electrically negative and has a repelling force exerted upon other electrons and, thereby, impedes the passage of current between cathode and plate.

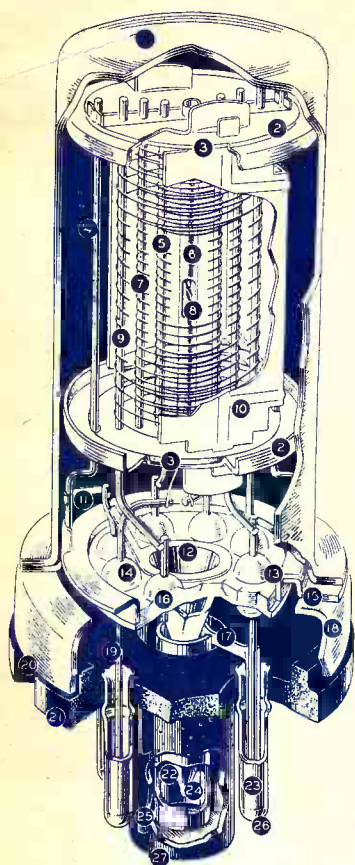


Tubes having a third electrode for control purposes are known as *triodes*. This control electrode is called the *grid*. The purpose of the grid is to control plate current. With a negative voltage on the grid, the grid exerts a force on electrons in the space between cathode and grid. This force drives the electrons back to the cathode. In this way, the negatively charged grid opposes the flow of electrons to the plate. When the voltage on the grid is made more negative, the grid exerts a stronger repelling force on the electrons and the plate current is decreased. When the grid voltage is made *less* negative, there is less repelling force exerted by the grid and the plate current increases.

The detrimental effect of the grid-plate capacitance is reduced greatly by the introduction of a fourth electrode, called the *screen* grid, placed between the grid and the plate. This screen in ordinary application is connected to a positive potential somewhat lower than the plate potential. A four element tube of this type is called a *tetrode*.

Electrons striking the plate dislodge other electrons from it. This indirect emission of electrons from the plate is called secondary emission in contrast to primary emission from the heated cathode. This limitation in turn may be removed by a further introduction of another electrode, known as the *suppressor*, placed

SIMILARITY OF RADIO TUBES



1. Metal envelope
2. Spacer shield
3. Insulating spacer
4. Mount support
5. Control grid
6. Coated cathode
7. Screen grid
8. Heater (filament)
9. Suppressor grid
10. Plate
11. Batalum getter
12. Conical stem
13. Header
14. Glass seal
15. Header insert
16. Stem seal
17. Base shield
18. Header skirt
19. Lead wire
20. Crimped lock
21. Octal base
22. Exhaust tube
23. Base pin
24. Exhaust tip
25. Aligning key
26. Solder
27. Aligning plug

between the screen and plate. The suppressor may be connected directly to the cathode or, as in some tubes for special applications, have an external prong. Since such tubes have five elements they are called pentodes.

There are a great many different tubes used in radio receiving sets. All the types are listed in the SYLVANIA tube chart, pages 17 to 35. Great many types are identical except for the fact that one series is for 2.5 volt operation, another series for 6.3 volt use, and some are for battery use requiring 1.4 or 2 volts. Note for example the corresponding types 58 and 78, or 57 and 77. Also in the same series there are many tubes almost alike electrically, see 6C6, 77, and 6J7. There are tubes to serve in A.C. sets, in combination AC-DC sets, in battery sets, and for many other special applications.

All the metal tubes have equivalent glass types. For example, 6K7 has a glass equivalent 6K7-G. The G type tubes may be used for metal tubes, or vice versa, provided space permits and the glass tubes substituted are covered with shields in certain cases. There are also many G type tubes not having metal equivalents, see 6K6G, 25A7G.

Now you have already noticed that the first column of the chart gives the type number. The next column tells the class of the tube. Is the tube a triode, a pentode, or is it a complex tube such as duotriode. Next is the "base" data. The code letters refer to the tube diagrams on pages 31 to 34. Look up type 6A8 for practice. You will note that it is a heptode (six elements). For base connections you are to refer to 8-A. As you find 8-A diagram, you will note that the tube requires an octal socket, uses eight pins and a grid cap on top.

When a diagram shows a tube socket, it is always the bottom view. You understand, of course, that when you look at the bottom of a socket, prongs located at the left (for example) will be found on the right when looking at the top of the socket. Most tests are made from the bottom and the bottom view is more important to us. But if you ever shift the set and work from the top remember the change from left to right.

Tubes that stick in their sockets may be removed easily by prying a screw driver between the base of the tube and chassis. When carrying out this work be sure power is *off*, since the screw driver blade may short the tube prongs to chassis.

On page 34, you will find important facts on panel lamps which are used in almost every modern radio. The color of the bead can be noticed inside the lamp and this information will help you in selecting a replacement. The wrong size bulb will either burn out when placed in service or give a very small amount of light. The bayonet base bulbs are similar to the types used in automobiles, while the screw types are like the house electric light bulb bases but, of course, much smaller. In an emergency, the socket may be changed, or a bayonet bulb can be forced into a screw socket, or the reverse. The value of the bulb (bead color) must be correct.

TUNING-EYE TUBES



The types 6E5, 6G5, and other tuning indicator tubes are finding extensive use in modern sets and for certain types of test equipment. These tubes may also be added to any radio having automatic volume control. In such cases, the tube filament is simply wired in series with other tubes in AC-DC type sets, or connected to the power transformer filament winding. In sets using 2.5 volt tubes, type 2E5 must be employed.

SYLVANIA

RADIO TUBES



Characteristics



Compiled by
COMMERCIAL ENGINEERING DEPARTMENT
SYLVANIA ELECTRIC PRODUCTS, INC.
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Type	Construction	Emitter		Notes (1) Capacitance Input		Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Microhms Conductance	Amplification Factor	Uniaxial Load for Stated Power Output	Type	
		Style	Class	Beam Diag.	Type												Volts	Amps	Cgp.	Chn.	Cont.
3Q4	Miniature	7-BA	Pentode	Filament	1.4 2.8	0.10 0.05	85 90 90	5.0 4.5 4.5	85 90 90	6.9 9.5 7.7	1.5 2.1 1.7	120,000 100,000 120,000	1,975 9,150 2,000	.....	10,000 10,000 10,000	3Q4
3Q5GT	GT	7-AP	Beam Amp.	Filament	1.4 2.8	0.10 0.05	90 90 90	4.5 4.5 4.5	90 90 90	8.0 9.5 8.0	1.3 1.3 1.3	75,000 2,000 80,000	2,200 2,000 2,000	.....	8,000 8,000 8,000	3Q5GT
354	Miniature	7-BA	Pentode	Filament	1.4 2.8	0.10 0.05	90 90 90	4.5 4.5 4.5	90 90 90	8.0 9.5 8.0	1.3 1.3 1.3	75,000 2,000 80,000	2,200 2,000 2,000	.....	8,000 8,000 8,000	354
4A6G	ST-12	8-L	Duodode	Filament	2.0 4.0	0.18 0.06	90 90 90	7.0 6.5 6.5	67.5 67.5 67.5	7.4 7.4 7.4	1.4 1.1 1.1	100,000 100,000 100,000	1,575 1,425 1,425	.....	8,000 8,000 8,000	4A6G
5T4	Metal	5-T	Duodode	Filament	2.0 4.0	0.18 0.06	90 90 90	1.5 1.5 1.5	.....	10.8 .....	.....	26,600 Signal	750	20	8,000	5T4
5U4G	ST-16	5-T	Duodode	Filament	5.0 5.0	3.00 2.00	450 A. C. Volts Per Plate, RMS, 225 Ma. Output Current. 350 A. C. Volts Per Plate, RMS, 225 Ma. Output Current.	10,000	5U4G
5V4G	ST-14	5-T	Duodode	Filament	5.0 5.0	3.00 2.00	450 A. C. Volts Per Plate, RMS, 225 Ma. Output Current. 350 A. C. Volts Per Plate, RMS, 225 Ma. Output Current.	10,000	5V4G
5W4GT	GT	5-L	Duodode	Filament	5.0 5.0	3.00 2.00	450 A. C. Volts Per Plate, RMS, 225 Ma. Output Current. 350 A. C. Volts Per Plate, RMS, 225 Ma. Output Current.	10,000	5W4GT
5X3	ST-14	4-C	Duodode	Filament	5.0 5.0	2.0 2.0	450 A. C. Volts Per Plate, RMS, 225 Ma. Output Current. 350 A. C. Volts Per Plate, RMS, 225 Ma. Output Current.	10,000	5X3
5X4G	ST-16	5-Q	Duodode	Filament	5.0 5.0	3.00 2.00	450 A. C. Volts Per Plate, RMS, 225 Ma. Output Current. 350 A. C. Volts Per Plate, RMS, 225 Ma. Output Current.	10,000	5X4G
5Y3GT	GT	5-T	Duodode	Filament	5.0 5.0	3.00 2.00	450 A. C. Volts Per Plate, RMS, 225 Ma. Output Current. 350 A. C. Volts Per Plate, RMS, 225 Ma. Output Current.	10,000	5Y3GT
5Y4G	ST-14	5-Q	Duodode	Filament	5.0 5.0	3.00 2.00	450 A. C. Volts Per Plate, RMS, 225 Ma. Output Current. 350 A. C. Volts Per Plate, RMS, 225 Ma. Output Current.	10,000	5Y4G
5Z3	ST-16	5-L	Duodode	Filament	5.0 5.0	3.00 2.00	450 A. C. Volts Per Plate, RMS, 225 Ma. Output Current. 350 A. C. Volts Per Plate, RMS, 225 Ma. Output Current.	10,000	5Z3
5Z4	ST-14	5-L	Duodode	Filament	5.0 5.0	3.00 2.00	450 A. C. Volts Per Plate, RMS, 225 Ma. Output Current. 350 A. C. Volts Per Plate, RMS, 225 Ma. Output Current.	10,000	5Z4
5Z4GT	GT	5-L	Duodode	Filament	5.0 5.0	3.00 2.00	450 A. C. Volts Per Plate, RMS, 225 Ma. Output Current. 350 A. C. Volts Per Plate, RMS, 225 Ma. Output Current.	10,000	5Z4GT
6A3	ST-16	4-D	Triode	Filament	6.3 6.3	1.00 0.30	950 325 325	45.0 68.0 68.0	.....	60.0 40.0 40.0	.....	800	5,250	4.2	2,500 3,000 3,000	6A3
6A4/LA	ST-14	5-B	Pentode	Filament	6.3 6.3	0.30 0.30	135 180	9.0 12.0	135 180	13.0 22.0	3.8 3.9	59,600 60,000	9,100 2,500	150	9,500 8,000 1,500	6A4/LA	
6A5G	ST-16	6-T	Triode	Cathode	6.3 6.3	1.25 0.80	250 325	45.0 68.0	.....	60.0 40.0	.....	800	5,250	4.2	2,500 3,000 3,000	6A5G
6A6	ST-14	7-B	Duodode	Cathode	6.3 6.3	0.80 0.30	300 250 294	0.0 3.0 6.0	.....	17.5 Per Plate, Class B Operation, Zero Signal 6.0 7.0	.....	11,300 11,000	3,100 3,200	35	10,000 (Class A Driver) (Class A Driver)	6A6
6A7, 6A7S	ST-12	7-C	Heptode	Cathode	6.3 6.3	0.30 0.30	.....	.....	.....	.....	.....	.....	.....	.....	.....	6A7, 6A7S
6A8	ST-12	8-A	Heptode	Cathode	6.3 6.3	0.30 0.30	.....	.....	.....	.....	.....	.....	.....	.....	.....	6A8
6A8G	GT	8-A	Heptode	Cathode	6.3 6.3	0.30 0.30	.....	.....	.....	.....	.....	.....	.....	.....	.....	6A8G
6A8S/6N5	T-9	8-R	Electron Ray	Cathode	6.3 6.3	0.15 0.45	.....	.....	.....	.....	.....	.....	.....	.....	.....	6A8S/6N5
6A87	ST-9	8-N	Pentode	Cathode	6.3 6.3	0.40 0.40	.....	.....	.....	.....	.....	.....	.....	.....	.....	6A87
6A85GT	T-9	6-O	Triode	Cathode	6.3 6.3	0.40 0.40	.....	.....	.....	.....	.....	.....	.....	.....	.....	6A85GT
6AC7	Metal	8-N	Pentode	Cathode	6.3 6.3	0.45 0.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	6AC7
6AD5G, GT	ST-12, GT	6-Q	Triode	Cathode	6.3 6.3	0.3 0.15	.....	.....	.....	.....	.....	.....	.....	.....	.....	6AD5G, GT
6AD6G	T-9	7-AG	Electron Ray	Cathode	6.3 6.3	0.15 0.15	.....	.....	.....	.....	.....	.....	.....	.....	.....	6AD6G
6AD7G	ST-14	8-AY	Tri. Pentode	Cathode	6.3 6.3	0.85 0.30	.....	.....	.....	.....	.....	.....	.....	.....	.....	6AD7G
6AE5GT	GT	6-Q	Triode	Cathode	6.3 6.3	0.30 0.15	.....	.....	.....	.....	.....	.....	.....	.....	.....	6AE5GT
6AE6G	ST-12	7-AH	Duo Plate Triode	Cathode	6.3 6.3	0.15 0.15	.....	.....	.....	.....	.....	.....	.....	.....	.....	6AE6G
6AE7GT	GT	7-AX	Duodode	Cathode	6.3 6.3	0.50 0.30	.....	.....	.....	.....	.....	.....	.....	.....	.....	6AE7GT
6AF5G	ST-12	6-O	Triode	Cathode	6.3 6.3	0.30 0.15	.....	.....	.....	.....	.....	.....	.....	.....	.....	6AF5G
6AF6G	T-9	7-AG	Twin Elec. Ray	Cathode	6.3 6.3	0.15 0.15	.....	.....	.....	.....	.....	.....	.....	.....	.....	6AF6G
6AG5	Miniature	7-BD	Pentode	Cathode	6.3 6.3	0.30 0.30	.....	.....	.....	.....	.....	.....	.....	.....	.....	6AG5
6AG7	Metal	8-Y	Pentode	Cathode	6.3 6.3	0.65 0.30	.....	.....	.....	.....	.....	.....	.....	.....	.....	6AG7
6AH7GT	GT	8-BE	Duodode	Cathode	6.3 6.3	0.9 0.30	.....	.....	.....	.....	.....	.....	.....	.....	.....	6AH7GT
6AH5G	ST-16	6-AP	Beam Amp.	Cathode	6.3 6.3	0.175 0.175	.....	.....	.....	.....	.....	.....	.....	.....	.....	6AH5G
6AK5	Miniature	7-BD	Pentode	Cathode	6.3 6.3	0.175 0.175	.....	.....	.....	.....	.....	.....	.....	.....	.....	6AK5
6AL5	Miniature	6-BT	Duodode	Cathode	6.3 6.3	0.30 0.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	6AL5
6AL6G	ST-16	6-AT	Beam Amp.	Cathode	6.3 6.3	0.30 0.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	6AL6G

Type	Construction		Emitter		Note (1) Capacitance Input		Use	Plate Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Micromhos Mutual Conductance	Amplification Factor	Oms Load for Stated Power Output	Type
	Style	Class	Type	Volts	Ampl.	Cap.	Cin.	Cout.								
6AQ6	Miniature	Duodiode-Tri.	7-BT	6.3	0.15	1.8	1.7	1.5	100	1.0	0.8	61,000	1,150	70	.....	6AQ6
6AT6	Miniature	Duodiode-Tri	7-BT	6.3	0.30	2.1*	2.3*	1.1*	100	1.0	0.8	54,000	1,300	70	.....	6AT6
6AU6	Miniature	Pentode	7-BK	6.3	0.30	.0035m*	5.5*	5.0*	250	3.0	1.0	58,000	1,200	70	.....	6AU6
6BA4	ST-16	Triode	5-S	6.3	1.00	16.0	7.0	5.0	100	1.0	5.2	600,000	3,900	.....	.....	6BA4
6B5	ST-14	Duodiode	6-AS	6.3	0.80	.....	.....	.....	250	2.0	0.9	91,000	1,100	100	.....	6B5
6B6G	ST-12	Duodiode-Tri.	7-V	6.3	0.30	1.7	1.7	3.8	100	3.0	5.8	300,000	950	.....	.....	6B6G
6B7S	ST-12	Duodi. Pent.	7-D	6.3	0.30	.007	3.5*	9.5*	180	3.0	75.0	1 Meg.	840	.....	.....	6B7S
6B8	Miniature	Triode	6-BG	6.3	0.15	1.4	1.8	2.5	250	4.5	0.65	800,000	1,000	.....	.....	6B8
6B8GT, 6B8G	Metal	Duodi. Pent.	8-E	6.3	0.30	.005m	6.0	9.0	250	2.0	0.9	91,000	1,100	100	.....	6B8GT, 6B8G
6BA6	GT, ST-12	Duodi. Pent.	8-E	6.3	0.30	.01m	3.6	9.5	100	10.8	4.4	250,000	4,300	.....	.....	6BA6
6BE6	Miniature	Pentode	7-BK	6.3	0.30	.0035m*	5.5*	5.0*	100	11.0	4.2	1.5 Meg.†	4,400	.....	.....	6BE6
6C4	Miniature	Heptode	7-CH	6.3	0.30	0.30m*	7.2*	8.6*	100	9.8	7.3	500,000	455 A	.....	.....	6C4
6C5	Miniature	Triode	6-BG	6.3	0.15	1.4	1.8	2.5	300	9.7	25	7,780	9,900	17	.....	6C5
6C5GT	Metal	Triode	6-Q	6.3	0.30	2.0	3.0	11.0	250	8.0	8.0	10,000	2,000	90	.....	6C5GT
6C6	ST-12	Pentode	6-F	6.3	0.30	.007m	5.0*	6.5*	100	3.0	2.0	1 Meg.†	1,225	.....	.....	6C6
6C7	ST-12	Duodiode-Tri.	7-G	6.3	0.30	.....	2.6	2.9	250	9.0	4.5	16,000	1,250	20	.....	6C7
6C8G	ST-12	Duodiode	8-G	6.3	0.30	2.6	2.6	2.9	250	4.5	3.2	92,500	1,600	36	.....	6C8G
6D4	Miniature	Gas Triode	5-AY	6.3	0.25	.....	.....	.....	350	50	Peak Cathode Current = 100 Ma. Cathode Current = 25 Ma. Approx. Volt Drop @ 25 Ma. = 16V	.....	.....	.....	.....	6D4
6D6	ST-12	Pentode	6-F	6.3	0.30	.007m	4.7*	6.5*	100	3.0	8.2	250,000	1,500	.....	.....	6D6
6D7	ST-12	Pentode	7-H	6.3	0.30	.....	.....	.....	100	3.0	100	800,000	1,600	.....	.....	6D7
6D8G	ST-12	Heptode	8-A	6.3	0.15	0.2	8.0	11.0	250	3.0	1.5	600,000	325 A	.....	.....	6D8G
6E5	T-9	Electron Ray	6-R	6.3	0.30	.....	.....	.....	100†	Series Plate Resistor 0.5 Meg. Target Current 1.0 Ma. Grid Bias = 3.3 for 90° Shadow.	.....	.....	.....	.....	.....	6E5
6E6	ST-14	Duodiode	7-B	6.3	0.60	.....	.....	.....	180	20.0	11.5	4,300	1,400	6.0	.....	6E6
6E7	ST-12	Pentode	7-H	6.3	0.30	.....	.....	.....	250	27.5	18.0	3,500	1,700	6.0	.....	6E7
6F5	Metal	Triode	5-M	6.3	0.30	2.3	5.5	4.0	250	2.0	0.9	66,000	1,500	100	.....	6F5
6F5GT	GT	Triode	5-M	6.3	0.30	2.8*	9.5*	3.2*	250	16.5	34.0	80,000	2,500	.....	.....	6F5GT
6F6, 6F6G, 6F6GT	Metal	Pentode	7-S	6.3	0.70	.....	.....	.....	285	28.5	38.0	78,000	2,550	.....	.....	6F6, 6F6G
6F7, 6F7S	ST-14	Pentode	7-S	6.3	0.70	.....	.....	.....	315	24.0	62.0	10,000†	10,000†	.....	.....	6F7, 6F7S
6F8G	ST-12	Pent-Triode	7-E	6.3	0.30	.008m	3.2	12.5	100	3.0	6.3	290,000	1,050	.....	.....	6F8G
6G5	Now Known as Type 6U5	Duodiode	8-G	6.3	0.60	3.8*	3.9*	1.0*	250	8.0	9.0	850,000	1,100	.....	.....	6G5
6G6G	ST-12	Pentode	7-S	6.3	0.15	.....	.....	.....	180	9.0	11.5	170,000	2,100	.....	.....	6G6G
6H4GT	GT	Diode	5-AF	6.3	0.15	.....	.....	.....	100	.....	4.0	.....	.....	.....	.....	6H4GT
6H6	Metal	Duodiode	7-Q	6.3	0.30	.....	.....	.....	135	11.5	2.0	170,000	2,300	.....	.....	6H6
6H6GT	GT	Duodiode	7-Q	6.3	0.30	.....	.....	.....	180	15.0	2.5	175,000	2,300	.....	.....	6H6GT
6J5	Metal	Triode	6-Q	6.3	0.30	3.4	3.4	3.6	250	8.0	9.0	7,700	2,600	90	.....	6J5
6J5GT	GT	Triode	6-Q	6.3	0.30	3.8	4.2	5.0	100	.....	8.5	7,100	5,300	38	.....	6J5GT
6J6	Miniature	Duodiode	7-BF	6.3	0.45	1.4	2.3	1.0	150	10	30	Push-pull Class C Operation	.....	.....	.....	6J6
6J7	Metal	Pentode	7-R	6.3	0.30	.005m	7.0	12.0	250	3.0	2.0	1.0 Meg.†	1,225	.....	.....	6J7
6J7GT	ST-12, GT	Pentode	7-R	6.3	0.30	.007m	5.4	12.0	250	3.0	1.3	4.0 Meg.	900 A	.....	.....	6J7GT
6J8G	ST-12	Tri-Heptode	8-H	6.3	0.30	.02m	4.4	10.0	250	Plate Supply Thru 90,000 Res. Grid Resistor 30,000, Grid Current 0.4 Ma. Plate Current 5.0 Ma. (Triode Section)	.....	.....	.....	.....	.....	6J8G

(1) Values are given shielded unless marked with (*).
 (2) Converter tube capacitances given are signal grid to plate.
 (3) Input/Output.
 (4) Applied through 250,000 ohms.
 (5) Per Tube or Section—No Signal.
 (6) m maximum.
 (7) Applied through 250,000 ohms.
 (8) Plate and Target Supply Voltage.
 (9) Pentode Operation.
 (10) For two tubes with 40 volts RMS applied to each grid.
 (11) Approximate.
 (12) Applied through 20,000 ohms.
 (13) Plate to Plate.
 (14) Conversion Coefficient.
 (15) 150 Volts RMS applied to two grids.

Type	Construction		Basing Diag.	Emitter		Note (1) Capacitance in p.f.		Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Microhmhos Mutual Conductance	Amplifi- cation Factor	Ohms Load for Stated Power Output	Undis- torted Power Output Milli- watts	Type	
	Style	Class		Type	Volts	Amps	Cap.													Cin.	Cont.
6K4	T3	Triode	None	Cathode	6.3	0.15	9.9*	0.85*	100	2.0	.....	12.0	.....	3,650	5,500	90	.....	6K4	6K4
6K5G	ST-12	Triode	5-U	Cathode	6.3	0.30	2.9	5.75	100	1.5	.....	0.35	.....	78,000	900	70	.....	6K5G	6K5G
6K5GT	GT	Triode	5-U	Cathode	6.3	0.30	2.9	4.7	250	3.0	.....	1.10	.....	50,000	1,400	70	.....	6K5GT	6K5GT
6K6GT	GT	Pentode	7-S	Cathode	6.3	0.40	.....	.....	100	7.0	100	9.0	1.6	104,000	1,500	.....	19,000	350	6K6GT
									250	18.0	250	39.0	5.5	68,000	9,300	.....	7,600	3,400	
									315	21.0	250	25.5	4.0	75,000	2,100	.....	9,000	4,500	
6K7	Metal	Pentode	7-R	Cathode	6.3	0.30	.005m	7.0	Characteristics Same as Type 6K7G, Except Capacitances.										6K7	6K7
6K7G	ST-12	Pentode	7-R	Cathode	6.3	0.30	.007m	5.0	90	3.0	90.0	5.4	1.3	300,000	1,275	.....	.....	.....	6K7G
									180	3.0	75.0	4.0	1.0	1 Meg.	1,100	.....	.....	.....	6K7G
									250	3.0	100	7.0	1.7	800,000	1,450	.....	.....	.....	6K7G
6K7GT	GT	Pentode	7-R	Cathode	6.3	0.30	.005m	Characteristics Same as Type 6K7G, Except Capacitances.										6K7GT	6K7GT
6K8	Metal	Tri-Hexode	8-K	Cathode	6.3	0.30	.03m	4.6	Characteristics Same as Type 6K8G, Except Capacitances.										6K8	6K8
6K8G	ST-12	Tri-Hexode	8-K	Cathode	6.3	0.30	.08m	6.6	950	3.0	100	2.5	6.0	600,000	350A	(Hexode Section)	.....	.....	6K8G
6K8GT	GT	Tri-Hexode	8-K	Cathode	6.3	0.30	.08m	4.8	100	Grid Resistor 50,000 Plate Current 3.8 Ma., Mutual Conductance 3,000 (Triode Section not Oscillating)							6K8GT	6K8GT		
6L5G	ST-12	Triode	6-Q	Cathode	6.3	0.15	2.8	2.8	100	3.0	.....	8.0	.....	10,000	1,900	15	.....	.....	6L5G
									250	9.0	.....	.....	.....	9,000	1,900	17	.....	.....	6L5G
6L6	Metal	Beam Amp.	7-AC	Cathode	6.3	0.90	.....	.....	250	14.0	250	72.0	5.0	22,500	6,000	.....	2,500	6,500	6L6
6L6G	ST-16								350	18.0	250	54.0	2.5	33,500	5,200	.....	4,200	10,800	6L6G
6L6GA	ST-14								250	17.5	250	134.0	11.0	23,500	3,700	.....	5,600	17,500	6L6GA
									360	22.5	270	88.0	5.0	Current & Output for Two Tubes			9,600	26,500		
									360	22.5	270	88.0	5.0	Current & Output for Two Tubes			9,600	26,500		
6L7	Metal	Heptode	7-T	Cathode	6.3	0.30	.001m	7.5	Characteristics Same as Type 6L7G, Except Capacitances.										6L7	6L7
6L7G	ST-12	Heptode	7-T	Cathode	6.3	0.30	.003m	6.0	250	6.0	150	3.3	9.9	1 Meg. +	350A	(G3 = Neg. 15 Volts)	.....	.....	6L7G
6N6G	ST-14	Duotriode	7-AU	Cathode	6.3	0.80	.....	.....	250	0.0	(Input Section)	5.3	6.5	600,000	1,100	(G3 = Neg. 3.0 Volts)	.....	.....	6N6G
									300	0.0	(Output Section)	45.0	8.0	24,000	2,400	58	7,000	4,000	6N6G	
6N7	Metal	Duotriode	8-B	Cathode	6.3	0.80	Characteristics Same as Type 6N7GT										6N7	6N7
6N7GT	GT	Duotriode	8-B	Cathode	6.3	0.80	.....	.....	300	0.0	.....	.....	.....	11,300	3,100	35	8,000	10,000	6N7GT
									250	5.0	.....	6.0	.....	11,000	3,200	35	(Class A Driver)	.....	6N7GT
6P5GT	GT	Triode	6-Q	Cathode	6.3	0.30	2.6	3.4	250	13.5	.....	5.0	.....	9,500	1,450	13.8	.....	.....	6P5GT
									250	20.0	.....	.....	.....	9,500	1,450	13.8	(Plate Current to be adjusted to 0.2 Ma. with no Input Signal)	.....	6P5GT
6P7G	ST-12	Pent-Triode	7-U	Cathode	6.3	0.30	.007m	2.8	Characteristics Same as Type 6P7G, Except Capacitances.										6P7G	6P7G
							2.0	9.5	250	6.0	.....	7.0	.....	11,000	3,200	35	.....	.....	6P7G
6Q7	Metal	Duotriode-Tri.	7-V	Cathode	6.3	0.30	1.4	5.0	Characteristics Same as Type 6Q7G, Except Capacitances.										6Q7	6Q7
6Q7G	ST-12	Duotriode-Tri.	7-V	Cathode	6.3	0.30	1.5	3.2	100	1.5	.....	0.35	.....	88,000	800	70	.....	.....	6Q7G
6Q7GT	GT	Duotriode-Tri.	7-V	Cathode	6.3	0.30	1.6	2.2	250	3.0	.....	1.1	.....	58,000	1,200	70	.....	.....	6Q7GT
6R6G	ST-12	Pentode	6-W	Cathode	6.3	0.3	.007m	4.5*	250	3.0	100	7.0	1.7	800,000	1,450	1,160	.....	.....	6R6G
6R7	Metal	Duotriode-Tri.	7-V	Cathode	6.3	0.30	2.3	4.8	Characteristics Same as Type 6R7GT, Except Capacitances.										6R7	6R7
6R7GT	GT	Duotriode-Tri.	7-V	Cathode	6.3	0.30	2.1	2.6	250	9.0	.....	9.5	.....	8,500	1,900	16	.....	.....	6R7GT/G
6S7	Metal	Pentode	7-R	Cathode	6.3	0.30	.005m	6.5	Characteristics Same as Type 6S7G, Except Capacitances.										6S7	6S7
6S7G	ST-12	Pentode	7-R	Cathode	6.3	0.15	.008m	4.4	135	3.0	67.5	3.7	0.9	1 Meg.	1,250	375	.....	.....	6S7G
									250	3.0	100	8.5	2.0	1 Meg.	1,750	1,100	.....	.....	6S7G
6SA7	Metal	Heptode	8-R	Cathode	6.3	0.30	.13m	9.5	Characteristics Same as Type 6SA7GT, Except Capacitances.										6SA7	6SA7
6SA7GT	GT	Heptode	8-AD	Cathode	6.3	0.30	.5m	11.0	100	2.0	100	3.3	8.5	500,000	425A	.....	.....	.....	6SA7GT
									250	2.0	100	3.5	8.5	1.0 Meg.	450A	.....	.....	.....	6SA7GT
6SC7	Metal	Duotriode	8-S	Cathode	6.3	0.30	2.0	2.2	250	2.0	.....	2.0	.....	53,000	1,325	70	(Each Triode)	.....	6SC7
6SC7GT	GT	Duotriode	8-S	Cathode	6.3	0.30	.....	.....	250	2.0	.....	2.0	.....	53,000	1,325	70	(Each Triode)	.....	6SC7GT
6SD7GT	GT	Pentode	8-N	Cathode	6.3	0.30	.0035	9.0	100	2.0	100	5.7	2.0	250,000	3,350	.....	.....	.....	6SD7GT
									250	2.0	100	6.0	1.9	1.0 Meg.	3,600	.....	.....	.....	6SD7GT
6SE7GT	GT	Pentode	8-N	Cathode	6.3	0.3	.0035m	6.0	100	1.0	100	5.5	2.4	250,000	3,100	.....	.....	.....	6SE7GT
									250	1.5	100	4.5	1.5	1,000,000	3,400	.....	.....	.....	6SE7GT
6SF5	Metal	Triode	6-AB	Cathode	6.3	0.30	2.4	4.0	Characteristics Same as Type 6SF5GT, Except Capacitances.										6SF5	6SF5
6SF5GT	GT	Triode	6-AB	Cathode	6.3	0.30	2.6	4.2	250	2.0	.....	0.9	.....	66,000	1,500	100	.....	.....	6SF5GT
6SF7	Metal	Diode Pent.	7-AZ	Cathode	6.3	0.30	.004m	5.5	100	1.0	100	12	3.4	700,000	1,975	.....	.....	.....	6SF7
									250	1.0	100	18.4	3.3	200,000	9,050	.....	.....	.....	6SF7
6SG7	Metal	Pentode	8-BK	Cathode	6.3	0.30	.003m	8.5	Characteristics Same as Type 6SG7GT, Except Capacitances.										6SG7	6SG7
6SG7GT	GT	Pentode	8-BK	Cathode	6.3	0.30	.004m	8.5	100	1.0	100	8.2	3.2	250,000	4,100	.....	.....	.....	6SG7GT
									250	1.0	100	11.8	4.4	900,000	4,700	.....	.....	.....	6SG7GT
									250	2.5	150	9.2	3.4	1 Meg. +	4,000	.....	.....	.....	6SG7GT
6SH7	Metal	Pentode	8-BK	Cathode	6.3	0.30	.003m	8.5	Characteristics Same as Type 6SH7GT, Except Capacitances.										6SH7	6SH7
6SH7GT	GT	Pentode	8-BK	Cathode	6.3	0.30	.004m	8.5	100	1.0	100	5.3	8.1	350,000	4,000	.....	.....	.....	6SH7GT
									250	1.0	150	10.8	4.1	900,000	4,900	.....	.....	.....	6SH7GT
6SJ7	Metal	Pentode	8-N	Cathode	6.3	0.30	.005m	6.0	Characteristics Same as Type 6SJ7GT, Except Capacitances.										6SJ7	6SJ7
6SJ7GT	GT	Pentode	8-N	Cathode	6.3	0.30	.005m	6.3	100	3.0	100	2.9	0.9	700,000	1,575	.....	.....	.....	6SJ7GT
									250	3.0	100	3.0	0.8	1.5 Meg.	1,650	.....	.....	.....	6SJ7GT
6SK7	Metal	Pentode	8-N	Cathode	6.3	0.30	.003m	6.0	Characteristics Same as Type 6SK7GT, Except Capacitances.										6SK7	6SK7
6SK7GT	GT	Pentode	8-N	Cathode	6.3	0.30	.005m	6.5	100	1.0	100	13.0	4.0	120,000	2,350	.....	.....	.....	6SK7GT
									250	3.0	100	9.2	2.6	80,000	3,500	.....	.....	.....	6SK7GT
6SL7GT	GT	Duotriode	8-BD	Cathode	6.3	300	.....	.....	250	2.0	.....	9.3	.....	44,000	1,600	70	.....	.....	6SL7GT

Type	Construction		Emitter	Plate Capacitance in pF			Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Micromhos Mutual Conductance	Amplification Factor	Output Power Watts	Type
	Style	Class		Base	Type	Volts												Amps
7C5	Lock-In	Beam Amp.	6-AA	Cathode	6.3	0.45	0.40	9.5	2.4	9.0	180	8.5	180	58,000	3,700	5,500	7C5
7C6	Lock-In	Duodiode-Tri.	8-W	Cathode	6.3	0.15	1.6	2.4	2.4	9.0	100	1.0	100	100,000	1,000	85	7C6
7C7	Lock-In	Pentode	8-V	Cathode	6.3	0.15	.007m	5.5	6.5	9.0	100	3.0	100	1.2 Meg.	1,985	100	7C7
7E5	Lock-In	Triode	8-BN	Cathode	6.3	0.15	1.5	3.6	2.8	9.0	150	3.5	150	8,500	1,900	16	7E5
7E6	Lock-In	Duodiode-Tri.	8-W	Cathode	6.3	0.30	1.5	3.0	2.4	9.0	100	9.0	100	11,000	1,500	16.5	7E6
7E7	Lock-In	Duodi. Pent.	8-AE	Cathode	6.3	0.30	.003m	4.6	5.5	9.0	100	1.0	100	150,000	1,600	100	7E7
7F7	Lock-In	Duodiode	8-AC	Cathode	6.3	0.30	1.6	2.4	2.0	9.0	100	2.0	100	62,000	1,195	70	7F7
7F8	Lock-In	Duodiode	8-BW	Cathode	6.3	0.30	1.2	2.8	1.4	9.0	250	2.0	250	44,000	1,600	70	7F8
7G7	Lock-In	Pentode	8-V	Cathode	6.3	0.45	.007m	9.0	7.0	9.0	250	2.5	250	800,000	4,500	50	7G7
7G8	Lock-In	Duodiode	8-BV	Cathode	6.3	0.30	0.15m	3.4	2.6	9.0	100	1.0	100	925,000	2,100	80	7G8
7H7	Lock-In	Pentode	8-V	Cathode	6.3	0.30	.007m	8.0	7.0	9.0	250	1.0	250	950,000	4,800	80	7H7
7J7	Lock-In	Tri-Heptode	8-BL	Cathode	6.3	0.30	.03m	4.6	7.5	9.0	100	3.0	100	500,000	280A	20	7J7
7K7	Lock-In	Duodiode-Tri.	8-BF	Cathode	6.3	0.30	1.8	2.6	3.0	9.0	250	2.0	250	44,000	1,600	70	7K7
7L7	Lock-In	Pentode	8-V	Cathode	6.3	0.30	.010m	8.0	6.5	9.0	100	1.0	100	100,000	3,100	80	7L7
7N7	Lock-In	Duodiode	8-AC	Cathode	6.3	0.60	3.0	3.4	2.4	9.0	90	8.0	90	6,700	3,000	90	7N7
7Q7	Lock-In	Heptode	8-AL	Cathode	6.3	0.30	0.20m	9.0	9.0	9.0	250	2.0	250	500,000	525A	20	7Q7
7R7	Lock-In	Duodi. Pent.	8-AE	Cathode	6.3	0.30	.004m	5.6	5.3	9.0	100	3.0	100	1,800,000	2,200	80	7R7
7S7	Lock-In	Tri-Heptode	8-BL	Cathode	6.3	0.30	.03m	5.0	8.0	9.0	250	3.0	250	500,000	525A	20	7S7
7T7	Lock-In	Pentode	8-V	Cathode	6.3	0.3	.005m	8.0	7.0	9.0	250	1.0	250	900,000	4,900	85	7T7
7V7	Lock-In	Pentode	8-V	Cathode	6.3	0.45	.004m	9.5	6.5	9.0	250	1.0	250	350,000	4,000	100	7V7
7W7	Lock-In	Pentode	8-BJ	Cathode	6.3	0.45	.0035m	9.5	7.0	9.0	300	1.0	300	350,000	5,800	100	7W7
7X7	Lock-In	Duodiode-Tri.	8-BZ	Cathode	6.3	0.30	0.30	...	...	...	100	1.0	100	350,000	5,800	100	7X7
7Y4	Lock-In	Duodiode	5-AB	Cathode	6.3	0.50	...	...	...	...	100	1.9	100	500,000	525A	...	7Y4
7Z4	Lock-In	Duodiode	5-AB	Cathode	6.3	0.90	...	...	...	...	100	3.0	100	500,000	525A	...	7Z4
10	ST-16	Triode	4-D	Filament	7.5	1.25	7.0*	4.0*	3.0*	...	...	...	...	...	...	400	10
12A	ST-14	Triode	4-D	Filament	5.0	0.25	8.5*	4.0*	2.0*	...	...	...	...	...	...	13,000	12A
12A5	ST-12	Pentode	7-F	Cathode	12.6	0.30	0.3	9.0	9.0	...	...	...	...	...	...	80	12A5
12A6	Metal	Beam Amp.	7-AC	Cathode	12.6	0.60	...	...	...	...	...	...	...	...	...	80	12A6
12A6GT	GT	Beam Amp.	7-AC	Cathode	12.6	0.15	...	...	...	...	...	...	...	...	...	80	12A6GT
12A7	ST-12	Diode-Pent.	7-K	Cathode	12.6	0.15	...	...	...	...	...	...	...	...	...	80	12A7
12A8GT	GT	Heptode	8-A	Cathode	12.6	0.15	.26	9.5	12.0	...	...	...	...	...	...	80	12A8GT
12AH7GT	GT	Duodiode	8-BE	Cathode	12.6	0.15	3.0	2.8	2.6	...	...	...	...	...	...	80	12AH7GT
12A16	Miniature	Duodiode-Tri	7-BT	Cathode	12.6	0.15	...	...	...	...	...	...	...	...	...	80	12A16
12B7	Now Known as Type 14A7	Pentode Tri.	8-T	Cathode	12.6	0.30	.015*	5.2*	9.6*	...	...	...	...	...	...	80	12B7
12BBGT	GT	Pentode Tri.	8-T	Cathode	12.6	0.30	9.3	5.0	6.3	...	...	...	...	...	...	80	12BBGT

Type	Construction	Emitter	Plate Capacitance In pF.	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Microphos Mutual Conductance	Amplification Factor	Choke Load or Stand Power Output	Grids or Power Output Milli-watts	Type
19BE6	Miniature	Heptode	7-CH	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19BE6
19C8	Metal	Duodiode Pentode	8-E	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19C8
19F5GT	GT	Triode	5-M	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19F5GT
19H6	Metal	Duodiode	7-Q	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19H6
19J5GT	GT	Triode	6-O	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19J5GT
19J7GT	GT	Pentode	7-R	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19J7GT
19K7GT	GT	Pentode	7-R	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19K7GT
19K8	Metal	Tri-Hexode	8-K	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19K8
19K8GT	GT	Tri-Hexode	8-K	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19K8GT
19L8GT	GT	Duo. Pentode	8-BU	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19L8GT
19Q7GT	GT	Duodiode-Tri.	7-V	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19Q7GT
19SA7	Metal	Heptode	8-R	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19SA7
19SA7GT	GT	Heptode	8-AD	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19SA7GT
19SC7	Metal	Duodiode	8-S	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19SC7
19SF5	Metal	Triode	6-AB	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19SF5
19SF5GT	GT	Triode	6-AB	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19SF5GT
19SF7	Metal	Diode Pent.	7-AZ	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19SF7
19SG7	Metal	Pentode	8-BK	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19SG7
19SH7	Metal	Pentode	8-BK	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19SH7
19SJ7	Metal	Pentode	8-N	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19SJ7
19SJ7GT	GT	Pentode	8-N	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19SJ7GT
19SK7	Metal	Pentode	8-N	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19SK7
19SK7GT	GT	Pentode	8-N	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19SK7GT
19SL7GT	GT	Duodiode	8-BD	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19SL7GT
19SN7GT	GT	Duodiode	8-BD	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19SN7GT
19SQ7	Metal	Duodiode-Tri.	8-O	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19SQ7
19SQ7GT	GT	Duodiode-Tri.	8-O	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19SQ7GT
19SR7	Metal	Duodiode-Tri.	8-Q	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19SR7
19T3	ST-12	Diode	4-G	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19T3
14A4	Lock-in	Triode	5-AC	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14A4
14A5	Lock-in	Beam Amp.	6-AA	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14A5
14A7	Lock-in	Pentode	8-V	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14A7
14AF7/XXD	Lock-in	Duodiode	8-AC	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14AF7/XXD
14B6	Lock-in	Duodiode-Tri.	8-W	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14B6
14B8	Lock-in	Heptode	8-X	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14B8
14C5	Lock-in	Beam Amp.	6-AA	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14C5
14C7	Lock-in	Pentode	8-V	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14C7
14E6	Lock-in	Duodiode-Tri.	8-W	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14E6
14E7	Lock-in	Duodi. Pent.	8-AE	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14E7
14F7	Lock-in	Duodiode	8-AC	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14F7
14H7	Lock-in	Pentode	8-V	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14H7
14J7	Lock-in	Tri-Heptode	8-BL	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14J7
14N7	Lock-in	Duodiode	8-AC	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14N7
14Q7	Lock-in	Heptode	8-AL	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14Q7
14R7	Lock-in	Duodi. Pent.	8-AE	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14R7
14S7	Lock-in	Tri. Heptode	8-BL	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14S7
14W7	Lock-in	Pentode	8-BJ	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14W7
14Y4	Lock-in	Duodiode	5-AB	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14Y4
15	ST-12	Pentode	5-F	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15
18	ST-14	Pentode	6-B	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18
19	ST-12	Duodiode	6-C	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19
20	T-8	Triode	4-D	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	20
22	ST-14	Tetrode	4-K	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	22
24A, 24S	ST-14	Tetrode	5-E	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24A, 24S

(1) Values are given shielded unless marked with (*).
 (2) Converter tube capacitances given are signal grid to plate, RF Input Mixer Output.
 m maximum.
 *Applied through 250,000 ohms.
 †Per tube or section—No Signal.
 ‡Plate and Target Supply Voltage.
 §With Average Power Input of 300 Mw. Grid to Grid.
 ¶Plate to Plate.
 ¶Applied through 20,000 ohms.
 ††Applied through 200,000 ohms.
 ‡‡Applied through 200,000 ohms.
 ‡‡‡Approximate.
 ‡‡‡‡Approximate.

Type	Construction	Base	Diag.	Class	Style	Capacitance in μ f.	Emitter	Volts	Amps	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Microphos Mutual Conduct- ance	Amplifi- cation Factor	Load Stated Power Output	Rated Output Milli- watts	Type
35Z6G	Duodiode	7-Q			ST-14		Cathode	35.0	0.30	Doubler H-W Rect.	117 A-C Volts Per Plate, RMS, 110 Ma. Output Current.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		35Z6G
36	Tetrode	5-E			ST-12		Cathode	6.3	0.30	R-F Amp.	235 A-C Volts Per Plate, RMS, 110 Ma. Output Current.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		36
37	Triode	5-A			ST-12		Cathode	6.3	0.30	Detector Amplifier	235 A-C Volts Per Plate, RMS, 110 Ma. Output Current.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		37
38	Pentode	5-F			ST-12		Cathode	6.3	0.30	Power Amp.	235 A-C Volts Per Plate, RMS, 110 Ma. Output Current.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		38
39/44	Pentode	5-F			ST-12		Cathode	6.3	0.30	R-F Amp.	235 A-C Volts Per Plate, RMS, 110 Ma. Output Current.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		39/44
40	Triode	4-D			ST-14		Filament	5.0	0.25	A-F Amp.	235 A-C Volts Per Plate, RMS, 110 Ma. Output Current.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		40
40Z5/45Z5GT	Diode	5-AM			40Z5/45Z5GT		Cathode	45.0	0.075	Amplifier	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		40Z5/45Z5GT
41	Diode	6-AD			ST-12		Cathode	45.0	0.15	H-W Rect.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		41
42	Pentode	6-B			ST-12		Cathode	6.3	0.40	Power Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		42
43	Pentode	6-B			ST-14		Cathode	6.3	0.65	Power Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		43
45	Triode	4-D			ST-14		Filament	2.5	1.50	Power Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		45
45Z3	Miniature	5-AM			45Z3		Cathode	45.0	0.075	H-W Rect.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		45Z3
45Z5GT	Now Known as Type 40Z5/45Z5GT	5-C			45Z5GT		Filament	2.5	1.75	Power Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		45Z5GT
46	Dual Grid Triode	5-C			ST-16		Filament	2.5	1.75	Power Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		46
47	Pentode	5-B			ST-16		Filament	2.5	1.75	Power Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		47
48	Tetrode	6-A			ST-16		Cathode	30.0	0.40	Power Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		48
49	Dual Grid Triode	5-C			ST-14		Filament	2.0	0.12	Power Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		49
50	Triode	4-D			ST-16		Filament	7.5	1.25	Power Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		50
50A5	Lock-In	6-AA			50A5		Cathode	50.0	0.15	Power Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		50A5
50B5	Miniature	7-BZ			50B5		Cathode	50.0	0.15	Power Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		50B5
50C6G	Beam Amp.	7-AC			50C6G		Cathode	50.0	0.15	Power Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		50C6G
50L6GT	Beam Amp.	7-AC			50L6GT		Cathode	50.0	0.15	Power Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		50L6GT
50Y6GT	Beam Amp.	7-Q			50Y6GT		Cathode	50.0	0.15	Power Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		50Y6GT
50Z7G	Duodiode	8-AN			50Z7G		Cathode	50.0	0.15	Power Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		50Z7G
52	Dual Grid Triode	5-C			ST-14		Filament	6.3	0.30	Class A Amplifier	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		52
53	Duodiode	7-B			ST-14		Cathode	2.5	2.0	Power Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		53
55, 55S	Duodiode-Tri.	6-G			ST-12		Cathode	2.5	1.0	Det. Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		55, 55S
56, 56S	Triode	5-A			ST-12		Cathode	2.5	1.0	Amplifier	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		56, 56S
56AS	Triode	5-A			ST-12		Cathode	6.3	0.40	Amplifier	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		56AS
57, 57S	Pentode	6-F			ST-12		Cathode	2.5	1.00	Detector	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		57, 57S
57AS	Pentode	6-F			ST-12		Cathode	6.3	0.40	Amplifier	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		57AS
58, 58S	Pentode	6-F			ST-12		Cathode	2.5	1.00	Amplifier	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		58, 58S
58AS	Pentode	6-F			ST-12		Cathode	6.3	0.40	Amplifier	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		58AS
59	Pentode	7-A			ST-16		Cathode	2.5	2.0	Power Amp.	117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp Connected, or 60 Ma. with Panel Lamp.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		59
70A7GT	Diode-Beam Amplifier	8-AB			70A7GT		Cathode	70.0	0.15	H-W Rect. Power Amp.	117 A-C Volts Per Plate, RMS, 60 Ma. Output Current.	135 180 250	1.5 3.0 6.0	67.5 90.0 90.0	2.8 3.1 3.2	Not Over 1/2 Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595		70A7GT

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate;
RF input; Mixer Output

m maximum.
*Applied through 250,000 ohms.
†Per Tube or Section—No Signal.

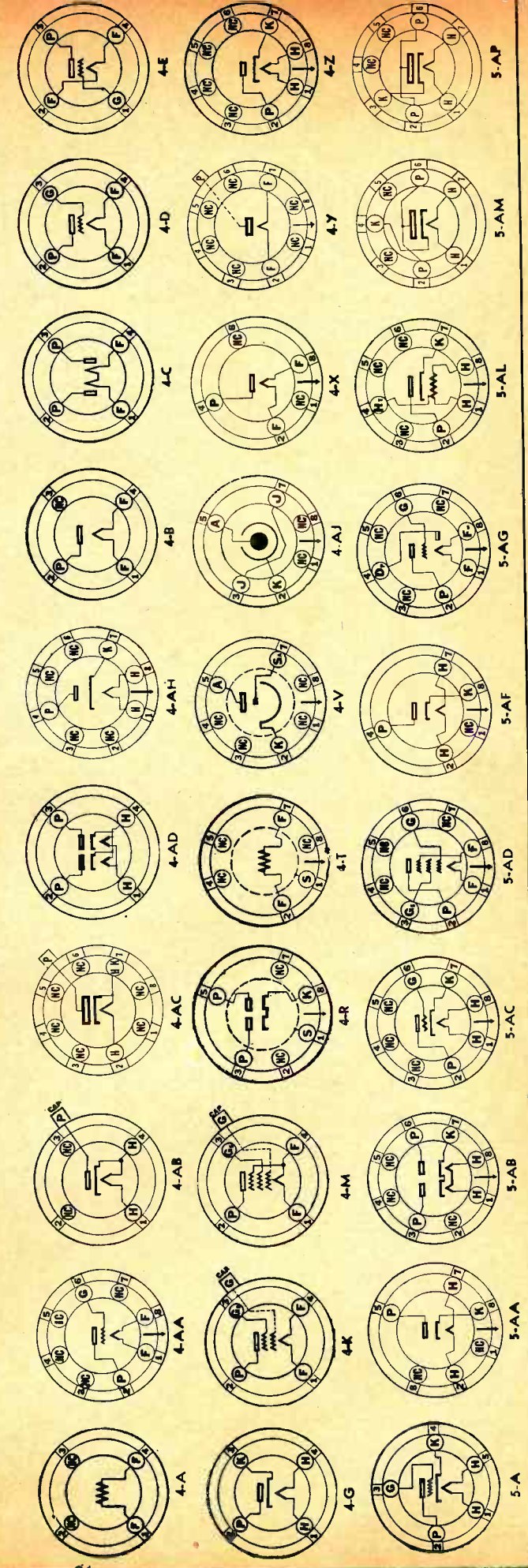
‡Plate and Target Supply Voltage.
§With Average Power Input of 320 Mw. Grid to Grid.
¶Pentode Operation.
‡‡Applied through 200,000 ohms.

Conversion Conductance.
150 Volts RMS applied to two grids.
††Applied through 20,000 ohms.
‡‡Approximate.

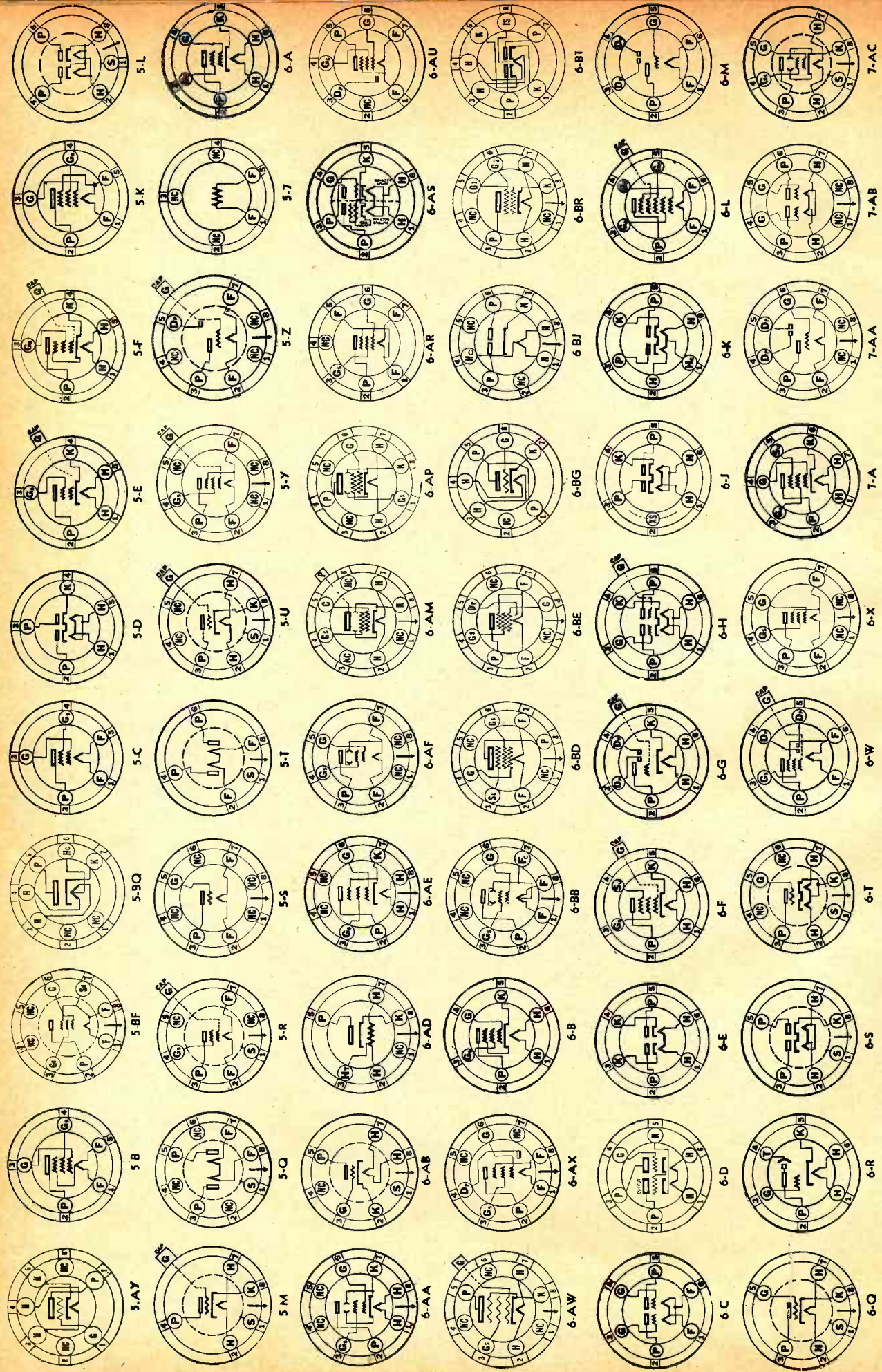
Type	Construction		Emitter		Note (1) O Capacitance in μ f.		Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Amplification Factor	Output for Stated Load	Power Output Watts	Type
	Style	Class	Base	Diag.	Type	Volts	Amps	Cgp.	Cin.	Cont.							
1991	Now Known as Type 3B7																1991
1993	Lock-in	Triode	4-AA		Filament	1.4	.11	1.7	1.7	3.0							1993
1994	Now Known as Type 1R4																1994
1999	Now Known as Type 3D6																1999
1612	Metal	Heptode	7-T		Cathode	6.3	0.30	.001m	7.5	11.0							1612
1626	ST-12	Triode	6-Q		Cathode	12.6	.25	4.4*	3.9*	3.4							1626
TC-9	GT	Electron Ray	7-AL		Cathode	12.6	0.15										2050
2050	ST-12	Gas Tetrode	6-BR		Cathode	6.3	0.60	0.36*	4.2*	3.6*							2051
2051	ST-12	Gas Tetrode	6-BR		Cathode	6.3	0.6	0.36*	4.2*	3.6*							XXFM
XXD	Now Known as Type 7X7																XXL
XXFM	Lock-in	Triode	5-AC		Cathode	6.3	0.30										XXL

(1) Values are given shielded unless marked with (*).
 (2) Converter tube capacitances given are signal grid to plate;
 # Per Tube or Section—No signal. † Applied through 20,000 ohms. ‡ For two tubes with 40 volts RMS applied to each grid. § With Average Power Input of 320 Mw. Grid to Grid. ¶ Applied through 20,000 ohms. †† Plate to Plate.
 m maximum. * Applied through 250,000 ohms. ** Triode Operation. †† For two tubes with 40 volts RMS applied to each grid. § With Average Power Input of 320 Mw. Grid to Grid. ¶ Applied through 20,000 ohms. † Plate to Plate.

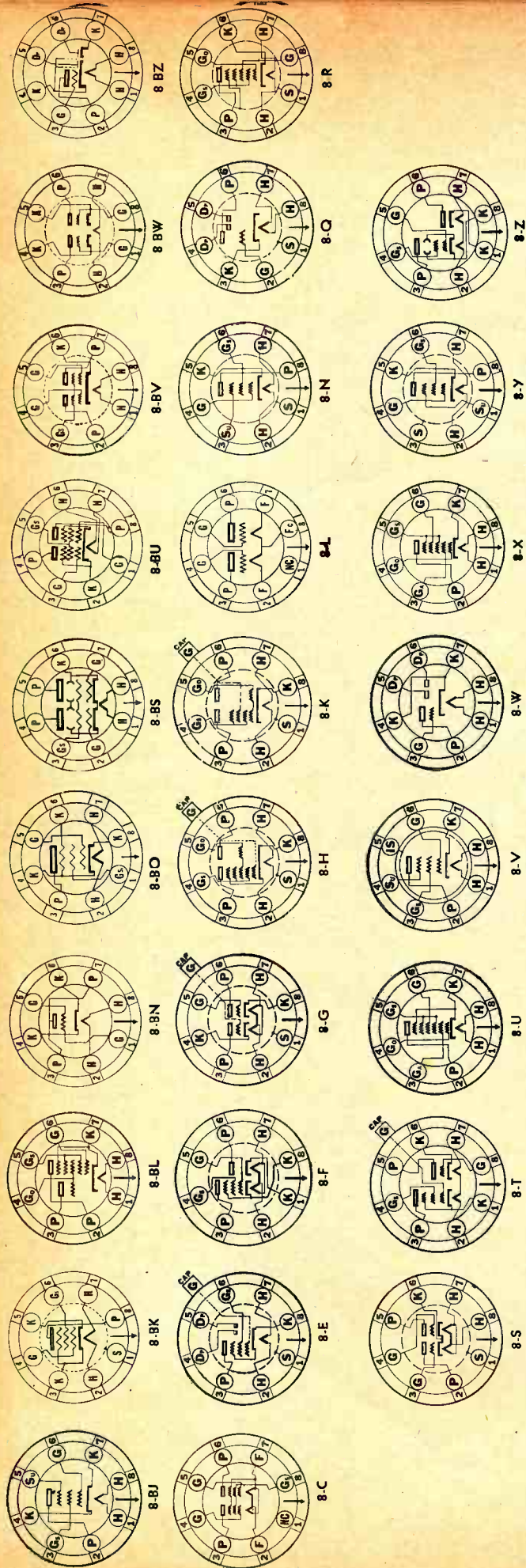
TUBE AND BASE DIAGRAMS (VIEWED FROM BOTTOM OF BASE—) RMA NUMBERING SYSTEM



SYMBOLS: A—Anode; A1—Anode 1; A2—Anode 2; D1—Deflector 1; D2—Deflector 2; D3—Deflector 3; D4—Deflector 4; Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Control Grid; Gc—Modulator Grid; Go—Oscillator Grid; Gs—Screen Grid; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection; IS—Internal Shield; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S—Metal Shelf; SA—Switcher Anode; Sp—Suppressor Grid; T—Target; X5—External Shield; □—Top Cap; → Locating Pin.



SYMBOLS: A—Anode, A1—Anode 1, A2—Anode 2, D1—Deflector 1, D2—Deflector 2, D3—Deflector 3, D4—Deflector 4, Dp—Diode Plate, F—Filament, Fc—Filament Center, G—Control Grid, G_a—Anode Grid, G_m—Modulator Grid, G_o—Oscillator Grid, G_s—Screen Grid, H—Heater, Hc—Heater Center, Ht—Heater Tap, IC—Internal Connection, IS—Internal Shield, J—Jumper, K—Cathode, NC—No Connection, P—Plate, Rc—Ray Control, S—Metal Shelf, SA—Starter Anode, Su—Suppressor Grid, T—Target, XS—External Shield, □—Top Cap, →—Locating Pin.



SYMBOLS: A—Anode; A1—Anode 1; A2—Anode 2; D1—Deflector 1; D2—Deflector 2; D3—Deflector 3; D4—Deflector 4; Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Control Grid; Ga—Anode Grid; Gm—Modulator Grid; Go—Oscillator Grid; Gs—Screen Grid; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection; IS—Internal Shield; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S—Metal Shelf; SA—Starter Anode; Su—Suppressor Grid; T—Target; XS—External Shield; □—Top Cap; ————Locating Pin.

SYLVANIA PANEL LAMP CHARACTERISTICS

Type No.	Circuit Volts	Design		Bead Color	Bulb Style	Miniature Base	Usual Service	Type No.
		Volts	Amp.					
S40	6-8	6.3	0.15	Brown	T-3½	Screw	Radio Dials	S40
S41	2.5	2.5	0.50	White	T-3½	Screw	Radio Dials	S41
S42	3.2	3.2	0.35	Green	T-3½	Screw	Radio Dials	S42
S43	2.5	2.5	0.50	White	T-3½	Bayonet	Radio Dials and Tuning Meters	S43
S44	6-8	6.3	0.25	Blue	T-3½	Bayonet	Radio Dials and Tuning Meters	S44
S45	3.2	3.2	0.35	White	T-3½	Bayonet	Radio Dials	S45
S46	6-8	6.3	0.25	Blue	T-3½	Screw	Radio Dials and Tuning Meters	S46
*S47	6-9	6.3	0.15	Brown	T-3½	Bayonet	Radio Dials	*S47
S48	2.0	2.0	0.06	Pink	T-3½	Screw	Battery Set Dials	S48
*S49	2.0	2.0	0.06	Pink	T-3½	Bayonet	Battery Set Dials	*S49
S50	6-8	7.5	0.20	White	G-3½	Screw	Auto Sets, Flash Lights	S50
S51	6-8	7.5	0.20	White	G-3½	Bayonet	Auto Sets, Auto Panels	S51
S55	6-8	6.5	0.40	White	G-4½	Bayonet	Auto Sets, Parking Lights	S55
S299	2.9	2.9	0.17	White	T-3½	Screw	Radio Dials	S299
S292A	2.9	2.9	0.17	White	T-3½	Bayonet	Radio Dials Coin Machines	S292A
S1455	18.0	18.0	0.25	Brown	G-5	Screw	Coin Machines	S1455
S1455A	18.0	18.0	0.25	Brown	G-5	Bayonet	Coin Machines	S1455A

*Sylvania Types S47 and S49 are interchangeable with Types 40A and 49A, respectively, in other brands.

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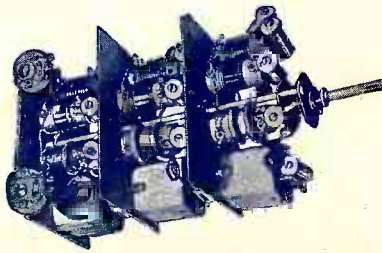
SYLVANIA ELECTRIC PRODUCTS INC.

EMPORIUM, PENN.

HOW A RADIO WORKS

The general idea how a radio set receives signals, amplifies these signals, and finally changes the electrical impulses to sound waves, is not hard to understand. At the transmitters of all radio stations operating, radio waves are sent out and all of these waves have an effect on the receiving antenna. These waves really set up tiny voltages, and the actual amount of voltage depends primarily on the distance of the transmitter and the power of the station.

The coil condenser combinations used for tuning the desired station only, serve as gates to permit only the wanted signal of a certain frequency to enter and keep out all other signals. The vacuum tubes amplify the signal. The signals must be increased greatly in order to operate a loudspeaker, but they must not be altered in any other way if good quality is to be obtained.



Courtesy Meissner Mfg. Co.

Coils and band switch of the type used in multi-band receiving sets.

At the transmitter radio frequency waves are generated with an oscillator. Audio frequencies (the sounds we hear) are picked up by the studio microphone or phonograph pickup and increased in intensity, that is amplified. Next these R.F. and audio frequencies are combined. The R.F. are very high, for example broadcasting stations have frequencies between 540,000 and 1,700,000 cycles per second, 540 and 1,700 KC. The audio frequencies handled by the average station lie between 50 and 5,000 cycles, much lower than R.F.

When these are mixed, the result is a R.F. which is varied in *intensity* in accordance with the audio (sound) variations. This is the wave the receiver picks up.

In the radio frequency stages this combined signal is handled by the tuned stages, tubes, and other parts. After one or more R.F. stages in a T.R.F. receiver, the audio signal must be separated and used in the balance of the receiver. Since the R.F. alone was used only as a carrier of the audio signals, it will no longer be needed and can be by-passed; i.e. eliminated.

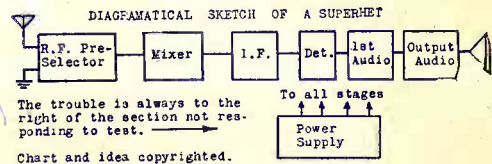
This separation process, known as detection, is performed in the detector stage, second detector in a superhet. After this stage only audio frequencies are present.

Superhet sets are similar to T.R.F. receivers, but incorporate several variations. There may or may not be a R.F. amplifier or pre-selector stage. But the real difference lies in the mixer-oscillator which changes all station frequencies, as they are selected, to a fixed new frequency called the I.F.



Inside view of I.F. transformers. The output type usually has four leads at the bottom. The input and interstage types have the grid lead coming out of the top.

When a station is selected by varying the condenser used for tuning, a gang of this condenser also changes the frequency of the oscillator, so that the oscillator and the incoming signal *beat* and produce the intermediate frequency, I.F. This may be 456 KC., but many other frequencies are also used.



Following the mixer tube, we have one or more I.F. stages designed to permit the passage and amplification of the I.F. frequency only. In a properly operating receiver, this new frequency will correspond to the signal carrier altered but still having the audio frequency of the broadcast influencing its intensity. If the oscillator stops functioning, while the balance of the set may be working, the station frequency will not be changed to the I.F. and will not get through the I.F. stages in its original form.

After the I.F. stages we again have a detector (sometimes called second detector since the mixer tube may be called the first detector). Following this stage, a regular audio amplifier is incorporated.

If a superhet works on some stations but not on others, suspect alignment or the oscillator tube. Tube tester or other simple tests are not dependable here, you better replace the mixer or oscillator tube for test purposes.

Remember that all frequencies of all stations are present on the antenna. Only the desired station is in the first tuned stage and before the mixer tube. A frequency of the station wanted plus the I.F. frequency (456 K.C. or other) present in the oscillator. Only the I.F. frequency in the I.F. stages. Only audio frequencies after the second detector.

WHAT GOES WRONG

Every radio repair job is of a two fold nature: (1) the fault must be discovered and (2) properly repaired. The actual repairing is commonly a simple mechanical task — a part is replaced, a wire soldered, or an adjustment made. But to find the fault is the big task. Fortunately, however, the majority of radio repairs are quite simple and the fault can be found in most cases by the *comparison* method which is to be described in detail after the preliminary information.

A great many radio faults can be easily discovered with a visual inspection. For example, if you noticed a broken radio tube in a faulty set, would you bother with a complete check of the circuit? No, you would simply replace the tube, turn the set "on," and if the set played right assume that the fault was repaired.

Now here is another example of a visual inspection repair. "That part (power transformer) smoked a long time before the set stopped playing," says the lady of the house. You will naturally suspect a burned out power transformer, probably overloaded by a faulty filter condenser or a power supply short.

And here is another. Complaint: *Poor tone*. Push-pull (two tubes in a special circuit of a balanced type) stage in the output using type 45 tubes. One of the 45's has no glow on the filament when the set is turned "on." Yes, of course, the 45 is burned out, and the circuit is out of balance because of this. Tube is quickly replaced.

In the case of a badly burned carbon resistor, suspect shorted associated by-pass condenser. Both resistor and the faulty condenser should be replaced. Always consider associated parts as also being at fault.

It is always worth while to ask the owner of the radio what happened before the set developed the fault. In the reply, many times, will be a clue to the difficulty. And the owner will be proud to have a chance to express his own opinion.

No radio expert can tell what is wrong with a radio by long distance analysis. You must have an opportunity to examine and test the set for possible faults. There is, however, an advantage to know what may go wrong with radio sets, so that you will look first where trouble probably lies.

Filter and by-pass condensers are the most common source of trouble. Usually when a condenser shorts, the voltage on one side of the condenser is by-passed to ground. If voltage is to be expected at a certain connection to a condenser, but is not there, suspect that condenser. To test, disconnect one side of the condenser, if the voltage will be present then, at this point, the condenser is bad.

Small carbon resistors give plenty of trouble. They may change their values, short, open, or vary with voltage and temperature and appear noisy. Sometimes resistors become bad because associated condensers or other parts short and pass excessive current through this resistor. Suspected resistors should be changed. A simple test may be made by disconnecting one end of the suspected resistor, and connecting in its place a new resistor of about the same size. For a 500,000 ohms you may try anything from 100,000 ohms up to 1 megohm.

Loose connections, poor contacts, shorts make up a large bulk of repairs. These may be found by visual inspection, changes in volume when set is shaken, slight blows on the chassis giving erratic operation. Try to find what is making or breaking temporary contact. See if voltages at different points correspond to values indicated on the comparison diagrams.

A few simple tube tests have already been outlined. A tube tester, of course, gives a more positive indication and should be used if available. The best tube test, under all conditions, is the replacement for a few moments of the suspected tube with one known to be good.



ONLY A FEW RADIO TYPES

According to the best estimates, there are in the U. S. close to fifty million radio sets made up of about 20,000 different models. There are many ways to classify these different sets, but if all similar types are grouped together, you will find only a handful of types. And even these types, few in number as they are, can be seen to have many similar sections and can be tested and serviced along the same lines.

The comparison technique requires the separation of all radios into groups and the ability of the serviceman to make the selection of the type into which the radio to be serviced will fit best. You will now be given suggestions how to go about finding the type of radio you may have in your shop.

Circuits have changed more with time than through any other influence. The group of early electric radios from about 1926 to 1929, were of the TRF type and used 26's or 27's for the RF and AF stages. These are similar triodes. A type of 27 tube was used as a detector. The final audio output stage used a single or push-pull triodes of 71A or 45 type. The speaker was usually dynamic type.

Many sets sold during the depression were of the four tube midget variety. These were for A.C. and for AC-DC operation. As some of the larger TRF sets, these midgets employed type 47 or other pentodes in the output. In the A.C. midgets an 80 tube was the rectifier. At first types 24A or similar type 35 tubes were used in R.F. stages and detector. As new tubes were developed in 1931-32, 58 was used as R.F. and 57 as detector. Then, of course, came other similar tubes in the 6.3 volt series, and in metal types.

The early AC-DC sets used 6.3 and 25 volt tubes, dropping the balance of the line voltage with a line cord resistor or ballast tube. You will find that even present day small TRF sets are exactly the same as these early types. Complete description on each type will be given later in the manual.

You must not be confused with minor variations in circuits or different placement of parts. Good training, at this point, is to examine many diagrams of radio sets and sort these out according to similar types.

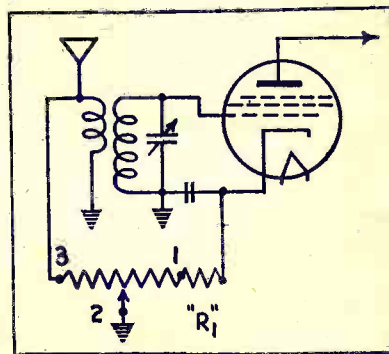
Also remember that the physical appearance of parts does not have an effect on the electrical similarity of radio sets. Five inch and twelve inch dynamic speakers while giving results which are really different, electrically behave very much alike.

While a few models of TRF sets using later tubes were manufactured, after 1932 practically every radio of five or more tubes was of the superhet type. You already know that one of the characteristic things about all superhets is the use of I.F. stages. These stages are basically alike, with only a few minor variations and sometimes different I.F. frequencies. There is complete

similarity even in the I.F. stages of battery sets, auto sets, and others.

The plate power and filament supplies of all AC-DC type sets are similar and are readily understood while studying the four tube circuits. The audio sections of all radios are very similar.

At this point the reader should be able to realize that while servicing by comparison the diagram of the nearest circuit will be of greatest help, sections of the radio requiring service may be explained in some other section of the manual. For example, let us say you are working on an AC-DC super which employs a ballast tube. The best information on the power supply many appear on page 47, while data on the ballast tube will be given on page 46. The actual circuit, however, may be discussed on page 58. This is why you must be familiar with the entire book to use this method at its best. The index will help also to find the needed material.



A type of volume control circuit used in all small TRF sets.

The oscillator-mixer stages of the early superhets were different from today's type. Sometimes two tubes were used for this application—one was the oscillator, the other the mixer. In special circuits, R.F. pentodes were sometimes used alone. The pentagrid converter tubes operate very much like two individual tubes combined in a single glass envelope. In all superhet oscillators the plate current must be controlled by two different frequencies—the incoming station frequency and the oscillator frequency.

This latter frequency can be generated by the same tube or by another triode. The function is seen to be the same, but the method differs.

To summarize, radio circuits are made up of similar sections usually placed together in the same manner. Ordinarily there are only physical variations in parts used and their placement, and minor differences in the circuits. Since new radio developments are available to practically all radio firms at the same time, and since each tries to make their sets best within a price limit, the resulting radios must be somewhat along the same lines.

HOW TO LOCALIZE TROUBLE

A comparison blueprint divides the set your are servicing into definite sections and suggests tests for finding the one section at fault. From an actual examination of a radio set it may be hard to see what parts actually make up a section of the receiver. This is because in construction the filter condenser of the power supply may be placed near the antenna coil, but the circuit will tell you that these parts belong to totally distinct sections. If the one faulty section is discovered, you need not search among all the parts of the radio for the fault, but instead you can confine your work to a limited number of components of this single section.

Here is the general way for finding the section at fault in any radio receiver. Every section of a radio receiver has an influence on the stages following, leading up to the loud-speaker. Every stage may also be upset electrically by *shorting* a voltage present, or touching a *sensitive* part of the circuit with your finger or resistor. The power supply section, however, should be tested first by a method outlined later.

If any stage is upset electrically as suggested, this change will influence the stages following and will cause the speaker to produce a click or other sounds. Certain sounds for a specific test will indicate that the stage being tested and all stages following are probably in good operating order. Lack of response or incorrect results, on the other hand, will suggest that one of the stages between the point of test and the speaker is at fault. Since this test may be carried at many points beginning at the speaker and working back to the antenna, the faulty stage can be isolated.

For example, in making this test in the first audio stage, a certain response may be expected (see table below) if this stage, the following output audio stage, the loudspeaker, and the power supply are working properly.

For the tests mentioned below and for the many similar tests outlined in connection with the comparison blueprints, a test unit made of a five cent resistor and two pieces of wire may be used. Use a 100 ohm, 1 watt resistor. The wires are used as test leads and are connected to the resistor.



It is best to test the power supply circuit first. For this, as well as for almost all other tests, hold one lead of the 100 ohm resistor *test unit* on the chassis of the radio (this is usually B-minus of the circuit). Touch the other lead to a B-plus point, such as the positive side of a filter condenser (red wire probably), or to the screen grid terminal of an output pentode tube. If there is a noticeable spark at the point of contact assume the voltage is correct. The contact must be momentary only.

Of course, a voltmeter can be used for this test with much greater accuracy. In AC-DC sets the voltage will be between 95 and 125 volts, in A.C. sets 250 to 350.

Specific test procedure will be given in sections of this manual, but in general the speaker should be tested next. Bring an iron blade near the field if the speaker is of the electro-dynamic type. There should be magnetic attraction—none will be present if set is "off" or field is not getting any current. A P.M. dynamic does not use a field coil.

To test voice coil operation, one prod should be held in contact with the chassis as mentioned before, and with the other lead touch the plate prong of the output tube. There will be a spark at the contact and a loud single click in the speaker. Any previously existing hum in the speaker will be reduced. These facts indicate that the speaker probably is operating properly. See the chart and comparison diagrams for many other tests.

LOCALIZING TEST CHART, IN RECOMMENDED ORDER				
First prod momentary contact only	Second prod	Visual observation at contact	Aural response	Where to look for faults.
B+ point before filter at rectifier tube	Chassis B-	Arc made, wire will weld.	Clicks, hiss.	Rectifier tube, 1st filter, pwr. transformer
B+ point after filter	Chassis B-	Large spark	Dual click	Choke, or field, 2nd filter cond. short in set
Plate prong output tube	Chassis B-	Spark	Click less hum	Output transformer
Control grid output tube	Hold in hand	None	Hiss	Wrong bias on output tube
Triode, or pentode detector tube cont. grid	Antenna post	None	Click, strong hiss	Bad condenser or resistor in circuit of detector tube
Control grid of any R.F. or I.F. tube	Hold in hand, remove grid cap	None	Strong oscillations, hum, change in tone	Parts of the associated circuit.

Occasionally trouble develops which makes the radio operate poorly for a time. However, a shaking of the cabinet, movement of the volume control, or turning on of an electric light in the house, will make the radio return to normal operation for a time. Such condition, known as intermittent operation, is very difficult to correct. Experts usually replace condensers and resistors one at a time until the one which may be causing the difficulty is found. This is about the only solution for this servicemen's headache.

Many times a radio works poorly or not at all because the antenna wire is disconnected or the power-line cord is not making contact in the socket. Tube grid caps may be off and prevent proper operation.

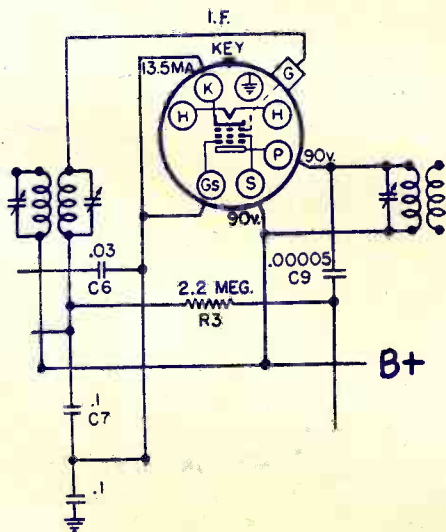
COMPARE CIRCUITS

In using the comparison method you must first find the circuit which is closest to the radio you are servicing. To do this you must be familiar with the basic diagrams included on the following pages. It is easy to tell if the radio is of the house, battery, or auto type. Superhets can be found by the I.F. transformers and oscillator coils they use.

Remember similar tubes. For example, the set you diagram blueprint shows a circuit using 58, 57, 2A5, are servicing uses 6D6, 6C6, 42, and 80. The similar and 80. The tube chart will tell you that these tubes are alike by types, but the radio uses tubes of the 6.3 volt series, while the blueprint shows tubes of the 2.5 volt series. In many cases similar tubes are listed to help you in this matter.

In the same way if the radio you are trying to repair is similar to one of the diagrams, but has two R.F. stages using type 58 tubes. You are correct in assuming that both R.F. stages are similar and the information given on one, in the diagram will apply.

As mentioned before all I.F. sections operate alike even if employed in entirely different type radio sets. Other sections of receivers may also be similar to circuits illustrated in other parts of the book. Special circuits and parts are described separately and should be looked up in the index.

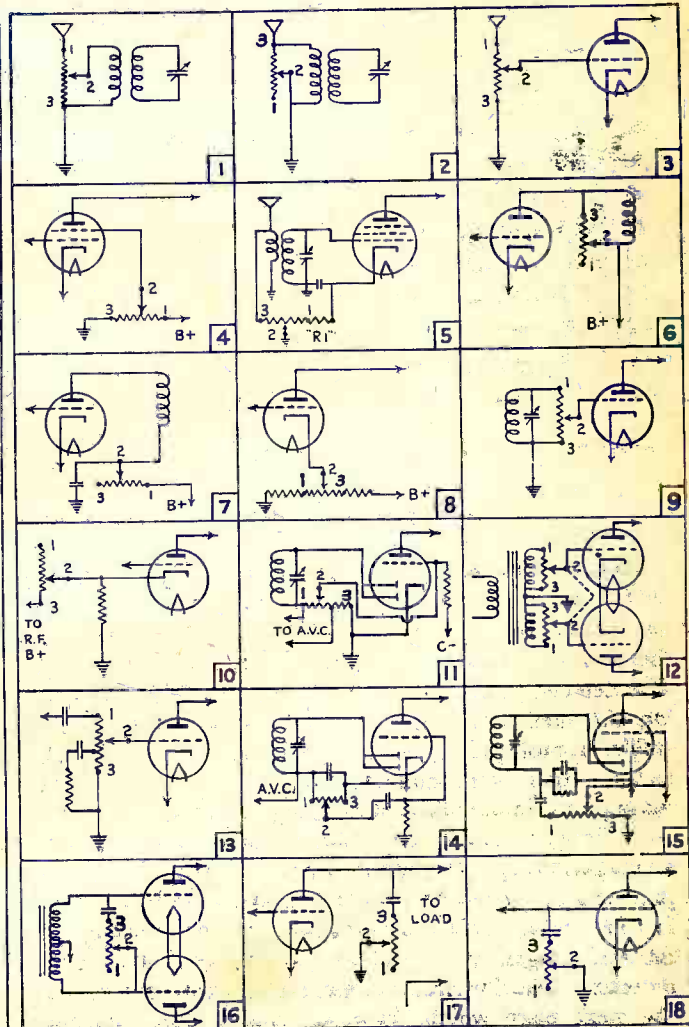


The circuit of an I.F. stage of an AC-DC superhet.

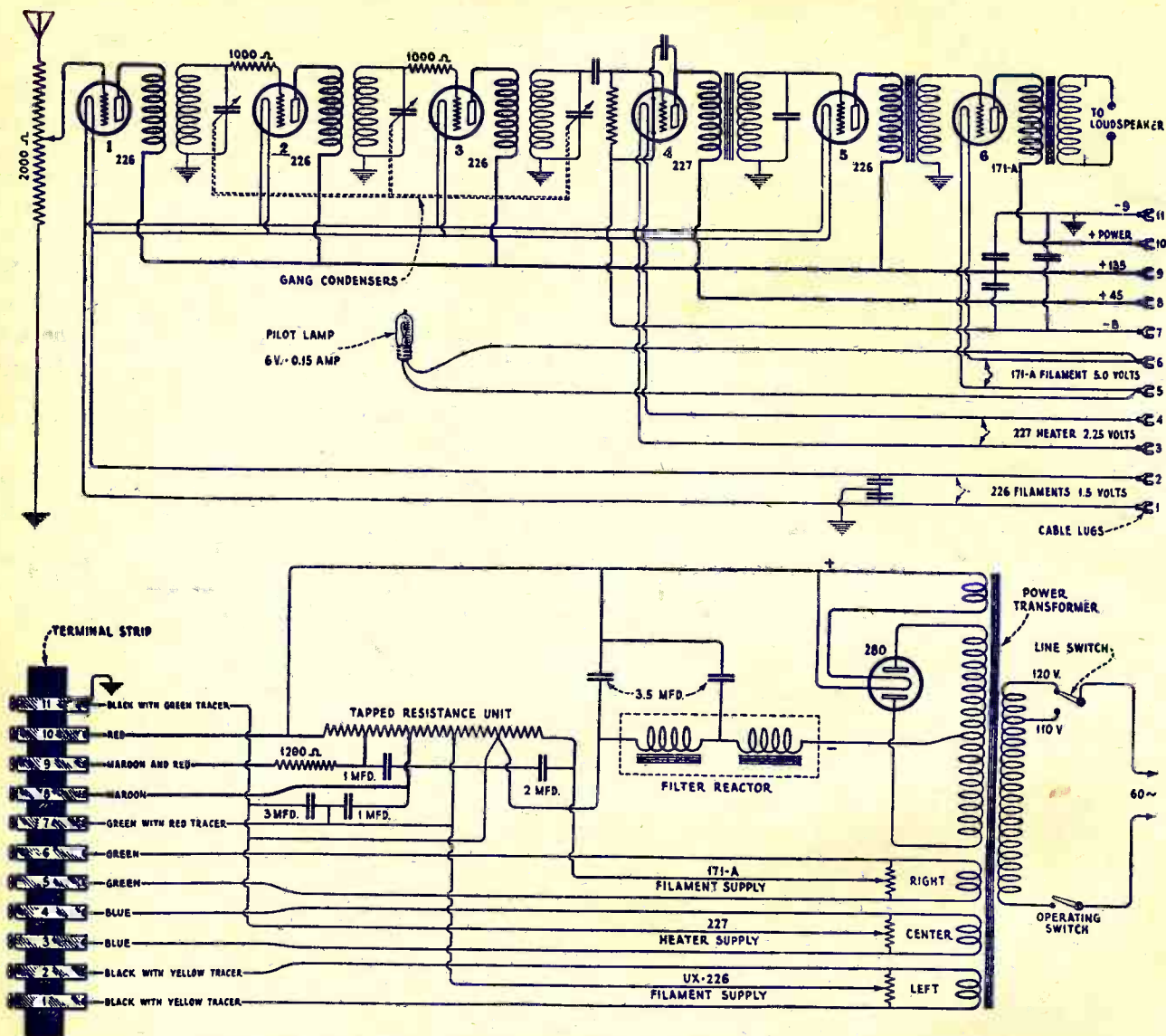
The knack of associating the circuit under consideration with the right blueprint and other tips in the text-book will develop with time. The period of the set's manufacture (date of sale will help) will enable you to place the radio in the right classification.

After the circuit is checked as suggested on the page containing the diagram, and the part at fault is isolated, you should look up the specific part or repair required in the index. The material in other parts of the manual will help you to test this section or part and explain the operation of the related circuit. For example, you are servicing a simple modern super. You follow the tests suggested on pages 53 and 54, but also refer to page 48 when checking the AC-DC power supply. You are able to discover that the trouble lies in the first I.F. transformer or a near-by condenser. You look up the section on condensers and test the unit according to the method suggested. The condenser proves to be in good working shape and you now know that the fault must be with the I.F. At this point you look up I.F. transformers in the index and find out how to test this unit and replace it.

Methods of Connecting Volume and Tone Controls



EARLY A.C. TRF SETS



Early sets originally used tubes with hundred-digits and these were dropped later; i. e., type 226 became 26.

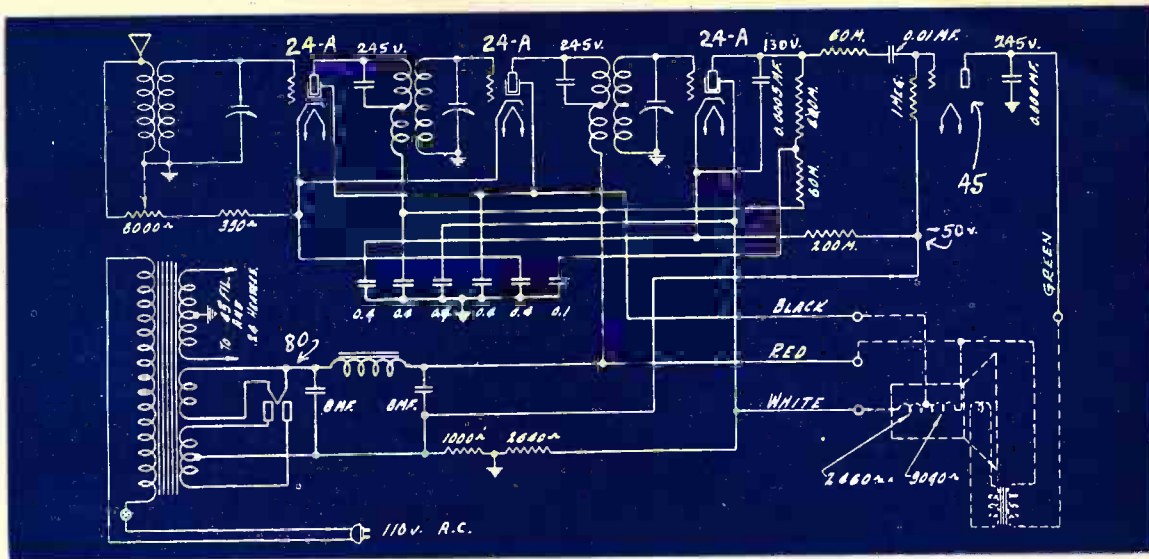
The first diagram shows a circuit very common during 1926 and 1927, and used by Majestic, Atwater Kent, and other manufacturers of this period. In these sets there were several R.F. stages, using type 26 tubes. The detector consisted of a 27. The audio stage following also used a type 26. The output may have been a single or push-pull type 12A, 71A, or 45 triodes. The audio stages were coupled with transformers. The tuning was done with a multi-gang condenser.

In little later type sets type 27 triodes were used for all stages, except the output which used single or push-pull 45's or (then the newly developed) 47 pentodes. In 1929, some of these sets began using 24A tetrodes for the R.F. stages, but a type 27 continued to be used as detector. See the circuit of the screen grid TRF set on the next page which, however, uses a 24A detector.

Power supplies in these early TRF radios were at times mounted separately. The general tests for these sets will be given now. Be sure plug makes connection in the power socket, and the antenna is connected. Turn the set "on." See if rectifier (80) tube lights. If out, replace with another, but watch for strong blue light inside. This would indicate an overload probably caused by bad filters.

Most of these sets used low capacity paper condensers in the filter circuit. These should be replaced, when necessary, with 8 mfd., 450 volt, electrolytics. If the choke used is defective, the choke may be shorted out entirely. If hum is too great, add more capacity. (This is a good solution at any time the customer says he wants the hum level reduced).

SCREEN GRID TRF SETS



Find highest B+ point and make a test for voltage as explained before. (Use resistor, one prod on chassis, the other on B+ point). Examine filaments of all tubes to see that they are operating, glow with light.

Remove quickly one at a time the output tubes in push-pull circuits. A sharp click should be heard in the speaker, hum should increase with only one tube in socket. If these results are not obtained, suspect filter condensers of power supply, or choke being open. For tests applicable to these parts, see the index.

Now remove one tube at a time, beginning at the tube next to the output stage and working back to the antenna. Only one tube should be removed at a time and placed back in the socket before the next one is removed for test. Every tube will have a small effect on the response, but as a bad tube is pulled out no click should be heard.

Another test is to touch with a moist finger the grid connections of each tube beginning with the tube next to the output stage. A loud hiss or hum should result. If you fail to get these responses, the trouble lies between the tube that failed to give a response and the one that seemed to be working right and which was tested just before.

Once the section at fault is located, you may test for the indicated voltage with a voltmeter or with the simplified resistor unit suggested. The voltages obtained, of course, may vary considerably in different radios. Detailed methods for testing parts which are suspected to be at fault, are given in other sections of this textbook.

Test speaker and audio section by the methods already outlined. Test the R.F. stages and detector by shifting the antenna. For this purpose, the antenna should be long and insulated from the ground. For alignment, if needed, see the special section included. In many sets

of this type, 24-A tubes may be replaced with 35's for better results.

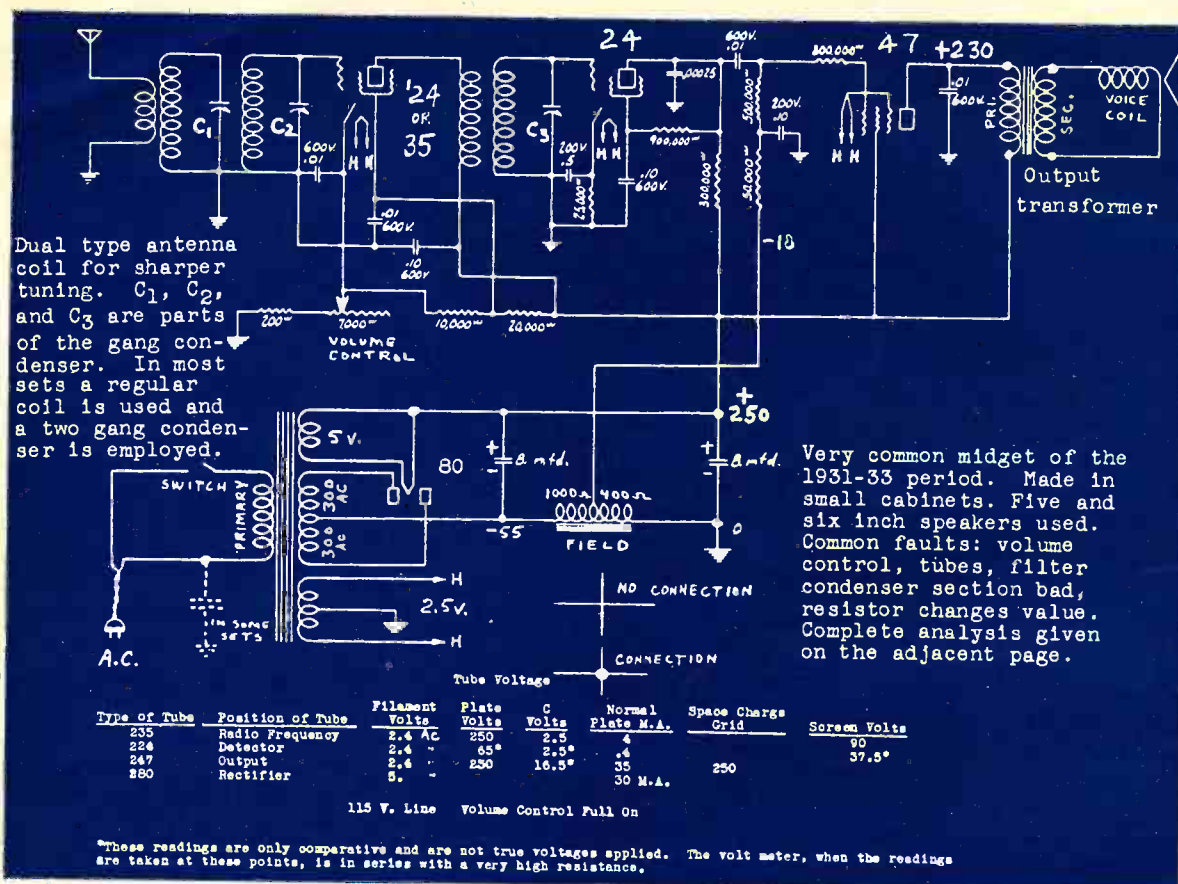
It is important to bear in mind, that only a single fault develops in a radio set, and only this one fault need to be eliminated. Let us assume that in servicing a radio of the type described, you isolated the fault to the second R.F. stage. To test the tube of this stage, simply interchange the first and second 24-A tubes, and apply the antenna test to the second stage. If still no response, probably the trouble is not with the tube.

You obtained a hiss response when you touched the grid of the third R.F. tube's grid. Now trace this grid wire to the second R.F. coil (between second and third R.F. tubes) and see if the very same response is obtained when this coil connection is touched with your finger. Also try the corresponding tuning condenser connection. This will let you know if anything is wrong with the wiring of this circuit.

Short the primary connections of the R.F. coil described in the previous paragraph. A click should be heard in the speaker each time you make this contact. If no click, suspect open primary. To test use the resistor unit, hold one lead on the chassis, touch the other first to the plate side of the coil's primary connection, then to the B+ side of the connection. If you get a spark in one place but not in the other, the coil is definitely open. If you fail to get a spark in both places, no plate voltage exists. Test all condensers connected to the same B+ line.

Coils can be best tested with an ohmmeter. If you have this instrument, use it for measuring the coil resistance. The value will differ with coils and may be as low as 5 ohms, or as high as 50 ohms. But a reading will be obtained if the coils are in good shape. On the ohmmeter, an open coil will test infinity, a shorted coil will indicate close to zero ohms.

ADDITIONAL FACTS ON MIDGETS



If pilot light is on, it will tell you that the transformer is in working order. If pilot light is out, try replacement with a $2\frac{1}{2}$ volt type in sets using $2\frac{1}{2}$ volt tubes. Quickly short filament winding (to 24 tubes) and watch for "hot" but short spark—this will also indicate voltage from transformer.

A small electrolytic (4 mfd., 450 volt unit will do) with long leads makes an excellent test-unit when working on the power supply. Watch the polarity when using this condenser. Always connect the red positive lead to the more positive point. If this condenser is placed into a circuit having a voltage, for ten seconds or longer, and then discharged by bringing together the two leads, a spark will jump across.

With this small electrolytic condenser you can easily test the filter condensers in any power supply (also AC-DC types). Connect this test condenser across one of the filter condensers. The connections of the filter section are first found. Usually one of the connections goes to the chassis. After you find these connections, you touch the test-condenser leads to the two points, observing polarity. Then disconnect and make the test described above. The size of the spark will enable you to judge the voltage present. Lack of voltage probably means a bad filter. Suspected filter condenser may be

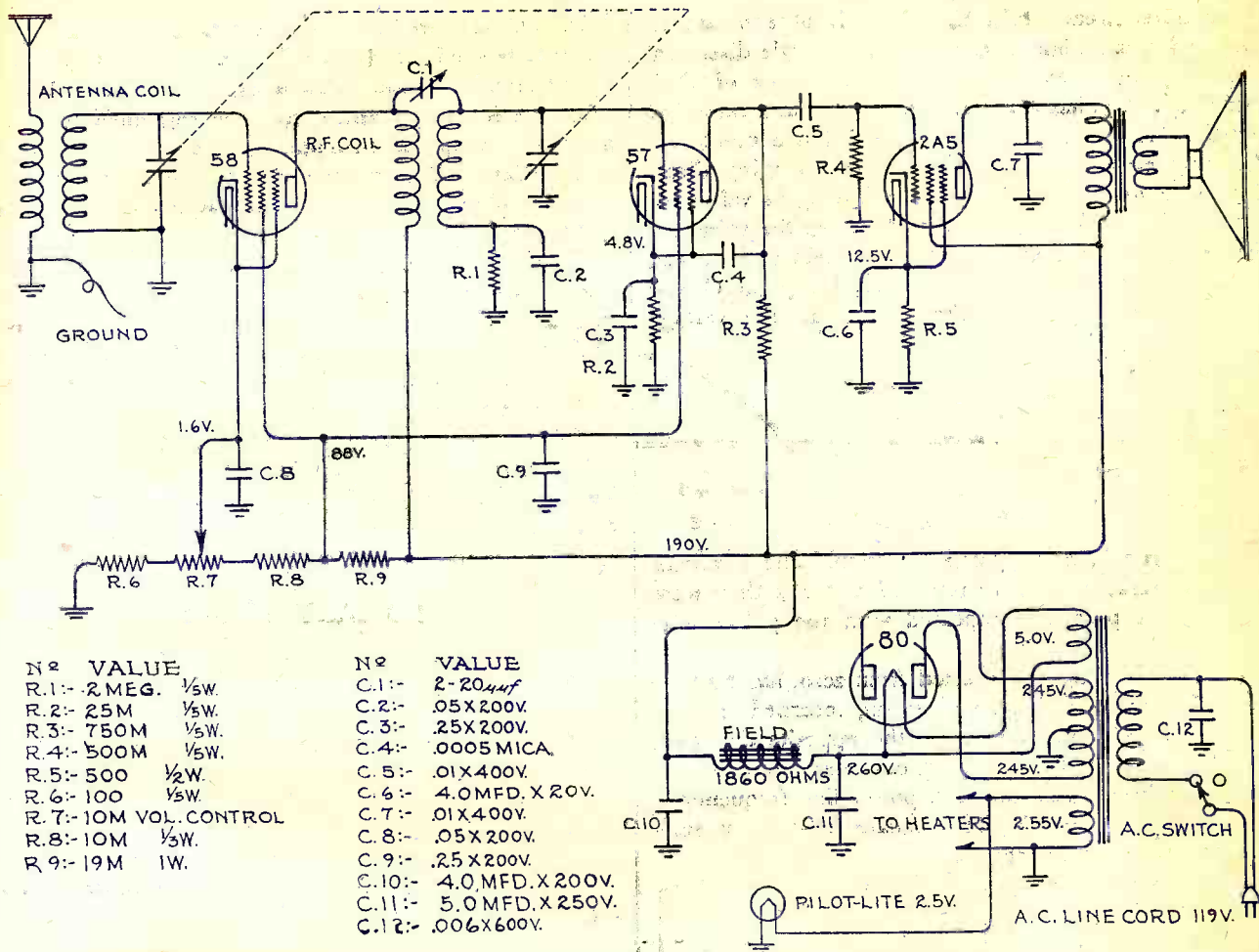
disconnected and your test unit placed instead to see if the set will then work.

In the same way voltage drop in the choke may be tested. This voltage varies in different sets, but should be about 70 volts in most sets. Voltages at other points may also be tested. Resistor unit tester may also be used. Better comparison will be possible with a voltmeter. Many actual voltages are indicated on the chart.

Filter choke may be in positive or negative leg of filter. Bias for output tube type 47 may be obtained with a resistor connected from the center of the $2\frac{1}{2}$ volt winding to ground, or from the cathode of the tube in case of output tubes such as 2A5, 41, 42, 43, 6F6. This resistor is by-passed with 5 or 10 mfd., 25 volt electrolytic condenser (minus connected to chassis).

Tests suggested for larger TRF sets will apply to smaller TRF sets just as well. Touching the grids should create a signal. Removing grid caps of type 24A tubes should create a loud whistle. If you have a pair of cheap headphones, connect one of the terminals of the headphones cord to a .05 mfd., 600 v. condenser. Use the other lead of the condenser and the remaining phone terminal for audio tests. This simple test unit may be used after the detector to receive actual signals. You are safe in connecting this test unit anywhere in the set.

4 TUBE A.C. MIDGETS



The diagram above shows another small TRF set with several differences from the previous circuit. Other tubes are used here. The bias for the 2A5 output tube is obtained with a resistor in the cathode circuit. There is about 16 volts across this resistor, but only 12.5 volts will be indicated on a 1000 ohms per volt meter. The voltages as shown are only suggestive and will differ in sets you are servicing and wish to compare.

The information given for other TRF sets, of course, applies here. We will also give you now more advanced tips and tests. These tests should be used if the simple ones fail to locate the fault. In using the tests, be careful to select the circuit recommended with care—it is an easy matter to work on an entirely wrong stage and obtain wrong results.

If the set works but distorts and whistles at some points, try turning trimmer condensers located above tuning condenser's sections (see *alignment* in index). If whistling oscillations are present on all frequencies and especially at the high end of the band, try shortening plate and grid leads. Keep these direct. Place tube

shields (tight fitting type) if not used originally. These shields must be connected to chassis. Keep wires away from coils. The best place for these coils in such sets is away from other parts. The antenna coil is usually placed above chassis; the R.F. coil below chassis and at right angles to the antenna coil.

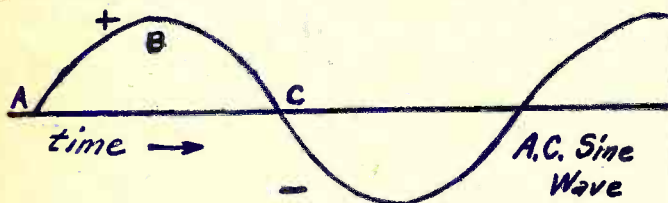
To increase sensitivity and volume, run wires from the grid caps of 58 and 57 tubes, and keeping these wires insulated where they come together, twist them for a few turns. Do not over do this, as whistling will result.

Tuning condenser plates must not touch. Even a single point contact will make the set dead at that spot. May be straightened with a knife. Reversal of a coil connection will diminish response and may stop operation completely.

Rectifier tubes, such as type 80, may have a slight blue glow when used in large sets, none in midgets. Pentodes used in the output stage have a normal purple-blue glow. Triodes should have no internal color under proper operation.

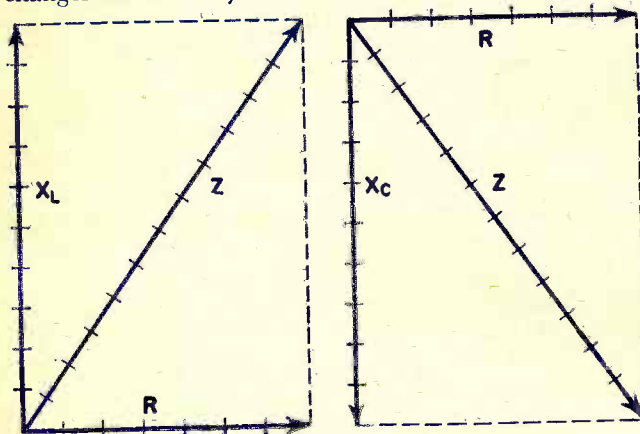
BEHAVIOR OF A.C. IN CIRCUITS

We have already said that D.C. is of constant or varying intensity, but always flows in a single direction. This may be taken to mean that a source of D.C. potential always has one terminal positive and the other negative. Alternating current (A.C.) has a constantly changing magnitude and periodically changing direction. First one terminal is positive having its value rising, see chart below points A to B. Then the value begins to fall, but the same terminals remain positive and negative as before, see B to C. At the point C, the voltage present is zero. After this point the voltage



begins to rise in the opposite direction. The terminals of this generator are now reversed to what they were before. The process is repeated with the polarity reversed.

When the voltage has started from zero, has risen to its maximum value in one direction, returned to zero, risen to the maximum value in the opposite direction, and then returned to zero again, one complete cycle has been completed. The common power line frequency is 60 cycles per second. This means that sixty such changes occur every second.



INDUCTANCE AND
RESISTANCE

CAPACITY AND
RESISTANCE

Inductance (choke coils) opposes changes in current intensity. Because in an A.C. circuit the voltage is constantly varying, the current also will vary in accordance. But any inductance present will attempt to prevent a change in the current, and the current will lag (fall behind) the voltage. In a pure inductive circuit (no resistance being present) the current will lag 90° behind the voltage.

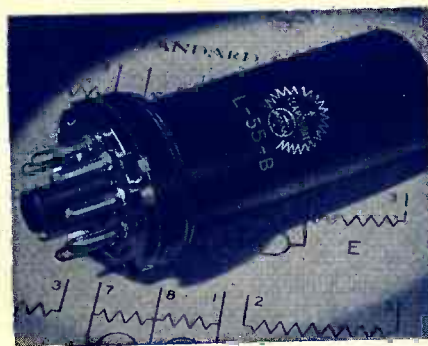
In A.C. circuits both inductance and resistance have an opposing effect. Inductive opposition is calculated by means of a formula and is called *reactance*. When resistance is also present, it must be combined with reactance in a special formula, and the result is known as *impedance*. Both reactance and impedance are measured in ohms since they are similar in some ways to resistance.

Capacity makes the current lead the voltage and also has reactance. If capacity and inductance are present in a circuit, they act in opposite ways, so that the resulting reactance is the difference of the two. In some circuits they (reactances) may completely eliminate each other for a definite frequency.

The relationship between resistance R , inductive reactance X , and impedance Z , is shown in the drawing. The phase angle tells by how much the voltage and current are apart.

BALLAST TUBES

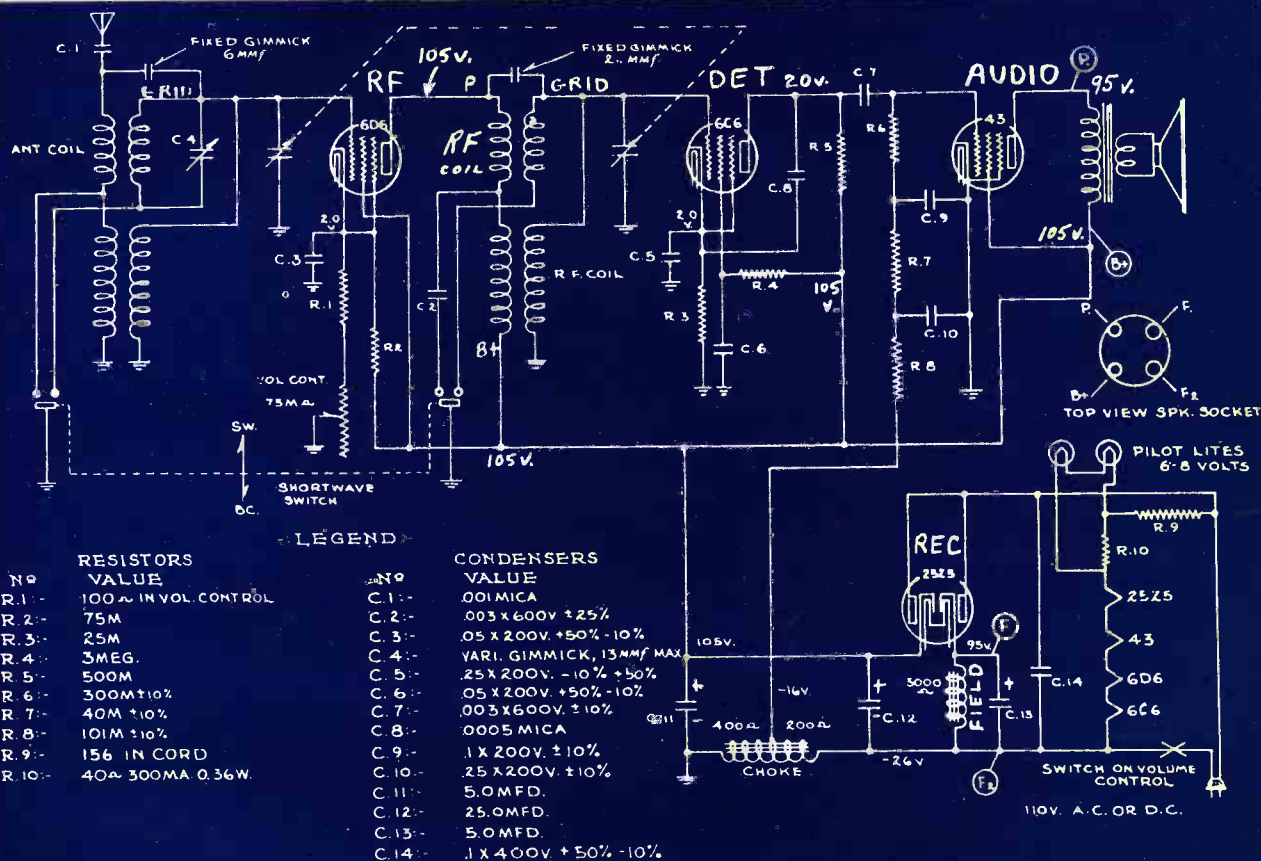
Ballast tubes are used in AC-DC radio sets and are resistors built to appear as tubes. A ballast tube does not need to have a vacuum and may be opened. These resistors, as they can more properly be called, are used to produce a voltage drop in sets having the tubes wired in series. For example, if the tubes used need 69 volts total, the remaining 46 volts of the 115 volt line may be lost in the ballast tube. At times several such tubes are used in series.



Since the ballast tube is a resistor, it may be replaced with a resistor of about 25 watt size and correct resistance. Replacements are also available at about 25c each.

In the standard series, the first letter K means that a 6 to 8 volt, 150 ma. pilot bulb is to be used. L means a similar 250 ma. bulb. The number following means the voltage drop in the resistor of the tube. The last letter designates the base wiring.

4 TUBE AC-DC MIDGETS



Similar tubes used in other sets are corresponding to 6D6: 78, 6K7, 12K7
 " " 6C6: 77, 6J7, 12J7
 " " 43: 25A6, 6F6, 38
 " " 25Z5: 12Z3, 25Z6, 35Z5

In wiring tubes in series, the detector (6C6 in this case) should be closest to chassis potential. If pilot lights pass less than .3 amp., they must be shunted with a resistor, R₁₀ in circuit.

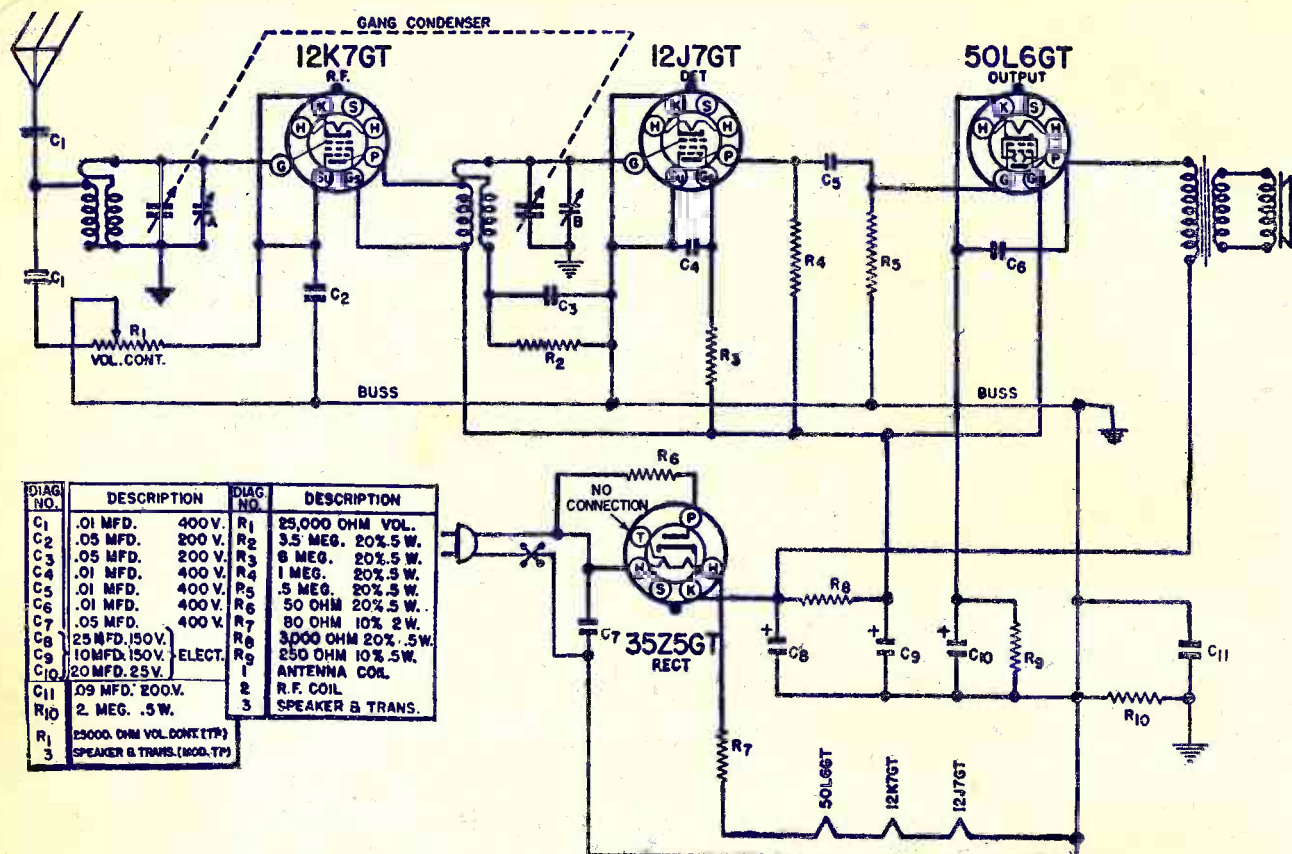
All AC-DC type of radios may be operated on A.C. or D.C. voltage, but for D.C. operation the plug must be placed in the socket the correct way. Most of these sets are used for A.C. operation and that is why the rectifier tube is included—for D.C. operation no rectifier is needed but may be left in the circuit.

The main difference between the AC-DC and regular A.C. sets lies in the power supply and the fact that the tubes operate with lower plate and screen grid voltages. Please examine the power supply circuit in the lower right of the blueprint. You will find the tubes connected in series. This requires that all tubes have the same current consumption, .3 amp. for the ones used in the circuit. If all the tubes in series do not require 110 volts of the supply, the difference must be *dropped* in a line cord or ballast tube. To figure out this re-

sistance, add total voltage used by all tubes and subtract this amount from 110. The result is the voltage to be lost in resistor. Divide this voltage by 0.3 (current) and the answer is the resistor needed in ohms.

No transformer is used and the voltage is applied directly to the rectifier tube plate (two used in 25Z5). The cathode *supplies* about 120 volts D.C. The actual voltage obtained depends on value of first filter condenser. The bigger this condenser, the more voltage obtained. One cathode of the 25Z5 serves the radio plate supply, while the second supplies current to excite the speaker field. Sometimes low resistance (under 1000 ohms) field is used for filter (choke) and the two cathodes may be connected together. Choke also may be in positive leg. In this case choke supplies bias for output tube; in some sets a resistor in cathode circuit is used instead.

4 TUBE AC-DC MIDGETS



Outside of power supply, circuit is similar to any other small TRF set. Voltages are lower at all corresponding points. No ground is to be used since chassis is automatically grounded through one side of the line (power lines usually have a ground circuit). Antenna lead should have a small condenser for safety. If antenna wire, with condenser in circuit, is touched to a steam or water pipe, no spark should be present. If spark is noticed, reverse power plug in socket.

Two-band tuning is made possible by shorting out some of the turns of the coils. Most midgets of this type, however, are for single band reception. The fixed gimmicks indicated as parts of the coils, are pieces of wire connected to antenna terminal in the antenna coil and to the plate terminal in the R.F. coil. These wires are twisted about the coil once or twice and act as a small coupling condenser.

The complete simplified process of servicing a four tube AC-DC midget will now be given. Many of these factors have already been presented before. To begin, connect cord and turn the set on. Examine tube filaments. If one tube is bad, all will be lacking filament current. To test for a bad tube, short circuit for an instant the filament of a single tube, using a piece of wire. When the bad tube is shorted in this manner, the other tubes will light. Replace bad tube.

If tubes light, test for plate voltage at rectifier cathode, positive connection of electrolytics, or SG of output tube. Resistor-spark test may be used. Or you can use an electrolytic condenser test for voltage. And, of course, if you have a voltmeter use it. Voltage lacking means: (1) bad filter condensers, (2) open field or choke, (3) bad rectifier tube but filament lights, and (4) some by-pass condenser bad.

Disconnect suspected condensers one at a time and see if voltage is then present. Only one lead need to be disconnected, and this should be placed back before testing the next condenser. A small voltage (under 40 volts in AC-DC sets) should develop across the choke; test for this. Too much voltage means open choke, lack of voltage means short. To test for emission of the 35Z5, or similar rectifier tubes, disconnect leads from both cathodes. Touch positive lead of the test electrolytic condenser to one cathode and hold minus lead of condenser to ground. After an instant, see if the condenser became charged. Try the other cathode. Poor charge means a bad rectifier tube.

Wire two leads to a 250,000 ohm, 1 watt resistor. Shunt this resistor (in parallel) across each of the high value resistances, such as R₂, R₄, R₆, while the set is on. If some resistor is open, you may get operation with the replacement.

USING SIMPLIFIED TESTS

SIMPLIFIED COMPARISON TEST CHART

Part in CIRCUIT	Voltage Across	Test with C*, R*, R _h *, F*	
		Results if part is good	Results if part is bad
C ₂	3 to 15	Test R. Maximum volume	Maximum volume always
C ₄	30	R _h . No change, distorts	Works badly, open cond.
R ₃	10	R _h . No change.	Operation obtained.
R ₂		F. Hum, hiss, not much	No change or loud noise
C ₅		F. Click, hiss.	F test, click on one side, not on the other.
R ₄	50	C. Small charge	Large charge, open R ₄
C ₆	105	C. Large charge.	No charge, shorted C ₆ .
R ₅		R _h . Little change.	Operation obtained.
C ₈ , C ₉	110	C. Powerful charge.	No voltage, shorted C.
R ₈	20	R. More hum.	Operation. Hum.
C ₁₀ , R ₉	15	C. Small charge.	No charge, better tone
R ₆	AC	R. No change.	Operation, voltage if missing before test.
R ₇	AC	R. Tube filaments a little brighter	Operation obtained.

This chart has been included to suggest to you and remind you of the many simplified tests which have been outlined so far in the text. The suggested tests* indicated by C, R, R_h, and F, are familiar to you, but will be briefly reviewed at this time.

By the C test we mean the use of a fixed condenser (about one mfd. paper type) to test the presence of voltage. If voltage is present between two points, this condenser may be charged by having its terminals in contact with these points.

The test using R, is the employment of a 100 ohm, 1 watt resistor. By R_h we mean a high value resistor, about 250,000 ohms. These values are not critical, of course.

By F we mean finger contact test. The majority of points in the circuit which are sensitive enough to respond to contact are safe to touch. Grid caps for example. You may also use the end of the antenna wire for contact tests.

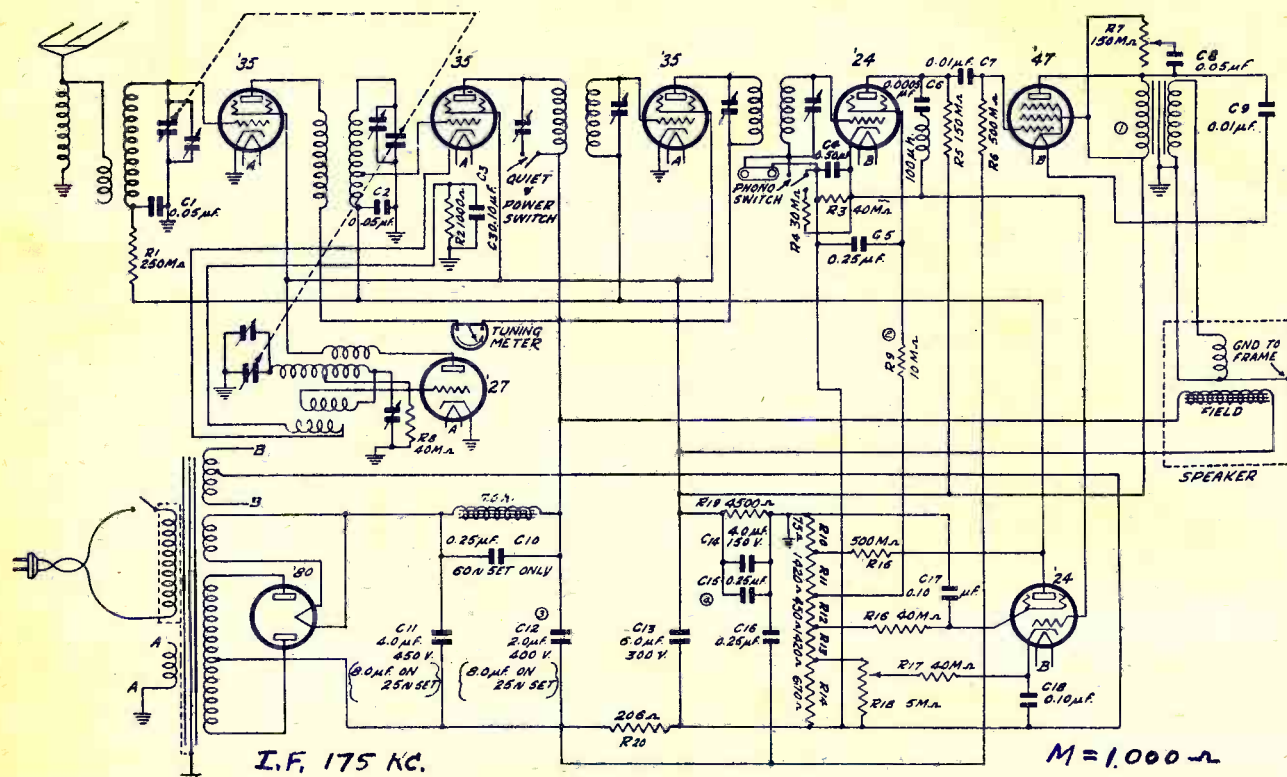
In compact AC-DC midjets the most common faults develop in filter condensers, pilot lights, tubes, line cord, volume control, and antenna coil primary. If you suspect the first stage, connect antenna through a .01

mfd. condenser to plate of first tube—this will cut out the first stage. If you suspect the speaker, connect headphones in series with a small condenser across output transformer secondary. Advance volume control to maximum. Operation with phones but not with the speaker will indicate fault in V.C. of speaker, or bad output transformer usually develops in the primary winding, to test connect headphones in series with condenser across primary. Operation indicates that primary winding is not open.

The resistor R₆ in the plate circuit of the rectifier tube (35Z5-GT) prevents sudden surges of current. It is a good idea to add a 50 ohm ½ watt resistor in all AC-DC power supplies that do not have this part. In some midjets which use a 35Z5 rectifier, the tap connection of the filament is used in conjunction with the pilot bulb. Part of the filament in parallel with the pilot bulb pass the plate current and take the place of the resistor described. Refer to the circuit on page 53.

In some AC-DC sets the ground returns are made to a common buss, but not to the chassis. The buss and chassis are connected through a by-pass condenser and resistor of several thousand ohms.

SUPERHETS 1930-1935



The advantages of the superhet circuit were incorporated in circuits of the period beginning with 1930. Tubes of the 2.5 volt series (numbers in the 50's) were available. Before pentagrid converter tubes such as 2A7, and the similar 6.3 volt tube 6A7, made their appearance; a type 35 or 57 was used as the mixer tube, with a 27 or a 56 triode as a separate oscillator. In many sets, similar 6.3 volt tubes were also used. Sometimes a single pentode, in a special circuit, combined the function of the mixer and oscillator.

Your knowledge of power supply and signal tests may be carried over to superhet circuits. Variations especially applicable to this circuit will now be discussed.

The first 35 tube serves in the R.F. preselector stage. Many sets omit this stage. You may omit this stage in testing by connecting antenna lead through a .01 mfd. condenser to plate terminal of this 35 tube socket. The volume control in the AVC circuit (lower right hand corner) is used to reduce the sensitivity and, thereby, reduce inter-station noise which is very loud between stations, but drops down when a station is tuned in. See section on AVC, page 54.

To find out if oscillator section is working in this set, break plate connection of the second type 35 tube, and insert headphones (no condenser) in this circuit. If you can receive a station on headphones, oscillator section is not working. If no signal or whistling is present, probably the oscillator is okay.

Shorting condenser C_1 or C_2 , will eliminate AVC action and will increase the signal. Please notice how R_{20} serves to produce the bias of 15 volts for the 47 output tube.

The oscillator coil is of a special type. There is a grid coil, and a plate coil to feed a signal back to the plate. And there is a third winding used to inject the oscillator signal into the cathode circuit of the 35 mixer tube. The number of turns on the grid coil is critical, but the other coils are not critical. It is, therefore, possible to repair a coil of this type — replacements are difficult to obtain.

The oscillator section of the gang condenser has specially shaped plates and no padder condenser is needed. (See page 52.) The order of use of the gangs of the condenser varies in different sets. You should find these sections and their trimmers by studying the circuit and tracing a few connections.

The tuning meter connected in the plate circuit of the first type 35 tube is a 0-5 or 0-10 ma. meter of special design. When the radio is most accurately tuned to a strong carrier, the A.V.C. will develop strong bias on tubes controlled, including the first type 35 tube. The plate current of this tube will be reduced and will be indicated on the tuning meter. Best adjustment is indicated by extreme movement of the needle to one side.

6D6
1st DET. & OSC.

6D6
I.F.

6C6
2nd DET.

41
OUTPUT

LINE VOLTAGE 115 VOLTS. VOLUME CONTROL ON FULL. ANTENNA GROUNDED RANGE SWITCH SET ON BROADCAST POSITION. SET TUNED TO 530 KC.

456 KC. I.F. FREQUENCY

84 RECT.

5" SPKR.

FRONT OF CHASSIS

VOLTAGES MEASURED BETWEEN SOCKET TERMINALS AND CHASSIS
BOTTOM VIEW

RECT. 84
275A.C.
59A.C.

OUTPUT 41
59A.C.

2nd 6C6
180
25
40
59A.C.

6D6
100
115
17
190
31
360
59A.C.

IMPORTANT: Use a high resistance voltmeter of 1000 ohms per volt. Readings will vary depending upon voltage range of meter, being higher for higher range instruments. This variation is most marked for second detector plate voltage.

Diag. No.	DESCRIPTION	Diag. No.	DESCRIPTION
1	3000 Ohm 1/4 watt Carbon Resistor.....	19	.02 mfd. 400 volt Paper Condenser.....
2	250,000 Ohm 1/4 watt Carbon Resistor.....	20	.001 mfd. 400 volt Paper Condenser.....
3	250 mfd. Mica Condenser.....	21	.01 mfd. 400 volt Paper Condenser.....
4	.012 mfd. 1000 volt Paper Condenser.....	22	8 mfd. 350 volt Electrolytic Condenser.....
5	Bial Lamp, 6-8 volt.....	23A & B	5 Gang Variable Condenser.....
6	110,000 ohm 1/4 watt Carbon Resistor.....	24 A	[Volume Control, 22,000 ohm]
7	1.1 megohm 1/4 watt Carbon Resistor.....	25	[Line Switch]
8	51 mfd. Mica Condenser.....	26	Range Switch.....
9	10,000 ohm 1 watt Carbon Resistor.....	27	Output Transformer.....
10	70,000 ohm 1/4 watt Carbon Resistor.....	28	1 mfd. 150 volt Paper Condenser.....
11	456 KC. Wave Trap Trimmer.....	29	Tone Control Switch.....
12	500 ohm 1/2 watt Wire Wound Resistor.....	30	1/2 Amp. Fuse.....
13	8 mfd. 350 volt Electrolytic Condenser.....	31	Diaphragm and voice coil.....
14	200 ohm 1/2 watt Wire Wound Resistor.....	32	1st I. F. Transformer.....
15	320 ohm 1 1/2 watt Wire Wound Resistor.....	33	2nd I. F. Transformer.....
16	456 KC. Wave Trap Coil.....		Power Transformer, 115 V-60 cycle.....
17	Antenna Coil.....		
18	Oscillator Coil.....		

51

ALIGNMENT AND I.F.

In order for a radio receiver to select the signal of a single station at one time, the various stages must operate, for any one setting of the dial, in a correct manner. In the TRF set all tuned sections should be tuned together to the desired station and must be aligned (adjusted) to receive the same frequency at the same setting of the tuning condenser.

In the superhet the problem of alignment is a little different. In selecting any station, the R.F. section must be tuned to the frequency of this station, but the oscillator is tuned, at the same time, to a frequency equal to the incoming station frequency plus the frequency of the I.F. stages. For example, you tune in a station operating on 900 KC. Assume the I.F. of this set is 456 KC. For proper operation at this point the oscillator frequency must be $900 + 456$, or 1356 KC.

It is not often that a set needs alignment. For best results a signal generator and an output meter should be used for alignment. But for the broadcast band a passing job can be done without equipment. The methods will be outlined below. For use of a signal generator see the section on instruments, page 70.

In practically all TRF type sets, the trimmers are located above the variable condenser sections. These trimmers are semi-adjustable condensers. The settings may be changed with a small screw driver. Since the metal of the tool may have an effect, a special screw driver made of insulating material may be purchased or made.

To align a TRF set without equipment, tune in a station on the high frequency end of the dial (at about 1400 KC.) and turn all trimmers until best and loudest reception is obtained.

In all cases of alignment, the manual volume control is advanced until the signal is audible. As the alignment makes the set work better, the output will become louder. This can be corrected by reducing the volume with the control as need arises. In sets with AVC, adjust for maximum volume also, but remember that the automatic volume control will try to keep the output at a fixed level. Because of this let the amount of background hiss and noise help you judge the proper point of alignment. Minimum background noise with maximum volume for any setting of the volume control should be your guide.

If a tuning indicator or tube is used, this may be employed as the indicator. The indication of correct tuning will also serve to indicate correct alignment.

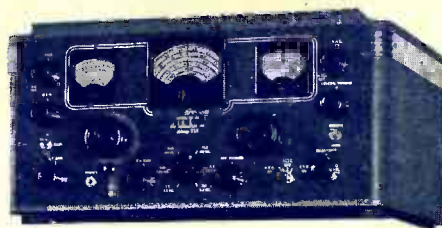
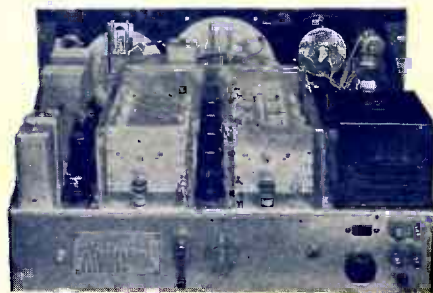
In a superhet, the I.F. transformers used must be *set* for the frequency of this section. At first, it is safe to assume that the I.F. transformers are not much off and may be left alone. Now tune in a strong local station having a frequency of about 1400 KC. Let us say in your locality you have a station operating at 1350 KC.

You turn the dial to 1350 KC., but find that the station will come in best at 1370 KC., or 137 on the dial. Set the dial on 1350 KC. anyway. Find the trimmer mounted above the condenser gang which tunes the oscillator coil. (In multi-band sets this trimmer will be inside of the can housing the oscillator coil). Turn this trimmer until the signal comes in as loud as possible without changing the volume control. Turn slowly, observe results.

Now turn the trimmer of the antenna section gang (also the R.F. trimmer, if used in the set). The set screw may have to be turned in one direction or another.

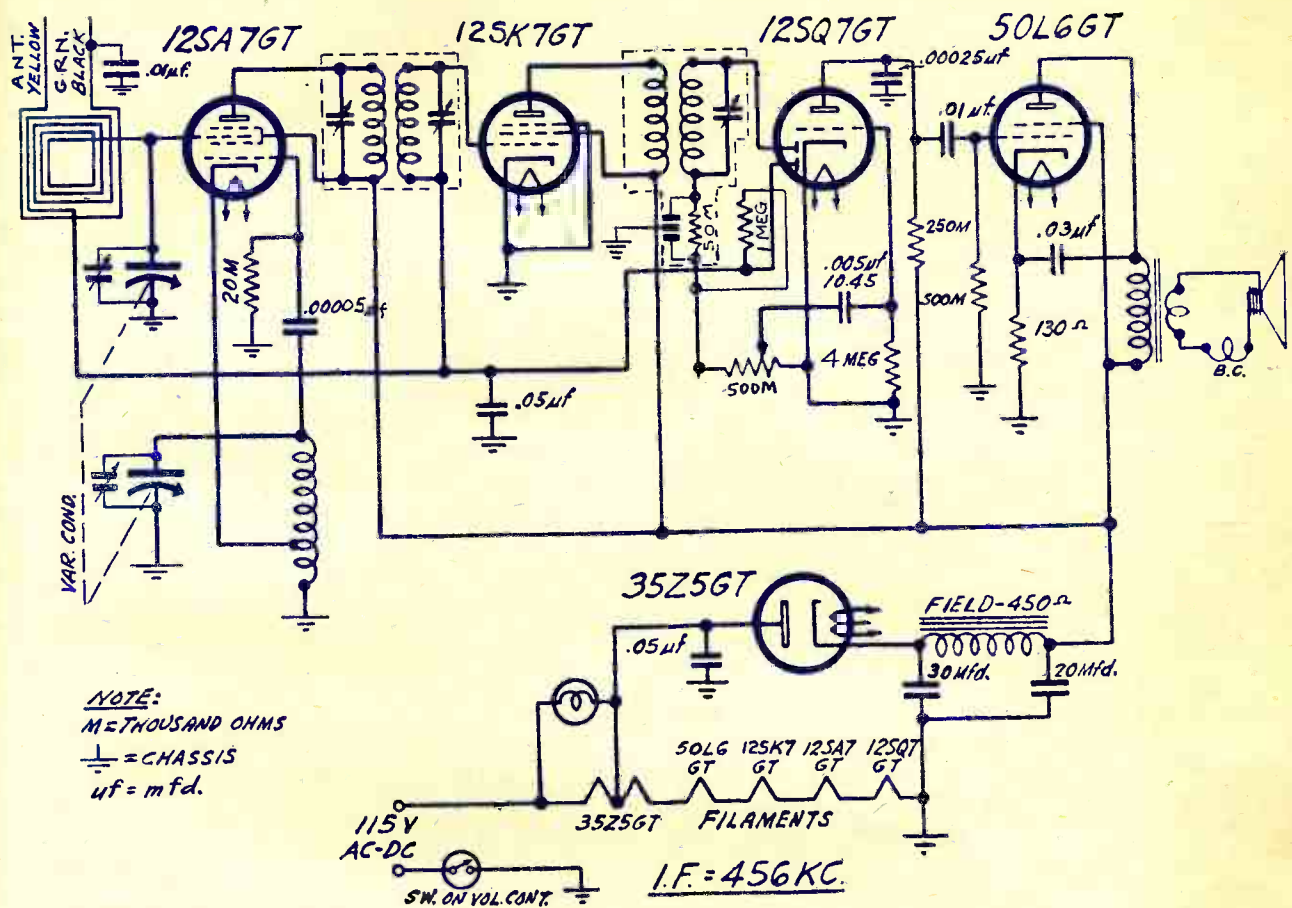
Now tune in a station at around 650 KC. Find the padder condenser which is usually mounted near the oscillator coil. While the station comes in, rock the tuning dial a little up and back past the point where the station comes in, and adjust the padder for loudest response. If the super uses a cut section tuning condenser, the outside moving plate of the oscillator section may have to be bent a little. The metal plates of a condenser must not touch, however.

Now go back to about 1400 KC. and check up on your work. Readjust a little. The trimmers of the I.F. transformers may be turned a little at this time. Be careful not to turn these too much.



The illustrations above show two views of a modern communications receiver. Such sets are difficult to align. Good quality signal generator should be employed and factory instructions should be followed. Fortunately, such sets do not get out of alignment very often.

AC-DC MODERN SUPERHETS



Many of the smaller radio sets you will service will correspond to the circuit shown on this page. You will find these sets housed in very tiny bakelite cabinets, or in larger plastic or wood cabinets. The loop antenna is incased in the rear cover, but some of these sets used a regular wire antenna.

As with other sets, first check to see that filament power is available. If tubes are not *lighted*, test with resistor to find burned out tube. Usually the total line voltage is needed for the filaments connected in series and no dropping resistor (or ballast) is used.

Majority of similar sets use a P.M. speaker (no field needed). Filter uses 3,000 ohm resistor. Plate supply for output beam power tube (50L6-GT in this case) in case resistor filter is used is taken directly from rectifier cathode. Test as any other AC-DC supply.

If filaments are receiving current, and B+ available at test points, reduce volume control setting, place finger or long wire lead on control grid of output tube 50L6. If you need help in finding where control grid of this tube is, refer to schematic and find associated parts or

look up the base connections of this tube in charts, page 29. If the final stage, loudspeaker, and the power supply are functioning correctly, hum will be heard when contact is made with the grid. Advance volume control and make the same test on the control grid of the triode section of 12SQ7-GT, or the tube used in the set you are testing in the corresponding position. Much louder results should be obtained. Lack of the expected results indicated trouble in section being tested.

Proceed back in similar manner to antenna. Have volume advanced while carrying on these tests. If you suspect some stage, make tests for voltage with condenser. If you have a meter use it instead. Test for voltage while the set is "on" and be sure it is "off" when using the ohmmeter.

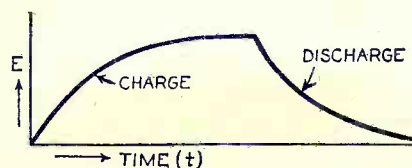
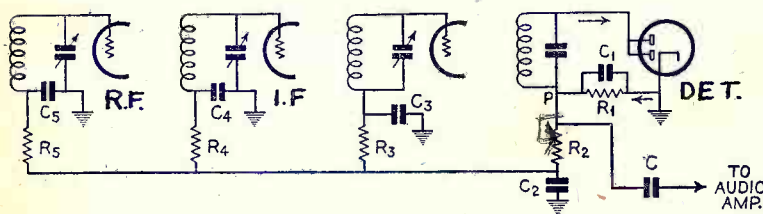
Faults commonly develop in the pentagrid converter tube although it may test *good* in a tube tester. Try a replacement if one is available. Need for alignment comes about gradually, never suddenly stops the radio from operating. Poor sensitivity, whistling between stations, reception of two stations together, may be blamed on alignment. Refer to page 52.

FACTS ABOUT A.V.C.

There are numerous varieties of automatic volume control circuits, but they all work on the same principle. The A.V.C. is intended to maintain the strength of the signal arriving at the detector stage nearly constant, thus compensating for different signal strengths of stations and correcting the effect of fading. A.V.C. does this by automatically varying the sensitivity of the R.F. and I.F. amplifiers. Actually the A.V.C. changes the bias on these tubes to secure this action. The actual volume, of course, is not kept constant but depends on the sound coming through at the moment.

tions, and gives the A.V.C. a needed time-delay action. Since the condenser, which is in series with the resistor R_2 , forms a path for alternating currents, the audio signal (being A.C.) will pass through C in preference to following the more impeding paths through R_8-C_8 , R_4-C_4 , and R_5-C_5 .

If the automatic volume control action followed the signal instantaneously no operation would be possible. The action would in such case flatten out all audio sounds to a single volume level. The resistor R_2 in combination with condenser C_2 delay the action since a



Courtesy Aerovox "Research Worker"

The schematic above shows an A.V.C. system often used in up-to-date sets. Forgetting for the moment the grid return resistors in the R.F. or I.F. circuits, let us begin with the diode detector. When the signal gets to the detector, it has been amplified and is quite high. Here the signal is rectified. Current can flow only when the diode becomes positive and the coil must be considered as a generator. This will help to explain why the resistor R_1 will carry current in the direction of the arrow. We are assuming for this discussion that electric current moves from positive to negative. This will make the point P negative with respect to the cathode of this tube and the chassis.

The current flowing between P and the chassis consists of a direct current component, a radio frequency component, and an audio frequency component. The condenser C_1 has been placed across the resistor to pass most of the R.F. currents and the audio frequency component is taken off to be applied to the grid of the next audio tube by means of the coupling condenser C.

The steady voltage at P, which is proportional to the strength of the incoming signal, must now be fed back to the R.F. and I.F. amplifiers. The audio component, however, must be kept out of the R.F. and I.F. stages, and steps must be taken to prevent inter-coupling between these stages. This latter requirement is accomplished by the network of resistors and condensers. Since the grids of the amplifying tubes are never drawing current, it does not matter, within limits, how much resistance is placed between point P and the individual grids.

Resistor R_2 and condenser C_2 form a resistance-capacity filter which smoothes out most of the audio fluctua-

time passes between the charging and discharging of this condenser through the resistor. This delay makes the A.V.C. system operate from the *average* carrier intensity instead of each individual audio variation.

The amount of time required to charge this condenser to 63% of its maximum value or to discharge this condenser to 37% of its original voltage, when expressed in seconds is equal to resistance in megohms multiplied by capacity in microfarads.

In any radio set if the condenser, which corresponds to C_2 in the circuit above on this page, shorts, the radio will play very loud on all stations and the background hiss will be present. If the resistor corresponding to R_2 opens, or changes greatly in value, the tone will be distorted and the A.V.C. may not function.

In many sets resistor R_2 is the volume control. This control must follow the tube used for A.V.C., because if the signal strength is reduced before this point, you can see that the A.V.C. will try to restore the output to the same level.

In some of the older radios a separate A.V.C. tube is used (see circuit on page 50). If you believe that is the case in the set you are servicing, to test simply find this tube and remove it from the socket. Much louder operation will result.

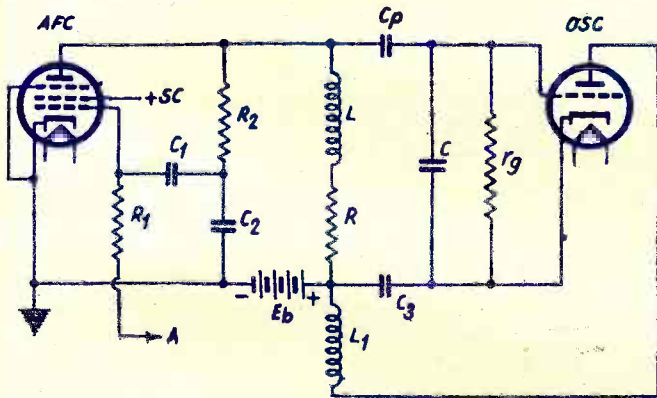
In some sets the A.V.C. voltage is amplified in an additional tube. In all sets with A.V.C. there is a loud hiss-noise between stations. This is due to the set becoming very sensitive when there is no station producing a signal on any point of the dial. In some sets to overcome this, a Q tube is included. This tube automatically silences the radio until a carrier of a station is actually tuned in.

AUTOMATIC FREQUENCY CONTROL

In a limited number of radio sets using push button tuning, automatic frequency control (AFC) has been incorporated. This circuit permits proper reception of a station even when the radio is not tuned exactly.

In any superhet receiver, the station frequency combines with the oscillator frequency to produce the I.F. If the set is not tuned properly, the station's frequency will be present in reduced intensity, but the oscillator will produce a different frequency than that required. Whether the detuning is above or below the station will make little difference. In each case, the oscillator will produce either a higher or a lower frequency than needed to combine with the station frequency for the I.F. And you know, if the I.F. frequency is off, the intermediate frequency stages will not permit the signal to go through.

If a radio is incorrectly tuned, the above described facts will occur and the voltage (of the signal) in the I.F. stages will be reduced. But it will be reduced in a similar manner whether the error in tuning happens to be in one direction or another.



Phase difference saves the day. The phase differs in detuning above or below the proper point. In AFC circuits a discriminator is used to produce a voltage in accordance with the amount of detuning of the radio. This circuit also takes into account in which direction the detuning is made.

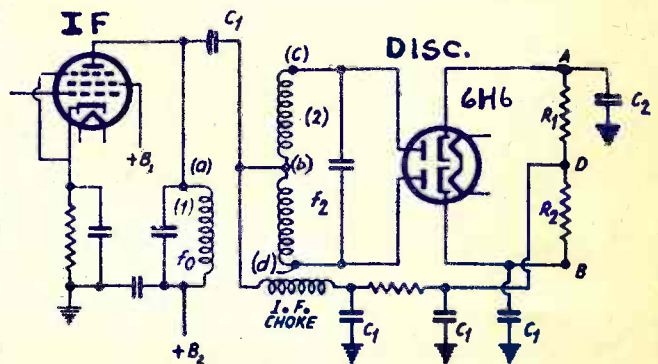
Now we must come back to our story of the superhet circuit action. If the set is detuned a little, the station's frequency will get through but will be a little reduced in intensity. However, the set will not work because the oscillator frequency will be wrong (because of the detuning) to produce the right I.F. If we could change at this time the oscillator frequency to be different by the required amount to combine with the station frequency and produce the proper I.F., all would be well.

This change, of course, can be made by turning the padder condenser, but we want this action to take place automatically. You remember we have a voltage which

depends on how far the set is detuned, or (what is the same thing) on how much the oscillator will have to change its frequency to permit the set to work.

And this voltage from the discriminator (usually a diode tube like the 6H6) is just what is used for this purpose. But the voltage first must be changed to act like an inductance or capacity.

Radio tubes shift the phase by a definite amount and in this respect act as inductances. The amount of shift can be made to depend on the bias voltage. By connecting a tube in a proper manner to the oscillator circuit of the superhet, and by controlling the bias of this tube from the voltage of the discriminator, we can realize automatic frequency control.



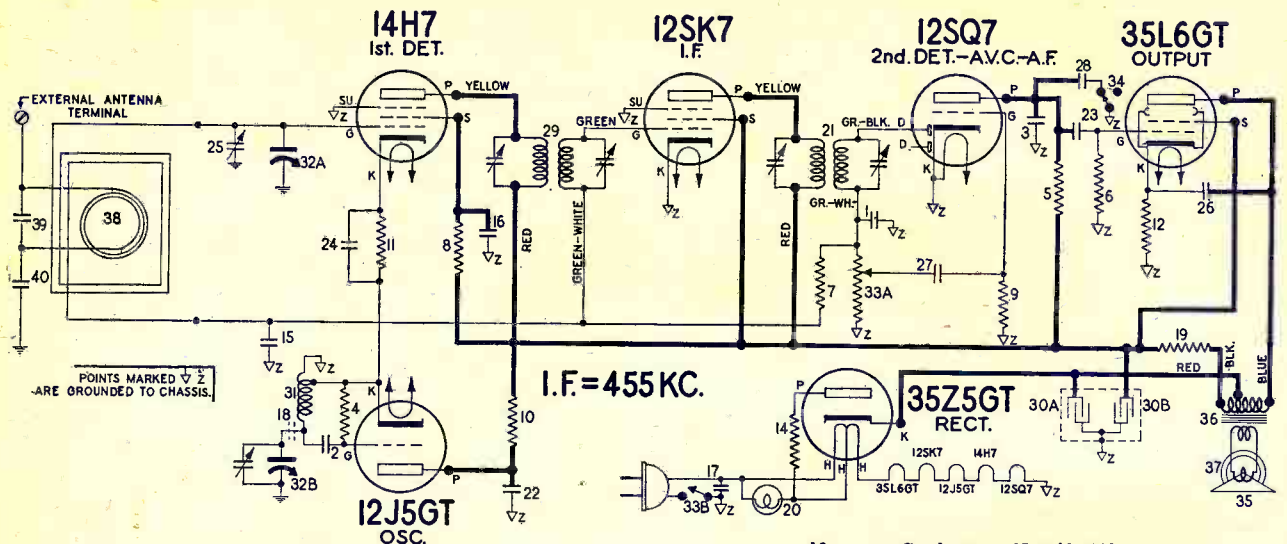
In examining the above circuit of the discriminator, you will notice that the I.F. tube feeds a special split-secondary transformer. This unit with the diode circuit develops a voltage across points A-B, depending on the amount of detuning and having a relationship with the direction of detuning. This voltage is applied to the circuit of a special AFC tube and usually controls the grid voltage of this tube. This tube acts as shunt inductance with the oscillator coil and has an effect on the oscillator frequency. Please notice that if the set is tuned correctly, the voltage developed is zero and the oscillator operates at the normal correct frequency.



Courtesy Cornell-Dubilier Elec. Corp.

Condensers and condenser-inductance combinations are used in interference filters to prevent man-made static from reaching radio receivers.

SEPARATE OSCILLATOR SUPER



- | | |
|-------|--|
| 1 | Condenser—mica, 260 mmd. |
| 2 | Condenser—mica, 110 mmd. |
| 3 | Condenser—mica, 510 mmd. |
| 4 | Resistor—carbon 47,000 ohms 1/4 watt. |
| 5 | Resistor—carbon 220,000 ohms 1/4 watt. |
| 6 | Resistor—carbon 470,000 ohms 1/4 watt. |
| 7 | Resistor—carbon 2.2 meg. 1/4 watt. |
| 8 | Resistor—carbon 68,000 ohms 1/4 watt. |
| 9 | Resistor—carbon 3.3 meg. 1/4 watt. |
| 10 | Resistor—carbon 680 ohms 1/4 watt. |
| 11 | Resistor—carbon 1200 ohms 1/4 watt. |
| 12 | Resistor—140 ohms, 1 watt W.W. |
| 13 | Condenser—.2 mfd. 600 volt (206C) |
| 14 | Resistor—33 ohms 1 watt W.W. |
| 15-17 | Condenser—.05 mfd. 600 volt. |
| 16 | Condenser—.01 mfd. 600 volt. |

- | | |
|----------|--|
| 18 | Condenser—.05 mfd. 600 volt |
| 19 | Resistor—carbon 1,500 ohms 1/2 watt. |
| 20 | Lamp—dial (Mazda No. 47). |
| 21 | Transformer—2nd I.F. |
| 22-23-24 | Condenser—.01 mfd. 600 volt. |
| 25 | Condenser—trimmer (loop) |
| 26 | Condenser—.02 mfd. 600 volt. |
| 27 | Condenser—.004 mfd. 600 volt. |
| 28 | Condenser—.002 mfd. 600 volt. |
| 29 | Transformer—1st I.F. |
| 30A-30B | Condenser—Electrolytic (A-40 mfd. 150 volt B-20 mfd. 150 volt) |
| 31 | Coil—oscillator |
| 32A-32B | Condenser—variable tuning with drum |
| 33A-33B | Volume Control—1 meg. (with switch) |
| 39 | Condenser—mica, 110 mmd. |
| 40 | Condenser—.01 mfd. 600 volt |

A modern superhet using a separate oscillator tube will be explained next. Quickly examine the circuit. The antenna coil is in the form of a large loop and, thereby, serves as the coil and the source of signal pickup. Provisions are incorporated for connecting an outside antenna if desired. No outside ground should be used with an AC-DC type radio set. A separate oscillator tube, type 12J5-GT, is used. The use of a separate oscillator gives higher I.F. signal to noise ratio, increases possible gain in the mixer tube, and segregates the tuning circuits. Please notice that the cathode (K) of the oscillator tube is connected to a tap of the oscillator coil (part 31) and not to the ground. The cathode bias resistor of the 14H7 mixer is also returned to this tap. The oscillator signal is, therefore, injected into the mixer (1st DET.) through the cathode. You have probably noticed that smaller superhets do not have R.F. pre-selectors.

The I.F. stage is of a standard type. Type 12SK7 tube is used. Notice the color code used for the leads of the I.F. transformers. The I.F. transformer feeding the diode detector is of a special type with the primary and secondary of the transformer placed closer together. The type 12SQ7 tube combines a diode detector which

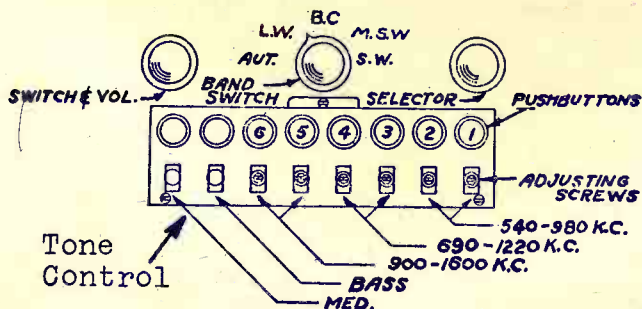
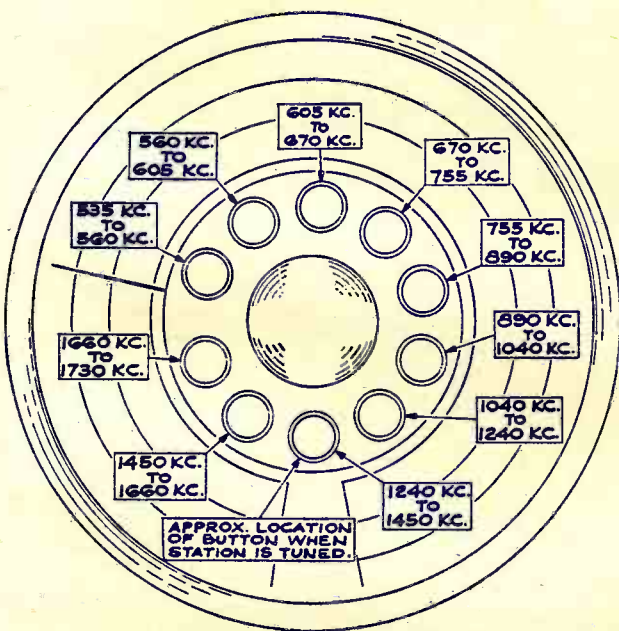
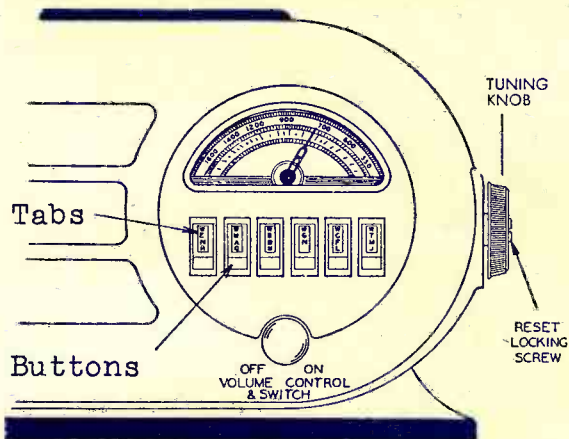
also supplies the AVC voltage, and besides contains a triode section which amplifies the audio signal. Review in your mind the complete action of this stage. No provisions have been made for grid bias in the triode section of the 12SQ7, but a very small voltage difference exists because of the fact that different materials are used for electron emission (cathode) and for the grid, and this voltage known as contact potential is sufficient for the bias.

A half-wave rectifier is used. The filaments are wired in series and add up to about 120 volts supplied by the power line. Notice that the plate current and part of the filament current for the 35Z5-GT tube passes through the pilot bulb. However, if the bulb burns out, the filaments will still light and the plate supply voltage will be obtained after a small drop through a part of the filament of the 35Z5-GT tube. The part number 14, 33 ohm resistor prevents surges of current through the rectified tube.

Condenser 3 is the usual tone correction capacitor used with pentode output tubes. Switch 28 permits the insertion of another larger capacity condenser for further reduction of high frequency audio response and the apparent stressing of bass.

PUSH-BUTTON TUNING

For convenience in selecting local stations, push-button tuning is used. Servicemen must be able to set these in new sets and make changes and corrections from time to time. It is important, therefore, to understand the general principles and be able to follow instructions in making these adjustments.



There have been three different types of automatic tuning employed in modern sets. One type depends on switching-in, with the push of the button, a fixed padder condenser or pre-tuned coil which permits the reception of the wanted station. When this method of automatic tuning is used, the regular tuning condenser must be turned to minimum capacity or disconnected.

Another type is entirely mechanical in operation. The pushing of a button moves a cam which revolves the tuning condenser to a position where the desired station is received. This method simply revolves the condenser to the exact position for the reception of the station corresponding to the push-button employed. Such automatic units are easy to adjust. The repairs are mechanical in nature. In trying to adjust push-buttons on any radio, it is good policy to ask the owner if a set of original instructions are still available. These should be followed if obtained. If not, you will probably be able to figure out the method of adjustment or may write to the factory for such instructions.

Illustration at the left is of a radio using mechanical method of push-button control. To adjust, depress one button, hold down and tune in a station. Next depress another and select another station. After five stations are selected tighten locking screw.

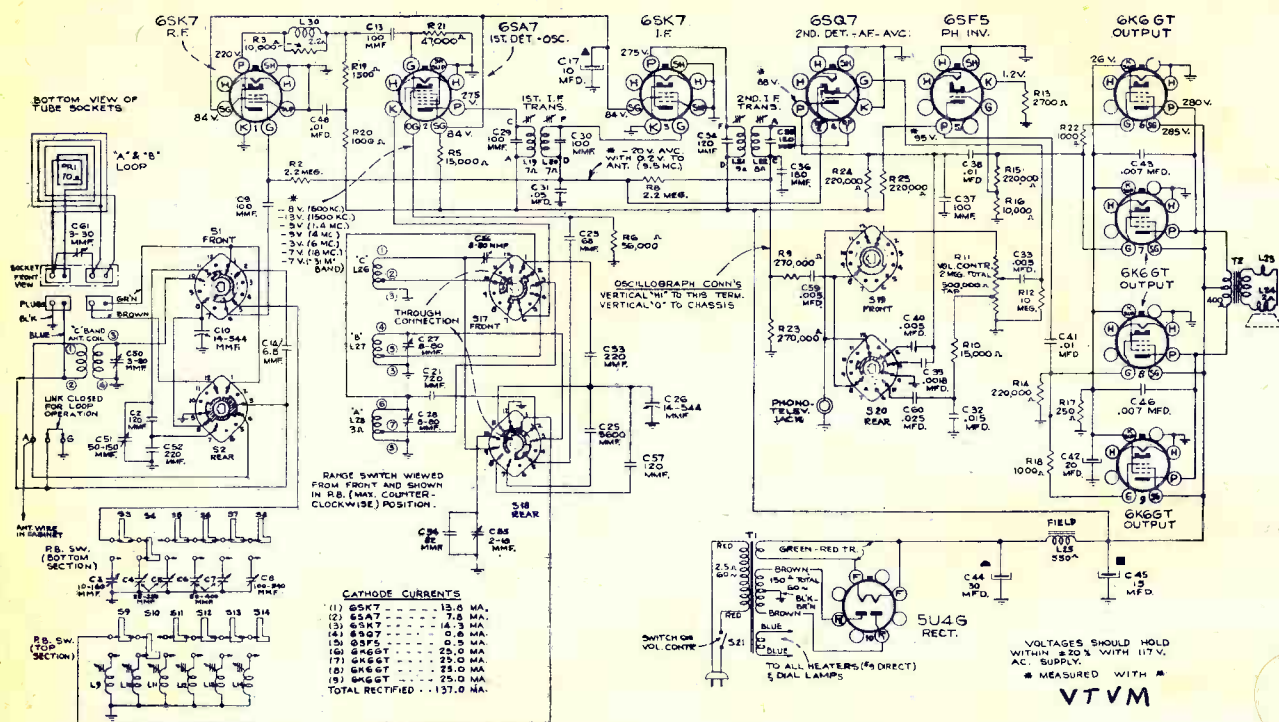
Still another type of automatic tuning uses electric motor to rotate the condenser to the correct position. This system is used on the higher priced sets. Such radios ordinarily also use AFC, and a method for silencing the radio while the tuning is taking place. It is difficult to figure out the repair or adjustment for such systems and instructions are almost always required.

In *Admiral* Model 8T and many other sets, automatic telephone dial selector is used. Adjustment is as follows:

- (1) Select a station and tune this station. Choose a button which includes the frequency of this one station.
- (2) Unscrew this button only. Now press the button all the way in and rock the tuning dial until a click is heard. Holding the button down, reset the tuning dial to a position where the desired station was received. Hold dial in this position and tighten button.
- (3) Do the same with other buttons for all stations.

Another type of push-button tuning system employing adjustable padding condensers is illustrated. Two of the buttons are used for tone control. To set buttons: tune in a station, set middle knob to "automatic" position, press button which has the frequency of the selected station and turn the adjusting screw of this button until the same station is heard clearly. Repeat for all other buttons. Middle knob in "automatic" position disconnects main tuning condenser.

LARGER, MODERN SUPERHETS



While the larger superhet receivers may appear more complex on the surface, the fault in these circuits may be isolated by the same simplified technique. Once you know in what stage the trouble lies, you work only on that stage and need not care how many other sections are a part of the same radio.

The larger superhets have these additions to the superhet circuits we have covered so far: (1) Usually a R.F. stage is used, (2) The oscillator section may use a mixer and a separate oscillator tube, (3) Probably two I.F. stages although many have only one, (4) Diode detector and triode amplifier as separate tubes, not in circuit illustrated, (5) Usually push-pull output stage, (6) Tuning eye tube which may also be connected to any set with AVC.

Tuned-circuits type push-buttons are also incorporated in this circuit. Notice that the antenna section controls are adjusted with capacity, while the oscillator section controls are adjusted by compressing the iron core material used. If a R.F. stage is used before the pentagrid converter, it is usually cut out (eliminated in the circuit) for push-button tuning and for the high frequency band if included in the set.

Test these sets in exactly the same way as outlined in the text so far. After the section at fault (only a single fault is usually present in any radio at any one time) is located, test that section by methods suggested and outlined for other simpler circuits.

When working on larger sets with several bands, the various tests should be conducted with the band-switch

in the broadcast band position (see page 59).

Phase inverter tube, 6SF5 in the circuit, is used to obtain out-of-phase signal to operate the second tube of a push-pull circuit. An audio transformer may serve the same purpose. Notice that the grid of this tube receives a very small signal because of the voltage divider R-15 and R-16. The ratio by which the signal is reduced in this voltage divider is exactly equal to the gain realized in the tube, so that the net result is the same signal strength, but a shift of phase. This circuit shows a push-pull parallel output stage using a total of four tubes.

It is possible to test radio tubes without a tester. In A.C. sets pull one tube out at a time while the set is on. If the set has no other faults, the bad tube will fail to produce a loud click. If several tubes give this reaction, the tube nearest the speaker is at fault. In AC-DC sets, first place the radio in operation. Using a piece of wire, touch the two filament prongs of each tube with the bare ends of the wire. When the burned out tube is tested in this manner, all the other tubes will light. Do not keep this wire in contact very long as the other tubes are receiving higher voltage.

While the radio may create internal noises, usually these "static" noises are due to interference picked up by the antenna or power line. Here is how you can tell which one of these two is causing the trouble.

With a very small piece of wire, short the antenna connection to chassis. Advance the volume control. (Continued on page 59)

BAND SWITCHING METHODS

All higher priced radio sets provide means for receiving broadcast stations and one or more short wave bands. These multi-band receivers are only different as far as their tuning arrangements. Usually coils for each application (Ant., Osc., and R.F. if used) and for each band are provided. All antenna type coils are grouped together and may be enclosed in a single shield. The other coils used are also grouped. By means of a switch, the coils for any one band can be selected at once. The I.F. section and audio stages, of course, need not be altered if the receiver is used for some other band than regular broadcast.

The circuit on the right illustrates the R.F. preselector, mixer, and separate oscillator (6C5) of a modern three band radio. To follow the switching arrangement examine the chart included in lower corner. The column marked "Position 1" will tell you that for broadcast reception, terminals 1 and 2 will be in contact, and also, 9-12, 5-8, of section *one* switch. Locate these in the drawing. Also for section *two* of the switch, 5-8, and 2-11, will be in contact. Different connections will be made for other bands.

Since grid and plate leads must connect to the band switch, the wires must be as short as possible. Usually the coils are grouped around the switch. In some midget sets for two band reception, the switching is done by making a connection to a tap on each coil. But the better sets have an arrangement similar to the one shown. When one of the coils is connected to the circuit, the others not used are short circuited to ground to eliminate dead spots on the band being used. Once in a while you will also find very unusual methods of switching, but in principle they are the same.

Each coil used, of course, requires separate trimmers. These trimmers are shown in the circuit and are included in the shield of the coil or nearby. The tuning condenser gang may not have any trimmers at all, or they may be used for one band and special trimmers will be used for other bands.

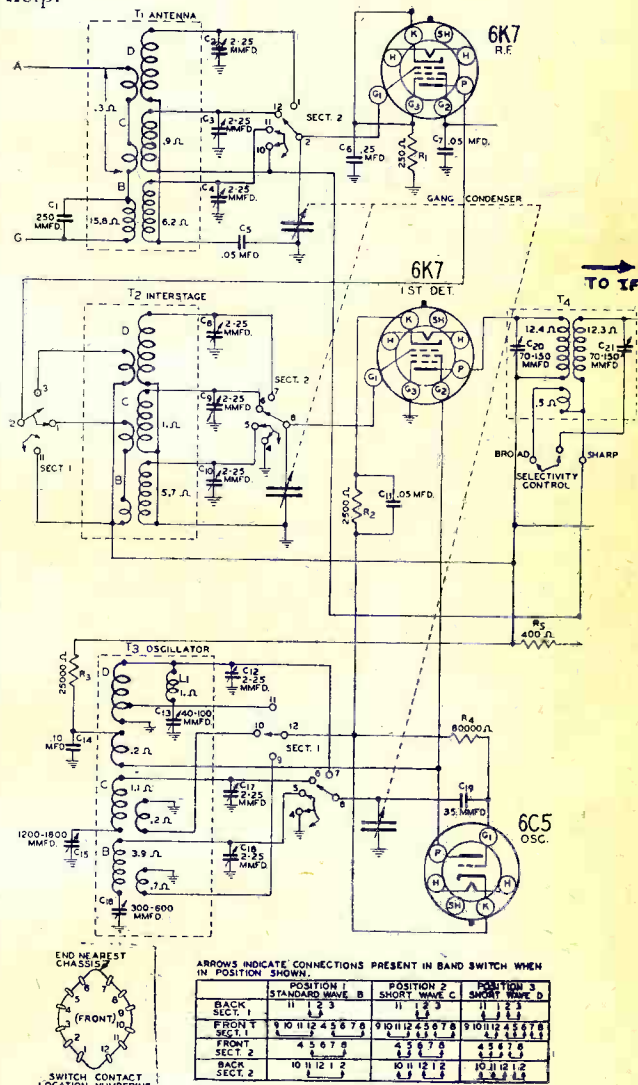
In multi-band radio sets, if reception can be obtained on any one band, you may be certain that the set is functioning properly and that the trouble lies in the coils or alignment of the bands not operating properly. Switch terminals may not be making contact, or a winding of a coil may be at fault.

Each band of a radio set is aligned individually, but the I.F. transformers are aligned only once with the first band tackled. It is best to start with the broadcast band. This alignment can be carried out as suggested on pages 52 and 70. Of course, when the broadcast band is being aligned the band switch is turned to the corresponding position, and only the trimmers and padder for this band need be adjusted.

You must know what frequencies are covered by each band in order to select the correct frequency for align-

ment work. If you are working on a medium short wave band which covers 7 to 2.3 megacycles, you will use a signal of about 6 MC. for trimmer adjustment on the high frequency end, and about 2.8 MC. for adjusting the padder.

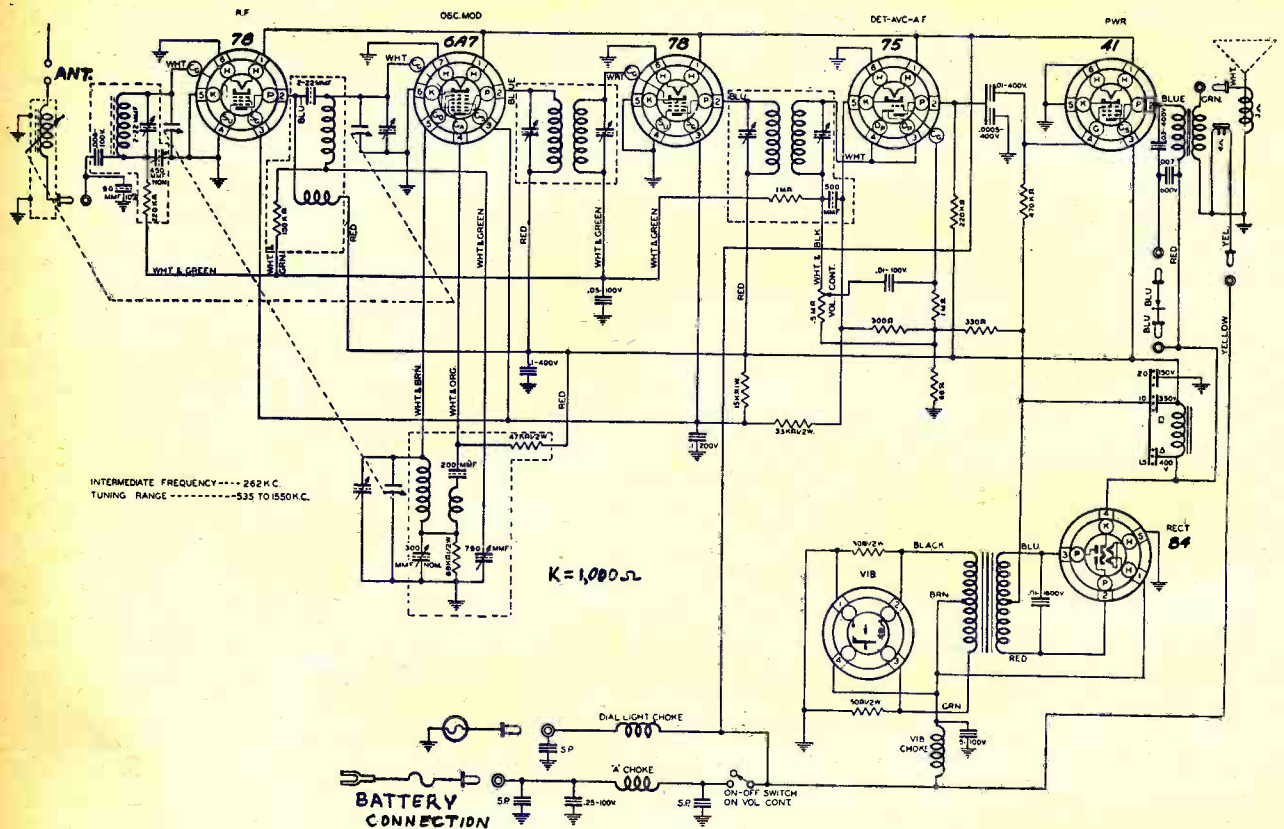
A signal generator must be used for short wave alignment. Sometimes only a single band is out of alignment, but more often the entire set will need realignment. The location of different trimmers and padders is quite a job in multi-band sets and a layout diagram is of great help.



(Continued from page 58)

If the noise stops, it is picked up by the antenna. But if the noise continues, the trouble is due to pickup by the power line. Use a power line interference filter or a better doublet antenna to solve these problems. Filters should be mounted near the source of interference generation, but will help even near the radio receiver.

EARLY AUTO RADIOS



The big job in servicing auto sets is to get the radio out of the car and to get at the parts for tests. Circuits are similar to other superhets and so are no more difficult.

In getting the set out of the car, you need not remove the cables controlling the volume and selector controls. These can be turned with a screw driver. Remove the battery connection at the fuse junction. The internal connection should go to one side of a six volt battery, the shield or metal frame of the radio should go to the other battery connection. In most sets polarity need not be observed.

After the set is out of its cabinet and ready for test, the battery should be connected. Power supply, which is different from other sets, should be tested first. Vibration of the vibrator unit can be heard and felt. It must work and is a common source of trouble. Exact duplicate can be obtained from your radio store. Using 100 ohm resistor unit test for voltage across each half of the secondary of the power transformer see page 40. If no voltage, suspect vibrator unit or transformer.

Next test for plate voltage after rectifier tube. In sets not using a rectifier tube, the test is the same. Charge a condenser and discharge to see if voltage is present. In some sets 0Z4 tube is used. The tube requires no filament current, but is easily damaged

with overload. If any tube needs replacement, check circuit anyway before replacing set.

In auto set power supplies there are additional by-pass condensers and R.F. chokes to eliminate interference created by the vibrator and the ignition system of the automobile. These additional parts increase possibility of faults developing in the power supply circuit.

All other repairs are carried out in the same way as on regular A.C. superhets of corresponding types. Auto sets almost always have a R.F. stage to bring up the gain since the antennas used are necessarily short and close to the ground.

The following corresponding types of tubes were used in some early auto sets: 6A7 or 6C6 as first detector; 6D6, 78, 6K7; 75, 85, 6Q7; 41, 42, 6F6, also in push-pull, and using 6A6 in class B; 84, 0Z4.

The older radio sets had their controls brought out to a panel mounted on the dash board. Automobiles beginning with 1935, provided a cut-out in the dash for mounting custom made plates with controls. New sets are supplied with instructions for mounting. Follow these in installing new sets, and make a plan for replacement work when removing a radio already used.

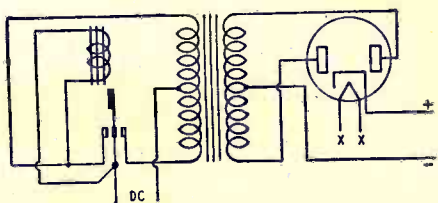
Auto sets use 6.3 volt tubes and have a total drain, from the auto 6 volt storage battery, of 5 to 9 amperes.

(Continued on page 66)

VIBRATOR POWER SUPPLY

In connection with the operation of auto radio power supplies, we must understand the action of vibrators. These units are usually enclosed in a plug-in type container and have a vibrating armature very similar to a buzzer.

A transformer will work only with changing voltage, A.C. type. The voltage need not be of sine wave type, but it must be changing. If a transformer is connected to a six volt battery through a switch and this switch is closed and opened very fast, the D.C. voltage of the battery will be interrupted. The voltage will change from zero to six volts many times per second and the transformer will operate. It is possible to produce this type of interrupted voltage even more efficiently with the aid of a special vibrator.



Examine the left hand side of the illustration above. Notice that the D.C. (6 volts in the case of most units) has one lead connected to the primary center-tap. The other side of the D.C. is connected to the center vibrating reed and also to a small electromagnet placed near this reed. Now trace the circuit through and you will see that the current passes through one-half the primary. Enough current goes through to make the small electromagnet attract the reed to the left, completing the circuit between the reed and the left-side terminal. This action *shorts* the electromagnet, but increases the current through the upper half of the primary. Now, since the electromagnet has lost its attraction, the reed will swing back all the way and make contact with the right-side terminal. The current will not be present in the upper half of the primary, but will now flow in the lower half and in the opposite direction. This is very much like the two loops of the A.C.

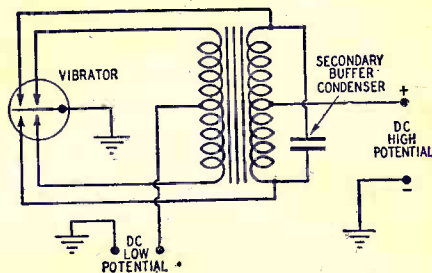
The reed is flexible and vibrates back to the center position. At that instant, the entire cycle repeats itself. This action takes place about 115 times per second, and we have a type of A.C. for the operation of our transformer. This transformer steps up the voltage to the required value and the balance of the power-supply is made up of the usual rectifier (shown) and filter (not shown).

There are some special precautions to be taken in the design of vibrator systems. When the contact is made, there is such a sudden increase of current that

a high voltage peak is induced in the secondary. Furthermore, sparks are likely to appear at the contacts. Various ways have been devised to eliminate the interference caused by the vibrator. Buffer condensers are generally placed across the secondary and sometimes across the primary. The buffer condensers used in the primary may be .5 mfd. 600 volt types, one across each half. The buffer condensers in the secondary circuit may be .008 mfd. tested at 2,000 volts. Other manufacturers connect a center-tapped resistor across the primary. The buffer condensers will absorb the sudden charges and, thereby, improve the waveform. Yet this alone is not sufficient to insure noise-free reception.

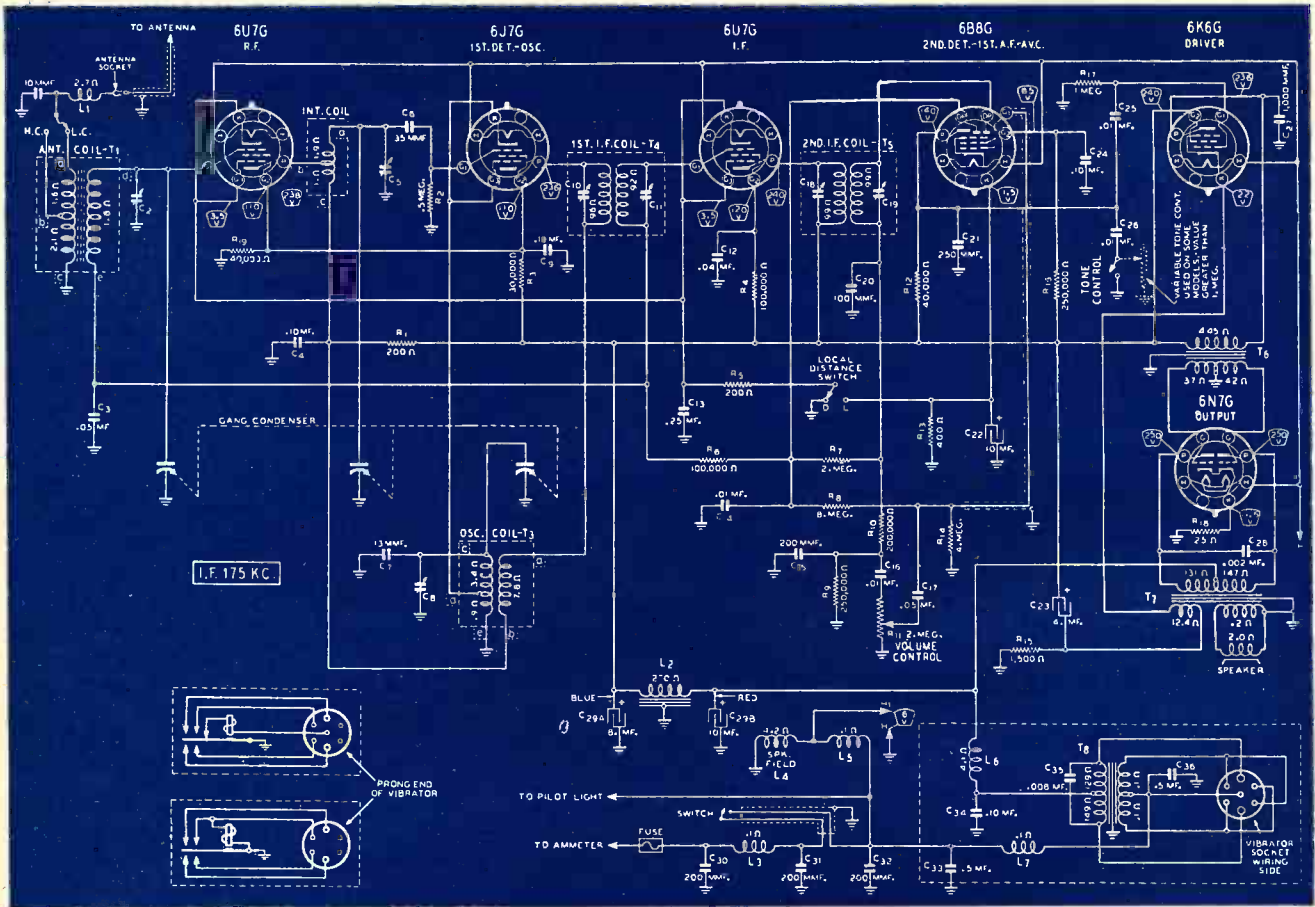


The supply filter may contain an R.F. filter in addition to the regular filter and the filament circuit may be filtered too. Also the filament circuit should not have any part in common with the vibrator circuit except the battery, of course.



Synchronous vibrators can be employed in auto radio power supplies and eliminate the need for the rectifier tube. The armature of a synchronous vibrator closes another set of contacts which serve to rectify the current in the secondary. The figure shows this principle. When the armature moves downwards, it not only closes the primary circuit but also the secondary; when it moves up, the other halves of both the primary and secondary are closed. A buffer condenser is again employed in the secondary to improve the wave form. The usual R.F. filters and the ripple filter are used as in the other vibrator system.

MODERN AUTO SETS



Newer type auto radios mount directly behind the dash into a space provided for this purpose. The speaker grill, dial, and control knobs are at the front. Most of these sets have a set of push-buttons for greater convenience in tuning. These sets have a very good audio system for large power output. Sturdy construction and good shielding is important in automobile radios.

To keep out ignition interference, a number of by-pass condensers and chokes are incorporated in the lead from the battery. The other battery connection, of course, is grounded to the frame of the car, and the radio makes this return connection with the mounting bolts. The vibrator is enclosed in a well shielded plug-in container, and the vibrator and transformer assembly are shielded again in another compartment. Besides these precautions, R.F. chokes and by-pass condensers are used in the leads from the transformer.

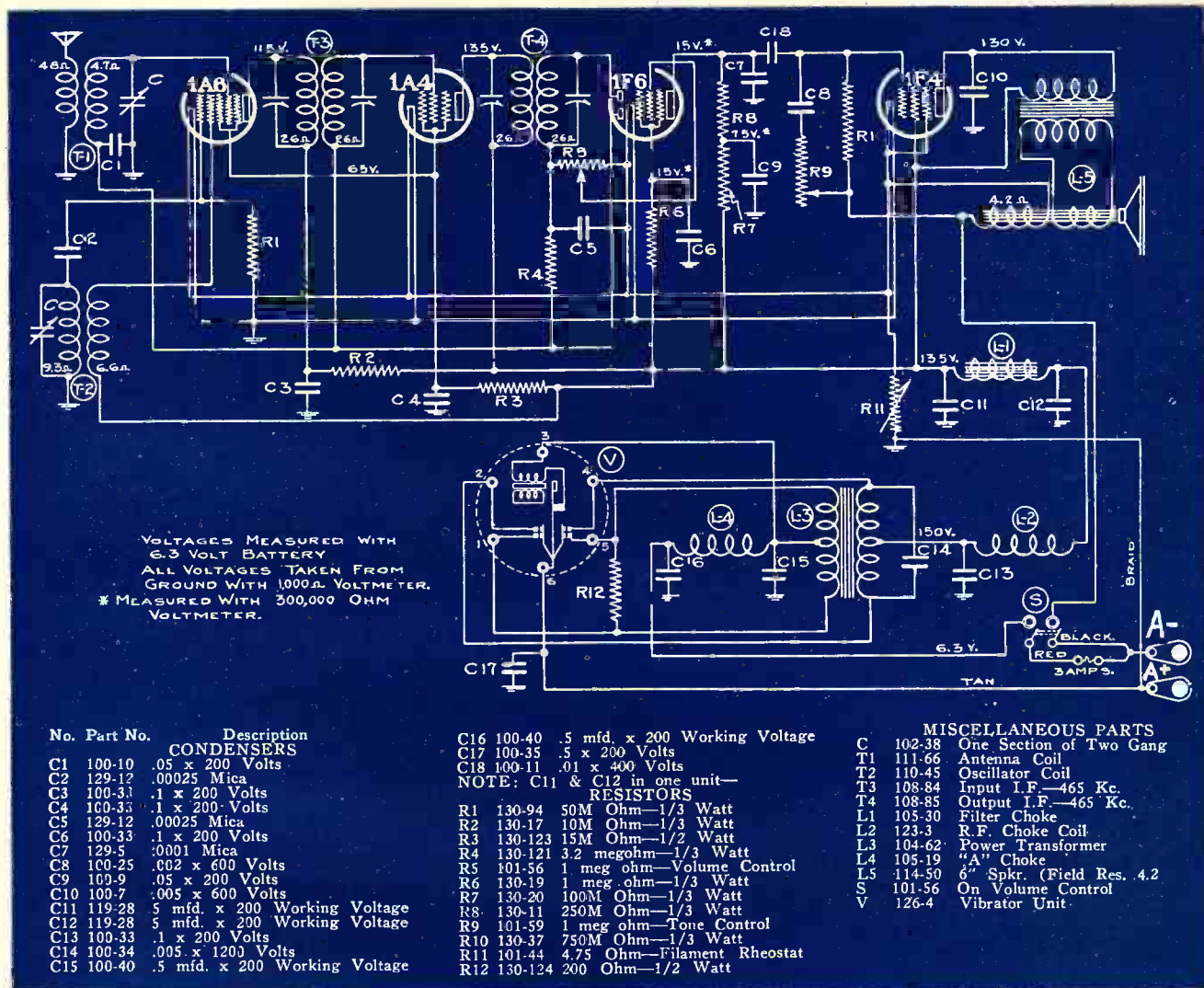
This circuit uses a synchronous vibrator eliminating the need for the rectifier tube (see page 61, last paragraph). Find the lead which has the fuse and leads to transformer and vibrator through chokes L_3 and L_7 . Make a momentary contact from this lead to chassis,

using a piece of wire. Hot spark will tell you that six volts supply is present. If you suspect the R.F. chokes, test in this way before and after the choke. If current is present before, but not after, choke is open. Now test plate voltage at electrolytic filter condensers, C_{29} in diagram. If no voltage here, disconnect condensers and then test, or test for voltage at secondary of power transformer. For this last test do not use the condenser, but use a low resistance R test. If no voltage at transformer probably the trouble is with vibrator. If points are badly worn, the unit will not work even if armature is vibrating.

The balance of the set is a regular superhet and should be serviced in a similar manner. The type 6B8G tube is similar to a 75, but has a pentode section which is used for audio. The type 6K6G is used as an output tube in many sets, but here it is used as a driver because the final audio stage uses a type 6N7G tube in class B operation. See page 72.

Automobile sets are designed for broadcast operation and use 175 KC. I.F. in many instances. In aligning auto sets, try to re-assemble the set as much as possible before making adjustments. A metal cover in place may change the correct point of alignment.

"HOME" BATTERY SETS



Battery operated sets of the types illustrated were sold during 1934-39 period. These are in use in rural areas not equipped with power lines. Battery type tubes with low filament current drain are used. The circuits are similar to other sets, but bias in many sets is obtained in the filament circuit since the filaments are also operated on direct current. Plate current is supplied by B-batteries, or from a vibrator power supply which is similar to the auto set power supply and works from the same six volt storage battery that is used for A-battery needs. With B-battery circuits, no filter is needed and bias may be obtained from separate C batteries. Vibrator supplies, of course, have regular filters.

While servicing technique is similar, great care must be exercised not to place the high plate voltage on the filaments as the battery type tubes are easily damaged. Best to make tests with condenser and by touching

control grid circuits. If a six volt battery is used, tubes may be wired in series and parallel.

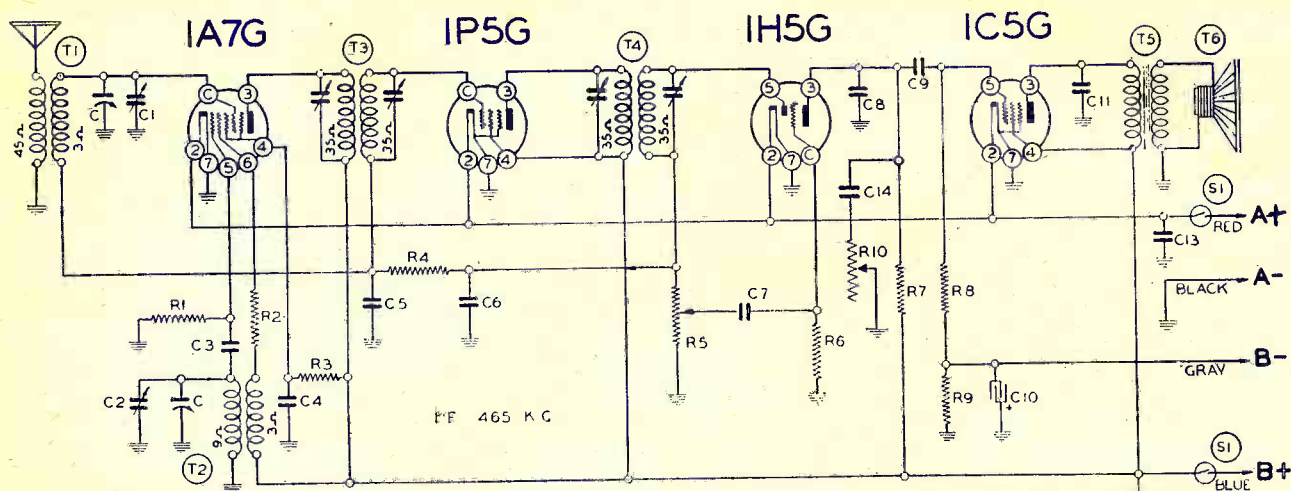
The battery portables and the more modern "home" battery sets use similar circuits and corresponding tubes. These tubes are of the 1.4 volt series and may be operated directly from 1.5 volt batteries. These tubes are very economical in operation having small filament current drain, and give good operation with only 90 volts on the plate (67½ volts in some circuits).

The A and B batteries are usually enclosed in a single pack and connected to the set with a plug-in connector. Superhet circuits usually employed. P.M. speakers are used.

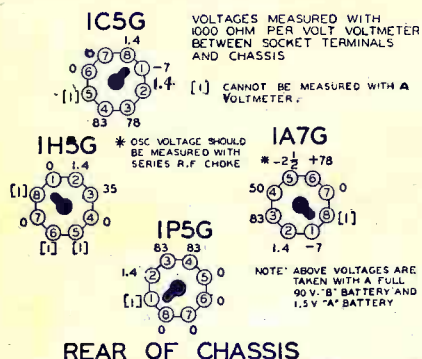
A-battery voltage may be tested with flashlight bulb. B-battery voltage may be tested with 110 volt bulb, but make test quickly. Use a low wattage bulb (10 watts). Common source of trouble is due to batteries

(Continued on page 64)

BATTERY PORTABLE SETS



BOTTOM VIEW OF CHASSIS



REAR OF CHASSIS

RESISTORS

R1	200M ohm— $\frac{1}{2}$ w.
R2	4M ohm— $\frac{1}{2}$ w.
R3	40M ohm— $\frac{1}{2}$ w.
R4	3 megohm— $\frac{1}{2}$ w.
R5	1 megohm volume control
R6	5 megohm— $\frac{1}{2}$ w.
R7	500M ohm— $\frac{1}{2}$ w.
R8	1 megohm— $\frac{1}{2}$ w.
R9	700 ohm— $\frac{1}{2}$ w.
R10	Tone Control (1 Megohm)

CONDENSERS

C	2 gang variable condenser
C1	Antenna Trimmer on gang
C2	Oscillator trimmer on gang
C3	.00025 mica
C4	.05 x 200 v.

C5	.05 x 200 v.
C6	.0001 mica
C7	.003 x 600 v.
C8	.0001 mica
C9	.01 x 400 v.
C10	10 mid. x 25 w. v.
C11	.003 x 600 v.
C12	.25 x 200 v.
C13	.1 x 200 v.
C14	.002 x 600 v.

PARTS

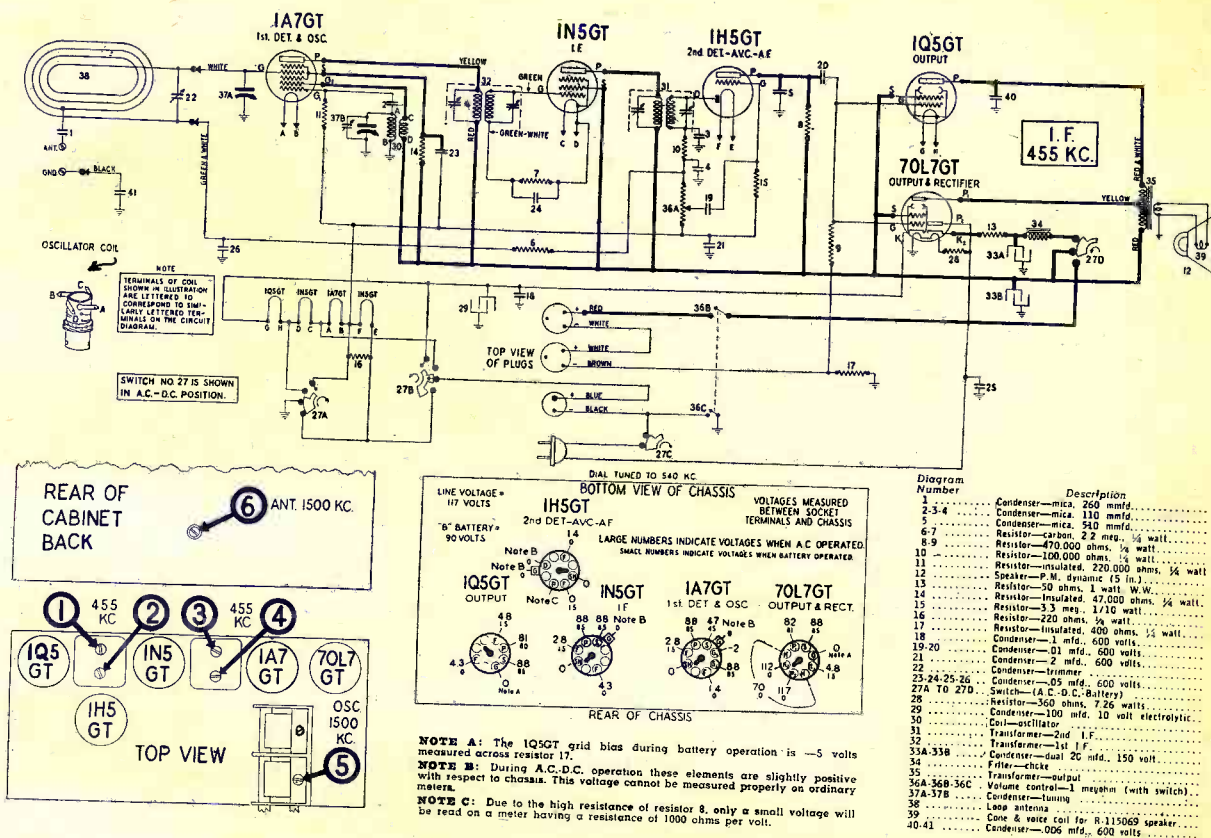
T1	Antenna Coil
T2	Oscillator Coil
T3	Input I. F. - 465 kc.
T4	Output I. F. - 465 kc.
T5	Output Transformer
T6	6 in. P. M. Speaker
S1	Off-on switch on Volume control

or 1A7G tube testing "good" but not oscillating. Try a replacement, if fault seems to lie in this stage and you are able to get a response of hiss or a click when you touch the grid of the I.F. tube (1P5G or 1N5G in some sets).

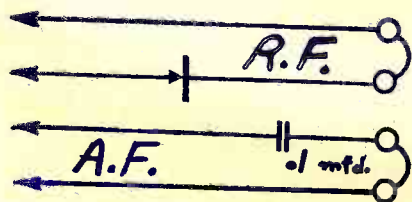
SIMPLIFIED TESTS WITH HEADPHONES AND ACCESSORIES

Test	Position of prod	If this result is obtained	Part bad
RF	Cap 1A7G	No signal can be tuned in	T ₁ or ant.
RF	Cap 1P5G	No signal received on phone	Oscillator not working 1A7G bad
RF	Term. 5, 1H5G	No reception on phones	1P5G, T ₄
AF	Across R ₅	No reception	R ₅ , C ₆ , 1H5G
AF	Across R ₆	No reception	C ₇
AF	Term. 3, 1C5G	No loud reception	C ₉ , C ₁₁ , 1C5
PW	A plus	No click	C ₁₃ , A bat
PW	B minus	No click	C ₁₀
PW	B plus	Very loud click missing	C ₁₂ , B bat

COMBINATION PORTABLES



These battery sets are best serviced with a signal tracer which can be made up of headphones, condenser, and crystal detector costing a few cents. Connect these as the circuits illustrated and in using keep one lead on A-minus or ground point. In the chart on the previous page, we will call circuit with crystal RF, with condenser AF, and just headphones PW. These tests may be used with all battery sets and, in many instances, with electric power radios.



The majority of portable radios sold during the last few years were designed for operation from compact batteries and also suitable for use directly from 110 volts A.C. or D.C. power supply. Many of these sets are regular portables as described in the last section, but include a power supply unit to provide the A and B voltages of the pack. The same switch disconnect the batteries and places in operation the special power supply. A few of these power supplies use type 25Z5

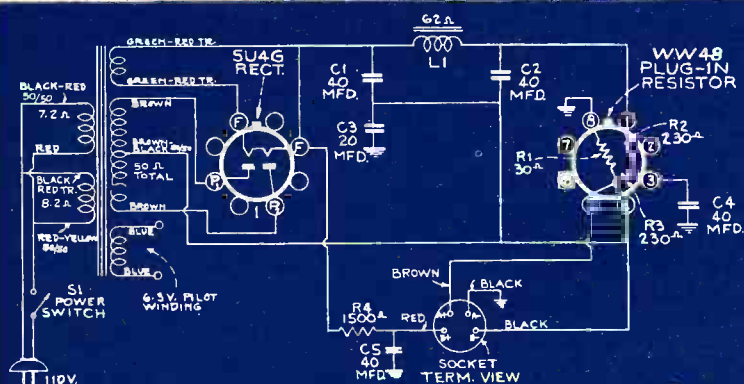
tube, but type 117Z6 has been developed especially for this service and has a 117 volt filament. In a few sets, for the power operation the final audio tube is also changed so that more audio output is secured. As in the circuit illustrated, the rectifier for the power supply and the special audio tube, may be combined in a single type 70L7-GT.

(Continued from page 51)

is changed, the negative bias is increased to a maximum of 30 volts. Of course, the changing of the volume control setting also causes losses of the antenna signal to ground to increase, as the slider is moved to the left. Resistor 14 is used to guarantee a minimum required negative bias.

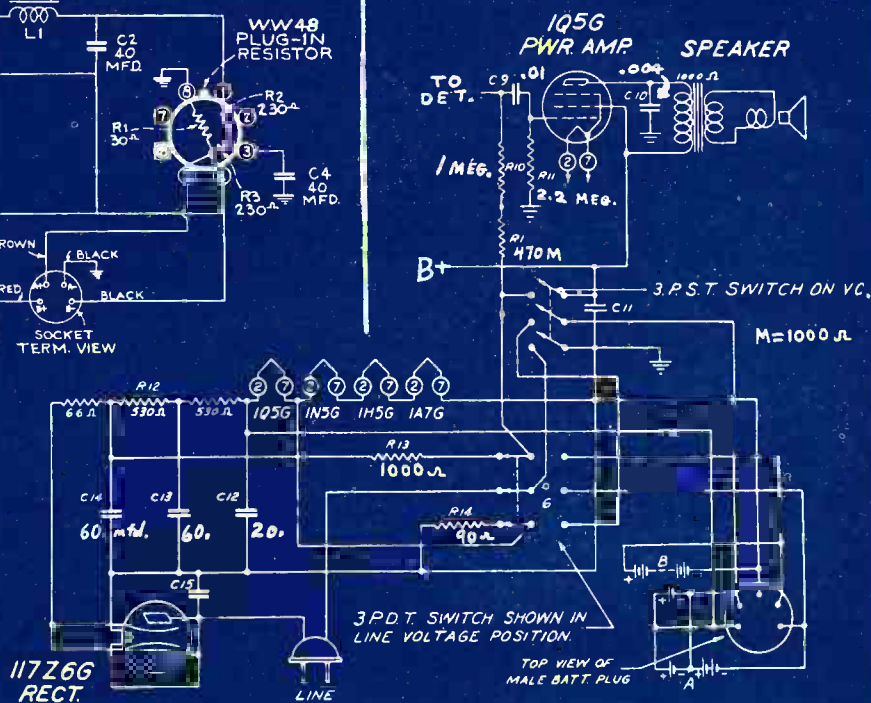
A type 6C6 tube is used as the detector (2ND DET.) and is of the grid leak type. The audio output from the detector is sufficient to drive a sensitive type 41 pentode output tube. Condenser 20 is the usual tone correction condenser used with pentodes. The output tube is coupled to a dynamic speaker. Notice that the field coil of this speaker is employed as the filter choke. In general, the heavy lines in the circuit indicate places where plate voltage is present. The understanding of the function of the receiver will aid you in carrying on service work in similar sets.

POWER SUPPLIES FOR PORTABLES



The circuit above shows a RCA power supply for operating battery sets on A.C. power.

The Zenith circuit on the right shows another power supply used for combination portables.



Power packs are also available, similar to the RCA circuit illustrated, which may be used with regular battery portables. In all cases the B-voltages are obtained in the regular manner, but novel circuits have been worked out to get the needed A-voltage. You understand, of course, that the A-battery supply must also be filtered.

If such a set is dead, use power from batteries and proceed with tests for regular battery portables. If set is working on power but not batteries, suspect battery connections or used out battery pack. If set works on batteries but not with power supply, the trouble lies in the AC-DC supply. (Note: Most supplies are for AC-DC operation, the RCA pack is for A.C. operation only).

Test for plate voltage in the same manner as you would any AC-DC power supply. You may find bad rectifier tube, or filter condensers, see page 47. Continue to trace this B+ voltage and test at several points in the actual receiver. You may find a break at the switch.

Place the radio in a darkened room and try to see if filaments are receiving current. If not, disconnect the filter condensers in the A (low voltage) supply. Disconnect one at a time and see if this action will restore operation. Resistors in this circuit may be open. Test

these with an ohmmeter or replace them with similar sizes.

If the set fails to operate on AC-DC power and a separate audio output tube is used for this operation, its circuit must be suspected. Make regular test here since this tube may be of the regular type used in AC-DC circuits. Please remember that if you obtain operation with battery power the trouble is not in the radio receiver proper.

(Continued from page 60)

The filaments are connected directly to the battery—through chokes in some sets. The plate supply is obtained with a vibrator unit and associated parts. Real old sets using "B" batteries should be junked. The genemotor supplies may be replaced.

Ignition interference is a common fault. Make sure the antenna is as large as possible. If whip type, have it open. By-pass condenser (.25 mfd. auto type) should be placed on generator lead. Distributor suppressor should be used and it will not have an ill effect on the operation of the motor. While motor and radio are in operation, try condensers in other points such as ammeter connection, dome light, regulator, electrical operated gas indicator. Be sure good frame-grounds exist for set connections and leads are shielded.

RADIO TESTERS

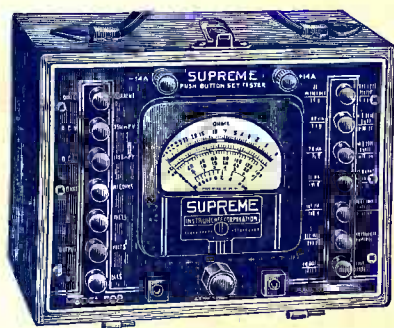
The factors associated with electricity are measured with meters. For example, the voltage in a circuit may be measured by simply connecting a voltmeter, having the correct scale, in the circuit. To repair radio sets faults existing must be discovered. In a radio, which is not in good working condition, voltage, current, resistance, and other electrical quantities present are commonly of values that are not to be expected or wanted for proper operation. The discovery of an incorrect electrical quantity points to the trouble and gives an easy and quick solution.

If a radio under test does not have power; i.e. no voltage is present, tubes do not light, an ohmmeter (resistance measuring meter) should be used. Also for testing resistors, coils, and other parts an ohmmeter is best adapted. The power switch of the radio must be shut off when using this unit.

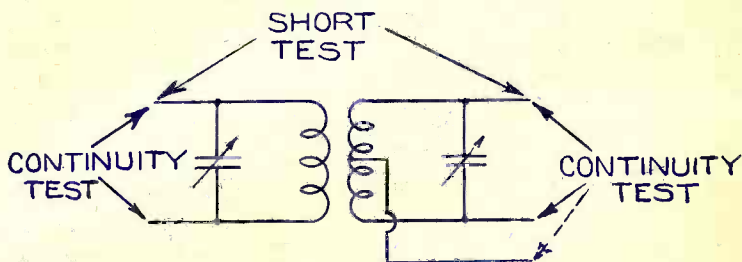
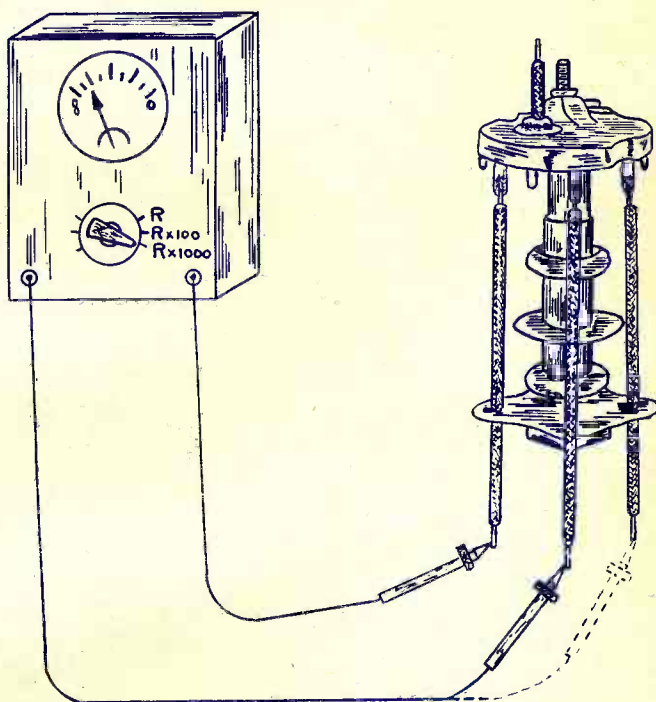
With the power on, voltage tests quickly help to find the source of trouble. Current measurements are taken

only once in a while. This is so because it is required to actually break the circuit (cut the wire) to measure current passing. For measuring voltage or resistance, the test prods are simply placed on terminals of parts to be tested. Some testers using these meters combine the measurements of these different quantities and also have several scales.

A combination volt-ohm-milliammeter, as these instruments are called, is shown. The resistance scale on all such instruments is crowded at the high end. The voltage and current in most radio circuits are D.C., but for voltage measurements this instrument provides A.C. scales also. Different lead connections are used for some tests, and the correct setting must be made not to burn out the meter. The decibel scale, if used, is simply a specially calibrated A.C. voltage scale. The capacity scales measure capacitive reactance at 60 cycles, but indicate actual capacity. Several scales are included for each measurement and this gives greater accuracy.



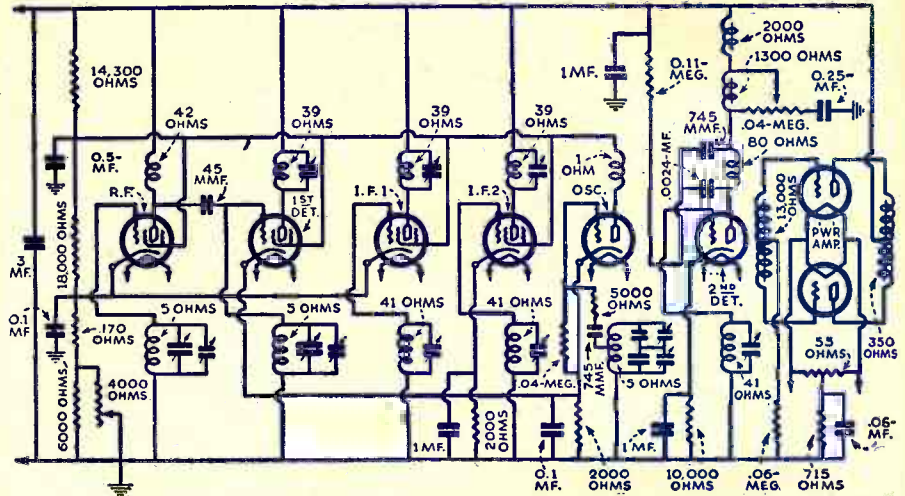
The selection of the different scales is made with a rotary switch in some units. In others the selection is made by changing the tips of the test leads to a different pair of jacks. In one Supreme model push-buttons are used. The figure at the right shows how to make continuity and short tests with an ohmmeter.



RADIO TESTERS



On the right is a schematic of a radio drawn to show resistance values expected across various parts.



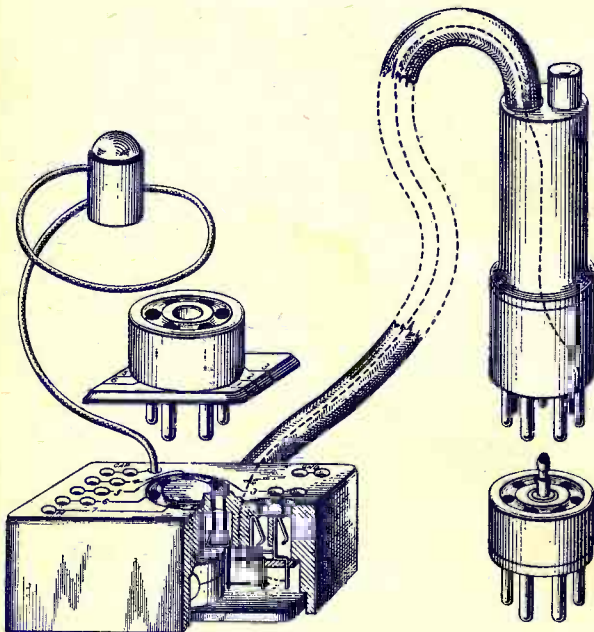
The voltages measured in radio circuits run between 2 or 3 volts and up to 500. Current up to 100 milliamperes.

The sensitivity of a voltmeter is expressed in “ohms-per-volt” and equals the total resistance in the meter circuit (meter resistance and the series resistor built in the unit) divided by the number of volts indicated at the full scale deflection. This figure indicates how much current is needed to operate the meter, that is deflect the needle of the meter all the way. The 1,000 ohms per volt meters have a movement of one milliampere. The greater the resistance per volt, the more sensitive the meter will

be. The more sensitive meter requires less current from the circuit being tested and will give more accurate reading if the circuit being measured has considerable resistance.

To enable the serviceman to test a receiver without removing the chassis from the cabinet, analyzers have been developed. These instruments incorporate a good quality volt-ohm-milliammeter, but besides providing connections for the test leads, have an adapter plug to fit the sockets of all tubes. When a circuit is to be tested, the tube of that circuit is removed. In place of the tube, the plug with the correct adapter is inserted. The tube in turn is placed into a socket (or socket adapter) provided on the panel of the analyzer. It is possible now to measure voltage or resistance between any two of the connections leading to the tube, or to break any single circuit and measure the current passing. This can be done quickly by simply turning the scale selector and plugging in a couple of leads.

Several test manufacturers have released signal tracing units which are supposed to simplify servicing. This they do in a few service jobs and especially intermittent reception repairs can be handled with some logic by means of signal tracing. These units, called Analysts, Channalists, and Channel Analyzers, consist of tuned stages (adjustable) to correspond to the tuned stages of a receiver. A vacuum tube voltmeter, requiring no current from the circuit under test, serves as an indicator. Tuning eye tubes sometimes are also incorporated. Servicing is done by substituting for the suspected stage and measuring under actual operating conditions. But we still say that most jobs can be handled without equipment, and only on rare occasions will you need a "signal tracer."



Courtesy Weston Electrical Inst. Corp.

TUBE TESTERS

Although faults in vacuum tubes can be detected without the aid of a tube tester, to make a positive statement that a vacuum tube is in good operating condition requires the use of a good tube tester. Testing and replacing tubes constitutes a large amount of work of radio servicemen. A very large number of apparent radio receiver defects do not actually require any repairs, but merely a replacement of one or two tubes.

Occasionally, when a tube tests defective, it will work quite well in a receiver tuned to a powerful local station. It is rather difficult in such a case to convince the owner that the tube needs replacing when he himself can hear the receiver working apparently in great style. To convince the receiver owner that the tube in question is really bad, simply place a *new* tube in place of the one mentioned. Tune in a rather weak distant station. Now replace the *bad* tube. The set will no longer be able to bring in the weak station.

Different test methods for tubes may be used. In laboratories, a method which places the tube under conditions of operation very similar to that existing in radio receivers is used. Since this method requires complex equipment and many adjustments, it is not practical for the service shop.



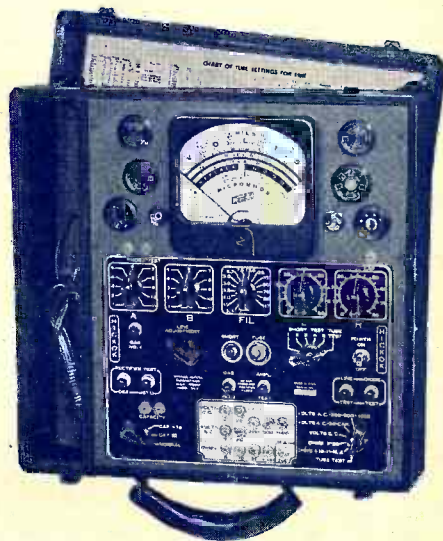
Emission and short tests are used in practical testers. While this method is not absolutely foolproof, it serves excellently for practical purposes.

A tube tester is provided with various sockets so that all tubes in use can be tested. There is a filament selector switch and this is pre-set to give the required filament voltage for the tube to be tested. Charts are supplied with tube testers to tell you the various settings for all tubes. Some testers also may have an adjustment to correct variations in line voltage. Most tube testers operate from 110 volts power.

All the elements of the tube, with the exception of the cathode or filament, are connected together through the circuit of the tube tester. A small positive voltage is applied to this grouping of elements which now act as a plate. In this "plate" circuit a meter is inserted. The amount of current which will pass depends on the voltage applied, type of tube, and condition of the

emission of this tube. By keeping the voltage at a pre-selected value (unchanging), and knowing what shunt setting will be needed across the meter for the type of tube being tested, the quality of emission can be determined. This is a good simple test of the tube's quality.

The adjustment which must be made for each tube to be tested, automatically corrects the reading on the meter for the tube under test. Similar tubes, of course, will have about the same setting. The meter itself is called *English reading*, and the scale is divided into a Good and Bad sections.



Another common fault with vacuum tubes is due to high resistance shorts existing between the different elements. By following the instructions supplied with the tester, and rotating certain switches, you will automatically place a voltage in series with a sensitive neon bulb across pairs of different elements. If this test is made on two elements which are actually shorted, the bulb will light. Dim light will result if there is a high resistance leak between the elements.

The simplified tube testers at times fail to detect a faulty tube. For example, in a multi-element tube if one of the grid connections is broken inside the tube, this may not be discovered by an emission tube tester. The current which causes the meter to indicate Good or Bad, is the result of all currents of the different elements acting as "plates." If the individual currents of each grid and the plate are compared, you will find the plate is responsible for a large amount. And so, if the grid wire is broken, the total plate current indicated on the meter will change but little, and the tube may still test in the Good section. Gas presence in the tube may be detected with the leakage test. But the presence of gas will actually increase the plate current and indicate better emission.

SIGNAL GENERATORS

A signal generator is similar to a miniature broadcasting station. The frequency of the output, however, is adjustable. The intensity of the audio signal superimposed on the R.F. carrier may be controlled. This is known as percentage of modulation. The audio frequencies may be used separately if need arises. The amount of output is also controllable with the attenuator.

The practical signal generator illustrated below covers frequencies from 100 KC. to 133 megacycles. This includes all I.F. frequencies used, and all communications frequencies including those used in modern television. The coverage is obtained in seven steps, by making different readings on the dial.



Courtesy Hickok Electrical Inst. Co.

In this unit audio frequencies from 100 to 10,000 cycles are provided. Many signal generators have but a single 400 cycle audio frequency. These audio frequencies may be taken directly from the unit or may be used to modulate the radio frequency carrier.

Some signal generators operate from battery power, but most units are designed for power line use. Audio frequencies are generated by a single tube. The R.F. oscillator uses one or more tubes. The circuits must be carefully designed to produce the exactly right frequency at any setting of the dial. To prevent stray radiations, the entire unit must be enclosed in a metal container which acts as a shield. The signal output must be strong enough to permit you to align a set entirely out of adjustment.

In selecting a signal generator make certain it covers the frequencies encountered in radio service work. Be sure the unit is easy to use and that it is well shielded. See that the audio output can be used separately and when used with the R.F. that the percentage modulation can be controlled. The error in dial reading should not be greater than 2% but better yet 1%. The output at maximum setting should be in the order of one volt.

A signal generator may be used for locating faults in radio receivers and as an aid in properly aligning all sets. With a signal generator you can produce a similar signal to the one which can be handled by any stage of the receiver. For example, you can generate a powerful audio signal to drive the output stage. Or you can produce a relatively weak I.F., of the correct frequency and with about 30% modulation, to excite the input to the first I.F. transformer.

As you can see, with a signal generator you will not need to upset the different circuits by some simplified method, but will instead test each stage with the type of signal that stage should be able to handle. Starting with the speaker, you can work back to the antenna until the faulty stage (failing to give a response) is discovered.

By adjusting the signal generator to the I.F. frequency of the receiver, the I.F. transformers can be correctly peaked. It is best to feed the signal into the primary of the last I.F. transformer and adjust the trimmers for maximum output. You may judge by the sound reproduced by the speaker, but it is better to have an output indicator. A cathode ray oscilloscope may be used for exacting results, but is not essential.



An oscilloscope is useful in carrying out exacting alignment work. It may also be used for tests, but is more adaptable in the laboratory than on the service bench.

In a manner similar to the alignment procedure explained previously, a signal generator may be used. Instead of tuning in a station of about 1400 KC. and then one of 650 KC., these frequencies can be generated with the signal generator.

In making the alignment on short wave bands, the same procedure is followed. However, the frequencies used for any one band correspond to a frequency at the upper limit of the band and one at the lower end. Separate trimmers and padder condensers are provided for each band. The I.F. transformers, of course, need not be touched once they are adjusted for any one band.

PUBLIC ADDRESS SYSTEMS



Allied Radio Corp.

In serving a large group of people, public address equipment finds its application. Most often a speaker's voice is amplified to a suitable volume to be audible to all present. Radio programs and phonograph records may also serve as a means of input. In motion picture work, a photo-cell serves as the source of input.

Essentially a P.A. system consists of one or more of the sources of input mentioned above, a suitable amplifier, and one or more loudspeakers so placed as to take advantage of the acoustics.

Most microphones used at present are of the high-impedance, low-level type. These include crystal, velocity, dynamic, and velotron types. The last one mentioned requires a polarizing voltage. All these microphones have a low level output in the order of minus 50 to 65 decibels, and require sufficient amplification in use. This output is lower than that of a phonograph pickup and needs one more stage of amplification than is needed with the phono input of an amplifier.

Because these microphones are of the high impedance output they may be coupled directly to the grid of the first tube. Velocity and dynamic microphones are also made in the *low* impedance types and should be used when the connecting lines are longer than 100 feet.

Low impedance microphones require a matching transformer at the input to the amplifier.

Carbon microphones are used only for voice and have many shortcomings. These microphones are used with a small battery and have an output level corresponding to that of a crystal phono pickup. Condenser microphones are not used any longer, and may be replaced with other low level types.



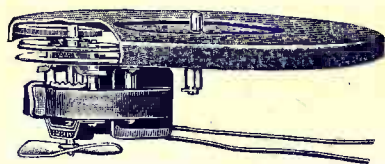
AMPLIFIER INSTALLATION

Phonograph pickups may be of the magnetic and crystal types. These are usually of the high impedance types and may be connected directly to the grid of a vacuum tube. The crystal pickups are shunted with a resistor in the order of one megohm. This resistor may be the volume control. Bass response may be increased by making the value of this shunt resistor larger.



Radio input may be obtained by connecting the chassis of a radio to the frame of the amplifier, and connecting the output of the detector through a .01 mfd. condenser to the "hot" side of the phono input of the amplifier.

Each input channel may be individually controlled. In the more economical amplifiers, two channels, which are usually not used at the same time, may be controlled with a single knob.



The different channels are combined or mixed by means of resistance volume control networks or by means of electronic mixing. This latter method uses a tube of a dual type (6C8G may be used). The two channels feed the two control grids. The plates are connected together and the plate current is influenced by both grids. This permits the inputs to be mixed or blended.

A public address amplifier is nothing more than a multi-stage, high power, audio amplifier. The stages may be coupled with resistance or transformer coupling. Various tubes suitable for audio work are employed. Each stage, except the final, acts as voltage amplifier. The final stage, of course, must deliver actual power to the loudspeaker.

The output stage may use triodes in class A operation. This operation was used extensively in older amplifiers and gives good quality, but low amplification in the final stage and high current consumption. Type 2A3, 45, and 50 tubes are used in such circuits.

Pentodes, such as 2A5, 42, and 47, were used to overcome the shortcomings mentioned, but had more distortion. Class B tubes, such as 6A6, 46, and 53, are very economical in operation and have very little distortion at high volume levels.

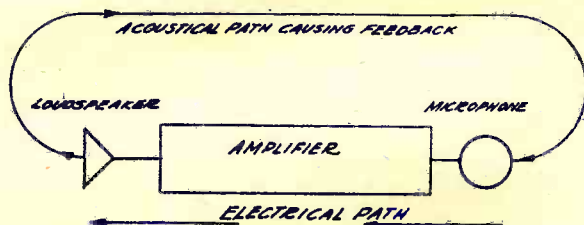
The beam power tubes (6L6, 6V6, and 25L6) are

ideal for final amplifier stage requirements. By feeding back a part of the signal to one of the previous stages (degeneration) exceptionally fine results are possible. These tubes also will operate properly with almost no filtering of the plate supply and deliver very high power (55 watts for two 6L6 tubes) in special circuits. You will find almost all present day amplifiers using these tubes in the output stages.

In most installations it is best to use only one or two speakers. The loudspeakers for P.A. are usually of 12-inch size and are capable of handling 15 watts. Out-of-doors or to serve very large areas, trumpets and directional baffles are used.

The speaker location is selected with two objectives in mind: (1) to make the program sound natural to all present, and (2) to reduce the possibility of acoustical feedback. The loudspeakers should be placed so that sound originating from the actual source (be it a singer or a complete orchestra) and the sound emitted by the loudspeakers should reach the majority of the audience at the same instance. This is why two speakers are used in auditoriums and dance halls, one on each side of the stage.

In all installations, some of the sound emitted by the loudspeaker will reach the microphone of the system. A continuous whistle known as feedback will result if the sound reaching the microphone is greater in intensity than the original sound input.



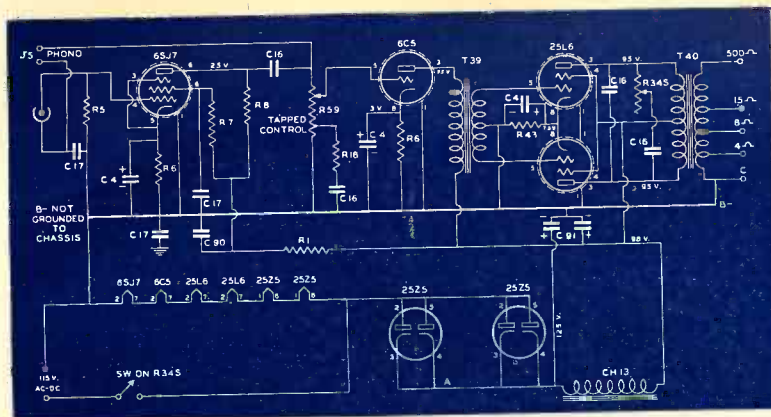
Reduction of amplification will always solve the feedback problem. But this is a poor solution since the high output is usually required. At times only a group of frequencies cause feedback and the tone control may eliminate this.

The best way to eliminate feedback is to prevent sound from the speakers reaching the microphone of the system. The speakers should be focused away from the microphone. Sound-absorbing materials deaden the sound and absorb its energy. The use of carpets, heavy curtains, and special materials on the walls and ceiling will greatly reduce feedback.

A public address amplifier should be serviced in a similar manner to any audio section of a radio receiver. A few additional hints will be given at this time.

SOUND AMPLIFICATION

ELECTRICAL VALUES



Condensers

C4	10 mfd., 25 volts
C16	.01 mfd., 400 volts
C17	0.1 mfd., 400 volts
C90	.25 mfd., 400 volts
C91	15-15 mfd., 300 volts

Resistors

R1	50,000 ohms, 1 watt
R5	5 megohms, 1/2 watt
R6	3,000 ohms, 1/2 watt
R7	2 megohms, 1 watt
R8	250,000 ohms, 1 watt
R18	25,000 ohms, 1 watt
R34S	100,000 ohms, potentiometer
R43	100 ohms, 10 watts
R59	500,000 ohms, potentiometer

A hissing background noise increasing with the setting of a volume control in a system which is defective, indicates a fault of the microphone or an open mike line. To test, short input terminals with a piece of wire. If fault is as mentioned above, noise will stop. If noise continues, see that grid caps are in place. Place finger on control grids of the tubes in different stages to find stage failing to give expected response. Test voltages with small resistor and "spark" reaction. Voltmeter may also be used. Voltages to be expected are the operating voltages listed in tube charts.

Hum may be due to filament-cathode leakage in a tube. Try other tubes especially in the first two stages. Chassis should be grounded. Reversing A.C. plug may help. Use a 4 mfd., 450 volt electrolytic condenser as a shunt across the different filter condensers. Improvement will be noticed when the test condenser is placed

in parallel with the faulty unit. See that the metal braid of shielded wires is really grounded to the chassis. If one of the output push-pull tubes is under par, distortion and hum will result. Speaker impedance must be matched to output, try several available connections for best obtainable results.

The amplifier illustrated below has its circuit shown at the top of this page. You will observe that this unit has the filaments of the tubes wired in series and may be operated from 110 volts A.C. or D.C. Two type 25Z5 rectifiers are wired in parallel to supply the total plate current. Outside of the power supply, the circuit employed is similar to other small P.A. amplifiers. A high impedance crystal or other low level microphone may be connected to the mike input. Since phono-graph pickup output is of a higher volume level, it is

connected directly to the second stage. This connection eliminates the extra gain provided by the first stage. The control R-59 varies the output volume intensity. Although the mike and phono inputs can be super-imposed on each other, they cannot be mixed in any special proportion. Separate volume controls are needed to accomplish this. Two type 25L6 beam power tubes in push-pull deliver 4.5 watts of audio power. This is enough power for a store, a small hall, several school rooms, a theatre hard-of-hearing system, and other similar applications. For auditoriums, an amplifier rated at least 15 watts should be used. Commercial amplifiers are made in various sizes. You will find the more powerful units using one more stage for voltage gain, and more powerful output tubes in the final stage.



FREQUENCY MODULATION

Radio transmission which is frequency modulated presents certain advantages over amplitude modulation. A number of broadcasting stations using this form of modulation are already in operation and considerable extension of this form of radio broadcasting is expected in the near future. An excellent paper on this subject was published in the *Aerovox Research Worker* for February, 1940. We will reproduce much of this material in this lesson and extend due credit to the source.

In explaining amplitude modulation, we have mentioned the presence of two side bands. At any one instance, if the transmitter is amplitude modulated with a single frequency sine wave at the moment, the energy radiated is made up of the carrier frequency and the two side bands. The frequencies of the side bands shift together and these side bands are always apart from the carrier frequency by an equal number of cycles. Since the side bands have their frequencies equal to the carrier frequency plus the modulating audio frequency for one and the carrier minus the audio frequency for the other, the frequencies of the two side bands shift together from moment to moment as the modulating audio frequency changes.

Now suppose we have a carrier which is frequency modulated. It is possible to *swing* the frequency by different amounts. The amount of frequency shift will determine the amplitude of the audio signal at the detector, while its "rate of change" or *speed* determines the audio frequency. Such a signal can be shown to consist of a carrier plus an infinite number of side bands. The side bands are in pairs, symmetrically placed with respect to the carrier and they are separated by the amount of the modulating frequency. A carrier of 1,000 KC. being frequency modulated at 1,000 cycles would have side bands at 1,001, 1,002, 1,003, etc., as well as at 999, 998, 997 KC. When the carrier is being swung, for instance 10 KC. to either side, the side bands situated between 990 KC. and 1,010 KC. only are of importance, the others becoming very weak. Therefore, the practical band-width of a frequency-modulated signal is equal to twice the frequency deviation employed and has no connection with the audio frequency.

Due to the wide band required, frequency modulated signals have to be restricted to the high frequency

channels. At present there are some stations near 40 MC., just below the television band. There is also an experimental station on 110 MC.

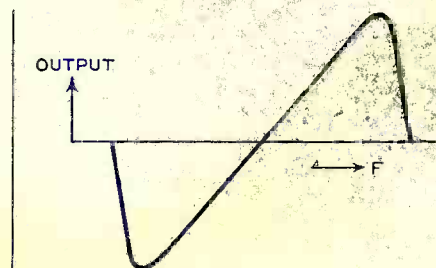
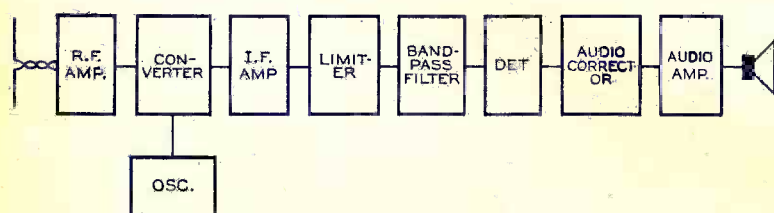
Since the present transmitters employ a frequency deviation of 80 KC., the receivers are superheterodynes with a band width of 200 KC. so that there will be some leeway for possible fluctuation of the signal frequency or the local oscillator frequency due to heat or voltage variation.

The receiver is shown in block diagram form. There is an oscillator and a converter with or without an R.F. stage. This is followed by a 200 KC. wide I.F. amplifier usually at about 3 MC. Then there is the limiter followed by another set of bandpass circuits so as to cut out the harmonics created. Next comes the detector and an audio corrector circuit. This audio corrector is needed because the stations are using a speech amplifier with a rising characteristic at the high frequency end so as to get a better signal to noise ratio at this frequency. The corrector, a type of tone control, reduces these excessive high frequencies to normal. This tuner is followed by a high-fidelity audio amplifier and a good speaker.

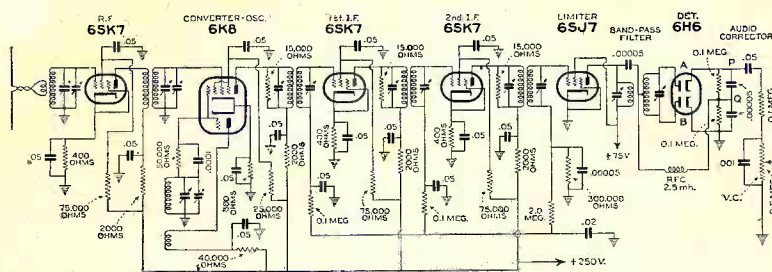
Since the R.F. end of the receiver is no different from that of an amplitude modulation receiver of the same range, it may be dismissed briefly, with this additional observation: the range of the receiver is usually from 39 to 44 MC. When the oscillator frequency is chosen above the signal frequency, it will fall within the television band. It has proven to blot out completely the image on a neighboring television receiver. It is better, therefore, to select the oscillator frequency below the signal frequency and keep the oscillations out of the television band.

The intermediate frequency seems to be little standardized. It is roughly between 1,500 KC. and 5 MC. At these frequencies, it is rather simple to obtain the required band-width since a 200 KC. width at 4 MC. corresponds to a 20 KC. width at 400 KC. The I.F. coils are now commercially available. They could also be made from standard 3 MC. variable selectivity coils by setting them for the required *width* and connecting a resistor of 15,000 ohms across the tuned circuits.

The limiter consists of a sharp cut-off pentode of the 6SJ7 type, with a low plate and screen voltage, while



FREQUENCY MODULATION

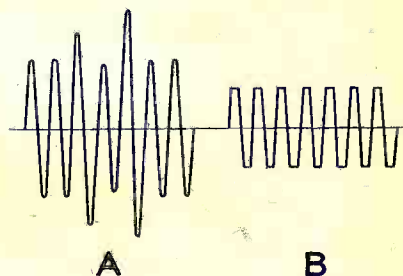


the bias is provided by a grid leak as shown in the figure. There will be a voltage drop across the grid leak and this may be used as A.V.C. for the preceding I.F. stages. The action of the limiter is illustrated by figures A and B. Figure A shows how the signal looks before it enters the limiter, and B shows how it appears in the plate circuit.

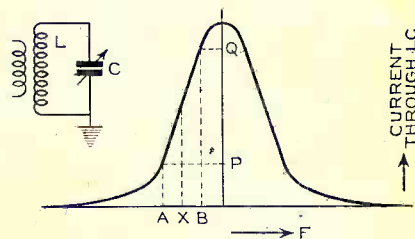
There are several detectors for frequency modulated waves. The old system consisted in changing the frequency modulation to amplitude modulation by means of a "slope filter" and then detecting it with circuits we have already studied. The slope filter can be a tuned circuit which is slightly out of tune with the incoming carrier. In the figure below, such a circuit is shown with its resonance curve. If the circuit is tuned so that the carrier falls at X, a frequency variation of the carrier between A and B will cause the current in the circuit (and the voltage drop across C) to vary between P and Q. So the signal now is also amplitude modulated. There are several disadvantages to this type of detector. If there is to be no distortion, the frequency can be varied only over the range where the side of the resonance curve is approximately straight. Also, a frequency-modulated signal results in less than 100 per cent amplitude modulation which gives best results.

The detector now generally employed for frequency modulation produces an audio frequency directly without first changing the signal into an amplitude modulated one. There are two diodes which are so connected to the special transformer that their diode currents are equal when the carrier is at its normal frequency. When the carrier frequency deviates in one direction, the current in diode A is larger than in diode B (see schematic diagram), while if the frequency deviates the other way, the current of second diode B is larger. The two equal load resistances are so connected that their voltage drops buck each other. So, the voltage drop between the point P and the chassis is equal to the difference between the voltage drops across the two diode loads. When the carrier is at its normal frequency, there is no potential difference between P and the chassis while a frequency modulated signal will cause the voltage at P to vary in accordance with the frequency modulation.

The output voltage at P is proportional to the frequency deviation as well as to the strength of the signal in the previous transformer. Since the limiter cuts all signals down to the same size, the output at the detector is practically independent of the strength of the incoming signal as long as it is above a certain minimum level. The characteristic of frequency-versus-output of this detector is shown. To avoid distortion, the sloping middle part of the curve should be straight and long enough to accommodate the 200 KC. swing. This curve is illustrated on page 74.



In (A) is the form of the voltage wave entering the limiter of a FM receiver. The output wave-form from the limiter is shown in (B).



A response curve of a slope filter. The carrier frequency corresponds to the point X. As the frequency swings between points A and B, the amplitude of the resulting signal shifts between the points P and Q.

The separation of the two peaks or the length of the sloping part depends on the Q of the tuned circuits. In order to have a wide enough curve, it may be necessary to employ resistance loading. The symmetry depends on the correct adjustment of tuned circuits.

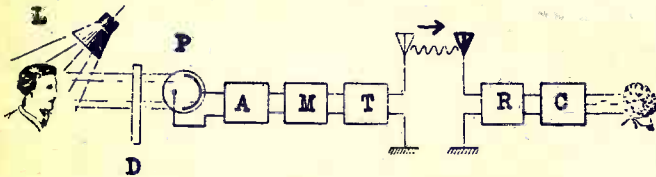
TELEVISION FACTS

The transmission of a visual scene by electrical (radio) means requires two fundamental processes of changing the light rays reflected from the item to be televised, to corresponding electrical energy and subdividing the image into many small elements.

The conversion of light energy to electrical current is performed by photo active materials—the intensity of light varying the current produced. If the light from an entire scene is *televised* by a single photo-cell, the current produced will vary with the average light present. Light from all parts of the image will fall on the photo-cell and will exercise its influence.

For intelligent television transmission it is essential to separate the image into many small elements and transmit these in a regular order. Since various parts of an object being televised reflect different amounts of light, if each one's light is permitted to act separately, a series of current variations will be produced in accordance with the light intensity of the elements scanned. A definite order of scanning these elements must be carried out, so that the image can be reconstructed later at the receiver.

The process of television (no longer used) is shown below. A man's head is located in a strongly illuminated field served by projector lamp L. The revolving Nipkow disc D, permits one element of the image, at a time, to reflect its light to the photo-cell P. The current in the photo-cell will vary in accord with the rays. If dark elements, maybe corresponding to sections of the hair,

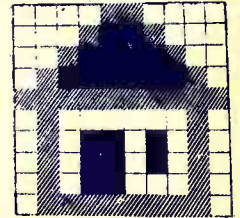
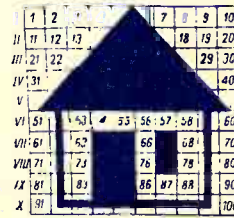


are scanned, low current will be created. If the light elements are scanned, much light will be reflected and the photo-cell current will increase. These small variations can be amplified in a pre-amplifier A, and modulator M, and then placed on the radio carrier produced in transmitter T.

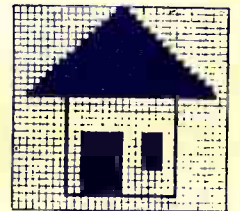
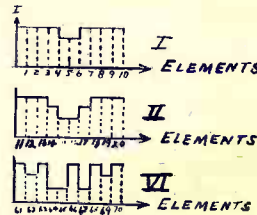
These radio waves, modulated with the electrical variations corresponding to the scanned picture, may be received by a special radio (television) receiver and used to recreate the picture with a special neon glow tube and synchronized scanning to remain in step with the transmitter. The light intensity of any element produced will correspond to the signal strength at that moment.

If a block diagram of a house is to be televised by means of 100 elements, we can assume that the illustration is superimposed upon ten horizontal lines each

having ten elements. The scanning may be performed horizontally from line to line, or vertically from row to row. Horizontal method is preferred. If the scanning process is started at the upper left hand corner, the first four elements (1, 2, 3, and 4) will produce



maximum current. These elements are white and will reflect a maximum of light. Elements 5 and 6 reflect less light, being partially covered with the dark roof of the picture. While these elements are scanned, less current will be generated by the photo-cell. Again, elements 7 to 10 of the first line, will produce a strong current. These changes are illustrated graphically. Follow the changes occurring as the other elements are scanned and check your results for the 2nd and 6th lines which are shown below.

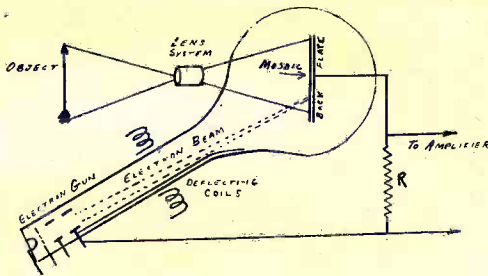


These changes in the photo-cell current may be amplified and used to amplitude modulate the transmitter carrier. At the receiver these amplitude changes will produce visual effects along similar 100 elements. Many details will be lost because of the small number of elements employed. Notice that when a change of shade occurs in a single elemental area, this change does not appear at the receiver but simply influences the tone of the entire element. Using 900 elements better definition is obtained as shown in the last illustration above.

In modern television, a cathode ray tube is used for pickup and the scanning is performed automatically. A mosaic is a mica plate having many thousands of photo active globules insulated from each other and from the back conducting plate. Each globule forms a tiny condenser with this back plate; the mica serving as the dielectric. The scene to be televised is projected upon the mosaic. Light sections of the image cause high electron emission from the photo active globules. The globules in the dark parts of the image emit very few electrons.

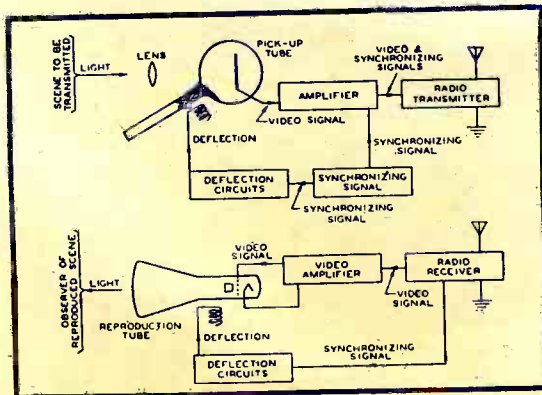
TELEVISION FACTS

The mosaic is mounted in the tube as shown. The scene is focused on the mosaic by means of a lens system in the same manner used in photography. An electron gun emitting a stream of electrons is made to scan the mosaic in a regular order. The electron spot falling on the mosaic covers a large number of globules and, in some Iconoscopes, measures 1/50 of an inch in diameter. The beam may be made to cover the surface of the mosaic in any predetermined order, but at present 525 line scans are used, interlaced two to one, the field of the image being scanned 60 times per second, and each two such fields making a complete frame of the image.



Now you will recall that light causes the photo active globules to emit electrons which form a space charge around the corresponding globules. Since each globule is actually one plate of a small condenser (the metal deposit on the back of the mica serving as the other plate), the small condenser so formed will become charged.

The electron stream sweeps over these charged "condensers" covering a number at a time and discharges the accumulated electrons through resistance R. The voltage across this resistance, therefore, will depend on the charge of the globules covered by the beam during the corresponding instant. Since the charge, in turn, depends on the light intensity of the image, the signal voltage produced will be in exact accord with the light of the elements covered.

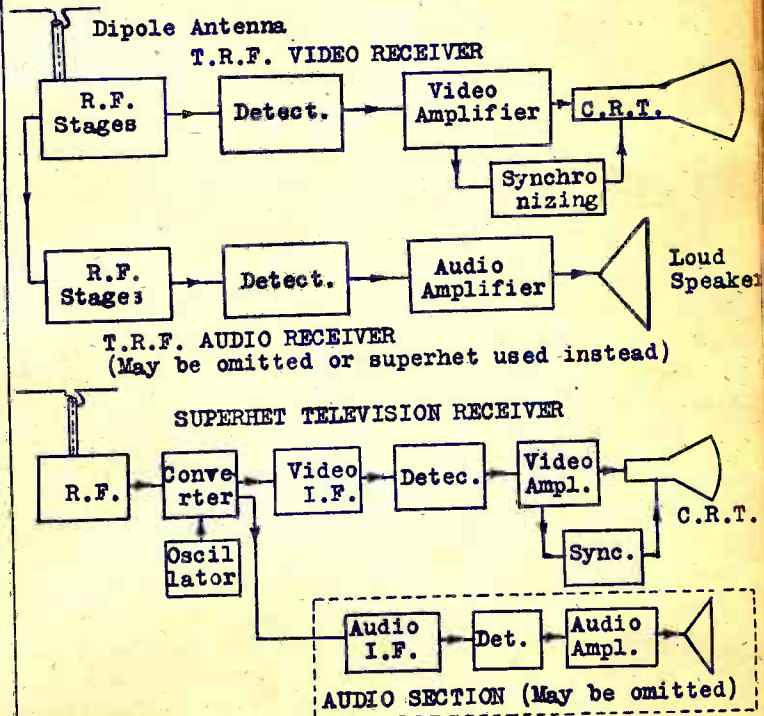


You will see from the diagrammatical illustration given (reprinted from the Proceedings of the Institute of Radio Engineers) how the synchronizing signals are applied to the pickup tube and are also transmitted to serve at the receiver.

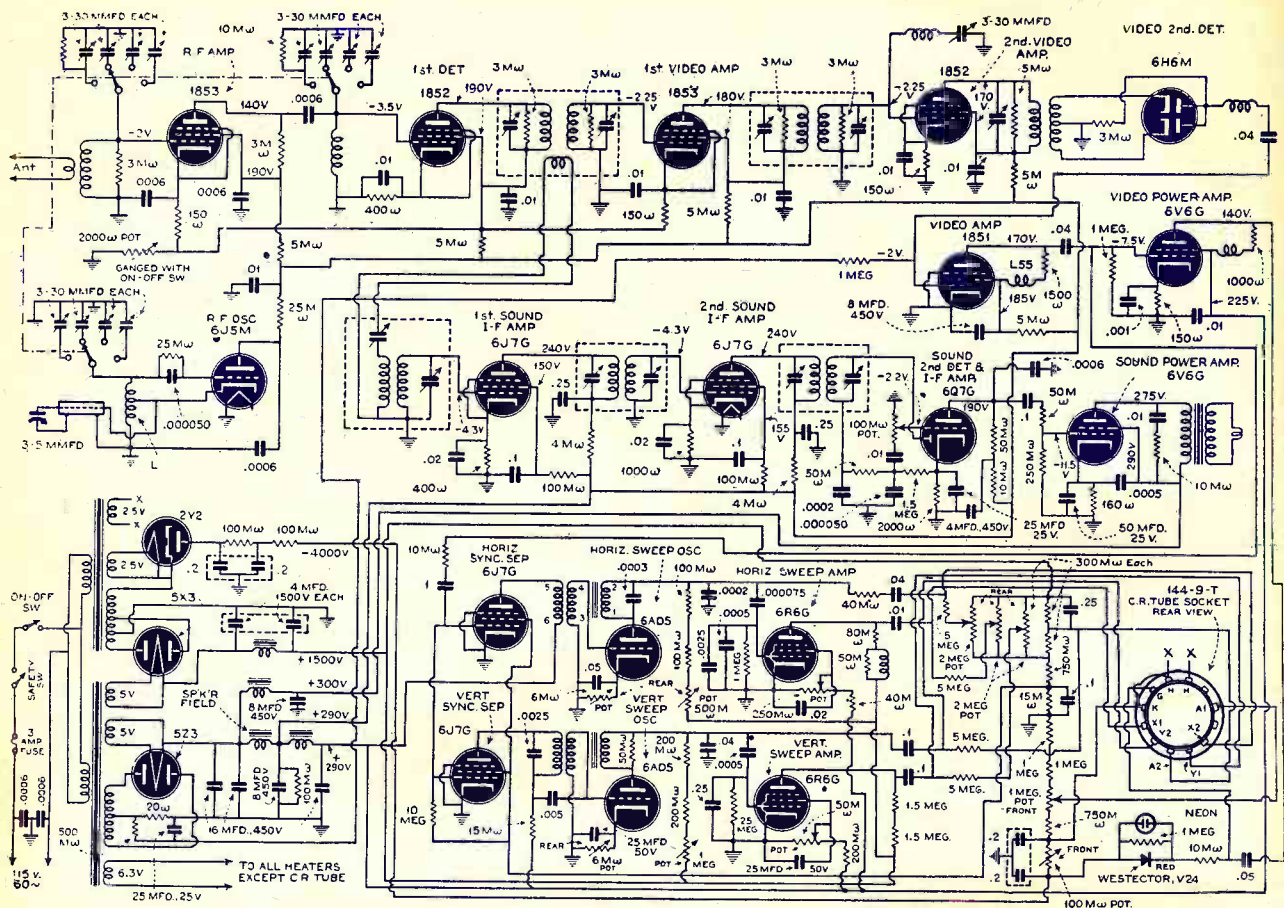
The actual deflection at the cathode ray tubes is accomplished by means of magnetic deflecting coils (electro-static plates may also be used). Two pairs of coils are employed mounted at right angles to each other. The beam will be deflected as a varying current is applied to the magnetic yokes, and, since electrons have infinitesimal mass, the deflections will be instantaneous.

Ultra high frequencies are used for transmission of television signals. This is essential because of the extremely high frequency of the side bands. The first television channel is from 44 to 50 MC., and the others are at still higher frequencies.

To the practical man, the actual function and repair of a television receiver is of prime importance. By dividing the receiver into sections, the problem of servicing is greatly simplified. The television receiver may be of the TRF or superhet type, may or may not have the audio channel receiver included. In the TRF type unit, an entirely separate receiver is used for audio although the controls may be combined. In the superhet type, the R.F. pre-selector and converter-oscillator are common to video and audio channels. If audio is not



TELEVISION FACTS



included, simplification of these first stages results and the audio channel I.F., detector and audio frequency amplifiers are omitted.

Since the majority of present day television receivers combine video and audio and are of the superhet type, we will use this type of set as the basis for our discussion. The Du Mont, Model 180, schematic illustrated is an excellent example.

Starting at the antenna input you will notice that the secondary is loaded with a 3,000 ohm resistor to flatten the response curve. The process of loading inductances is used in television equipment to permit the passage of extremely wide side-band. Tuning is accomplished by means of pre-set trimmers connected to a push-button switch. The local oscillations produced by the 6J5 tube, beat with both the video and audio carriers producing two different useful I.F. frequencies. One is used for the video I.F., while the other corresponds to the audio I.F. frequency. There are two stages of I.F. in each channel. Ordinary receiving type tubes are employed in the audio section, but special low inter-electrode capacity tubes must be employed in the video I.F. channel. The balance of the audio signal

receiving equipment is similar to the type used in regular radio sets.

In the video section also, a second detector is used followed by a video amplifier. After the first video stage part of the signal is tapped off and serves the horizontal and vertical sweep circuits. The synchronizing signal received simply controls the local vertical and horizontal oscillators and locks them in step.

By noticing the apparent action of the image, the location of the fault may be detected. A few service hints will be given to illustrate this technique.

If absolutely no fluorescent light is noticed it is probably that the difficulty lies in the cathode ray tube. The anode voltage may be shorted or missing. Emission may be lacking because of heater supply failure. If the scan is deflected completely off the screen, this condition may exist. If tests indicate that these faults are not present, the tube itself should be changed.

Sometimes the scanning is present, but there is no modulation so that the entire image is of one shade. First suspect the final video stage, because this is the only stage that does not carry the synchronizing pulses which are operating correctly. Next proceed testing back to the converter tube.

COMMUNICATIONS RECEIVERS

A communications receiver may be used in the home for receiving regular broadcasts. However, the main function of such receivers is to permit reception on the commercial and amateur bands. On these bands, separation of stations operating on closer adjacent frequencies is needed and the messages must be received at times under adverse atmospheric conditions.

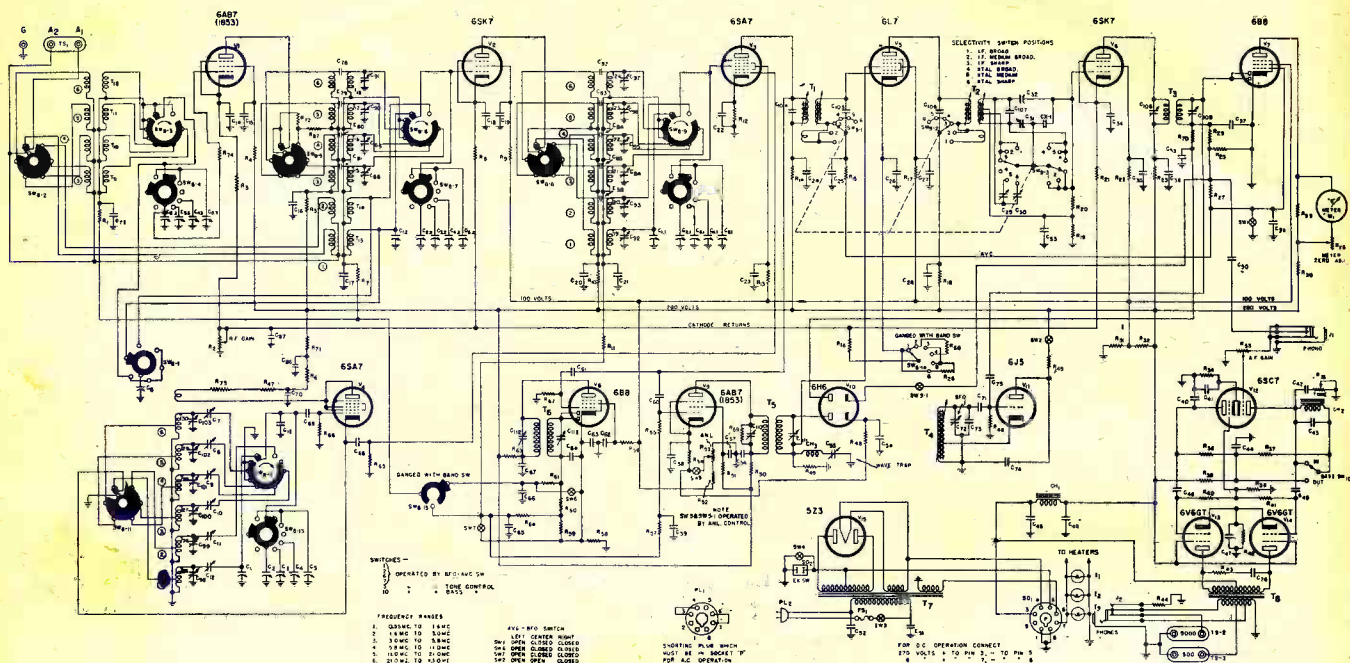
The receiver illustrated on this page and shown in schematic form on the next page is of a more advanced type, incorporating all the features ordinarily included in communications receivers. Please note the following features which are not ordinarily included in home type receivers: (1) separate gain controls for A. F. and R. F.; (2) band spread tuning controlled by a separate dial and employed for *spreading out* the frequency spectrum; (3) various degrees of selectivity controllable by a knob in the lower right hand corner; (4) a switch for shutting off A. V. C.; (5) crystal filter with manual control; (6) signal strength meter; and (7) phone jack which permits the direct use of headphones. The insertion of the phone plug automatically shuts off the loudspeaker which is housed in a separate cabinet.

This receiver will tune from 550 KC. to 42 MC., in six bands. Each band overlaps the adjacent ones, so that stations operating on frequencies which are received near the end of any one band, may also be received on the next band.

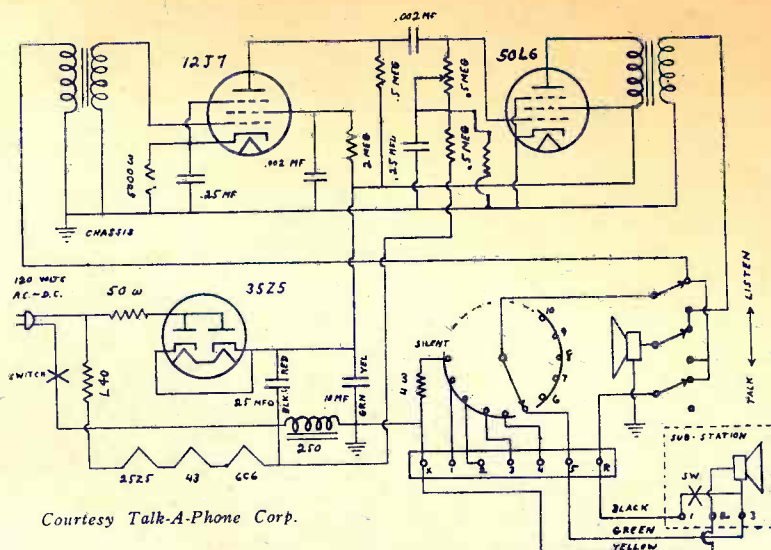
Since all communication receivers are designed for similar application, they have similar features and are operated in the same manner. Usually the "on-off" switch is controlled by the A.F. gain control. To use the strength meter, the R.F. gain control must be advanced all the way. The output volume can be controlled with the A.F. gain control. The band wanted is selected. A.V.C. is left on for voice or music, off for code reception. A.N.L. (automatic noise limiter) is left on if static condition is encountered. B.F.O. may be placed "on" to help find operating stations—a whistle is heard as you tune past a station. Not needed once a 'phone station is tuned in, may be needed for a code station. Crystal phasing may be used to eliminate closely located interfering station. Tone control adjusted for most pleasing results.



COMMUNICATIONS RECEIVERS



INTER-COMMUNICATORS

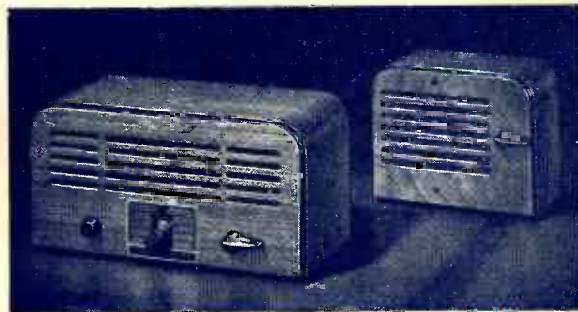


Courtesy Talk-A-Phone Corp.

Inter-communicators permit direct conversation between two or more remote points and employ audio amplifiers. When someone, perhaps 20 years ago placed the loudspeaker some distance away from the audio amplifier and microphone, the first inter-communicator was born. The loudspeaker could be located in a room different from the one containing the amplifier and mike. By using a second system and placing the equipment *in reverse* to the first system, a two way conversation could be carried on. If both systems were left in the operating position, a loud howl would develop because of the electro-acoustic feedback. Means, therefore, were provided for breaking the circuit of each system at some point. The individuals using the equipment controlled these switches as the conversation shifted up and back between the two points.

The realization that a magnetic or a P.M. speaker could serve as a microphone for voice frequencies made a great change in the design of inter-communicators. Assume you have a simple audio amplifier (see the schematic) incorporating a suitable input transformer to match the P.M. voice coil impedance to the *grid* and another transformer in the output to match the 50L6 tube to the same type of speaker. Also, assume you have two identical P.M. speakers. Call these speakers No. 1, and No. 2. By connecting one speaker to the input of the amplifier, and the other speaker to the output, conversation may proceed from No. 1 *speaker* (used as a mike, at this time) to No. 2 speaker. The No. 1 *speaker* may be in one room with the amplifier, while No. 2 speaker is connected with a long cable and is placed in another room. By employing a suitable switch, the connections of speaker No. 1, and speaker

No. 2, could be reversed. Conversations can now originate at *speaker* No. 2 (used as a mike, now), and reproduced from speaker No. 1. The physical position

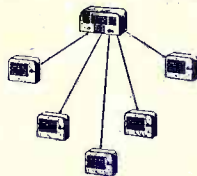


(placement) of the speakers may remain the same. The controlling switch for the speaker-connections is included in the cabinet of the amplifier.

The natural outgrowth from the basic system described, is the *master selective* system. One amplifier unit with its speaker is still used at one location, but instead of one speaker at some other single point, several speakers are used and each is located at a different desk, or room, or station. In the commercial units, facilities are provided for five such sub-stations, but any number less than five can be used. The *Talk-A-Phone* KR-40 system permits private two-way communication between the amplifier (known as Master) station and any of the sub-stations. The master station can call all sub-stations simultaneously if need for this operation arises. The sub-stations can answer and call the master station, but cannot call one another. It is possible to place the units as far as 3,000 feet apart from each other, but shorter distances are recommended. The person operating the master unit, of course, must control the *talk-listen* switch.

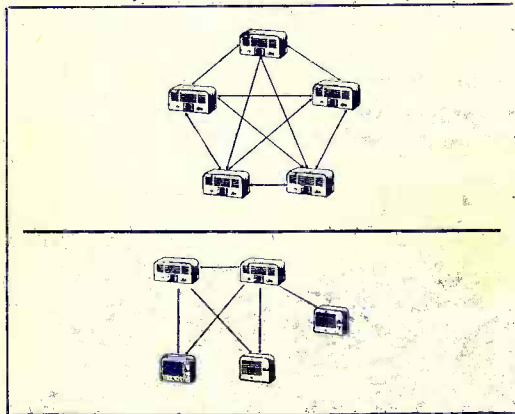
SERVICING INTER-COMMUNICATORS

A complete system may be made up of master stations only to permit great freedom and versatility of operation. For example, in a system made up of ten such master stations five two-way private conversations



Diagrammatical illustration which shows how a single master is connected to several sub-stations.

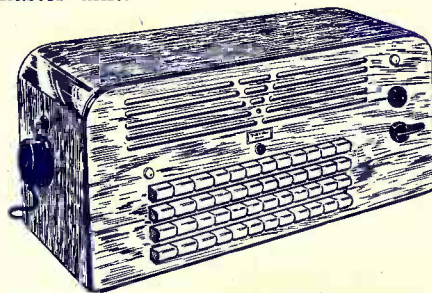
can be held simultaneously without interference or cross-talk. Each station can call any other regardless of whether the station being called has the power "on" or not. Such a system is known as *super-selective*.



It is possible to combine master stations, sub-stations, and special booster units to serve special requirements. You can readily understand that certain applications may require the master stations to have facilities to call any other master or any sub-station, but the sub-station may not require to originate the calls. Headphones may be incorporated for privacy of conversation. A booster unit is a high power amplifier which is used in connection with a sub-station for louder reproduction and paging.

The understanding of the basic facts about inter-communicators is essential before any servicing can be successfully accomplished. Let us first consider service tests in locating faults that may come up in a master selective system. If any one sub-station cannot call the master, but the master can call and carry on conversation with this sub-station, the fault must lie in the third wire of the cable (*black* in diagram). To test this lead, or any other, use an ohmmeter or small flashlight bulb and a couple of dry cells. Disconnect cable from units, but leave in place. Short any two at one end and test for continuous circuit from the other end. By taking different combinations of two wires, the faulty wire (the one having the break) can be found.

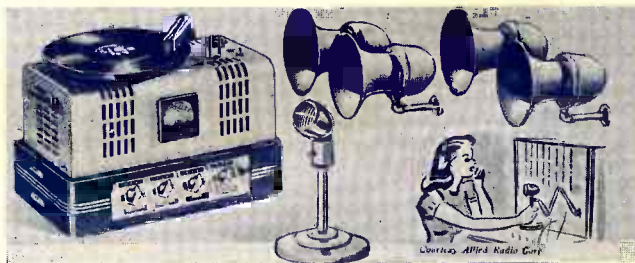
If a sub-station is suspected, remove it from its circuit and connect another one in its place. This will tell you if the fault lies in the sub-station or in the associated wires and master station circuit. If the fault is not in the cable and not in the sub-station, but the system fails to work only for one of the sub-stations, the fault probably is in the switch of the station selector in the master unit.



The master station is simply a high gain audio amplifier. For tests, it is best to connect one speaker (from a sub-station) to the output transformer, and another speaker (to serve as the mike) to the input. If equipment will work with this arrangement, fault must lie in the switch or cable. Tests for faults in power supply as explained on page 48.

PAGING EQUIPMENT

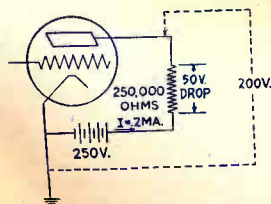
Booster units are separate amplifiers which are excited from the output of the master station. These units are used for paging or calling. In some installations a powerful audio amplifier and a number of loudspeakers placed in various locations serve the same purpose. A public address system used for paging can be used for specific *one way* instructions and usually depends on the telephone for the response.



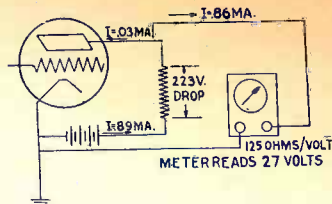
Hard-of-hearing installations use regular P.A. equipment. Loudspeakers may be included, but part of the output serves a group of headphones connected in series-parallel to match the output impedance of the amplifier. Usually a volume control is incorporated at each headphone junction box to permit the individual using each 'phone to adjust the volume level for his own needs.

ERRORS IN MEASUREMENTS

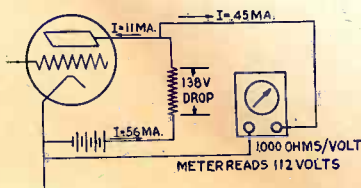
Meter Range—250 Volts Full Scale in All Cases



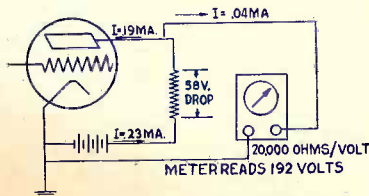
Normal Operation No Meter In Circuit



Conditions Using 125 Ohms Per Volt Meter



Conditions Using 1,000 Ohms Per Volt Meter



Conditions Using 20,000 Ohms Per Volt Meter

A voltmeter connected to make a voltage measurement is always across a circuit containing resistance. If you will recall that batteries have internal resistance, you will realize that this is so even when the voltage of a battery is being measured. Now consider the resistance-loaded plate circuit as illustrated. A plate voltage supply of 250 volts is indicated. The current passing through the 250,000 ohm resistor and plate circuit of the tube is 0.2 ma., or .0002 amperes. You can easily calculate the voltage drop across the plate resistor as 50 volts. This leaves 200 volts at the plate of the tube as measured to ground. The tube is actually a pentode with a plate resistance of about one megohm.

Let us see what happens when we use a none too sensitive voltmeter of 125 ohms/volt to make the measurement of voltage from the plate to ground. Because the meter has such low internal resistance, it will pass a great deal of current. The IR drop in the circuit leading to the plate will increase to 223 volts. The current through the tube will be smaller, and the voltage at the plate under these conditions will be only 27 volts. The value will be closer to the actual voltage with more sensitive meters, but in all cases will be somewhat smaller than the value actually present without the meter being connected in the circuit.

You must remember when making voltage tests in circuits where high resistance is present, that the reading will be off. By considering the circuit with the meter connected, you can estimate whether a much lower value obtained with the meter implies that the actual voltage is correct (without the meter being in the circuit), or that a fault exists.



All meters lack perfection of accuracy. In practical work very rough reading is usually sufficient and 5% accuracy is very satisfactory. The errors are due to several causes. The meter cannot be calibrated perfectly. The scales are printed from a drawing which is based on a typical meter of the type considered. However, not all bearings, springs, magnets, and coils are exactly alike and slight variations in responding to the same current always result. The same current, therefore, may give slightly different readings in several similar meters. Errors are also due to the associated resistors and to the width of the pointer.

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SYLVANIA RADIO TUBE CHARACTERISTICS CHART



NOTICE

This chart has been completely revised and many new and old types have been added to make it of more use to servicemen.

Please note that the inclusion of many of these old types does not mean that they are available from Sylvania. They are included for your reference in finding substitutes, etc. Consult our price list for types currently available.

The data published here have been compiled from various sources and while believed to be accurate, no responsibility can be assumed in case of error.

HOW TO USE THIS CHART

The types are listed in numerical and alphabetical order because there are now so many types it is difficult to remember even the style of construction or whether it has a filament or cathode as emitter. The second column now lists the style of construction. Lock-in, Miniature and GT are, of course, well known, but the

letters "T" and "ST" may need explaining. "T" means tubular bulb and "ST" is the dome topped bulb as now used in Type 6D6, 24, etc. The following number gives the nominal maximum diameter in eighths of inches.

New columns have been added to show the type of emitter, (cathode or filament), and for interelectrode capacitances on those types having capacitance ratings. On converters the capacitances shown are respectively, Signal Grid to Plate; R-F Input; and Mixer Output. The capacitance values shown are for a shielded tube when the data are available, since this is the latest standard method. Except in the case of obsolete (or newly announced) types, more complete technical data may be found in the Manual

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SYLVANIA ELECTRIC

EMPORIUM, PENNSYLVANIA

