RADIO

Servicing Course

PRACTICAL RADIO TRAINING FOR HOME-STUDY

THEORY
PRACTICE EXPERIENCE

Compiled by
M. N. BEITMAN

SUPREME PUBLICATIONS
1959

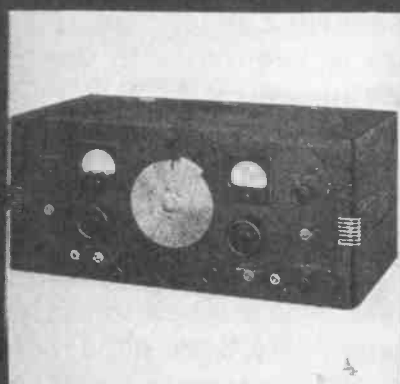
PRICE $2.50



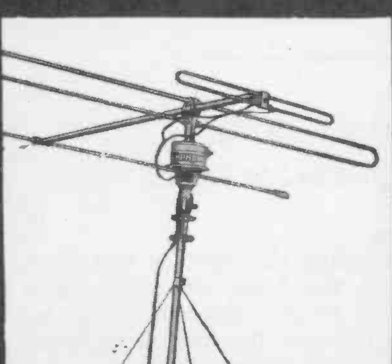
73,000,000 RADIOS TO BE REPAIRED

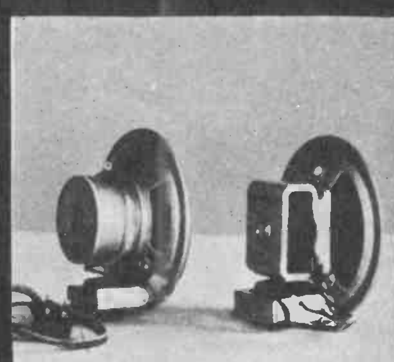


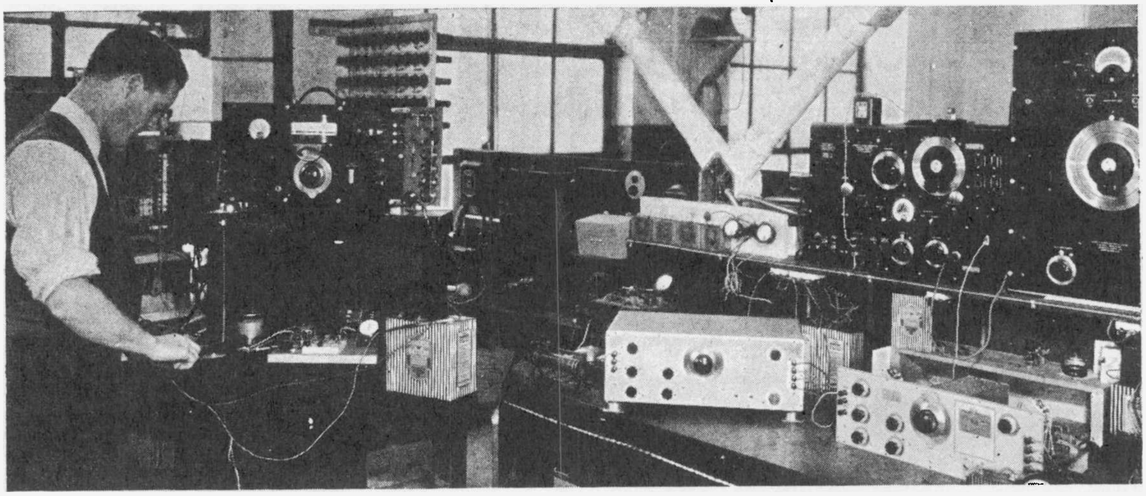





HERE IS YOUR COMPLETE COURSE OF TRAINING IN RADIO SERVICING







RADIO is today's opportunity field. In spite of the tremendous increase of the use of television, more radio receivers have been sold in the last few years than ever before. Amplifiers for public address use are finding extensive application and are serviced and installed by radio servicemen. The use of frequency modulation is increasing and this subject is covered in a complete lesson in this course-book. The study of television requires a background of radio knowledge and this text will give such training.

Study this course with a will to learn, slowly, going over the more difficult parts several times. Other technical radio reading will help you. Be sure to keep up with the latest developments by reading technical radio magazines. For practice build radio sets and test equipment available in kit form. Study real radio receivers and other electronic equipment whenever you have the chance.

This course is adaptable for the use of a beginner, but the subject matter goes beyond the elementary and will prove of aid to the professional serviceman who wishes to brush up on basic facts and modern service methods. We have hundreds of letters from users of the earlier editions of this course, who have expressed their thanks for the aid given them by this course. May your success in radio also improve through the study of this course.

THEORY
PRACTICE
EXPERIENCE

THIS IS A MARK OF SUPREME PUBLICATIONS

LESSON 1

INTRODUCTION AND FUNDAMENTAL FACTS

Originally the text to this course was prepared by the staff of instructors of the Radio Technical Institute. This material has been revised several times and brought up to date. These lessons were the stepping stones to success for thousands of men. You will enjoy and benefit through your study. Here is your complete training in radio and background for future study of television.

Although modern radios use complex circuits, their function is based on surprisingly few principles that can be easily mastered. Once the material presented in these lessons is clearly understood, you will possess the knowledge essential to be a first class radio serviceman and will be able to continue your studies in television. But you need not wait until you finish this course to begin to earn extra money servicing sets. After only a few lessons you will be ready to purchase a simple tester and begin to do some types of radio repair work.

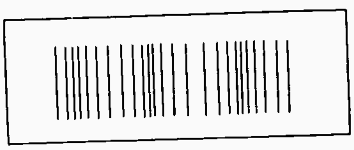
Since the entire purpose of radio is to receive sound in the form of voice or music, a few basic facts about sound are of interest and importance to radio servicemen. Sounds must be conducted through some medium. In general, solids are good conductors of sound, but porous materials are poor conductors. Air is the most useful medium for sound conduction. In air the velocity of sound is about 1,090 feet per second, at 0° C. This velocity increases about two feet per second per degree C. The velocity in other media differs. In water the velocity of sound is about four times as great as in air.

Vibrations are either transverse or longitudinal. Water waves are transverse to the line of motion. There is no forward movement of the water itself, but there is a rising and falling motion as the water wave advances. Any single particle of water on the surface will rise and fall, but will move neither forward nor backwards.

When a body vibrates, the air immediately in front is first compressed and then released. The cone of a loudspeaker acts in this manner. In this way, a series of condensations and rarefactions is produced. This train of waves is longitudinal since it takes place in the direction of motion. There is but little movement of the air forward since each pulse communicates its energy to the air directly in front of itself.

A single cycle is completed when the vibrating body completes two vibrations (one forward and one backwards) and returns to the original position. A period is the time required to complete one such cycle. The number of cycles per second is the frequency (per second).

As a radio serviceman you may expect to be called upon to repair and install public address amplifiers and high fidelity systems, therefore it is important to you to understand the behavior of sound in enclosed rooms. A few fundamentals will be discussed now while a more advanced lesson will deal with practical problems of this nature.



Crowded lines represent condensations, the other lines rarefactions, in this analogy of the effect of sound on a medium.

Acoustics is the science that deals with the behavior of sound. All sounds created proceed outwards in spherical waves until they strike the boundaries of the room. Upon striking the walls and other objects, sounds are absorbed, reflected, and transmitted in varying amounts depending upon the character of the object. Sound energy is diminished with each reflection because of the absorption, and this action finally results in the sound dying out. Continuous reflection has the advantage of loudness, but always introduces prolonged existance of each sound. This prolongation or reverberation is the most common acoustic fault found in auditoriums.

When you actually begin to do radio repair work you will find that for majority of repairs one or more replacement parts will be needed. All parts that may be required for replacement are sold by radio parts distributors also known as jobbers. The location of such firms may be known to you or you may be able to find their addresses in a telephone book. If you do not live in a large city, mail order houses will be glad to aid you and distribute free catalogs listing parts.

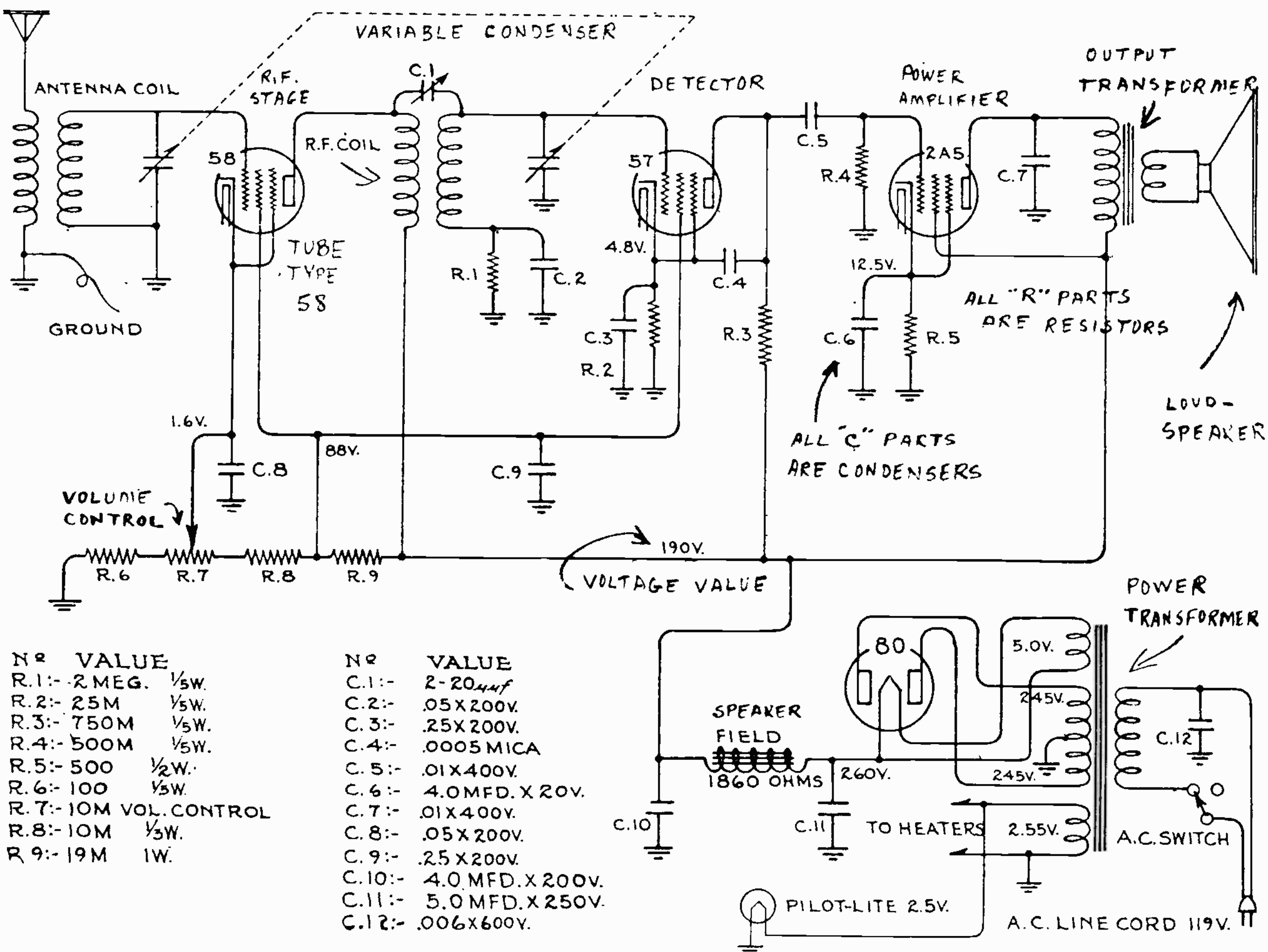
Usually you are able to secure replacement parts at 40% discount from list prices and in charging your customers you make a profit by making your bill out for the actual list price. This is a fair profit to you since you must spend time and effort in buying needed parts or carry a small stock of popular parts on hand. Of course, your service charge is in addition to any profit you may be making on the parts themselves.

It is a good idea to introduce yourself by mail or in person to a nearby jobber and secure his suggestions and assistance. You can especially benefit by his suggestion of parts that should be included in your stock so that you need not waste time each time a part is needed.

As a future radio serviceman you should begin reading technical radio magazines. The magazines with the greatest circulation in this field are "Radio & TV News," and "Radio-Electronics." There are other excellent magazines as well. Besides finding helpful articles in these publications you will benefit by reading the advertisements that offer lists of parts for sale as well as free catalogs.

To do actual experiments and repair of radios, you should have a place to work. This may be a basement work shop, garage, or even a corner in a kitchen. In time when you begin to do more serious and profitable radio repairing you can consider expanding to a rental location.

On page 10 you will find symbols for commonly used radio parts. While the function of these parts may not be clear to you at this time you could readily understand that these symbols are a shorthand method for illustrating parts used in radio receivers, Since in actual radio receivers these parts are interconnected with wires or with conducting surfaces in printed circuits, some method must be used in illustrating the same connections. This is done in diagrams by means of straight lines joining the parts and providing the same electrical path as exists in the radio set itself. We illustrate a simple radio circuit with the names of the parts next to most of the symbols.



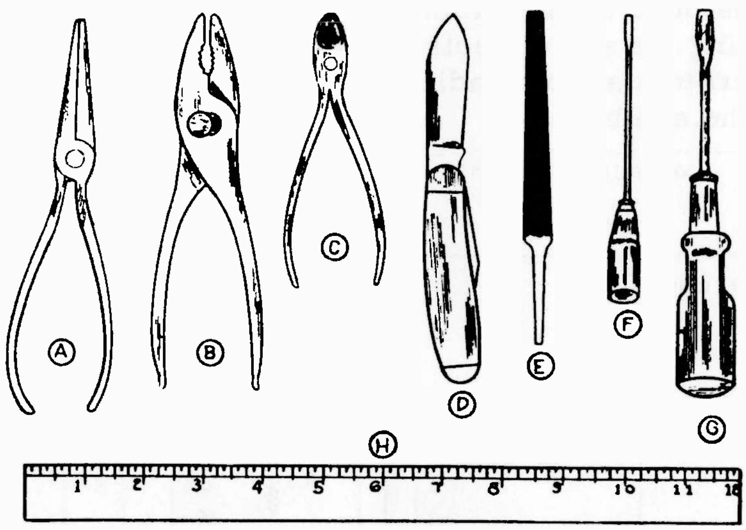
Nº	VALUE
R.1:-	2 MEG. 1/3W.
R.2:-	25M 1/3W.
R.3:-	750M 1/3W.
R.4:-	500M 1/3W.
R.5:-	500 1/2W.
R.6:-	100 1/3W.
R.7:-	10M VOL. CONTROL
R.8:-	10M 1/3W.
R.9:-	19M 1W.

Nº	VALUE
C.1:-	2-20 $\mu\mu f$
C.2:-	.05 X 200V.
C.3:-	.25 X 200V.
C.4:-	.0005 MICA
C.5:-	.01 X 400V.
C.6:-	4.0 MFD. X 20V.
C.7:-	.01 X 400V.
C.8:-	.05 X 200V.
C.9:-	.25 X 200V.
C.10:-	4.0 MFD. X 200V.
C.11:-	5.0 MFD. X 250V.
C.12:-	.006 X 600V.

As you study this course you will realize that circuit diagrams and other service data are not only helpful but actually are essential to conserve time. As you probably know, Surpreme Publications issues annually a manual covering all popular radio sets and a separate volume covering television receivers. These are low price manuals and contain practically all material that you will need in your work. Certainly they will serve well at first and the more expensive volumes of other publishers can be considered at a much later date.

Your initial tools are illustrated below. Probably you already have these tools in your procession and will not need to spend any additional funds at the present time.

Majority of connections in radio sets are made electrically secure with solder and a soldering iron is needed for disconnecting parts and for making new connections. For most radio work an electrically heated iron is employed.



These are common radio tools needed for radio repairing and construction work. (A) Long-nose pliers, (B) Gas pliers, (C) Diagonal cutters, (D) Pocket knife, (E) Flat file, (F) Small screwdriver, (G) Medium-size screwdriver, (H) Scale.

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 former 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.

It is advisable for a radio repairman to carry an inexpensive wood finishing kit obtainable at paint stores. A great deal of good will can be secured by touching up any mars or scratches that are noticeable on the cabinet of the radio being repaired. It is also possible actually to offer this service on a fee basis and this manner supplement your income.

Your first radio repair jobs will come from friends and acquaintances. Do not hesitate to accept work even at an early stage in your study. You will derive a great deal of valuable experience by trying to carry out the repair. In most cases only a simple fault may be present and you will be able to correct it. Should the job prove beyond your ability at this early stage in your career, you can make arrangements with a more experienced serviceman to take over such work from you and allow you a percentage of his charges as a commission for finding this work.

Several of the larger manufacturers of radio tubes offer shop garments and tools with the purchase of a quantity of tubes. Since a great many of repairs you will be making will require replacement of tubes, by joining one of these plans you will be able to secure various items needed to establish your business practically free of charge. Sylvania Electric Products offers imprinted stationary at a very low price. The reason that this is done is to secure the good will and publicity resulting by imprinting a small message about Sylvania tubes. We suggest that you write to this firm at Emporium, Pa.

REVIEW QUESTIONS

1. Roughly what is the speed of sound in water?
2. What happens to sound when it strikes a wall? How different is this behavior when sound strikes a cloth drape?
3. Name ten different parts used in radio sets.
4. How can you tell if a connection was properly soldered?

DO NOT RUSH YOUR PROGRESS, KNOW EVERYTHING IN THIS LESSON.

LESSON 2

ELEMENTARY ELECTRICITY

For comparative purposes of the quantities that are encountered in electrical circuits, selected units are employed. These units are inter-related and are based on absolute basic reactions. Because of the nature of electricity and the associated force magnetism, we cannot measure or note these forces directly with our senses, but must resort to indirect indicators (meters, lights, etc.) operated by these forces.

Electrical current in a circuit consists of a large number of electrons flowing in a complex manner through the conductor such as a wire cord. Since electrons are negatively charged particles, the current actually consists of a motion of negative electrical charges. The measurement of quantity of current, therefore, is the measure of the sum of all the charges. An electric or magnetic charge may be measured by the force of attraction or repulsion which exists between this charge and some other charge. It is important to remember that unlike charges attract, and like charges repel.

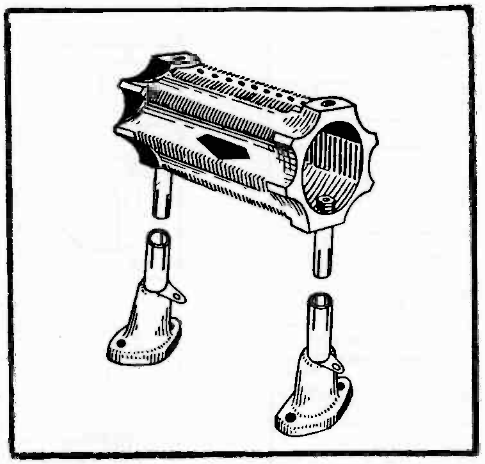
If we connect two bodies that have different charges (one positive and one negative), a current will flow. The positive body lacks electrons, and the negative body has an excess of electrons; the current is the passage of these electrons from the negative body to the positive one.

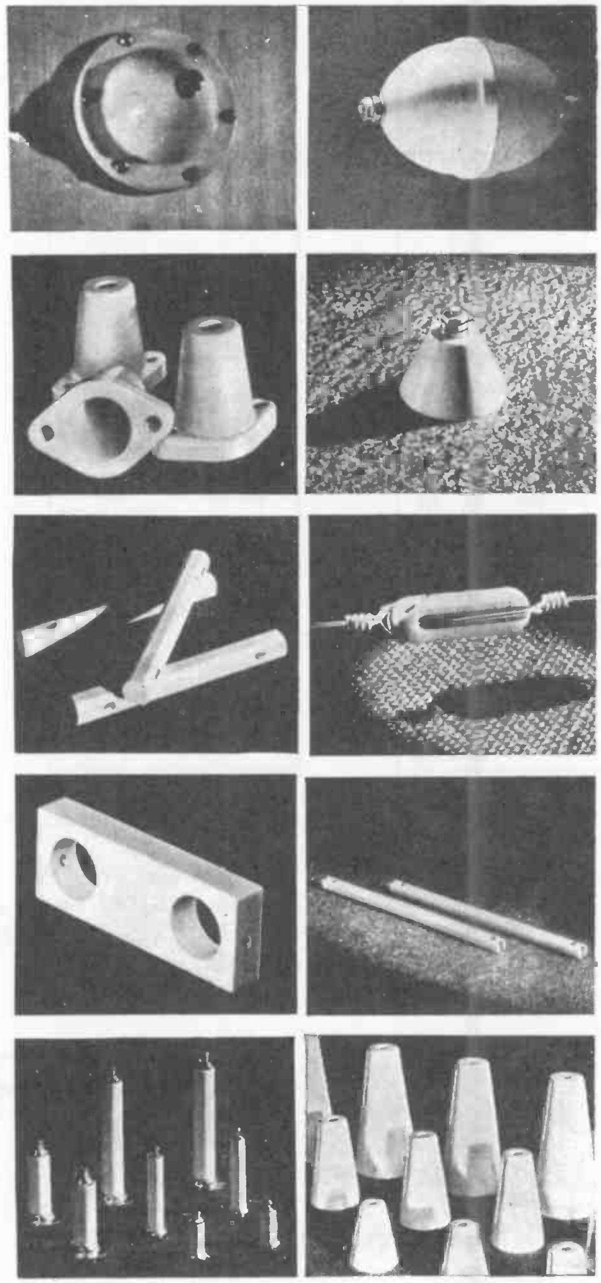
Electro-motive force, E.M.F., which will force electrons to flow through a conductor can be generated in a number of different ways. Friction was the earliest known method, but is not used commercially today. In dynamos a conductor is moved in a magnetic field. Chemical changes generate an electrical current in batteries.

The flow of electricity is the passage of electrons between the heavier atoms of the conductor. The solid substances which conduct electricity best are the metals. Copper is the best conductor of the materials practical to employ for this purpose. Other metals, iron, alloys of nickel, have greater opposition (resistance) to the flow of electric current and find certain special applications.

It is evident that some substances are very good electrical <u>conductors</u>, others have greater resistance, while still others have almost no conducting properties and are called <u>insulators</u>. Hard rubber, bakelite, glass, porcelain are used extensively as radio insulators to separate parts that should not have electrical current flowing between them.

For the beginner student we have included a number of illustrations of radio parts that are excellent examples of conductors and insulators. Note the coil form which is made of special insulating material, Isotex; while the terminal jacks are of good conducting metal. The application of these parts may not be clear at this time, but will be explained later.

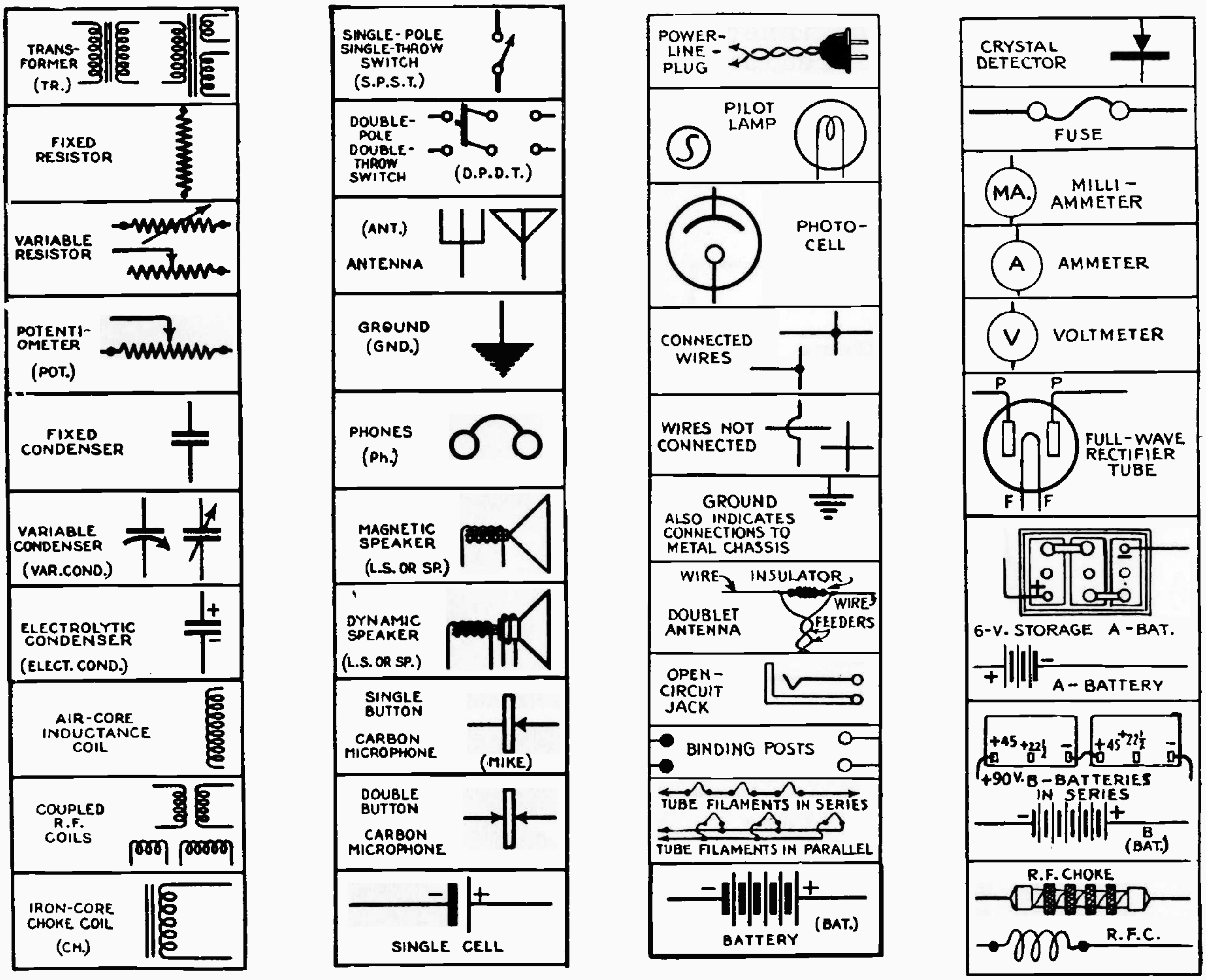




Many different insulators are shown on the right. These are employed for various applications in antenna systems, transmitters, and receivers. Special ceramic materials are used to reduce the electrical losses and make the units better insulators.

Every radio part, naturally, must have some conducting material. In coils we have the wire, in condensers the metal plates — and every circuit has the many parts wired and interconnected with copper hook-up wire.

The radio serviceman has his own language of radio symbols. Circuits are always shown in these symbols and the radio manuals use them. There are only a few used and once these are mastered, the understanding of radio becomes a simpler problem. These symbols will appear as we progress with the course.



Much information on new developments is presented in many technical radio magazines. You, as a future radio serviceman, should begin reading these magazines at an early stage of your career.

REVIEW QUESTIONS

1. Of what potential are electrons?

2. Name two ways an electric current can be generated.

3. Name several good conductors of electricity.

4. Make a sketch showing the connection of a fixed condenser and a fixed resistor connected to a meter.

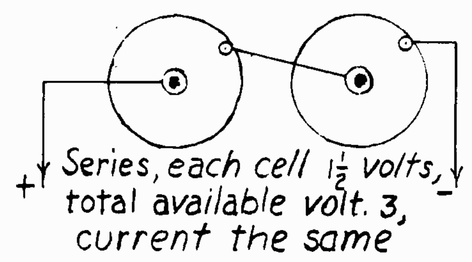
5. Examine several circuits in radio magazines and name each part used.

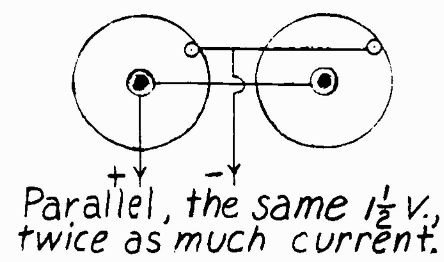
LESSON 3

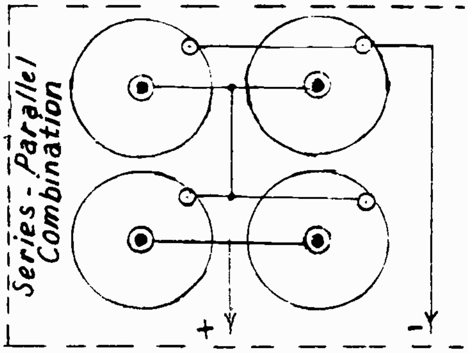
RADIO BATTERIES

A cell is a unit that produces electrical energy by means of chemical action. A battery is a combination of two or more cells connected in series or parallel. A primary cell is a unit that produces an electrical current because of a chemical reaction. Once the acting material is used up or an equalibrium is reached, no further appreciable current can be produced.

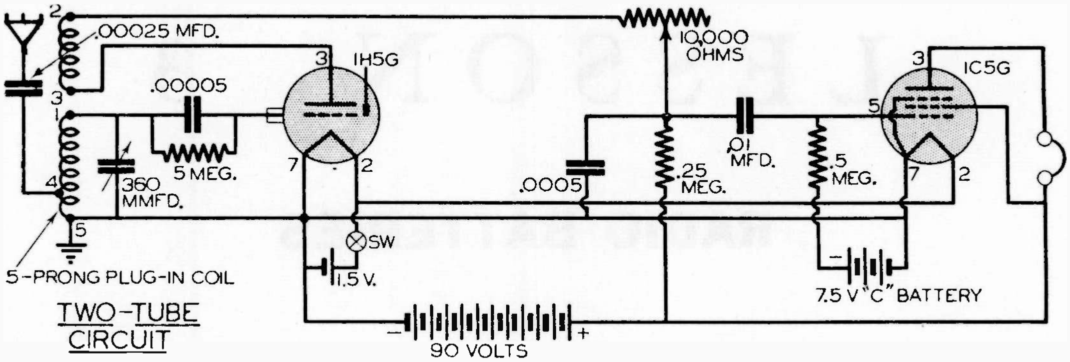
The ordinary flash-light battery is of this type. This "dry" cell has an outside foil of zinc that acts as the negative electrode and a center positive electrode of carbon (copper could be used instead). There is also a chemical solution in paste form. The common type "B" batteries are made up of a great number of these cells connected in series and thereby furnishing relatively high voltages. Different methods of connecting cells are illustrated below.







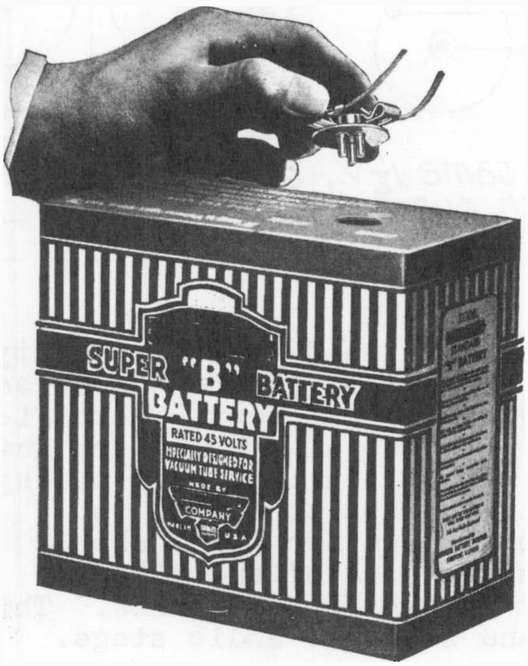
While A.C. operated receivers are used in the majority of homes, battery type radio sets are still finding widespread use in rural communities that as yet have not been electrified, and for portable use. Some house sets and all the modern auto sets obtain their operating power from a single 6 volt storage battery. Means are incorporated in the set to change the available low D.C. voltage to high voltage for plate supply requirements. Some battery sets still use "B" and "C" batteries and we refer the student to the circuit below. This is a simple set using a detector and a single audio stage.

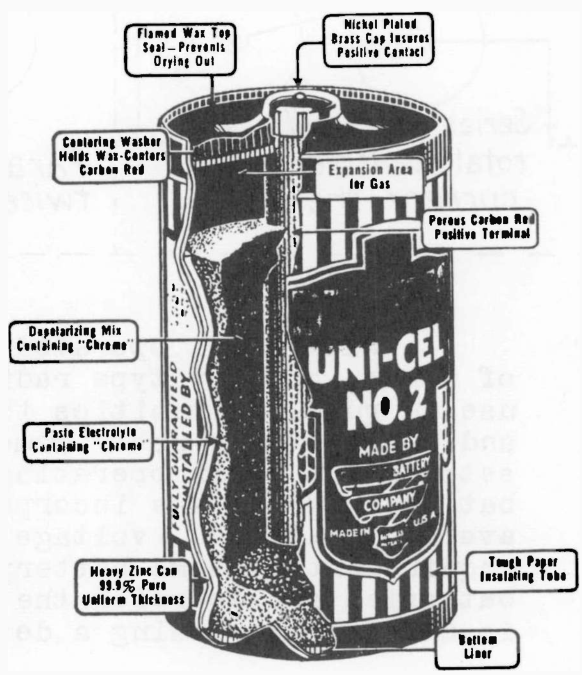


TWO-TUBE CIRCUIT

The storage battery is a secondary battery because it cannot produce an electrical current of itself, but must at first be charged. The current used for charging is stored and may be obtained when needed. The battery actually does not store electricity, it stores chemical energy created by the charging current. When the current is used during the discharge period, chemical energy is used up. Radio storage batteries are tested with a hydrometer since the specific gravity of the solution changes with the "charge" condition of the battery. The acid level should be at 1.275 when the battery is fully charged, and the battery should be recharged when the level reaches the 1.150 point.

The storage battery may be recharged by means of a charger from a 110 volt line, or a generator rotated by the wind may be used in conjunction with the battery to keep it always in operating condition. There are now also available inexpensive gasoline driven generators for quickly charging batteries.





LESSON 4

CIRCUITS - MAGNETISM - ELECTROMAGNETS

A coulomb is a definite quantity of electricity just like a gallon of oil is a quantity of oil. An ampere is the rate of current flow and is the passage of one coulomb per second. For measuring small electric currents a unit, milliampere, equal to 1/1000 of an ampere is used. 1,000 milliamperes are equal to one ampere. Meters used to measure electrical current are called ammeters or milliameters depending upon the currents they are designed to measure.

A current passes along a conductor because of an electromotive force (e.m.f.) or a potential difference. The volt is commonly used to measure potential difference and e.m.f. is often referred to as voltage.

The e.m.f. developed by a single standard dry cell, such as a flash light cell, is $1\frac{1}{2}$ volts. A single storage battery cell fully charged has a potential (voltage) slightly over 2 volts.

All conductors of electricity oppose the flow of current through them. They have electrical resistance. The unit of resistance is the ohm. In radio circuits very high resistance are sometimes encountered and the term megohm is used for 1,000,000 ohms. The student should memorize all the terms underlined as they are of prime importance in radio work. If an Encyclopedia is available at the library, the history of each term should be looked up.

NUMBERS, FRACTIONS, DECIMALS, SIMPLE FORMULAS EXPLAINED AS A TOOL

Mathematics is a symbolic way of explaining and analyzing physical occurances. Arithmetical numbers represent quantity. Ten volts is ten times the standard measure — the volt. Numbers tell how many, is it larger or smaller, is it too small ... all these are measures of quantity. Algebraic symbols (usually letters of the English and Greek alphabet) represent specific measureable quantities. For example, E usually stands for voltage in electrical work. This is really another way of writing "voltage", i.e. we write E instead of the word voltage. In a like manner we usually write I for current, and R for resistance. Using letters saves time and greatly simplifies the writing of formulas. The Ohm's Law may be written in words as:

Voltage = Current (multiplied by) Resistance

or in symbols as $E = I \times R$

Of course, the algebraic way of writing is much simpler.

Sometimes in the same problem there are two different voltages, such as the grid and plate voltages in a vacuum tube. Here again we may use some letter, as "E", to represent voltage and use small letters after E and a little below it, to stand for grid and plate voltages respectively. As:

$E_g \longrightarrow$ grid voltage

$E_p \longrightarrow$ plate voltage

Many times in radio work quantities are parts of a whole unit and are called <u>fractions</u>. $\frac{1}{2}$ volt is a fraction of a volt. 5-1/4 is a whole number and a fraction. The number above the line is called the numerator, and the one below the denominator. The denominator tells what part of the whole, the numerator tells how many parts.

<u>Decimals</u> are more convenient than fractions and, therefore, find greater application. Multiplication and division by ten or some multiple of ten simply shifts the decimal point. Fractions, of course, may be expressed as decimals, and vice versa. For example, 5 2/5 may be written as 5.4. The number 5. representing the whole part of the fraction, and 2/5 changed to tenths becoming 4/10 and written .4 . In radio work, decimals are almost exclusively employed.

A number multiplied by itself is said to be squared.

$$A \times A = A^2$$

The small raised ^{2} indicates that "A" has been multiplied by A; that is, by itself.

The square root sign $\sqrt{}$ means that it is required to find a number that multiplied by itself will give the number under the $\sqrt{}$ sign. For example, find $\sqrt{9}$. A number that multiplied by itself will give 9, is 3, so that:

$$\sqrt{9} = 3 \qquad 3^2 = 9$$

OHM'S LAW

We now come to an important relation between voltage, current, and resistance. It is easily seen that the greater the voltage, the larger is the number of electrons flowing or the larger is the equivalent current. But the larger the resistance, the smaller is the current. In mathematical words, the current in amperes equals the voltage in volts divided by the resistance in ohms.

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

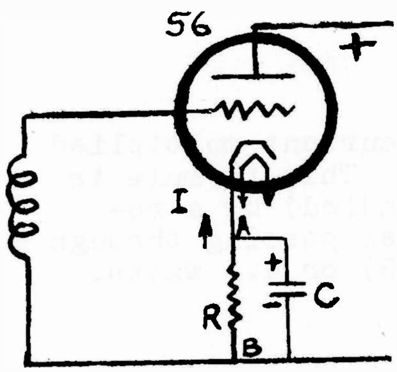
where I stands for current, E for voltage, R for resistance. This equation enables us to calculate the current when the voltage and the resistance of the circuit are known. For example, in a 110 volt circuit the resistance is 10 ohms. Dividing 110 by 10, we obtain 11 amperes which is the current.

Ohm's Law may also be written as $E = I \times R$

The voltage is equal to the product of the current by the resistance. If a current of 2 amperes flows through a resistor of 6 ohms, the voltage drop is (2 x 6) or 12 volts. In some devices the voltage drop produced in a resistance is used to reduce the over all high voltage. In some other cases, the current is made to flow through a resistor purposely to create a voltage drop for some special need. This latter application is used for "C" bias in vacuum tube circuits.

By means of Ohm's Law, if the voltage and current are known, the circuit resistance may be found. For this purpose the formula below is used.

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



In the circuit to the left, a resistor R is used to create a negative bias on the grid of the vacuum tube. There is a constant D.C. current I passing through the tube and the associated resistor R. The A.C. component of tube-current is by-passed by condenser C. The voltage difference between points A and B, will be equal to the IR drop of the D.C. Point B will be more negative since electrons will move from point B to A, and then from cathode to the positive plate. Since the grid is connected to point B through the coil winding of low D.C. resistance, the grid will be at IR lower potential than the cathode connected to A.

A formula is an equation used to represent a relation between a number of related factors. Usually a formula is applied to find one unknown factor when the others are known. The Ohm's Law is a simple formula:

$$E = I \times R$$

Suppose in a certain circuit we know that I = 2, and R = 50, substituting these values in the formula above, we are able to find the unknown E.

$$E = 2 \times 50$$

$$E = 100 \text{ volts}$$

In this case by knowing the current and the associated resistance and by applying the Ohm's Law formula, we were able to find the value of the voltage.

WATTAGE OR ELECTRICAL POWER

Electricity can do work or create heat and is therefore a source of power. The unit of electrical power is the watt. The watt is the power produced by one ampere flowing under the pressure of one volt. Numerically the power in watts equals the product of volts by amperes of current.

$$W = E \times I$$

where W stands for watts, E stands for the voltage, and I stands for the current. The filament of a common type 56 vacuum tube operates on 2½ volts and requires 1 ampere of current. The filament wattage is, therefore, 2½ x 1 or 2½ watts. If current and voltage are known, wattage can be calculated.

By recalling from Ohm's Law that E = IR and substituting in the equation above, another important formula for wattage in terms of current and resistance is obtained.

$$W = I^2R$$

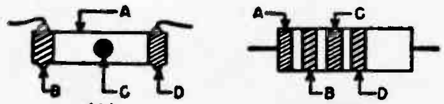
This means that the wattage is equal to the current multiplied by itself, and multiplied by the resistance. This formula is useful in finding the wattage dissipated (handled) by a resistor. For example, a current of 1.5 amperes passing through a resistor of 2 ohms, dissipates (1.5 x 1.5 x 2) or 4.5 watts. This power is actually lost as heat.

It is important in working on a radio circuit to have clearly in mind the relation existing between the different electrical factors. The Ohm's Law applies only to Direct Current, but is also applicable with certain modification to Alternating Current.

The resistance of any wire is directly proportional to its length. A piece of wire 10 feet long has twice the resistance of a similar piece 5 feet long. On the other hand, the larger the cross sectional area of the conductor the smaller is the resistance. The wire sizes are rated according to a number of different systems, but in the United States the B. & S. gauge is usually used. The larger the gauge number, the thinner is the wire. In radio work, wire sizes from # 12 to # 38 are commonly employed. Wire is obtainable with different insulation such as enamel, cotton, silk, or the combination of these materials.

Carbon composition resistors are commonly employed in radio circuits. For conveniency in determining the size of a resistor in repair work, resistors are color coded according to a standard code adopted by the R.M.A. Three indications are employed: the body, the end, and the middle dot. Ten colors are used, one for each number from 1 to 9, and 0. The table below gives color-figure code.

RESISTOR COLOR CODE



(A) (B)

RETMA COLOR CODE CHART

COLOR	VALUE	MULTIPLIER
Black	0	1
Brown	1	10
Red	2	100
Orange	3	1000
Yellow	4	10,000
Green	5	100,000
Blue	6	1,000,000
Violet	7	10,000,000
Grey	8	100,000,000
White	9	1,000,000,000

TOLERANCE CODE

Gold—±5% Silver—±10%
No Color—±20%

The ohmic value of a resistor can be determined by means of the color code. There are two standard methods of indicating this value.

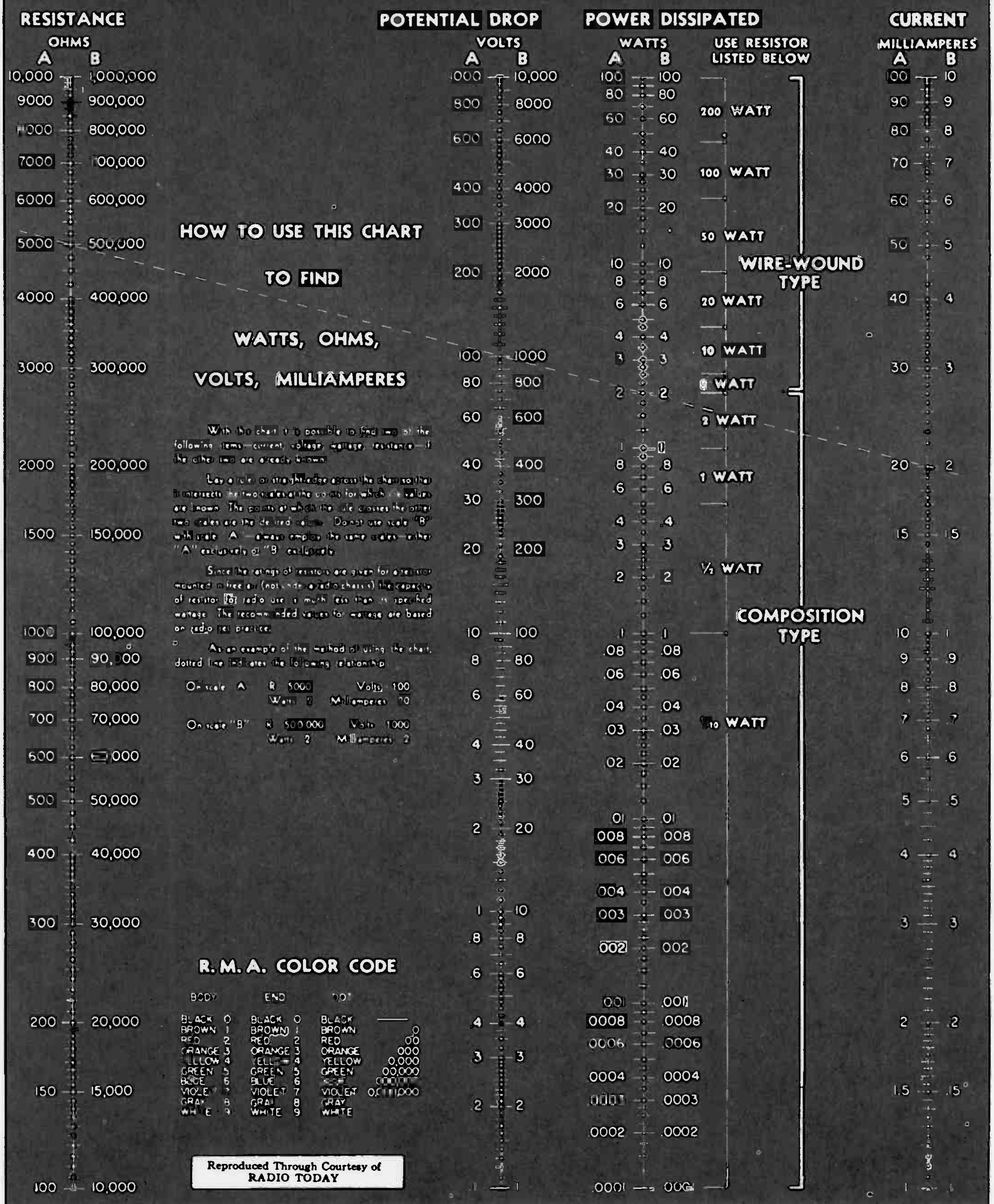
In Fig. A, the body (A) and end (B) indicate the first and second digits of the value while the dot (C) indicates the multiplier to be used. The tolerance of the unit is indicated by the end color (D). For example, if the body (A) is green the number is 5; if the end (B) is grey the second number is 8. If the dot (C) is red the multiplier is 100 or two zeros should be added. The resistor is then a 5800 ohm unit. If the end (D) has no color, the tolerance is ±20%.

In Fig. B, the first two stripes indicate the first two digits; the third stripe the multiplier; the fourth stripe the tolerance. Thus, if stripe (A) is green, (B) is grey, (C) is red, and (D) is silver, the resistor is a 5800 ohm, ±10% unit.

Besides being rated in ohms, every resistance possesses another electrical rating corresponding to its power handling ability or wattage. Composition-type carbon resistors are rated from 1/4 to 2 watts depending on their size. Wire-wound resistors begin with about 5 watt size and go up to larger sizes.

The power dissipated by the resistor is changed to heat; if the heat is excessive due to overloading the resistor by more than just the normal current flow, the heat so developed may injure the resistor element. The rating commonly given is for open air mounting and where there are no close parts that may be injured by the heat. In mounting resistors in a closed chassis adjacent to other easily harmed parts, it is best not to load the resistor more than 50% of their rated wattage.

HOW TO TELL WHAT RESISTOR TO USE



HOW TO USE THIS CHART

TO FIND

WATTS, OHMS, VOLTS, MILLIAMPERES

With the chart it is possible to find two of the following items—current, voltage, wattage, resistance—if the other two are already known.

Lay a ruler or straightedge across the chart so that it intersects the two scales at the points for which the values are known. The points at which the rule crosses the other two scales are the desired values. Do not use scale "B" with scale "A"—always employ the same scales—either "A" exclusively or "B" exclusively.

Since the ratings of resistors are given for a resistor mounted in free air (not under a radio chassis) the capacity of resistor for radio use is much less than its specified wattage. The recommended values for wattage are based on radio set practice.

As an example of the method of using the chart, dotted line indicates the following relationship:

On scale "A"	R 5000		Volts 100	
	Watts 2		Milliamperes 20	
On scale "B"	R 500,000		Volts 1000	
	Watts 2		Milliamperes 2	

R. M. A. COLOR CODE

BODY		END		DOT	
BLACK	0	BLACK	0	BLACK	—
BROWN	1	BROWN	1	BROWN	0
RED	2	RED	2	RED	00
ORANGE	3	ORANGE	3	ORANGE	000
YELLOW	4	YELLOW	4	YELLOW	0,000
GREEN	5	GREEN	5	GREEN	00,000
BLUE	6	BLUE	6	[illegible]	[illegible]
VIOLET	7	VIOLET	7	VIOLET	0,[illegible]000
GRAY	8	GRAY	8	GRAY	
WHITE	9	WHITE	9	WHITE	

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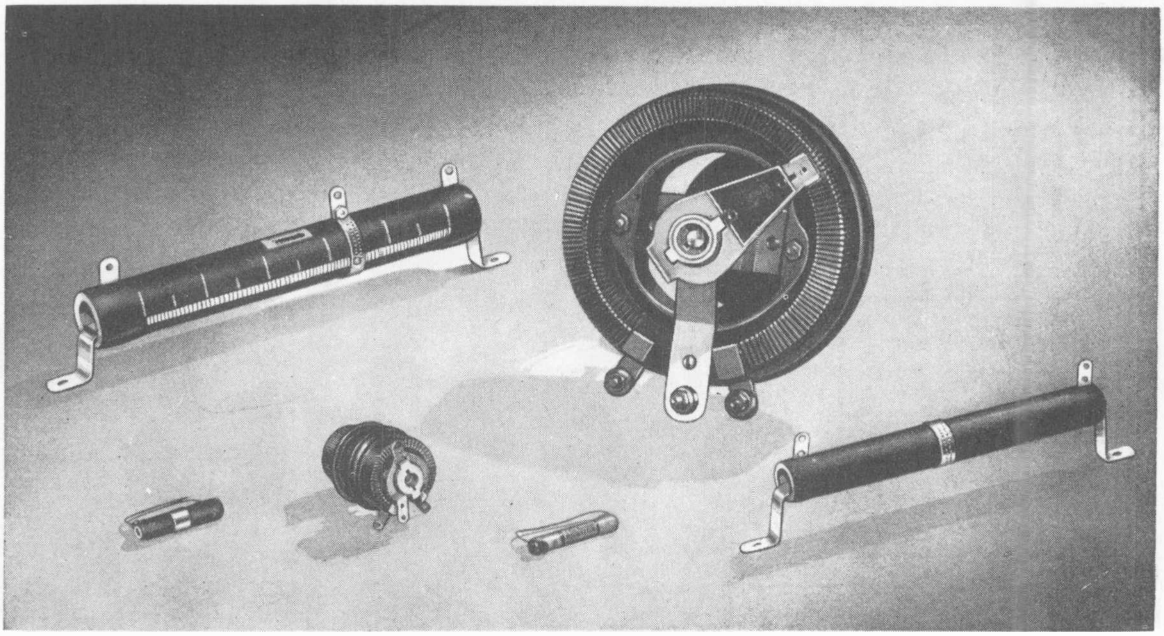


If a resistor of 3 ohms, carries a current of 2 amperes, what is the wattage dissipated?

$$W = I^2R = 2^2 \times 3 = 2 \times 2 \times 3 = 12 \text{ watts}$$

A biasing resistor causes a drop of 30 volts, with a current of 15 milliamperes (.015 amperes). What is the wattage of the resistor?

$$W = I \times E = .015 \times 30 = .45 \text{ watts}$$

Rheostats have a single end terminal and a connection to the movable contact. Potentiometers have two end terminals and a movable arm. Volume controls are a form of variable resistors.

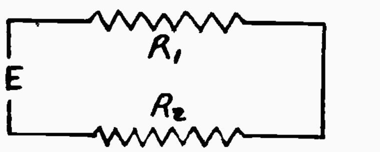
Resistances are used not only individually, but are combined in series, in parallel, and sometimes in more complex networks. The total resistance of two resistors R_1 and R_2 connected in series is the sum total of the individual resistances. In a like manner if more than just two resistors are connected in series, the total resistance is the sum total of all individual resistances. If we let R_s stand for the total resistance of a circuit having series resistances, than:

$$R_s = R_1 + R_2 + \ldots \text{ (all the other resistors present)}$$

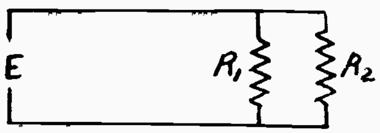
If in the series circuit above voltage E is impressed across the two resistors, the voltage drop across each resistor will be equal to IR_1, and IR_2, where I is the current. These two voltage drops together will equal to E.

$$E = IR_1 + IR_2$$

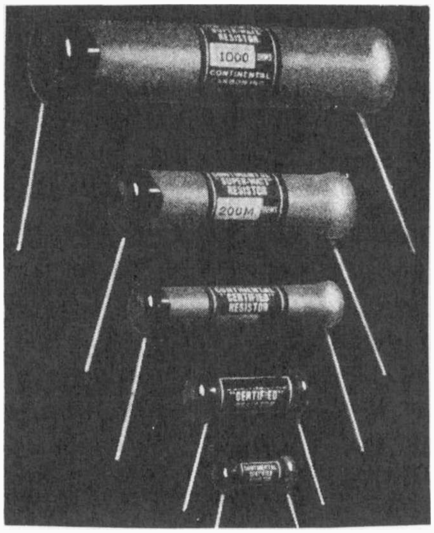
The larger voltage drop will be across the larger resistance, and by selecting proper sizes for R_1, and R_2, E may be subdivided in any way required. Care must be taken that neither of the resistors is overloaded. The wattage formula should be applied as a test.

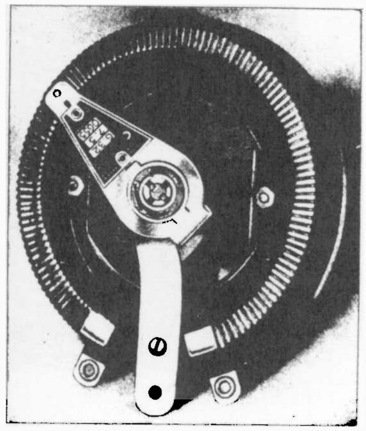


SERIES



PARALLEL





In a four tube midget radio set, three tubes are of the type that require 6.3 volts each, and one requires 25 volts. All these tubes are connected in series and use a current of 0.3 amperes. The total voltage required to operate all these tubes in series is the sum of the individual voltages, or 43.9 volts. We can round this figure into 44 volts. If the set is to be used on a 110 volt line (110 - 44) or 66 volts must be lost in a series resistor. Recalling Ohm's Law and solving:

$E = I \times R_1$ $\quad$ $66 = 0.3 \times R_1$ $\quad$ $R_1 = 220$ ohms

What wattage will this resistor dissipate?

Using the formula $W = I^2R$

$$W = (.3)^2 \times 220 = .09 \times 220 = 19.8 \text{ watts}$$

A twenty watt resistor could be used, but a slightly larger size would be better. Sometimes line cords are built with the proper resistor already incorporated.

What is the total resistance of the four tubes in series?

$$R_2 = \frac{E}{I} = \frac{3(6.3)+25}{0.3} = \frac{44}{.3} = 146.7 \text{ ohms}$$

The table on the next page and the explanation below have been reprinted from the "Aerovox Worker."

The chart covers a range which should be large enough for all radio and TV work. The ranges are from 1 to 1000 volts, from 0.1 ma. to 10 amperes, from 0.1 ohm to 10 megohms, and from 0.1 milliwatt to 10 kilowatts.

The lines are plotted on regular full logarithmic coordinate paper. Current is measured along the horizontal axis (X-axis), and voltage along the vertical axis (Y-axis). When this is done, the locus (position) of all points representing a given resistance will form a line making an angle of 45^{o} with the X-axis. All these lines are parallel, slopping upwards to the right. All points representing the same power are situated on a straight line which makes an angle of 135^{o} with the horizontal, slopping upwards towards the left.

A few examples will help you understand the use of this chart. Suppose the EMF in a circuit is 100 volts and the current is 100 ma.; what is the resistance of the circuit and power consumed? Beginning with the 100 ma. mark on the horizontal axis, and follow the vertical line upwards to the intersection with the horizontal 100 volt line. This junction is also the intersection of related slanting lines. Following the slant-line going upwards to the left read 10 watts for power; and following the other towards the upper right read 1000 ohms.

If a 5000 ohm resistor has a power rating of 20 watts, what is the maximum current and corresponding voltage with which this resistor may be used? Following the 5000 ohm slant line until the 20 watt slant line is reached, observe the junction point. From this point follow the vertical lines down, and interpolating by estimation read 63 ma. Then follow the horizontal lines from the junction point, and at the left read 316 volts.

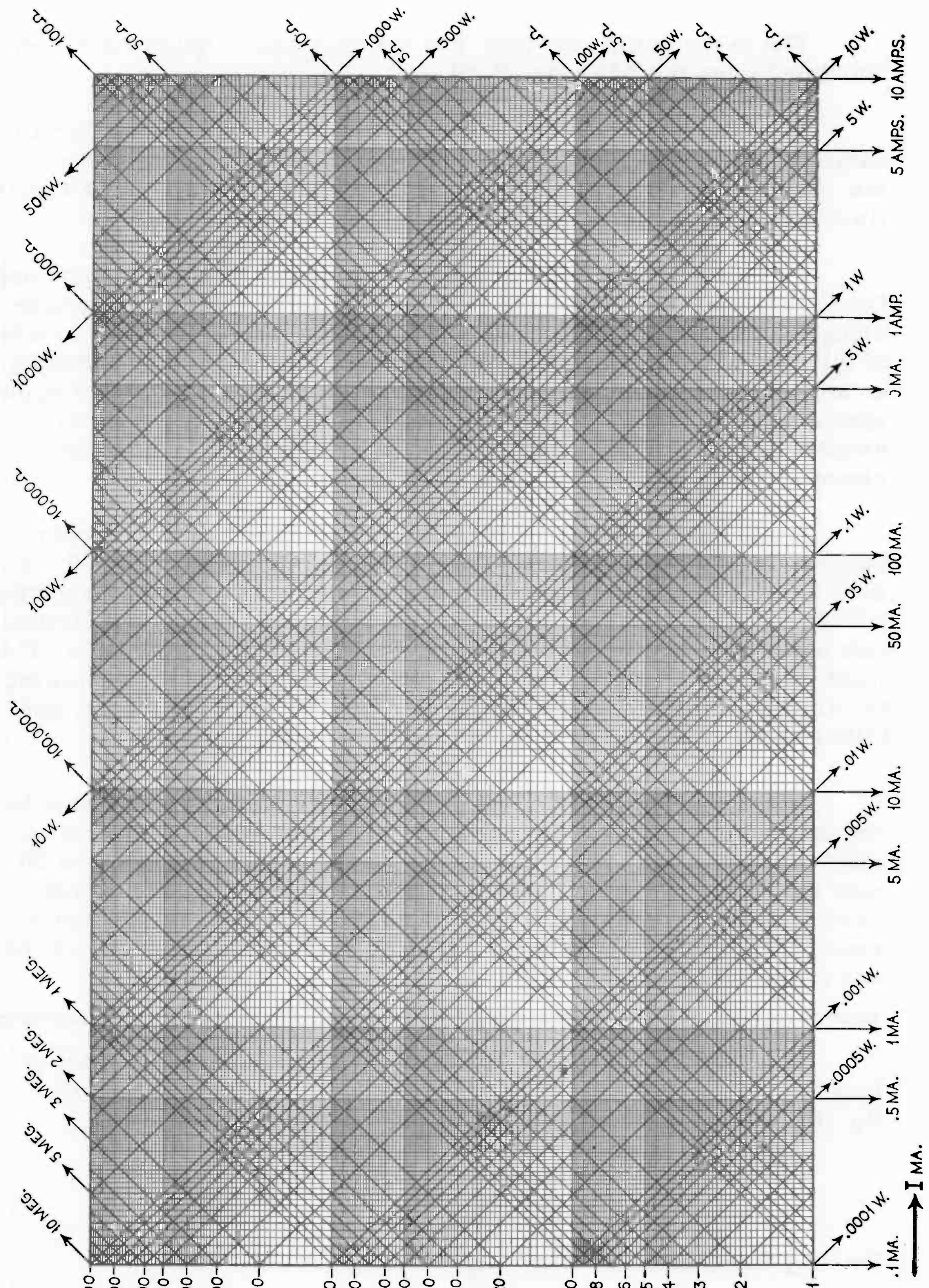
The total resistance of two resistors connected in parallel is less than the resistance of either resistor. For many resistors R_1, R_2, R_3, etc. connected in parallel, the total resistance

$$R_p = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots}$$

for only two resistors, this formula simplifies to:

$$R_p = \frac{R_1 \times R_2}{R_1 + R_2}$$

(See also page 46.)


100-Ω
50-Ω
10-Ω
1000 W.
5-Ω
500 W.
1-Ω
100W.
.5-Ω
50W.
.2-Ω
.1-Ω
10W.
10 AMPS.
5 W.
5 AMPS.
50 KW.
1000-Ω
1000 W.
1 W
1 AMP.
.5 W.
10,000-Ω
100 W.
.1 W.
100 MA.
.05 W.
50 MA.
100,000-Ω
10 W.
.01 W.
10 MA.
.005 W.
5 MA.
1 MEG.
2 MEG.
3 MEG.
5 MEG.
10 MEG.
.001 W.
1 MA.
.0005 W.
.5 MA.
.0001 W.
.1 MA.
I MA.
X
1000
800
600
500
400
300
200
100
80
60
50
40
30
20
10
8
6
5
4
3
2
1
Y
E VOLTS

In the preceding formula if we let $R_1 = 3$, and $R_2 = 5$ ohms,

$$R_p = \frac{3 \times 5}{3 + 5} = \frac{15}{8} = 1.875 \text{ ohms}$$

If a total current I_t flows in the circuit, only a fraction of this current will be in each resistor. However, the full voltage E will be across each resistor. The current in the resistors may be found from the formulas:

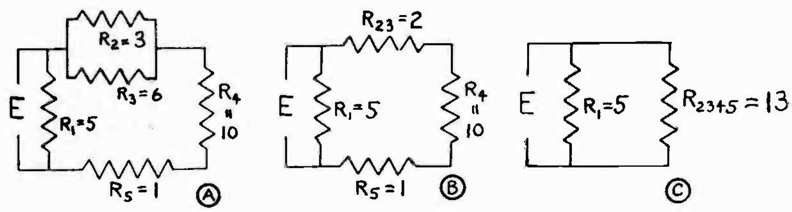
$$I_1 = \frac{E}{R_1} \qquad I_2 = \frac{E}{R_2}$$

and, of course, ... $I_t = I_1 + I_2$

The power handled by each resistor may be found easiest by applying the formula: $W = \frac{E^2}{R}$

In circuits where more complex combinations of resistances are present, individual parts are solved separately and combined. This process is best illustrated with an example.

In circuit A, we may consider R_2 and R_3 as parallel resistors.



Now we can replace circuit A by B, placing a single resistor R_{23} in place of R_2 and R_3. Consider now R_{23}, R_4, and R_5 as a single series circuit.

$$R_{2345} = R_{23} + R_4 + R_5 = 2 + 10 + 1 = 13 \text{ ohms}$$

We now can replace B, with circuit C. This circuit is a simple parallel circuit having two resistances of 5 and 13 ohms.

$$\text{Total equivalent resistance} = \frac{5 \times 13}{5 + 13} = \frac{65}{18} = 3.6 \text{ ohms}$$

This method of solving complex circuits is always used. While the steps may appear a little difficult the actual work is quite simple. The student should draw some circuits having resistors in series and parallel combinations, and solve these circuits for practice. The student may also examine the circuit diagrams in later lessons for actual examples of similar use of resistors.

MAGNETISM

Magnetic force plays a very important role in the operation of many radio components. Transformers of all types, phonograph pickups, loud-speakers operate on the principle of magnetism. In other fields of electricity, magnetism also is of a great importance. Being similar to electricity we cannot actually see or feel magnetism, but the effects of this force can be noticed and accurately measured.

There are certain natural magnets found already magnetized. If a piece of hard steel is stroked continuously in the same direction with a piece of natural magnet, the steel will become magnetized. For practical use, small percentage of nickel, chromium, cobalt, or tungsten are added to steel for making permanent magnets that have greater magnetic strength and other desirable properties.

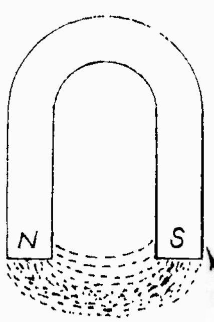
Just as in the case of electrical charges,

UNLIKE MAGNETIC POLES ATTRACT EACH OTHER

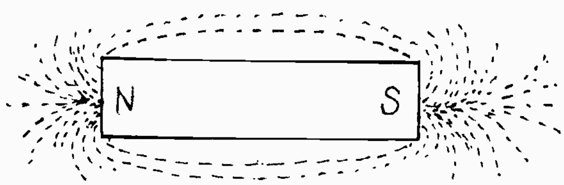
LIKE MAGNETIC POLES REPEL EACH OTHER.

Also it is important to remember that the force of attraction or repulsion between two magnets is inversely proportional to the square of the distance. A north and south magnetic poles will attract each other four times as much at 1 inch distance, as at 2 inch distance. This is why the space between the field and the armature in a generator is made as small as practical.

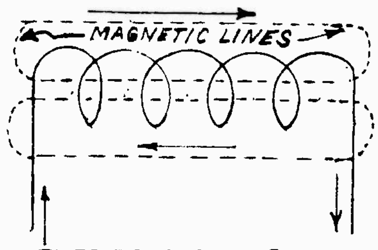
If either end of a bar magnet is dipped into iron filings, most of the filings will stick to the pole indicating that the attractive force is the greatest at the poles. This magnetic effect is noticeable for a considerable distance around the magnet. This force constitutes the magnetic field and is made up of lines of force. The filings around the magnet follow the lines of force.



HORSE SHOE MAGNET



BAR MAGNET



ELECTRIC CURRENT

If a strong magnet is dipped in a barrel of nails made of soft iron, many nails will be picked up. Some nails in turn will hold other nails becoming themselves temporary magnets. However, once these nails are removed from the magnet, their magnetism will be lost. Hardened steel substances on the other hand will retain some magnetism once they are brought into contact with a magnet.

ELECTROMAGNETISM

Although many devices employed in radio circuits depend on permanent magnets for their operation, magnetism produced by the flow of electric current through a conductor finds even greater application. Every wire carrying electric current has an associated magnetic field proportional to the current strength and the arrangement of the wire.

The fact that an electric current in a conductor has an associated magnetic field may be easily proven. If a compass is held near the wire, the needle of the compass (actually a small magnet on a pivot) will take a position at right angles to the wire. If no current is present in the wire, the needle will assume its natural N — S position.

An electromagnet is made by winding a number of turns of wire in the form of a coil, a much stronger magnetic field can be created since the fields of all the individual turns will add up. Since the magnetic field of force of each turn adds to that of the next turn, the greater the number of turns of wire the coil has, the stronger will be the magnetic field.

The total magnetic flux (lines of force) depends on the number of turns and the current strength. If the current is strong, relatively few turns of thick wire will be needed to produce a given magnetic field. On the other hands, if the current is very minute, a great many turns of fine wire will be needed.

If a bar of iron is placed in the center of the coil, the iron will become magnetized when the current will flow through the coil, but will loose its magnetism once the current is stopped. This principle is used to operate relays, door bells, and other devices.

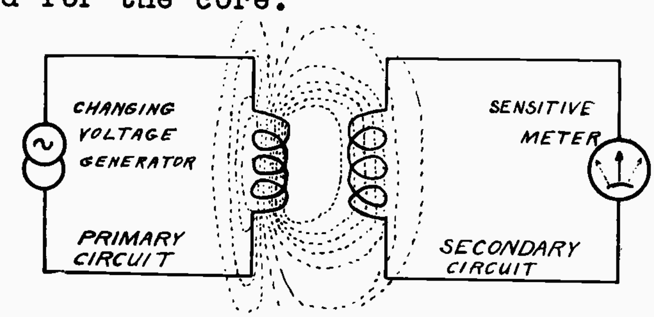
After a certain value, the effect of the applied electromagnetizing force will be diminished and, if the force is increased past a definite limit, no further effect will be noticed. The substance is then said to be saturated. For example, Wrought Iron will have a very strong flux when inserted in a coil of 10 ampere-turns. Increasing this to 20 ampere-turns only increases the lines of force per square inch from 89,000 to 97,000. At 40 ampere-turns this figure is only 106,000 lines per square inch. Saturation is reached when a further increase in ampere-turns has no effect on the flux.

ELECTROMAGNETIC INDUCTION

We have learned that an electrical current in a conductor sets up an associated magnetic field. If a conductor, connected to some indicating instrument such as a sensitive galvanometer, is moved across the magnetic field of a permanent magnet, a current will be noticed to exist in the circuit. The current will only be present while the motion continues and will be proportional to the rate of motion, the number of turns of wire being swept across, and the total flux or the number of lines of force. This principle of current generation is employed in all electrical dynamos.

It is also possible to <u>induce</u> a current in one conducting circuit by means of the magnetism produced by the current flowing in another associated, but not electrically connected, circuit. The flux set up by the first circuit induces a current in the second circuit. This action takes place only while the current in the first circuit is changing (increasing or decreasing), as in the case when the first circuit is connected to a source of Alternating Current (A.C.) that is periodically rising and falling. The circuits must be located closely together, that is <u>coupled</u>. A device used to transform electrical energy by induction is called a <u>transformer</u>. A transformer does not create energy, it simply separates two circuits, or steps up or down voltage. When any voltage is stepped up by means of a transformer, the current correspondingly in the same <u>ratio</u> is stepped down.

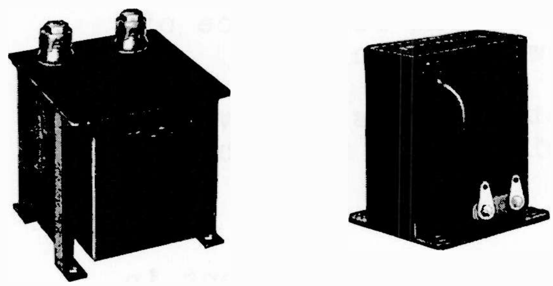
The coil receiving the original current is called the <u>primary</u>, and the coil in which the current is induced by electromagnetic induction is called the <u>secondary</u>. In the illustration it is evident that since only a part of the lines of force set up by the primary link the secondary coil, the current induced is not as great as would be in case all the lines of force linked the secondary. The lines of force not linking the secondary and, therefore, not being useful are termed the leakage flux. To keep the lines of force in the desired path, soft steel material is used for the core.

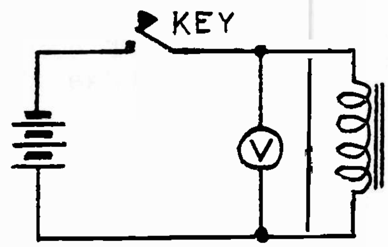


Transformers and inductors having air cores are used in radio receiving circuits where the frequencies encountered are very high and would create heavy losses due to eddy currents and hysteresis if iron cores were used. Where the frequencies are relatively low as in the case of audio frequencies, (commonly employed 30 to 12,000 cycles per second) and power frequency of 60 cycles, iron laminated cores are used.

SELF INDUCTION

An electric current flowing through a conductor sets up a magnetic field around the wire. If the current is varied, the magnetic field also varies correspondingly. This varying field sets up in the wire itself, a counter or self-induced e.m.f. which opposes any changes. A voltmeter connected in the battery circuit illustrated above to the right, will indicate the battery voltage when the key is closed. Upon again opening the key, the voltmeter will momentarily indicate a large diflection (voltage) in the opposite direction. This action indicates that the magnetic lines of force around the coil have broken down to refrain the current of the coil from changing. This effect is similar to that of inertia found in mechanical devices. Inertia tends to oppose any changes in the speed or direction of motion. The effect of self-induction is especially noticeable in a solenoid (coil) since the inductance is consentrated in a small space. The unit of inductance is the Henry. The symbol for inductance is L.





Audio chokes which may be used in this test.

The Henry is a relatively large unit and while some audio coils having special iron cores have an inductance of several hundred henries, the inductance encountered in coils used in radio frequency work and having air cores is only a small fraction of a henry. One/thousand of a henry is a millihenry, and one/million part of a henry is called a microhenry. Coils used for tuning the broadcast frequencies are in the order of 250 microhenries.

Inductive coils may be connected in series, in parallel, and in other combinations without the magnetic fields interlinking to any degree. When inductors are connected in series, the total effective inductance is the sum total of the individual inductances.

If a coil having an air core has a given current passing, a magnetic flux of a certain value will be produced. If an iron core is slipped in, replacing the air core, the electromagnet so formed will have a flux 200 times as strong. By using special nickel-iron material for the core, the strength can be made even greater. The ratio of the strength of the magnetic field with a given substance to the strength of the field when air is used as the core is the permeability. The permeability of air is taken as 1, all magnetic substances have a permeability greater than one.

REVIEW QUESTIONS

1. What does the prefix "milli" mean?

2. Since each cell in a "B" battery generates 1½ volts, how many cells are connected in series to produce the full voltage of 45 volts? Do you understand why a "C" battery has 4½ volts and not 5 volts?

3. Rewrite the following decimals as fractions: 0.5, 4.25, .05, 2.3, and 0.1.

4. Rewrite the following fractions as decimals: 1/10, 3/100, 3/50, 3/2, and 1/3.

5. What is the square root of 81? Of 49? Of 2.25?

6. In a 110 volt D.C. circuit an electric bulb takes 1/2 ampere of current. What is the resistance of the bulb? (Use the Ohm's Law relation).

7. A 100 ohm resistor is connected across a 10 volt battery. What current is being taken from the battery?

8. In Question 7, what power is being used?

9. Examining a radio circuit, estimate the current in the various resistors and calculate the voltage drops and power dissipated. You may use the chart for this purpose.

10. If a 12 ohm and a 6 ohm resistors are connected in series, what is the equivalent resistance?

11. If a 4 ohm and a 8 ohm resistors are connected in parallel, what is the equivalent resistance?

12. Make up your own complex circuit of resistors and solve it following the example given in the text.

13. On what two factors does the magnetic flux depend?

14. Make a sketch of a buzzer and battery and explain how this unit operates?

15. How are power transformers made? What materials are used and how does the transformer operate?

16. What effect does a choke coil have upon the changing current in a circuit?

LESSON 5

RADIO FREQUENCY INDUCTANCES

MUTUAL INDUCTANCE

In the section on Self-Inductance, above, the definition of "Self-Inductance," and the properties thereof were briefly explained. If, in the example of the bunched winding, half of the turns formed one circuit and the remaining half formed another circuit, a change in magnetic flux occasioned by a change in current in one winding, would induce two voltages, one in its own winding opposing the change in current, and the other in the second coil. This phenomenon of a voltage induced in the turns of one coil by a change in current in another coil is known as "Mutual Inductance."

The unit of Mutual Inductance is the "henry" defined as that value of mutual inductance in which one volt is generated across the terminals of one coil when the current in the other coil is changing at the rate of one ampere per second.

The practical units for Mutual Inductance are the same as those for self inductance, namely the Henry, Millihenry and Microhenry.

A very convenient property of mutual inductance is that the mutual inductance existing between two dissimilar coils is the same, whether the current change is in the large coil and the voltage is measured in the small one or vice versa, regardless of how dissimilar the coils may be.

This phenomenon called mutual inductance makes the formulae for inductances in series or in parallel much different from the formulae for resistances. In the latter case, the equivalent resistance of two resistances in series is the sum of the individual resistances; but in the case of two inductances in series, there may be a mutual inductance between the coils that may seriously disturb that simple relationship. If the two coils are placed so that the wires of one coil and those of the other coil occupy practically the same space, as in the case of winding the second coil as a single layer directly over the first single layer coil, or between the turns of the first coil, the overall inductance of two equal coils wound as above, will be twice the sum of the inductances of the two individual coils, if the coils are connected "Aiding" and will be practically zero if connected "Opposing." This is a special case which seldom occurs, but shows one of the extremes of mutual inductance which can influence the equivalent inductance of two coils connected in series.

The general expression for any case involving only two coils in series is: overall inductance equals the sum of the individual inductances plus or minus twice the mutual inductance. The reason for this relationship is given in the following explanation.

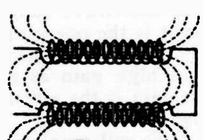


Figure I

A current change in coil No. 1 induces in itself a voltage proportional to its inductance, and similarly in coil No. 2 a voltage proportional to the inductance of coil No. 2. The current change in coil No. 1 induces a voltage in coil No. 2 proportional to the mutual inductance between the two coils, and similarly the current change in coil No. 2 induces a voltage in coil No. 1 of the same magnitude because the mutual inductance is the same whether measured from the first to the second coil, or in the reverse direction. The overall inductance is proportional to the total voltage induced, and is consequently equal to the sum of the individual inductances plus or minus twice the mutual inductance. The "plus or minus" provision is made because the voltage induced in one coil by a current change in the other does not necessarily aid the self-induced voltage in the coil. Inductances themselves are positive, there being no negative inductances; nor, strictly speaking, are there any negative mutual inductances; but a mutual inductance may be connected into a circuit so that its effect may oppose some other effect and can be considered as a negative mutual inductance *when so connected.*

COUPLING COEFFICIENT

When two coils are arranged so that some definite mutual inductance exists, the coils are said to be magnetically coupled.

In many calculations, it is frequently convenient to express the amount of coupling as a percentage of the maximum that could possibly exist, rather than a numerical value of mutual inductance. In such a case, the term applied to this percentage is "coupling coefficient" which, for inductance, is defined as the quotient resulting from dividing the existing mutual inductance by the maximum possible mutual inductance (square-root of the product of the two separate inductances).

The losses in a coil may be divided into the following classes:

1 — Ohmic or D.C. losses in the wire
2 — Eddy-current losses in the conductor
3 — Eddy-current losses in the shield
4 — Eddy-current losses in the core material
5 — Skin effect
6 — Dielectric loss in the wire insulation
7 — Dielectric loss in the terminal strip

None of these items is independent of the others, and a change to improve one usually changes one or more of the remaining factors.

Since all of the losses in a coil taken together make up the radio frequency resistance of the coil, a single number can be used to express this quantity, but the resistance alone does not give sufficient information to judge the electrical excellence of the coil. Resistance is usually the undesired quantity in a coil, and practically all coil designs attempt to make it as low as possible. Reactance is the desired characteristic of the coil and is the product of frequency, inductance and the usual multiplier, 2π. A special term has been given to the ratio of the desired to the undesired characteristic of the coil. This term is "Q" which is defined as the reactance divided by the resistance.

ANTENNA COILS

The basic types of antenna coils have high-impedance inductive, high-impedance capacitive, low-impedance inductive and low-impedance capacitive couplings. Typical values of capacity, self inductance and mutual inductance for these four types of broadcast coils are shown in Fig. 3.

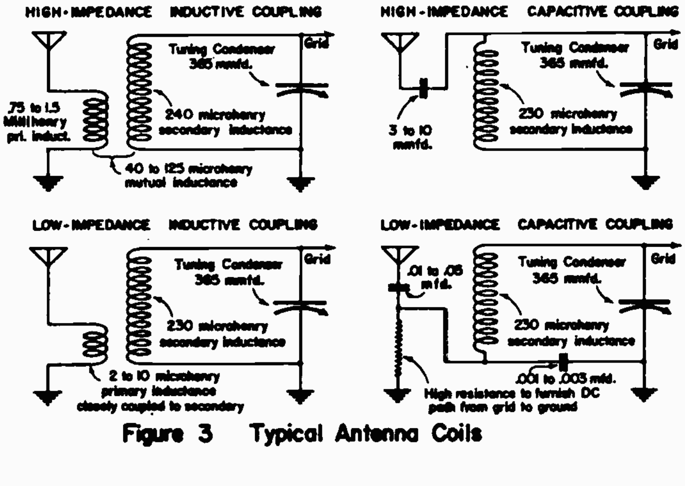


Figure 3 Typical Antenna Coils

HIGH-IMPEDANCE PRIMARY

High-impedance magnetic coupling, usually spoken of as "High-Impedance Primary" is the most universal type of coupling on the broadcast range of household receivers. It has good image ratio, reasonable gain, and, when properly designed, almost negligible misaligning of the first tuned circuit as the size of antennas is changed. With the usual design of coil, this type of coupling results in higher gain at the low-frequency than at the high-frequency end of the tuning range. Sometimes, to compensate for this deficiency at the high frequency end, a small amount of high-impedance capacity coupling is used. This capacity is connected from the antenna to the grid terminals of the coil. Its size is from 3 to 10 MMF.

It is to be noted that capacity coupling can reduce as well as raise the gain of a high-impedance magnetically coupled transformer, depending upon the polarity of the windings. **If capacity coupling is to aid the magnetic coupling, a current entering the antenna terminal of the primary and the grid terminal of the secondary must go around the coil form in opposite directions, and the coupling capacity must be connected between these two points.**

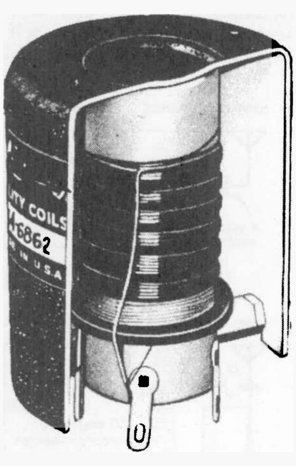
LOW-IMPEDANCE PRIMARY

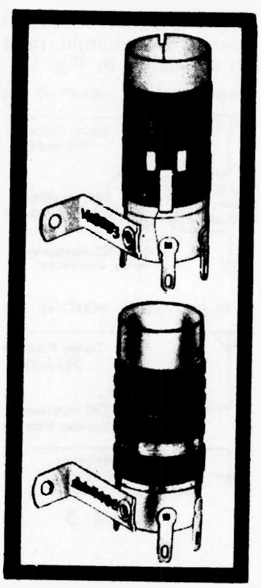
Antenna coils with low-impedance primaries, although cheaper to manufacture than high-impedance primaries, are rare on the broadcast band of modern home radio receivers.

This type of coupling, when used with any of the conventional household antennas, gives a great deal more gain at the high-frequency end than at the low-frequency end of the tuning range. This gives rise to very poor image-ratio when used in a superheterodyne receiver.

The closely coupled low-impedance primary reflects the antenna capacity across the tuned circuit in an amount depending upon its inductance and coupling coefficient. Without attempting to derive an expression for the actual magnitude of this effect, suffice it to say that if the primary is large enough to give reasonable gain at the low-frequency end of the frequency range, the reflected antenna capacity will be so high that the secondary tuning condenser will not be able to tune to the high-frequency end of the band, and every different antenna capacity would change the amount of mis-tracking. Because of this sensitivity to changes in antenna capacity, and because of poor image ratio, the low-impedance primary is seldom used on broadcast-band antenna coils.

On short-wave coils, the low-impedance primary is used almost exclusively because the antenna gain is usually higher than with a high-impedance primary, and the antenna is usually resonant in or below the broadcast band. For this reason, the image-ratio does not suffer nearly as much as in the case of using low-impedance broadcast coils in place of coils with high-impedance primaries.





Courtesy Meissner Mfg. Co.

HIGH-IMPEDANCE CAPACITY COUPLING

The high-impedance capacity coupling scheme consists essentially of connecting the antenna directly to the grid end of the first tuned circuit through a capacity, usually from 1 to 10 mmf. This method of coupling has been popularly used on amateur receivers of simple design, where simplicity of coil construction was imperative, but is not used in broadcast receivers by recognized manufacturers because of the very poor image-ratio that results.

Practically speaking, the only use for high-impedance capacity coupling in a broadcast receiver is as reinforcement to a high-impedance primary, as discussed in the paragraph on "High-Impedance Primaries."

LOW-IMPEDANCE CAPACITY COUPLING

Low-impedance capacity coupling, familiarly known among radic engineers as the Hazeltine coupling system, consists of coupling the antenna directly to the junction of the low side of the tuning inductance with the high side of a high-capacity coupling condenser which is connected to ground. (See Fig. 3.) The voltage across this coupling condenser is multiplied by the resonance phenomena of the tuned circuit to give appreciable voltage at the grid.

This circuit is particularly adapted to receivers that must use a high-capacity shielded lead-in such as an automobile radio receiver. In such a circuit, the shielded lead-in is made part of the coupling capacity because of the circuit arrangement and, practically speaking, causes no loss in voltage as would be occasioned if this capacity would be connected across a high-impedance primary. For this statement to be strictly true, it is necessary that the shielded lead-in have a good power factor or else the losses in the lead will slightly reduce the effective circuit "Q," thereby bringing down the gain in the antenna coil by a corresponding amount.

This type of coil has high gain and excellent image-ratio. The drawbacks to its use are that the R.F. amplifier circuit, if used, must have a value of capacity included in its tuned circuit equal to the antenna coupling capacity in order that proper tracking may result.

R. F. COILS

R.F. coils may be divided essentially into four types: high-impedance magnetic, low-impedance magnetic, high-impedance magnetic with high-impedance capacity coupling, and choke-coupled circuits.

The high-impedance magnetically coupled R.F. coil has characteristics very similar to the high-impedance antenna coil and therefore needs little discussion.

The low-impedance magnetically coupled R.F. coil has the same deficiency as the similar antenna coil and is consequently seldom used in the broadcast range of a superheterodyne receiver. Like the antenna coil, it has possibilities for higher gain than the high-impedance type, but usually the selectivity is enough worse to rule out this type of coupling on modern receivers.

In the shortwave range, this is the most popular type of circuit, because it is the one giving the highest gain and since, with a fixed capacity of gang condenser, it becomes increasingly more difficult to obtain high gain as the frequency is increased, this circuit with its high gain is the almost universal choice in spite of its deficiencies in image-ratio.

The R.F. coil employing a high-impedance primary in combination with high-impedance capacity coupling is the most flexible design, and is popularly used for that reason. By shifting the primary resonant frequency and by changing the amount of capacity coupling together with changes in "Q" of the secondary circuit, the overall gain of an amplifier stage can be made to have almost any desired shape with respect to frequency; that is, it may give high gain in the middle, at the high-frequency end, at the low-frequency end, or almost any shape desired, to compensate for the frequency characteristics of the other stages employed in the receiver.

The choke-coupled R.F. circuit is very similar to the high-impedance primary with high-impedance capacity coupling, except that, in choke coupling, the magnetic coupling has been made zero, but design still requires that the choke have as much inductance as a primary would have, in order that the resonance of the primary circuit may fall outside of the tuning range of the secondary.

IF TRANSFORMERS

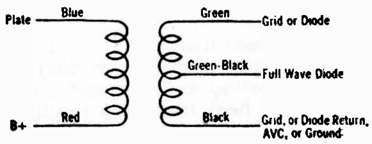
Intermediate-frequency transformers used in radio receivers have taken a variety of forms and have operated at many different frequencies. They may be divided into several classes according to the number of selective circuits: untuned or self-tuned, single-tuned, double-tuned, and triple-tuned.

SINGLE-TUNED IF TRANSFORMERS

The single-tuned IF transformer has taken two important forms, the bi-filar coil and the double coil types.

In the former case, the two wires constituting primary and secondary are wound simultaneously, forming a coil that is a single physical unit yet having two independent circuits. The start of the primary was usually the plus "B". connection and the start of the secondary was ground. The outside of the primary was the plate connection and the outside of the secondary was the grid connection. These transformers were characterized by very high gain and comparatively little selectivity.

I F TRANSFORMER LEADS



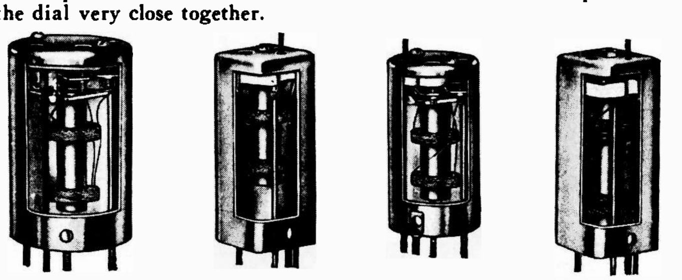
With this transformer redesigned to have two physically separate coils wound side by side, the objectionable features of leakage, corrosion and hum transfer are reduced to a very small per cent of their original importance, and transformers acceptable in today's critical market can be produced. The largest remaining objection to the single-tuned transformer is selectivity. In a low-frequency amplifier operating at 125 KC or 175 KC, the transformers are too sharp for good audio fidelity, and at the higher intermediate frequencies such as 456 KC, the transformers do not add sufficient adjacent-channel selectivity.

Single-tuned transformers may be divided into two classes according to the circuit tuned; some have their primaries tuned while the remainder have their secondaries tuned. As far as secondary voltage is concerned, there is not a great deal of difference regardless of which winding is tuned, but if there is a question of single-stage oscillation in the tube driving the single-tuned transformer, greater stability is had by tuning the secondary than by tuning the primary.

DOUBLE-TUNED IF TRANSFORMERS

The double-tuned IF transformer is, by far, the most popular type. It is simple in construction, has negligible leakage, no measurable hum transfer into diode circuits and can have its selectivity curve made as sharp as two single-tuned transformers in cascade, or can be considerably broader at the "Nose" of the selectivity curve than two cascaded single-tuned transformers, yet on the broader part of the selectivity curves maintain practically the same width as the cascaded single-tuned transformers.

If the coupling on a double-tuned transformer is made sufficiently loose, the transformer is quite selective and has a resonance curve of the same general shape as a single circuit, except sharper. As the coupling is increased, the gain will go up until the point of "critical coupling" is approached where the gain of the transformer is practically constant but the selectivity curve is changing, particularly at the "nose" of the curve. As the coupling continues to increase, first there is a decided flattening on the nose of the selectivity curve, after which continued increase in coupling produces an actual hollow in the nose of the curve. Still greater increase in coupling can spread the two "humps" and deepen the "hollow" in the nose of the response curve until a station can be tuned in at two places on the dial very close together.



TRIPLE-TUNED IF TRANSFORMERS

Triple-tuned IF transformers have been used for two general purposes: greater adjacent-channel selectivity without increasing the number of tubes and transformers, or a better shape on the nose of the selectivity curve to produce better audio fidelity than is produced by double-tuned transformers.

CAPACITY-COUPLING IN IF TRANSFORMERS

The ordinary circuit diagram of a double-tuned IF transformer is as shown in Fig. 6, but actually the circuit in Fig. 7 is more representative of true conditions.

The capacity coupling, shown in dotted lines, is a very important part of the coupling in practically all transformers operating at frequencies above 400 KC. This statement applies with even greater emphasis as the frequency, or the "Q," of the coils is raised.

The capacity that is effective in the above mentioned "capacity coupling" is that which exists between any part of the plate end of the primary circuit and any part of the grid end of the secondary circuit; to be more specific, the capacity between the plate and grid sides of the trimmer condensers, the plate and grid ends of the coils, the plate and grid leads, the grid lead and the plate end of

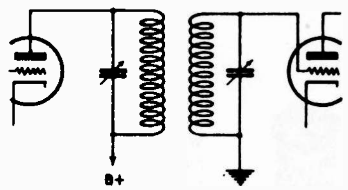


Figure 6

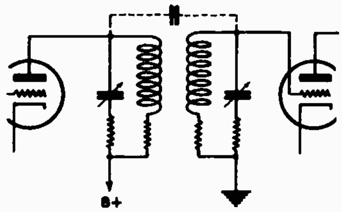


Figure 7

the primary coil, and between the plate lead and the grid end of the secondary coil.

The capacity between the two high-potential plates of a trimmer condenser such as the Meissner unit shown in Fig. 8 is 0.35 mmfd. if both trimmers have an even number of plates and the bottom plate of each trimmer (on the same base) is a high-potential (either grid or plate) electrode. If an odd number of plates is used on both trimmers, the capacity drops to 0.07 MMF. The difference between these two coupling capacities, amounting to only 0.28 MMF. is sufficient to make quite a difference in the gain of transformers operating above 400 KC.

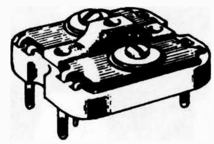


Figure 8

Double-tuned IF transformers may be built with the magnetic coupling either aiding or opposing the capacity coupling. For reasons of production economy, both coils on one dowel are usually wound simultaneously, which means they must be wound in the same direction. For reasons of production uniformity, the insides of both windings are usually chosen as the high-potential ends of the coil so that the outside (low-potential) ends of the coils will automatically act as spacers to keep the high-potential hook-up wires from approaching the high-potential ends of the coils.

Triple-tuned IF transformers, particularly output transformers where diode and plate leads both pass through the open end of the shield can, are particularly subject to gain and selectivity variations as a function of variation in capacity coupling.

As an example, in a particular triple-tuned output transformer where the plate and diode leads ran close together, it was found that in attempting to align the transformer, the middle circuit was effective as long as either the input circuit or the output circuit was out of tune, but as soon as both input and output circuits were aligned, the center circuit had a very peculiar action. If the gain of the transformer is plotted against the capacity of the middle circuit, a curve similar to Fig. 11 was obtained. From this it is seen that there is one adjustment (A) that produces an increase in the overall amplification of the transformer. At this point the center circuit is contributing to the selectivity of the transformer. At another point (B) the amplification through the center circuit opposes the capacity coupling from the input to the output winding and results in a considerable decrease in amplification. At all other settings of its tuning condenser, the center circuit is so far out of resonance that it has no effect upon the gain of the transformer, which for all practical considerations, may be assumed to be a double-tuned capacity-coupled transformer. When the capacity between the high-potential input and output leads was reduced to a very low value by keeping the leads in opposite corners of the shield can, the transformer behaved as a triple-tuned transformer should, with all three circuits effective.

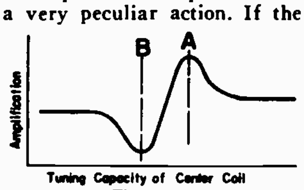
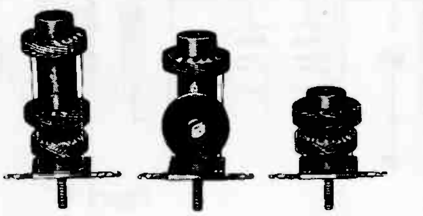


Figure 11

RADIO COILS

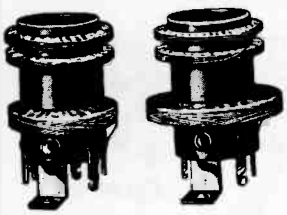
Examples of the type of coils commonly used in radio receivers are illustrated. Please read the descriptions carefully and be able to identify any of the types. Notice the advantages of each type. Selector switches are used in multi-band receivers. The loop antenna has replaced the antenna coil in most portable and midget radio sets.

TRF AND SUPERHETERODYNE COILS
DUO-LATERAL WOUND



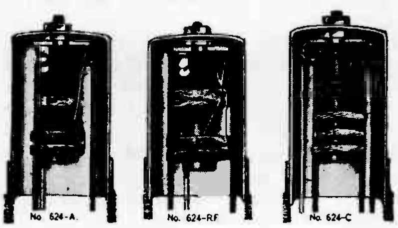
Single-section, Litz-wire-wound duo-lateral secondary. High-impedance primaries. Wound on treated hard-wood dowel with bakelite terminal plate. Use with .000365 mfd. variable condenser.

HIGH GAIN SERIES



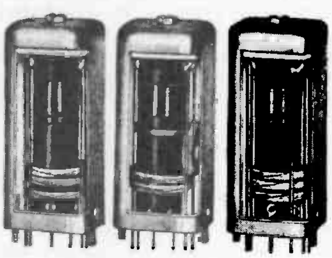
Sectional wound duo-lateral secondary, using No. 15/41. Litz-wire High-impedance primaries for uniform gain with any screen grid tubes. Wound on XXX bakelite tubing. Use with .000365 mfd, variable condenser.

IRON CORE COILS



Sectional-Duo-lateral-wound on Armite sleeves. Special iron-core provides extremely high "Q" in minimum space. Especially adapted to auto and aircraft receivers. Use with .000365 mfd. variable condenser. Antenna coil has a low-impedance primary for operation on mobile antenna equipment. R.F. Coil has high-impedance primary for maximum gain.

TWO BAND COILS



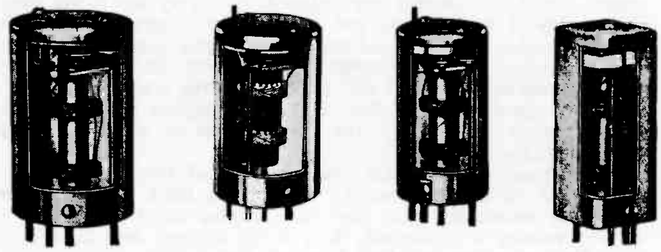
Especially designed for the constructor who wishes to build an inexpensive 2-band receiver covering standard broadcast band and either of two short-wave bands. Adaptable to Marine receivers. Wound on high-grade bakelite tubing. Assembled in aluminum shields with trimmer condensers. For use with .000365 mfd. variable condenser and 455 KC I.F. Amplifier.

AIR CORE UNSHIELDED CHOKES

Duo-Lateral-Wound, single-section, Radio Frequency Chokes are ideally suited for receiver applications wherein a moderately priced unit is required. These chokes are wound with silk-covered wire, on impregnated hard-wood dowels. A bakelite terminal plate, 1⅛" in diameter, is fastened to the dowel with a tubular brass eyelet, providing for single-hole mounting with a #6/32 machine screw. The winding on these chokes is impregnated to prevent any moisture absorption. Inductance values accurate to within three per-cent.

MICA COMPRESSION TYPE
DOUBLE TUNED AIR CORE

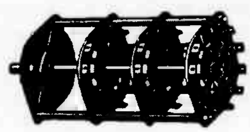
Mica-Compression trimmers used in I. F. Transformers are treated with our exclusive automatic cycling heat treatment consisting in alternately heating to 200°F and cooling to 90°F through 5 complete cycles. This heat treatment results in a much higher degree of capacity-stability, which insures perfect alignment of the I. F. Transformer under conditions of varying temperatures encountered in modern Radio receivers. **All Shields Aluminum.**



REPLACEMENT I.F. TRANSFORMERS
DOUBLE TUNED

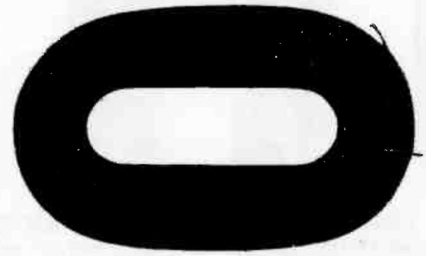
These Transformers are an essential part of the stock of every service man and dealer. In many cases they give better performance than the original unit. Only the finest materials are used. Every precaution is taken to insure a long and trouble-free life. Coils have Duo-lateral windings on treated hardwood dowels. Double tuned. Heat-Cycled, Low-Drift, Mica-Compression Trimmers. Impregnated in special moisture-resistant wax. Pre-tuned to nominal frequency. Easily identified, color-coded leads. Assembled in "Okite" finished Aluminum shields. Spade-bolt mounting.

BAND SELECTOR SWITCHES

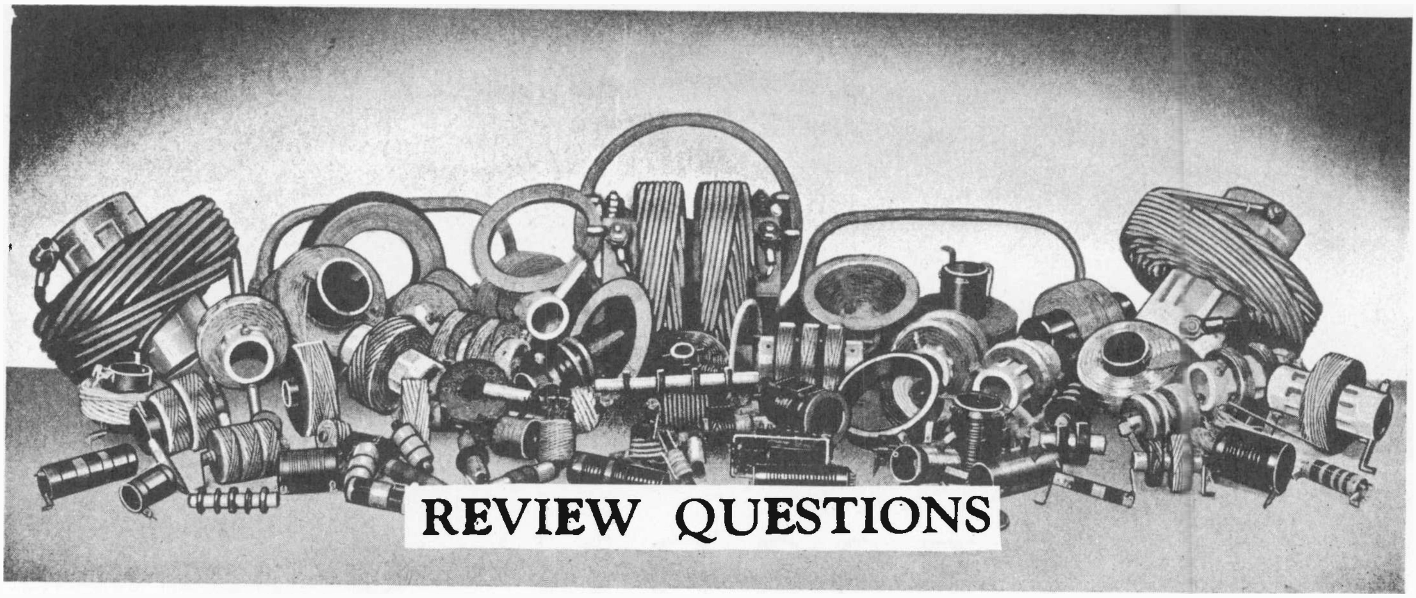


The successful operation of a multi-band receiver depends to no little degree upon the excellence of the switch used. These switches are of a positive self-cleaning type with silver plated contacts. All switches are provided with an adjustable stop

LOOP ANTENNA



Loop Antenna is applicable to most portable-receiver assemblies. The inductance of the loop is high to permit removal of turns to match different sets. The loops are wound from low-distributed capacity wire and are of the flat, pancake type of winding.



REVIEW QUESTIONS

1. What is the unit of mutual inductance?

2. What three factors must be considered in designing R.F. coils?

3. Name several losses that may be present in a coil.

4. What factors determine the value of Q?

5. What is the advantage of high-impedance primaries in antenna coils?

6. What type of primary is used on short wave coils? What advantages are obtained because of this?

7. What type of IF transformers are most commonly used?

8. Why is the bi-filar type IF transformer not used very much?

9. Name some advantages of a double-tuned IF transformer.

10. Were the early "single-dial control" receivers really such? Why not? How about present day sets?

11. What new design in antenna coils eliminated the "Antenna Compensator"?

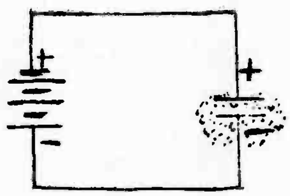
12. Why are trimmers used in gang condensers?

13. What effect will poor alignment have on the operating efficiency of a four tube receiver?

14. Make a pictorial sketch of an antenna coil.

RADIO CAPACITORS

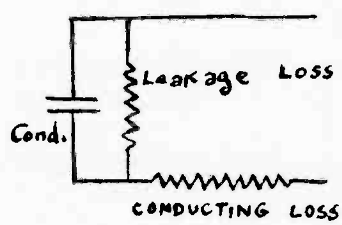
LESSON 6



If a condenser is connected to a source of D.C. potential such as a battery, the negative side will become charged with electrons. If the battery connections are removed and the condenser shorted, a spark will jump across the point of contact, and the two plates will again be in electrical equilibrium or will be neutral. The strength of the charge will depend on a number of factors as we shall see later.

A condenser must have two plates made of conducting material, and a separation of a nonconducting material or vacuum. The material between the plates is called the dielectric. Any insulator will serve as the dielectric, but only a limited number of insulators have characteristics that make them especially well suited for this application. Every condenser has certain losses which are almost negligible in a high quality unit.

For one thing, there is an actual resistance loss in the conducting plates of the condenser. The dielectric, while having very high insulating value, does permit a certain leakage. A practical condenser, therefore, may be assumed to be a perfect condenser with no losses, with a resistor connected in series to represent the loss in the conducting plates, and another resistor in parallel to represent the leakage. Because of the leakage loss, a charged condenser will soon loose its charge. There are also other losses, but they are not of importance from the practical point of view.



The degree of ability of a condenser to store electrical charges is known as the capacity of the unit. Since the quantity of the electrical charge depends directly upon the

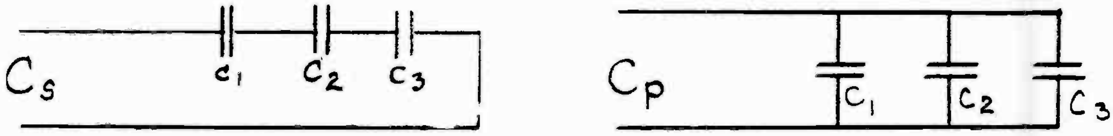
E.M.F. (voltage) of the source, capacity is defined in terms of not only how much charge is stored, but also in terms of how much voltage is applied. The unit of capacity is the Farad. The farad is equal to the capacity of a condenser that will store one coulomb of electricity at the pressure of one volt.

The Farad is much too large a unit for radio applications, the microfarad, or mfd. equal to one-millionth of a farad, is commonly used. Condensers of very small capacity are also rated in still smaller units of micro-microfarads or mmfd. being equal to one/millionth of a microfarad.

Condensers, similarly to resistors, may be connected in series and in parallel. When condensers are connected in parallel, the final capacity is greater than that of any condenser used in the combination. The total capacity is equal to the sum of all the individual condensers connected in parallel.

$$C_p = C_1 + C_2 + C_3 + \ldots\ldots\ldots$$

Where C_p is the total capacity of units in parallel. This formula suggests a means of obtaining larger capacity from a number of smaller units. Each condenser used, however, must be able to withstand the applied voltage of the circuit. Should 15 mfd. be required and only 5 mfd. units be on hand, three of these may be employed and connected in parallel with equally satisfactory results as might be obtained from a single 15 mfd. condenser.



When condensers are connected in series, the final capacity of the combination is always less than that of the smallest used in the combination. It is very rarely that condensers are used in series, except when all are of the same capacity. In such cases, the total capacity

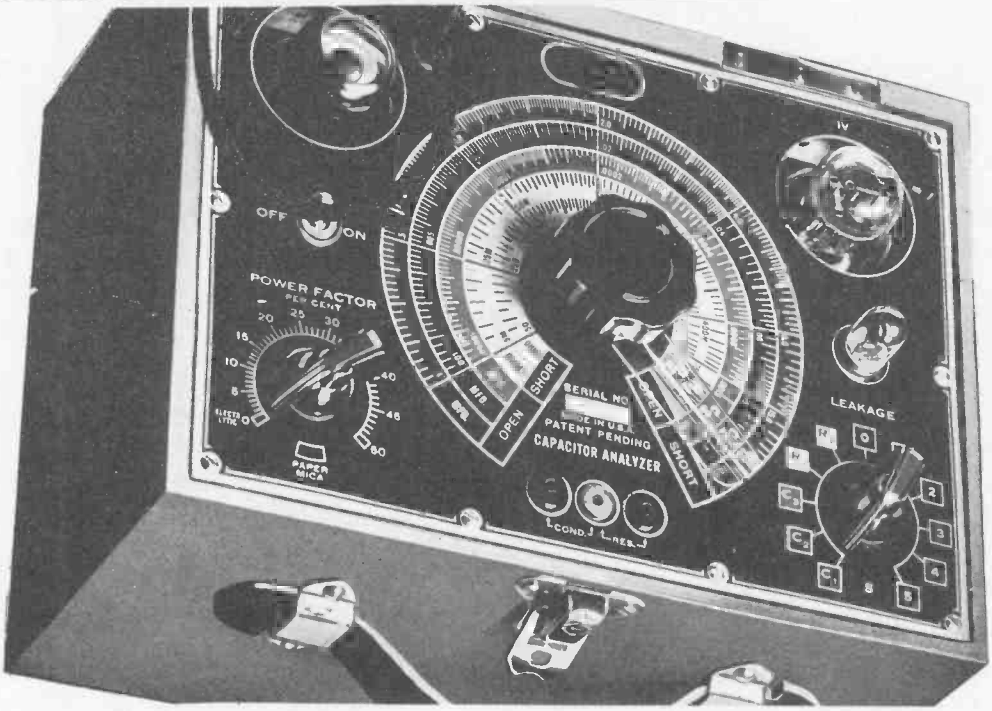
$$C_s = \frac{C}{n}$$

where n = number of condensers of capacity C, connected in series.

There are three factors affecting the capacity of a condenser.

(1) The type of dielectric used
(2) The area of the plates in contact with the dielectric
(3) The actual thickness of the dielectric, or what is the same thing the separation between the plates.

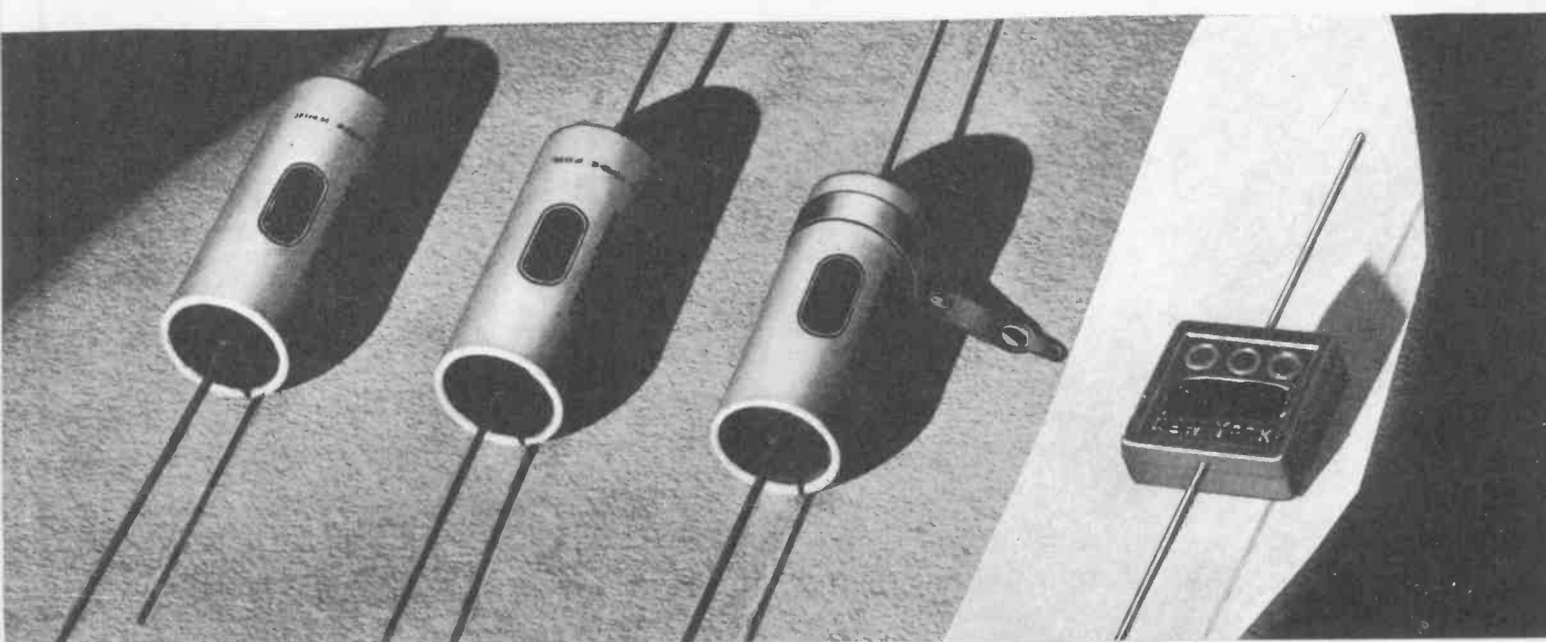
It has been found that the capacity of a condenser using air and other substances for the dielectric changed for each definite substance used. For example, certain wax employed for the dielectric made a condenser have twice the capacity as when this same condenser had an air dielectric. Bakelite gave a value 6½ times as large as air, etc. This property of different materials used for the dielectric of condensers is known as the dielectric constant. Air is taken as standard and its dielectric constant is assumed to be 1.



The actual capacity of different condensers may be calculated from formulas, but the serviceman uses commercial units already supplied with the capacity indicated and for the serviceman there will be little need for such calculations. Certain test analyzers have provisions for indicating the capacity of paper and electrolytic condensers directly.

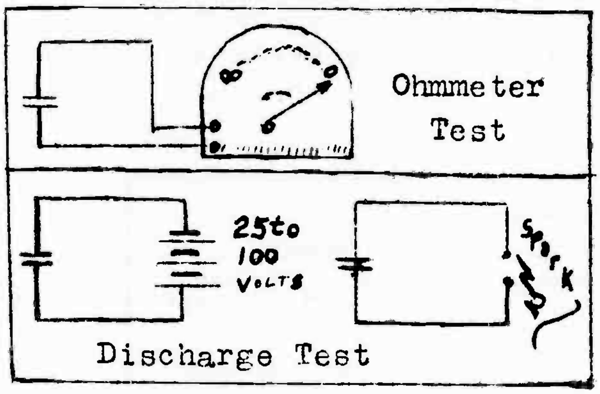
F I X E D C O N D E N S E R S

Condensers commonly used in radio sets are so constructed that their capacity is fixed at one definite value. The exception is the variable condenser used for tuning the radio circuits into resonance. For low capacity, under .02 mfd., mica insulation is employed. Such condensers are molded in bakelite and are uneffected



by moisture. The value of capacity is marked on the case and for service work suitable similar replacements are easily obtained. Larger sizes are made with paper dielectric and in tubular form. We urge you to carefully note (1) the relation of capacity, break down voltage or the working voltage, and the physical size, (2) the general appearance of the units, and (3) the general methods used for connecting the units into the circuits.

While special condenser testers may be used to detect the faults in condensers, a simple ohmmeter will serve the purpose. A small capacity fixed condenser should test open on an ohmmeter. If the condenser has noticeable low resistance (below 50,000 ohms) or is completely shorted, the unit should be replaced. A good test is to connect the condenser momentarily to a source of D.C. potential between 25 and 100 volts. Quickly disconnect the condenser and connect the terminals together. A spark should be noted at the point of contact if the condenser is in good condition.



Electrolytics can be quickly tested by the ohmmeter method. They will first upon being connected show a shorted condition, but the resistance will quickly increase. The ohmmeter must be correctly connected, i.e. positive side of the battery to the positive side of the electrolytic condenser. The D.C. potential discharge test may also be used.

In replacing fixed condensers, the serviceman need not be too critical. A slight difference of capacity will ordinarily not upset the circuit and this is especially true if the unit is used as a filter. 8 or 12 mfd. units may be used for 10 mfd. However, the rated working voltage is important and must not be overworked. Condensers rated at 550 volts D.C. may be used on any voltage up to this maximum rated voltage, but not above. A.C. voltage peaks are 1.4 higher than the measured and indicated R.M.S. voltage. For example, 110 volts A.C. has peak voltage of 110 x 1.4 or 154 volts.

CONSIDERATIONS OF ELECTROLYTIC CONDENSERS

An electrolytic condenser is a fixed condenser of high capacity and compact size suitable for use with voltages not exceeding about 550 volts. These condensers must further be used only with D.C. or pulsating D.C. Because of these characteristics, electrolytic condensers are especially well suited for use in radio filter circuits where these advantages over paper type condensers are fully realized, and their limitations are of no consequence.

The electrolytic condenser consists of an anode to which the positive connection is made, the cathode used in conjunction with the negative connection, and the electrolyte. Aluminum is usually used as the anode in condensers for radio application. Other metals such as tantalum and magnesium find some use; the chief advantage of tantalum being its ability to withstand acid corrosion. For the cathode either aluminum or copper is used in connection with an aluminum anode.

The dielectric film forms electro-chemically on the surface of the anode. The properties of the electrolytic condenser are due to this film formation. The exact nature of this film is not known, but it is extremely thin making possible high capacity per unit area. The capacitance of a film formed at 300 volts on aluminum is 0.12 mfd. per square inch, about eight hundred times that of a paper condenser for this voltage.

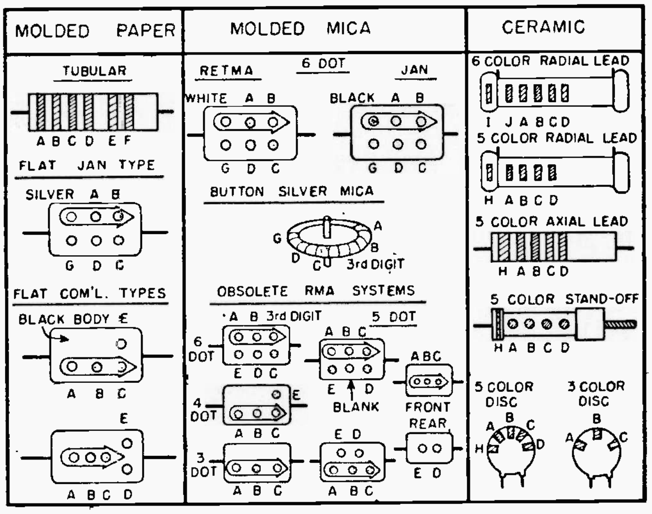
In the actual circuit when the potential is first applied, the current is only limited by the resistance of the electrolyte and the external resistance present. Naturally under this condition high currents flow. The film forms quite rapidly, however, and the leakage current drops to a safe value of about 0.2 milliamperes per microfarad. A radio rectifier circuit takes care of this leakage current without difficulty.

CAPACITOR COLOR CODE

Color	MOLDED PAPER Multiplier	MOLDED PAPER Tolerance	MOLDED MICA Multiplier	MOLDED MICA Tolerance	CERAMIC Multiplier	CERAMIC Tolerance
Black	1	20%	1	20%	1	20% or 2.0µµfd.*
Brown	10		10		10	1%
Red	100		100	2%	100	2%
Orange	1000		1000	3% (RETMA)	1000	2.5% (RETMA)
Yellow	10,000	5%	10,000		10,000	
Green				5% (RETMA)		5% or 0.5µµfd.*
Blue						
Violet						
Gray					0.01	0.25µµfd.*
White		10%			0.1	10% or 1.0µµfd.*
Gold	0.1	5%	0.1	5% (JAN)		
Silver		10%	0.01	10%		
None		20%				

*Capacitance less than 10µµfd.

Capacitance is given in µµfd. Colors have same values as on resistors, except as indicated in tables. Colors (A) and (B) are for first two digits; (C) is for multiplier. (D) is for tolerance. (E) and (F) give voltage rating in hundreds of volts; (E) is used only for ratings less than 1000 volts. (E) and (F) for first two digits of ratings 1000 volts or more. Values of colors for (E) and (F) are same as in resistance values. (G) is class or characteristic of capacitor. (H), (I), and (J) give temperature coefficient. (G), (H), (I), and (J) are not listed in the tables, since this information is seldom needed by the average home builder.



SOME IMPORTANT PRACTICAL FACTS CONCERNING CONDENSER REPLACEMENTS

When there is something wrong with the radio which you are servicing, you are almost safe in saying, "It's a condenser." Of course, there are a great many different types of condensers used in a radio set -- more condensers than any other parts. And also stresses occuring in circuits usually result in higher voltage on some condenser. Keeping this in mind, you will want to know how to find a faulty condenser and how to make the replacement quickly and inexpensively.

You know that condensers do not pass D.C. If they do, you better start replacing the condenser. Now most condensers used in circuits have a higher potential on one side than the other. Test for voltage across such units -- if there is no voltage there must be a short in the unit. You may proceed to shunt similar condenser across each unit suspected. If the condenser under test is in good operating condition, the test condenser will take a charge at the voltage impressed on the original unit. The discharge may be noticed and will be an indication that the unit is not shorted.

What about open condensers? The test suggested will take the place of the defective condenser when used in the circuit for test. Therefore, if this is the fault, during the moment the test is being made operation will be restored. Then just replace the condensers and the radio is repaired.

Are the values of condensers important? Voltage rating is important only in so far as the new unit used for replacement must have equivalent or higher rating. Notice that a higher rating can always be used. In fact it is advisable to use a replacement condenser for higher voltage rating to prevent the same fault to re-appear again.

Condensers used for by-pass purposes may be replaced by similar units but either larger or smaller in capacity. For example, a 0.1 mfd. cathode condenser can be replaced with a condenser anywhere from 0.01 to 1. mfd. capacity. Filter condensers are in the same line. Larger capacity is strongly recommended.

REVIEW QUESTIONS

1. If a total of 20 mfd. capacity is needed and only 4 and 8 mfd. units are available, how can the required capacity be obtained?

2. What three factors determine the capacity of a condenser?

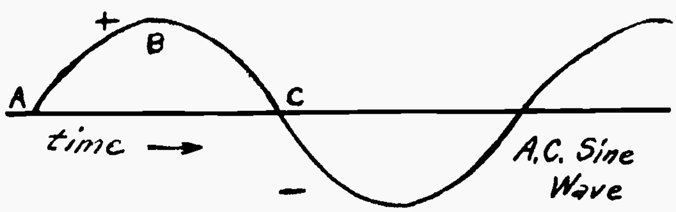
3. Why cannot electrolytic condensers be used in A.C. circuits?

4. If a single section of a multi-section electrolytic condenser was at fault, would you replace the entire unit, or would you install an extra condenser to replace the damaged section? Explain why.

LESSON 7

ALTERNATING CURRENT THEORY & FILTERS

In our discussion of batteries, we talked about direct current, (D.C.). This current is of constant or varying value but flows in one direction all the time. When the magnitude of D.C. changes, there results pulsating direct current. Alternating current (A.C.) has a changing magnitude and direction. First one terminal is positive having its value rising, see chart A to B. Then the value begins to fall, but the polarity remains the same, see B to C. At C the voltage present is zero, and then it begins to rise in the opposite direction. The process is repeated, but the terminals are reversed. The usual A.C. generated forms sine waves which graphically appear as the one illustrated.



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, 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. This explains why in dealing with A.C time must be considered.

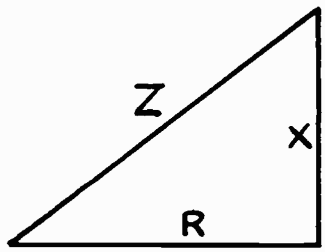
Inductance opposes changes in current intensity. Because in an A.C. circuit the voltage is constantly varying, the current too will vary in accordance. But the inductance present will attempt to prevent a change in the current, and the current will lag behind the voltage. In a pure inductive circuit (no resistance being present), the current will lag 90° behind the voltage and no power will be used. In actual circuits, of course, resistance is always present and the phase angle by which the current will lag behind the voltage will always be less than 90°.

Since, in A.C. circuits, current changes continuously, an inductance will show a definite "resistance" or opposition to the flow of A.C. current. This opposition is known as reactance. The reactance of a coil in ohms may be calculated if the frequency F, and inductance L in henries are known.

INDUCTIVE REACTANCE $X_L = 6.28 \times F \times L$ (in ohms)

Since every circuit contains resistance, in fact an inductance itself uses wire and, therefore, has resistance, both the reactance and the resistance constitute an impeding force. Please bear in mind that this opposition is equivalent to resistance in a D.C. circuit and by itself has nothing to do with the time lag. The relation between the inductance and the resistance of the circuit will determine the angle of the lag; the frequency does not enter directly in this case. The total opposition to the current is that of the resistance and the reactance and is expressed as the impedance of the circuit, designated by the symbol Z. Impedance like reactance is expressed in ohms. The formula given is used to compute the impedance.

$$Z = \sqrt{R^2 + X_L^2}$$



This means that the impedance Z is the hypotenuse (long, slant side) of a right triangle that has the resistance R, and the reactance X, as its two sides; see figure. From these two formulas we see that where inductance is involved, the impedance and reactance increase with the frequency.

In a radio filter circuit, the current that comes from a full wave rectifier tube contains a large 120 cycle component. It is interesting to see what impedance is offered by a 10 henry choke coil having 300 ohm D.C. resistance, to this 120 cycle component. Substituting the values and solving:

$$X_L = 6.28 \times F \times L = 6.28 \times 120 \times 10 = 7{,}536 \text{ ohms}$$

$$Z = \sqrt{(300)^2 + (7{,}536)^2} = 7{,}542 \text{ ohms}$$

The 120 cycle component receives a reactance from the choke of 7,536 ohms as compared to the 300 ohm resistance offered to D.C. The impedance or the combined effect of the choke's reactance and resistance is equal to 7,542 ohms.

CAPACITANCE REACTANCE If a D.C. voltage is impressed across the plates of a perfect condenser, there will be an initial rush of current which will charge the condenser to the supply voltage. After this, there is no further flow of current if the voltage remains constant. If the plates are short-circuited, current will flow out of the condenser.

The current in a capacitance circuit tends to keep the voltage constant and leads the voltage. This is exactly opposite to the action of an inductance. Therefore, the capacitance reactance is assumed to be opposite to inductive reactance and when both appear in a circuit the following formula is applied to calculate the capacitance reactance. This formula is also used when the capacity exists in a non-inductive circuit.

$$X_c = \frac{1}{6.28 \times f \times C}$$

Here also F is the frequency and C is the capacity in farads. Use the simplified formula

$$X_c = \frac{159{,}236}{f \times C}$$

when C is expressed in microfarads.

If a circuit has both inductive and capacitance reactances, their effects will be opposite to each other and the larger will predominate. For example, in a 60 cycle circuit there is an inductance of 3 henries and a condenser of 10 mfd. connected in series. Figuring we find the inductance having a reactance of 1130.4 ohms, the capacitance reactance equal to 265.4 ohms. The total reactance is equivalent to 1130.4 — 265.4 = 865. ohms and the circuit will behave inductively.

The impedance formula for circuits having capacity and resistance is similar to the one we already had where inductance was present instead of the condenser. X_c is simply substituted for X_L

$$Z = \sqrt{R^2 + X_c^2} \text{ in ohms}$$

If both inductive and capacitance reactances are present, X the total reactance is the algebraic sum of the two, vis:

$$Z = \sqrt{R^2 + (X_L - X_c)^2}$$

Note: X_L AND X_c are always taken to be opposite in sign.

The student should design simple series circuits envolving resistance, capacity, and inductance and apply these formulas.

<u>FILTERS</u> Filters are electrical circuits that show varied "shut-out" discrepancies to different frequencies present. In other words, filters change their impedance to different frequencies. By utilizing capacity and inductance (also resistance sometimes) in circuit combinations, it is possible to vary the amount of suppression of any group of frequencies. By combining a number of similar sets of filters, much sharper and more exact results may be obtained.

The use of filters in radio receivers and similar equipment is large. By-pass condensers across bias resistances, detector radio frequency chokes, and power supply chokes and condensers are but a few representative examples.

In one manner filters may be divided into four classes, depending upon the functions they are called to perform. Filters may be low pass, high pass, band pass, and band elimination types. The classification is relative to the frequencies passed or attenuated (kept out)

<u>TUNED CIRCUITS</u> A radio frequency air core transformer is used to couple the antenna to the radio set. In a practical input R.F. circuit, the secondary of the transformer is shunted with a variable condenser C. For practical purposes we may assume that the antenna picks up all signals equally well. These signals are transformed to the secondary with a slight voltage step up. On first appearance, the secondary of the "tuning" transformer and the condenser seem to be in a parallel circuit, however, this is not so. The voltage in the tuned circuit is induced in the windings of the secondary coil, and is in series with the winding.

REACTANCE AND RESISTANCE*

IN PARALLEL

When a resistance is in parallel with a reactance (either inductive or capacitive), the resultant impedance of the combination is found from the expression

$$Z = \frac{XR}{\sqrt{R^2 + X^2}}$$

Sometimes Z and R are given and X has to be found or Z and X are given and R is the unknown. In that case the equation can be solved for X and R and we have

$$X = \frac{ZR}{\sqrt{R^2 - Z^2}} \qquad R = \frac{ZX}{\sqrt{X^2 - Z^2}}$$

In all three of the above equations X can be either inductive reactance (X=6.28 fL) or it can be capacitive in which case X=1/(6.28 f C) where f is in cycles, L in henries and C in farads.

The table, Figure 3, has been prepared to permit the finding of any one of the three quantities X, R or Z when the other two are given. When X and R are given, divide the larger of the two quantities into the smaller one and thus get a ratio less than 1. Find this ratio in the left column and multiply the number obtained in the second column by R or X whichever is the larger and find Z.

Suppose R equals 1000 ohms and X is 200 ohms, which makes X/R = .20. The table shows us that Z/R is then 0.1961. Multiplying by R, we have Z = 0.1961 x 1000 = 196.1 ohms.

IN SERIES

The impedance, Z, of a combination resistance, R, and a reactance, X, in series is given by the equation

$$Z = \sqrt{R^2 + X^2}$$

When Z is given and either X or R is the unknown, this equation can be re-written:

$$R = \sqrt{Z^2 - X^2}$$

$$X = \sqrt{Z^2 - R^2}$$

In all these equations all three quantities are expressed in ohms and X can be either capacitive reactance (1/6.28 fC) or inductive reactance (6.28 fL).

The table, Figure 4, gives the value of all three quantities for the case that either X or Z is equal to 1. In other cases, find the ratio R/X or X/R refer to the table and find the corresponding ratio Z/X or Z/R. The table can also be used when Z is given together with one of the other quantities. It was for this reason that the table had to be extended for values of R/X or X/R from .1 to 10 since otherwise it would have been sufficient to include values from 1 upwards or downwards but not both. Example: suppose X = 1.600 ohms and R = 1,000 ohms. Then X/R = 1.6; the table shows Z/R = 1.8868. Then Z equals 1.8868 R or 1886.8 ohms.

REACTANCE AND RESISTANCE VALUES IN PARALLEL

X/R or R/X	Z/R or Z/X	X/R or R/X	Z/R or Z/X	X/R or R/X	Z/R or Z/X
0.10	0.0995	0.49	0.4400	0.88	0.6606
0.11	0.1093	0.50	0.4472	0.89	0.6648
0.12	0.1191	0.51	0.4543	0.90	0.6690
0.13	0.1289	0.52	0.4613	0.91	0.6730
0.14	0.1386	0.53	0.4683	0.92	0.6771
0.15	0.1483	0.54	0.4751	0.93	0.6810
0.16	0.1580	0.55	0.4819	0.94	0.6849
0.17	0.1676	0.56	0.4886	0.95	0.6888
0.18	0.1771	0.57	0.4952	0.96	0.6925
0.19	0.1867	0.58	0.5017	0.97	0.6963
0.20	0.1961	0.59	0.5082	0.98	0.6999
0.21	0.2055	0.60	0.5145	0.99	0.7036
0.22	0.2149	0.61	0.5208	1.00	0.7071
0.23	0.2242	0.62	0.5269	1.10	0.7400
0.24	0.2334	0.63	0.5330	1.20	0.7682
0.25	0.2425	0.64	0.5390	1.30	0.7926
0.26	0.2516	0.65	0.5450	1.40	0.8137
0.27	0.2607	0.66	0.5508	1.50	0.8320
0.28	0.2696	0.67	0.5566	1.60	0.8480
0.29	0.2785	0.68	0.5623	1.70	0.8619
0.30	0.2874	0.69	0.5679	1.80	0.8742
0.31	0.2961	0.70	0.5735	1.90	0.8850
0.32	0.3048	0.71	0.5789	2.00	0.8944
0.33	0.3134	0.72	0.5843	2.20	0.9104
0.34	0.3219	0.73	0.5895	2.40	0.9231
0.35	0.3304	0.74	0.5948	2.60	0.9333
0.36	0.3387	0.75	0.6000	2.80	0.9418
0.37	0.3470	0.76	0.6051	3.00	0.9487
0.38	0.3552	0.77	0.6101	3.20	0.9545
0.39	0.3634	0.78	0.6150	3.40	0.9594
0.40	0.3714	0.79	0.6199	3.60	0.9635
0.41	0.3793	0.80	0.6246	3.80	0.9671
0.42	0.3872	0.81	0.6289	4.00	0.9702
0.43	0.3950	0.82	0.6341	5.00	0.9807
0.44	0.4027	0.83	0.6387	6.00	0.9864
0.45	0.4103	0.84	0.6432	7.00	0.9902
0.46	0.4179	0.85	0.6477	8.00	0.9921
0.47	0.4254	0.86	0.6520	9.00	0.9939
0.48	0.4327	0.87	0.6564	10.00	0.9950

Figure 3

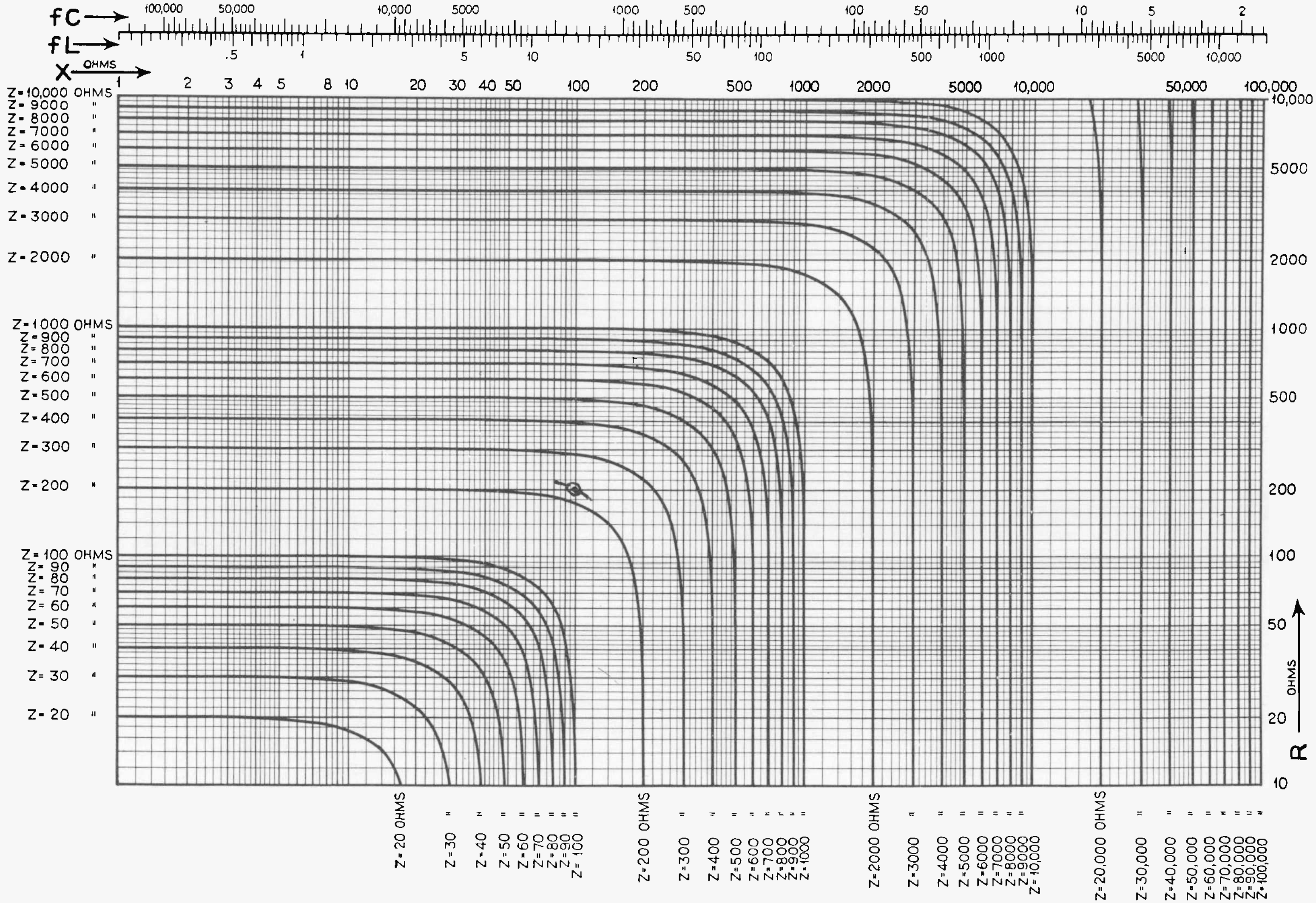
REACTANCE AND RESISTANCE VALUES IN SERIES

X/R or R/X	Z/R or Z/X	X/R or R/X	Z/R or Z/X	X/R or R/X	Z/R or Z/X
0.10	1.0050	0.70	1.2207	4.1	4.2202
0.11	1.0060	0.71	1.2264	4.2	4.3174
0.12	1.0072	0.72	1.2322	4.3	4.4147
0.13	1.0084	0.73	1.2381	4.4	4.5122
0.14	1.0097	0.74	1.2440	4.5	4.6098
0.15	1.0112	0.75	1.2500	4.6	4.7074
0.16	1.0127	0.76	1.2560	4.7	4.8052
0.17	1.0144	0.77	1.2621	4.8	4.9030
0.18	1.0161	0.78	1.2682	4.9	5.0009
0.19	1.0179	0.79	1.2744	5.0	5.0990
0.20	1.0198	0.80	1.2806	5.1	5.1971
0.21	1.0218	0.81	1.2869	5.2	5.2952
0.22	1.0239	0.82	1.2932	5.3	5.3935
0.23	1.0261	0.83	1.2996	5.4	5.4918
0.24	1.0284	0.84	1.3060	5.5	5.5901
0.25	1.0308	0.85	1.3125	5.6	5.6885
0.26	1.0333	0.86	1.3190	5.7	5.7871
0.27	1.0358	0.87	1.3255	5.8	5.8856
0.28	1.0384	0.88	1.3321	5.9	5.9841
0.29	1.0412	0.89	1.3387	6.0	6.0828
0.30	1.0440	0.90	1.3454	6.1	6.1814
0.31	1.0469	0.91	1.3521	6.2	6.2801
0.32	1.0499	0.92	1.3588	6.3	6.3789
0.33	1.0530	0.93	1.3656	6.4	6.4777
0.34	1.0562	0.94	1.3724	6.5	6.5764
0.35	1.0595	0.95	1.3793	6.6	6.6752
0.36	1.0628	0.96	1.3862	6.7	6.7741
0.37	1.0662	0.97	1.3932	6.8	6.8731
0.38	1.0698	0.98	1.4001	6.9	6.9720
0.39	1.0733	0.99	1.4071	7.0	7.0711
		1.00	1.4141		
0.40	1.0770	1.1	1.4866	7.1	7.1701
0.41	1.0808	1.2	1.5621	7.2	7.2691
0.42	1.0846	1.3	1.6401	7.3	7.3681
0.43	1.0885	1.4	1.7205	7.4	7.4671
0.44	1.0925	1.5	1.8028	7.5	7.5662
0.45	1.0966	1.6	1.8868	7.6	7.6654
0.46	1.1007	1.7	1.9723	7.7	7.7646
0.47	1.1049	1.8	2.0591	7.8	7.8638
0.48	1.1092	1.9	2.1471	7.9	7.9630
0.49	1.1136	2.0	2.2361	8.0	8.0623
0.50	1.1180	2.1	2.3259	8.1	8.1615
0.51	1.1225	2.2	2.4166	8.2	8.2608
0.52	1.1271	2.3	2.5080	8.3	8.3600
0.53	1.1318	2.4	2.6000	8.4	8.4594
0.54	1.1365	2.5	2.6926	8.5	8.5580
0.55	1.1413	2.6	2.7857	8.6	8.6576
0.56	1.1461	2.7	2.8792	8.7	8.7572
0.57	1.1510	2.8	2.9732	8.8	8.8566
0.58	1.1560	2.9	3.0676	8.9	8.9560
0.59	1.1611	3.0	3.1623	9.0	9.0554
0.60	1.1662	3.1	3.2573	9.1	9.1548
0.61	1.1714	3.2	3.3526	9.2	9.2542
0.62	1.1765	3.3	3.4482	9.3	9.3536
0.63	1.1819	3.4	3.5440	9.4	9.4530
0.64	1.1873	3.5	3.6400	9.5	9.5524
0.65	1.1927	3.6	3.7362	9.6	9.6518
0.66	1.1981	3.7	3.8327	9.7	9.7512
0.67	1.2037	3.8	3.9293	9.8	9.8507
0.68	1.2093	3.9	4.0262	9.9	9.9503
0.69	1.2149	4.0	4.1231	10.0	10.0499

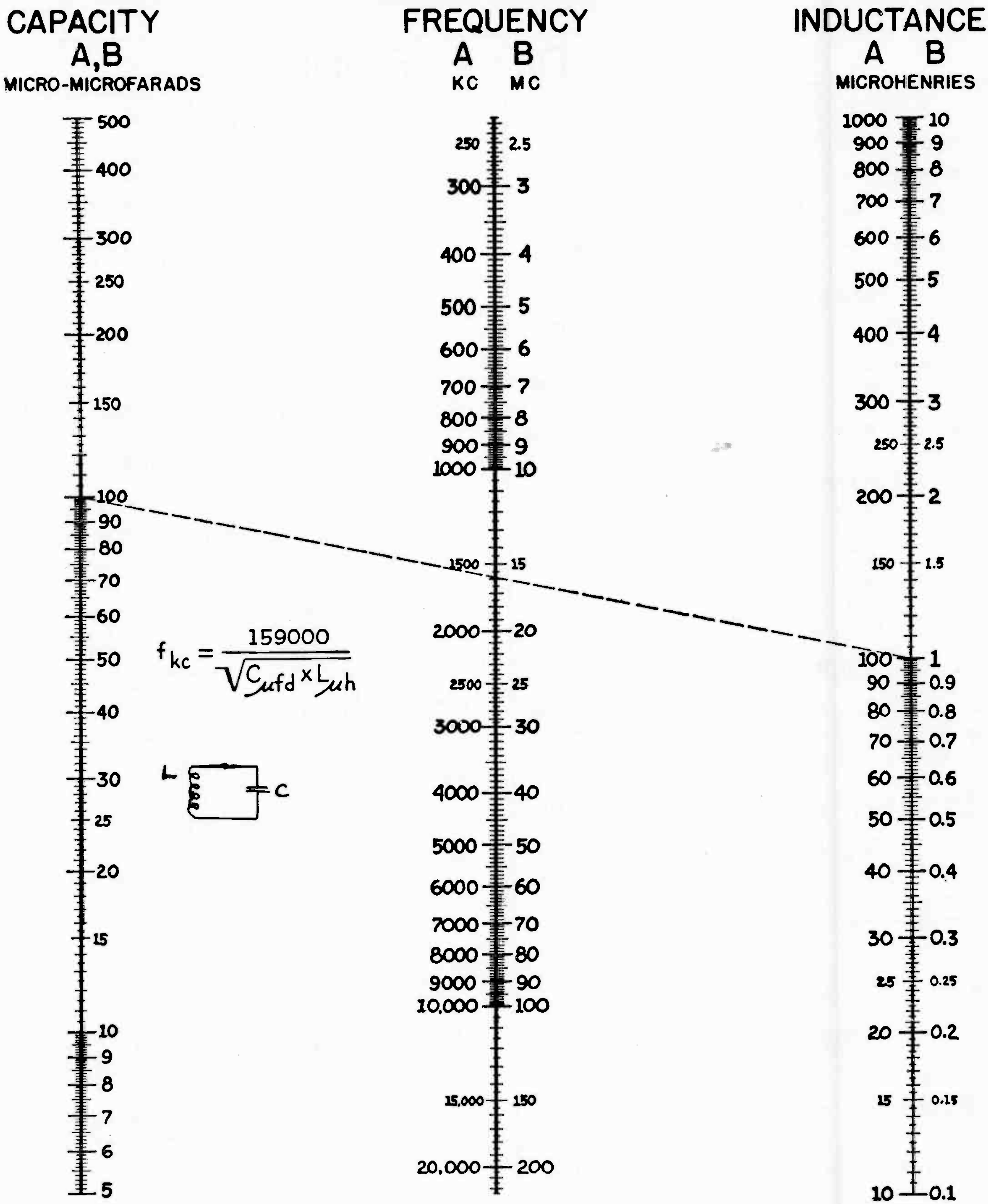
Figure 4

*Reprinted from Aerovox Research Worker.

REACTANCE AND RESISTANCE IN SERIES



Use this graph to find impedance Z, when resistance R and reactance X, connected in series, are given. Holding the page sideways so that resistance R-scale (10 to 10,000 ohms) is at the right, you will find the reactance X-scale at the top. You will find that fC scale corresponds to X scale provided C is taken in microfarads. For example if the product of frequency f and capacity C in mfd. equals 5000, reactance X is 32 ohms. Check this above. In a similar way fL scale corresponds to the X scale values, but here L is taken in henries. For any given values of X and R, find their junction. The chart has a mark for X=100 and R = 200 ohms. Notice that this junction is close to the heavy line representing Z = 200 ohms, but is somewhat at a distance towards the 300 value. By interpolation you can estimate that Z = 220 ohms is about the right value. In this manner other problems involving X and R in series can be solved.



When any two of the quantities F, L, or C are known the third can be found by drawing a straight line. Example: 100 mmfd. and 100 microhenries tune to 1590 kc. (reading all A scales) or 100 mmfd. and 1 microhenry reonates at 15.9 mc. (reading all B scales).

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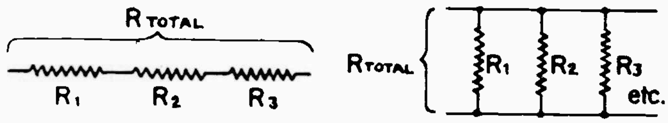
HANDY RADIO FORMULAE

Direct Current Relations

VOLTS	=	IR	$\frac{W}{I}$	$\sqrt{RW}$
AMPERES	=	$\frac{E}{R}$	$\frac{W}{E}$	$\sqrt{\frac{W}{R}}$
OHMS	=	$\frac{E}{I}$	$\frac{W}{I^2}$	$\frac{E^2}{W}$
WATTS	=	EI	I^2R	$\frac{E^2}{R}$

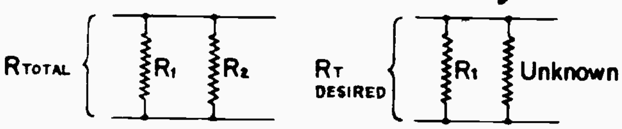
Resistance Relations



$R_{TOTAL} = R_1 + R_2 + R_3$ etc.

$\frac{1}{R_{TOTAL}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ etc.

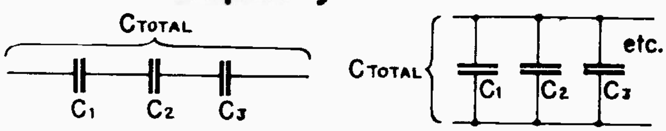
Two Resistances Only



$R_{TOTAL} = \frac{R_1 \times R_2}{R_1 + R_2}$

$\text{Unknown} = \frac{R_T \times R_1}{R_1 - R_T}$

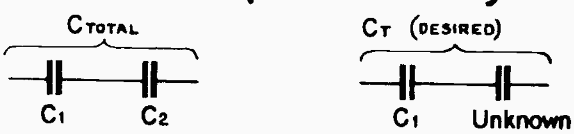
Capacity Relations



$\frac{1}{C_{TOTAL}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ etc.

$C_{TOTAL} = C_1 + C_2 + C_3$ etc.

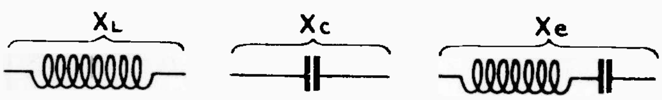
Two Capacities Only



$C_{TOTAL} = \frac{C_1 \times C_2}{C_1 + C_2}$

$\text{Unknown} = \frac{C_1 \times C_T}{C_1 - C_T}$

Simple Reactance



$X_L = 2\pi FL$

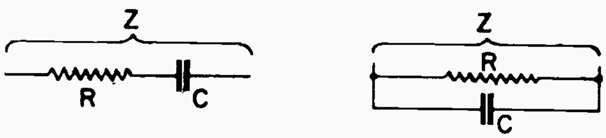
$X_C = \frac{1}{2\pi FC}$

$X_e = 2\pi FL - \frac{1}{2\pi FC}$

Complex Impedance

$Z = \sqrt{R^2 + 4\pi^2 L^2 F^2}$

$Z = \frac{2\pi LRF}{\sqrt{R^2 + 4\pi^2 L^2 F^2}}$



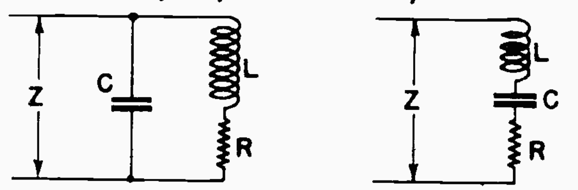
$Z = \sqrt{R^2 + \frac{1}{4\pi^2 C^2 F^2}}$

$Z = \frac{R}{\sqrt{4\pi^2 R^2 C^2 F^2 + 1}}$

Resonance Formulae

$F = \frac{1}{2\pi\sqrt{LC}}$ $L = \frac{1}{4\pi^2 F^2 C}$ $C = \frac{1}{4\pi^2 F^2 L}$

Where F is in cycles, L is in henries, and C in Farads



$Z = \frac{2\pi FL}{4\pi^2 F^2 LC - 1}$

At Resonance:

$Z = Q\,2\pi FL$

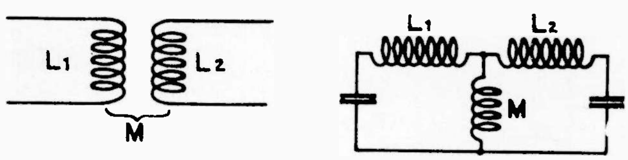
Where $Q = \frac{2\pi FL}{R}$

$Z = \sqrt{\left(2\pi FL - \frac{1}{2\pi FC}\right)^2 + R^2}$

At Resonance:

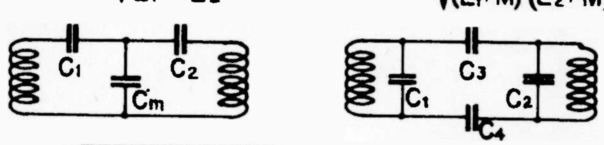
$Z = R$

Coupling Coefficient



$K = \frac{M}{\sqrt{L_1 + L_2}}$

$K = \frac{M}{\sqrt{(L_1+M)(L_2+M)}}$



$K = \frac{\sqrt{\frac{C_1 \times C_m}{C_1 + C_m} \times \frac{C_2 \times C_m}{C_2 + C_m}}}{C_m}$

$K = \frac{\sqrt{\frac{C_1 \times C_m}{C_1 + C_m} \times \frac{C_2 \times C_m}{C_2 + C_m}}}{C_m}$

Where $C_m = \frac{C_3 \times C_4}{C_3 + C_4}$

When you have a circuit problem requiring a mathemtical solution, refer to this page for an applicable formula to help you secure the correct answer.

REVIEW QUESTIONS

1. How many changes of direction does 60 cycle current have each second?

2. In an inductive circuit, does voltage lead the current?

3. What is the inductive reactance of a 20 henry choke in a 60 cycle A.C. circuit?

4. What is the total impedance if this choke is connected in series with a 1,000 ohm resistor? Work this problem and then check with the chart.

5. What reactance does a 0.1 mfd. condenser offer to 500 cycle current? What happens if a 1.0 mfd. is used instead?

6. In a series circuit, the resistance is 4 ohms, the inductive reactance 11 ohms, and the capacitive reactance 8 ohms. Find the equivalent impedance.

7. What kind of filter would be needed to eliminate the high frequencies in an audio amplifier?

8. Is it true that when a condenser and a choke are connected in series, the resulting impedance is in value smaller than the inductive reactance or the capacitive reactance taken separately? Why?

9. Set up several circuit problems and solve them with the aid of the charts included.

10. Using a coil of 220 microhenries and a condenser that can be varied from 20 to 400 micro-microfarads, what frequency coverage will be secured?

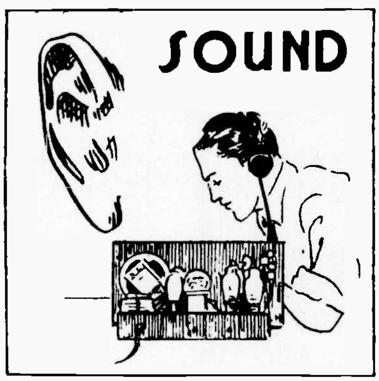
11. Refer to the "Handy Radio Formulae" listing and make up a problem with real values for each of the formulae. Then proceed to solve these problems.

12. Remembering the results obtained in problem 10, try to see the reason why several different coils must be used for all-wave coverage.

LESSON 8

Practical Aspects of Radio Servicing

In being called to repair a defective radio set you should inquire from the owner just what was observed to be wrong. Such information may be of aid to you in trouble shooting. In general, although a radio set is a complex instrument you can assume that it was in good working condition before the particular fault developed and, therefore, only a single fault must be found. This fact greatly simplifies your work since by using a simple test procedure you can isolate a section of the set at fault and then find the particular part or adjustment requiring repair.



First examine the A.C. cord connection and antenna connection (if used). If found in order, the radio chassis should now be removed from the cabinet. Usually this will require the removal of front control knobs and unscrewing bolts below and in back of the cabinet.

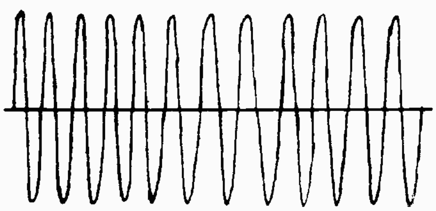
When the set is out of the cabinet, it may be examined for any noticeable fault such as a broken grid cap, leaky condenser, or burnt out coils. You will also be able to see if the radio tubes light. In an AC-DC set one burnt out tube will prevent the filaments of other tubes from lighting. In A.C. sets using transformers, the filaments are connected in parallel and receive their operating current independently.

If your examination does not disclose any obvious fault a quick test may be made by touching with your screw driver the control qrids of the various tubes. A click should be heard each time this contact is made and this click reproduced by the loudspeaker should become louder as you move from the grid of the stage next to the speaker to stages closer to the antenna. If along your testing no click is heard at a particular stage, that stage is at fault.

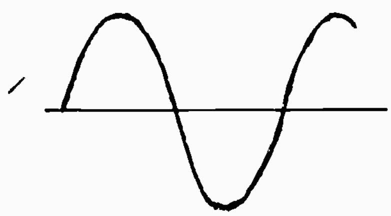
The test to determine if plate voltage is present may be made by taking an electrolytic condenser and making temporary contact with + lead to a point where positive plate voltage may be expected (cathode of rectifier tube, plate or screen grid of output power tube) and the negative connection to a ground or a common chassis. After making this contact, the two wires of the condenser are brought almost in contact and a spark will indicate that a voltage existed and charged the condenser. Lack of spark suggests lack of voltage.

The main reason for introducing some of these simple tests at this early stage of your study is to convince you of the ease and simplicity of finding radio faults. Once the fault is found the actual repair is usually mechanical in nature and presents no problems in itself. You should have some understanding how a radio signal is produced. At the radio station equipment is employed to produce a radio frequency signal and this in turn is modulated (varied in intensity for AM stations) by the audio frequencies resulting from the amplification of music or voice picked up by a microphone. The carrier frequency when modulated occupies a channel twice the width of the audio frequency. Since the present day broadcasting channels are 10 KC. (kilocycles) wide or 5 KC. on each side of the carrier, the program transmitted may have audio frequency up to 5,000 cycles per second.

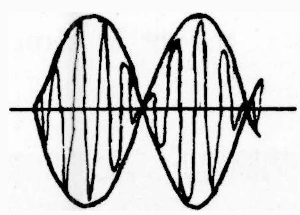
At the receiver the antenna (which may also be a coil or loop in the set itself) is excited by all frequencies of all stations. However, only near-by stations have a pronounced effect and the combination of coils and condensers used select the desired station and descriminate against the others. The selectivity is accompanied with amplification in the R.F. and I.F. stages that precede the detector.



Carrier Wave



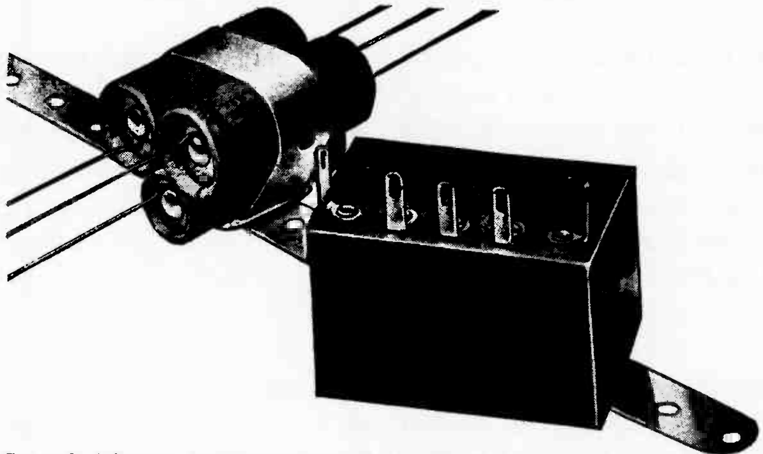
Audio Frequency



Modulated Wave

The detector removes from the modulated R.F. (or I.F.) the audio signal which in turn is further amplified in the audio stages. The audio output stage not only amplifies but also supplies power to the loudspeaker while it is excited by voltage variations. The loudspeaker, of course, is a device for changing electrical energy of audio frequencies to actual sound.

Since the majority of repairs will require the removal of a defective part and the replacement of this part with one in good condition, you will

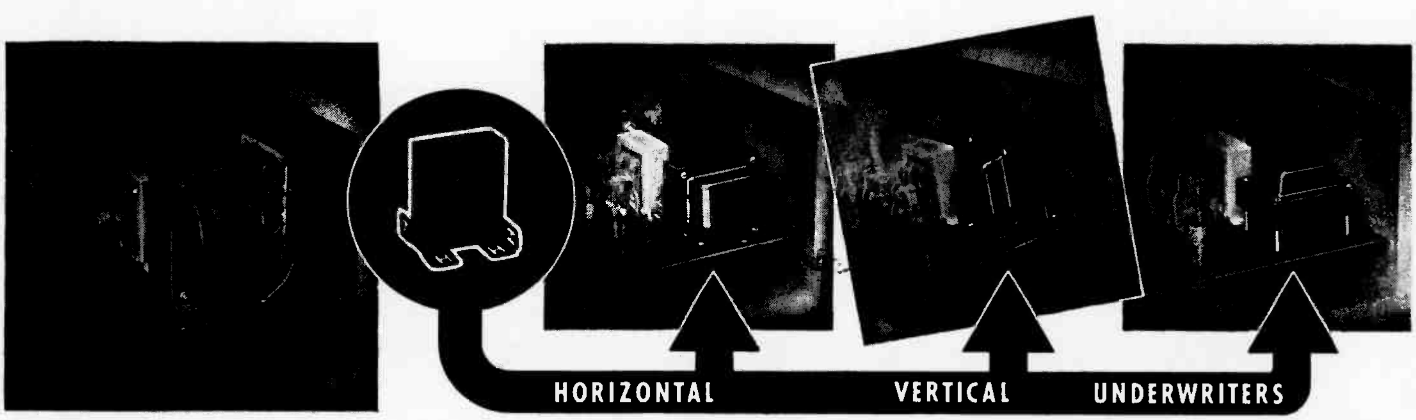


Several different condensers may be enclosed in a single container.
In making a repair, only the section at fault need be replaced.

have to understand how radio parts are mechanically mounted in place. We will talk about such parts as require replacement from time to time. Items such as tube sockets, tuning condensers, etc. seldom need replacement.

Radio tubes plug into sockets and are removed with a pull upwards while a slight rocking motion is introduced. A guide pin or irregular placing of holes prevents insertion of tubes incorrectly. Some types of electrolytic condensers in more modern sets twist into position. Fuses (more commonly found on TV sets) are mounted in several different ways but usually are removed by snapping them out of the terminals.

Power transformers are bolted or riveted originally. Rivets in this instance or when found holding other parts that need removal must be drilled out. The replacement transformer need not be identical physically with the unit originally used in the set but should provide correct voltages. Some replacement transformers are called universal and are designed to mount in almost any position.



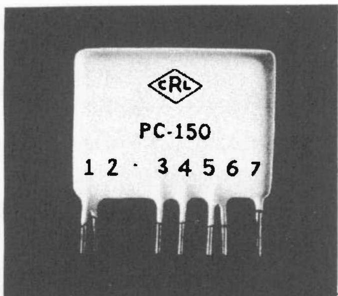
With the power transformer burned out, the set originally looked like this.

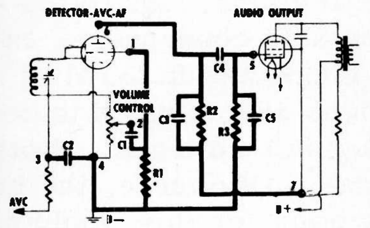
With the new Universal unit, servicing is simple—the finished product is neat. Three possible methods of mounting the unit without drilling holes, are shown. Half shell mounting is just as easy.

Parts that are mounted on pigtails (wire leads) are simply cut off and a replacement condenser or resistor mounted in their place in the same fashion. Printed circuit plates which contain several components may be replaced with suitable similiar unit or just a defective component may be replaced in the circuit provided both the leads to this compenent are used for external wiring of the plate.

Unshielded coils are usually held in place with small brackets that are bolted to the chassis. The replacements are mounted in the same manner. I.F. transformers and other coils that are shielded should be replaced with units of identical electrical characteristics and mounted in cans of about the same physical size.

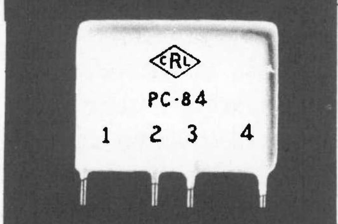
To simplify assembly at the factory and to reduce cost several resistors and condensers are combined to form a "plate." Centralab makes these units under the trade name "Couplate." A number of such units that are used in radio receivers are illustrated together with their circuits and values of parts employed.

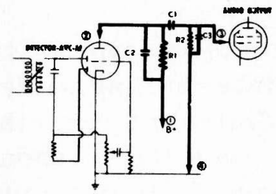




$R_1 = 6.8$ Meg
$R_2 = 470K$
$R_3 = 470K$
$C_1 = 2000$ mmf.
$C_2 = 220$ mmf.
$C_3 + C_5 = 250$ mmf.
$C_4 = 5000$ mmf.

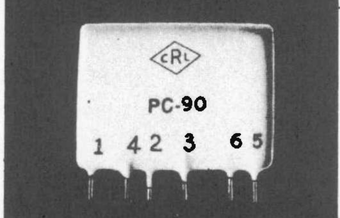
AUDET OUTPUT STAGE

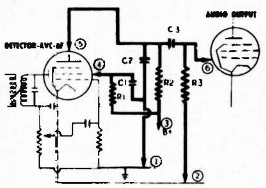




$R_1 = 500K$
$R_2 = 500K$
$C_1 = .01$ mfd.
$C_2 + C_3 = 500$ mmf.

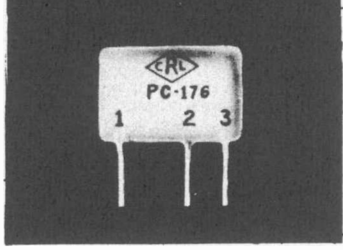
STANDARD COUPLATE

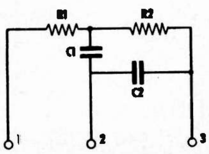




$R_1 = 4.7$ Meg
$R_2 = 1$ Meg
$R_3 = 2.2$ Meg
$C_1 = 500$ mmf.
$C_2 = 50$ mmf.
$C_3 = 2000$ mmf.

PENTODE





$R_1 = 82K$
$R_2 = 39K$
$C_1 = .001$ mfd.
$C_2 = .002$ mfd.

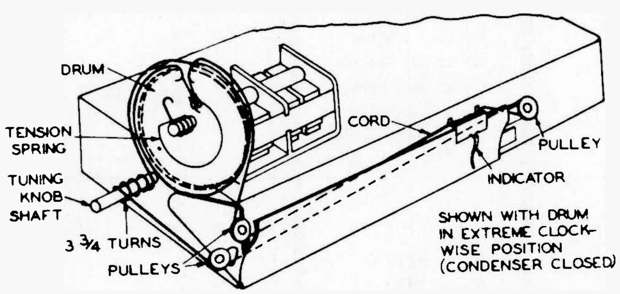
SPECIAL

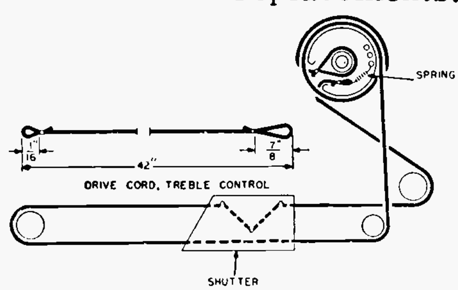
Tuning is needed in order to select the wanted station from the signals of all others. As you know from previous lessons this is done with a coil-condenser combination. In most radio sets the coils for any one band are fixed and the condensers are varied (capacity is changed). The inductance of the coil may be altered to permit tuning in some sets. In some push-button tuning sets, a number of semi-fixed condensers are used and are selected one at a time by means of a switch.

A gang tuning condenser is used for tuning in many modern sets. Such a unit may have two or three gangs turning on a common shaft (electrically and mechanically common), each such gang tuning a different coil. With proper adjustment (alignment), these stages will produce tuning selectivity required. In superhet sets, one such rotating gang may be somewhat smaller and is called cut-section. This section is used with the oscillator coil to give a required higher frequency to mix with the signal frequency to produce a new signal for the I. F. stages.

The rotors of a gang condenser are connected to the frame and are grounded to the chassis through the mounting bolts. The stationary plates are insulated from the frame. The terminal lugs to the stator plates are on one side or on both. Small adjustable condensers, called trimmers, may be placed on one side and are connected in parallel with the corresponding tuning gang. These trimmers are adjusted to compensate for differences in capacity of gangs and associated leads. Slotted plates permit slight bending for alignment purposes. Of course, the rotary plates must not touch stationary plates at any point for this would produce a short circuit and stop reception.

Quite often the tuning condenser or other type of tuning unit is driven with a dial cord. The pointer may rotate or may slide along a long ruler-like dial. Service data usually gives dial-cord restringing instructions for more complex applications. In most cases the method used can be figured out from the examination of the remains of the old cord or from a study of the dial, pointer, and pulleys. Dial cord should be used for replacements.





Two typical dial-cord restringing diagrams are shown above. Before putting on a new cord, see if all rotating parts turn freely. If necessary, use light oil in very small amount. You will find that a piece of tape can be of great help in holding the cord in place while you are working at another part of the dial-cord drive system.

Practically all modern auto sets provide pushbutton tuning and a great many pre-War home sets also included pushbutton tuning of various types. In the older home sets one type of pushbutton control connected trimmer condensers across coils. These trimmers were adjusted to tune specific local stations, and in this way each button automatically tuned a different station. In majority of sets buttons rotate the tuning condenser to the exact position for a particular station. This is done mechanically with a separate cam position for each station, the buttons being connected to adjustable push-rods. In other types of mechanical pushbutton tuning, gear action is combined with a rocker bar to move the tuning condenser to a pre-selected position of each wanted station.

In pushbutton tuning sets using trimmers for tuning, each set of trimmers is adjusted for one local station. The trimmers with most capacity (most plates) are used for low frequency stations, while those with least capacity are used for higher frequency stations of the broadcast band. The I. F. transformers are aligned in the usual manner and this is explained in a later lesson. Then the trimmers are adjusted for maximum signal for the corresponding station for which they are used.

On page 54 important practical facts on replacing parts and carrying out repairs in printed circuit chassis are given. This material is reprinted through the courtesy of Emerson Radio and Phonograph Corp.

In conventionally wired circuits it may be important to properly position wires moved or replaced in making a repair. In general, it is a good rule to make all connections as short as possible and to place wires close to the metal of the chassis. Do not run parallel wires carrying the actual signal, such as leads connecting to grid and plate terminals of tubes.

REVIEW QUESTIONS

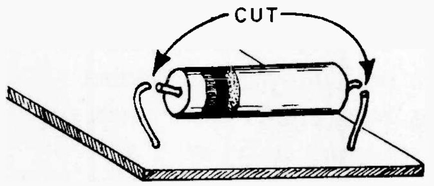
1. What can be wrong with a radio set that can be repaired without removing the set from the cabinet?

2. Can a voltmeter be used to determine if plate voltage is present? Where would you make the connections for this test?

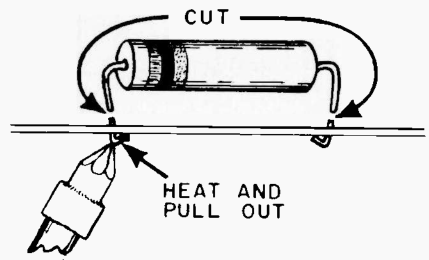
3. Examine the chassis of a radio you have at home. List at least three different methods used for mounting some of the parts.

4. Examine the printed circuit at the bottom of page 51. Note that if C2 condenser becomes open a repair can be made by wiring a .002 mfd. capacitor across terminals 2 and 3. Can a repair be made without replacing the entire plate if any one of the other components opens?

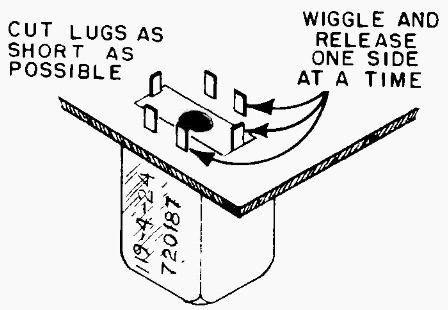
Service Hints for Replacing Parts on Printed Circuit Chassis



Cut resistor or capacitor leads as close to the component as possible, then connect the replacement part to the remaining section of the original leads and carefully solder.

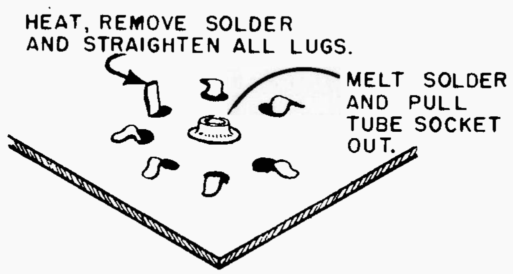


Cut resistor or capacitor leads as close to the chassis as possible. Heat connections just long enough to melt solder and remove leads from bottom one at a time. Clean area around the mounting holes and insert leads from replacement part through holes provided. Clip off excess lead, leaving a small piece to bend over and solder.

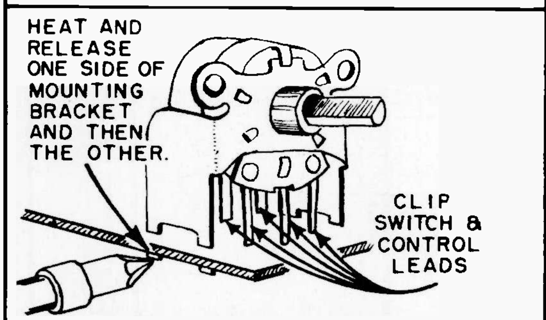


Cut transformer lugs (including spring clips) as close to chassis as possible. Heat connections (on one side) long enough for solder to melt, then wiggle loose first one side and then the other. Clean area around mounting holes and insert replacement part through same holes. Carefully resolder connections.

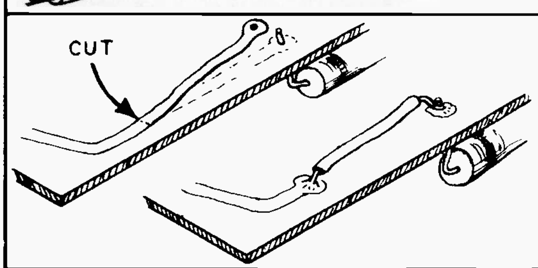
NOTE: The position of the part number with respect to the transformer lug numbers are fixed. When putting in a new transformer make sure the position of the part number with respect to the chassis is the same as the original.



Melt and brush excess solder from socket pins and straighten out bent pins (one at a time). Remove solder from center ground lug of socket and remove socket (it may be necessary to reheat some of the lugs). Clean the area around mounting holes and insert new socket (with tube in it) in same holes. Bend socket lugs over and then carefully solder.



Cut the volume control and a.c. switch leads close to top of chassis. Heat these clipped leads from under the chassis and pull out with long nose pliers. Melt solder around mounting bracket lugs and straighten out these lugs if bent. Clip these lugs off as close to chassis as possible. Heat and remove one side of mounting bracket and then the other. Clean area around mounting holes and insert new part, bend lugs over slightly and carefully solder all connections.

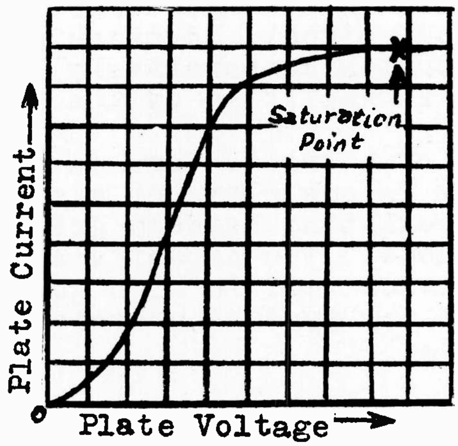


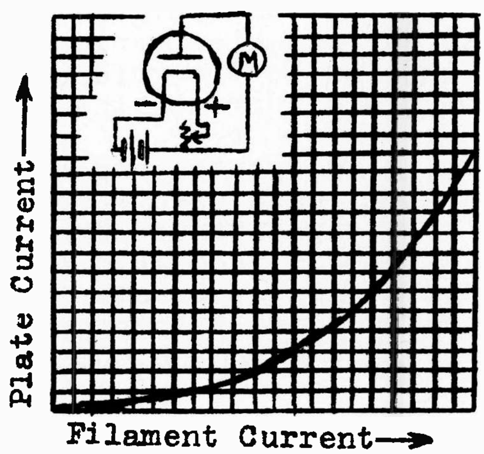
Cut off the section of the printed wiring strip that has lifted from the chassis and replace this section with a small piece of regular insulated wire. Bare wire may be used to replace short sections.

LESSON 9
RADIO 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 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. Some substances are far better emitters than others. Coating a poor emitter with an oxide of certain metals may raise the emission thousand times. The emission also increases with the termperature.

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 positive potential 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. The complete action is easy to analyze.





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 recified 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. By increasing the plate voltage, more electrons will be attracted and the tendency to form a space charge will be reduced.

Once the plate voltage reaches a certain maximum when all the electrons leaving the cathode are attracted to the plate, a further increase of the plate voltage will have no effect on the plate current. This maximum current is known as the saturation current.

Tubes having a third electrode for control purposes are known as triodes. This control electrode is usually called the grid because it is made of fine wire in a form of a mesh. 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. When the voltage on the grid is varied in accordance with a signal, the plate current also varies with the signal. Because a small voltage applied to the grid can control a comparatively large amount of plate current, the signal is amplified by the tube.

The grid, plate, and cathode of a triode form an electrostatic system, each electrode acting as one plate of a small condenser. The capacitances are those existing between grid and plate, plate and cathode, and grid and cathode. The capacitance between grid and plate is of greatest importance and, in high gain radio-frequency circuits, this capacitance may produce undesired coupling between the input and output circuits.

A much smaller change in the grid voltage will produce the same change in the plate currrent as a much larger plate voltage change. The ratio of the small change in the plate voltage (E_p) to the smaller change in the grid voltage (E_g) that will vary the plate current by an equal small amount is called the amplification factor, or μ (mu). Mathematically:

$$\mu = \frac{dE_p}{dE_g}$$ where d means the differential, a very small change.

For example, a type 56 triode tube operating in a conventional circuit with

$$E_g = -13.5 \text{ volts}, \quad E_p = 250 \text{ volts}, \quad I_p = 5 \text{ milliamperes}$$

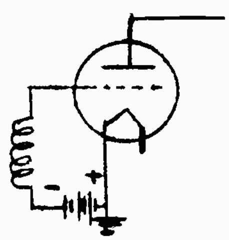
will have one milliampere less of plate current (I_p) by either a change of 0.87 volts in E_g, or a change in E_p of approximately 12 volts. The ratio of the two will give about 13.8 as the mu of this particular tube.

The plate resistance (r) of a tube is the resistance to the alternating current of a path between the plate and the cathode. It is the ratio of a small change in plate voltage (E_p) to the corresponding change in the plate current (I_p). This is:

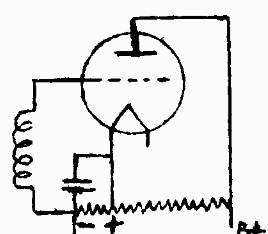
$$r_p = \frac{dE_p}{dI_p} \qquad \text{when } E_g \text{ is constant}$$

The grid may be made to assume either positive or negative values with respect to the cathode. When the grid is negative with respect to the cathode, the grid will not attract electrons and no current will flow between it and the cathode. This means that the grid will not take power from the circuit connected to it. In this manner, minute power can be used to control comparatively large plate power. Because of this and other reasons, it is desirable to keep the grid at some negative potential at all times. The negative potential applied to the grid must, therefore, be at all times larger than the greatest positive swing of the grid input voltage.

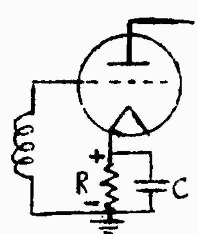
This constant negative potential is called the <u>bias</u> and may be obtained from batteries, but usually a section of the voltage divider is tapped off for this purpose or a resistor of a correct value is placed in the cathode return circuit and causes a drop of potential because of the passage of the direct plate current. A by-pass condenser offering very low impedance to the alternating current component of the plate current is employed to act as an easy path for all currents except the direct current component.



Battery Bias



Voltage Divider Bias



Self Bias

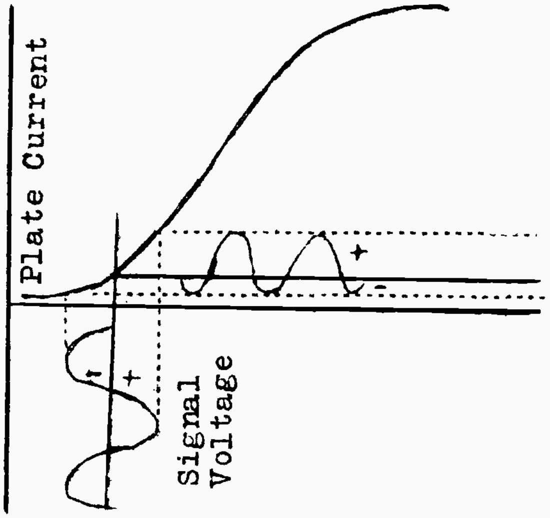
The detrimental effect of the grid-plate capacitance is reduced greatly by the introduction of a fourth electrode, called the screen grid, placed between the grid and the plate. This screen in ordinary application is connected to a positive potential somewhat lower than the plate potential. Since the screen voltage largely determines the electron flow, large variations in the plate voltage will have but little effect on the plate current.

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. In the diode or triode, this action does not cause any difficulties because of the absence of any positive bodies in the vicinity of the plate. In the screen grid type tetrode, however, the screen is positive and close to the plate and does attract electrons emitted by the secondary emission action. This effect lowers the plate current and limits the permissible plate swing.

This limitation in turn may be removed by a further introduction of another electrode, known as the suppressor, between the screen and the 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.

BEAM POWER TUBES A beam power tube makes use of a different method for suppressing secondary emission. In this tube there are four electrodes, a cathode, control grid, screen grid, and plate so spaced that secondary emission from the plate is suppressed without an actual suppressor. Because of the way the electrodes are spaced, electrons traveling to the plate slow down when the plate voltage is low, almost to zero velocity in a certain region between the screen and plate. In this region the electrons form a stationary cloud, a space charge, repelling secondary electrons emitted from the plate and cause them to return to the plate. In this manner, secondary emission is suppressed. Another feature of the beam power tube is the low current drawn by the screen, as well as economical operation.

BIAS DETECTOR After about 1929, detectors were operated at the lower bend of their characteristic curves by using sufficient bias. Detection took place because a positive swing in the grid voltage caused a much larger increase in plate current than a corresponding decrease when an equal negative grid voltage was applied. Notice the rectification-detection that takes place in the illustrated example of a simple sine wave.



The bias may be obtained in any of the ways described previously; i.e., C batteries, voltage divider, or self biased.

GRID LEAK DETECTOR Working on a different principle, grid leak detectors were extensively used some time ago. However, these detectors have many disadvantages when considered for use in modern radio receivers and find but little present day applications.

Plate Characteristics, 46 Class A

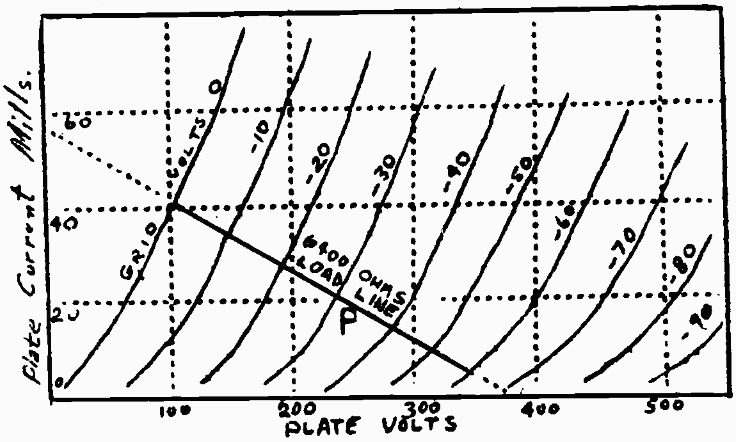


Plate characteristic curves are useful in determining the best operating conditions of a tube. The plate current is plotted as the ordinate, and the plate voltage as the abscissa. Keeping the grid potential fixed at some value, the variations in plate voltage are plotted against the corresponding variations of plate current. By repeating this process for a number of different grid potentials, a group of similar curves are obtained, as illustrated for type 46 tube in class A operation. It will be noted that an increase in negative grid potential shifts the curve to the right.

To plot the load line having been given $E_g = -31$ volts $E_p = 250$ volts, $I_p = 22$ milliamperes, Load resistance = 6,400. First, find where the given E_p and I_p intersect, mark this point P. Place a straight edge on point P; rotate it until the value of plate voltage intersected divided by the plate current also intersected, will equal the given load resistance, 6,400 ohms in this case. The edge will cut 58 milliamperes and 371 volts at the same time. Since 371/.058 = 6,400, this is the correct line.

If the grid swing may be considered to be between zero and the value twice the fixed bias, then the formulas below may be applied in calculating the amount of second harmonics and power output. Second harmonics are frequencies twice the signal frequency generated by the tube and usually not wanted.

At any value of grid potential, the plate current value is directly to the left of the load line and that grid potential intersection; the plate voltage is directly below this intersection. For example in the previous graph, when $E_g = -10$, the plate voltage is 150, and the plate current is about 34 milliamp.

$$\text{POWER OUTPUT} = \frac{(I_{max} - I_{min}) \times (E_{max} - E_{min})}{8}$$

$$\%\ \text{2nd HARMONICS} = 50 \times \frac{(I_{max} + I_{min} - 2I_{average})}{I_{max} - I_{min}}$$

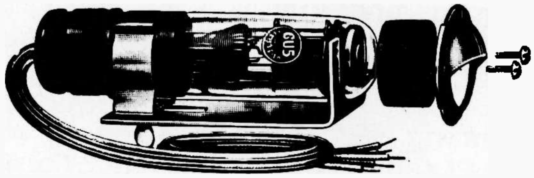
The functions of vacuum tubes are varied. In a receiving radio set, vacuum tubes are used primarily as voltage and power amplifiers, and to a limited extent as detectors and oscillators. The current change in the plate circuit of a vacuum tube may produce a voltage variation across a resistance, a high impedance, or the impedance of the primary of an audio transformer or a R.F. transformer. If the plate current is passed through a high resistance connected between the plate and the positive side of the plate voltage supply, voltage variations will be produced in proportion to the changes in the plate current. The voltage drop will distribute itself in proportion to the resistance of the tube (r) and the load resistance (R). The voltage amplification will be a fraction of the amplification factor μ, expressed by the relation:

$$\text{Voltage Amplification} = \frac{\mu R}{r + R}$$

In case the load is an impedance Z, it may be substituted for R in the above formula.

The types 6E5, 6G5, and other tuning indicator tubes are finding extensive use in modern sets, and may be added to any radio having automatic volume control. The tube's filament is simply wired in series with other tubes in AC-DC type sets, or connected to the power transformer filament winding. Usually the transformer can easily handle an additional tube. In sets using 2.5 volt tubes, type 2E5 must be employed.

The adapter sockets supplied (as illustrated) have an internal screen resistor and are simply connected to the filament supply, B-plus point, chassis or negative return, and a point of the correct A.V.C. voltage. Complete instructions are always supplied with the unit you may purchase.



There are a great many different type of tubes used in radio sets. All these types are listed in the Sylvania tube chart beginning on page 65. A great many types are identical except for the fact that one series is for 2.5 volt operation, and another is for 6.3 volt use. Note, for example, the correspondence between types 58 and 78, or 55 and 6V7G. Also in the same series there may be many types almost alike, see 6C6, 77, and 6J7. There are tubes to serve in A.C. sets, in AC-DC sets, in battery sets, in auto sets, and for many special applications.

All the metal tubes have equivalent glass types. For example, 6K7 has a glass equivalent 6K7G. The G-type tubes may be used for metal or vice versa, provided space permits and the glass tubes substituted are provided with shields in certain cases. There are also many G and GT type tubes not having metal equivalents, see 6K6GT, or 25A7GT.

Now you have already noticed that the first column of the chart gives type numbers. The next column tells style of bulb and class. Is the tube a triode, a pentode, or a dual type? Next is the base data. The code letters refer to base connections applicable and these are shown at the bottom of each double page. Look up type 6A8 for practice. You will note that it is a heptode (6 elements). Base connections given under 8A-1-0. You find diagram 8A and note that this tube uses a grid cap and an octal socket. The figure -1 tell you that the external shield (metal envelope) is connected to lug #1 of the socket. The next figure -0 tells you that internal shielding is not used with an outside terminal.

The filament current and voltage for each type are given in next listing. Here alsois stated whether the emitter is of the cathode or filament type. The capacitances stated in the next column are average between grid-plate, input, and output. In the column marked "Use" the usual application of each type of tube is given. The average operating conditions given in other columns will permit you to check operating conditions in sets or even to design actual circuits.

In checking a stage of a radio using any one particular tube, you can refer to these characteristics. The corresponding values of voltage and current should be found within wide limits. For example, 6BA6 is used as an I.F. tube in an A.C. set with about 250 volt plate supply. Plate and screen grid current should be within ten or twenty percent of stated values. Such information can be used to find faults.

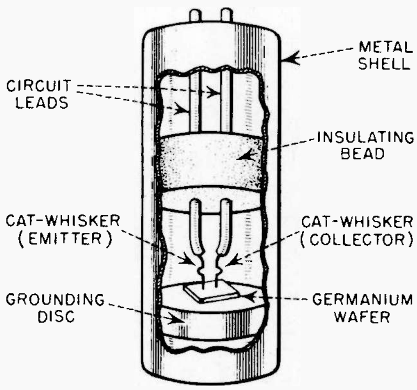
For practice, look up the information for all tubes in a few radio sets. See if the tubes are used for purposes recommended and if correct bases are used. If you have a multimeter use it to measure voltage and current of each type and compare to data given in chart.

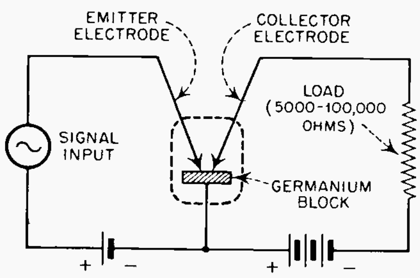
On page 96 you will find technical information on crystal diodes. These units work in the manner of old style crystal detectors, passing current only in one direction. Crystal diodes are used in some radios, but find their greatest application in television circuits. Do not bring your soldering iron too close to these units. If you must unsolder a lead from a crystal diode, do so quickly with a small iron.

Crystal diodes have a life much longer than vacuum tubes. To test, remove one lead from circuit. Measure resistance with ohmmeter both directions (reverse leads). The reading one way should be one hundred or so times as great as the other. For 1N34 diode, your reading may be 1,000 and 200,000 ohms.

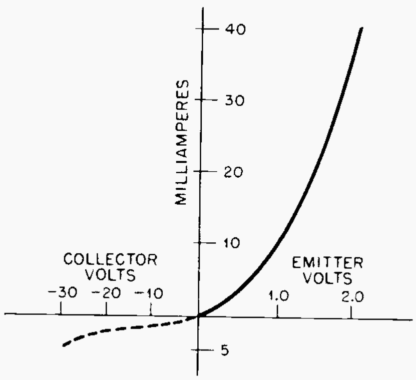
The basic type A transistor consists of a conventional crystal diode modified with an additional (second) cat-whisker contact. The two contacts are spaced close together at the point of contact with the semiconductor. Please examine the illustration of an early type A transistor, as shown below. The small metal tube is about 3/16 inch in diameter and 3/4 inch long; about the size of a half-watt resistor. The illustrations and much of the material on transistors in this lesson are reproduced courtesy of the Aerovox Research Worker published by Aerovox Corporation.

The basic electrical circuit of a simple transistor is shown below. The input electrode called "emitter is maintained at a small positive potential with respect to the germanium block. The impedance in this direction is small and the small positive "bias" voltage under a volt causes an appreciable "forward" current to flow in the emitter circuit. Also, because of this low impedance to forward currents, a small increment in emitter voltage caused by a change in the impressed signal will result in a large increase in electron current flowing from the semiconductor to the cat-whisker. The static voltage-current characteristic of the emitter circuit, when considered alone, is similar to that of the typical germanium point-contact rectifier, and this is shown below at right.





BASIC TRANSISTOR CIRCUIT

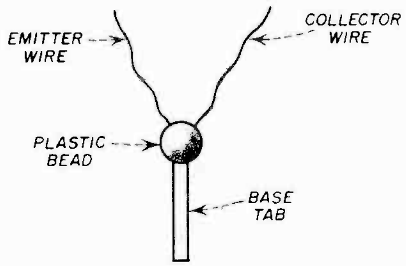


On the other hand, the "collector" or output contact of a transistor is biased negatively with respect to the germanium. At this polarity the impedance to current flow is relatively high (exceeding 10,000 ohms), so that 30 volts may be applied to the collector before appreciable "back" current flows in the semiconductor. The dotted line in the graph above represents the static characteristic of the collector circuit in the absence of the emitter.

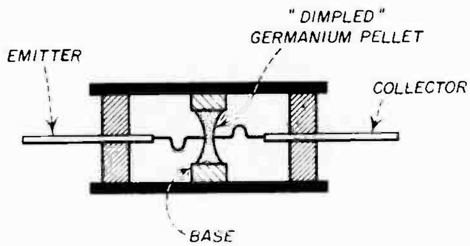
The close proximity of the two cat-whiskers with their respective operating voltages modifies these characteristics considerably. It is the ability of the transistor to transfer an emitter voltage change to the collector circuit in the form of a resistance change that gives this device its name and comes from the words: transfer resistor. This property results in effective power gain of 100 times being possible.

Current in a semiconductor is carried in one of two possible ways. Semiconductors that have free electrons are of the n-type, while those that lack the normal amount of electrons (possess positive holes) are of the p-type. Usually the type of impurity added determines the conducting qualities.

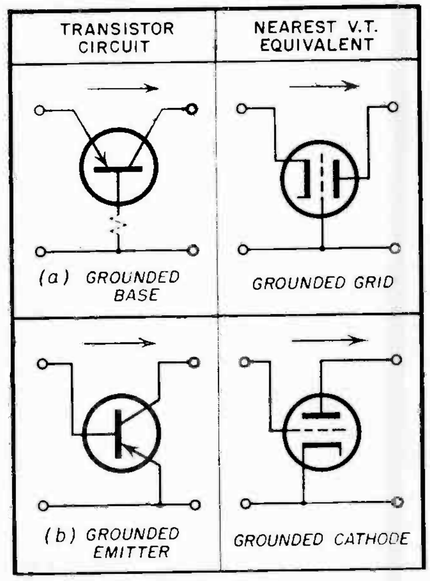
Similar to the point contact type A transistor is the bead type which is essentially a miniaturized version of this type. Another form is the coaxial configuration. Here the two cat whiskers make contact with opposite sides of the semiconducting germanium made only .004 inch thick by concave grinding on both sides. See figures below.



Bead Transistor



Coaxial Transistor

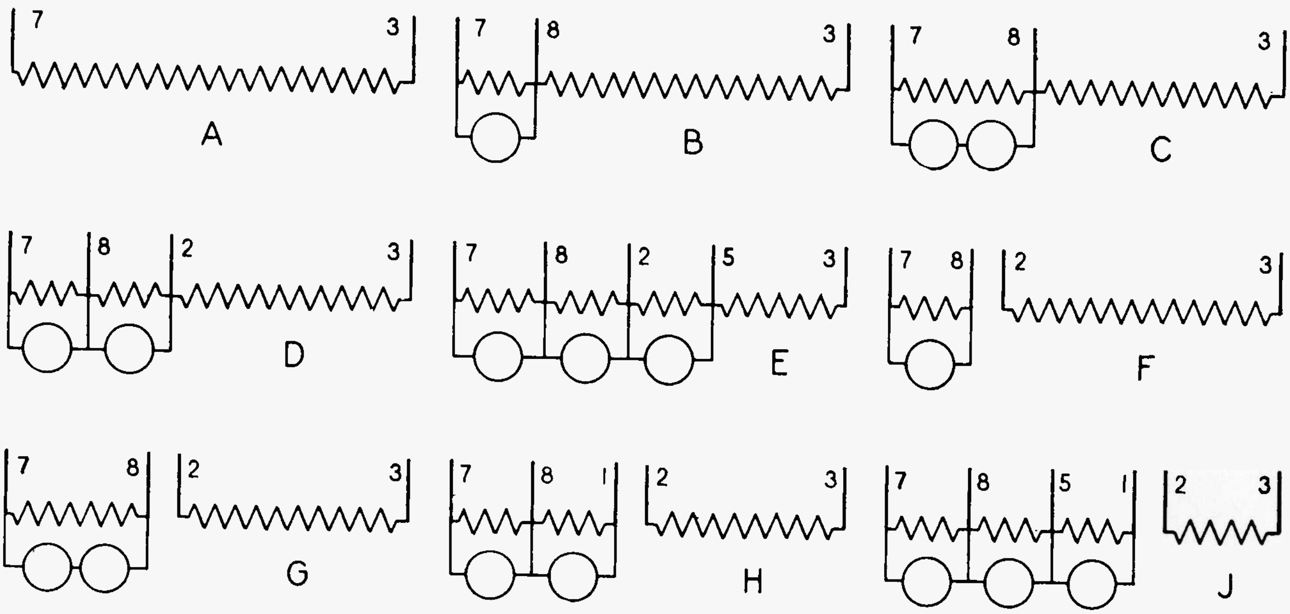


By employing tubes that draw the same value of current (but not necessarily of the same filament voltage), it is possible to wire such tubes in series. This is a practice in AC-DC sets and eliminates the need for a power transformer. If the voltage rating of the tubes wired in series do not add up to 110 volts (line voltage), a resistor of some sort must be wired in series to produce this additional voltage drop.

Usually resistor tubes or line cords are used to produce additional voltage drop in AC-DC sets. The four or five tubes used required, as for example, 69 volts, and the remaining 46 volts of the 115 volt supply was lost in the ballast tube. At times several such tubes were used in series. In modern sets, using 12 or 14 volt series tubes requiring .15 amperes and designed to operate at fairly high voltages, all the available line voltage is used up in the tube filaments.

The serviceman does need to replace resistor tubes in older sets. Sometimes non-standard ballast tubes are used, and the actual wiring has to be altered. In almost every case the resistor in the tube is tapped for use with a pilot light of smaller current drain.

WIRE-WOUND TUBE TYPE RESISTORS



In the standard series, the first letter K means that a 6 to 8 volts, 150 ma. pilot bulb is to be used. L means a 250 ma. bulb. The number following means the voltage drop in the resistor of the tube. The last letter designates the base wiring as illustrated above. Of course, at all times a plain wire-wound resistor of proper power rating can be substituted.

REVIEW QUESTIONS

1. In the consideration of plate current and plate voltage of a vacuum tube, what is the saturation point?

2. Can any element in a tube, having a negative potential in respect to the cathode, attract electrons?

3. How does the screen grid of a tetrode reduce the capacity between the control grid and plate?

4. What is the meaning of amplification factor?

5. In radio receiving circuits, why must the control grid be biased negatively?

6. How does secondary emission take place?

7. What advantages do beam power tubes have?

8. Examining the chart, state the average amplification of triodes? Pentodes?

9. What is the advantage of metal type tubes?

SYLVANIA RADIO AND TELEVISION TUBE CHARACTERISTICS CHART

HOW TO USE THIS CHART

The types are listed in numerical and alphabetical order. The second column now lists the Bulb size or style of construction, whichever is most helpful in describing the type. Lock-in is, 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. Subminiature types are marked T3, T2 or T1 depending on the bulb diameter.

Columns are included 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 SYLVANIA Technical Manual.

The "Basing Diagram" column indicates the internal and external shield connections. For example, this column now shows the basing for Type 7A7 to be 8V-L-5. This means that the active elements are connected as shown in the base diagram 8V, and that the external shielding (in this case the Lock-in base) is connected to the lug (L) and the internal shield to pin 5. This avoids having a separate base diagram for types with a minor difference in shielding. The figures 0-0 indicate no external and no internal shielding respectively.

When replacing tubes in series string television receivers, attention should be given to the complete type number including the suffix. Prototypes should not be substituted for series string types.

Heater voltage, heater current and heater-cathode voltage ratings of the new series string tubes may, due to the requirements of such operation, differ widely from those of their prototypes. All the new series string types have controlled heater warm-up time for series string operation. In addition, heater current production tolerances have been tightened on all series string tubes to insure proper steady state voltage distribution. Two examples are shown in the following table.

	Series String Type 5AQ5	Proto-Type 6AQ5	Series String Type 6SN7GTB	Proto-Type 6SN7GTA
Series String Controlled Heater Warm-up Time..................	YES	NO	YES	NO
Heater Voltage..................	4.7	6.3	6.3	6.3
Heater Current (ma).............	600	450	600	600
Tolerance (ma)..................	±25	±40	±25	±50
Heater-Cathode Voltage..........	200	200	200	200

It should be noted that the 5AQ5 and 6AQ5 differ in all characteristics shown except for heater cathode voltage. The 6SN7GTB and 6SN7GTA are identical except for heater current tolerance and controlled series string heater warm-up time. However, substitution of a 6SN7GTA in a series string receiver may, due to the absence of the controlled series string heater warm-up characteristic and wider heater current production tolerance, cause premature failure.

Series string types differ from their prototypes only in those characteristics necessary to insure dependable operation in series string television receivers. All other characteristics and ratings are identical to those of the prototypes.

NOTICE

This chart contains the very latest radio and television tubes in addition to many out-of-date types. It is designed to be of maximum use to servicemen as a quick reference chart.

Please note that all types listed are not 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.

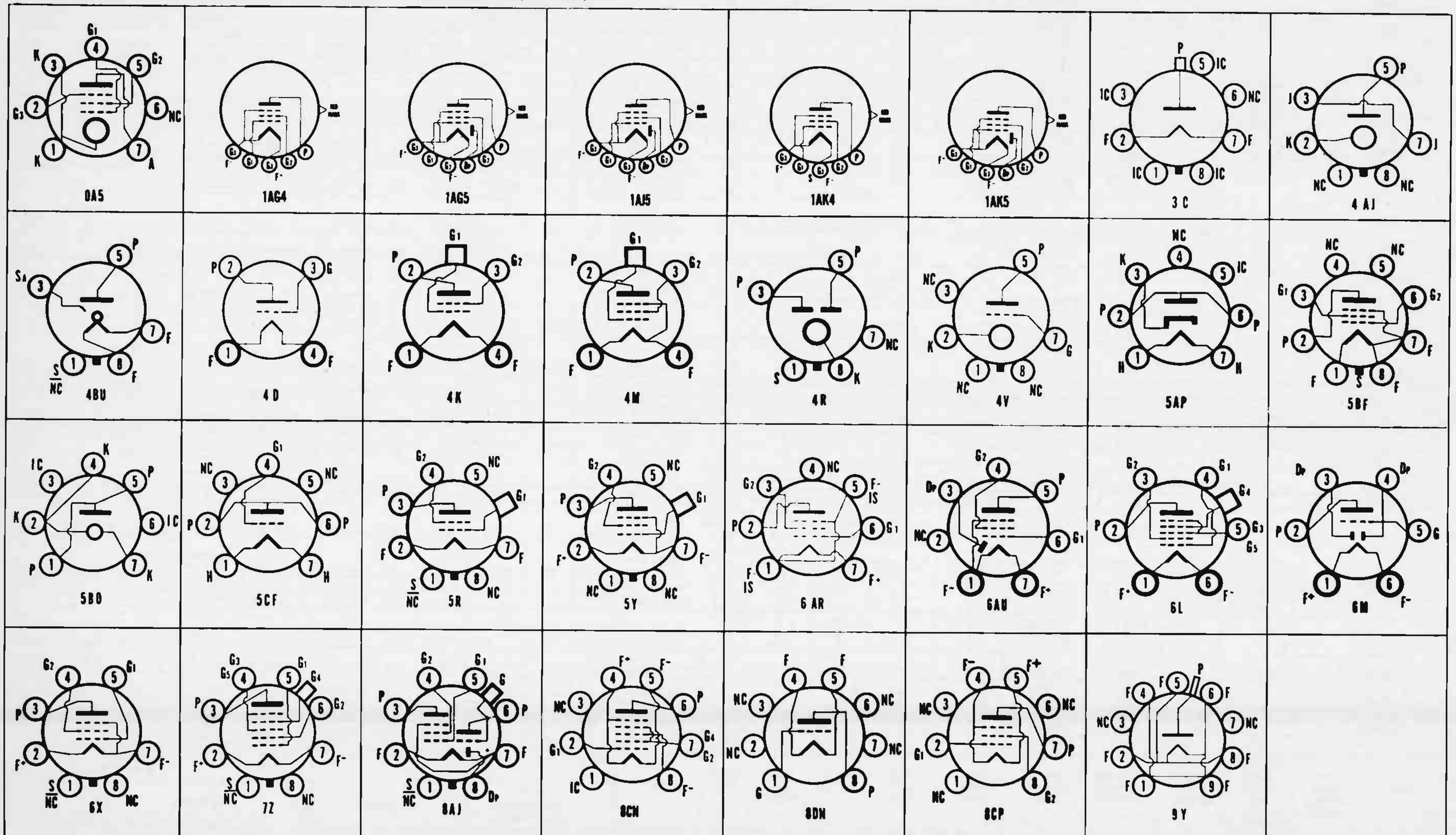
Mention or reference to patented circuits does not constitute permission for their use. The license agreement under which Sylvania tubes are sold is enclosed in the tube carton.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (¹)(²) Capacitances in µµf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Undistorted Power Output Milliwatts	Type
OOA	ST-14	Triode	4D-0-0	Filament	5.0	0.250	8.5	3.2	2.0	Detector	45	0	.....	1.5	....	30,000	666	20	....	....	OOA
OA2	T-5½	Diode	5BO-0-0	Cold K	....	....	....	....	....	Voltage Regulator with starting Voltage at 155, Operating Voltage 150, Operating Current 5 to 30 Ma.											OA2
OA3/VR75	ST-12	Diode	4AJ-0-0	Cold K	....	....	....	....	....	Voltage Regulator with starting Voltage at 100, Operating Voltage 75, Operating Current 5 to 40 Ma.											OA3/VR75
OA4G	ST-12	Gas Triode	4V-0-0	Cold K	....	....	....	....	....	Relay Tube Peak Cathode Ma.=100 D-C Cathode Ma.=25 Max. Starter Anode Drop=60V. Approx. Anode Drop=70V. Approx.											OA4G
OA5	T-5½	Gas Pentode	OA5	Cold K	....	....	....	....	....	Switching	750	Trigger Grid Voltage = +90 Volts. Trigger Pulse Voltage = 85 Volts. Keep Alive Current = 50 µa. Trigger Grid Circuit Resistance = 0.25 Meg.									OA5
OB2	T-5½	Diode	5BO-0-0	Cold K	....	....	....	....	....	Voltage Regulator with starting Voltage at 115, Operating Voltage 105, Operating Current 5 to 30 Ma.											OB2
OB3	ST-12	Diode	4AJ-0-0	Cold K	....	....	....	....	....	Voltage Regulator with starting Voltage at 125, Operating Volts 90, Operating Current 5 Ma. Min. 30 Ma. Max.											OB3
OC2	T-5½	Diode	5BO	Cold K	....	....	....	....	....		Voltage Regulator With Starting Voltage at 105, Operating Voltage 75, Operating Current 5 Ma. Min., 30 Ma. Max.										OC2
OC3	ST-12	Diode	4AJ-0-0	Cold K	....	....	....	....	....	Voltage Regulator with starting Voltage at 135, Operating Volts 105, Operating Current 5 Ma. Min. 40 Ma. Max.											OC3
OD3	ST-12	Diode	4AJ-0-0	Cold K	....	....	....	....	....	Voltage Regulator with starting Voltage at 180, Operating Volts 150, Operating Current 5 Ma. Min. 40 Ma. Max.											OD3
OY4 OY4G	Metal T-7	Gas Diode	4BU-1-0 4BU-0-0	Cathode	Ionic	....	....	....	....	H-W Rect.	117 A.C. Volts Per Plate, RMS, 75 Ma. Max., 40 Ma. Min. Output Current. Starter Anode Connects to Anode thru 10 Megohms By-Passed with .002µµf.										OY4 OY4G
OZ4	Metal	Gas Duodi.	4R-1-0	Cathode	Ionic	....	....	....	....	F-W Rect.	300 A.C. Volts Per Plate, RMS, 90 Ma. Max. 30 Ma. Min. Output Current.										OZ4
OZ4A	Metal	Gas Duodi.	4R-1-0	Cathode	Ionic	....	....	....	....	F-W Rect.	300 A.C. Volts Per Plate, RMS, 110 Ma. Max., 30 Ma. Min. Output Current										OZ4A
OZ4G	T-7	Gas Duodi.	4R-0-0	Cathode	Ionic	....	....	....	....	F-W Rect.	300 A.C. Volts Per Plate, RMS, 90 Ma. Max. 30 Ma. Min. Output Current.										OZ4G
O1A	ST-14	Triode	4D-0-0	Filament	5.0	0.250	8.1	3.1	2.2	Amplifier	90 135	4.5 9.0	....	2.5 3.0	....	11,000 10,000	725 800	8.0 8.0	....	....	O1A
1A3	T-5½	Diode	5AP-0-5	Cathode	1.4	0.150	....	....	....	Detector	Half Wave Cathode Type Rectifier for H. F. Use										1A3
1A4P	ST-12	Pentode	4M-0-4	Filament	2.0	0.060	.007m	5.0	11.0	R-F Amp.	135 180	3.0 3.0	67.5 67.5	2.2 2.3	0.9 0.8	1 Meg. 1 Meg.	625 725	....	....	....	1A4P
1A4T	ST-12	Tetrode	4K-0-3	Filament	2.0	0.060	.01m	5.0	11.0	R-F Amp.	135 180	3.0 3.0	67.5 67.5	2.2 2.2	0.7 0.7	350,000 600,000	625 650	....	....	....	1A4T
1A5GT	T-9	Power Pent.	6X-0-0	Filament	1.4	0.050	....	....	....	Power Amp.	85 90	4.5 4.5	85 90	3.5 4.0	0.7 0.8	300,000 300,000	800 850	....	25,000 25,000	100 115	1A5GT
1A6	ST-12	Heptode	6L-0-0	Filament	2.0	0.060	0.25	10.5	9.0	Converter	135 180	3.0 3.0	67.5 67.5	1.8 1.5	2.1 2.0	400,000 500,000	275▲ 300▲	(Ga = 135V.☐ Max. 2.0 Ma.) (Ga = 180V.☐ Max. 2.5 Ma.)			1A6
1A7GT	T-9	Heptode	7Z-1-0	Filament	1.4	0.050	0.5m	7.0	10.0	Converter	90	0.0	90	0.6	1.2	600,000	250▲	(Ga = 90V. Max. 1.2 Ma.)			1A7GT
1AB5	Lock-In	Pentode	5BF-L-0	Filament	1.2	0.130	0.25m	2.8	4.2	R-F Amp.	90 150	0 1.5	90 150	3.5 6.8	0.8 2.0	275,000 120,000	1,100 1,350	.....	....	....	1AB5
1AC5	T-3	Pentode	8CP-0-0	Filament	1.25	0.040	....	....	....	Power Amp.	30 45 67.5	2.0 3.0 4.5	30 45 67.5	0.5 1.0 2.0	0.1 0.2 0.4	200,000 170,000 150,000	450 600 750	....	50,000 40,000 25,000	5 15 50	1AC5
1AD5	T-3	Pentode	8CP-0-0	Filament	1.25	0.040	.009	1.9	3.0	R-F Amp.	30 45 67.5	0 0 0	30 45 67.5	0.45 0.9 1.85	0.16 0.35 0.75	700,000 700,000 700,000	430 580 735	....	....	....	1AD5
1AE4	T-5½	Pentode	6AR-0-0	Filament	1.25	0.100	.008m	3.6	4.4	R-F Amp.	90	0	90	3.5	1.2	500,000	1,550	.....	....	....	1AE4
1AF4	T-5½	Pentode	6AR-0-1&5	Filament	1.4	0.025	.008m	3.8	7.6	R-F Amp.	67.5 90	0 0	67.5 90	1.2 1.8	0.32 0.55	2.2 Meg. 1.8 Meg.	925 1,050	....	....	....	1AF4
1AF5	T-5½	Diode Pent.	6AU-0-0	Filament	1.4	0.025	0.2	2.5	4.3	Det. Amp.	67.5 90	0 0	67.5 90	0.7 1.1	0.25 0.4	2.8 Meg. 2.0 Meg.	550 600	....	....	....	1AF5
1AG4	T-2X3	Pentode	1AG4-0-0	Filament	1.25	0.040	....	....	....	Power Amp.	41.4	3.6	41.4	2.4	0.6	180,000	1,000	.....	12,000	35	1AG4
1AG5	T-2X3	Diode Pent.	1AG5	Filament	1.25	0.030	0.1	1.7	2.4	Amplifier	45	2.0	45	0.28	0.12	2.5 Meg.	250	.....	....	....	1AG5
1AJ5	T-2X3	Diode Pent.	1AJ5-4-0	Filament	1.25	0.040	0.1	1.7	2.4	Det. Amp.	45	0	45	1.0	0.3	300,000	425	.....	....	....	1AJ5
1AK4	T-2X3	Pentode	1AK4-3-0	Filament	1.25	0.020	.01m	3.5	4.5	Class A1 Amp.	45 67.5	0 0	45	0.75 0.75	0.2 0.2	1,500,000 2,000,000	750 750	(Screen Supply = 67.5 Volts Thru .11 Meg. Res.)			1AK4
1AK5	T-2X3	Diode Pent.	1AK5-4-0	Filament	1.25	0.020	0.1m	2.0	2.7	Det. Amp.	45	0	45	0.5	0.2	400,000	280	.....	....	....	1AK5
1AX2	T-6½	Diode	9Y	Filament	1.4	0.650	....	....	....	Flyback H-W Rect.	Maximum Peak Inverse Plate Voltage = 25,000 Volts. Maximum Peak Plate Current = 45 Ma. Maximum Average Current = 0.5 Ma.										1AX2
1B3GT	T-9	Diode	3C	Filament	1.25	0.200	....	....	1.3*	Flyback H-W Rect.	Maximum Peak Inverse Plate Voltage = 26,000 Volts. Maximum Peak Plate Current = 50 Ma. Maximum Average Plate Current = 0.5 Ma.										1B3GT
1B4P	ST-12	Pentode	4M-0-4	Filament	2.0	0.060	.007m	5.0*	11.0*	R-F Amp.	135 180	3.0 3.0	67.5 67.5	1.6 1.7	0.7 0.6	1.5 Meg.♦ 1.5 Meg.♦	560 650	....	....	....	1B4P
1B5	ST-12	Duodiode Tri.	6M-0-5	Filament	2.0	0.060	3.6	1.6	1.9	Det. Amp.	135	3.0	.....	0.8	....	35,000	575	20	....	....	1B5
1B7GT	T-9	Heptode	7Z-1-0	Filament	1.4	0.100	0.34	7.0	7.5	Converter	90	0.0	45	1.5	1.3	350,000	350▲	(Ga = 90V., 1.6 Ma.)			1B7GT
1B8GT	T-9	Diode Triode Pentode	8AJ-0-7	Filament	1.4	0.100	....	....	....	Det. Amp. Power Amp.	90 90	0 6.0	 90	0.15 6.3	.... 1.4	240,000	275 1,150	....	 14,000	 210	1B8GT
1C3	T-5½	Triode	5CF-0-0	Filament	1.4	0.050	1.8	0.9	4.2	Amplifier	90 90	0 3.0	....	4.5 1.4	....	11,200♦ 19,000♦	1,300 760	14.5 14.5	....	....	1C3
1C5GT	T-9	Power Pent.	6X-0-0	Filament	1.4	0.100	....	....	....	Power Amp.	83 90	7.0 7.5	83 90	7.0 7.5	1.6 1.6	110,000 115,000	1,500 1,550	165 180	9,000 8,000	200 240	1C5GT
1C6	ST-12	Heptode	6L-0-0	Filament	2.0	0.120	0.3	10.0	10.0	Converter	135 180	3.0 3.0	67.5 67.5	1.3 1.5	2.5 2.0	600,000 700,000	300▲ 325▲	(Ga = 135V.☐ Max. 3.1 Ma.) (Ga = 180V.☐ Max. 4.0 Ma.)			1C6
1C7G	ST-12	Heptode	7Z-0-0	Filament	2.0	0.120	0.26	10.0	14.0	Converter	135 180	3.0 3.0	67.5 67.5	1.3 1.5	2.5 2.0	600,000 700,000	300▲ 325▲	(Ga = 135V.☐ Max. 3.1 Ma.) (Ga = 180V.☐ Max. 4.0 Ma.)			1C7G
1C8	T-3	Heptode	8CN-0-0	Filament	1.25	0.040	0.25m	6.5	4.0	Converter	30	0.0	30	0.32	0.75	300,000	100▲	.....	....	....	1C8
1D3	T-3	Triode	8DN-0-0	Filament	1.25	0.300	2.6*	1.0*	1.0*	Amplifier	90	5.0	.....	12.5	....	......	3,400	8.7	....	....	1D3

1D5GP	ST-12	Pentode	5Y-0-7	Filament	2.0	0.060	.007m	5.0*	12.0*	R-F Amp.	135 180	3.0 3.0	67.5 67.5	2.2 2.3	0.9 0.8	1 Meg. 1 Meg.	625 725	....	....	....	1D5GP
1D5GT	ST-12	Tetrode	5R-0-4	Filament	2.0	0.060	.01m	4.4	10.8	R-F Amp.	135 180	3.0 3.0	67.5 67.5	2.2 2.2	0.7 0.7	350,000 600,000	625 650	....	....	....	1D5GT
1D7G	ST-12	Heptode	7Z-0-0	Filament	2.0	0.060	0.25	10.5	9.0	Converter	135 180	3.0 3.0	67.5 67.5	1.8 1.5	2.1 2.0	400,000 500,000	275▲ 300▲	(Ga = 135V.□ Max. 2.0 Ma.) (Ga = 180V.□ Max. 2.5 Ma.)			1D7G
1D8GT	T-9	Diode Triode Pentode	8AJ-0-2	Filament	1.4	0.100	....	....	....	Det. Amp. Power Amp.	45 67.5 90 45 67.5 90	0 0 0 4.5 6.0 9.0	.... 45 67.5 90	0.3 0.6 1.1 1.6 3.8 5.0	.... 0.3 0.8 1.0	77,000 55,500 43,500 300,000♦ 200,000♦ 200,000♦	325 450 575 650 875 925	25 25 25	.... 20,000 16,000 12,000	.... 35 100 200	1D8GT

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate; RF Input, Mixer Output.
I Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
* Cathode Resistor (ohms).



SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection. DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (1) (2) Capacitances in μμf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Power Output Milliwatts	Type
1DN5	T-5½	Diode Pent.	6BW	Filament	1.4	0.050	....	....	....	Det. Amp.	67.5	0	67.5	2.1	0.55	.6 Meg. ♦	630	....	....	....	1DN5
1E4G	T-9	Triode	5S-0-0	Filament	1.4	0.050	2.4	2.4	6.0	Amplifier	90 90	0.0 3.0	....	4.5 1.5	....	11,000 17,000	1,325 825	14.5 14	....	....	1E4G
1E5GP	ST-12	Pentode	5Y-0-7	Filament	2.0	0.060	.007m	5.5	12.0	R-F Amp.	135 180	3.0 3.0	67.5 67.5	1.6 1.7	0.7 0.6	1.5 Meg. ♦ 1.5 Meg. ♦	560 650	....	....	....	1E5GP
1E7GT	T-9	Duo. Power Pent.	8C-0-0	Filament	2.0	0.240	....	....	....	P.P.A1 Amp.	135	7.5	135	7.0	2.0	220,000	1,600	350	24,000¶	575	1E7GT
1E8	T-3	Heptode	8CN-0-0	Filament	1.25	0.040	0.4	6.0	5.0	Converter	30 45 67.5	0 0 0	30 45 67.5	0.30 0.60 1.0	0.8 1.1 1.5	300,000 400,000 400,000	115▲ 140▲ 150▲	....	....	....	1E8
1F4	ST-12	Power Pent.	5K-0-0	Filament	2.0	0.120	....	....	....	Power Amp.	135	4.5	135	8.0	2.4	200,000	1,700	.....	16,000	310	1F4
1F5G	ST-12	Power Pent.	6X-0-0	Filament	2.0	0.120	....	....	....	Power Amp.	135	4.5	135	8.0	2.4	200,000	1,700	.....	16,000	310	1F5G
1F6	ST-12	Duodiode Pentode	6W-0-6	Filament	2.0	0.060	.007m	4.0	9.0	R-F or I-F A-F Amp.	180	1.5	67.5	2.2	0.7	1 Meg.	650	....	....	....	1F6
											EB = 135 V. thru 0.25 Meg. Res., EC2 = 135 V. thru 0.8 Meg. Res., EC1 = 2.0 V, RG1 = 1 Meg. (Voltage Gain = 46).										
1F7G	ST-12	Duodiode Pentode	7AD-0-7	Filament	2.0	0.060	.01m	3.8*	9.5*	R-F or I-F A-F Amp.	180	1.5	67.5	2.2	0.7	1 Meg.	650	....	....	....	1F7G
											EB = 135 V. thru 0.25 Meg. Res., EC2 = 135 thru 0.8 Meg. Res., EC1 = 2.0 V., RG1 = 1 Meg. (Voltage Gain = 46).										
1F7GV	ST-12	Duodi. Pent.	7AF-0-7	Filament	2.0	0.600	....	....	....	Same as 1F7G Except Diodes One Above the Other on Negative Filament.											1F7GV
1G3	T-9	Diode	3C	Filament	1.25	0.200	....	....	....	Flyback H-W Rect.	Maximum Peak Inverse Plate Voltage = 26,000 Volts. Maximum Peak Plate Current = 50 Ma. Maximum Average Plate Current = 0.5 Ma.										1G3
1G4GT	T-9	Triode	5S-0-0	Filament	1.4	0.050	....	....	....	Amplifier	90	6.0	.....	2.3	....	10,700	825	8.8	....	....	1G4GT
1G5G	ST-14	Pentode	6X-0-0	Filament	2.0	0.120	....	....	....	Power Amp.	90	6.0	90	8.5	2.5	133,000 ♦	1,500	....	8,500	250	1G5G
1G6GT	T-9	Duotriode	7AB-0-0	Filament	1.4	0.100	....	....	....	S.T.A1 Amp. P.P. Class B	90 90	0.0 0.0	....	1.0‡ 2-14†	....	40,000	825	33	(Each Triode Class A) 12,000¶	 675	1G6GT
1H2	T-6½	Diode	9DT	Cathode	1.4	0.550	....	....	....	Flyback H-W Rect.	Maximum Peak Inverse Plate Voltage = 24,000 Volts. Maximum Peak Plate Current = 50 Ma. Maximum Average Plate Current = 0.5 Ma.										1H2
1H4GT	T-9	Triode	5S-0-0	Filament	2.0	0.060	....	....	....	Det. Amp.	90 135 180	4.5 9.0 13.5	....	2.5 3.0 3.1	....	11,000 10,300 10,300	850 900 900	9.3 9.3 9.3	....	....	1H4GT
1H5GT	T-9	Diode Triode	5Z-1-7	Filament	1.4	0.050	1.1	0.35	4.0	Det. Amp.	90	0.0	.....	0.15	....	240,000	275	65	....	....	1H5GT
1H6GT	T-9	Duodiode Tri.	7AA-0-6	Filament	2.0	0.060	3.6	1.6	1.9	Det. Amp.	135	3.0	.....	0.8	....	35,000	575	20	....	....	1H6GT
1J3	T-9	Diode	3C	Filament	1.25	0.200	....	....	1.6*	Flyback H-W Rect.	Maximum Peak Inverse Volts = 26,000 Volts. Maximum Peak Plate Current = 50 Ma. Maximum Average Plate Current = 0.5 Ma.										1J3
1J5G	ST-14	Pentode	6X-0-0	Filament	2.0	0.120	....	....	....	Power Amp.	135	16.5	135	7.0	2.0	125,000	1,000	125	13,500	575	1J5G
1J6G 1J6GT	ST-12 T-9	Duotriode	7AB-0-0	Filament	2.0	0.240	....	....	....	Power Amp.	Characteristics Same as Type 19.										1J6G 1J6GT
1K3	T-9	Diode	3C	Filament	1.25	0.200	....	....	....	Flyback H-W Rect.	Maximum Peak Inverse Volts = 26,000 Volts. Maximum Peak Plate Current = 50 Ma. Maximum Average Plate Current = 0.5 Ma.										1K3
1L4	T-5½	Pentode	6AR-0-1&5	Filament	1.4	0.050	.008m	3.8	7.5	R-F Amp.	90 90	0 0	67.5 90	2.9 4.5	1.2 2.0	600,000 350,000	925 1,025	....	....	....	1L4
1L6	T-5½	Heptode	7DC-0-0	Filament	1.4	0.050	0.36m	7.5	12.0	Converter	90	0	45	0.5	0.6	650,000 ♦	300▲	(Ga = 90 V., 1.2 Ma.)			1L6
1LA4	Lock-in	Power Pent.	5AD-L-0	Filament	1.4	0.050	....	....	....	Power Amp.	85 90	4.5 4.5	85 90	3.5 4.0	0.7 0.8	300,000 300,000	800 850	....	25,000 25,000	100 115	1LA4
1LA6	Lock-in	Heptode	7AK-L-0	Filament	1.4	0.050	0.4	7.5	8.0	Converter	90	0.0	45	0.55	0.6	750,000	250▲	(Ga = 90 V. Max., 1.2 Ma.)			1LA6
1LB4	Lock-in	Power Pent.	5AD-L-0	Filament	1.4	0.050	....	....	....	Power Amp.	45 67.5 90	4.5 6.0 9.0	45 67.5 90	1.6 3.8 5.0	0.3 0.8 1.0	400,000 300,000 250,000	650 875 925	....	20,000 16,000 12,000	35 100 200	1LB4
1LB6	Lock-in	Heptode	8AX-L-0	Filament	1.4	0.050	0.1	3.8	8.0	Converter	90	0.0	67.5	0.40	2.2	2 Meg. ♦	100▲	.....	....	....	1LB6
1LC5	Lock-in	Pentode	7AO-L-8	Filament	1.4	0.050	.007m	3.2	7.0	R-F Amp.	45 90	0.0 0.0	45 45	1.1 1.15	0.35 0.30	700,000 1.5 Meg.	750 775	....	....	....	1LC5
1LC6	Lock-in	Heptode	7AK-L-0	Filament	1.4	0.050	0.28	9.0	5.5	Converter	45 90	0.0 0.0	35 35	0.7 0.75	0.75 0.7	300,000 650,000	250▲ 275▲	(Ga = 45 V. Max., 1.4 Ma.) (Ga = 45 V. Max., 1.4 Ma.)			1LC6
1LD5	Lock-in	Diode Pent.	6AX-L-8	Filament	1.4	0.050	0.18	3.2	6.0	Amplifier	45 90	0.0 0.0	45 45	0.55 0.6	0.12 0.1	750,000 750,000	550 575	....	....	....	1LD5
1LE3	Lock-in	Triode	4AA-L-0	Filament	1.4	0.050	1.7	1.7	3.0	Amplifier	90 90	0.0 3.0	....	4.5 1.4	....	11,200 19,000	1,300 760	14.5 14.5	....	....	1LE3
1LG5	Lock-in	Pentode	7AO-L-8	Filament	1.4	0.050	.007m	3.2	7.0	R-F Amp.	45 90 90	0 0 1.5	45 45 90	1.5 1.7 3.7	0.45 0.4 0.9	350,000 ♦ 1,000,000 ♦ 500,000 ♦	800 800 1,050	....	....	....	1LG5
1LH4	Lock-in	Diode Triode	5AG-L-1	Filament	1.4	0.050	....	....	....	Det. Amp.	90	0.0	.....	0.15	....	240,000	275	65	....	....	1LH4
1LN5	Lock-in	Pentode	7AO-L-8	Filament	1.4	0.050	.007m	3.4	8.0	R-F Amp.	90	0.0	90	1.6	0.35	1.1 Meg.	800	.....	....	....	1LN5
1N5GT	T-9	Pentode	5Y-1-7	Filament	1.4	0.050	.007m	2.8	10.0	R-F Amp.	90	0.0	90	1.2	0.3	1.5 Meg. ♦	750	.....	....	....	1N5GT
1N6GT	T-9	Diode Pent.	7AM-0-0	Filament	1.4	0.050	....	....	....	Det. Amp.	90	4.5	90	3.4	0.7	300,000 ♦	800	.....	25,000	100	1N6GT
1P5GT	T-9	Pentode	5Y-1-7	Filament	1.4	0.050	.007m	3.0	10.0	R-F Amp	90	0.0	90	2.3	0.7	800,000	750	.....	....	....	1P5GT
1Q5GT	T-9	Beam Pent.	6AF-0-0	Filament	1.4	0.100	....	....	....	Power Amp.	90	4.5	90	9.5	1.3	......	2,200	.....	8,000	270	1Q5GT
1Q6	T-3	Diode Pent.	8CO-0-0	Filament	1.25	0.040	.085	1.8	4.2	Det. Amp.	30 67.5	0.0 0.0	30 67.5	0.33 1.60	0.09 0.40	500,000 400,000	330 600	....	....	....	1Q6

1R4	Lock-in	H. F. Diode	4AH-L-2	Cathode	1.4	0.150	....	....	....	Detector	Half Wave Cathode Type Rectifier for High Frequency Use.										1R4
1R5	T-5½	Heptode	7AT-0-0	Filament	1.4	0.050	0.4m	7.0	12.0	Converter	45 90	0.0 0.0	45 67.5	0.7 1.5	2.1 3.5	500,000♦ 400,000♦	210▲ 280▲	....	....	....	1R5
1S4	T-5½	Power Pent.	7AV-0-0	Filament	1.4	0.100	....	....	....	Power Amp.	45 90	4.5 7.0	45 67.5	3.8# 7.4#	0.8# 1.4#	100,000♦ 100,000♦	1,250 1,575	....	8,000 8,000	65 270	1S4
1S5	T-5½	Diode Pent.	6AU-0-0	Filament	1.4	0.050	0.2	2.0	4.0	Det. Amp.	67.5	0.0	67.5	1.6	0.4	600,000	625	....	....	....	1S5
1S6	T-3	Diode Pent.	8DA-0-0	Filament	1.25	0.040	....	....	....	Det. Amp.	30 45 67.5	0 0 0	30 45 67.5	0.32 0.75 1.6	0.1 0.21 0.4	500,000 500,000 400,000	330 475 600	....	....	....	1S6

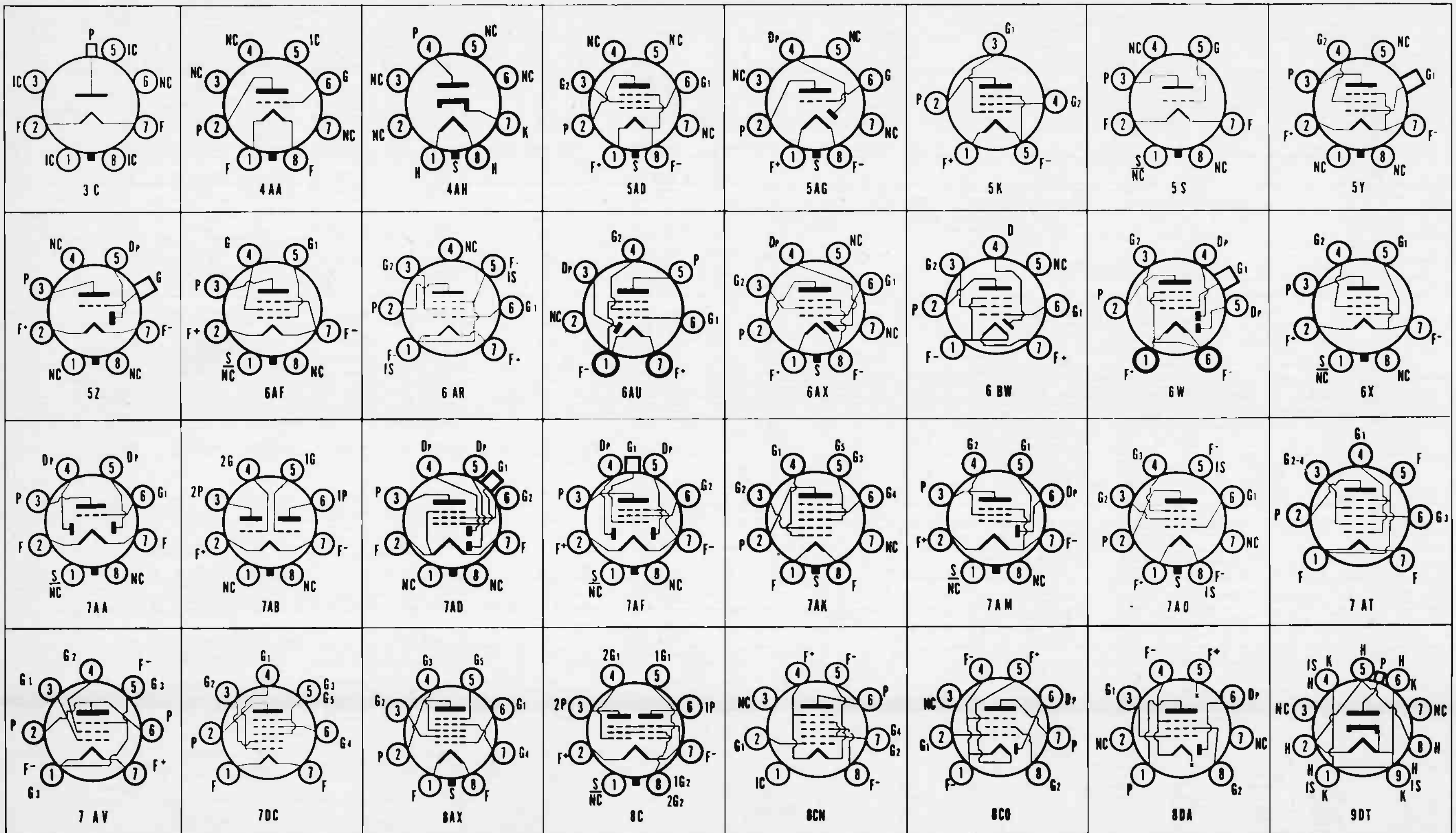
(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate; RF Input, Mixer Output.
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
I Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)

* Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.

□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.

¶ Plate to Plate.
♦ Approximate.

m maximum.
■ Cathode Resistor (ohms).

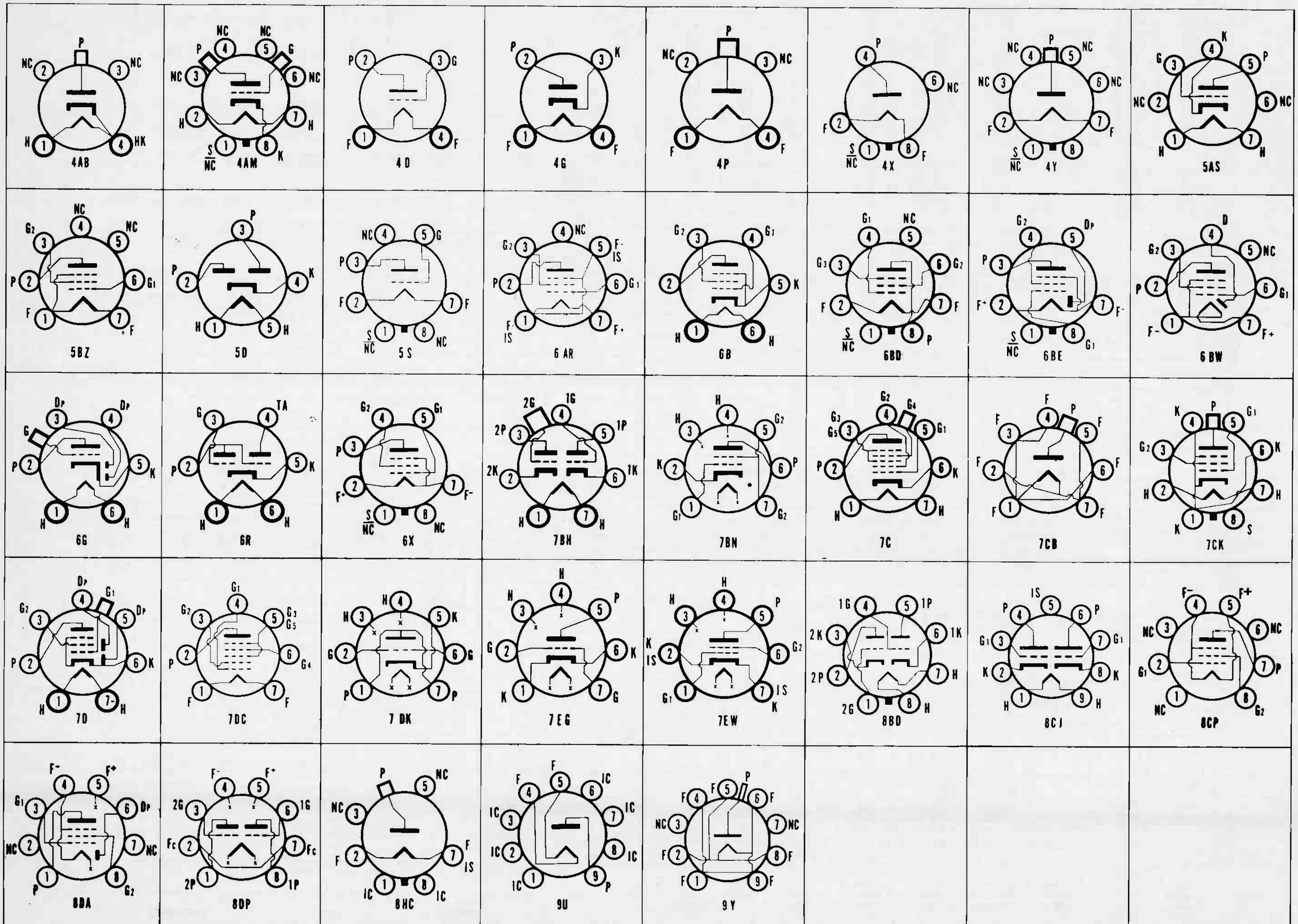


SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection. DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction			Emitter			Note (1) (2) Capacitances in μμf.			Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Undistorted Power Output Milliwatts	Type
	Bulb Size or Style	Class	Basing Diag.	Type	Volts	Amps.	Cgp.	Cin.	Cout												
1SA6GT	T-9	Pentode	6BD-0-0	Filament	1.4	0.050	.01m	5.2	8.6	R-F Amp.	45 67.5 90	0 0 0	45 67.5 67.5	1.1 2.4 2.45	0.3 0.7 0.68	700,000 600,000 800,000	750 950 970	....	....	....	1SA6GT
1SB6GT	T-9	Diode Pent.	6BE-0-0	Filament	1.4	0.050	0.25	3.2	3.0	Det. Amp.	90 45	0 0	67.5 45	1.45 0.6	0.38 0.16	700,000 900,000	665 500	....	....	....	1SB6GT
1T4	T-5½	Pentode	6AR-0-1&5	Filament	1.4	0.050	.008m	3.8	7.5	R-F Amp.	45 90	0.0 0.0	45 67.5	1.7 3.5	0.7 1.4	350,000 500,000	700 900	....	....	....	1T4
1T5GT	T-9	Power Pent.	6X-0-0	Filament	1.4	0.050	0.5	4.8	8.0	Power Amp.	90	6.0	90	6.5	1.4	......	1,150	.....	14,000	170	1T5GT
1T6	T-3	Diode Pent.	8DA-0-0	Filament	1.25	0.040	....	....	....	Det. Amp.	30 45 67.5	0 0 0	30 45 67.5	0.33 0.75 1.6	0.1 0.21 0.4	500,000 500,000 400,000	330 475 600	....	....	....	1T6
1U4	T-5½	Pentode	6AR-0-1&5	Filament	1.4	0.050	.008m	3.6	7.5	R-F Amp.	90	0	90	1.6	0.45	1.6 Meg. ♦	900	.....	....	....	1U4
1U5	T-5½	Diode Pent.	6BW-0-0	Filament	1.4	0.050	0.2	2.2	2.4	Det. Amp.	Characteristics Same as Type 1S5.										1U5
1U6	T-5½	Heptode	7DC-0-0	Filament	1.4	0.025	0.4	8.0	12.0	Converter	67.5 90	0 0	45 45	0.5 0.6	0.7 0.6	500,000 500,000	260▲ 275▲	(Gs = 67.5 V., 1.0 Ma.) (Gs = 90 V., 1.1 Ma.)			1U6
1V	T-9	Diode	4G-0-0	Cathode	6.3	0.300	....	....	....	H-W Rect.	325 A.C. Volts Per Plate, RMS, 45 Ma. Output Current. Condenser input to Filter.										1V
1V2	T-6½	Diode	9U-0-0	Filament	0.625	0.300	....	....	....	H-W Rect.	Television Service. RF or Flyback Supply. Peak Inverse Volts = 8,250. Output = 0.5 Ma.										1V2
1V5	T-3	Pentode	8CP-0-0	Filament	1.25	0.040	....	....	....	Power Amp.	Characteristics Same as Type 1AC5.										1V5
1W4	T-5½	Power Pent.	5BZ-0-0	Filament	1.4	0.050	....	....	....	Power Amp.	45 62.5 67.5 90	4.5 5.0 6.0 9.0	45 62.5 67.5 90	1.6 3.8 3.8 5.0	0.3 0.8 0.8 1.0	400,000 300,000♦ 300,000♦ 250,000♦	650 875 875 925	....	20,000 16,000 16,000 12,000	35 90 100 200	1W4
1W5	T-3	Pentode	8CP-0-0	Filament	1.25	0.040	.01m	2.3	3.5	R-F Amp.	30 67.5	0.0 0.0	30 67.5	0.42 1.85	0.16 0.75	700,000♦ 700,000♦	430 735	....	....	....	1W5
1X2	T-6½	Diode	9Y-0-1 etc.	Filament	1.25	0.200	....	....	....	H-W Rect.	Television Service. RF or Flyback Supply. Peak Inverse Volts = 15 KV, Output = 1 Ma.										1X2
1X2A	T-6½	Diode	9Y-0-1 etc.	Filament	1.25	0.200	....	....	....	H-W Rect.	Television Service. RF or Flyback Supply. Peak Inverse Volts = 17.5 KV, Output = 1 Ma.										1X2A
1X2B	T-6½	Diode	9Y	Filament	1.25	0.200	....	....	....	H-W Rect.	Television Service. RF or Flyback Supply. Peak Inverse Volts = 22 KV, Output = 0.5 Ma.										1X2B
1Y2	ST-12	Diode	4P-0-0	Filament	1.5	0.290	....	....	....	H-W Rect.	15,000 A-C Volts Per Plate, RMS, 2.0 Ma. Output Current.										1Y2
1Z2	T-5½	Diode	7CB-0-0	Filament	1.5	0.300	....	....	....	H-W Rect.	7,800 Volts RMS Plate, 2.0 Ma. D.C. Output Current.										1Z2
2A3	ST-16	Triode	4D-0-0	Filament	2.5	2.500	16.0	7.0	5.0	S.T. A1 Amp. P.P.AB1 Amp.	250 300	45.0 62.0	.....	60.0 80-147†, Push Pull, Fixed Bias	.....	800	5,250	4.2	2,500 3,000¶	3,500 15,000	2A3
2A4G	ST-12	Gas Triode	5S-0-0	Filament	2.5	2.500	....	....	....	Relay Tube	Instantaneous Forward or Inverse Anode Volts = 200 Peak Anode Amps. = 1.25 Average Anode. Current = 0.1 Amp. Max. Averaging Time = 45 Seconds. Cold Starting Time = 2 Seconds.										2A4G
2A5	ST-14	Beam Pent.	6B-0-0	Cathode	2.5	1.750	....	....	....	Power Amp.	Characteristics Same as Type 6F6G.										2A5
2A6	ST-12	Duodiode Tri.	6G-0-0	Cathode	2.5	0.800	1.7	1.7	3.8	Det. Amp.	250	2.0		0.9	....	91,000	1,100	100	....	....	2A6
2A7 2A7S	ST-12	Heptode	7C-0-0 7C-6-0	Cathode	2.5	0.800	0.3m	8.5	9.0	Converter	Characteristics Same as Type 6A7.										2A7 2A7S
2AF4A 2AF4B	T-5½	Triode	7DK	Cathode	2.35I	0.600	1.9	2.2	1.4	UHF Osc.	100	Grid Resistor = 17.5. 10,000 Ohms. Plate Resistor = 220 Ohms. Grid Current = 750 μa. Type 2AF4B Has Higher Heater-Cathode Voltage Ratings Than Otherwise Identical Type 2AF4A.									6AF4
2B3	T-9	Diode	8HC-0-7	Filament	1.75	0.250	....	....	....	H-W Rect.	Television Service. Flyback Supplies. Peak Inverse Volts = 22 KV. Output = 0.5 Ma.										2B3
2B5	T-3	Duotriode	8DP-0-0	Filament	2.4 1.2	0.130 0.260	1.2* 1.2*	0.9* 0.9*	1.9* 2.2*	Amplifier ƒ	90	1.0	.....	2.6	....	18,700	.....	21.5	....	....	2B5
2B7 2B7S	ST-12	Duodi. Pent.	7D-0-6 7D-6-6	Cathode	2.5	0.800	See Type 6B7			Det. Amp.	Characteristics Same as Type 6B7.										2B7 2B7S
2BN4	T-5½	Triode	7EG	Cathode	2.3I	0.600	1.2	3.2	1.4	VHF Amp.	Characteristics Same as Type 6BN4. (2BN4 Designed for Series String TV Receivers.)										2BN4
2C4	T-5½	Gas Triode	5AS-0-0	Cathode	2.5	0.650	....	....	....	Relay Tube	350	50	Peak Cathode Ma. = 20, DC Cathode Ma. = 5, Approx. Drop at 5 Ma. = 16 V.								2C4
2C21	ST-12	Duotriode	7BH-0-0	Cathode	6.3	0.600	2.4 1.6	2.6 1.6	1.4 2.0	Amplifier Power Amp.	250 250	16.5 60.0	....	8.3 20.0	....	7,600	1,375	10.4	20,000	 3,500	2C21
2C22	T-9	Triode	4AM-0-0	Cathode	6.3	0.300	3.6	2.2	0.7	Amplifier	300	10.5	.....	11.0	....	6,600	3,000	20.0	....	....	2C22
2C50	T-9	Duotriode	8BD-0-0	Cathode	12.6	0.300	....	....	....	Amplifier ƒ	200	11	.....	18	....	3,450	2,900	10	....	....	2C50
2C51	T-6½	Duotriode	8CJ-0-5	Cathode	6.3	0.300	1.3	2.2	1.0	Amplifier	150	240■	.....	8.2	....	6,500	5,500	35	....	....	2C51
2C52	T-9	Duotriode	8BD-0-0	Cathode	12.6	0.300	2.7*	2.3*	0.75*	Amplifier	250	2.0	.....	1.3	....	......	1,900	100	....	....	2C52
2CY5	T-5½	Tetrode	7EW-0-2,7	Cathode	2.4I	0.600	.03	4.5	3.0	VHF Amp.	Characteristics Same as Type 6CY5. (2CY5 Designed for Series String TV Receivers).										2CY5
2D21	T-5½	Gas Tetrode	7BN-0-0	Cathode	6.3	0.600	.02*	2.4*	1.6*	Relay Tube	400	5	Average Cathode Current = 100 Max. Ma., Averaged over any 30 Sec. Interval.								2D21
2E5	T-9	Electron Ray	6R-0-0	Cathode	2.5	0.800	....	....	....	Indicator	Characteristics Same as Type 6E5.										2E5
2E26	T-9	Beam Pent.	7CK-8-1,4,6	Cathode	6.3	0.800	.02*	12.5*	7.0*	Class C Amp.	500	40.0	185	60.0	11.0	Driving Power = 0.12 Watts. D.C. Grid No. 1 Current = 3.0 Ma.				20,000	2E26
2S/4S	ST-12	Duodiode	5D-4-0	Cathode	2.5	1.350	....	....	....	Detector	The Two Diode Plates each Draw Approximately 40.0 Ma. with 50 Volts D.C. on the Plates.										2S/4S
2T4	T-5½	Triode	7DK-0-0	Cathode	2.35I	0.600	1.7*	2.6*	0.4*	UHF Osc.	Characteristics Same as Type 6T4. (2T4 Designed for Series String TV Receivers).										2T4
2V3G	ST-12	Diode	4Y-0-0	Filament	2.5	5.000	....	....	....	H-W Rect.	6000 A.C. Volts Per Plate, RMS, 2 Ma. Output Current. Condenser Input to Filter.										2V3G
2W3GT	T-9	Diode	4X-0-0	Filament	2.5	1.500	....	....	....	H-W Rect.	350 A.C. Volts Per Plate, RMS, 55 Ma. Output Current. Condenser Input to Filter.										2W3GT
2X2A (3)										Characteristics Same as Type 2X2											2X2A (3)

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate, RF Input, Mixer Output.
I Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
ƒ Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



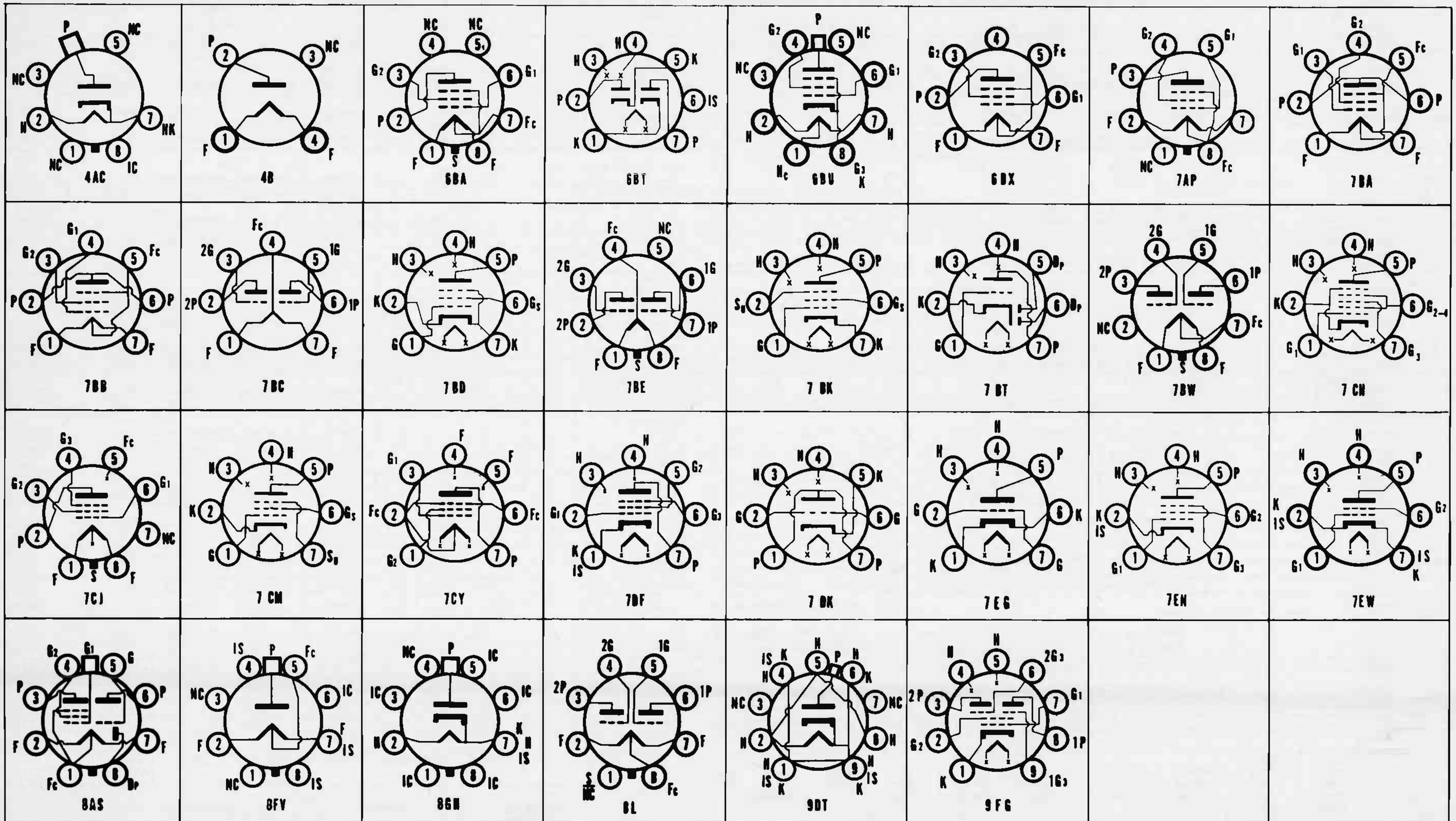
SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection, DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction			Emitter			Note (¹) (²) Capacitances in μμf.			Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Power Output Milliwatts	Type
	Bulb Size or Style	Class	Basing Diag.	Type	Volts	Amps.	Cgp.	Cin.	Cout												
2Z2/G84	ST-12	Diode	4B-0-0	Filament	2.5	1.500	....	....	....	H-W Rect.	350 A.C. Volts Per Plate, RMS, 50 Ma. Output Current.										2Z2/G84
3A2	T-6½	Diode	9DT-0-1	Cathode	3.15	0.220	....	....	....	H-W Rect.	Television Service. Peak Inverse Volts = 18 KV. Peak Current = 80 Ma. Average Current = 1.5 Ma.										3A2
3A3	T-9	Diode	4AC-0-7	Cathode	3.15	0.220	....	....	....	H-W Rect.	Television Service. Peak Inverse Volts = 30 KV. Peak Current = 80 Ma. Average Current = 1.5 Ma.										3A3
3A4	T-5½	Pentode	7BB-0-0	Filament	1.4 2.8	0.200 0.100	0.35m	4.8	7.0	Power Amp.	135 150	7.5 8.4	90 90	14.8 13.3	2.6 2.2	90,000 100,000	1,900 1,900	....	8,000 8,000	600 700	3A4
3A5	T-5½	Duotriode	7BC-0-0	Filament	1.4 2.8	0.220 0.110	3.0	1.1	1.9	Amplifier	90 135	2.5 20.0	....	3.7# 30.0	.... Push-Pull Class C R.F. Amplifier	8,300#	1,800#	15	....	 2,000	3A5
3A8GT	T-9	Diode Triode Pentode	8AS-0-1	Filament	1.4 2.8	0.100 0.050	2.0 .012m	2.6 3.0	4.2 10.0	Tri. Amp. Pent. Amp.	90 90	0.0 0.0	 90	0.2 1.5	.... 0.3	200,000 800,000	325 750	....	....	....	3A8GT
3AF4A	T-5½	Triode	7DK-0-0	Cathode	3.2‡	0.450	1.9	2.2	1.4	UHF Osc.	Characteristics Same as Type 2AF4A.										3AF4A
3AL5	T-5½	Duodiode	6BT-0-6	Cathode	3.15‡	0.600	....	....	....	Detector	Characteristics Same as Type 6AL5. (3AL5 Designed for Series String TV Receivers).										3AL5
3AU6	T-5½	Pentode	7BK-0-2	Cathode	3.15‡	0.600	.0035m	5.5*	5.0*	R-F Amp.	Characteristics Same as Type 6AU6. (3AU6 Designed for Series String TV Receivers).										3AU6
3AV6	T-5½	Duodiode Tri.	7BT-2-0	Cathode	3.15‡	0.600	2.1	2.3	0.9	Det. Amp.	Characteristics Same as Type 6AV6. (3AV6 Designed for Series String TV Receivers).										3AV6
3B2	T-12	Diode	8GH-0-7	Cathode	3.15	0.220	....	....	....	H-W Rect.	Television Service. Pulsed Rectifier Service. Max. Peak Inverse Volts = 35 Kv, Output = 1.1 Ma.										3B2
3B4	T-5½	Beam Amp.	7CY	Filament	2.50 1.25	0.165 0.330	0.16	4.6	7.6	VHF Power Amp.	150	75	135	....	....	....	1,700	....	....	1,250	3B4
3B5GT	T-9	Beam Amp.	7AP-0-0	Filament	1.4 2.8	0.100 0.050	....	....	....	Power Amp.	45 67.5	4.5 7.0	45 67.5	4.4 6.7	0.3 0.5	100,000 100,000	1,400 1,500	....	8,000 5,000	70 180	3B5GT
3B7	Lock-in	Duotriode	7BE-L-0	Filament	2.8 1.4	0.110 0.220	2.6	1.4	2.6	Power Amp. Oscillator	135 180	0 0	....	22.0 25.0	(Class AB2) (Class C)	...... R.F. Power Amp. 2800 mw at 25 mc 1400 mw at 125 mc	1,900	20	16,000	1,500	3B7
3BA6	T-5½	Pentode	7BK-0-2	Cathode	3.15‡	0.600	.0035m*	5.5*	5.0*	I-F or R-F Amplifier	Characteristics Same as Type 6BA6. (3BA6 Designed for Series String TV Receivers).										3BA6
3BC5	T-5½	Pentode	7BD-0-2&7	Cathode	3.15‡	0.600	.02	6.6	2.6	VHF Amp.	Characteristics Same as Type 6BC5. (3BC5 Designed for Series String TV Receivers).										3BC5
3BE6	T-5½	Heptode	7CH-0-0	Cathode	3.15‡	0.600	0.1m*	5.5*	8.0*	Converter	Characteristics Same as Type 6BE6. (3BE6 Designed for Series String TV Receivers).										3BE6
3BN4	T-5½	Triode	7EG	Cathode	3.0‡	0.450	1.2	3.2	1.4	VHF Amp.	Characteristics Same as Type 6BN4. (3BN4 Designed for Series String TV Receivers).										3BN4
3BN6	T-5½	Gated Beam	7DF-0-1	Cathode	3.15‡	0.600	....	....	....	Quad. Det.	Characteristics Same as Type 6BN6. (3BN6 Designed for Series String TV Receivers).										3BN6
3BU8	T-6½	Duo Pentode	9FG-0-2	Cathode	3.15‡	0.600	G3 to P 1.9	6.0	3.0	Sync. Sep.	Characteristics Same as Type 6BU8. (3BU8 Designed for Series String TV Receivers.)										3BU8
3BY6	T-5½	Heptode	7CH-0-0	Cathode	3.15‡	0.600	.08m*	5.4*	7.6*	Sync. Sep.	Characteristics Same as Type 6BY6. (3BY6 Designed for Series String TV Receivers).										3BY6
3BZ6	T-5½	Pentode	7CM-0-7	Cathode	3.15‡	0.600	.015m	7.5	2.8	VHF Amp.	Characteristics Same as Type 6BZ6. (3BZ6 Designed for Series String TV Receivers).										3BZ6
3C2	T-12	Diode	8FV-0-4,7,8	Filament	3.15/ 1.58	0.210/ 0.420	....	....	....	H-W Rect.	Television Service. Flyback Supplies. Peak Inverse Volts = 28 KV. Output = 1.1 Ma.										3C2
3C5GT	T-9	Pentode	7AP-0-0	Filament	1.4 2.8	0.100 0.050	....	....	....	Power Amp.	90 90	9.0 9.0	90 90	6.0 6.0	1.4 1.4	....	1,550 1,450	....	8,000 10,000	240 260	3C5GT
3C6/XXB	Lock-in	Duotriode	7BW-0-0	Filament	1.4 2.8	0.100 0.050	....	....	Sec. 1 Sec. 2 Sec. 1 Sec. 2	Det. Amp.	90 90 90 90	0 0 0 0	....	4.5 4.5 4.5 3.2	....	11,200 11,200 11,200 12,800	1,300 1,300 1,300 1,100	14.5 14.5 14.5 14.1	....	....	3C6/XXB
3CB6	T-5½	Pentode	7CM-0-7	Cathode	3.15‡	0.600	.02m*	6.5*	2.0*	Amplifier	Characteristics Same as Type 6CB6. (3CB6 Designed for Series String TV Receivers).										3CB6
3CE5	T-5½	Pentode	7BD	Cathode	3.15‡	0.600	.03*	6.5*	1.9*	VHF Amp.	Characteristics Same as Type 6CE5 (3CE5 Designed for Series String TV Receivers).										3CE5
3CF6	T-5½	Pentode	7CM	Cathode	3.15‡	0.600	.015*	6.5*	3.0*	VHF Amp.	Characteristics Same as Type 6CF6 (3CF6 Designed for Series String TV Receiver)										3CF6
3CS6	T-5½	Heptode	7CH-0-0	Cathode	3.15‡	0.600	.05* 0.36*	5.5* 7.0*	.... 7.5*	Sync. Separator	Characteristics Same as Type 6CS6. (3CS6 Designed for Series String TV Receivers).										3CS6
3CY5	T-5½	Tetrode	7EW-0-2,7	Cathode	2.9‡	0.450	.03	4.5	3.0	VHF Amp.	Characteristics Same as Type 6CY5. (3CY5 Designed for Series String TV Receivers).										3CY5
3D6	Lock-in	Beam Pent.	6BA-L-0	Filament	2.8 1.4	0.110 0.220	0.3	7.5	6.5	Power Amp.	150 150	4.5 20.0	90 135	10.2 23.0	1.8 6.0	(Class A) (Class C)	2,400 R. F. Power	..... Amp. at 50 mc.	14,000	600 1,400	3D6
3D21A 3D21B	ST-14 T-12	Beam Pent.	6BU	Cathode	6.3 12.6	1.700 0.850	....	....	....	HV Pulse Blocking Osc. and Modulator	Maximum Peak Positive Pulse Plate Voltage = 5,000 Volts. Maximum Plate Dissipation = 15 Watts. 600	30	300	30	2.5	....	5,500	....	....	....	3D21A 3D21B
3DK6	T-5½	Pentode	7CM-0-7	Cathode	3.15‡	0.600	.02*	6.3*	1.9*	VHF Amp.	Characteristics Same as Type 6DK6. (3DK6 Designed for Series String TV Receivers).										3DK6
3DT6	T-5½	Gated Beam	7EN-0-0	Cathode	3.15‡	0.600	.02	....	....	Quad. F. M. Det.	Characteristics Same as Type 6DT6. (3DT6 Designed for Series String TV Receivers).										3DT6
3E5	T-5½	Power Pent.	6BX-0-0	Filament	1.4 2.8	0.050 0.025	....	....	....	Class A1 Parallel Fil. Class A1 Series Fil.	67.5 90 67.5 90	5.0 7.0 5.0 7.0	67.5 90 67.5 90	5.5 8.0 4.4 6.8	1.1 1.6 0.9 1.4	120,000 100,000 130,000 120,000	1,400 1,550 1,300 1,450	....	8,000 8,000 11,000 9,000	125 250 115 225	3E5
3E6	Lock-in	Pentode	7CJ-L-5	Filament	1.4 2.8	0.100 0.050	.007m	5.5	7.5	R-F Amp.	90 90	0 0	90 90	4.2 2.9	1.7 1.2	250,000 325,000	2,000 1,700	....	....	....	3E6
3LE4	Lock-in	Power Pent.	6BA-L-0	Filament	2.8 1.4	0.050 0.100	....	....	....	Power Amp.	90 90	9.0 9.0	90 90	9.0 10.0	1.8 2.0	110,000 100,000	1,600 1,750	....	6,000 6,000	300 325	3LE4
3LF4	Lock-in	Beam Pent.	6BA-L-0	Filament	1.4 2.8	0.100 0.050	....	....	....	Power Amp.	85 90 110 90 110	5.0 4.5 6.6 4.5 6.6	85 90 110 90 110	7.0 9.5 10.0 8.0 8.5	0.8 1.3 1.4 1.0 1.1	70,000♦ 90,000♦ 100,000♦ 80,000♦ 110,000♦	1,950 2,200 2,200 2,000 2,000	....	9,000 8,000 8,000 8,000 8,000	250 270 400 230 330	3LF4
3Q4	T-5½	Power Pent.	7BA-0-0	Filament	1.4 2.8	0.100 0.050	....	....	....	Power Amp.	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 2,150 2,000	....	10,000 10,000 10,000	250 270 240	3Q4
3Q5GT	T-9	Beam Pent.	7AP-0-0	Filament	1.4 2.8	0.100 0.050	....	....	....	Power Amp.	90 90	4.5 4.5	90 90	9.5 8.0	1.3 1.0	90,000♦ 80,000♦	2,200 2,000	....	8,000 8,000	270 230	3Q5GT

3S4	T-5½	Power Pent.	7BA-0-0	Filament	1.4 2.8	0.100 0.050	0.3	5.0	7.0	Power Amp.	90 90	7.0 7.0	67.5 67.5	7.4 6.1	1.4 1.1	100,000 100,000	1,575 1,425	....	8,000 8,000	270 235	3S4
3V4	T-5½	Power Pent.	6BX-0-0	Filament	1.4 2.8	0.100 0.050	....	....	....	Power Amp.	Characteristics Same as Type 3Q4.										3V4
3Z4	T-5½	Power Pent.	7BA	Filament	1.4 2.8	0.050 0.025	....	....	....	Power Amp.	67.5	7.0	67.5	6.5	1.3	100,000	1,450	....	8,000	210	3Z4
4A6G	ST-12	Duotriode	8L-0-0	Filament	2.0 4.0	0.120 0.060	....	....	....	Power Amp.	90 90	1.5 1.5	....	1.1 10.8	.... Class B. Max. Signal	26,600	750	20	 8,000	 1,000	4A6G
4AU6	T-5½	Pentode	7BK-0-2	Cathode	4.2I	0.450	.0035*	5.5*	5.0*	R-F Amp.	Characteristics Same as Type 6AU6. (4AU6 Designed for Series String TV Receivers).										4AU6
4BA6	T-5½	Pentode	7BK	Cathode	4.2I	0.450	.0035*	5.5*	5.0*	R-F Amp.	Characteristics Same as Type 6BA6. (4BA6 Designed for Series String TV Receivers).										4BA6
4BC5	T-5½	Pentode	7BD-0-2&7	Cathode	4.2I	0.450	.02	6.6	2.6	VHF Amp.	Characteristics Same as Type 6BC5. (4BC5 Designed for Series String TV Receivers).										4BC5

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate; RF input, Mixer Output.
I Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
☐ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



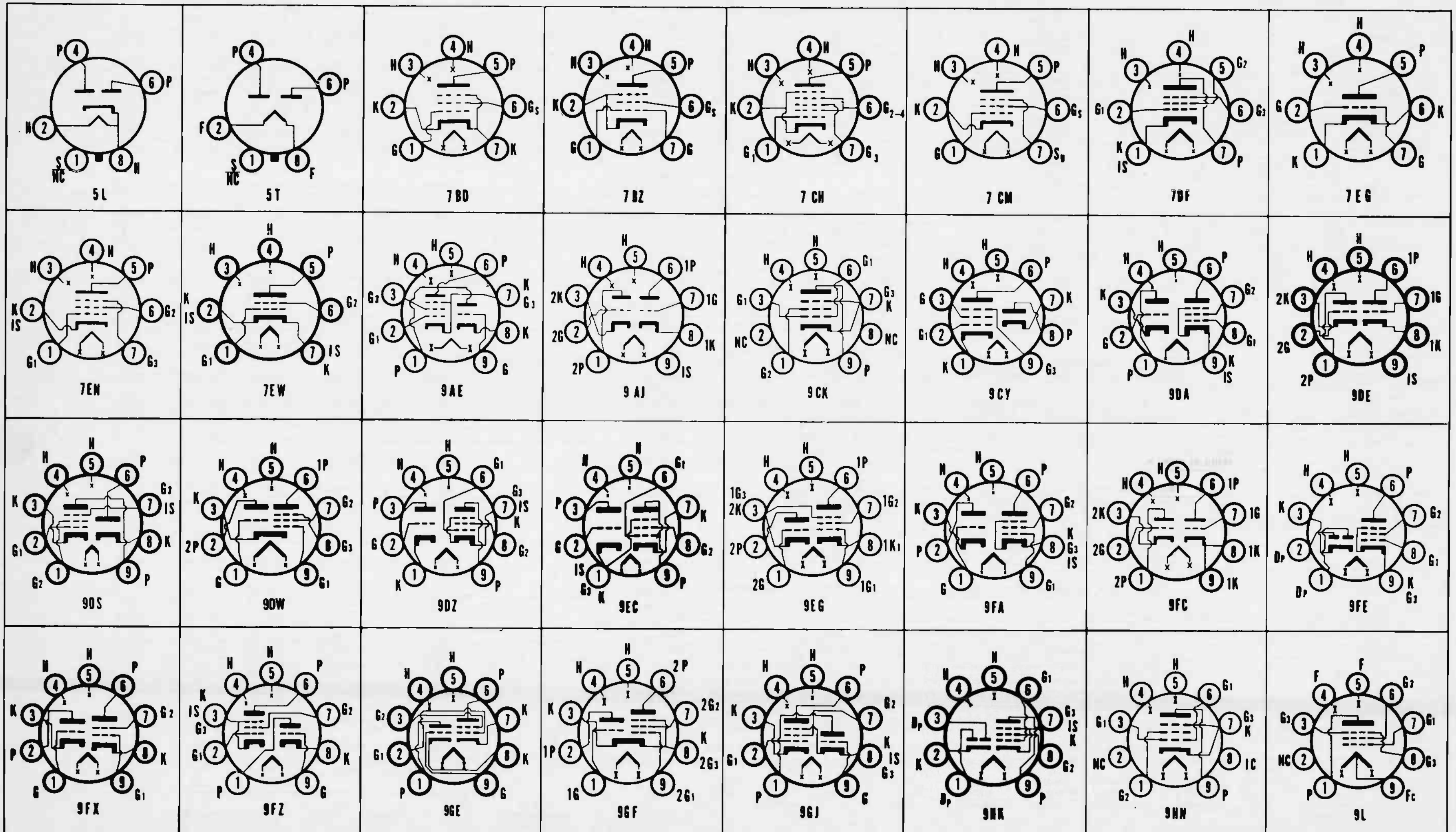
SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection, DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; ☐—Top Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (¹) (²) Capacitances in μμf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Undistorted Power Output Milliwatts	Type
4BC8	T-6½	Duotriode	9AJ-0-9	Cathode	4.2‡	0.600	1.4	2.5	1.3	Class A1 Amp.	Characteristics Same as Type 6BC8. (4BC8 Designed for Series String TV Receivers).										4BC8
4BE6	T-5½	Heptode	7CH	Cathode	4.2‡	0.450	0.3*	7.0*	8.0*	Converter	Characteristics Same as Type 6BE6. (4BE6 Designed for Series String TV Receivers).										4BE6
4BN4	T-5½	Triode	7EG	Cathode	4.2	0.300	1.2	3.2	1.4	VHF Amp.	Characteristics Same as Type 6BN4.										4BN4
4BN6	T-5½	Gated Beam	7DF-0-1	Cathode	4.2‡	0.450	....	....	....	Quad. F. M. Det.	Characteristics Same as Type 6BN6. (4BN6 Designed for Series String TV Receivers).										4BN6
4BQ7A	T-6½	Duotriode	9AJ-0-9	Cathode	4.2.	0.600	1.15	2.85	1.35	VHF Amp.	Characteristics Same as Type 6BQ7A. (4BQ7A Designed for Series String TV Receivers).										4BQ7A
4BS8	T-6½	Duotriode	9AJ	Cathode	4.5‡	0.600	1.15	2.6	1.2	VHF Amp.	Characteristics Same as Type 6BS8. (4BS8 Designed for Series String TV Receivers).										4BS8
4BX8	T-6½	Duotriode	9AJ	Cathode	4.5‡	0.600	1.4 1.4	4.9 2.4	2.6 1.25	VHF Amp.	Characteristics Same as Type 6BX8. (4BX8 Designed for Series String TV Receivers.)										4BX8
4BZ6	T-5½	Pentode	7CM	Cathode	4.2‡	0.450	.015m	7.5	2.8	R-F Amp.	Characteristics Same as Type 6BZ6.										4BZ6
4BZ7	T-6½	Duotriode	9AJ-0-9	Cathode	4.2‡	0.600	1.15	2.5	1.35	VHF Amp.	Characteristics Same as Type 6BZ7. (4BZ7 Designed for Series String TV Receivers).										4BZ7
4BZ8	T-6½	Duotriode	9AJ-0-9	Cathode	4.2‡	0.600	....	....	....	VHF Amp.	Characteristics Same as Type 6BZ8. (4BZ8 Designed for Series String TV Receivers.)										4BZ8
4CB6	T-5½	Pentode	7CM-0-7	Cathode	4.2‡	0.450	.015	6.5	3.0	VHF Amp.	Characteristics Same as Type 6CB6. (4CB6 Designed for Series String TV Receivers).										4CB6
4CE5	T-5½	Pentode	7BD	Cathode	4.2‡	0.450	.03*	6.5*	1.9*	VHF Amp.	Characteristics Same as Type 6CE5. (4CE5 Designed for Series String TV Receivers).										4CE5
4CS6	T-5½	Dual Control Heptode	7CH	Cathode	4.2	0.450	.07* 0.36*	5.5* 7.0*	.... 7.5*	Sync. Sep.	Characteristics Same as Type 6CS6. (4CS6 Designed for Series String TV Receivers).										4CS6
4CX7	T-6½	Duotriode	9FC-0-2	Cathode	4.2‡	0.600	1.2	2.4	1.3	Amplifier	Characteristics Same as Type 6CX7. (4CX7 Designed for Series String TV Receivers).										4CX7
4CY5	T-5½	Tetrode	7EW-0-2,7	Cathode	4.5‡	0.300	.03	4.5	3.0	VHF Amp.	Characteristics Same as Type 6CY5. (4CY5 Designed for Series String TV Receivers).										4CY5
4DE6	T-5½	Pentode	7CM	Cathode	4.2‡	0.450	.015m	6.5	3.0	VHF Amp.	Characteristics Same as Type 4DE6. (4DE6 Designed for Series String Receivers).										4DE6
4DK6	T-5½	Pentode	7CM-0-7	Cathode	4.2‡	0.450	.02*	6.3*	1.9*	VHF Amp.	Characteristics Same as Type 6DK6. (4DK6 Designed for Series String TV Receivers).										4DK6
4DT6	T-5½	Gated Beam	7EN-0-0	Cathode	4.2‡	0.450	.02	....	....	Quad. F. M. Det.	Characteristics Same as Type 6DT6. (4DT6 Designed for Series String TV Receivers).										4DT6
4ES8	T-6½	Duotriode	9DE	Cathode	4.0	0.600	1.85	....	0.17	VHF Amp.	Characteristics Same as Type 6ES8. (4ES8 Designed for Series String Receivers).										4ES8
5A6	T-6½	Power Pent.	9L-0-0	Filament	5.0 2.5	0.230 0.460	0.1	8.5	9.5	Class B. Amp. Class C. Amp.	150 150	15 24	139.5 150	40 40	7 11	....	....	....	....	2,800 3,100	5A6
5AM8	T-6½	Diode Pent.	9CY-0-0	Cathode	4.7‡	0.600	.015	6.0	3.4	Amp. Det.	Characteristics Same as Type 6AM8. (5AM8 Designed for Series String TV Receivers).										5AM8
5AN8	T-6½	Tri. Pentode	9DA-0-9	Cathode	4.7‡	0.600	1.5* .04m*	2.0* 7.0*	0.27* 2.3*	Tri. Amp. Pent. Amp.	Characteristics Same as Type 6AN8. (5AN8 Designed for Series String TV Receivers).										5AN8
5AQ5	T-5½	Beam Pent.	7BZ-0-0	Cathode	4.7‡	0.600	0.4*	8.0*	8.5*	Power Amp.	Characteristics Same as Type 6AQ5 (5AQ5 Designed for Series String TV Receivers).										5AQ5
5AS8	T-6½	Diode Pent.	9DS-0-7	Cathode	4.7‡	0.600	.02*	7.0*	2.4*	Det. Amp.	Characteristics Same as Type 6AS8. (5AS8 Designed for Series String TV Receivers).										5AS8
5AT8	T-6½	Tri. Pentode	9DW-0-0	Cathode	4.7‡	0.600	1.5 .016m	2.4 4.7	1.0 1.6	Tri. Osc. Converter	Characteristics Same as Type 6AT8. (5AT8 Designed for Series String TV Receivers).										5AT8
5AV8	T-6½	Tri. Pentode	9DZ-0-7	Cathode	4.7‡	0.600	1.5* .04m*	2.0* 7.0*	0.34* 3.0*	Tri. Amp. Pent. Amp.	Characteristics Same as Type 6AN8. (5AV8 Designed for Series String TV Receivers).										5AV8
5AW4	T-12	Duodiode	5T-0-0	Filament	5.0	4.000	....	....	....	F-W Rect.	450 A.C. Volts Per Plate, RMS, 250 Ma. Output Current with Cap. Input to Filter. Peak Current = 750 Ma. Per Plate.										5AW4
5AX4GT	T-9	Duodiode	5T-0-0	Filament	5.0	2.250	....	....	....	F-W Rect.	350 A.C. Volts Per Plate, R.M.S., 150 Ma. D.C. Output Current. Condenser Input to Filter. 500 A.C. Volts Per Plate, R.M.S., 150 Ma. D.C. Output Current. Choke Input to Filter.										5AX4GT
5AZ4	Lock-in	Duodiode	5T-L-0	Filament	5.0	2.000	....	....	....	F-W Rect.	Characteristics Same as Type 5Y3GT.										5AZ4
5B8	T-6½	Tri. Pentode	9EC-0-1	Cathode	4.7‡	0.600	1.7* .05m*	1.9* 6.0*	1.4* 2.6*	Tri. Amp. Pent. Amp.	200 200 (5B8 Designed for Series String TV Receivers).	6 180 ■	 150	13 9.5	.... 2.8	5,750 300,000	3,300 6,200	19	....	....	5B8
5BE8	T-6½	Tri. Pentode	9EG-0-3	Cathode	4.7‡	0.600	1.8* .04m*	2.8* 4.4*	1.5* 2.6*	Tri. Osc. Converter	Characteristics Same as Type 6U8. (5BE8 Designed for Series String TV Receivers).										5BE8
5BK7A	T-6½	Duotriode	9AJ-0-9	Cathode	4.7‡	0.600	1.8 1.8	3.0 3.0	1.0 0.9	VHF Amp.	Characteristics Same as Type 6BK7A. (5BK7A Designed for Series String TV Receivers).										5BK7A
5BQ7A	T-6½	Duotriode	9AJ-0-9	Cathode	5.6‡	0.450	1.2	2.6	1.2	VHF Amp.	Characteristics Same as Type 6BQ7A. (5BQ7A Designed for Series String TV Receivers).										5BQ7A
5BR8	T-6½	Triode Pentode	9FA	Cathode	4.7‡	0.600	.008 1.8	5.0 2.5	3.5 1.0	Osc. Mixer	Characteristics Same as Type 6BR8. (5BR8 Designed for Series String TV Receivers).										5BR8
5BT8	T-6½	Duodi. Pent.	9FE	Cathode	4.7‡	0.600	.04m*	7.0*	2.3*	Amp. Det.	Characteristics Same as Type 6BT8. (5BT8 Designed for Series TV Receivers).										5BT8
5BW8	T-6½	Duodi. Pent.	9HK	Cathode	4.7‡	0.600	.02m*	4.8*	2.6*	R-F or I-F Amplifier	Characteristics Same as Type 6BW8. (5BW8 Designed for Series String Receivers).										5BW8
5BZ7	T-6½	Duotriode	9AJ-0-9	Cathode	5.6‡	0.450	1.2 1.2	2.5 4.9	1.35 2.27	VHF Amp.	Characteristics Same as Type 6BZ7. (5BZ7 Designed for Series String TV Receivers).										5BZ7
5CG4	T-9	Duodiode	5L	Cathode	5.0	2.0	....	....	....	F-W Rect.	350 A.C. Volts Per Plate, RMS, 125 Ma. Max. D.C. Output Current.										5CG4
5CG8	T-6½	Tri. Pentode	9GF	Cathode	4.7‡	0.600	1.5 .02	2.4 4.8	1.0 1.6	Osc. Mixer	Characteristics Same as 6CG8 (5CG8 Designed for Series String TV Receivers.)										5CG8
5CL8	T-6½	Tri. Tetrode	9FX	Cathode	4.7‡	0.600	1.8 .016m	2.7 5.0	1.2 3.0	Osc. Mixer	Characteristics Same as Type 6CL8. (5CL8 Designed for Series String TV Receivers.)										5CL8
5CL8A	T-6½	Tri. Tetrode	9FX	Cathode	4.7‡	0.600	1.8 .01	2.7 5	1.2 3.4	VHF Osc. VHF Amp.	Characteristics Same as Type 6CL8A. (5CL8A Designed for Series String Receivers).										5CL8A
5CM6	T-6½	Beam Pent.	9CK	Cathode	4.7‡	0.600	0.7	8.0	8.5	Power Amp.	Characteristics Same as Type 6CM6. (5CM6 Designed for Series String TV Receivers).										5CM6
5CM8	T-6½	Tri. Pentode	9FZ	Cathode	4.7‡	0.600	1.9 .04m	1.6 6.0	0.22 2.6	Class A1 Amp.	Characteristics Same as 6CM8. (5CM8 Designed for Series String TV Receivers.)										5CM8
5CQ8	T-6½	Tri. Tetrode	9GE	Cathode	4.7‡	0.600	1.8 .015	2.7 5.0	1.2 3.3	VHF Tri. Osc. VHF Pent. A.	Characteristics Same as Type 6CQ8. (5CQ8 Designed for Series String TV Receivers).										5CQ8
5CR8	T-6½	Tri. Pentode	9GJ	Cathode	4.7‡	0.600	1.6* .018*	2.0* 6.0*	1.4* 2.8*	Tri. Amp. Pent. Amp.	Characteristics Same as Type 6CR8. (5CR8 Designed for Series String Receivers).										5CR8

5CZ5	T-6½	Beam Pent.	9HN	Cathode	4.7I	0.600	0.4*	6.0*	6.0*	Vert. Defl. Amp.	Characteristics Same as Type 6CZ5. (5CZ5 Designed for Series String TV Receivers).										5CZ5
5DH8	T-6½	Tri. Pentode	9EG	Cathode	5.2I	0.600	1.6* .03m*	2.4* 6.5*	1.4* 2.2*	Vert. Osc. Video Amp.	250 125	390■ 56■	 125	7.3 13.5	.... 3.8	12,000 150,000	4,400 8,600	53	....	....	5DH8
5EA8	T-6½	Tri. Pentode	9AE	Cathode	4.7I	0.600	1.7 .01	3.2 5	1.1 3.4	Tri. VHF Amp. Pent VHF Amp	Characteristics Same as Type 6EA8. (5EA8 Designed for Series String Receivers).										5EA8

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate; RF Input, Mixer Output.
I Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection, DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell, SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (¹) (²) Capacitances in μμf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Power Output Milli-watts	Type
5J6	T-5½	Duotriode	7BF-0-0	Cathode	4.7‡	0.600	1.5 1.5	2.6 2.6	1.6 1.0	R-F Amp. Osc. Amp.	Characteristics Same as Type 6J6. (5J6 Designed for Series String TV Receivers).										5J6
5R4GY 5R4GYA	ST-16 T-12	Duodiode	5T-0-0	Filament	5.0	2.000	....	....	....	F-W Rect.	900 Volts RMS Per Plate, 150 Ma. D-C Output, Condenser Input to Filter. 950 Volts RMS Per Plate, 175 Ma. D-C Output, Choke Input to Filter.										5R4GY 5R4GYA
5T4	Metal	Duodiode	5T-0-0	Filament	5.0	2.000	....	....	....	Rectifier	450 A.C. Volts Per Plate, RMS, 225 Ma. Output Current. Condenser Input to Filter. 550 A.C. Volts Per Plate, RMS, 225 Ma. Output Current. Choke Input to Filter.										5T4
5T8	T-6½	Triple Dio. Tri.	9E-0-3&7	Cathode	4.7‡	0.600	1.7	1.7	2.4	Det. Amp.	Characteristics Same as Type 6T8. (5T8 Designed for Series String TV Receivers).										5T8
5U4G	ST-16	Duodiode	5T-0-0	Filament	5.0	3.000	....	....	....	F-W Rect.	450 A.C. Volts Per Plate, RMS, 225 Ma. Output Current. Condenser Input to Filter.										5U4G
5U4GA	T-11	Duodiode	5T-0-0	Filament	5.0	3.000	....	....	....	F-W Rect.	450 A.C. Volts Per Plate, RMS, 250 Ma. Output Current with Cap. Input to Filter. Peak Current = 900 Ma. Per Plate.										5U4GA
5U4GB	T-12	Duodiode	5T-0-0	Filament	5.0	3.000	....	....	....	F-W Rect.	450 A.C. Volts Per Plate, RMS, 275 Ma. Output Current with Cap. Input to Filter. Peak Current = 1 Amp. Per Plate.										5U4GB
5U4WG (3)	T-12	Duodiode	5T-0-0	Filament	5.0	3.000	....	....	....	F-W Rect.	Characteristics Same as Type 5U4G.										5U4WG (3)
5U8	T-6½	Tri. Pentode	9AE-0-7	Cathode	4.7‡	0.600	1.8 .006m	2.5 5.0	1.0 3.5	VHF Osc. VHF Mixer	Characteristics Same as Type 6U8. (5U8 Designed for Series String TV Receivers).										5U8
5V3	T-12	Duodiode	5T-0-0	Filament	5.0	3.800	....	....	....	F-W Rect.	425 A.C. Volts Per Plate, RMS, 350 Ma. Output Current. Capacitor Input to Filter. 500 A.C. Volts Per Plate, RMS, 350 Ma. Output Current. Choke Input to Filter.										5V3
5V4G	ST-14	Duodiode	5L-0-0	Cathode	5.0	2.000	....	....	....	F-W Rect.	375 A.C. Volts Per Plate, RMS, 175 Ma. Output Current. Condenser Input to Filter.										5V4G
5V4GA	T-12	Duodiode	5L-0-0	Cathode	5.0	2.000	....	....	....	F-W Rect.	375 A.C. Volts Per Plate, RMS, 175 Ma. Output Current with Cap. Input to Filter. Peak Current = 525 Ma. per Plate.										5V4GA
5V6GT	T-9	Beam Pent.	7S-0-0	Cathode	4.7‡	0.600	0.7°	9.0°	7.5°	Power Amp.	Characteristics Same as Type 6V6GT. (5V6GT Designed for Series String TV Receivers).										5V6GT
5W4 5W4GT	Metal T-9	Duodiode	5T-1-0 5T-0-0	Filament	5.0	1.500	....	....	....	F-W Rect.	350 A.C. Volts Per Plate, RMS, 110 Ma. Output Current. Condenser Input to Filter.										5W4 5W4GT
5X3	ST-14	Duodiode	4C-0-0	Filament	5.0	2.000	....	....	....	Rectifier	400 A.C. Volts Per Plate, RMS, 110 Ma. Output Current. Choke or Condenser Input to Filter. 1275 A.C. Volts Per Plate, RMS, 30 Ma. Output Current. Choke or Condenser Input to Filter.										5X3
5X4G	ST-16	Duodiode	5Q-0-0	Filament	5.0	3.000	....	....	....	F-W Rect.	450 A.C. Volts Per Plate, RMS, 225 Ma. Output Current. Condenser Input to Filter.										5X4G
5X4GA	T-12	Duodiode	5Q-0-0	Filament	5.0	3.000	....	....	....	F-W Rect.	450 A.C. Volts Per Plate, RMS, 250 Ma. Output Current. Capacitor Input to Filter.										5X4GA
5X8	T-6½	Tri. Pentode	9AK-0-0	Cathode	4.7‡	0.600	1.4 .06	2.6 4.5	1.0 1.4	Oscillator Mixer	Characteristics Same as Type 6X8. (5X8 Designed for Series String TV Receivers).										5X8
5Y3GT 5Y3GA	T-9 T-12	Duodiode	5T-0-0	Filament	5.0	2.000	....	....	....	F-W Rect.	350 A.C. Volts Per Plate, RMS, 125 Ma. Output Current. Condenser Input to Filter. 500 A.C. Volts Per Plate, RMS, 125 Ma. Output Current. Choke Input to Filter.										5Y3GT 5Y3GA
5Y4GT 5Y4GA	T-9 T-12	Duodiode	5Q-0-0	Filament	5.0	2.000	....	....	....	F-W Rect.	Characteristics Same as Type 5Y3GT.										5Y4G 5Y4GA
5Z3	ST-16	Duodiode	4C-0-0	Filament	5.0	3.000	....	....	....	F-W Rect.	450 A.C. Volts Per Plate, RMS, 225 Ma. Output Current. Condenser Input to Filter.										5Z3
5Z4 5Z4GT	Metal T-9	Duodiode	5L-1-0 5L-0-0	Cathode	5.0	2.000	....	....	....	F-W Rect.	350 A.C. Volts Per Plate, RMS, 125 Ma. Output Current. Condenser Input to Filter.										5Z4 5Z4GT
6A3	ST-16	Power Triode	4D-0-0	Filament	6.3	1.000	16.0	7.0	5.0	S.T. A1 Amp. P.P.AB1 Amp. P.P.AB1 Amp.	250 325 325	45.0 68.0	....	60.0 80-147† 80-100†	.... (Push Pull, Fixed Bias) (Push Pull, Self Bias Resistor 850 Ohms)	800	5,250	4.2	2,500 3,000¶ 5,000¶	3,200 15,000 10,000	6A3
6A4/LA	ST-14	Power Pent.	5B-0-0	Filament	6.3	0.300	....	....	....	Power Amp.	135 180	9.0 12.0	135 180	13.0 22.0	2.8 3.9	52,600 60,000	2,100 2,500	150 150	9,500 8,000	700 1,500	6A4/LA
6A5G	ST-16	Triode	6T-0-0	Cathode	6.3	1.250	....	....	....	S.T. A1 Amp. P.P.AB1 Amp.	250 325	45.0 68.0	....	60.0 40.0 Per Tube, Push Pull, Fixed Bias	....	300	5,250	4.2	2,500 3,000¶	3,750 15,000	6A5G
6A6	ST-14	Duotriode	7B-0-0	Cathode	6.3	0.800	....	....	....	Power Amp. Driver Driver	300 250 294	0.0 5.0 6.0	....	17.5-35† 6.0 7.0	Per Plate, Class B Push-Pull Operation Sections Paralled	 11,300 11,000	 3,100 3,200	 35 35	10,000¶ (Class A Driver) (Class A Driver)	10,000	6A6
6A7, 6A7S	ST-12	Heptode	7C-0-0	Cathode	6.3	0.300	0.3	8.5	9.0	Converter	Characteristics Same as Type 6A8G, Except Capacitances										6A7, 6A7S
6A8 6A8G 6A8GT	Metal ST-12 T-9	Heptode	8A-1-0 8A-0-0 8A-1-0	Cathode	6.3	0.300	.06 0.26 0.26	12.0 9.5 9.5	12.0 12.0 12.0	Converter	100 250	1.5 3.0	50 100	1.1 3.5	1.3 2.7	600,000 360,000	360▲ 550▲	(Ga = 100V., 2.0 Ma.) (Ga = 250 V.□, Max., 4.0 Ma.)			6A8 6A8G 6A8GT
6AB4	T-5½	Triode	5CE-0-2	Cathode	6.3	0.150	1.5	2.2	1.4	R-F Amp.	250	200■	.....	10	....	10,900	5,500	60		....	6AB4
6AB5/6N5	T-9	Electron Ray	6R-0-0	Cathode	6.3	0.150	....	....	....	Indicator	135§	(Series Plate Resistor 0.25 Meg., Target Current 2.0 Ma., Grid Bias = 10 for 0° Shadow.)									6AB5/6N5
6AB6G	ST-12	Duotriode	7AU-0-0	Cathode	6.3	0.500	....	....	....	Power Amp.	250 250	0	Input Tri. Output Tri.	5.0 34.0	....	 40,000	 1,800	....	 8,000	 3,500	6AB6G
6AB7	Metal	Pentode	8N-1-1	Cathode	6.3	0.450	.015m	8.0	5.0	Amplifier	300	3.0	200	12.5	3.2	700,000♦	5,000	3,500	....	....	6AB7
6AC5GT	T-9	Triode	6Q-0-0	Cathode	6.3	0.400	....	....	....	Power Amp.	250 250 250	+13 (Bias from 76 Driver) 0.0	....	32.0 32.0 10-80†	.... (Class A1, One Tube, Dynamic Coupled) (Class B, Two Tubes)	36,700	3,400	125	 7,000 10,000¶	 3,700 8,000	6AC5GT
6AC6GT	T-9	Duotriode	7W-0-0	Cathode	6.3	1.100	....	....	....	Power Amp.	180 180	0.0 0.0	....	7.0 45.0	(Input Section) (Output)	 180,000	 3,000	 54	 3,500	 3,600	6AC6GT
6AC7	Metal	Pentode	8N-1-1	Cathode	6.3	0.450	.015m	11.0	5.0	Video Amp.	300	160■	150	10.0	2.5	1.0 Meg.♦	9,000	6,750♦	....	....	6AC7
6AD4	T-3	Triode	8DK-0-0	Cathode	6.3	0.150	0.7	1.9	2.2	Osc. Amp.	100	820■	.....	1.4	....	35,000	2,000	70	....	....	6AD4
6AD5G, GT	ST-12, T-9	Triode	6Q-0-0	Cathode	6.3	0.300	3.3°	4.1°	3.9°	Amplifier	250	2.0		0.9	....	66,000	1,500	100	....	....	6AD5G, GT
6AD6G	T-9	Electron Ray	7AG-0-0	Cathode	6.3	0.150	....	....	....	Indicator	100§ (Ray Control Volts = 45 Approx. For 0° Shadow, Approx. = 23 Volts for 135° Shadow.) 150§ (Ray Control Volts = 75 Approx. For 0° Shadow, Approx. = 50 Volts for 135° Shadow.)										6AD6G
6AD7G	ST-14	Tri. Pentode	8AY-0-0	Cathode	6.3	0.850	....	....	....	Tri. Amp. Pent. Amp.	250 250	25.0 16.5	 250	4.0 34.0	.... 6.5	19,000♦ 80,000♦	325 2,500	6	 7,000	 3,200	6AD7G
6AE5GT	T-9	Triode	6Q-0-0	Cathode	6.3	0.300	....	....	....	Amplifier	95	15	.....	7.0	....	3,500	1,200	4.2	....	....	6AE5GT
6AE6G	ST-12	Duo Plate Triode	7AH-0-0	Cathode	6.3	0.150	....	....	....	Remote Cut-Off Sharp Cut-Off	250 250 250 250	1.5 35.0 1.5 9.5	....	6.5 0.01 4.5 0.01	....	2,500 ...... 3,500	1,000 ..... 950	25 ..... 33	....	....	6AE6G

6AE7GT	T-9	Duotriode	7AX-0-0	Cathode	6.3	0.500	2.5 2.5	3.0 3.0	1.8 1.8	Amplifier	250	13.5	.....	10.0	....	4,650	3,000	14	....	....	6AE7GT
											(Driver for P.P. 6AC5GT = 250 V. 10 Ma., 6AC5GT Plate Ma. = 64. Output 9.5 Watts with 10,000 Ohms Load Bias Developed in Circuit.) (Sections in Parallel)										
6AF3	T-6½	Diode	9CB	Cathode	6.3	1.200	....	....	....	T.V. Damper	Maximum Peak Inverse Plate Voltage = 4,500 Volts. Maximum D.C. Plate Current = 185 Ma.										6AF3
6AF4A 6AF4	T-5½	Triode	7DK	Cathode	6.3	0.225	1.9	2.2	1.4	UHF Osc.	100	Grid Resistor = 17. 10,000 Ohms. Plate Resistor = 220 Ohms. Grid Current = 750 μa.									6AF4A
6AF5G	ST-12	Triode	6Q-0-0	Cathode	6.3	0.300	....	....	....	Amplifier	180	18.0	.....	7.0	....	4,900	1,500	7.4	....	....	6AF5G
6AF6G	T-9	Twin Elec. Ray	7AG-0-0	Cathode	6.3	0.150	....	....	....	Indicator	100§ (Ray Control Volts = Approx. 60 for 0° Shadow, Approx. Zero Volts for 100° Shadow.) 135§ (Ray Control Volts = Approx. 81 for 0° Shadow, Approx. Zero Volts for 100° Shadow.)										6AF6G

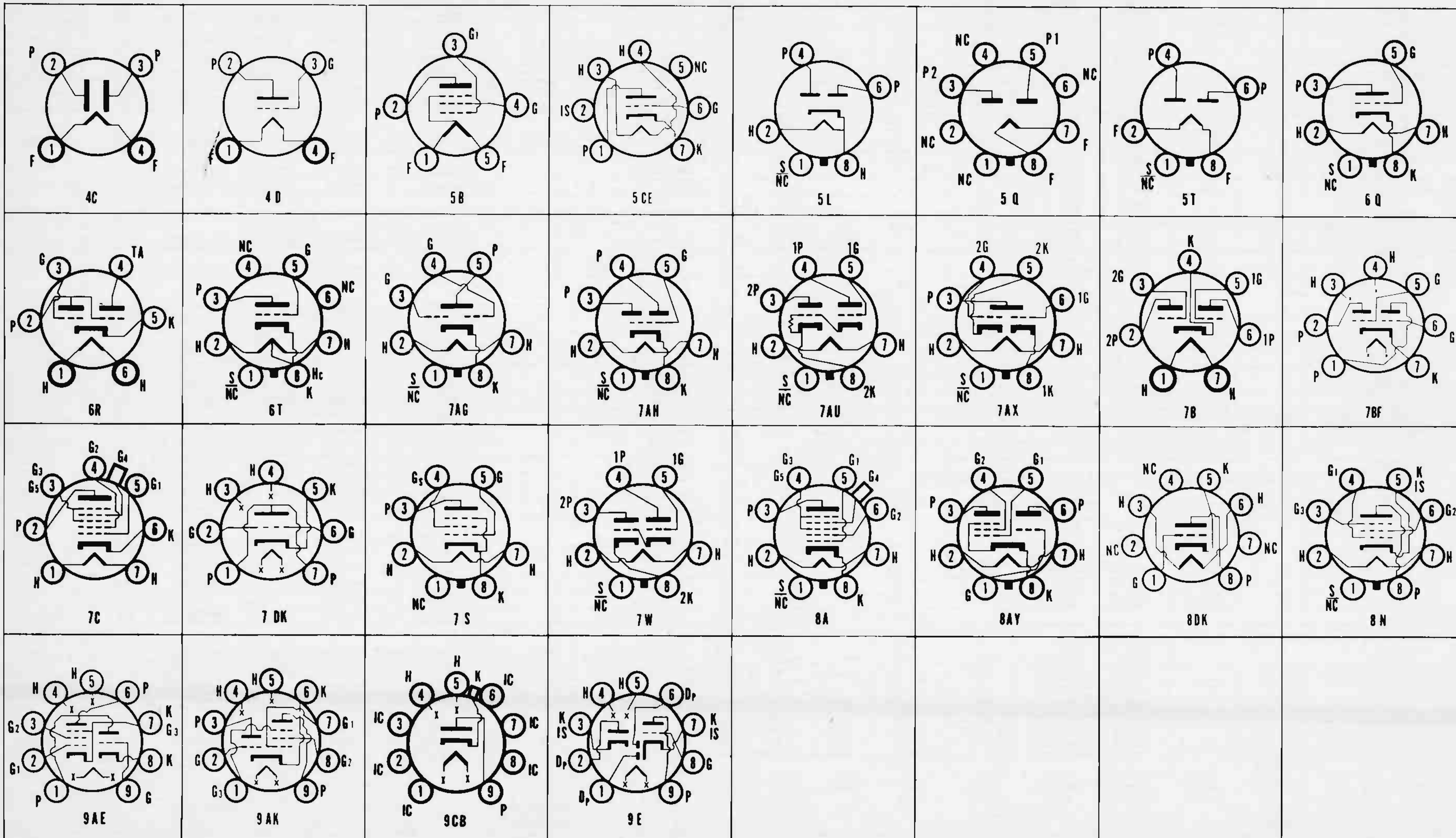
(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate; RF Input, Mixer Output.
I Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.

Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.

☐ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.

¶ Plate to Plate.
♦ Approximate.

m maximum.
■ Cathode Resistor (ohms).

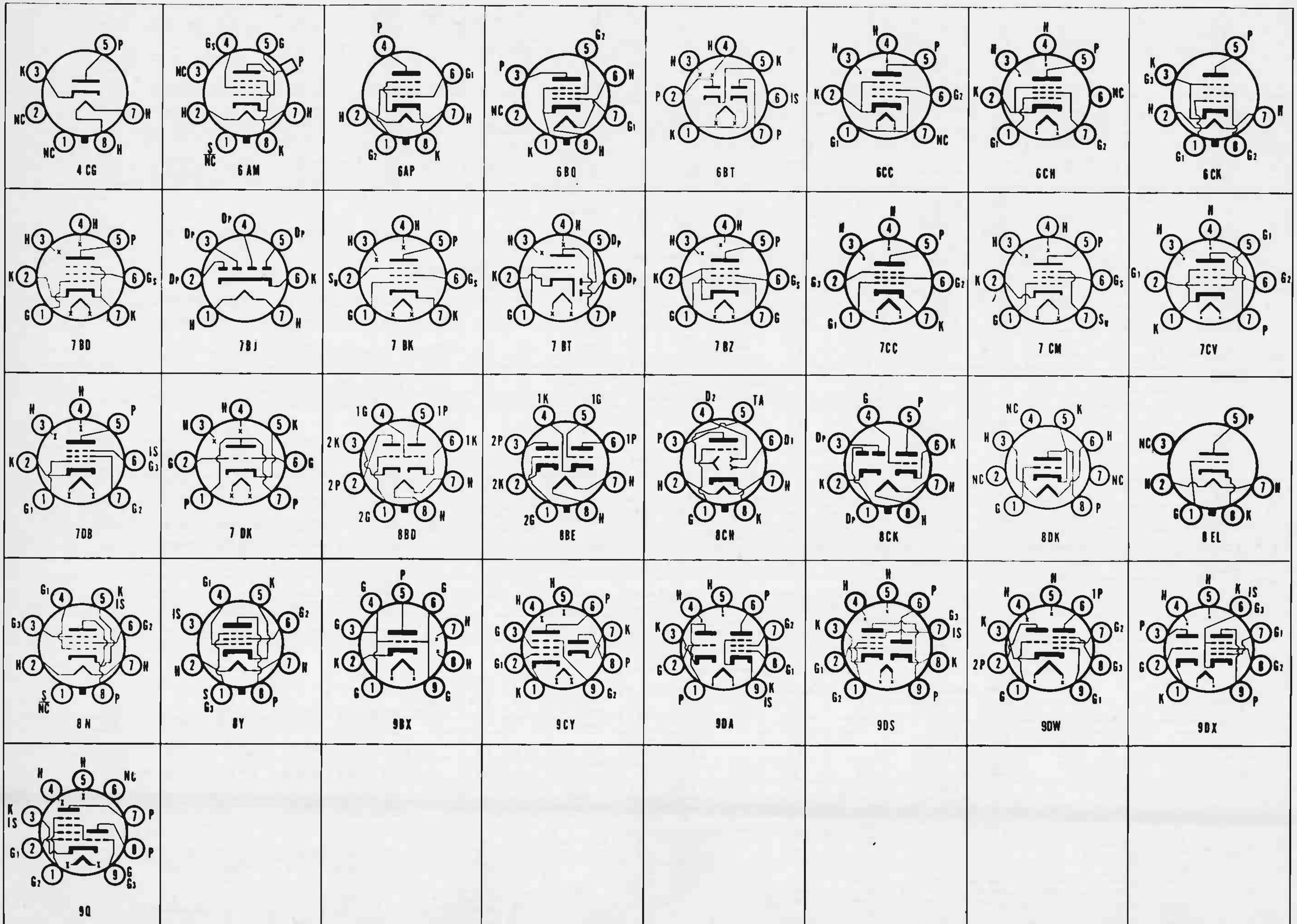


SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection, DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; ☐—Top Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (1) (2) Capacitances in μμf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Power Output Milli-watts	Type
6AG5	T-5½	Pentode	7BD-0-2&7	Cathode	6.3	0.300	.025m	6.1	2.3	R-F Amp.	100 125 250	180■ 100■ 180■	100 125 150	4.5 7.2 6.5	1.4 2.1 2.0	600,000♦ 500,000♦ 800,000♦	4,500 5,100 5,000	....	....	....	6AG5
6AG7	Metal	Pentode	8Y-1-3	Cathode	6.3	0.650	.06	13.0	7.5	Amplifier	300	3	150	30.0	7.0	130,000	11,000	....	10,000	3,000	6AG7
6AH4GT	T-9	Triode	8EL	Cathode	6.3	0.750	4.4*	7.0*	1.7*	Defl. Amp.	250	23	..	30	....	1,780	4,500	8	....	....	6AH4GT
6AH5G	ST-16	Beam Pent.	6AP-0-0	Cathode	6.3	0.900	....	....	....	Power Amp.	350	18	250	54	2.5	33,000	5,200	....	4,200	10,800	6AH5G
6AH6	T-5½	Pentode	7CC-0-0	Cathode	6.3	0.450	.02m	10.0	3.6	Pent. Amp. Tri. Amp.	300 150	160■ 160■	150	10 12.5	2.5	500,000 3,600	9,000 11,000	 40	....	....	6AH6
6AH6V							.035m	10.0	3.6		Designed Especially for Video Amplifier Applications.										6AH6V
6AH7GT	T-9	Duotriode	8BE-0-0	Cathode	6.3	0.300	....	....	....	Amplifier	Characteristics Same as Type 12AH7GT.										6AH7GT
6AJ4	T-6½	Triode	9BX	Cathode	6.3	0.225	....	....	....	UHF Amp.	125	68■	....	16	....	4,200♦	10,000	42	....	....	6AJ4
6AJ5	T-5½	Pentode	7BD-0-0	Cathode	6.3	0.175	.02	4.0	2.8	R-F Amp.	28	1.0	28	2.7	1.0	100,000	2,500	....	....	....	6AJ5
6AJ7	Metal	Pentode	8N-1-1	Cathode	6.3	0.450	....	....	....	R-F Amp.	300	160■	300	10.0	2.5	1 Meg.♦	9,000	9,000	....	....	6AJ7
6AK4	T-3	Triode	8DK	Cathode	6.3	0.125	1.3	2.2	2.2	UHF Amp.	200	680■	....	9.5	....	5,300	3,800	20	....	....	6AK4
6AK5	T-5½	Pentode	7BD-0-2&7	Cathode	6.3	0.175	.02	4	2.8	VHF Amp.	120 180	180■ 180■	120 120	7.5 7.7	2.5 2.4	300,000 500,000	5,000 5,100	1,700 3,500	....	....	6AK5
6AK6	T-5½	Power Pent.	7BK-0-0	Cathode	6.3	0.150	0.12*	3.6*	4.2*	Power Amp.	180	9.0	180	15.0	2.5	200,000	2,300	....	10,000	1,100	6AK6
6AK7	Metal	Power Pent.	8Y-1-3	Cathode	6.3	0.650	.06	13.0	7.5	Power Amp.	300	3.0	150	30.0	7.0	130,000	11,000	....	10,000	3,000	6AK7
6AL5	T-5½	Duodiode	6BT-0-6	Cathode	6.3	0.300	....	....	....	Detector	117 A.C. Volts Per Plate, RMS, 9 Ma. Output Current. 300 Ohms Min. Effective Plate Supply Impedance.										6AL5
6AL6G	ST-16	Beam Pent.	6AM-0-0	Cathode	6.3	0.900	....	....	....	Power Amp.	Characteristics Same as Type 6L6G.										6AL6G
6AL7GT	T-9	Electron Ray	8CH-0-0	Cathode	6.3	0.150	....	....	....	Indicator	315§	Grid Voltage for Fluorescent C.O. = —7.0 (App.). Deflection Sens = 1.0 MM. Per Volt (App.).									6AL7GT
6AM4	T-6½	Triode	9BX	Cathode	6.3	0.225	2.8	4.6	0.16	UHF Amp.	200	100■	....	10	....	8,700♦	9,800	85	....	....	6AM4
6AM5	T-5½	Pentode	6CH-0-0	Cathode	6.3	0.200	....	....	....	Power Amp.	250	13.5	250	16	2.4	130,000	2,600	....	16,000	1,400	6AM5
6AM6	T-5½	Pentode	7DB-0-6	Cathode	6.3	0.300	.01	10.0	3.25	R-F Amp.	250	2.	250	10	2.5	1 Meg.♦	7,500	....	....	....	6AM6
6AM8 6AM8A	T-6½	Diode Pent.	9CY	Cathode	6.3 6.3I	0.450 0.450	.015*	6.5*	2.6*	Amplifier Detector	125 Diode Plate Voltage 10 Volts for 50 Ma. Current. (Test Condition Only.)	56■	125	12.5	3.2	0.3 Meg.	7,800	....	....	....	6AM8 6AM8A
6AN4	T-5½	Triode	7DK	Cathode	6.3	0.225	1.7*	2.9*	0.25*	UHF Amp.	200	100■	....	13	....	7,000	10,000	70	....	....	6AN4
6AN5	T-5½	Power Pent.	7BD-0-0	Cathode	6.3	0.450	.075	9.0	4.8	Power Amp.	120	6.0	120	35.0	12.0	12,500♦	8,000	....	2,500	1,300	6AN5
6AN6	T-5½	Quadruple Di.	7BJ-0-0	Cathode	6.3	0.200	....	....	....	Rectifier	75 Volts RMS Per Plate, 8 Ma. D-C Output Per Plate.										6AN6
6AN7	T-6½	Tri. Hexode	9Q-0-3	Cathode	6.3	0.230	0.1	3.8	9.2	Tri. Osc. Converter	250 250 250	Applied through 33,000 Ohms. Grid Res. = 22,000 Ohms, Ib = 5.1 Ma. Applied through 33,000 Ohms. Grid Res. = 47,000 Ohms, Ib = 4.8 Ma. 2	 85	 3.0	 3.0	 100,000	 750▲				6AN7
6AN8 6AN8A	T-6½	Tri. Pentode	9DA	Cathode	6.3 6.3I	0.450 0.450	1.5* .04m*	2.0* 7.0*	0.26* 0.24*	Tri. Amp. Pent. Amp.	200 125	6.0 56■	 125	13.0 12	.... 3.8	5,750♦ .017 Meg. m	3,300 7,800	19	....	....	6AN8 6AN8A
6AQ5 6AQ5A	T-5½	Beam Pent.	7BZ-0-0	Cathode	6.3 6.3I	0.450 0.450	.... 0.17	.... 8.0	.... 11.0	Power Amp.	250 180	12.5 8.5	250 180	45.0 29.0	4.5 3.0	52,000 58,000	4,100 3,700	....	5,000 5,500	4,500 2,000	6AQ5 6AQ5A
6AQ6	T-5½	Duodiode Tri.	7BT-0-0	Cathode	6.3	0.150	1.8	1.7	1.5	Det. Amp.	100 250	1.0 3.0	....	0.8 1.0	....	61,000 58,000	1,150 1,200	70 70	....	....	6AQ6
6AQ7GT	T-9	Duodiode Tri.	8CK-0-0	Cathode	6.3	0.300	2.8	2.3*	1.5*	Det. Amp.	250	2.0	....	2.3	....	44,000	1,600	70	....	....	6AQ7GT
6AR5	T-5½	Power Pent.	6CC-0-0	Cathode	6.3	0.400	....	....	....	Power Amp.	250 250	16.5 18.0	250 250	34 32	5.7 5.5	65,000 68,000	2,400 2,300	....	7,000 7,600	3.2 3.4	6AR5
6AR6	T-11	Pentode	6BQ-0-0	Cathode	6.3	1.200	0.55*	11.0*	7.0*	Pent. Amp. Tri. Amp.	250 300 200	22.5 36.0 12.5	250 300	77 58 90	5.0 4.0	21,000 22,000 1,000	5,400 4,300 6,000	113 95 6	....	....	6AR6
6AS5	T-5½	Beam Pent.	7CV-0-0	Cathode	6.3	0.800	0.6*	12.0*	6.2*	Power Amp.	150	8.5	110	35	2.0	....	5,600	....	4,500	2,200	6AS5
6AS6	T-5½	Pentode	7CM-0-0	Cathode	6.3	0.175	.02	4.0	3.0	R-F Amp.	120	2.0	120	5.2	3.5	11,000	3,200	....	....	....	6AS6
6AS7G	ST-16	Duo. Pwr. Tri.	8BD-0-0	Cathode	6.3	2.500	....	....	....	Regulator	135	250■	....	112	....	280	7,000	2	....	....	6AS7GT
6AS8	T-6½	Diode Pent.	9DS-0-7	Cathode	6.3I	0.450	.02*	7.0*	2.4*	Det. Amp.	200	180■	150	9.5	3.0	300,000	6,200	....	....	....	6AS8
6AT6	T-5½	Duodiode Tri.	7BT-0-0	Cathode	6.3	0.300	2.1*	2.3*	1.1*	Det. Amp.	100 250	1.0 3.0	....	0.8 1.0	....	54,000 58,000	1,300 1,200	70 70	....	....	6AT6
6AT8 6AT8A	T-6½	Tri. Pentode	9DW-0-0	Cathode	6.3 6.3I	0.450 0.450	1.5 .016m	2.4 4.7	1.0 1.6	VHF Osc. VHF Amp.	100 250	100■ 200■	 150	8.5 7.7	.... 1.6	6,900 750,000♦	5,800 4,600	40	....	....	6AT8 6AT8A
6AU4GT	T-9	Diode	4CG-0-0	Cathode	6.3	1.800	....	....	....	T.V. Damper	P.I.V. = 4,500 Volts Abs. Max. D.C. Plate Current = 175 Ma. Max.										6AU4GT
6AU4GTA	T-9	Diode	4CG-0-0	Cathode	6.3	1.800	....	....	....	T.V. Damper	P.I.V. = 4,500 Volts Abs. Max. D.C. Plate Current = 190 Ma. Max.										6AU4GTA
6AU5GT	T-9	Beam Pent.	6CK-0-0	Cathode	6.3	1.250	0.5*	11.3*	7.0*	Horiz. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 5,500 Volts. Maximum D-C Plate Current = 110 Ma. Maximum Plate Dissipation = 10 Watts. Maximum Screen Dissipation = 2.5 Watts.										6AU5GT
6AU6 6AU6A	T-5½	Pentode	7BK-0-2	Cathode	6.3 6.3I	0.300 0.300	.0035*	5.5*	5.0*	R-F Amp.	100 250 250	150■ 100■ 68■	100 125 150	5.0 7.6 10.6	2.1 3.0 4.3	500,000♦ 1.5 Meg.♦ 1.0 Meg.♦	3,900 4,500 5,200	....	....	....	6AU6 6AU6A
6AU8	T-6½	Tri. Pentode	9DX-0-6	Cathode	6.3I	0.600	2.2* .046*	2.8* 7.0*	0.32* 2.6*	Tri. Amp. Pent. Amp.	150 200 (6AU8 Designed for Series String TV Receivers).	150■ 82■	 150	9.5 17.0	.... 3.6	7,200 140,000	5,600 8,000	40	....	....	6AU8

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate; RF Input, Mixer Output.
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
I Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
‡ Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



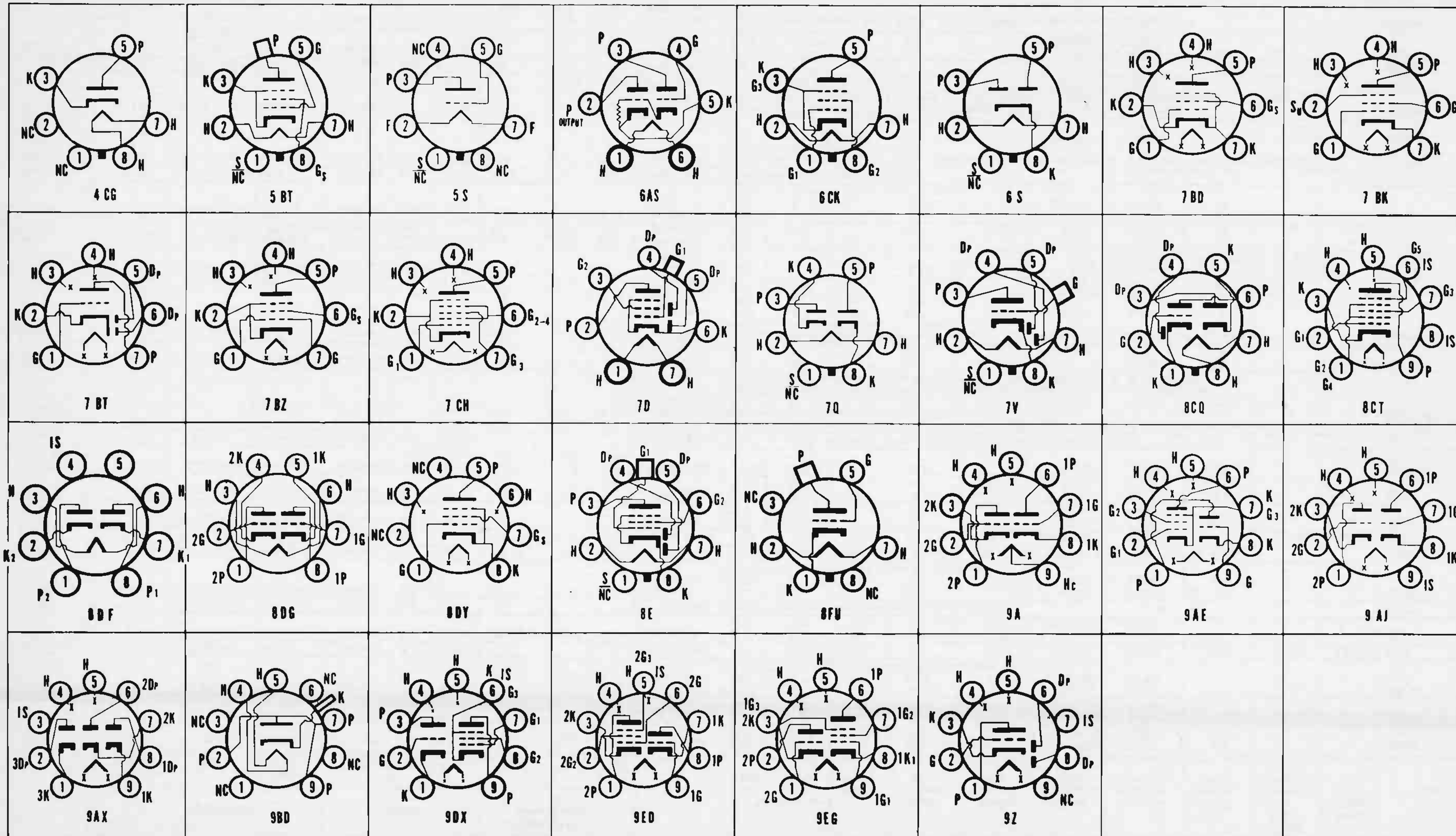
SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center, G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center, Ht—Heater Tap; IC—Internal Connection, DO NOT USE, J—Jumper, K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction			Emitter			Note (1) (2) Capacitances in μμf.			Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Undistorted Power Output Milliwatts	Type
	Bulb Size or Style	Class	Basing Diag.	Type	Volts	Amps.	Cgp.	Cin.	Cout												
6AU8A	T-6½	Tri. Pentode	9DX	Cathode	6.3‡	0.600	2.2* .06*	2.6* 7.5*	0.34* 3.4*	Tri. Amp. Pent. Amp.	150 200	150 ■ 82 ■	 125	9.5 17	.... 3.4	8,100 100,000	5,300 8,000	....	40	....	6AU8A
											Instantaneous Plate Knee Values for 6AU8A: EB = 40 Volt, EC_2 = 125 Volt, EC1 = 0. IB = 28 Ma, IC_2 = 10 Ma.										
6AV5GT	T-9	Beam Pent.	6CK-0-0	Cathode	6.3	1.200	....	....	....	Horiz. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 5,500 Volts. Maximum D-C Plate Current = 110 Ma. Maximum Plate Dissipation = 11 Watts. Maximum Screen Dissipation = 2.5 Watts.										6AV5GT
											250	22.5	150	55	2.1	20,000	5,500	....	....	....	
6AV5GA	T-11 or T-12	Beam Pentode	6CK-0-0	Cathode	6.3	1.200	0.5*	14.0*	7.0*	Horizontal Def. Amp.	60 250	0 22.5	150 150	225 55	25 2.1	Plate Knee Characteristics 20,000	 5,500	.... 4.3**	.... When Eb = 150	....	6AV5GA
6AV6	T-5½	Duodiode Tri.	7BT-0-0	Cathode	6.3	0.300	2.1	2.3	0.9	Det. Amp.	250 100	2.0 1.0	....	1.2 0.5	....	62,500 80,000	1,600 1,250	100 100	....	....	6AV6
6AW7GT	T-9	Duodiode Tri.	8CQ-1-0	Cathode	6.3	0.300	....	....	....	Det. Amp.	100	0	.....	1.4	....	......	1,200	80	....	....	6AW7GT
6AW8 6AW8A	T-6½	Tri. Pentode	9DX-0-6	Cathode	6.3‡	0.600	2.2 .03 2.2 .03	3.4 11.0 3.4 10.0	1.7 3.6 1.7 4.5	Tri. Amp. Pent. Amp.	200 200	2.0 180 ■	 150	4.0 13.0	.... 3.5	17,500 250,000	4,000 9,000	70	....	....	6AW8 6AW8A
											6AW8 and 6AW8A are Similar Except for Plate Knee Characteristics of 6AW8A. Instantaneous Plate Knee Values for 6AW8A. EB = 65 Volt, EC^2 = 150 Volt, EC^1 = 0. IB = 42 Ma., IC^2 = 12.5 Ma.										
6AX4GT	T-9	Diode	4CG	Cathode	6.3	1.200	....	....	....	T.V. Damper	P.I.V. = 4,400 Volts Max., D-C Plate Current = 125 Ma. Max.										6AX4GT
6AX5GT	T-9	Duodiode	6S-0-0	Cathode	6.3	1.200	....	....	....	F-W Rect.	350 A.C. Volts Per Plate, R.M.S., 125 Ma. D.C. Output. Condenser Input to Filter. 450 A.C. Volts Per Plate, R.M.S., 125 Ma. D.C. Output. Choke Input to Filter.										6AX5GT
6AX6G	ST-14	Duodiode	7Q-0-0	Cathode	6.3	2.500	....	....	....	F-W Rect.	350 A.C. Volts Per Plate, R.M.S., 250 Ma. Output. Condenser Input to Filter.										6AX6G
6AX7	T-6½	Duotriode	9A-0-0	Cathode	6.3/ 3.15‡	0.300/ 0.600	1.7* 1.7*	1.6* 1.6*	0.46* 0.34*	Amplifier	Characteristics Same as Type 12AX7. (6AX7 Designed for Series String TV Receivers).										6AX7
6AX8	T-6½	Tri. Pentode	9AE-0-7	Cathode	6.3	0.450	1.8 .006m	2.5 5.0	1.0 3.5	Sync. Sep. Video Amp.	150 250	56 ■ 120 ■	 110	18 10	.... 3.5	5,000 400,000	8,500 4,800	40	....	....	6AX8
6AZ5	T-3	Duodiode	8DF-0-4	Cathode	6.3	0.150	....	....	....	Rectifier	Plate Supply Voltage = 50 Volts, RMS, Each Plate. DC Output Current = 4 Ma. Each Plate. Capacitor Input to Filter.										6AZ5
6AZ8	T-6½	Tri. Pentode	9ED-0-5	Cathode	6.3	0.450	1.7* .02*	2.0* 6.5*	1.7* 2.2*	Sync. Sep. Video Amp.	200 200	6 180 ■	 150	13.0 9.5	.... 3.0	5,750 300,000	3,300 6,000	19	....	....	6AZ8
6B3	T-6½	Diode	9BD-0-0	Cathode	6.3	1.200	....	....	....	T.V. Damper	Maximum Peak Inverse Plate Voltage = 4,400 Volts. Maximum D.C. Plate Current = 150 Ma.										6B3
6B4G	ST-16	Triode	5S-0-0	Filament	6.3	1.000	16.0	7.0	5.0	Power Amp.	Characteristics Same as Type 6A3.										6B4G
6B5	ST-14	Duotriode	6AS-0-0	Cathode	6.3	0.800	....	....	....	Power Amp.	Characteristics Same as Type 6N6G.										6B5
6B6G	ST-12	Duodiode Tri.	7V-0-0	Cathode	6.3	0.300	1.7	1.7	3.8	Det. Amp.	250	2.0	.....	0.9	....	91,000	1,100	100	....	....	6B6G
6B7 6B7S	ST-12	Duodi. Pent.	7D-0-6 7D-6-6	Cathode	6.3	0.300	.007	3.5*	9.5	R-F or I-F Det. Amp. A-F Amp.	100 180 250 250	3.0 3.0 3.0 4.5	100 75.0 100 50.0	5.8 3.4 6.0 0.65	1.7 0.9 1.5	300,000 1 Meg. 800,000	950 840 1,000	....	....	....	6B7 6B7S
6B8	Metal	Duodi. Pent.	8E-1-1	Cathode	6.3	0.300	.005m	6.0	9.0	Det. Amp.	Characteristics Same as Type 6B7, Except Capacitances.										6B8
6B8G 6B8GT	ST-12 T-9	Duodi. Pent.	8E-0-8 8E-1-8	Cathode	6.3	0.300	.01m	3.6	9.5	Det. Amp.	Characteristics Same as Type 6B7.										6B8G 6B8GT
6BA5	T-3	Pentode	8DY-0-0	Cathode	6.3	0.150	.065	3.4	3.6	A-F Amp.	100	270 ■	100	5.5	2.0	175,000	2,150	.....	....	....	6BA5
6BA6	T-5½	Pentode	7BK-0-2	Cathode	6.3	0.300	.0035m*	5.5*	5.0*	R-F Amp.	100 250	68 ■ 68 ■	100 100	10.8 11.0	4.4 4.2	250,000 ♦ 1.0 Meg. ♦	4,300 4,400	....	....	....	6BA6
6BA7	T-6½	Heptode	8CT-0-6&8	Cathode	6.3	0.300	0.19m	9.5	8.3	Converter	100 250	1.0 1.0	100 100	3.6 3.8	10.2 10.0	500,000 1 Meg.	900▲ 950▲	....	....	....	6BA7
6BA8 6BA8A	T-6½	Tri. Pentode	9DX-0-6	Cathode	6.3‡	0.600	2.2 .03 2.2 .03	2.7 11.0 2.7 10.0	2.2 3.6 1.9 4.5	Tri. Amp. Pent. Amp.	200 200	8.0 180 ■	 150	8.0 13.0	.... 3.5	6,700 400,000	2,700 9,000	18	....	....	6BA8 6BA8A
											6BA8 and 6BA8A are Similar Except for Plate Knee Characteristics of 6BA8A. Instantaneous Plate Knee Values for 6BA8A EB = 65 Volt, EC^2 = 150 Volt, EC^1 = 0. IB = 42 Ma., IC^2 = 12.5 Ma.										
6BC5	T-5½	Pentode	7BD-0-2&7	Cathode	6.3	0.300	.02	6.6	2.6	Tri. Amp. Pent. Amp.	250 180 100 125 250	820■ 330■ 180■ 100■ 180■	.... 100 125 150	6.0 8.0 4.7 8.0 7.5	.... 1.4 2.4 2.1	9,000 ♦ 6,000 ♦ 600,000 ♦ 500,000 ♦ 800,000 ♦	4,400 6,000 4,900 6,100 5,700	40 42	....	....	6BC5
6BC7	T-6½	Triple Diode	9AX-0-3	Cathode	6.3	0.450	....	....	....	F. M. Det.	High Perveance Diode										6BC7
6BC8	T-6½	Duotriode	9AJ-0-9	Cathode	6.3	0.400	1.4	2.5	1.3	Class A1 Amplifier #	150	220 ■	.....	10.0	....	......	6,200	35	....	....	6BC8
6BD4	T-12	Beam Triode	8FU	Cathode	6.3	0.600	1.0*	3.8*	0.04m*	Hi-Volt. Reg.	20,000 Max. D.C. Plate Volts. 125 Max. D.C. Grid Volts. 1.5 Ma. Max. D.C. Plate Current.										6BD4
6BD4A	T-12	Beam Triode	8FU-0-0	Cathode	6.3	0.600	1.0*	3.8*	0.04m*	Hi-Volt. Reg.	27000 Max. D.C. Plate Volts. 125 Max. D.C. Grid Volts. 1.5 Ma. Max. D.C. Plate Current.										6BD4A
6BD5GT	T-9	Beam Pent.	6CK-0-0	Cathode	6.3	0.900	....	....	....	Horiz. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 4,000 Volts. Maximum D-C Cathode Current = 100 Ma. Maximum Plate Dissipation = 10 Watts. Maximum Screen Dissipation = 3.0 Watts.										6BD5GT
6BD6	T-5½	Pentode	7BK-0-2	Cathode	6.3	0.300	.004	4.3	5.0	R-F Amp.	250 100	3.0 1.0	100 100	9.0 13	3.5 5.0	700,000 120,000	2,000 2,350	....	....	....	6BD6
6BD7	T-6½	Duodiode Tri.	9Z-0-7	Cathode	6.3	0.230	1.3	2.4	1.3	Det. Amp.	250	3	.....	1.0	....	58,000	1,200	70	....	....	6BD7
6BE6	T-5½	Heptode	7CH-0-0	Cathode	6.3	0.300	0.3*	7.0*	8.0*	Converter	100 250	1.5 1.5	100 100	2.6 2.9	7.0* 6.8	400,000 ♦ 1.0 Meg. ♦	455▲ 475▲	(Osc. Grid Res. = 20,000 Ohms) (Osc. Grid Current 0.5 Ma.)			6BE6
6BE8 6BE8A	T-6½	Tri. Pentode	9EG	Cathode	6.3 6.3‡	0.450 0.450	1.8* .04*	2.8* 4.4*	1.5* 2.6*	VHF Osc. VHF Amp.	150 250	56 ■ 68 ■	 110	18.0 10.0	.... 3.5	5,000 400,000	8,500 5,200	40	....	....	6BE8 6BE8A

6BF5	T-5½	Pentode	7BZ	Cathode	6.3	1.200	0.65*	14*	6.0*	S.T. A1 Amp.	110	7.5	110	36	4	12,000	7,500	....	2,500	1,900	6BF5
6BF6	T-5½	Duodiode Tri.	7BT-0-0	Cathode	6.3	0.300	1.9	1.9	1.2	Det. Amp.	250	9.0	....	9.5	....	8,500	1,900	16	10,000	300	6BF6
6BF7	T-3	Duotriode	8DG-0-0	Cathode	6.3	0.300	1.5 1.5	2.0 2.0	1.6 2.0	R-F Amp.#	100 100	100 ■ 100 ■	.....	8.0 8.0	....	7,000 ♦ 7,000 ♦	4,800 4,800	35 35	....	....	6BF7
6BF7A	T-3	Duotriode	8DG-0-0	Cathode	6.3	0.300	1.5 1.5	2.0 2.0	1.6 2.0	R-F Amp.#	100	100 ■	.....	8.0	....	7,300 ♦	4,800	35	Cout Sec. 1 = 1.6 μμf.		6BF7A
6BF7W (3)	T-3	Duotriode	8DG-0-0	Cathode	6.3	0.300	1.5 1.5	2.0 2.0	1.6 2.0	R-F Amp.	Ruggedized Version of Type 6BF7.										6BF7W (3)
6BG6G 6BG6GA	ST-16 T-12	Beam Pent.	5BT-0-0	Cathode	6.3	0.900	0.34m* 0.8*	12.0* 11.0*	6.5* 6.0*	Horiz. Defl. Amp.	Max. Peak Positive Plate Voltage = 6,600 Volts. Max. D.C. Cathode Current = 110 Ma. Max. Plate Dissipation = 20 Watts. Max. Screen Dissipation = 3.2 Watts.										6BG6G 6BG6GA

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate; RF Input, Mixer Output.
X Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



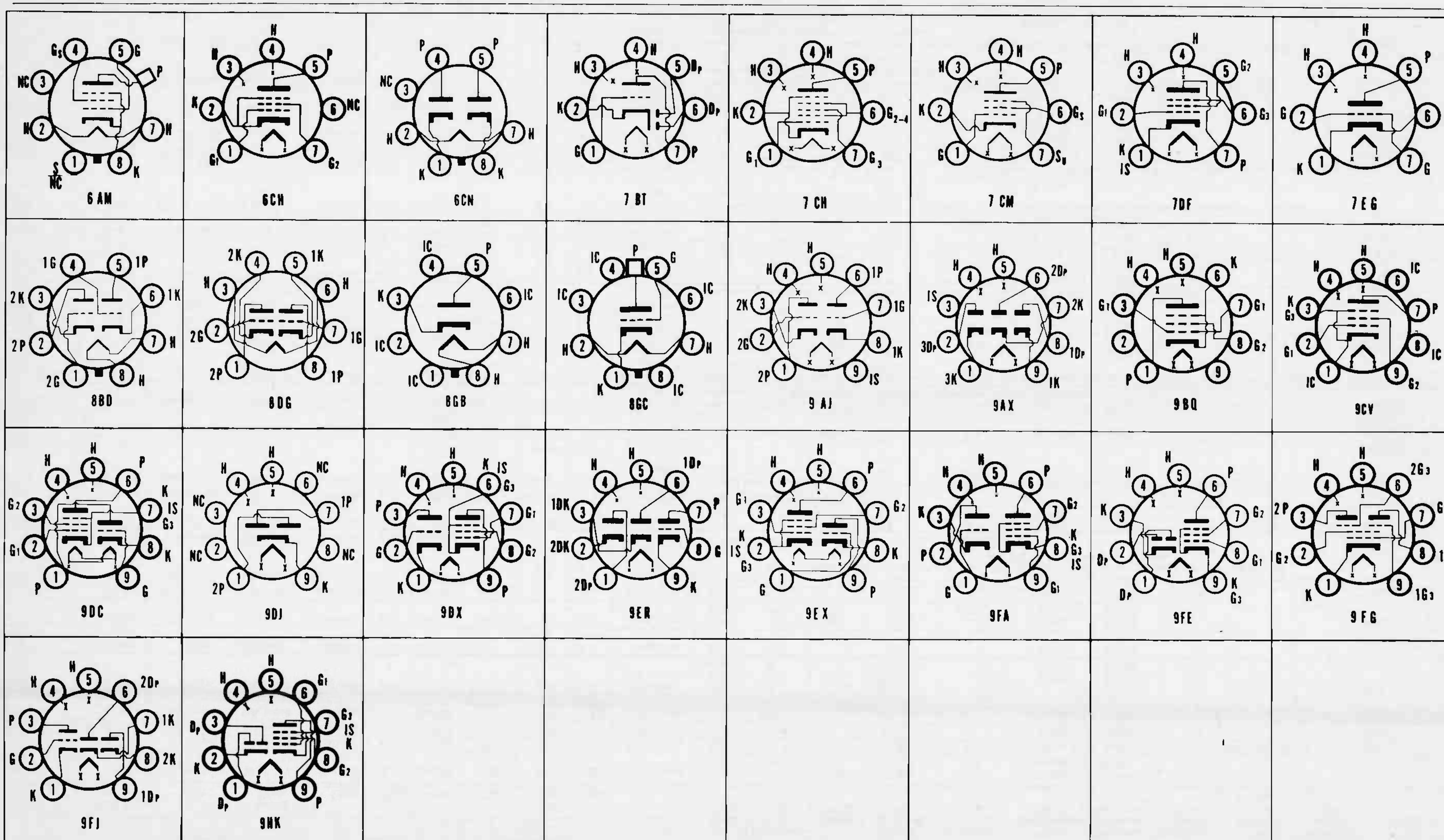
SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection, DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Tap Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction			Emitter			Note (1) (2) Capacitances in μμf.			Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Power Output Milliwatts	Type
	Bulb Size or Style	Class	Basing Diag.	Type	Volts	Amps.	Cgp.	Cin.	Cout												
6BG7	T-3	Duotriode	8DG-0-0	Cathode	6.3	0.300	1.5 1.5	2.0 2.0	1.6 2.0	R-F Amp.# R-F Amp.	100 100	100■ 100■	....	8.0 8.0	....	7,000♦ 7,000♦	4,800 4,800	35 35	....	....	6BG7
6BH6	T-5½	Pentode	7CM-0-7	Cathode	6.3	0.150	.0035m*	5.4*	4.4*	R-F Amp.	100 250	1.0 1.0	100 150	3.6 7.4	1.4 2.9	0.7 Meg.♦ 1.4 Meg.♦	3,400 4,600	....	....	....	6BH6
6BH8	T-6½	Tri. Pentode	9DX-0-6	Cathode	6.3†	0.600	2.4* .046*	2.6* 7.0*	3.8* 2.4*	Tri. Amp. Pent. Amp.	150 200	5 82■	 125	9.5 15.0	.... 3.4	5,150 150,000	3,300 7,000	17	....	....	6BH8
											(6BH8 Designed for Series String TV Receivers).										
6BJ5	T-5½	Pentode	6CH	Cathode	6.3	0.640	....	....	....	Power Amp.	250	5.0	250	3.5	5.5	40,000	10,500	450	7,000	4,000	6BJ5
6BJ6	T-5½	Pentode	7CM-0-7	Cathode	6.3	0.150	.0035m*	4.5*	5.0*	R-F Amp.	250 100	1.0 1.0	100 100	9.2 9.0	3.3 3.5	1.3 Meg. 250,000	3,600 3,650	....	....	....	6BJ6
6BJ7	T-6½	Triple Diode	9AX-0-3	Cathode	6.3	0.450	....	....	....	TV DC Rest'r	Each Section Similar to Each Section of a 6AL5.										6BJ7
6BJ8	T-6½	Duodiode Tri.	9ER-0-0	Cathode	6.3†	0.600	2.6*	2.8*	0.31*	Class A1 Amplifier	90 250	0 9	....	13.5 8.0	....	4,700 7,150	4,700 2,800	22 20	....	....	6BJ8
											(6BJ8 Designed for Series String TV Receivers).										
6BK4	T-12	Beam Triode	8GC-0-0	Cathode	6.3	0.200	.03*	2.6*	1.0*	Hi-Volt. Reg.	25000 Max. D.C. Plate Volts. 125 D.C. Grid Volts. 1.5 Ma. Max. D.C. Plate Current.										6BK4
6BK5	T-6½	Beam Pent.	9BQ-0-0	Cathode	6.3	1.200	0.6*	13.0*	5.0*	Power Amp.	250	5.0	250	35	3.5	0.1 Meg.♦	8,500	....	6,500	3,500	6BK5
6BK6	T-5½	Duodiode Tri.	7BT-0-2	Cathode	6.3	0.300	....	....	....	Det. Amp.	100 250	1.0 2.0	....	0.5 1.2	....	80,000 62,500	1,250 1,600	100 100	....	....	6BK6
6BK7	T-6½	Duotriode	9AJ-0-9	Cathode	6.3	0.450	1.9 1.9	3.0 3.0	1.1 1.0	VHF Amp.	100 150	120■ 56	....	9.0 18	....	6,100 4,700	6,100 8,500	37 40	....	....	6BK7
6BK7A 6BK7B	T-6½	Duotriode	9AJ-0-9	Cathode	6.3 6.3†	0.450 0.450	1.8* 1.8*	3.0* 3.0*	1.0* 0.9*	VHF Amp.	150	56■	....	18.0	....	4,600	9,300	43	....	....	6BK7A 6BK7B
6BL4	T-12	Diode	8GB-0-0	Cathode	6.3	3.000	....	....	....	T.V. Damper	P.I.V. = 4,500 Volts Abs. Max. D.C. Plate Current = 200 Ma. Max.										6BL4
6BL7GT 6L7GTA	T-9	Duotriode	8BD	Cathode	6.3	1.500	6.0* 6.0*	4.2* 4.6*	0.9* 0.9*	Vert. Osc. Vert. Defl. Amp.‡	Maximum Peak Positive Pulse Plate Voltage = 2,000 Volts. Maximum D.C. Cathode Current = 60 Ma. Maximum Plate Dissipation = 10 Watts.										6BL7GT 6BL7GTA
											250	9	....	40	....	2,150	7,000	15	....	....	
											6BL7GT and 6BL7GTA are Similar Except for Plate Knee Characteristics of 6BL7GTA. Instantaneous Plate Knee Values for 6BL7GTA: EB = 150, EC = 0, IB = 65 Ma.										
6BL8	T-6½	Tri. Pentode	9DC-0-7	Cathode	6.3	0.450	.025* 1.5*	5.5* 2.5*	3.8* 1.8*	VHF Osc. VHF Amp.	100 170	2.0 2.0	 170	14.0 10.0	.... 2.8	 400,000	5,000 6,200	20 47	....	....	6BL8
6BM8	T-6½	Tri. Pentode	9EX-0-2	Cathode	6.3	0.780	4.0* 0.3*	2.7* 9.3*	4.0* 8.0*	Pent. Vert.	Maximum Peak Positive Pulse Plate Voltage = 2,500 Volts. Maximum D.C. Cathode Current = 50 Ma. Maximum Plate Dissipation = 7 Watts.										6BM8
										Defl. Amp. Tri. Vert. Osc.	200 100	16.0 0	200	35.0 3.5	7.0	20,000	6,400 2,500	9.5 70	....	....	
6BN4	T-5½	Triode	7EG	Cathode	6.3	0.200	1.2	3.2	1.4	VHF Amp.	150	220■	....	9.0	....	6,300	6,800	43	....	....	6BN4
6BN6	T-5½	Gated Beam	7DF-0-1	Cathode	6.3	0.300	....	....	....	Quad. F. M. Det.	65	1.3♦	60	0.23	5.0	Grid No. 1 Signal Voltage (RMS) = 30 Volts. Grid No. 3 Signal Voltage (RMS) = 4 Volts.					6BN6
6BN7	T-6½	Duotriode Note: Triode sections are different	9AJ-0-0	Cathode	6.3	0.750	0.7 3.0	1.4 5.5	0.3 1.6	Oscillator Amplifier	120 250	1.0 15.0	....	5.0 24.	....	14,000 2,200	2,000 5,500	28 12	....	....	6BN7
6BN8	T-6½	Duodiode Tri.	9ER	Cathode	6.3†	0.600	2.5*	3.6*	0.25*	Class A1 Amp	100 250	1 3	....	1.5 1.6	....	21,000 28,000	3,500 2,500	75 70	....	....	6BN8
											(6BN8 Designed for Series String Receivers.)										
6BQ5	T-6½	Beam Pent.	9CV	Cathode	6.3	0.760	0.5m*	10.8*	6.5*	Power Amp.	Characteristics Same as Type EL84.										6BQ5
6BQ6G 6BQ6GA 6BQ6GTA 6BQ6GTB	ST-12 T-11 T-9 T-9	Beam Pent.	6AM-0-0	Cathode	6.3	1.200	0.6*	15.0*	7.0*	Horiz. Defl. Amp.	6,000 Max. Peak Pos. Plate Volts. 110 Ma. Max. Cathode Current. 11 Watts Max. Plate Dissipation. 2.5 Watts Max. Screen Dissipation.										6BQ6G 6BQ6GA 6BQ6GTA
											250	22.5	150	57	2.1	14,500	5,900	....	....	....	
6BQ6GT	T-9	Beam Pent.	6AM-0-0	Cathode	6.3	1.200	0.6*	15.0*	7.0*	Horiz. Defl. Amp.	Characteristics Same as Type 6BQ6G. Dissipation Ratings Same as Type 6BQ6G. Maximum Peak Positive Plate Voltage = 5,500 Volts. Maximum D.C. Cathode Current = 110 Ma.										6BQ6GT
6BQ7	T-6½	Duotriode	9AJ-0-9	Cathode	6.3	0.400	1.15	2.55	1.30	VHF Amp.	150	220■	....	9.	....	5,800	6,000	35	....	....	6BQ7
6BQ7A	T-6½	Duotriode	9AJ	Cathode	6.3	0.400	1.2	2.6	1.2	VHF Amp.	150	220■	....	9	....	5,800	6,000	38	....	....	6BQ7A
6BR8	T-6½	Triode Pentode	9FA	Cathode	6.3	0.450	1.8 .008	2.5 5.0	1.0 3.5	Oscillator Mixer	150 250	56■ 68■	 110	18 10	.... 3.5	5,000 400,000	8,500 5,200	40	....	....	6BR8
6BR8A	T-6½	Tri. Pentode	9FA	Cathode	6.3†	0.450	1.8 .008	2.5 5.0	1.0 3.5	VHF Osc. VHF Amp.	Characteristics Same as Type 6BR8. (6BR8A Designed for Series String Receivers).										6BR8A
6BS8	T-6½	Duotriode	9AJ	Cathode	6.3	0.400	1.15	2.6	1.2	VHF Amp.	150	220■	....	10	....	5,000	7,200	36	....	....	6BS8
6BT6	T-5½	Duodiode Tri.	7BT-0-2	Cathode	6.3	0.300	....	....	....	Det. Amp.	100 250	1.0 3.0	....	0.8 1.0	....	54,000 58,000	1,300 1,200	70 70	....	....	6BT6
6BT8	T-6½	Duodi. Pent.	9FE	Cathode	6.3	0.450	.04m*	7.0*	2.3*	Amp. Det.	200	180■	150	9.5 8.0 with 10 Volts D.C. Each Unit.	2.8	300,000	6,200	....	....	....	6BT8
6BU4	T-12	Triode	8GC	Cathode	6.3	0.450	.03*	2.0*	8.0*	H.V. Reg.	25,000	8.4		1.0	....	8.2 Meg.♦	185	1,515			6BU4
6BU6	T-5½	Duodiode Tri.	7BT-0-2	Cathode	6.3	0.300	....	....	....	Det. Amp.	100 250	3.0 9.0	....	3.9 9.5	....	11,000 8,500	1,500 1,900	16.5 16.0	 10,000	 300	6BU6
6BU8	T-6½	Duo Pentode	9FG-0-2	Cathode	6.3	0.300	G3 to P 1.9	6.0	3.0	Sync. Sep.	100 100	0 Grid 1 ..	67.5 67.5	.... 2.2	....	....	180 Gr. 3 1500 Gr. 1	Grid #3 Volts = −4.5 Grid #1 Volts = −2.3			6BU8
6BV8	T-6½	Duodiode Tri.	9FJ-0-0	Cathode	6.3†	0.600	2.0*	3.6*	0.4*	Det. Amp.	200	330■	....	11.0	....	5,900	5,600	33	....	....	6BV8
6BW4	T-6½	Duodiode	9DJ	Cathode	6.3	0.900	....	....	....	F-W Rect.	325 A.C. Volts Per Plate, RMS, 100 Ma. Output Current. Capacitor Input to Filter. 450 A.C. Volts Per Plate, RMS, 100 Ma. Output Current. Choke Input to Filter.										6BW4

6BW8	T-6½	Duodi. Pent.	9HK	Cathode	6.3⧗	0.450	.02m*	4.8*	2.6*	R-F or I-F Amplifier	250	68■	110	10.0	3.5	250,000	5,200	....	....	....	6BW8
6BX7GT	T-9	Duotriode	8BD	Cathode	6.3	1.500	4.2 4.0	5.0 5.0	3.4 3.2	Vert. Amp. Vert. Osc.	Maximum Peak Positive Pulse Plate Volts = 2,000 Volts. Maximum D.C. Cathode Current = 60 Ma. Maximum Plate Dissipation = 10 Watts. 250	390■	....	42	....	1,300	7,600	10	....	....	6BX7GT
6BX8	T-6½	Duotriode	9AJ	Cathode	6.3	0.400	1.4 1.4	4.9 2.4	2.6 1.25	VHF Amp.	65	1.0	.....	9	....	......	6,700	25	....	....	6BX8
6BY5G	ST-14	Duodiode	6CN-0-0	Cathode	6.3	1.600	....	....	....	F-W Rect.	375 A.C. Volts Per Plate, R.M.S., 175 Ma. D.C. Output Current. Condenser Input to Filter.										6BY5G
6BY5GA	T-12	Duodiode	6CN-0-0	Cathode	6.3	1.600	....	....	....	T.V. Damper	P.I.V. = 3,000 Volts Abs. Max. D.C. Plate Current = 175 Ma. Max. Each Plate.										6BY5GA
6BY6	T-5½	Heptode	7CH-0-0	Cathode	6.3	0.300	.08m*	5.4*	7.6*	Sync. Separator	10	G1&2=0	25	1.4	3.5	Plate Current = 50μ Amps. When Grid 3 Voltage = 2.5					6BY6

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate; RF Input, Mixer Output.
⧗ Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection, DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

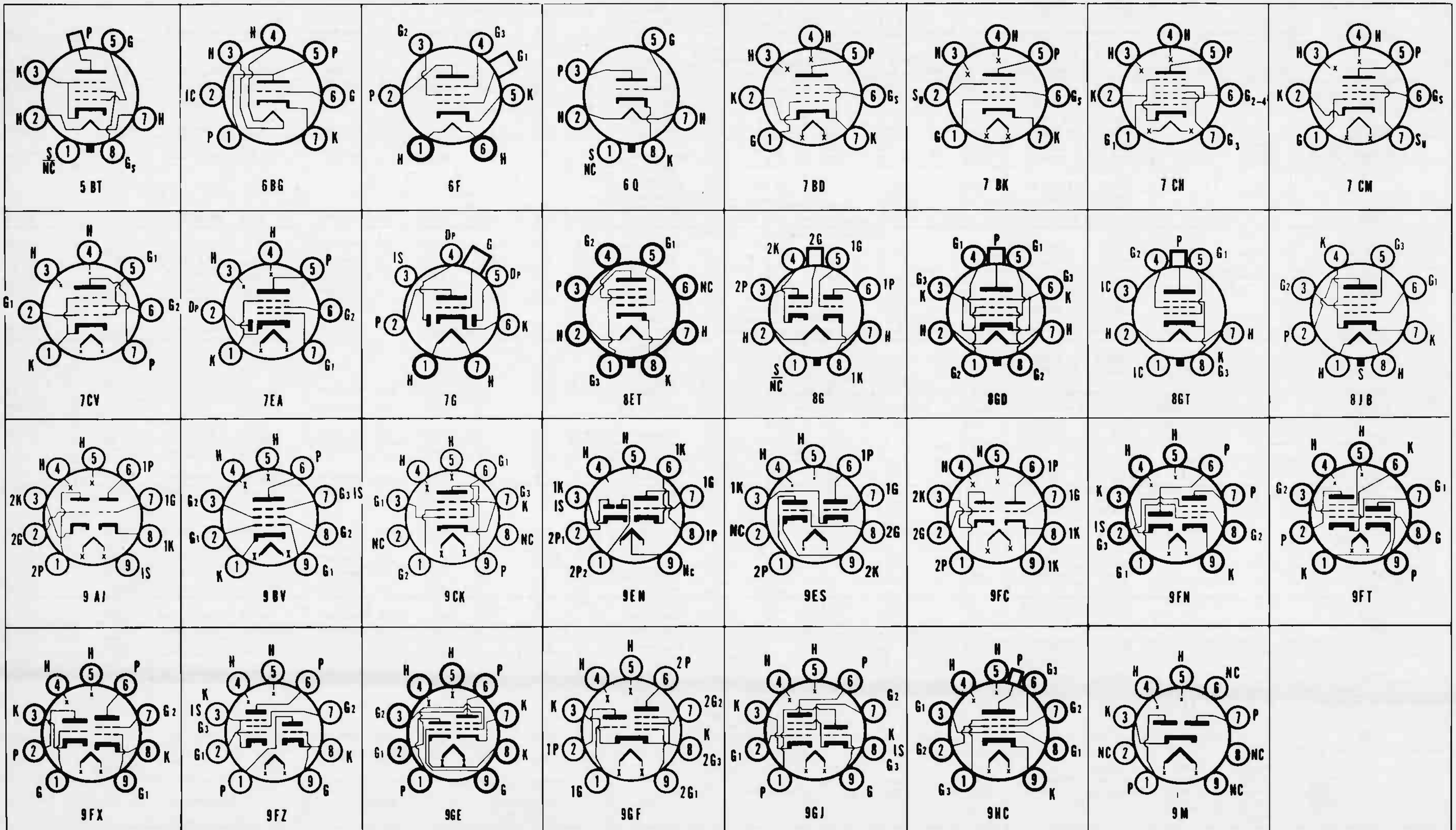
SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (¹) (²) Capacitances in µµf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Power Output Milli-watts	Type
6BY8	T-6½	Diode Pent.	9FN	Cathode	6.3‡	0.600	.0035*	5.5*	5.0*	Det. Amp.	100 250	150■ 68■	100 150	5.0 10.6	2.1 4.3	500,000 1.0 Meg.	3,900 5,200	....	....	....	6BY8
6BZ6	T-5½	Pentode	7CM-0-7	Cathode	6.3	0.300	.015m	7.5	2.8	R-F Amp.	200	180■	150	11.0	2.6	0.6 Meg.♦	6,100	Semi-Remote Cutoff.			6BZ6
6BZ7	T-6½	Duotriode	9AJ-0-9	Cathode	6.3	0.400	1.2	2.6	1.2	VHF Amp.	150	220■	.....	10	....	5,300	6,800	36	....	....	6BZ7
6BZ8	T-6½	Duotriode	9AJ-0-9	Cathode	6.3	0.400	1.15* 1.15*	2.5* 4.95*	1.35 3.27*	VHF Amp.	125	100■	.....	10	....	5,600	8,000	45	....	....	6BZ8
6C4	T-5½	Triode	6BG-0-0	Cathode	6.3	0.150	1.4	1.8	2.5	R-F Osc. R-F Amp.	300 250 100	27 8.5 0	....	25 10.5 11.8	....	...... 7,700 6,250	..... 2,200 3,100	..... 17 19.5	Class C	5,500	6C4
6C5 6C5GT	Metal T-9	Triode	6Q-1-1	Cathode	6.3	0.300	2.0 2.2	3.0 4.8	11.0 12.0	Amplifier	250	8.0	.....	8.0	....	10,000	2,000	20	....	....	6C5 6C5GT
6C6	ST-12	Pentode	6F-0-5	Cathode	6.3	0.300	.007m*	5.0*	6.5*	Amplifier	100 250	3.0 3.0	100 100	2.0 2.0	0.5 0.5	1 Meg. 1 Meg.>	1,185 1,225	....	....	....	6C6
6C7	ST-12	Duodiode Tri.	7G-3-6	Cathode	6.3	0.300	....	....	....	Det. Amp.	250	9.0	.....	4.5	....	16,000	1,250	20	....	....	6C7
6C8G	ST-12	Duotriode	8G-0-0	Cathode	6.3	0.300	2.6 1.8	2.6 1.3	2.0 2.2	Amplifier Inverter	250 250	4.5 3.0	.....	3.2	....	22,500	1,600	36	(One Section)		6C8G
											Plate Load 100,000 Ohms, Self-Bias Resistor 1,500 Ohms, Voltage Amplification 48. Output Volts 80, RMS for Inverter Service.										
6CA4	T-6½	Duodiode	9M-0-0	Cathode	6.3	1.000	....	....	....	F-W Rect.	350 A.C. Volts Per Plate, RMS, 150 Ma. Output Current.										6CA4
6CA5	T-5½	Beam Pent.	7CV-0-0	Cathode	6.3	1.200	0.5*	15.0*	9.0*	Power Amp.	110 125	4.0 4.5	110 125	32 37	3.5 4.0	16,000 15,000	8,100 9,200	....	3,500 4,500	1,100 1,500	6CA5
6CA7	T-10 (SP)	Beam Pent.	8ET	Cathode	6.3	1.500	1.0*	15.5*	7.2*	Power Amp.	Characteristics Same as Type EL34.										6CA7
6CB5	ST-16	Beam Pent.	8GD-0-0	Cathode	6.3	2.500	0.8*	24.0*	10.0*	Horiz. Defl. Amp.	6,800 Max. Peak Pos. Pulse Plate Volts. 23 Watts Max. Plate Dissipation. 3.6 Watts Max. Screen Dissipation.										6CB5
											175	30	175	90	6.0	5,000	8,800	.....	....	....	
6CB5A	T-12						0.4*	22.0*	10.0*												6CB5A
6CB6 6CB6A	T-5½	Pentode	7CM-0-7	Cathode	6.3 6.3‡	0.300 0.300	.02*	6.3*	1.9*	VHF Amp.	200	180■	150	9.5	2.8	600,000♦	6,200	.....	....	....	6CB6 6CB6A
6CD6G	ST-16	Beam Pent.	5BT-0-0	Cathode	6.3	2.500	0.8*	24*	9.5*	Horiz. Defl. Amp.	Maximum Peak Positive Plate Voltage = 6,600 Volts. Maximum D.C. Plate Current = 200 Ma. Maximum Plate Dissipation = 15 Watts. Maximum Screen Dissipation = 3 Watts.										6CD6G
6CD6GA	T-12	Beam Pent.	5BT-0-0	Cathode	6.3	2.500	1.1*	22.0*	8.5*	Horiz. Defl. Amp.	7,000 Max. Peak Pos. Pulse Plate Volts. 200 Ma. Max. Cathode Current. 20 Watts Max. Plate Dissipation. 3.0 Watts Max. Screen Dissipation.										6CD6GA
											175	30	175	75	5.5	7,200	7,700	.....	....	....	
6CE5	T-5½	Pentode	7BD	Cathode	6.3	0.300	.03*	6.5*	1.9*	VHF Amp.	125	1.0	125	111	3.7	1.0 Meg.♦	7,600	....	....	....	6CE5
6CF6	T-5½	Pentode	7CM	Cathode	6.3	0.300	.015*	6.5*	3.0*	Amplifier	125	56■	125	12.5	3.7	0.3 Meg.	7,800	.....	....	....	6CF6
6CG6	T-5½	Pentode	7BK-0-2	Cathode	6.3	0.300	.008m	5.0	5.0	R-F Amp.	250	8.0	150	9.	2.3	720,000	2,000	.....	....	....	6CG6
6CG7	T-6½	Duotriode	9AJ-0-9	Cathode	6.3‡	0.600	4.0*	2.3*	2.2*	Amplifier	Characteristics Same as Type 6SN7GT. (6CG7 Designed for Series String TV Receivers).										6CG7
6CG8 6CG8A	T-6½	Tri. Pentode	9GF	Cathode	6.3 6.3‡	0.450 0.450	1.5 .02	2.4 4.3	1.0 1.6	Osc. Mixer	125 125	1.0 1.0	 125	12 9.	.... 2.2	6,000 .3 Meg.	6,500 5,500	40	....	....	6CG8 6CG8A
6CH7	T-6½	Duotriode	9FC-0-2	Cathode	6.3	0.400	1.1	2.4	0.8	Amplifier	150	220■	.....	10	....	5,300	6,800	36	....	....	6CH7
6CH8	T-6½	Tri. Pent.	9FT-0-0	Cathode	6.3	0.450	1.6* .025m*	1.9* 7.0*	1.6* 2.25*	Tri. Amp. Pent. Amp.	200 200	.... 180■	 150	13.0 9.5	.... 2.8	5,750 300,000	3,300 6,200	19	....	....	6CH8
6CK4	T-9	Power Triode	8JB	Cathode	6.3	1.250	6.5	8.0	1.8	Vert. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 2,000 Volts. Maximum D.C. Cathode Current = 100 Ma. Maximum Plate Dissipation = 12 Watts.										6CK4
											250	28	.....	40	....	1,200	5,500	6.6	....	....	
6CL5	T-12	Beam Pent.	8GD	Cathode	6.3	2.500	0.7*	20.0*	11.5*	Horiz. Defl.	7,000 Max. Peak Pos. Pulse Plate Volts. 25 Watts Max. Plate Dissipation. 4.0 Watts Max. Screen Dissipation.										6CL5
6CL6	T-6½	Power Pent.	9BV	Cathode	6.3	0.650	0.12	11	5.5	Video Amp.	250	3	150	30	7	0.15 Meg.♦	11,000	....	....	....	6CL6
6CL8	T-6½	Tri. Tetrode	9FX	Cathode	6.3‡	0.450	1.8 .016m	2.7 5.0	1.2 3.0	Osc. Mixer	125 125	0 1.0	 125	15 12	.... 4.0	5,000 100,000	8,000 5,800	40	....	....	6CL8
6CL8A	T-6½	Tri. Tetrode	9FX	Cathode	6.3‡	0.450	1.8 .01	2.7 5	1.2 3.4	VHF Osc. VHF Amp.	125 125	56■ 1.0	 125	15 12	 4	5,000 100,000	8,000 6,400	40	....	....	6CL8A
6CM5	T-9	Beam Pent.	8GT-0-1&3	Cathode	6.3	1.250	1.1*	17.5*	7.7*	Horiz. Defl. Amp.	Maximum Peak Positive Plate Voltage = 7,000 Volts. Maximum D.C. Cathode Current = 200 Ma. Maximum Plate Dissipation = 10 Watts.										6CM5
											100	7.7	100	100	7.0	5,300	14,000	....	....	....	
6CM6	T-6½	Beam Pent.	9CK	Cathode	6.3	0.450	0.7*	8.0*	8.5*	Vert. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 2,000 Volts. Maximum D.C. Cathode Current = 40 Ma. Maximum Plate Dissipation = 8 Watts.										6CM6
											250	12.5	250	45	4.5	50,000	4,100	.....	....	....	
										Power Amp.	180 250 315	8.5 12.5 13.0	180 250 225	29.0 45.0 34.0	3.0 4.5 2.2	50,000 50,000 80,000	3,700 4,100 3,750	....	5,500 5,000 8,500	2,000 4,500 5,500	
6CM7	T-6½	Duotriode	9ES	Cathode	6.3‡	0.600	3.8* 3.0*	2.0* 3.5*	0.5* 0.4*	Sect. 2 Vert. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 2,200 Volts. Maximum D.C. Cathode Current = 70 Ma. Maximum Plate Dissipation = 5 Watts.										6CM7
											250	8.0	.....	20.0	....	4,100	4,400	18	....	....	
										Sect. 1 Vert. Osc.	200	7.0	.....	5.0	....	11,000	2,000	20	....	....	
6CM8	T-6½	Tri. Pentode	9FZ	Cathode	6.3‡	0.450	1.9 .04m	1.6 6.0	0.22 2.6	Class A1 Amp.	250 200	2 180■	 150	1.8 9.5	.... 2.8	50,000 600,000	2,000 6,200	100	....	....	6CM8
6CN7	T-6½	Duodiode Tri.	9EN-0-3	Cathode	6.3	0.300	1.8*	1.5*	0.5*	Det. Amp.	100 250	1.0 3.0	....	0.8 1.0	....	54,000 58,000	1,300 1,200	70 70	....	....	6CN7
6CQ8	T-6½	Tri. Tetrode	9GE	Cathode	6.3‡	0.450	1.8 .015	2.7 5.0	1.2 3.3	VHF Tri. Osc. VHF Tet. Amp	125 125	56■ 1.0	 125	15 12	....	5,000 140,000	8,000 5,800	40	....	....	6CQ8
6CR5	T-6½	Beam Pent.	9HC-0-0	Cathode	6.3	1.200	0.32*	12.9*	6.9*	Horiz. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 5,500 Volts. Maximum D.C. Cathode Current = 112.5 Ma. Maximum Plate Dissipation = 11 Watts.										6CR5
											250	22.5	150	65.0	2.1	18,000	6,000	.....	....	....	

6CR6	T-5½	Diode Pent.	7EA	Cathode	6.3	0.300	....	....	....	Det.-Audio Amplifier	250	2.0	100	9.5	3.0	200,000	1,950	.....	....	....	6CR6
6CR8	T-6½	Tri. Pentode	9GJ-0-8	Cathode	6.3I	0.450	1.6* .018*	2.0* 6.0*	1.4* 2.8*	Tri. Amp. Pent. Amp.	125 125	2.0 56■	 125	12.0 13.0	.... 3.0	5,500 300,000	4,000 7,700	22	....	....	6CR8
6CS5	T-6½	Beam Pent.	9CK	Cathode	6.3	1.200	0.5	15.0	9.0	Power Amp. Triode Conn.	110 200 225	7.5 180■ 30	110 125	49 46 22	4.0 2.2	13,000 28,000 1,500	8,000 8,000 3,800	.... 6.2	2,000 4,000	2,100 3,800	6CS5
6CS6	T-5½	Dual Control Heptode	7CH	Cathode	6.3	0.300	.07* 0.36*	5.5* 7.0*	.... 7.5*	SYNC. Separator	100 100	0 Grid 1 -1 Grid 1	30 30	0.8 1.0	5.5 1.3	0.7 Meg. 1.0 Meg.	1,500 Gr. 3 1,100 Gr. 1	Grid #3 Volts = —1.0 Grid #3 Volts = 0			6CS6

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate; RF Input, Mixer Output.
I Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.

\# Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection. DO NOT USE, J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

SYLVANIA TUBES—AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (¹) (²) Capacitances in μμf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Power Output Milliwatts	Type
6CS7	T-6½	Duotriode	9EF-0-0	Cathode	6.3I	0.600	2.6* 2.6*	1.8* 3.0*	0.5* 0.5*	Sect. 2 Vert. Defl. Amp. Sect. 1 Vert. Osc.	Maximum Peak Positive Pulse Plate Voltage = 1,500 Volts. Maximum D.C. Cathode Current = 45 Ma. Maximum Plate Dissipation = 4.5 Watts.										6CS7
											250 250	10.5 8.5	....	19.0 10.5	....	3,450 7,700	4,500 2,200	15.5 17	....	....	
6CS8	T-6½	Tri. Pentode	9FZ-0-3	Cathode	6.3I	0.450	1.6* .02*	1.9* 6.0*	0.26* 2.8*	Tri. Amp. Pent. Amp.	125 125	2.0 56■	 125	12.0 13.0	.... 3.0	5,500 300,000	4,000 7,700	22	....	....	6CS8
6CU5	T-5½	Pentode	7CV	Cathode	6.3	1.200	0.6*	13*	8.5*	Power Amp.	120	8	110	49	4	10,000	7,500	.....	2,500	2,300	6CU5
6CU6	T-12	Beam Pent.	6AM-0-0	Cathode	6.3	1.200	0.6*	15.0*	7.0*	Horiz. Amp.	Characteristics and Ratings Same as Type 6BQ6GTA.										6CU6
6CU8	T-6½	Tri. Pentode	9GM	Cathode	6.3I	0.450	1.6* .025*	1.9* 7*	1.6* 2.4*	Tri. Amp. Pent. Amp.	200 200	6 180■	 150	13 9.5	.... 2.8	5,750 300,000	3,300 6,200	19	....	....	6CU8
6CX7	T-6½	Duotriode	9FC-0-2	Cathode	6.3	0.400	1.2	2.4	1.3	Amplifier	150	220■	.....	9.0	....	......	6,400	39	....	....	6CX7
6CY5	T-5½	Tetrode	7EW-0-2,7	Cathode	6.3	0.200	.03	4.5	3.0	VHF Amp.	125	1.0	80	10.0	1.5	100,000	8,000	.....	....	....	6CY5
6CY7	T-6½	Duotriode	9EF	Cathode	6.3	0.750	1.8* 4.4*	1.5* 5.0*	0.3* 1.0*	Vert. Osc. Vert. Defl. A.	250 150	3 620■	....	1.2 30	....	52,000 920	1,300 5,400	68 5	....	....	6CY7
6CZ5	T-6½	Beam Pent.	9HN	Cathode	6.3I	0.450	0.4*	6.0*	6.0*	Vert. Defl. Amp.	Maximum Peak Positive Plate Voltage = 2,200 Volts. Maximum D.C. Cathode Current = 40 Ma. Maximum Plate Dissipation = 10 Watts.										6CZ5
											250	14	250	46.0	4.6	73,000♦	4,800	....	....	....	
6D4	T-5½	Gas Triode	5AY-0-0	Cathode	6.3	0.250	....	....	....	Relay Tube	350	50	Peak Cathode Current=100 Ma. Cathode Current=25 Ma. Approx. Volt Drop @ 25 Ma.=16V.								6D4
6D6	ST-12	Pentode	6F-0-5	Cathode	6.3	0.300	.007m	4.7*	6.5*	Amplifier	100 250	3.0 3.0	100 100	8.0 8.2	2.2 2.0	250,000 800,000	1,500 1,600	....	....	....	6D6
6D7	ST-12	Pentode	7H-5-6	Cathode	6.3	0.300	.007*	5.0*	6.5*	Amplifier	Characteristics Same as Type 6C6.										6D7
6D8G	ST-12	Heptode	8A-0-0	Cathode	6.3	0.150	0.2	8.0	11.0	Converter	135 250	3.0 3.0	67.5 100	1.5 3.5	1.7 2.6	600,000 400,000	325▲ (Ga=135 V., 1.8 Ma.) 550▲ (Ga=250 V.□, 4.5 Ma.)				6D8G
6DA4	T-9	Diode	4CG	Cathode	6.3	1.200	....	....	....	T.V. Damper	Maximum Peak Inverse Plate Voltage = 4,400 Volts. Maximum D. C. Plate Current = 155 Ma.										6DA4
6DA7	T-6½	Duotriode	9EF-0-0	Cathode	6.3	1.000	2.3* 6.9*	2.0* 5.5*	0.415* 0.82*	Sect. 2 Vert. Defl. Amp. Sect. 1 Vert. Osc.	Maximum Peak Positive Pulse Plate Voltage = 1,800 Volts. Maximum D.C. Cathode Current = 40 Ma. Maximum Plate Dissipation = 6 Watts.										6DA7
											150 250	17.5 8.0	....	40.0 9.0	....	1,100 7,700	5,700 2,600	6.3 20	....	....	
6DB5	T-6½	Beam Pent.	9GR-0-0	Cathode	6.3	1.200	0.2	13	8	Vert. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 2,000 Volts. Maximum D.C. Cathode Current = 55 Ma. Maximum Plate Dissipation = 10 Watts.										6DB5
											200	180■	125	46.0	2.2	28,000	8,000	.....	....	....	
6DB6	T-5½	Pentode	7CM-0-2	Cathode	6.3	0.300	.0035*	6.0*	5.0*	Color Demod.	150	1.0	150	5.8	6.6	50,000	2,050 μmhos when Eg 3 = −3 Volts.				6DB6
6DC6	T-5½	Pentode	7CM-0-7	Cathode	6.3	0.300	.02*	6.5*	2.0*	Amplifier	200	180■	150	9.0	3.0	500,000	5,500	Semi-Remote Cutoff.			6DC6
6DC8	T-6½	Duodi. Pent.	9HE	Cathode	6.3	0.300	.0025*	5.0*	5.2*	R-F Amp.	200	1.5	100	11	3.3	.6 Meg.♦	4,500	....	....	....	6DC8
6DE6	T-5½	Pentode	7CM	Cathode	6.3	0.300	.015m	6.5	3.0	VHF Amp.	125	56■	125	15.5	4.2	250,000	8,000	.....	....	....	6DE6
											EC1 = −9 Volts for Ib = 20 μa.										
6DE7	T-6½	Duotriode	9HF	Cathode	6.3	0.900	4.0* 8.5*	2.2* 5.5*	0.52* 1.0*	Sect. No. 2 Vert. Defl. Amp. Sect. No. 1 Vert. Osc.	Maximum Peak Positive Plate Voltage = 1,500 Volts. Maximum Cathode Current = 50 Ma. Maximum Plate Dissipation = 7.0 Watts.										6DE7
											150 250	17.5 11.0	....	35.0 5.5	....	925♦ 8,750♦	6,500 2,000	6 17.5	....	....	
6DG6GT	T-9	Beam Pent.	7S-0-0	Cathode	6.3	1.200	....	....	....	Power Amp.	110 200	7.5 180■	110 125	49 46	4.0 2.2	13,000 28,000	8,000 8,000	....	2,000 4,000	2,100 3,800	6DG6GT
6DG7	T-6½	Pentode	9BA	Cathode	6.3	0.300	.0018*	5.5*	5.0*	R-F or I-F Amplifier	100 250	68■ 68■	100 100	10.8 11.0	4.4 4.2	250,000♦ 1 Meg.♦	4,300 4,400	....	....	....	6DG7
6DJ8	T-6½	Duotriode	9DE	Cathode	6.3	0.365	1.4*	3.3*	1.8*	VHF Amp.	90	1.3	.....	15	....	2,700	12,500	33	....	....	6DJ8
6DK6	T-5½	Pentode	7CM-0-7	Cathode	6.3	0.300	.02*	6.3*	1.9*	VHF Amp.	125	56■	125	12.0	3.8	......	9,800	.....	....	....	6DK6
6DN6	T-12	Beam Pent.	5BT-0-0	Cathode	6.3	2.500	0.8*	22.0*	11.5*	Horiz. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 6,600 Volts. Maximum D.C. Cathode Current = 200 Ma. Maximum Plate Dissipation = 15 Watts.										6DN6
											125	18	125	70	6.3	4,000	9,000	.....	....	....	
6DN7	T-9	Duotriode	8BD	Cathode	6.3	0.900	5.5 4.0	4.6 2.2	1.0 0.7	Sect. 2 Vert. Defl. Amp. Sect. 1 Vert. Osc.	Maximum Peak Positive Pulse Plate Voltage = 2,500 Volts. Maximum D.C. Cathode Current = 50 Ma. Maximum Plate Dissipation = 10 Watts.										6DN7
											250 250	9.5 8	....	41 8.0	....	2,000 9,000	7,700 2,500	15.4 22.5	....	....	
6DQ5	T-12	Beam Pent.	8JC	Cathode	6.3	2.500	0.5*	23*	11*	Horiz. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 7,000 Volts. Maximum D.C. Cathode Current = 285 Ma. Maximum Plate Dissipation = 24 Watts.										6DQ5
											175	25	125	110	5	5,500	10,500	....	....	....	
6DQ6	T-12	Beam Pent.	6AM-0-0	Cathode	6.3	1.200	0.55*	15.0*	7.0*	Horiz. Defl. Amp.	6,000 Max. Peak Pos. Plate Volts. 120 Ma. Max. Cathode Current. 15 Watts Max. Plate Dissipation. 2.5 Watts Max. Screen Dissipation.										6DQ6
											250	22.5	150	75	2.4	20,000	6,000	.....	....	....	
6DQ6A	T-12	Beam Pent.	6AM	Cathode	6.3	1.200	0.55*	15.0*	7.0*	Horiz. Defl. Amp.	6,000 Max. Peak Pos. Plate Volts. 140 Ma. Max. Cathode Current. 15 Watts Max. Plate Dissipation. 2.5 Watts Max. Screen Dissipation.										6DQ6A
											250	22.5	150	75	2.4	20,000	6,600	.....	....	....	
6DR7	T-6½	Duotriode	9HF	Cathode	6.3	0.900	4.5* 8.5*	2.2* 5.5*	0.34* 1.0*	Sect. 2 Vert. Defl. Amp. Sect. 1 Vert. Osc.	Maximum Peak Positive Pulse Plate Voltage = 1,500 Volts. Maximum Cathode Current = 50 Ma. Maximum Plate Dissipation = 7.0 Watts.										6DR7
											150 250	17.5 3	....	10 1.4	....	925 40,000	6,500 1,600	6 68	....	....	

6DS5	T-5½	Beam Pent.	7BZ	Cathode	6.3	0.800	0.19*	9.5*	6.3*	Power Amp.	200 250	180 ■ 270 ■	200 200	34.5 27	3.5 3	28,000 28,000	6,000 5,800	....	6,000 8,000	2,800 3,600	6DS5
6DT5	T-6½	Beam Pent.	9HN	Cathode	6.3	1.200	0.57*	12.5*	4.9*	Vert. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 2,200 Volts. Maximum D.C. Cathode Current = 55 Ma. Maximum Plate Dissipation = 9.0 Watts.										6DT5
											250	16.5	250	38	2.0	....	6,250	....	....	....	
6DT6	T-5½	Gated Beam	7EN-0-0	Cathode	6.3	0.300	.02	....	....	Quad. F. M. Det.	150	560 ■	100	1.1	2.1	150,000	615 Gr. #1 515 Gr. #3	−4.5 Gr. #1 for 10 μa IB −3.5 Gr. #3 for 10 μa IB			6DT6
6DT8	T-6½	Duotriode	9DE	Cathode	6.3	0.300	1.6	2.7	1.6	Amplifier	100 250	270 ■ 200 ■	....	3.7 10	....	15,000 10,900	4,000 5,500	60 60	....	....	6DT8
6DW5	T-6½	Beam Pent.	9CK	Cathode	6.3	1.200	0.5	14	9	Vert. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 2,200 Volts. Maximum D.C. Cathode Current = 65 Ma. Maximum Plate Dissipation = 11 Watts.										6DW5
											200	22.5	150	55	2.0	15,000	5,500	....	....	....	

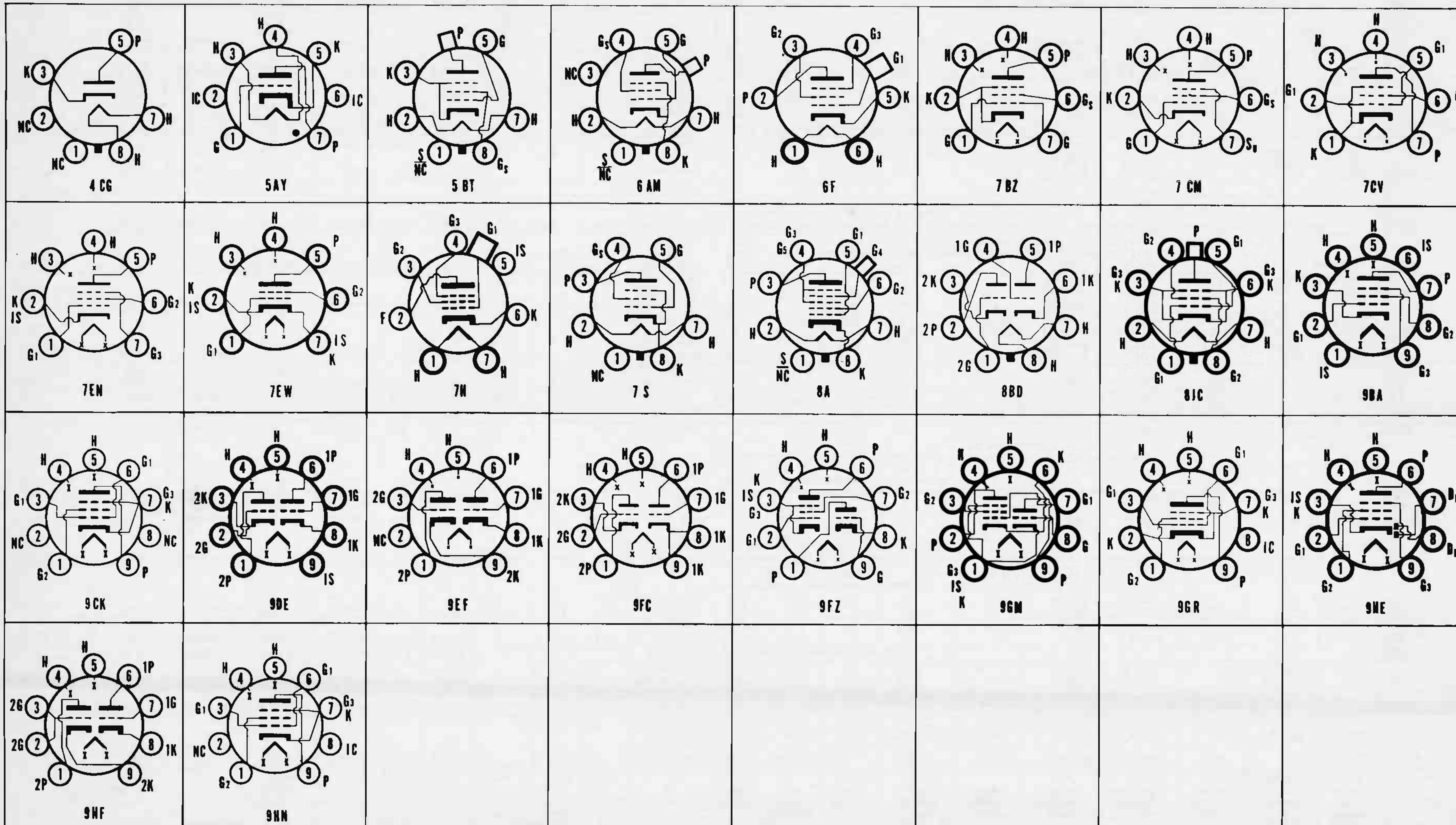
(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate; RF Input, Mixer Output.
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
I Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)

Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.

□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.

¶ Plate to Plate.
♦ Approximate.

m maximum.
■ Cathode Resistor (ohms).



SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection, DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

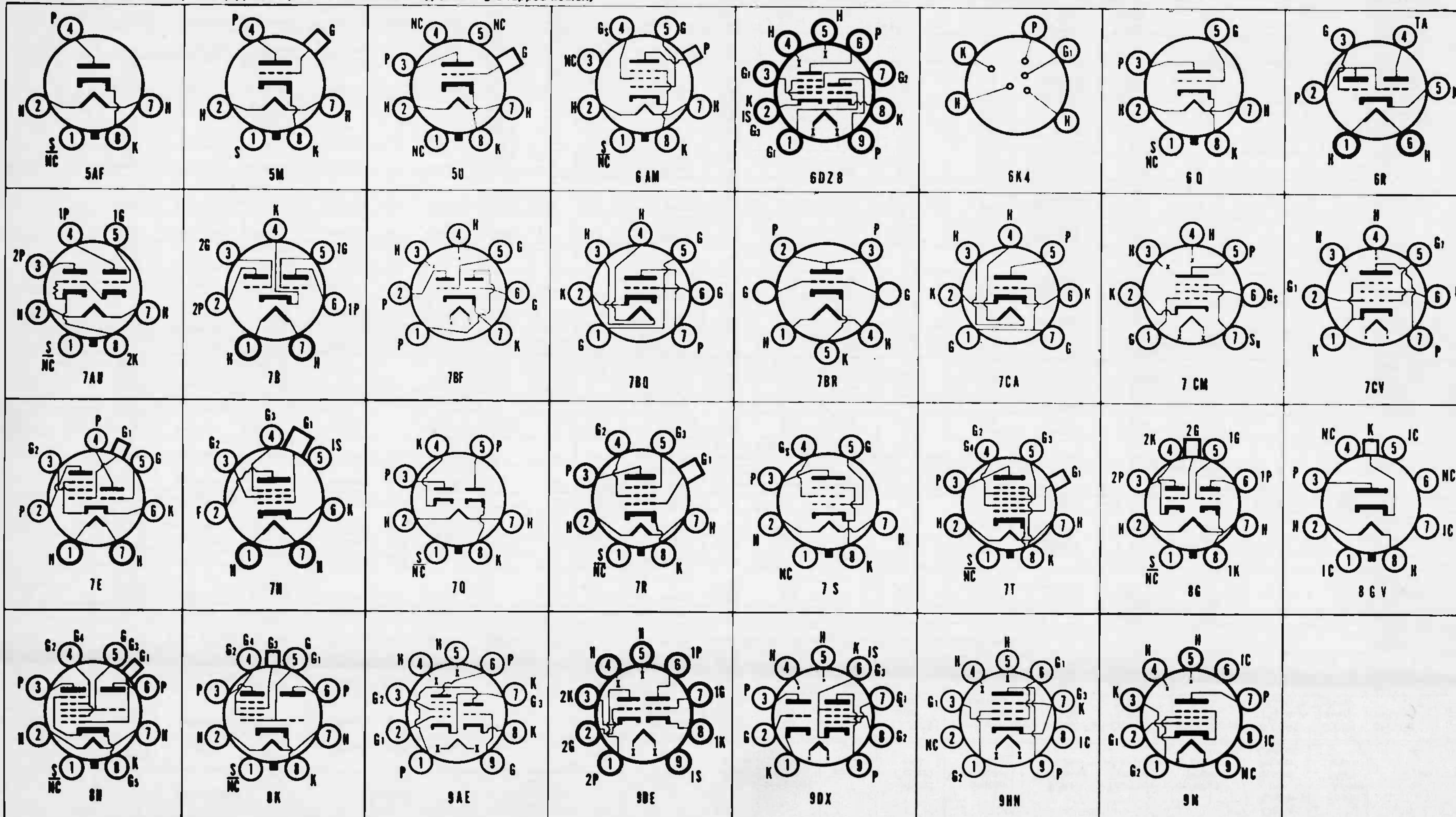
SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (1) (2) Capacitances in μμf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Undistorted Power Output Milliwatts	Type
6DZ8	T-6½	Tri. Beam Pent.	6DZ8	Cathode	6.3	0.900	....	....	....	A-F Triode Volt. Amp. and Pent. Power Amp.	120 145	1500 ■ 180 ■	 120	0.8 45	 6	71,000 2,500	1,400 7,500	100	 2,500	 2,000	6DZ8
6E5	T-9	Electron Ray	6R-0-0	Cathode	6.3	0.300	....	....	....	Indicator	100§ 250§	(Series Plate Resistor 0.5 Meg. Target Current 1.0 Ma. Grid Bias = 3.3 for 90° Shadow) (Series Plate Resistor 1.0 Meg. Target Current 4.0 Ma. Grid Bias = 8.0 for 90° Shadow.)									6E5
6E6	ST-14	Duotriode	7B-0-0	Cathode	6.3	0.600	.. .	....	....	Power Amp. (1 Section)	180 250	20.0 27.5	.....	11.5 18.0	....	4,300 3,500	1,400 1,700	6.0 6.0	15,000¶ 14,000¶	750 1,600	6E6
6E7	ST-12	Pentode	7H-5-6	Cathode	6.3	0.300	....	....	....	Amplifier	Characteristics Same as Type 6D6.										6E7
6EA8	T-6½	Tri. Pentode	9AE	Cathode	6.3‡	0.450	1.7 .01	3.2 5	1.1 3.4	Tri. VHF Amp. Pent. Amp.	150 125	56 ■ 1.0	 125	18 12	 4	5,000 6,400	8,500 80,000	40	....	....	6EA8
6EB8	T-6½	Tri. Pentode	9DX	Cathode	6.3	0.750	4.4 0.1	2.4 11	0.36 4.2	A-F Amp. Video Amp.	250 200	2.0 68 ■	 125	2 25	 7	37,000 75,000	2,700 12,500	100	....	....	6EB8
											Instantaneous Plate Knee Values. EB = 45 Volts, EC^2 = 125 Volts, EC^1 = 0. (Pentode Section) IB = 40 Ma, IC^2 = 15 Ma.										
6EF6	T-9	Beam Pent.	7S	Cathode	6.3	0.900	0.8*	11.5*	9.0*	Vert. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 2,000 Volts. Maximum D.C. Cathode Current = 60 Ma. Maximum Plate Dissipation = 10 Watts.										6EF6
											250	18	250	50	2	....	5,000	....	....	....	
6EH5	T-5½	Beam Pent.	7CV	Cathode	6.3	1.200	0.65*	17*	9*	S.T. A1 Amp.	110	62 ■	115	42	11.5	11,000	14,600	.....	3,000	1,400	6EH5 12EH5
											3 Volts Peak Driving Voltage Required for 1.4 Watts Output.										
6EM5	T-6½	Beam Pent.	9HN	Cathode	6.3	0.800	0.7*	10*	5.1*	Vert. Defl. Amp.	Maximum Peak Positive Plate Voltage = 2,200 Volts. Maximum D.C. Cathode Current = 60 Ma. Maximum Plate Dissipation = 10 Watts.										6EM5
											250	18	250	35	3	......	5,100	8.7 G1 to G2			
											Instantaneous Plate Knee Values = EB = 60 Volts, EC^2 = 250 Volts, EC^1 = 0 Volts. IB = 180 Ma. and IC^2 = 30 Ma.										
6ES8	T-6½	Duotriode	9DE	Cathode	6.3	0.365	1.85	....	0.17	VHF Amp.	90	1.2	.....	15	....	......	12,500	.....	....	....	6ES8
6EW6	T-5½	Pentode	7CM	Cathode	6.3	0.400	.03	10	3.4	VHF Amp.	125	56 ■	125	11	3.2	200,000	14,000	.....	....	....	6EW6
6F4	Acorn	Triode	7BR-0-0	Cathode	6.3	0.225	1.9*	2.0*	0.6*	Amplifier	80	150 ■	.....	13.0	....	2,900	5,800	17	....	....	6F4
6F5 6F5GT	Metal T-9	Triode	5M-1-0 5M-0-0	Cathode	6.3	0.300	2.3 2.8*	5.5 2.2*	4.0 3.2*	Amplifier	250	2.0	.....	0.9	....	66,000	1,500	100	....	....	6F5 6F5GT
6F6 6F6G 6F6GT	Metal ST-14 T-9	Power Pent.	7S-1-0 7S-0-0	Cathode	6.3	0.700	....	....	....	Power Amp. S.T.A1 Amp. P.P.A1 Amp. P.P.AB2 Amp.	250 285 315 375	16.5 20.0 24.0 26.0	250 285 285 250	34.0 38.0 62-80† 34-82†	6.5 7.0 12-19.5† 5-19.5†	80,000 78,000 (Current & Output for Two Tubes) (Current & Output for Two Tubes)	2,500 2,550	....	7,000 7,000 10,000¶ 10,000¶	3,200 4,800 11,000 18,000	6F6 6F6G 6F6GT
6F7 6F7S	ST-12	Pent. Triode	7E-0-6 7E-6-6	Cathode	6.3	0.300	.008m 2.0*	3.2 2.5*	12.5 3.0*	Pent. Amp. Pent. Amp. Tri. Amp.	100 250 100	3.0 3.0 3.0	100 100	6.3 6.5 3.5	1.6 1.5	290,000 850,000 16,200	1,050 1,100 525	.... 8.5	Pentode Section Pentode Section Triode Section		6F7 6F7S
6F8G	ST-12	Duotriode	8G-0-0	Cathode	6.3	0.600	3.8* 3.2*	3.2* 1.9*	1.0* 1.9*	Amplifier Inverter	250 250	8.0 5.5	.....	9.0		7,700	2,600	20	(One Section)		6F8G
											Plate Load 50,000 Ohms Per Plate, Self Bias Resistor 1,150 Ohms, Voltage Amplification 29, Output Volts 65 RMS, for Inverter Service.										
6FH6	T-12	Beam Pent.	6AM	Cathode	6.3	1.200	0.4	33	8	Horiz. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 6,000 Volts. Maximum D.C. Cathode Current = 155 Ma. Maximum Plate Dissipation = 17 Watts.										6FH6
											250	22.5	150	75	1.7	12,000	6,000	.....	....	....	
6G5	Now Known as Type 6U5																				6G5
6G6G	ST-12	Power Pent.	7S-0-0	Cathode	6.3	0.150	....	....	....	Power Amp.	135 180	6.0 9.0	135 180	11.5 15.0	2.0 2.5	170,000 175,000	2,100 2,300	....	12,000 10,000	600 1,100	6G6G
6H4GT	T-9	Diode	5AF-0-0	Cathode	6.3	0.150	....	....	....	Rectifier	100	....	.....	4.0	....	....	.....	.....	....	....	6H4GT
6H6, 6H6GT	T-9, Metal	Duodiode	7Q-0-1	Cathode	6.3	0.300	...	....	....	Rectifier	117 A-C Volts Per Plate, RMS, 8.0 Ma. Output Current Per Plate.										6H6GT, 6H6
6J4	T-5½	Triode	7BQ-0-0	Cathode	6.3	0.400	3.9	4.6	0.24	Amplifier	150	100 ■	.....	15.0	....	4,500	12,000	55	....	....	6J4
6J5 6J5GT	Metal T-9	Triode	6Q-1-0	Cathode	6.3	0.300	3.4 3.8	3.4 4.2	3.6 5.0	Amplifier	250	8.0	.....	9.0	....	7,700	2,600	20	....	....	6J5 6J5GT
6J6 6J6A	T-5½	Duotriode	7BF-0-7	Cathode	6.3 6.3‡	0.450 0.450	1.5 1.5	2.6 2.6	1.6 1.0	VHF Osc. VHF Amp.#	150 100	10.0 50 ■	....	30.0 8.5	....	Push-Pull Class C Operation 7,100	5,300	38		3,500	6J6 6J6A
6J7 6J7G 6J7GT	Metal ST-12 T-9	Pentode	7R-1-1 7R-0-1 7R-1-1	Cathode	6.3	0.300	.005m .007m .007m	7.0 5.4 5.4	12.0 12.0 12.0	R-F Amp.	250	3.0	100	2.0	0.5	1.0 Meg.>	1,225	.....	....	....	6J7 6J7G 6J7GT
6J8G	ST-12	Tri. Heptode	8H-0-8	Cathode	6.3	0.300	.02m	4.4	10.0	Mixer Oscillator	250	3.0	100	1.3	2.9	4.0 Meg.	290▲	(Heptode Section)			6J8G
											250 Plate Supply Thru 20,000 Res., Grid Resistor 50,000, Grid Current 0.4 Ma. Plate Current 5.0 Ma. (Triode Section)										
6K4	T-3	Triode	6K4	Cathode	6.3	0.150	2.2*	2.4*	0.85*	Osc. Amp.	100	2.0	.....	12.0	....	3,650	5,500	20	....	....	6K4
6K5G 6K5GT	ST-12 T-9	Triode	5U-0-0 5U-0-0	Cathode	6.3	0.300	2.0 2.8	2.9 2.9	5.75 4.7	Amplifier	100 250	1.5 3.0	....	0.35 1.10	....	78,000 50,000	900 1,400	70 70	....	....	6K5G 6K5GT
6K6GT	T-9	Power Pent.	7S-0-0	Cathode	6.3	0.400	...	....	....	S.T. A1 Amp.	100 250 315	7.0 18.0 21.0	100 250 250	9.0 32.0 25.5	1.6 5.5 4.0	104,000 68,000 75,000	1,500 2,300 2,100	....	12,000 7,600 9,000	350 3,400 4,500	6K6GT
6K7 6K7G 6K7GT	Metal ST-12 T-9	Pentode	7R-1-0 7R-0-8 7R-1-8	Cathode	6.3	0.300	.005m .007m .005m	7.0 5.0 4.6	12.0 12.0 12.0	R-F Amp.	100 250 250	1.0 3.0 3.0	100 100 125	9.5 7.0 10.5	2.7 1.7 2.6	150,000♦ 800,000♦ 600,000♦	1,650 1,450 1,650	....	....	....	6K7 6K7G 6K7GT
6K8 6K8G 6K8GT	Metal ST-12 T-9	Tri. Hexode	8K-1-0 8K-0-8 8K-1-8	Cathode	6.3	0.300	.03m .08m .08m	6.6 4.6 5.0	3.5 4.8 4.3	Mixer Osc.	250	3.0	100	2.5	6.0	600,000	350▲	(Hexode Section)			6K8 6K8G 6K8GT
											100	Grid Resistor 50,000 Plate Current 3.8 Ma., Mutual Conductance 3,000 (Triode Section not Oscillating)									
6L4	Acorn	Triode	7BR-0-0	Cathode	6.3	0.225	1.6*	1.8*	0.5*	Osc. Amp.	80	150 ■	.....	9.5	....	4,400	6,400	28	....	....	6L4
6L5G	ST-12	Triode	6Q-0-0	Cathode	6.3	0.150	2.8	2.8	5.0	Amplifier	100 250	3.0 9.0	....	4.0 8.0	....	10,000 9,000	1,500 1,900	15 17	....	....	6L5G

6L6 6L6G 6L6GA 6L6GB	Metal ST-16 ST-14 T-12	Beam Pent.	7S-1-0 7S-0-0 7S-0-0 7S-0-0	Cathode	6.3	0.900	0.9*	11.5*	9.5*	S.T. A1 Amp. S.T. A1 Amp. P.P.AB1 Amp. P.P.AB2 Amp.	250 350 270 360 360	14.0 18.0 17.5 22.5 22.5	250 250 270 270 270	72.0 54.0 134-155† 88-132† 88-205†	5.0 2.5 11-17† 5-15† 5-16†	22,500 33,000 23,500 (Current & Output for Two Tubes) (Current & Output for Two Tubes)	6,000 5,200 5,700	....	2,500 4,200 5,000¶ 6,600¶ 3,800¶	6,500 10,800 17,500 26,500 47,000	6L6 6L6G 6L6GA 6L6GB
6L6GAY	ST-14	Beam Pent.	7S-0-0	Cathode	6.3	0.900	....	....	....	Power Amp.	Low Loss Base. Characteristics Same as 6L6GA.										6L6GAY
6L7 6L7G	Metal ST-12	Heptode	7T-1-1 7T-0-8	Cathode	6.3	0.300	.001m .005m	7.5 6.0	11.0 10.0	Amplifier Mixer Amp.	250 250	6.0 3.0	150 100	3.3 5.3	9.2 6.5	1 Meg.> 600,000	350▲ 1,100	(G3 = Neg. 15 Volts) (G3 = Neg. 3.0 Volts)			6L7 6L7G
6M3	T-12	Diode	8GV	Cathode	6.3	3.000	....	....	....	H-W Rect.	Television Service. Peak Inverse Volts = 6 KV. Output = 320 Ma.										6M3
6M5	T-6½	Beam Pent.	9N-0-0	Cathode	6.3	0.710	1.0m	10.0	6.2	Power Amp.	250	170■	250	36	5.2	40,000	10,000	.....	7,000	3,900	6M5
6N4	T-5½	Triode	7CA-0-0	Cathode	6.3	0.200	1.1	3.0	1.6	Amplifier	180	3.5	.....	12.0	...	5,400♦	6,000♦	32	....	....	6N4
6N6G	ST-14	Duotriode	7AU-0-0	Cathode	6.3	0.800	....	....	....	Power Amp.	300 300	0.0 0.0	(Input Section) (Output Section)		8.0 45.0	...... 24,000♦	 2,400	 58	 7,000	 4,000	6N6G

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate, RF Input, Mixer Output.
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
⌶ Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)

♯ Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection, DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction			Emitter			Note (1) (2) Capacitances in μμf.			Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Power Output Milliwatts	Type
	Bulb Size or Style	Class	Basing Diag.	Type	Volts	Amps.	Cgp.	Cin.	Cout												
6N7GT 6N7	T-9 Metal	Duotriode	8B-0-0	Cathode	6.3	0.800	....	....	....	Power Amp. Driver Driver	300 250 294	0.0 5.0 6.0	....	17.5-35† 6.0 7.0	Per Plate, Class B Push-Pull Operation, Zero Signal Sections Paralleled	11,300 11,000	3,100 3,200	35 35	8,000¶ (Class A Driver) (Class A Driver)	10,000	6N7GT 6N7
6N8	T-6½	Duodi. Pent.	9T-0-0	Cathode	6.3	0.300	.002m	4.0	4.6	R-F Amp.	250	2	8.5	5	1.75	1.6 Meg.	2,200	.....	....	....	6N8
6P5GT	T-9	Triode	6Q-0-0	Cathode	6.3	0.300	2.6	3.4	5.5	Amplifier Detector	250 250	13.5 20.0♦	....	5.0 (Plate Current to be adjusted to 0.2 Ma. with no Input Signal)		9,500	1,450	13.8	....	....	6P5GT
6P7G	ST-12	Pent. Triode	7U-0-8	Cathode	6.3	0.300	.007m 2.0	2.8 2.7	12.0 2.5	R-F Amp.	Characteristics Same as Type 6F7, Except Capacitances.										6P7G
6Q4	T-6½	Triode	9S-0-0	Cathode	6.3	0.480	3.4	5.4	.06m	R-F Amp.	250	1.0	.....	15	....	......	12,000	80	....	....	6Q4
6Q7 6Q7G 6Q7GT	Metal ST-12 T-9	Duodiode Tri.	7V-1-8 7V-0-8 7V-1-8	Cathode	6.3	0.300	1.4 1.5 1.6	5.0 3.2 2.2	3.8 5.0 5.0	Det. Amp.	100 250	1.5 3.0	....	0.8 1.1	....	58,000 58,000	1,200 1,200	70 70	....	....	6Q7 6Q7G 6Q7GT
6R4	T-6½	Triode	9R-0-0	Cathode	6.3	0.200	1.5	1.7	0.5	Oscillator	150	2	.....	30	....	......	5,500	16	....	....	6R4
6R6G	ST-12	Pentode	6AW-0-0	Cathode	6.3	0.300	.007m	4.5*	11.0*	R-F Amp.	250	3.0	100	7.0	1.7	800,000	1,450	1,160	....	....	6R6G
6R7 6R7GT	Metal T-9	Duodiode Tri.	7V-1-1 7V-0-8	Cathode	6.3	0.300	2.3 2.1	4.8 2.6	3.8 5.2	Det. Amp.	250	9.0	.....	9.5	....	8,500	1,900	16	....	....	6R7 6R7GT
6R8	T-6½	Triple Dio. Tri.	9E-0-3&8	Cathode	6.3	0.450	2.4	1.5*	1.1*	Det. Amp.	250	9	.....	9.5	....	8,500	1,900	16	10,000	300	6R8
6S4	T-6½	Triode	9AC-0-0	Cathode	6.3	0.600	2.6*	4.2*	0.9*	Vert. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 2,200 Volts. Maximum D-C Cathode Current = 30 Ma. Maximum Plate Dissipation = 7.5 Watts.										6S4
6S4A	T-6½	Triode	9AC-0-0	Cathode	6.3‡	0.600	2.6*	4.2*	0.9*	Vert. Defl. Amp.	Characteristics Same as Type 6S4. (6S4A Designed for Series String TV Receivers) Except Plate Dissipation = 8.5 Watts										6S4A
6S7 6S7G	Metal ST-12	Pentode	7R-1-1 7R-0-8	Cathode	6.3	0.150	.005m .008m	6.5 4.4	10.5 8.0	R-F Amp.	135 250	3.0 3.0	67.5 100	3.7 8.5	0.9 2.0	1 Meg. 1 Meg.	1,250 1,750	.....	....	....	6S7 6S7G
6S8GT	T-9	Triple Dio. Tri.	8CB-0-2	Cathode	6.3	0.300	2.0	1.2	5.0	Det. Amp.	250	2.0	.....	0.9	....	91,000	1,100	100	....	....	6S8GT
6SA7 6SA7GT 6SA7GTY	Metal T-9 T-9	Heptode	8R-1-0 8AD-0-6 8AD-1-6	Cathode	6.3	0.300	0.25m 0.5m 0.5m	9.5 9.5 9.5	9.5 9.5 9.5	Converter	100 250 Low Loss Base	2.0 2.0	100 100	3.3 3.5	8.5 8.5	500,000♦ 1.0 Meg.♦	425▲ 450▲	.....	....	....	6SA7 6SA7GT 6SA7GTY
6SB7Y	Metal	Heptode	8R-1-0	Cathode	6.3	0.300	0.13m	9.6	9.2	Converter	250	1.5	100	4.0	8.5	......	880▲	.....	....	....	6SB7Y
6SC7, 6SC7GT	Metal, T-9	Duotriode	8S-1-0	Cathode	6.3	0.300	2.0	2.0	3.0	Amplifier	250	2.0	.....	2.0	....	53,000	1,325	70	(Each Triode)		6SC7, 6SC7GT
6SD7GT	T-9	Pentode	8N-1-5	Cathode	6.3	0.300	.0035	9.0	7.5	R-F Amp.	100 250	2.0 2.0	100 100	5.7 6.0	2.0 1.9	250,000♦ 1.0 Meg.♦	3,350 3,600	.....	....	....	6SD7GT
6SE7GT	T-9	Pentode	8N-1-5	Cathode	6.3	0.300	.0035m	6.0	7.5	R-F Amp.	100 250	1.0 1.5	100 100	5.5 4.5	2.4 1.5	250,000♦ 1,000,000♦	3,100 3,400	.....	....	....	6SE7GT
6SF5 6SF5GT	Metal T-9	Triode	6AB-1-0 6AB-0-0	Cathode	6.3	0.300	2.4 2.6	4.0 4.2	3.6 3.8	Amplifier	250	2.0	.....	0.9	....	66,000	1,500	100	....	....	6SF5 6SF5GT
6SF7	Metal	Diode Pent.	7AZ-1-1	Cathode	6.3	0.300	.004m	5.5	6.0	Det. Amp.	100 250	1.0 1.0	100 100	12 12.4	3.4 3.3	200,000♦ 700,000♦	1,975 2,050	.....	....	....	6SF7
6SG7 6SG7GT	Metal T-9	Pentode	8BK-1-1	Cathode	6.3	0.300	.003m .004m	8.5 8.5	7.0 7.0	R-F Amp.	100 250 250	1.0 1.0 2.5	100 125 150	8.2 11.8 9.2	3.2 4.4 3.4	250,000♦ 900,000♦ 1 Meg.>	4,100 4,700 4,000	.....	....	....	6SG7 6SG7GT
6SH7 6SH7GT	Metal T-9	Pentode	8BK-1-1	Cathode	6.3	0.300	.003m .004m	8.5 8.5	7.0 7.0	R-F Amp.	100 250	1.0 1.0	100 150	5.3 10.8	2.1 4.1	350,000♦ 900,000♦	4,000 4,900	.....	....	....	6SH7 6SH7GT
6SJ7 6SJ7GT 6SJ7WGT (3) 6SJ7GTY	Metal T-9 T-9 T-9	Pentode	8N-1-5 8N-0-5 8N-0-5 8N-0-5	Cathode	6.3	0.300	.005m .005m .005m .005m	6.0 7.0 7.0 7.0	7.0 7.0 7.0 7.0	R-F Amp.	100 250 Ruggedized Version Low Loss Base	3.0 3.0	100 100	2.9 3.0	0.9 0.8	700,000♦ 1.0> Meg.♦	1,575 1,650	.....	....	....	6SJ7 6SJ7GT 6SJ7WGT (3) 6SJ7GTY
6SK7 6SK7GT 6SK7GTY	Metal T-9 T-9	Pentode	8N-1-1 8N-1-5 8N-1-5	Cathode	6.3	0.300	.003m .005m .005m	6.0 6.5 6.5	7.0 7.5 7.5	R-F Amp.	100 250 Low Loss Base	1.0 3.0	100 100	13.0 9.2	4.0 2.6	120,000♦ 800,000♦	2,350 2,000	.....	....	....	6SK7 6SK7GT 6SK7GTY
6SL7GT 6SL7WGT (3)	T-9	Duotriode	8BD-0-0	Cathode	6.3	0.300	2.8* 2.8*	3.0* 3.4*	2.8* 3.2*	Amplifier#	250	2.0	.....	2.3	....	44,000	1,600	70			6SL7GT 6SL7WGT (3)
6SN7GT 6SN7WGT(3)	T-6½	Duotriode	9BD-0-0	Cathode	6.3	0.600	3.8* 4.0*	2.8* 3.0*	0.8* 1.2*	Amplifier	90 250	0 8.0	....	10.0 9.0	....	6,700 7,700	3,000 2,600	20 20	....	....	6SN7GT 6SN7WGT(3)
6SN7GTA 6SN7GTB	T-9	Duotriode	8BD	Cathode	6.3 6.3‡	0.600 0.600	4.0* 3.8*	2.2* 2.6*	0.7* 0.7*	Vertical Osc. Amp.	Same as 6SN7GT except for Higher Maximum Plate Voltage and Dissipation Ratings. (6SN7GTB designed for Series String TV Receivers)										6SN7GTA 6SN7GTB
6SQ7 6SQ7GT	Metal T-9	Duodiode Tri.	8Q-1-1 8Q-1-3	Cathode	6.3	0.300	1.6 1.8	3.2 4.2	3.0 3.4	Det. Amp.	250	2.0	.....	1.1	....	85,000	1,175	100	....	....	6SQ7 6SQ7GT
6SR7 6SR7GT	Metal T-9	Duodiode Tri.	8Q-1-1 8Q-0-3	Cathode	6.3	0.300	2.4 2.3	3.6 3.5	2.8 3.8	Det. Amp.	250	9.0	.....	9.5	....	8,500	1,900	16	....	....	6SR7 6SR7GT
6SS7	Metal	Pentode	8N-1-0	Cathode	6.3	0.150	.004m	5.5	7.0	R-F Amp.	100 250	1.0 3.0	100 100	12.2 9.0	3.1 2.0	120,000♦ 1,000,000♦	1,950 1,850	.....	....	....	6SS7
6ST7	Metal	Duodiode Tri.	8Q-1-0	Cathode	6.3	0.150	1.5	2.8	3.0	Det. Amp.	250	9.0	.....	9.5	....	8,500	1,900	16.0	....	....	6ST7
6SU7GTY	T-9	Duotriode	8BD-0-0	Cathode	6.3	0.300	....	....	....	Amplifier	250	2.0	.....	2.3	....	44,000	1,600	70	....	....	6SU7GTY
6SV7	Metal	Diode Pent.	7AZ-1-0	Cathode	6.3	0.300	.004m	6.5	6.0	Det. Amp.	250	1.0	150	7.5	2.8	1.5 Meg.	3,600	.....	....	....	6SV7
6SZ7	Metal	Duodiode Tri.	8Q-1-0	Cathode	6.3	0.150	1.1	2.6	2.8	Amplifier	250	3.0	.....	1.0	....	58,000	1,200	70	....	....	6SZ7
6T4	T-5½	Triode	7DK	Cathode	6.3	0.225	1.7*	2.6*	0.4*	UHF Osc.	80	150	.....	18	....	1,860	7,000	13	....	....	6T4
6T5	ST-12	Electron Ray	6R-0-0	Cathode	6.3	0.300	....	....	....	Indicator	250§	Series Plate Resistor 1.0 Meg. Target Current 3.0 Ma. Grid Bias 22 Volts for Max. Target Illumination.									6T5
6T7G	ST-12	Duodiode Tri.	7V-0-8	Cathode	6.3	0.150	1.7	1.8	3.1	Det. Amp.	100 250	1.5 3.0	....	0.3 1.2	....	95,000 62,000	680 1,050	65 65	....	....	6T7G

6T8 6T8A	T-6½	Triple Dio. Tri.	9E-0-3 & 7	Cathode	6.3 6.3⧗	0.450 0.450	.... 1.7	.... 1.7	.... 2.4	Det. Amp.	100 250	1.0 3.0	....	0.8 1.0	....	54,000 58,000	1,300 1,200	70 70	....	....	6T8 6T8A
6U4GT	T-9	Diode	4CG-0-0	Cathode	6.3	1.200	....	....	....	H-W Rect.	350 A.C. Volts Per Plate, R.M.S., 125 Ma. Output Current. Condenser Input to Filter.										6U4GT
6U5	T-9	Electron Ray	6R-0-0	Cathode	6.3	0.300	....	....	....	Indicator	100§ 250§	(Series Plate Resistor 0.5 Meg., Target Current 1.0 Ma., Grid Bias −8.0 for 0° Shadow.) (Series Plate Resistor 1.0 Meg., Target Current 4.0 Ma., Grid Bias −22.0 for 0° Shadow.)									6U5
6U6GT	T-9	Beam Pent.	7S-0-0	Cathode	6.3	0.750	....	....	....	Power Amp.	110 200	10.5 14.0	110 135	44.0 55.0	4.0 3.0	10,000 ♦ 20,000 ♦	5,600 6,200	....	2,000 3,000	2,000 5,500	6U6GT
6U7G	ST-12	Pentode	7R-0-8	Cathode	6.3	0.300	.007m	5.0	9.0	R-F Amp.	100 250	3.0 3.0	100 100	8.0 8.2	2.2 2.0	250,000 800,000	1,500 1,600	....	....	....	6U7G
6U8 6U8A	T-6½	Tri. Pentode	9AE-0-7	Cathode	6.3 6.3⧗	0.450 0.450	1.8 .006	2.8 5.0	2.0 3.5	VHF Osc. VHF Amp.	125 125	−1 −1	 110	13.5 9.5	.... 3.5	5,000 200,000	7,500 5,000	40	....	....	6U8 6U8A

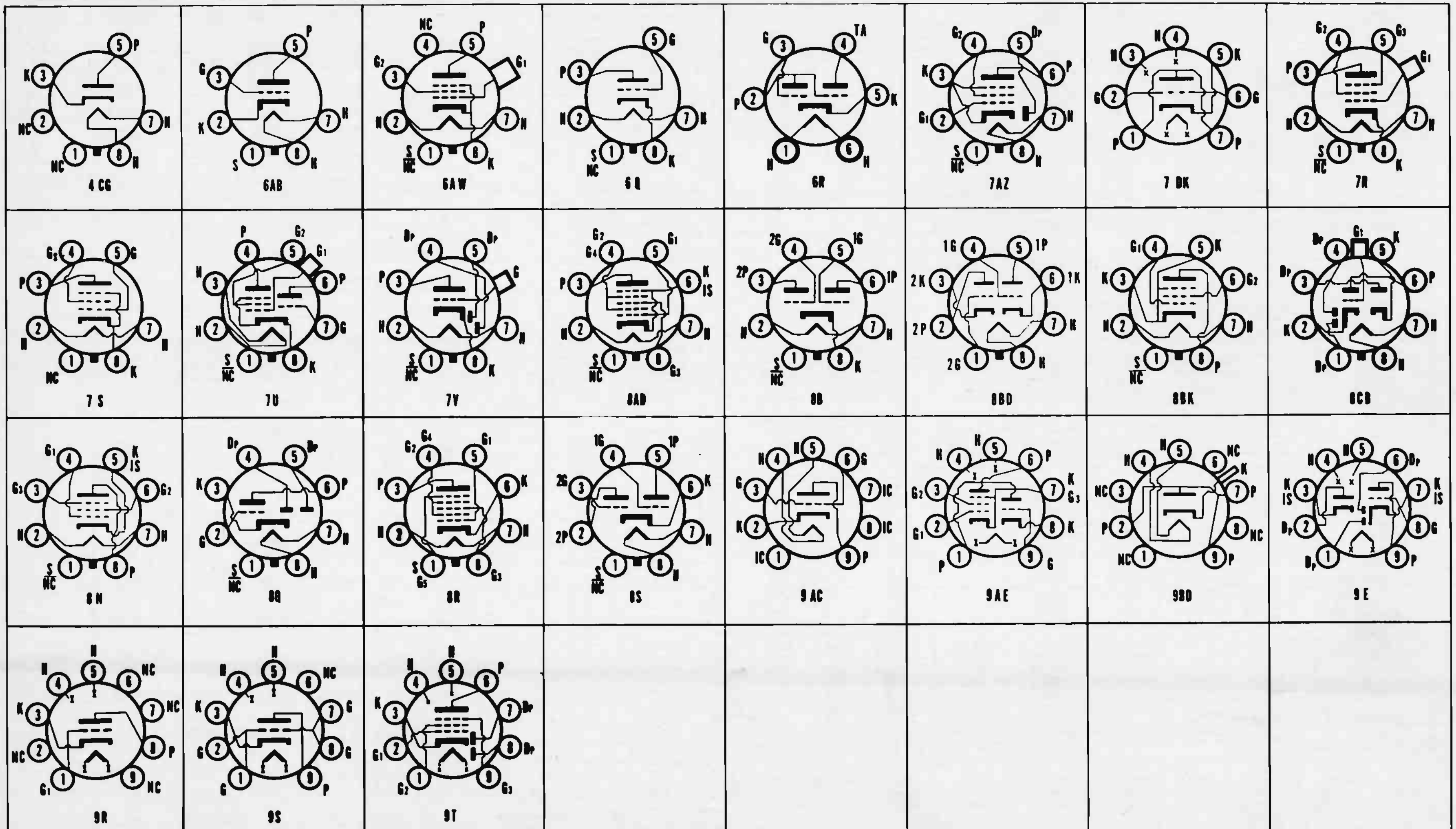
(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate, RF Input, Mixer Output.
⧗ Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.

♯ Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.

□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.

¶ Plate to Plate.
♦ Approximate.

m maximum.
■ Cathode Resistor (ohms).



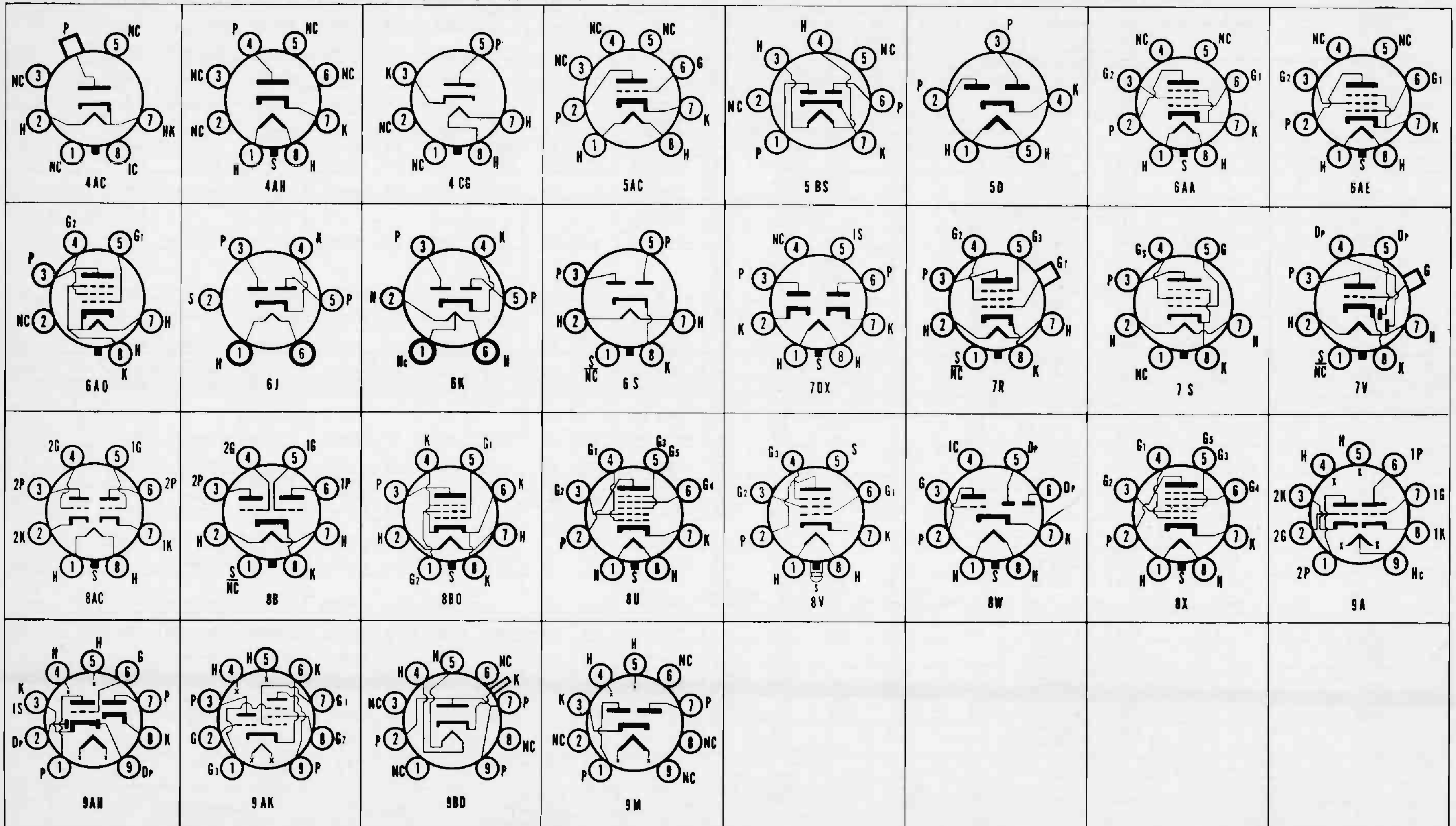
SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection. DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (1) (2) Capacitances in μμf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Power Output Milliwatts	Type
6V3, 6V3A	T-6½	Diode	9BD	Cathode	6.3	1.750	....	....	....	T.V. Damper	P.I.V. = 6,000 Volts Abs. Max., D-C Plate Current = 135 Ma. Max.										6V3, 6V3A
6V4	T-6½	Duodiode	9M-0-0	Cathode	6.3	0.600	....	....	....	F-W Rect.	350 A.C. Volts Per Plate, R.M.S. 90 Ma. Output Current. Condenser Input to Filter.										6V4
6V5GT	T-9	Pentode	6AO-0-0	Cathode	6.3	0.450	0.6	9.0	10.0	Power Amp. Push Pull	250 250	12.5 15	250 250	45 70	4.5 5.0	....	4,100	....	5,000 10,000¶	4,500 10,000	6V5GT
6V6 6V6GT 6V6GTY 6V6GTA	Metal T-9 T-9 T-9	Beam Pent.	7S-1-0 7S-0-0 7S-0-0 7S-0-0	Cathode	6.3 6.3‡	0.450 0.450	0.3 0.7* 0.7* 0.7*	10.0 9.0* 9.0* 9.0*	11.0 7.5* 7.5* 7.5*	Power Amp. Class A1 Amplifier Class AB1 Amplifier	180 250 315 250 285 Low Loss Base for Type 6V6GTY.	8.5 12.5 13.0 15.0 19.0	180 250 225 250 285	29.0 45.0 34.0 70-79† 70-92†	3.0 4.5 2.2 5-13† 4-13.5†	50,000 50,000 80,000 (Class AB1 Two Tubes) (Class AB1 Two Tubes)	3,700 4,100 3,750	....	5,500 5,000 8,500 10,000¶ 8,000¶	2,000 4,500 5,500 10,000 14,000	6V6 6V6GT 6V6GTY 6V6GTA
6V7G	ST-12	Duodiode Tri.	7V-0-8	Cathode	6.3	0.300	1.3	1.5	6.0	Det. Amp.	135 180 250	10.5 13.5 20.0	....	3.7 6.0 8.0	....	11,000 8,500 7,500	750 975 1,100	8.3 8.3 8.3	25,000 20,000 20,000	75 160 350	6V7G
6V8	T-6½	Triple Diode Triode	9AH-0-3	Cathode	6.3	0.450	....	....	....	Det. Amp.	100 250	1.0 3.0	....	0.8 1.0	....	54,000 58,000	1,300 1,200	70 70	....	....	6V8
6W4GT	T-9	Diode	4CG-0-0	Cathode	6.3	1.200	....	....	....	H-W Rect.	350 A-C Volts, RMS, 125 Ma. DC Output. Condenser Input to Filter.										6W4GT
6W5G	ST-12	Duodiode	6S-0-0	Cathode	6.3	0.900	....	....	....	F-W Rect.	325 A-C Volts Per Plate, RMS, 90 Ma. Output Current. Condenser Input to Filter. 450 A-C Volts Per Plate, RMS, 90 Ma. Output Current. Choke Input to Filter.										6W5G
6W6GT	T-9	Beam Pent.	7S-0-0	Cathode	6.3	1.200	0.8* Triode Connection	15.0*	9.0*	Power Amp. Vert. Defl. Amp.	110 200 Maximum Peak Positive Pulse Plate Voltage = 1,200 Volts. Maximum Plate Dissipation = 7.5 Watts.	7.5 180 ■	110 125	49 46	4.0 2.2	13,000 ♦ 28,000 ♦	8,000 8,000	.....	2,000 4,000	2,100 3,800	6W6GT
6W7G	ST-12	Pentode	7R-0-8	Cathode	6.3	0.150	.007m	5.0	8.5	R-F Amp.	250	3.0	100	2.0	0.5	1.5 Meg. ♦	1,225	.....	....	....	6W7G
6X4	T-5½	Duodiode	5BS-0-0	Cathode	6.3	0.600	....	....	....	F-W Rect.	310 Volts RMS Per Plate, 70 Ma. D-C Output. Condenser Input to Filter.										6X4
6X5 6X5GT 6X5WGT (3)	Metal T-9 T-9	Duodiode	6S-0-0	Cathode	6.3	0.600	....	....	....	F-W Rect.	325 A-C Volts Per Plate, RMS, 70 Ma. Output Current. Condenser Input to Filter. 450 A-C Volts Per Plate, RMS, 70 Ma. Output Current. Choke Input to Filter.										6X5 6X5GT 6X5WGT (3)
6X8 6X8A	T-6½	Triode Pentode	9AK	Cathode	6.3 6.3‡	0.450 0.450	1.5 .06	2.4 4.8	1.0 1.6	VHF Osc. VHF Amp.	125 125	1.0 1.0	 125	12 9	.... 2.2	6,000 0.3 Meg. ♦	6,500 5,500	40	....	....	6X8 6X8A
6Y3G	ST-12	Diode	4AC-0-0	Cathode	6.3	0.700	....	....	....	H-W Rect.	5,000 A-C Volts Per Plate, RMS, 7.5 Ma. Output Current. Choke or Condenser Input to Filter.										6Y3G
6Y5	ST-12	Duodiode	6J-2-0	Cathode	6.3	0.800	....	....	....	F-W Rect.	350 A-C Volts Per Plate, RMS, 50 Ma. Output Current.										6Y5
6Y6G 6Y6GA	ST-14 T-12	Beam Pent.	7S-0-0	Cathode	6.3	1.250	....	....	....	Power Amp.	135 200	13.5 14.0	135 135	58.0 61.0	3.5 2.2	9,300 18,300	7,000 7,100	....	2,000 2,600	3,600 6,000	6Y6G 6Y6GA
6Y7G	ST-12	Duotriode	8B-0-0	Cathode	6.3	0.600	....	....	....	Power Amp.	250	0.0	.....	10.5-46†	....	(Class B Operation)		.....	14,000¶	8,000	6Y7G
6Z4	ST-12	Duodiode	5D-0-0	Cathode	6.3	0.500	....	..	..	F-W Rect.	325 A-C Volts Per Plate, RMS, 60 Ma. Output Current. Condenser Input to Filter. 450 A-C Volts Per Plate ,RMS ,60 Ma. Output Current. Choke Input to Filter.										6Z4
6Z5/12Z5	ST-12	Duodiode	6K-0-0	Cathode	6.3 12.6	0.800 0.400	....	....	....	F-W Rect.	230 A-C Volts Per Plate, RMS, 60 Ma. Output Current.										6Z5/12Z5
6Z7G	ST-12	Duotriode	8B-0-0	Cathode	6.3	0.300	....	....	....	Power Amp.	135	0.0	.....	6-40†	....	(Class B Operation)		.....	9,000¶	2,500	6Z7G
6ZY5G	ST-12	Duodiode	6S-0-0	Cathode	6.3	0.300	....	....	....	F-W Rect.	325 A-C Volts Per Plate, RMS, 40 Ma. Output Current. Condenser Input to Filter.										6ZY5G
7A4/XXL	Lock-in	Triode	5AC-L-0	Cathode	6.3	0.300	4.0	3.4	3.0	Amplifier	90 250	0.0 8.0	....	10.0 9.0	....	6,700 7,700	3,000 2,600	20 20	....	....	7A4/XXL
7A5	Lock-in	Beam Pent.	6AA-L-0	Cathode	6.3	0.750	0.44	13.0	7.2	Power Amp.	110 125	7.5 9.0	110 125	40.0 44.0	3.0 3.3	16,000 17,000	5,800 6,000	....	2,500 2,700	1,500 2,200	7A5
7A6	Lock-in	Duodiode	7DX-L-5	Cathode	6.3	0.150	....	....	....	Det. Rect.	150 A-C Volts Per Plate, RMS, 8 Ma. Current Output Per Plate.										7A6
7A7	Lock-in	Pentode	8V-L-5	Cathode	6.3	0.300	.003m	6.0	7.0	R-F Amp.	100 250	1.0 3.0	100 100	13.0 9.2	4.0 2.6	120,000 ♦ 800,000 ♦	2,350 2,000	....	....	....	7A7
7A8	Lock-in	Octode	8U-L-7	Cathode	6.3	0.150	0.15m	7.5	9.0	Converter	100 250	3.0 3.0	75 100	1.8 3.0	2.7 3.2	650,000 ♦ 700,000 ♦	375▲ 550▲	(Ga = 100 V., 2.8 Ma.) (Ga = 250 V.□, 4.2 Ma.)			7A8
7AB7	Lock-in	Pentode	8BO-L-0	Cathode	6.3	0.150	.06m	3.5	4.0	R-F Amp.	250	2.0	100	4.0	1.3	500,000	1,800	.....	....	....	7AB7
7AD7	Lock-in	Pentode	8V-L-5	Cathode	6.3	0.600	.03	11.5	7.5	Amplifier TV Amplifier	300 300	68 ■ 68 ■	150 125	28 25	7.0 6.0	300,000	9,500	....	....	....	7AD7
7AF7	Lock-in	Duotriode	8AC-L-0	Cathode	6.3	0.300	2.3*	2.2*	1.6*	Amplifier (per unit)	100 100 250	0 3.0 10	....	10.8 5.0 9.0	....	6,500 8,400 7,600	2,600 1,900 2,100	17 16 16	....	....	7AF7
7AG7	Lock-in	Pentode	8V-L-5	Cathode	6.3	0.150	.005m	7.0	6.0	R-F Amp.	250	250 ■	250	6.0	2.0	1.0 Meg.>	4,200	.....	....	....	7AG7
7AH7	Lock-in	Pentode	8V-L-5	Cathode	6.3	0.150	.005m	7.0	6.5	R-F Amp.	250	250 ■	250	6.8	1.9	1 Meg.	3,300	.....	....	....	7AH7
7AJ7	Lock-in	Pentode	8V-L-5	Cathode	6.3	0.300	.007m	6.0	6.5	R-F Amp.	100 250	1.0 3.0	100 100	5.7 2.2	1.8 0.7	400,000 1.0 Meg.>	2,275 1,575	....	....	....	7AJ7
7AK7	Lock-in	Pentode	8V-L-0	Cathode	6.3	0.800	4.0 SutoP 0.7	12.0	9.5	R-F Amp.	150 150 150	0 11 0	90 90 90	40 2.5 Max. 2.0 Max.	21 0.45 60 Max.	11,500	6,000	....	....	....	7AK7
7AU7	T-6½	Duotriode	9A-0-0	Cathode	7.0/ 3.5‡	0.300/ 0.600	1.5* 1.5*	1.6* 1.6*	0.4* 0.32*	Amplifier	Characteristics Same as Type 12AU7A. (7AU7 Designed for Series String TV Receivers).										7AU7
7B4	Lock-in	Triode	5AC-L-0	Cathode	6.3	0.300	1.6	3.2	3.2	Amplifier	100 250	1.0 2.0	....	0.4 0.9	....	85,000 66,000	1,150 1,500	100 100	....	....	7B4
7B5	Lock-in	Power Pent.	6AE-L-0	Cathode	6.3	0.400	0.8	7.4	8.0	Power Amp.	100 250 315	7.0 18.0 21.0	100 250 250	9.0 32.0 25.5	1.6 5.5 4.0	104,000 68,000 75,000	1,500 2,300 2,100	....	12,000 7,600 9,000	350 3,400 4,500	7B5

7B6	Lock-in	Duodiode Tri.	8W-L-7	Cathode	6.3	0.300	1.6	3.0	2.4	Det. Amp.	100 250	1.0 2.0	....	0.4 0.9	....	110,000 91,000	900 1,100	100 100	....	....	7B6
7B7	Lock-in	Pentode	8V-L-5	Cathode	6.3	0.150	.004m	5.0	6.0	R-F Amp.	100 250	3.0 3.0	100 100	8.2 8.5	1.8 1.7	300,000 750,000	1,675 1,750	.. ..	....	....	7B7
7B8	Lock-in	Heptode	8X-L-0	Cathode	6.3	0.300	0.2m	10.0	9.0	Converter	100 250	1.5 3.0	50 100	1.1 3.5	1.3 2.7	600,000 360,000	360▲ 550▲	(Ga = 100 V., 2.0 Ma.) (Ga = 250 V.□, 4.0 Ma.)			7B8
7C4	Lock-in	H. F. Diode	4AH-L-0	Cathode	6.3	0.150	....	....	....	Detector	Half Wave Cathode Type Rectifier for High Frequency Use.										7C4
7C5	Lock-in	Beam Pent.	6AA-L-0	Cathode	6.3	0.450	0.4	9.5	9.0	Power Amp. Class A1 Class AB1	180 250 315 250 285	8.5 12.5 13.0 15.0 19.0	180 250 225 250 285	29.0 45.0 34.0 70-79† 70-92†	3.0 4.5 2.2 5-13† 4-13.5†	58,000 52,000 77,000 (Class AB1 Two Tubes) (Class AB1 Two Tubes)	3,700 4,100 3,750	....	5,500 5,000 8,500 10,000¶ 8,000¶	2,000 4,500 5,500 10,000 14,000	7C5

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate, RF Input, Mixer Output.
⧗ Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



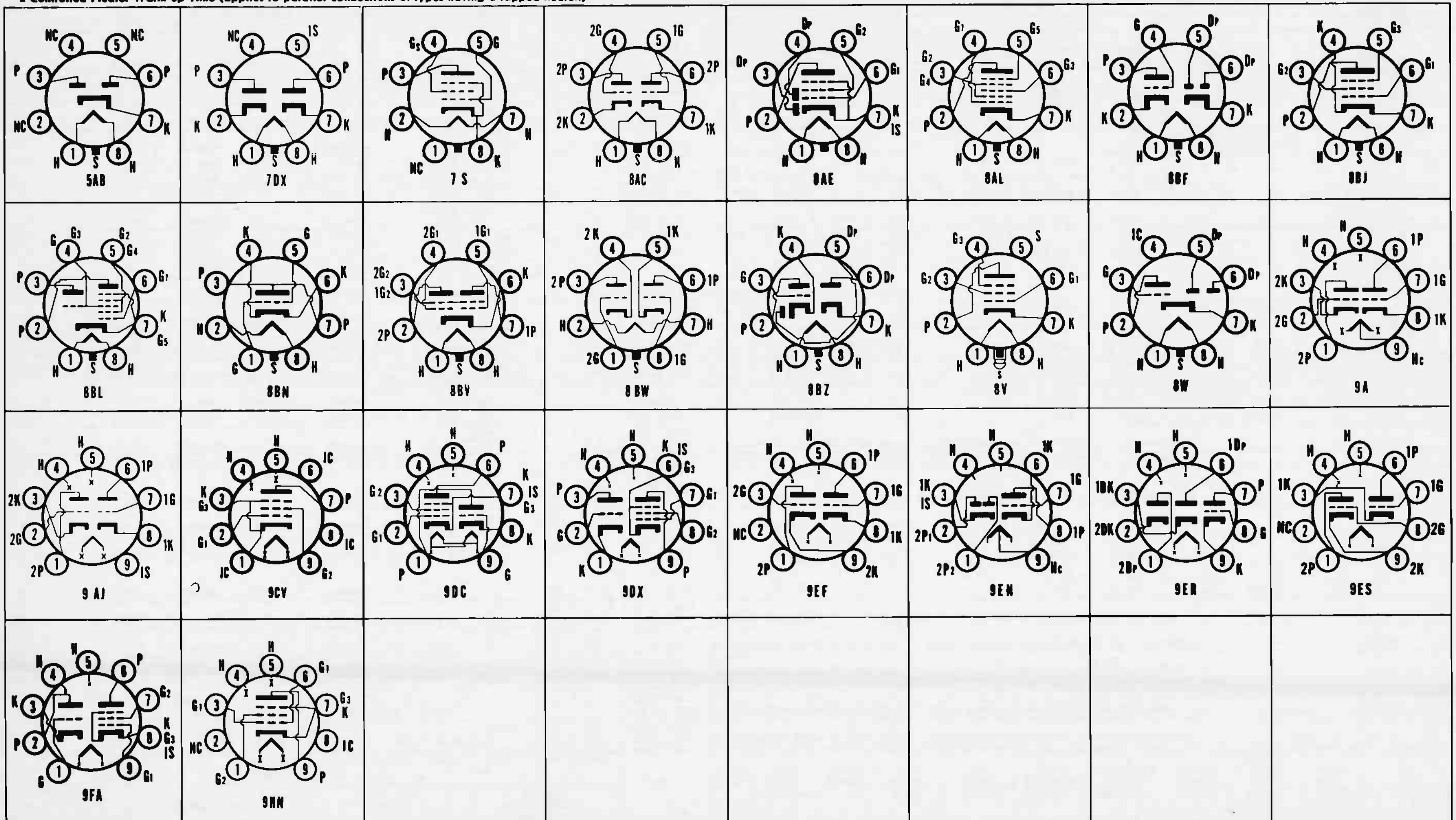
SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection. DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction			Emitter			Note (1) (2) Capacitances in μμf.			Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Power Output Milliwatts	Type
	Bulb Size or Style	Class	Basing Diag.	Type	Volts	Amps.	Cgp.	Cin.	Cout												
7C6	Lock-in	Duodiode Tri.	8W-L-7	Cathode	6.3	0.150	1.6	2.4	2.4	Det. Amp.	100 250	0.0 1.0	....	1.0 1.3	....	100,000 100,000	850 1,000	85 100	....	....	7C6
7C7	Lock-in	Pentode	8V-L-5	Cathode	6.3	0.150	.004m	5.5	6.5	R-F Amp.	100 250	3.0 3.0	100 100	1.8 2.0	0.4 0.5	1.2 Meg. ♦ 2.0 Meg. ♦	1,225 1,300	....	....	....	7C7
7E5	Lock-in	Triode	8BN-L-0	Cathode	6.3	0.150	1.5	3.6	2.8	Osc. Amp.	250 150	3.5 10.2	....	13.0 16.0	....	Oscillator for 750 mc. Service. Oscillator-Amplifier for 300 mc. Service.				 200	7E5
7E6	Lock-in	Duodiode Tri.	8W-L-7	Cathode	6.3	0.300	1.5	3.0	2.4	Det. Amp.	250 100	9.0 3.0	....	9.5 3.9	....	8,500 11,000	1,900 1,500	16 16.5	....	....	7E6
7E7	Lock-in	Duodi. Pent.	8AE-L-7	Cathode	6.3	0.300	.005m	4.6	5.5	Det. Amp.	100 250	1.0 3.0	100 100	10.0 7.5	2.7 1.6	150,000 ♦ 700,000 ♦	1,600 1,300	....	....	....	7E7
7EY6	T-9	Beam Pent.	7S	Cathode	7.2I	0.600	0.7*	8.5*	7.0*	Vert. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 2,500 Volts. Maximum D.C. Cathode Current = 60 Ma. Maximum Plate Dissipation = 11 Watts. 250	 17.5	 250	 44	 3.0	 60,000	 4,400				7EY6
7F7	Lock-in	Duotriode	8AC-L-0	Cathode	6.3	0.300	1.6	2.4	2.0	Amplifier#	100 250	1.0 2.0	....	0.65 2.3	....	62,000 ♦ 44,000 ♦	1,125 1,600	70 70	....	....	7F7
7F8	Lock-in	Duotriode	8BW-L-0	Cathode	6.3	0.300	1.7 1.7	2.8 2.8	1.4 1.4	Osc. Amp.	250	500 ■	.....	6.0#	....	......	3,300#	48	....	....	7F8
7F8W (3)	Lock-in	Duotriode	8BW-L-0	Cathode	6.3	0.300	1.6	3.0	1.7	Osc. Amp.	250	200 ■	.....	11.0	....	......	5,200	50	....	....	7F8W (3)
7G7	Lock-in	Pentode	8V-L-5	Cathode	6.3	0.450	.006m	9.0	7.0	R-F Amp.	250	2.0	100	6.0	2.0	800,000 ♦	4,500	.....	....	....	7G7
7G8	Lock-in	Duotetrode	8BV-L-0	Cathode	6.3	0.300	0.15m	3.4	2.6	R-F Amp. #	250	2.5	100	4.5	0.8	225,000	2,100	.....	....	....	7G8
7H7	Lock-in	Pentode	8V-L-5	Cathode	6.3	0.300	.004m	8.0	7.0	Amplifier	100 250	1.5 180 ■	100 150	7.5 10.0	2.6 3.2	350,000 ♦ 800,000 ♦	4,000 4,000	....	....	....	7H7
7J7	Lock-in	Tri. Heptode	8BL-L-7	Cathode	6.3	0.300	.03m	4.6	7.5	Hep. Mixer Tri. Osc.	100 250 100 250□	3.0 3.0 0.05 Meg. 0.05 Meg.	100 100	1.5 1.4 3.2 5.0	2.6 2.8 (Triode Grid Current 0.3 Ma.) (Triode Grid Current 0.4 Ma.)	500,000 1.5 Meg.	280▲ 290▲	....	....	....	7J7
7K7	Lock-in	Duodiode Tri.	8BF-L-7	Cathode	6.3	0.300	1.8	2.6	3.0	Det. Amp.	250	2.0	.....	2.3	....	44,000	1,600	70	....	....	7K7
7L7	Lock-in	Pentode	8V-L-5	Cathode	6.3	0.300	.01m	8.0	6.5	R-F Amp.	100 250	1.0 1.5	100 100	5.5 4.5	2.4 1.5	100,000 ♦ 1.0 Meg.	3,000 3,100	....	....	....	7L7
7N7	Lock-in	Duotriode	8AC-L-0	Cathode	6.3	0.600	3.0 3.0	3.4 2.9	2.0 2.4	Amplifier (per unit)	90 250	0.0 8.0	....	10.0 9.0	....	6,700 7,700	3,000 2,600	20 20	....	....	7N7
7Q7	Lock-in	Heptode	8AL-L-0	Cathode	6.3	0.300	0.15m	9.0	9.0	Converter	100 250	2.0 2.0	100 100	3.3 3.5	8.5 8.5	500,000 1.0 Meg.	525▲ 550▲	(Osc. Grid Resistor 20,000) (Osc. Grid Current 0.5 Ma.)			7Q7
7R7	Lock-in	Duodi. Pent.	8AE-L-7	Cathode	6.3	0.300	.004m	5.6	5.3	Det. Amp.	100 100 250 250	2.0 1.0 2.0 1.0	100 100 100 100	3.4 5.5 3.5 5.7	1.0 2.2 1.0 2.1	500,000 ♦ 350,000 ♦ 1,800,000 ♦ 1,000,000 ♦	2,100 3,000 2,200 3,200	....	....	....	7R7
7S7	Lock-in	Tri. Heptode	8BL-L-7	Cathode	6.3	0.300	.03m	5.0	8.0	Hep. Mixer Tri. Osc.	100 250 100 250□	2.0 2.0 0.05 Meg. 0.05 Meg.	100 100	1.9 1.8 3.0 5.0	3.0 3.0 (Triode Grid Current 0.3 Ma.) (Triode Grid Current 0.4 Ma.)	500,000 ♦ 1.25 Meg. ♦	500▲ 525▲	....	....	....	7S7
7T7	Lock-in	Pentode	8V-L-5	Cathode	6.3	0.300	.005m	8.0	7.0	R-FAmp.	250 100	1.0 1.0	150 100	10.8 5.3	4.1 2.1	900,000 ♦ 350,000 ♦	4,900 4,000	....	....	....	7T7
7V7	Lock-in	Pentode	8V-L-5	Cathode	6.3	0.450	.002m	9.5	6.5	R-F Amp.	300	160 ■	150	10.0	3.9	300,000	5,800	.....	....	....	7V7
7W7	Lock-in	Pentode	8BJ-L-5	Cathode	6.3	0.450	.002m	9.5	7.0	R-F Amp.	Characteristics Same as Type 7V7, Except Capacitances.										7W7
7X6	Lock-in	Duodiode	7DX-L-0	Cathode	6.3	1.200	....	....	....	H-W Rect. Doubler	235 Volts Per Plate, RMS, 75 Ma. DC Output Per Plate. 117 Volts Per Plate, RMS, 75 Ma. DC Output.										7X6
7X7	Lock-in	Duodiode Tri.	8BZ-L-4	Cathode	6.3	0.300	....	....	....	Det. Amp.	100 250	0 1.0	....	1.2 1.9	....	85,000 67,000	1,000 1,500	85 100	....	....	7X7
7Y4	Lock-in	Duodiode	5AB-L-0	Cathode	6.3	0.500	....	....	....	F-W Rect.	325 A-C Volts Per Plate, RMS, 70 Ma. Output Current. Condenser Input to Filter. 450 A-C Volts Per Plate, RMS, 70 Ma. Output Current. Choke Input to Filter.										7Y4
7Z4	Lock-in	Duodiode	5AB-L-0	Cathode	6.3	0.900	....	....	....	F-W Rect.	325 A-C Volts Per Plate, RMS, 100 Ma. Output Current. Condenser Input to Filter. 450 A-C Volts Per Plate, RMS, 100 Ma. Output Current. Choke Input to Filter.										7Z4
8AU8 8AU8A	T-6½	Tri. Pentode	9DX-0-6	Cathode	8.4I	0.450	2.2* .046*	2.8* 7.0*	0.32* 2.6*	Tri. Amp. Pent. Amp.	Characteristics Same as Type 6AU8. (8AU8 and 8AU8A Designed for Series String Operation). 8AU8A Characteristics Same as Type 6AU8A.										8AU8 8AU8A
8AW8A	T-6½	Tri. Pentode	9DX-0-6	Cathode	8.4I	0.450	2.2 .03	3.4 10.0	1.7 4.5	Sync. Sep. Video Amp.	Characteristics Same as Type 6AW8A. (8AW8A Designed for Series String TV Receivers).										8AW8A
8BA8A	T-6½	Tri. Pentode	9DX-0-0	Cathode	8.4I	0.450	2.2* .03*	2.7* 10.0*	1.9* 4.5*	Sync. Sep. Video Amp.	Characteristics Same as Type 6BA8A. (8BA8A Designed for Series String TV Receivers).										8BA8A
8BH8	T-6½	Tri. Pentode	9DX-0-6	Cathode	8.4I	0.450	2.4* .046*	2.6* 7.0*	3.8* 2.4*	Tri. Amp. Pent. Amp.	Characteristics Same as Type 6BH8. (8BH8 Designed for Series String TV Receivers).										8BH8
8BN8	T-6½	Duodiode Tri.	9ER	Cathode	8.4I	0.450	2.5*	3.6*	0.32*	Amplifier	Characteristics Same as Type 6BN8. (8BN8 Designed for Series String TV Receivers).										8BN8
8BQ5	T-6½	Beam Pent.	9CV	Cathode	8.0I	0.600	....	....	....	*P.P.AB1 Amp.	Characteristics Same as Type 6BQ5. (8BQ5 Designed for Series String Receivers).										8BQ5
8CG7	T-6½	Duotriode	9AJ-0-9	Cathode	8.4I	0.450	4.0*	2.3*	2.2*	Amplifier	Characteristics Same as Type 6CG7. (8CG7 Designed for Series String TV Receivers).										8CG7
8CM7	T-6½	Duotriode	9ES-0-0	Cathode	8.4I	0.450	3.8* 3.0*	2.0* 3.5*	0.5* 0.4*	Vert. Osc. Vert. Defl. A.	Characteristics Same as Type 6CM7. (8CM7 Designed for Series String TV Receivers).										8CM7
8CN7	T-6½	Duodiode Tri.	9EN-0-3	Cathode	8.4/ 4.2I	0.225/ 0.450	1.8*	1.5*	0.5*	Det. Amp.	Characteristics Same as Type 6CN7. (8CN7 Designed for Series String TV Receivers).										8CN7
8CS7	T-6½	Duotriode	9EF-0-0	Cathode	8.4I	0.450	2.6* 2.6*	1.8* 3.0*	0.5* 0.5*	Vert. Osc. Vert. Defl. Amp.	Characteristics Same as Type 6CS7. (8CS7 Designed for Series String TV Receivers).										8CS7

8CY7	T-6½	Duotriode	9EF	Cathode	7.9⧗	0.600	1.8* 4.4*	1.5* 5.0*	0.3* 1.0*	Vert. Osc. Vert. Defl. A.	Characteristics Same as Type 6CY7. (8CY7 Designed for Series String TV Receivers).										8CY7
8EB8	T-6½	Tri. Pentode	9DX	Cathode	8.0⧗	0.600	4.4 0.1	2.4 11	0.36 4.2	A-F Amp. Video Amp.	Characteristics Same as Type 6EB8. (8EB8 Designed for Series String Receivers).										8EB8
8EM5	T-6½	Beam Pent.	9HN	Cathode	8.4⧗	0.600	0.7*	10*	5.1*	Vert. Defl. Amp.	Characteristics Same as Type 6EM5. (8EM5 Designed for Series String Operation).										8EM5
9A8	T-6½	Tri. Pentode	9DC-0-7	Cathode	9.0	0.300	.025* 1.5*	5.5* 2.5*	3.8* 1.8*	VHF Osc. VHF Amp.	Characteristics Same as Type 6BL8.										9A8
9AU7	T-6½	Duotriode	9A-0-0	Cathode	9.4/ 4.7⧗	0.225/ 0.450	1.5	1.8	2.0	Amplifier	Characteristics Same as Type 7AU7. (9AU7 Designed for Series String TV Receivers).										9AU7
9BR8	T-6½	Tri. Pentode	9FA	Cathode	9.45	0.300	1.8 .008m	2.5 5.0	1.0 3.5	VHF Osc. VHF Amp.	150 250	56■ 68■	 110	18 10	... 3.5	5,000 400,000	8,500 5,200	40	....	....	9BR8

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate; RF Input, Mixer Output.
⧗ Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection. DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

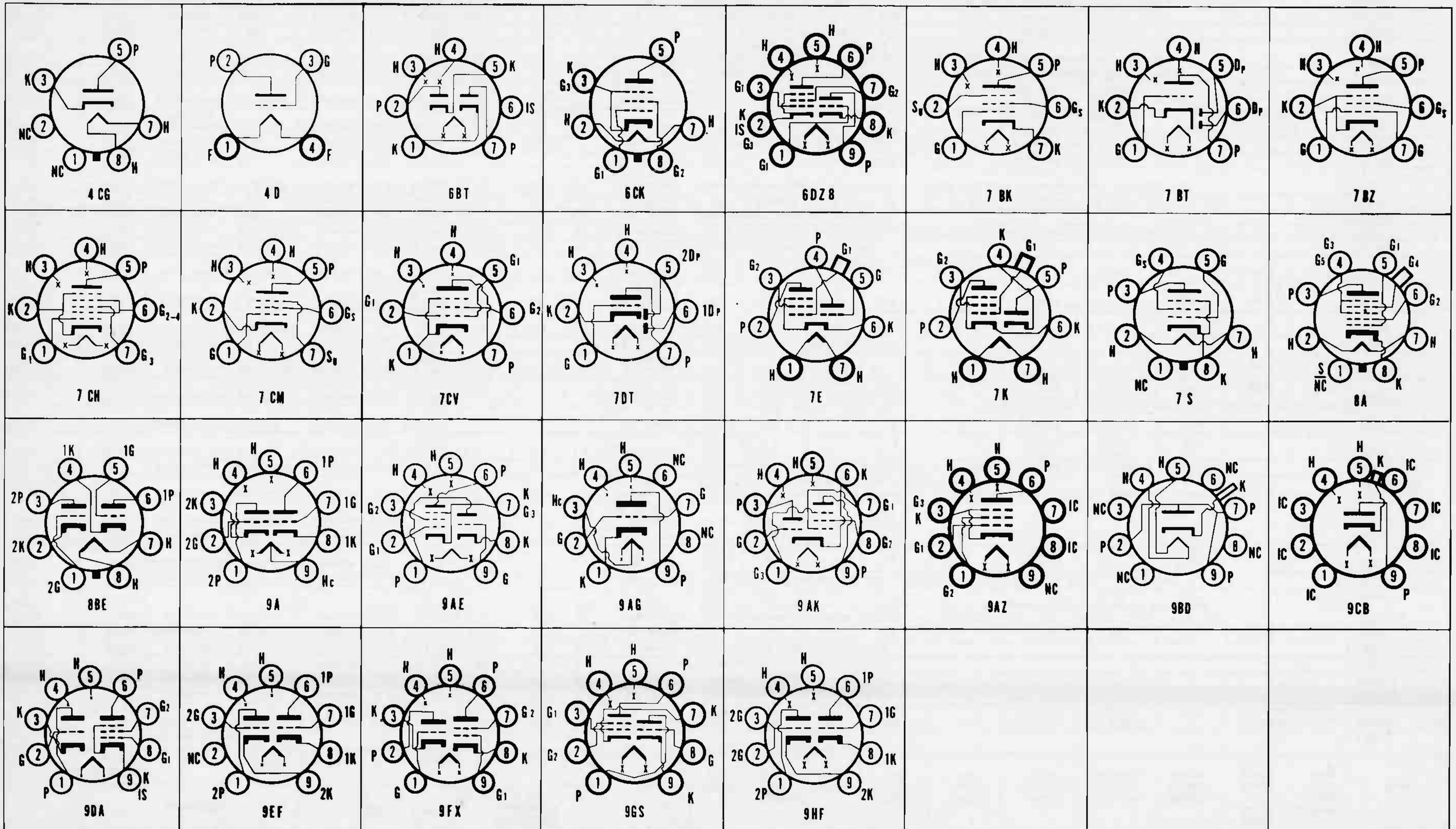
SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (¹) (²) Capacitances in μμf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Power Output Milli-watts	Type
9CL8	T-6½	Tri. Tetrode	9FX-0-0	Cathode	9.5‡	0.300	1.8 .016	2.7 5.0	1.2 3.0	VHF Osc. VHF Amp.	Characteristics Same as Type 6CL8. (9CL8 Designed for Series String TV Receivers).										9CL8
9DZ8	T-6½	Tri. Beam Pent.	6DZ8	Cathode	9.0	0.600	....	....		A-F Voltage Amp. and Power Amp.	Characteristics Same as Type 6DZ8. (9DZ8 Designed for Series String Receivers).										9DZ8
9EF6	T-9	Beam Pent.	7S	Cathode	9.4‡	0.600	0.8*	11.5*	9.0*	Vert. Defl. Amp.	Characteristics Same as Type 6EF6. (9EF6 Designed for Series String TV Receivers).										9EF6
9U8A	T-6½	Tri. Pentode	9AE	Cathode	9.45‡	0.300	1.8 .006	2.5 5.0	1.0 3.5	VHF Osc. VHF Amp.	Characteristics Same as Type 6U8. (9U8A Designed for Series String TV Receivers).										9U8A
9X8	T-6½	Tri. Pentode	9AK	Cathode	9.5‡	0.300	1.4 .06	2.6 4.5	1.0 1.4	VHF Osc. VHF Amp.	Characteristics Same as Type 6X8. (9X8 Designed for Series String TV Receivers).										9X8
10	ST-16	Triode	4D-0-0	Filament	7.5	1.250	7.0*	4.0*	3.0*	Power Amp.	250 350 425	23.5 32.0 40.0	....	10.0 16.0 18.0	....	6,000 5,150 5,000	1,330 1,550 1,600	8.0 8.0 8.0	13,000 11,000 10,200	400 900 1,600	10
10C8	T-6½	Tri. Pentode	9DA-0-9	Cathode	10.5‡	0.300	1.6* .04*	2.4* 7.0*	0.2* 2.2*	Tri. Amp. Pent. Amp.	250 135	390 ■ 100 ■	 135	7.3 11.5	.... 3.2	12,000 190,000	4,400 8,000	53	....	....	10C8
10DA7	T-6½	Duotriode	9EF-0-0	Cathode	10.5‡	0.600	2.3* 6.9*	2.0* 5.5*	0.415* 0.82*	Vert. Osc. Vert. Defl. A.	Characteristics Same as Type 6DA7. (10DA7 Designed for Series String TV Receivers).										10DA7
10DE7	T-6½	Duotriode	9HF	Cathode	9.7‡	0.600	4.0* 8.5*	2.2* 5.5*	0.52* 1.0*	Vert. Osc. Vert. Defl. Amp.	Characteristics Same as Type 6DE7. (10DE7 Designed for Series String TV Receivers).										10DE7
11C5	T-5½	Beam Pent.	7CV	Cathode	11.6‡	0.450	0.6*	....	....	Power Amp.	Characteristics Same as Type 35C5. (11C5 Designed for Series String TV Receivers).										11C5
11CY7	T-6½	Duotriode	9EF	Cathode	11‡	0.450	1.8* 4.4*	1.5* 5.0*	0.3* 1.0*	Vert. Osc. Vert. Defl. A.	Characteristics Same as Type 6CY7. (11CY7 Designed for Series String TV Receivers).										11CY7
12A	ST-14	Triode	4D-0-0	Filament	5.0	0.250	8.5*	4.0*	2.0*	Det. Amp.	180	13.5	.....	7.7	....	4,700	1,800	8.5	10,650	285	12A
12A4	T-6½	Triode	9AG-0-0	Cathode	6.3 12.6	0.600 0.300	5.6*	4.9*	0.9*	Amplifier	250	9.0	.....	23	....	2,500	8,000	20	....	....	12A4
12A5	ST-12 T-9	Beam Pent.	7E-0-0	Cathode	12.6 6.3	0.300 0.600	0.3	9.0	9.0	Power Amp.	100 180	15.0 25.0	100 180	17.0 45.0	3.0 8.0	50,000 ♦ 35,000 ♦	1,700 2,400	....	4,500 3,300	800 3,400	12A5
12A6 12A6GT	Metal T-9	Beam Pent.	7S-1-0 7S-0-0	Cathode	12.6	0.150	....	....	....	Power Amp.	250	12.5	250	30	3.5	70,000	3,000	....	7,500	3,400	12A6 12A6GT
12A7	ST-12	Diode Pent.	7K-0-0	Cathode	12.6	0.300	....	....	....	H-W Rect. Power Amp.	125 RMS 135	 13.5	 135	30.0 Max. 9.0	.... 2.5	 102,000	 975	 100	 13,500	 550	12A7
12A8G 12A8GT	T-12 T-9	Heptode	8A-1-0	Cathode	12.6	0.150	0.26	9.5	12.0	Converter	Characteristics Same as Type 6A8G.										12A8G 12A8GT
12AC6	T-5½	Pentode	7BK	Cathode	12.6	0.150	.004	4.3	5.0	R.F Amp.	12.6	0	12.6	550 μa.	200 μa.	0.5 Meg.	730	....	....	....	12AC6
12AD5	T-6½	Pentode	9AZ	Cathode	12.6	0.100	.002m*	5.1	8.1	R-F Amp.	100	2.5	100	6.0	1.75	600,000 ♦	2,200	....	....	....	12AD5
12AD6	T-5½	Heptode	7CH	Cathode	12.6	0.150	0.25m	8.0	13	Hep. Mixer	12.6	1.6	12.6	450 μa.	1.5	......	260▲	....	....	....	12AD6
12AD7	T-6½	Duotriode	9A	Cathode	12.6/ 6.3	0.225/ 0.450	1.8 1.8	1.7 1.7	1.6 1.9	Amplifier #	250	2	.....	1.25	....	62,500	1,600	100	....	....	12AD7
12AE6	T-5½	Duodiode Tri.	7DT	Cathode	12.6	0.150	2.0	1.8	1.1	Class A1 Amp.	12.6	0	.....	0.75	....	15,000	1,000	15	....	....	12AE6
12AF3	T-6½	Diode	9CB	Cathode	12.6‡	0.600	....	....	....	T.V. Damper	Characteristics Same as Type 6AF3. (12AF3 Designed for Series String Receivers).										12AF3
12AF6	T-5½	Pentode	7BK-0-2	Cathode	12.6	0.150	.006*	5.5*	4.8*	R-F Amp.	12.6	0	12.6	1.1	0.45	0.35 Meg.	1,500	.....	....	....	12AF6
12AG6	T-5½	Heptode	7CH	Cathode	12.6	0.150	.065m*	5.5*	7.5*	Converter	12.6	0.85	12.6	0.55	1.4	......	300▲	G1 = 20,000 Ohms; G1 = 0.050 Ma.		....	12AG6
12AH7GT	T-9	Duotriode	8BE-0-0	Cathode	12.6	0.150	3.0 2.2	2.8 3.2	2.6 3.0	Amplifier (per unit)	100 180	3.6 6.5	....	3.7 7.6	....	10,300 8,400	1,550 1,900	16 16	....	....	12AH7GT
12AJ6	T-5½	Duodiode Tri.	7DT	Cathode	12.6	0.150	2.0*	2.2*	0.8*	Det. Amp.	12.6	0	.....	.075	....	45,000	1,200	55	....	....	12AJ6
12AL5	T-5½	Duodiode	6BT-0-6	Cathode	12.6	0.150	...	....	....	Detector	Characteristics Same as Type 6AL5.										12AL5
12AL8	T-6½	Tri. Tetrode	9GS	Cathode	12.6	0.550	5.7* 14.0*	1.8* 13.0*	0.4* 1.6*	Tri. Amp. Tet. Amp.	12.6 12.6 G2 = 0.5' G1 = 12.6 40 Designed for Space-Change Grid Operation.	0.9'	.....	0.5	 75	13,000 480	1,000 15,000	13	....	....	12AL8
12AQ5	T-5½	Beam Pent.	7BZ-0-0	Cathode	12.6	0.225	0.35*	8.3*	8.2*	Power Amp.	Characteristics Same as Type 6AQ5.										12AQ5
12AT6	T-5½	Duodiode Tri.	7BT-0-0	Cathode	12.6	0.150	2.1*	2.2*	1.1*	Det. Amp.	Characteristics Same as Type 6AT6.										12AT6
12AT7	T-6½	Duotriode	9A-0-0	Cathode	6.3 12.6	0.300 0.150	1.45* 1.45*	2.5* 2.5*	0.45* 0.35*	Amplifier	100 250	270■ 200■	....	3.7 10.0	....	....	4,000 5,500	60 60	....	....	12AT7
12AU6	T-5½	Pentode	7BK-0-2	Cathode	12.6	0.150	.0035m*	5.5*	5.0*	R-F Amp.	Characteristics Same as Type 6AU6.										12AU6
12AU7, 12AU7A	T-6½	Duotriode	9A-0-0	Cathode	12.6 6.3	0.150 0.300	1.5* 1.5*	1.6* 1.6*	0.4* 0.32*	Amplifier	250 100	8.5 0	....	10.5 11.8	....	7,700 6,500	2,200 3,100	17 20	....	....	12AU7 12AU7A
12AV5GA	T-11 or T-12	Beam Pent.	6CK-0-0	Cathode	12.6‡	0.600	0.5*	14.0*	7.0*	Horizontal Defl. Amp.	Characteristics Same as Type 6AV5GA. (12AV5GA Designed for Series String TV Receivers).										12AV5GA
12AV6	T-5½	Duodiode Tri.	7BT-0-0	Cathode	12.6	0.150	2.1*	2.5*	0.9*	Det. Amp.	Characteristics Same as Type 6AV6.										12AV6
12AV7	T-6½	Duotriode	9A-0-0	Cathode	12.6 6.3	0.225 0.450	1.7 1.7	1.8 1.8	1.9 1.9	Amplifier	100 150	120■ 56■	....	9.0 18	....	6,100 4,800	6,100 8,500	37 41	....	....	12AV7
12AW6	T-5½	Pentode	7CM-0-7	Cathode	12.6	0.150	.025m*	6.5*	1.5*	R-F Amp.	250 125 100	200■ 100■ 100■	150 125 100	7.0 7.2 5.5	2.0 2.1 1.6	0.8 Meg. 0.5 Meg. 0.3 Meg.	5,000 5,100 4,750	....	....	....	12AW6
12AX4GT 12AX4GTA	T-9	Diode	4CG-0-0	Cathode	12.6 12.6‡	0.600 0.600	....	....	....	T.V. Damper	P.I.V. = 4,400 Volts Max., D-C Plate Current = 125 Ma. Max. (12AX4GTA Designed for Series String TV Receivers).										12AX4GT 12AX4GTA

12AX7	T-6½	Duotriode	9A-0-0	Cathode	12.6 6.3	0.150 0.300	1.7* 1.7*	1.6* 1.6*	0.46* 0.34*	Amplifier#	100 250	1 2	....	0.5 1.2	....	80,000 62,500	1,250 1,600	100 100	....	....	12AX7
12AX7A	T-6½	Duotriode	9A	Cathode	12.6 6.3	0.150 0.300	1.7* 1.7*	1.6* 1.6*	0.46* 0.34*	Audio Amplifier	Low Noise and Low Microphoism Version of Identical Type 12AX7.										12AX7A
12AY7	T-6½	Duotriode	9A-0-0	Cathode	12.6	0.150	1.3*	1.3*	0.6*	Audio Amp.#	250	4.0	.....	3.0	....	......	1,750	40	....	....	12AY7
12AZ7	T-6½	Duotriode	9A-0-0	Cathode	6.3 12.6	0.450 0.225	1.9 1.9	2.8 2.8	1.2 1.6	Amplifier	100 250	270 ■ 200 ■	....	3.7 10.0	....	15,000 10,900	4,000 5,500	60 60	....	....	12AZ7
12B3	T-6½	Diode	9BD-0-0	Cathode	12.6I	0.600	....	....	....	T.V. Damper	Characteristics Same as Type 6B3. (12B3 Designed for Series String TV Receivers).										12B3
12B4 12B4A	T-6½	Triode	9AG-0-0	Cathode	6.3I/ 12.6	0.600/ 0.300	4.0	6.2	4.2	Vert. Defl. Amp.	Max. Peak Pos. Pulse Plate Voltage = 1,000 Volts Max. D.C. Cathode Current = 30 Ma. Max. Plate Dissipation = 6 Watts. (12B4A Designed for Series String TV Receivers). 150	17.5	.....	35	....	......	6,500	6.5	....	....	12B4A 12B4

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate; RF Input, Mixer Output.
I Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.

\# Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection, DO NOT USE, J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction			Emitter			Note (1) (2) Capacitances in μμf.			Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Power Output Milliwatts	Type
	Bulb Size or Style	Class	Basing Diag.	Type	Volts	Amps.	Cgp.	Cin.	Cout												
12B7	Now Known as Type 14A7																				12B7
12B8GT	T-9	Pentode Tri.	8T-0-1	Cathode	12.6	0.300	.015* 2.3	5.2* 5.0	9.6* 6.3	Pent. Amp. Tri. Amp.	90 90	3.0 0	90	7.0 2.8	2.0	200,000 35,000	1,800 2,400	 90	(Pentode Section) (Triode Section)		12B8GT
12BA6	T-5½	Pentode	7BK-0-0	Cathode	12.6	0.150	.0035*	5.5*	5.5*	R-F Amp.	Characteristics Same as Type 6BA6.										12BA6
12BA7	T-6½	Heptode	8CT-0-6&8	Cathode	12.6	0.150	0.19m	9.5	8.3	Converter	Characteristics Same as Type 6BA7.										12BA7
12BD6	T-5½	Pentode	7BK-0-2	Cathode	12.6	0.150	.004	4.3	5.0	R-F Amp.	Characteristics Same as Type 6BD6.										12BD6
12BE6	T-5½	Heptode	7CH-0-0	Cathode	12.6	0.150	0.3*	7.0*	8.0*	Converter	Characteristics Same as Type 6BE6.										12BE6
12BF6	T-5½	Duodiode Tri.	7BT-0-0	Cathode	12.6	0.150	1.9*	1.9*	1.2*	Det. Amp.	250	9.0	.....	9.5	....	8,500	1,900	16	10,000	300	12BF6
12BH7 12BH7A	T-6½	Duotriode	9A-0-0	Cathode	6.3‡/ 12.6	0.600/ 0.300	2.4 2.4	3.0 3.0	2.0 2.0	Vert. Defl. Amp.	Max Peak Pos. Pulse Plate Voltage = 1,500 Volts Max. D.C. Cathode Current = 20 Ma. Max. Plate Dissipation = 3.5 Watts. (12BH7A Designed for Series String TV Receivers).										12BH7A
											250	10.5	.....	11.5	....	.....	3100	17	....	....	12BH7
12BK5	T-6½	Beam Amp.	9BQ-0-0	Cathode	12.6‡	0.600	0.6*	13.0*	5.0*	Power Amp.	Characteristics Same as Type 6BK5. (12BK5 Designed for Series Sring TV Receivers).										12BK5
12BK6	T-5½	Duodiode Tri.	7BT-0-2	Cathode	12.6	0.150	....	....	....	Det. Amp.	100 250	1.0 2.0	....	0.5 1.2	....	80,000 62,000	1,250 1,600	100 100	....	....	12BK6
12BL6	T-5½	Pentode	7BK	Cathode	12.6	0.150	.006	5.5	4.8	R-F Amp.	12.6	0.65[4]	12.6	1.35	0.5	500,000♦	1,350	....	....	...	12BL6
12BN6	T-5½	Gated Beam	7DF-0-1	Cathode	12.6	0.150	....	....	....	Quad. F. M. Det.	Characteristics Same as Type 6BN6.										12BN6
12BQ6GA 12BQ6GTA	T-11 T-9	Beam Pent.	6AM-0-0	Cathode	12.6‡	0.600	0.8*	14.0*	6.5*	Horiz. Defl. Amp.	Characteristics Same as Type 6BQ6GA. (12BQ6GA and 12BQ6GTA Designed for Series String TV Receivers) 12BQ6GTA Characteristics Same as Type 6BQ6GTA.										12BQ6GA 12BQ6GTA
12BQ6GTB	T-9	Beam Pent.	6AM-0-0	Cathode	12.6‡	0.600	0.6*	15.0*	7.5*	Horiz. Amp.	Characteristics Same as Type 6BQ6GTB. (12BQ6GTB Designed for Series String TV Receivers).										12BQ6GTB
12BR7	T-6½	Duodiode Tri.	9CF	Cathode	12.6/ 6.3	0.225/ 0.450	1.9	2.8	1.0	Amplifier	100 250	270■ 200■	....	3.7 10.0	....	15,000 10,900	4,000 5,500	60 60	....	....	12BR7
12BT6	T-5½	Duodiode Tri.	7BT-0-2	Cathode	12.6	0.150	....	....	....	Det. Amp.	100 250	1.0 3.0	....	0.8 1.0	....	54,000 58,000	1,300 1,200	70 70	....	....	12BT6
12BU6	T-5½	Duodiode Tri.	7BT-0-2	Cathode	12.6	0.150	....	....	....	Det. Amp.	250 100	3.0 9.0	....	3.9 9.5	....	11,000 8,500	1,500 1,900	16.5 16	 10,000	 300	12BU6
12BV7	T-6½	Pentode	9BF-0-3&9	Cathode	12.6/ 6.3	0.300/ 0.600	.055*	11.0*	3.0*	Class A1 Amplifier	250	68■	150	27	6.0	85,000	13,000	10,000	....	....	12BV7
12BW4	T-6½	Duodiode	9DJ	Cathode	12.6	0.450	....	....	....	F-W Rect.	Characteristics Same as Type 6BW4.										12BW4
12BY7	T-6½	Pentode	9BF-0-3&4	Cathode	6.3 12.6	0.600 0.300	.063*	10.2*	3.5*	Video Amp.	250	100■	180	26	5.75	93,000	11,000	1,035	....	....	12BY7
12BZ7	T-6½	Duotriode	9A-0-0	Cathode	6.3/ 12.6	0.600/ 0.300	0.45	6.5		Sync Sep. or Amplifier #	250	2	.....	2.5	....	31,800	3,200	100	Cout Sec. 1 = 0.7 μμf.		12BZ7
12C5	T-5½	Beam Pent.	7CV-0-0	Cathode	12.6‡	0.600	0.6*	13.0*	8.5*	Power Amp.	120 (12C5 Designed for Series String TV Receivers).	8	110	49	4.0	10,000	7,500	.....	2,500	2,300	12C5
12C8	Metal	Duodi. Pent.	8E-1-1	Cathode	12.6	0.150	.005m	6.0	9.0	Det. Amp.	Characteristics Same as Type 6B8.										12C8
12CA5	T-5½	Beam Pent.	7CV-0-0	Cathode	12.6‡	0.600	0.5*	15.0*	9.0*	Power Amp.	Characteristics Same as Type 6CA5. (12CA5 Designed for Series String TV Receivers).										12CA5
12CM6	T-6½	Beam Pent.	9CK-0-0	Cathode	12.6	0.225	0.7*	8.0*	8.5*	Power Amp.	Characteristics Same as Type 6CM6.										12CM6
12CN5	T-5½	Pentode	7CV	Cathode	12.6	0.450	.02	....	....	I-F Amp.	12.6	2.2Meg.[4]	12.6	4.5	0.35	40,000♦	3,800	....	....	....	12CN5
12CR5	T-6½	Beam Pent.	9HC-0-0	Cathode	12.6‡	0.600	0.32*	12.9*	6.9*	Horiz. Defl. Amp.	Characteristics Same as Type 6CR5. (12CR5 Designed for Series String TV Receivers).										12CR5
12CR6	T-5½	Diode Pent.	7EA	Cathode	12.6	0.150	....	....	....	Audio Amp.	250	2	100	9.6	2.6	800,000	2,200	....	....	....	12CR6
12CS5	T-6½	Beam Pent.	9CK	Cathode	12.6‡	0.600		15.0		Power Amp.	Characteristics Same as Type 6CS5. (12CS5 Designed for Series String TV Receivers.)										12CS5
12CS6	T-5½	Dual Control Heptode	7CH-0-0	Cathode	12.6	0.150	.05m 0.36m	5.5 7.0	7.5	Sync. Sep.	100 100	0.0Gr.#1 1.0Gr.#1	30 30	0.8 0.75	4.0 1.1	700,000 1.0 Meg.	950 Gr. #1 1250 Gr. #3	Grid #3 Volts = 0 Grid #3 Volts = 1.0			12CS6
12CT8	T-6½	Tri. Pentode	9DA-0-9	Cathode	12.6‡	0.300	2.2* .044*	2.4* 7.5*	0.19* 2.4*	Sync. Amp. Video Amp.	150 200	150■ 82■	 125	9.0 15.0	.... 3.4	8,200 150,000	4,900 7,000	40	....	....	12CT8
12CU5	T-5½	Beam Pent.	7CV	Cathode	12.6‡	0.600	0.6*	13*	8.5*	Power Amp.	Characteristics Same as Type 6CU5. (12CU5 Designed for Series String TV Receivers.)										12CU5
12CU6	T-12	Beam Pent.	6AM-0-0	Cathode	12.6‡	0.600	0.55*	15.0*	7.0*	Horiz. Defl. Amp.	Characteristics Same as Type 6BQ6G, Except Max. D.C. Plate Supply = 550 Volts. (12CU6 Designed for Series String TV Receivers).										12CU6
12CX6	T-5½	Pentode	7BK	Cathode	12.6	0.150	.05*	7.6*	6.2*	R-F Amp.	12.6	2.2Meg.[4]	12.6	3.0	1.4	40,000	3,100	....	....	....	12CX6
12CY6	T-5½	Pentode	7BK	Cathode	12.6	0.200	0.18*	8.5*	4.0*	R-F Amp.	12.6	2.2Meg.[4]	12.6	1.6	0.4	140,000	3,250	....	....	....	12CY6
12D4	T-9	Diode	4CG-0-0	Cathode	12.6‡	0.600	....	....	....	T.V. Damper	Maximum Inverse Peak Plate Voltage = 4,400 Volts. Maximum D.C. Plate Current = 155 Ma.										12D4
12DB5	T-6½	Beam Pent.	9GR-0-0	Cathode	12.6‡	0.600	0.2	1.3	8.0	Vert. Defl. Amp.	Characteristics Same as Type 6DB5. (12DB5 Designed for Series String TV Receivers).										12DB5
12DE8	T-6½	Diode Pent.	12DE8	Cathode	12.6	0.200	.006*	5.5*	5.7*	R-F or I-F Amplifier	12.6	0.8[4]	12.6	1.3	0.5	300,000♦	1,500	....	....	....	12DE8
12DF5	T-6½	Duodiode	9BS	Cathode	12.6 6.3	0.450 0.900	....	....	....	F-W Rect.	325 A.V. Volts Per Plate, RMS, 100 Ma. Output Current. Condenser Input. 450 A.C. Volts Per Plate, RMS, 100 Ma. Output Current. Choke Input.										12DF5
12DF7	T-6½	Duotriode	9A	Cathode	12.6 6.3	0.150 0.300	1.4* 1.4*	1.6* 1.6*	0.4* 0.3*	Audio Amp.	Characteristics Same as Type 12AX7. (Special Low Noise).										12DF7
12DK5	T-6½	Pentode	9GT	Cathode	12.6	0.300	.045	9.5	2.65	R-F Amp.	12.6	2.2Meg.[4]	12.6	2.0	0.65	100,000	3,300	....	....	....	12DK5
12DK7	T-6½	Duodiode Tetrode	9HZ	Cathode	12.6	0.500	....	....	....	Det. Power Amp. Driver	12.6	15 Meg.[4]	12.6	6.0	1.0	4,000	5,000	....	3,500	10	12DK7
12DL8	T-6½	Duodiode Tetrode	9HR	Cathode	12.6	0.550	14*	12*	1.3*	Det. Power Amp. Driver	12.6 (Space-Charge Grid Operation).	G2 − 2	G1 − 12.6	8	75	480	15,000	....	800	40	12DL8
12DM5	T-5½	Beam Pent.	7CV	Cathode	12.6‡	0.450	0.55*	13.0*	9.0*	Power Amp.	110	7.5	110	49.0	4.0	14,000	7,500	....	2,500	1,900	12DM5

12DQ6	T-12	Beam Pent.	6AM-0-0	Cathode	12.6ꟾ	0.600	0.55*	15.0*	7.0*	Horiz. Def. Amp.	Characteristics Same as Type 6DQ6. (12DQ6 Designed for Series String TV Receivers).										12DQ6
12DQ6A	T-12	Beam Pent.	6AM	Cathode	12.6ꟾ	0.600	0.55*	15.0*	7.0*	Horiz. Defl. Amp.	Characteristics Same as Type 6DQ6A. (12DQ6A Designed for Series String TV Receivers.)										12DQ6A
12DQ7	T-6½	Pentode	9BF	Cathode	12.6/ 6.3ꟾ	0.300 0.600	0.1*	10*	3.8*	Video Amp.	200	68■	125	26	5.6	53,000	10,500	.....	....	....	12DQ7
											Instantaneous Plate Knee Values: EB = 40 Volt, EC² = 125 Volt, EC¹ = 0 Volt, IB = 45 Ma. and IC² = 16 Ma.										
12DS7	T-6½	Duodiode Tetrode	9JU	Cathode	12.6	0.400	12.5*	13*	2*	Def. Power Amp. Driver	12.6	2.2 Meg⁴	G1 −12.6	40-8†	75	......	.....	.....	800	40	12DS7
											(Space-Charge Grid Operation).										

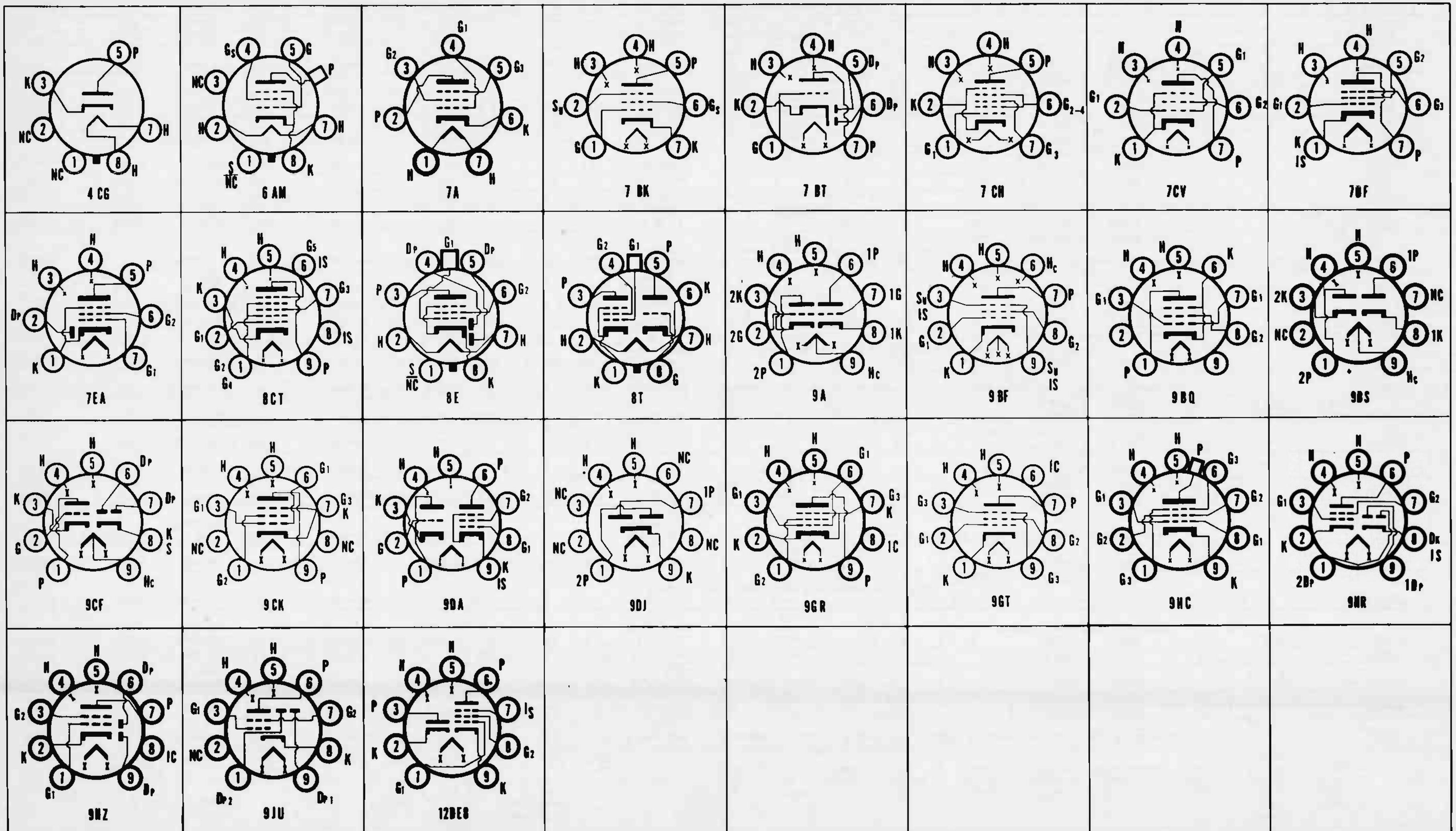
(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate, RF Input, Mixer Output.
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
ꟾ Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)

Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.

□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.

¶ Plate to Plate.
♦ Approximate.

m maximum.
■ Cathode Resistor (ohms).



SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection, DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (1) (2) Capacitances in μμf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Power Output Milli-watts	Type
12DT5	T-6½	Beam Pent.	9HN	Cathode	12.6I	0.600	0.57*	12.5*	4.9*	Vert. Defl. Amp.	Characteristics Same as Type 6DT5. (12DT5 Designed for Series String TV Receivers).										12DT5
12DT8	T-6½	Duotriode	9DE	Cathode	12.6	0.150	1.6	2.7	1.6	Amplifier	100 250	270 ■ 200 ■	....	3.7 10	....	15,000 10,900	4,000 5,500	60 60	....	....	12DT8
12DU7	T-6½	Duodiode Tetrode	9JX	Cathode	12.6	0.275	0.6*	11*	3.6*	Det. Power Amp. Driver	12.6	2.2 Meg[4]	12.6	12	1.5	6,000	6,200	.....	2,700	25	12DU7
12DV7	T-6½	Duodiode Tri.	9JY	Cathode	12.6	0.150	1.6*	1.3*	0.38*	Det. Amp.	12.6	2.2 Meg[4]	.....	0.4	....	19,000	750	14	....	....	12DV7
12DV8	T-6½	Duodiode Tetrode	9HR	Cathode	12.6	0.375	12*	9*	1.0*	Detector, Power Amp. Driver	12.6	18 Ohm ■ and 4.7 Meg[4]	G1 = 12.6	6.8	54	900 (Space Charge Grid Operation).	8,500	7.6	1,250	5	12DV8
12DW5	T-6½	Beam Pent.	9CK	Cathode	12.6I	0.600	0.5	14	9	Vert. Defl. Amp.	Maximum Peak Positive Plate Voltage = 2,200 Volts. Maximum D.C. Cathode Current = 65 Ma. Maximum Plate Dissipation = 11 Watts. 200	22.5	150	55	2.0	15,000	5,500	....	....	....	12DW5
12DZ6	T-6½	Pentode	7BK	Cathode	12.6	0.190	0.15m*	9.5*	4.0*	R-F Amp.	12.6	G1 = 10meg.[4] G3 = 0	12.6	4.5	2.2	25,000 ♦	3,800	....	....	....	12DZ6
12DZ8	T-6½	Tri. Beam Pent.	6DZ8	Cathode	12	0.450	....	....	....	A-F Voltage Amp. and Power Amp.	Characteristics Same as Type 6DZ8. (12DZ8 Designed for Series String Receivers).										12DZ8
12E5GT	T-9	Triode	6Q-1-0	Cathode	12.6	0.150	2.6	3.4	5.5	Amplifier	100 250	5.0 13.5	....	2.5 5.0	....	12,000 9,500	1,150 1,450	13.8 13.8	....	....	12E5GT
12EA6	T-5½	Pentode	7BK	Cathode	12.6	0.190	.04m*	11*	4*	I-F Amp.	12.6	G1 = 10meg.[4] G3 = 0	12.6	3.2	1.4	32,000 ♦	3,800	....	....	....	12EA6
12EC8	T-6½	Tri. Pentode	9FA	Cathode	12.6	0.225	1.7 .02	2.6 4.6	0.4 2.6	FM Osc. FM Amp.	12.6 12.6	0 0	..... 12.6	2.4 0.66	.... 0.28	6,000 750,000	4,700 2,000	25	....	....	12EC8
12ED5	T-5½	Pentode	7CV	Cathode	12.6	0.450	0.26	14	8.5	S.T.A1 Amp.	110 125	4.0 4.5	110 125	32 37	4 7	14,000 14,000	8,100 8,500	....	4,500 4,500	1,100 1,500	12ED5
12EF6	T-9	Beam Pent.	7S	Cathode	12.6I	0.450	0.8*	11.5*	9.0*	Vert. Defl. Amp.	Characteristics Same as Type 6EF6. (12EF6 Designed for Series String TV Receivers).										12EF6
12EG6	T-5½	Heptode	7CH	Cathode	12.6	0.150	0.25	6.5	12	Mixer Oscillator	12.6 12.6 Volts Grid No. 4 and 2.2 Megohms Grid No. 1 (Osc. Grid).	0.8[4]	12.6	.04	0.24	150,000	800	....	....	....	12EG6
12EH5	T-5½	Beam Pent.	7CV	Cathode	12.6I	0.600	0.65*	17*	9*	S.T. A1 Amp.	Characteristics Same as Type 6EH5. (12EH5 Designed for Series String Receivers).										12EH5
12EK6	T-5½	Pentode	7BK	Cathode	12.6	0.190	.032	10	5.5	FM Amp.	12.6	2.2[4]	12.6	4.4	2	40,000	4,200	.....	....	....	12EK6
12EL6	T-5½	Duodiode Tri.	7FB	Cathode	12.6	0.150	1.8*	2.2*	1.0*	Detector	12.6	1.0Meg.[4]	....	.75	....	45,000	1,200	55	....	....	12EL6
12EM6	T-6½	Diode Tetrode	9HV	Cathode	12.6	0.500	....	....	....	Det. Power Amp.	12.6	15 Meg.[4]	12.6	6.0	1.0	4,000	5,000	....	3,500	10	12EM6
12EN6	T-9	Beam Pent.	7S	Cathode	12.6I	0.600	0.65*	14*	8.0*	Vert. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 1,200 Volts. Maximum D.C. Cathode Currents = 50 Ma. Maximum Plate Dissipation = 7.0 Watts. 200	9.5	110	50	2.2	28,000	8,000	....	....	....	12EN6
12EZ6	T-5½	Pentode	7BK	Cathode	12.6	0.175	.008*	7.8*	5.5*	R-F or I-F Amp.	12.6	0.7 2.2 Meg.[4]	12.6	1.9	0.7	400,000	2,700	.....	....	....	12EZ6
12F5GT	T-9	Triode	5M-0-0	Cathode	12.6	0.150	2.8*	2.2*	3.2*	Amplifier	Characteristics Same as Type 6F5GT.										12F5GT
12F8	T-6½	Duodi. Pent.	9FH	Cathode	12.6	0.150	.06	4.5	3.0	Amplifier	12.6	0	12.6	1.0	0.38	0.33 Meg.	1,000	.....	....	....	12F8
12FA6	T-5½	Heptode	7CH	Cathode	12.6	0.150	0.25	7.2	12	Converter	12.6	0.5 2.2 Meg.[4] Osc. Grid Values = 2.5 Volts RMS across 33,000 Ohm Res.	12.6	.45	1.0	800,000	320▲	.....	....	....	12FA6
12FK6	T-5½	Duodiode Tri.	7BT	Cathode	12.6	0.150	1.6*	1.8*	0.7*	Det. Amp.	12.6	2.2 Meg[4]	.....	1.3	....	6,200	1,200	7.4	....	....	12FK6
12FM6	T-5½	Duodiode Tri.	7DT	Cathode	12.6	0.150	1.7*	2.7*	1.7*	Det. Amp.	12.6	2.2 Meg[4]	.....	1.0	....	7,700	1,300	10	....	....	12FM6
12G4	T-5½	Triode	6BG	Cathode	12.6	0.150	3.4	2.6	3.2	Amplifier	Identical to One Section of Type 6SN7GT.										12G4
12G8	T-6½	Duotriode	9CZ	Cathode	12.6	0.400	....	....	....	Amplifier	12.6 12.6	0 ..	Input Tri. Output Tri.	3.0 7.2	....	 8,500	 2,600	 22	 2,000	 25	12G8
12H4	T-5½	Triode	7DW	Cathode	6.3/ 12.6	0.300/ 0.150	3.4	2.6	3.2	Amplifier	90 250	0 8	....	10 9.0	....	....	3,000 2,600	20 20	....	....	12H4
12H6	Metal	Duodiode	7Q-1-1	Cathode	12.6	0.150	....	....	....	Rectifier	Characteristics Same as Type 6H6.										12H6
12J5GT	T-9	Triode	6Q-0-0	Cathode	12.6	0.150	3.8	4.2	5.0	Amplifier	Characteristics Same as Type 6J5GT.										12J5GT
12J7GT	T-9	Pentode	7R-1-1	Cathode	12.6	0.150	.007m	5.4	12.0	R-F Amp.	Characteristics Same as Type 6J7G.										12J7GT
12J8	T-6½	Duo. Tetrode	9GC	Cathode	12.6	0.300	0.7*	10.5*	4.4*	Det. Amp.	12.6	2.2Meg.[4]	12.6	12	1.5	6,000	5,500	....	2,700	20	12J8
12K5	T-5½	Tetrode	7FD	Cathode	12.6	0.400	....	....	....	Power Amp. Driver	12.6 (Designed for Space-Change Grid Operation).	G2 = 2	G1 = 12.6	8	75	480	15,000	7.2	800	40	12K5
12K7GT	T-9	Pentode	7R-1-8	Cathode	12.6	0.150	.007m	5.0	12.0	R-F Amp.	Characteristics Same as Type 6K7G.										12K7GT
12K8 12K8GT	Metal T-9	Tri. Hexode	8K-1-8	Cathode	12.6	0.150	.03m .08m	6.6 5.0	3.5 4.8	Mixer Osc. Converter	Characteristics Same as Type 6K8GT.										12K8 12K8GT
12L6GT	T-9	Beam Pent.	7S-0-0	Cathode	12.6I	0.600	....	....	....	Power Amp.	Characteristics Same as Type 25L6GT. (12L6GT Designed for Series String TV Receivers).										12L6GT
12L8GT	T-9	Duo. Pentode	8BU-0-0	Cathode	12.6	0.150	0.7*	5.0*	6.0*	Power Amp.	110 180	5.5 9.0	110 180	6.1# 13.0#	1.3# 2.8#	220,000# 160,000#	1,680# 2,150#	....	14,000# 10,000#	300# 1,000#	12L8GT
12Q7GT	T-9	Duodiode Tri.	7V-1-8	Cathode	12.6	0.150	1.6	2.2	5.0	Det. Amp.	Characteristics Same as Type 6Q7GT.										12Q7GT
12R5	T-5½	Beam Pent.	7CV-0-0	Cathode	12.6I	0.600	0.55*	13.0*	9.0*	Vert. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 1,500 Volts. Maximum D.C. Cathode Current = 45 Ma. Maximum Plate Dissipation = 4.5 Watts. 110	8.5	110	40.0	3.3	13,000	7,000	.....	....	....	12R5
12S8GT	T-9	Triple Dio. Tri.	8CB-0-2	Cathode	12.6	0.150	2.0	1.2	5.0	Det. Amp.	Characteristics Same as Type 6S8GT.										12S8GT

12SA7 12SA7GT	Metal T-9	Heptode	8R-1-0 8AD-1-6	Cathode	12.6	0.150	0.25 0.5m	9.5 11.0	9.5 11.0	Converter	Characteristics Same as Type 6SA7.	12SA7 12SA7GT
12SC7	Metal	Duotriode	8S-1-0	Cathode	12.6	0.150	2.0	2.2	3.0	Amplifier	Characteristics Same as Type 6SC7	12SC7

(1) Values are given shielded unless marked with (*).
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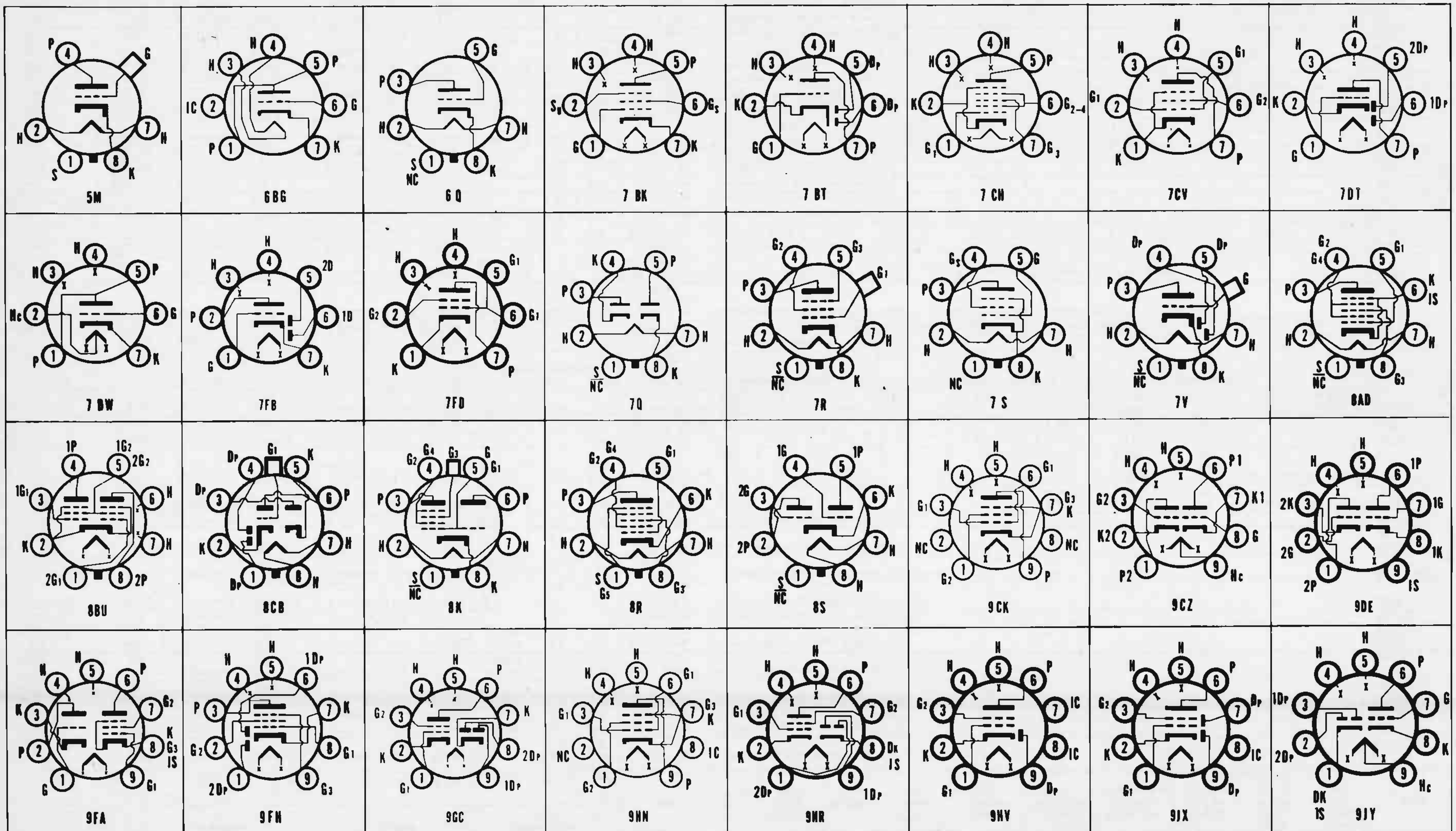
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
I Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)

Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
☐ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



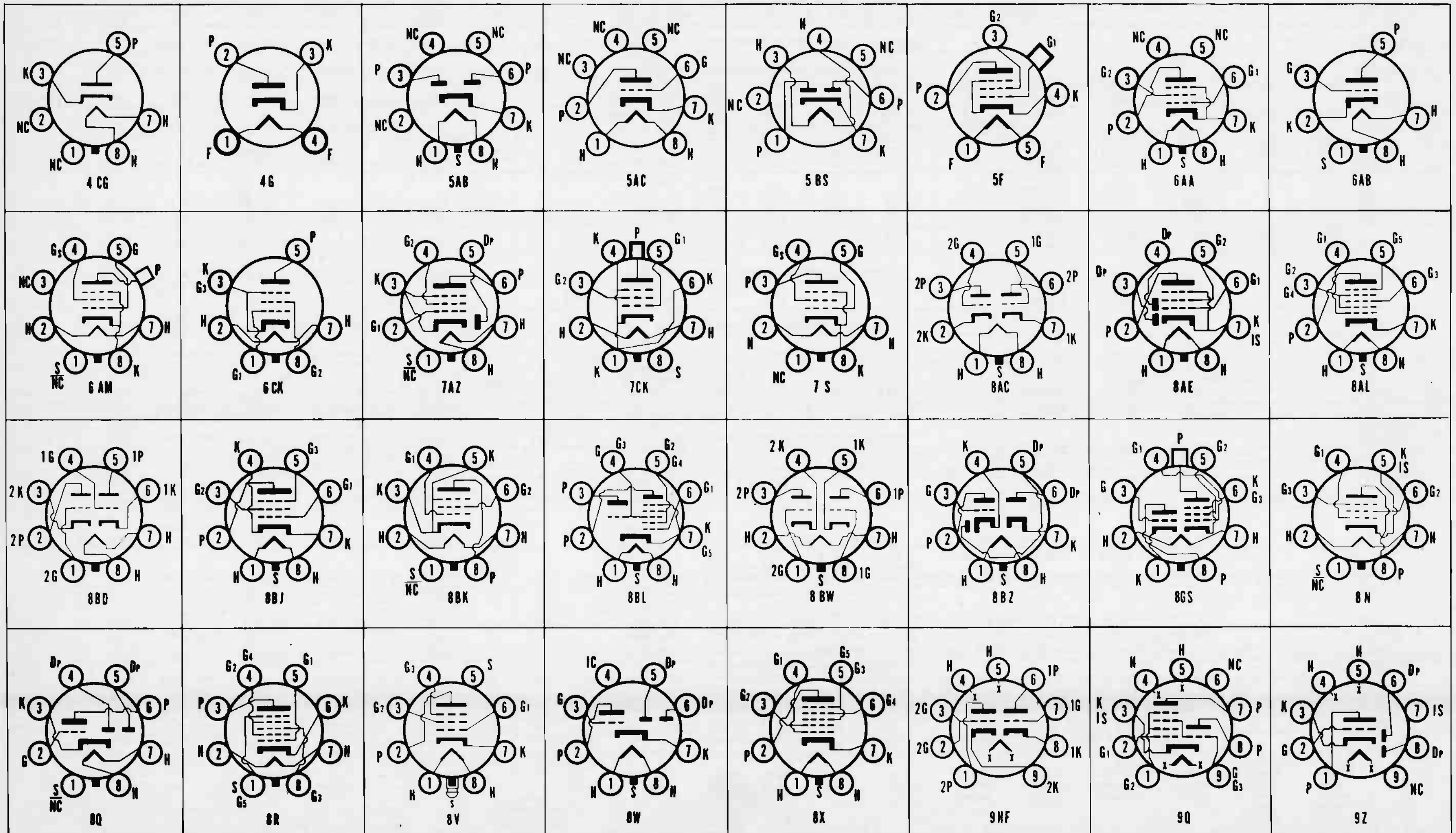
SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection, DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; ☐—Top Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (¹) (⁷) Capacitances in μμf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Power Output Milli-watts	Type
12SF5 12SF5GT	Metal T-9	Triode	6AB-0-0	Cathode	12.6	0.150	2.4 2.6	4.0 4.2	3.6 3.8	Amplifier	Characteristics Same as Type 6SF5.										12SF5 12SF5GT
12SF7	Metal	Diode Pent.	7AZ-1-0	Cathode	12.6	0.150	.004m	5.5	6.0	Det. Amp.	Characteristics Same as Type 6SF7.										12SF7
12SG7	Metal	Pentode	8BK-1-1	Cathode	12.6	0.150	.003m	8.5	7.0	R-F Amp.	Characteristics Same as Type 6SG7.										12SG7
12SH7 12SH7GT	Metal T-9	Pentode	8BK-1-0 8BK-1-1	Cathode	12.6	0.150	.003m	8.5	7.0	R-F Amp.	Characteristics Same as Type 6SH7.										12SH7 12SH7GT
12SJ7 12SJ7GT	Metal T-9	Pentode	8N-1-1 8N-1-5	Cathode	12.6	0.150	.005m .005m	6.0 6.3	7.0 7.5	R-F Amp.	Characteristics Same as Type 6SJ7.										12SJ7 12SJ7GT
12SK7 12SK7GT	Metal T-9	Pentode	8N-1-1 8N-1-5	Cathode	12.6	0.150	.003m .005m	6.0 6.5	7.0 7.5	R-F Amp.	Characteristics Same as Type 6SK7.										12SK7 12SK7GT
12SL7GT	T-9	Duotriode	8BD-0-0	Cathode	12.6	0.150	....	....	....	Amplifier	Characteristics Same as Type 6SL7GT.										12SL7GT
12SN7GT	T-9	Duotriode	8BD-0-0	Cathode	12.6	0.300	3.8° 4.0°	2.8° 3.0°	0.8° 1.2°	Amplifier	Characteristics Same as Type 6SN7GT.										12SN7GT
12SN7GTA	T-9	Duotriode	8BD-0-0	Cathode	12.6	0.300	4.0° 3.8°	2.2° 2.6°	0.7° 0.7°	Vertical Osc. Amp.	Characteristics Same as Type 6SN7GTA.										12SN7GTA
12SQ7 12SQ7GT	Metal T-9	Duodiode Tri.	8Q-1-3	Cathode	12.6	0.150	1.6 1.8	3.2 4.2	3.0 3.4	Det. Amp.	Characteristics Same as Type 6SQ7.										12SQ7 12SQ7GT
12SR7	Metal	Duodiode Tri.	8Q-1-1	Cathode	12.6	0.150	2.3	3.0	3.0	Det. Amp.	Characteristics Same as Type 6SR7.										12SR7
12SW7	Metal	Duodiode Tri.	8Q-1-0	Cathode	12.6	0.150	2.4	3.0	2.8	Det. Amp.	26.5 250	Self 9	....	1.1 9.5	....	15,500 8,500	1,100 1,900	17 16	(2 Meg. Grid Res.)		12SW7
12SX7GT	T-9	Duotriode	8BD-0-0	Cathode	12.6	0.300	3.6° 3.6°	3.0° 2.8°	0.8° 1.2°	Amplifier	26.5 90 250	Self 0 8	....	....	....	11,500 6,700 7,700	1,800 3,000 2,500	21 20 20	(.05 Meg. Grid Res.)		12SX7GT
12SY7	Metal	Heptode	8R-1-0	Cathode	12.6	0.150	0.13°	9.5°	12.0°	Converter	250	2.0	100	3.5	8.5	1 Meg.♦	450▲	.....	....	....	12SY7
12U7	T-6½	Duotriode	7CK	Cathode	12.6	0.150	1.5	1.8	2.0	Class A1 Amp.	12.6	0	.....	1.0	....	12,500	1,600	20	....	....	12U7
12V6GT	T-9	Beam Pent.	7S	Cathode	12.6	0.225	0.7	9.0	7.5	Power Amp.	180 250	8.5 12.5	180 250	29 45	3 4.5	50,000♦ 50,000♦	3,700 4,100	....	5,500 5,000	2,000 4,500	12V6GT
12W6GT	T-9	Beam Pent.	7S-0-0	Cathode	12.6‡	0.600	0.8°	15.0° Triode Connection	9.0°	Power Amp. Vert. Defl. Apm.	Characteristics Same as Type 6W6GT. (12W6GT Designed for Series String TV Receivers).										12W6GT
12X4	T-5½	Duodiode	5BS	Cathode	12.6	0.450	....	....	....	F-W Rect.	Characteristics same as type 6X4.										12X4
12Z3	T-9	Diode	4G-0-0	Cathode	12.6	0.300	....	....	....	H-W Rect.	235 A-C Volts Per Plate, RMS, 55 Ma. Output Current. Condenser Input to Filter.										12Z3
13DE7	T-6½	Duotriode	9HF	Cathode	13.0‡	0.450	4.0° 8.5°	2.2° 5.5°	0.52° 1.0°	Vert. Osc. Vert. Defl. Amp.	Characteristics Same as Type 16DE7. (13DE7 Designed for Series String TV Receivers).										13DE7
13DR7	T-6½	Duotriode	9HF	Cathode	13‡	0.450	4.5° 8.5°	2.2° 5.5°	0.34° 1.0°	S. 2 Ver. Amp. S. 1 Ver. Osc.	Characteristics Same as Type 6DR7. (13DR7 Designed for Series String Receivers).										13DR7
14A4	Lock-in	Triode	5AC-L-0	Cathode	12.6	0.150	4.0	3.4	3.0	Amplifier	Characteristics Same as Type 7A4.										14A4
14A5	Lock-in	Beam Amp.	6AA-L-0	Cathode	12.6	0.150	0.4	6.8	7.0	Power Amp.	250	12.5	250	30.0	3.5	70,000♦	3,000	.....	7,500	2,800	14A5
14A7	Lock-in	Pentode	8V-L-5	Cathode	12.6	0.150	.003m	6.0	7.0	R-F Amp.	Characteristics Same as Type 7A7.										14A7
14AF7/XXD	Lock-in	Duotriode	8AC-L-0	Cathode	12.6	0.150	2.3°	2.2°	1.6°	Amplifier	Characteristics Same as Type 7AF7.										14AF7/XXD
14B6	Lock-in	Duodiode Tri.	8W-L-7	Cathode	12.6	0.150	1.5	3.0	2.4	Det. Amp.	Characteristics Same as Type 7B6.										14B6
14B8	Lock-in	Heptode	8X-L-0	Cathode	12.6	0.150	0.2m	10.0	9.0	Converter	Characteristics Same as Type 7B8.										14B8
14C5	Lock-in	Beam Pent.	6AA-L-0	Cathode	12.6	0.225	0.4	9.5	9.0	Power Amp.	Characteristics Same as Type 7C5.										14C5
14C7	Lock-in	Pentode	8V-L-5	Cathode	12.6	0.150	.004m	6.0	6.5	R-F Amp.	100 250	1.0 3.0	100 100	5.7 2.2	1.8 0.7	400,000♦ 1.0 Meg.♦	2,275 1,575	....	....	....	14C7
14E6	Lock-in	Duodiode Tri.	8W-L-7	Cathode	12.6	0.150	1.5	3.0	2.4	Det. Amp.	Characteristics Same as Type 7E6.										14E6
14E7	Lock-in	Duodi. Pent.	8AE-L-7	Cathode	12.6	0.150	.005m	4.6	5.5	Det. Amp.	Characteristics Same as Type 7E7.										14E7
14F7	Lock-in	Duotriode	8AC-L-0	Cathode	12.6	0.150	1.6#	2.4#	2.0#	Amplifier	Characteristics Same as Type 7F7.										14F7
14F8	Lock-in	Duotriode	8BW-L-0	Cathode	12.6	0.150	1.6	2.8#	1.4#	Osc. Amp.	Characteristics Same as Type 7F8.										14F8
14G6	T-6½	Duodiode Tri.	9Z	Cathode	14	0.100	1.3°	2.4°	1.3°	Det. Amp.	100	1.0	....	0.8	....	50,000	1,400	70	....	....	14G6
14H7	Lock-in	Pentode	8V-L-5	Cathode	12.6	0.150	.004m	8.0	7.0	R-F Amp.	Characteristics Same as Type 7H7.										14H7
14J7	Lock-in	Tri. Heptode	8BL-L-7	Cathode	12.6	0.150	.03m	4.6	7.5	Mixer Osc.	Characteristics Same as Type 7J7.										14J7
14N7	Lock-in	Duotriode	8AC-L-0	Cathode	12.6	0.300		See 7N7		Amplifier	Characteristics Same as Type 7N7.										14N7
14Q7	Lock-in	Heptode	8AL-L-0	Cathode	12.6	0.150	0.15m	9.0	9.0	Converter	Characteristics Same as Type 7Q7.										14Q7
14R7	Lock-in	Duodi. Pent.	8AE-L-7	Cathode	12.6	0.150	.004m	5.6	5.3	Det. Amp.	Characteristics Same as Type 7R7.										14R7
14S7	Lock-in	Tri. Heptode	8BL-L-7	Cathode	12.6	0.150	.03m	5.0	8.0	Mixer Osc.	Characteristics Same as Type 7S7.										14S7
14W7	Lock-in	Pentode	8BJ-L-5	Cathode	12.6	0.225	.002m	9.5	7.0	R-F Amp.	Characteristics Same as Type 7V7, Except Capacitances.										14W7
14X7	Lock-in	Duodiode Tri.	8BZ-L-4	Cathode	12.6	0.150	....	....	....	Det. Amp.	Characteristics Same as Type 7X7.										14X7
14Y4	Lock-in	Duodiode	5AB-L-0	Cathode	12.6	0.300	....	....	....	F-W Rect.	325 A-C Volts Per Plate, RMS, 70 Ma. Output Current. Condenser Input to Filter. 450 A-C Volts Per Plate, RMS, 70 Ma. Output Current. Choke Input to Filter.										14Y4
14Y7	T-6½	Tri. Hexode	9Q	Cathode	14.0	0.100	1.4° 0.1°	5.6° 3.8°	2.4° 9.2°	Tri. Osc. Hex. Amp.	100 100	0 1.0	 43	10 1.2	.... 1.46	.... 1.0 Meg.♦	2,800 530▲	22	....	....	14Y7
15	ST-12	Pentode	5F-0-4	Cathode	2.0	0.220	.01m	2.4°	8.0°	R-F Amp.	67.5 135	1.5 1.5	67.5 67.5	1.85 1.85	0.3 0.3	630,000 800,000	710 750	450 600	....	....	15
15A8	T-9	Tri. Beam Pent.	8GS	Cathode	15.0‡	0.600	3.4 0.7	2.6 11.0	0.9 5.0	Pent. Vert. Defl. Amp. Tri. Vert. Osc.	Maximum Peak Positive Pulse Plate Voltage = 1,200 Volts. Maximum D.C. Cathode Current = 40 Ma. Maximum Plate Dissipation = 7.5 Watts. 110 250	 7.5 8.0	 110	 45.0 9.0	 4.0	 13,000 7,700	 7,300 2,600				15A8

17AV5GA	T-11 or T-12	Beam Pent.	6CK-0-0	Cathode	16.8Ɪ	0.450	0.5*	14.0*	7.0*	Horiz. Defl. Amp.	Characteristics Same as Type 6AV5GA. (17AV5GA Designed for Series String TV Receivers).	17AV5GA
17AX4GT	T-9	Diode	4CG-0-0	Cathode	16.8Ɪ	0.450	....	....	....	T.V. Damper	Characteristics Same as Type 6AX4GT. (17AX4GT Designed for Series String TV Receivers).	17AX4GT
17BQ6GTB	T-12	Beam Pent.	6AM	Cathode	16.8Ɪ	0.450	0.6*	15.0*	7.5*	Horiz. Defl. Amp.	Characteristics Same as Type 6BQ6GTB. (17BQ6GTB designed for Series String TV Receivers).	17BQ6GTB

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate; RF Input, Mixer Output.
Ɪ Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



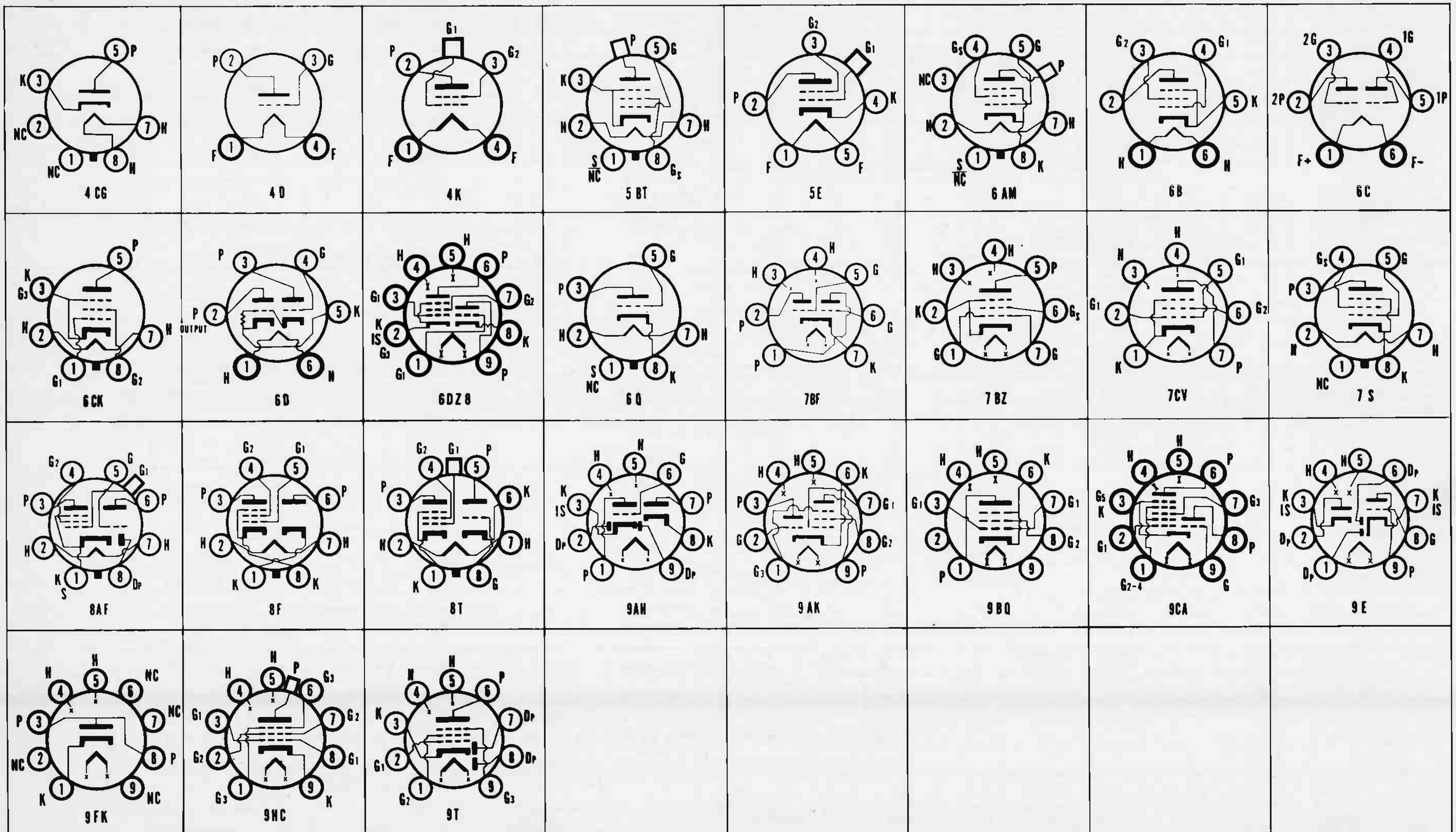
SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection, DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (1) (2) Capacitances in μμf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Power Output Milliwatts	Type
17C5	T-5½	Beam Pent.	7CV-0-0	Cathode	16.8‡	0.450	0.6*	13.0*	8.5*	Power Amp.	Characteristics Same as Type 12C5. (17C5 Designed for Series String TV Receivers).										17C5
17C8	T-6½	Pentode	9T	Cathode	17	0.100	.0025*	4.2*	4.9*	R-F Amp.	200	295■	60	5	1.75	1 Meg. ♦	2,200	....	....	....	17C8
17CA5	T-5½	Beam Pent.	7CV-0-0	Cathode	16.8‡	0.450	0.5*	15.0*	9.0*	Power Amp.	Characteristics Same as Type 12CA5. (17CA5 Designed for Series String TV Receivers).										17CA5
17D4	T-9	Diode	4CG	Cathode	16.8‡	0.450	....	....	....	T.V. Damper	Maximum Peak Inverse Plate Voltage = 4,400 Volts. Maximum D.C. Plate Current = 155 Ma.										17D4
17DQ6 17DQ6A	T-12	Beam Pent.	6AM	Cathode	16.8‡	0.450	0.55*	15.0*	7.0*	Horiz. Defl. Amp.	Characteristics Same as Type 6DQ6. (17DQ6 and 17DQ6A are Designed for Series String TV Receivers). Characteristics Same as Type 6DQ6A.										17DQ6 17DQ6A
17H3	T-6½	Diode	9FK-0-0	Cathode	17.5‡	0.300	....	....	....	T.V. Damper	Maximum Peak Inverse Plate Voltage = 2,000 Volts. Maximum D.C. Output Current = 75 Ma.										17H3
17L6GT	T-9	Beam Pent.	7S-0-0	Cathode	16.8‡	0.450	....	....	....	Power Amp.	Characteristics Same as Type 25L6GT. (17L6GT Designed for Series String TV Receivers).										17L6GT
17R5	T-5½	Beam Pent.	7CV-0-0	Cathode	16.8‡	0.450	0.55*	13.0*	9.0*	Vert. Defl. Amp.	Characteristics Same as Type 12R5. (17R5 Designed for Series String TV Receivers).										17R5
18	ST-14	Beam Pent.	6B-0-0	Cathode	14.0	0.300	....	....	....	Power Amp.	Characteristics Same as Type 6F6G.										18
18A5	T-9	Beam Pent.	6CK-0-0	Cathode	18.5‡	0.300	0.7*	13.0*	7.0*	Horiz. Defl. Amp.	Maximum Peak Positive Pulse Plate Voltage = 3,000 Volts. Maximum D.C. Cathode Current = 90 Ma. Maximum Plate Dissipation = 9 Watts. 200	17.0	125	40.0	1.1	27,000	4,800	.....	....	....	18A5
18DZ8	T-6½	Tri. Beam Pent.	6DZ8	Cathode	18	0.300	....	....	...	A-F Voltage Amp. and Power Amp.	Characteristics Same as Type 6DZ8. (18DZ8 Designed for Series String Receivers).										18DZ8
19	T-9	Duotriode	6C-0-0	Filament	2.0	0.260	....	....	....	Power Amp.	135	0.0	.....	5-18†	....	(Class B Operation)		.....	10,000¶	2,100	19
19AQ5	T-5½	Beam Pent.	7BZ	Cathode	18.9	0.150	....	....	....	Power Amp.	Same as 6AQ5.										19AQ5
19AU4	T-9	Diode	4CG-0-0	Cathode	18.9‡	0.600	....	....	....	T.V. Damper	Characteristics Same as Type 6AU4GT. (19AU4 Designed for Series String TV Receivers).										19AU4
19AU4GTA	T-9	Diode	4CG-0-0	Cathode	18.9‡	0.600	....	....	....	T.V. Damper	Characteristics Same as Type 6AU4GTA. (19AU4GTA Designed for Series String TV Receivers).										19AU4GTA
19BG6G 19BG6GA	ST-16 T-12	Beam Pent.	5BT-0-0	Cathode	18.9	0.300	0.34* 0.8*	12.0* 11.0*	6.5* 6.0*	Horiz. Defl. Amp.	Characteristics Same as Type 6BG6G.										19BG6G 19BG6GA
19C8	T-6½	Triple Dio. Tri.	9E-0-0	Cathode	18.9	0.150	....	....	....	Det. Amp.	100	1.0	.....	0.5	....	80,000	1,250	100	....	....	19C8
19D8	T-6½	Tri. Heptode	9CA	Cathode	19.0	0.100	1.0 .006	2.6 4.8	2.1 7.9	F.M. Tri. Osc. A.M. Hept. Converter	100 100	0 1.1	63	13.5 1.7	3.7	800,000	3,700 620▲	22	....	....	19D8
19J6	T-5½	Duotriode	7BF-0-0	Cathode	18.9	0.150	1.5*♦	2.0*♦	0.4*♦	VHF Osc. Amp.	150	810■	.....	4.8	....	10,200	1,900	.....	....	....	19J6
19T8	T-6½	Triple Diode Triode	9E-0-3 & 7	Cathode	18.9	0.150	1.7*	1.7*	2.4*	Det. Amp.	Characteristics Same as Type 6T8.										19T8
19V8	T-6½	Triple Diode Triode	9AH-0-3	Cathode	18.9	0.150	....	....	....	Det. Amp.	100 250	1.0 3.0	....	0.8 1.0	....	54,000 58,000	1,300 1,200	70 70	....	....	19V8
19X8	T-6½	Tri. Pentode	9AK	Cathode	18.9	0.150	....	....	....	VHF Osc. Amp.	Characteristics Same as Type 6X8.										19X8
20	T-8	Triode	4D-0-0	Filament	3.3	0.132	....	....	....	Power Amp.	90 135	16.5 22.5	....	2.8 6.0	....	7,800 5,850	450 600	3.5 3.5	9,600 6,500	50 130	20
22	ST-14	Tetrode	4K-0-3	Filament	3.3	0.132	.02m	4.0*	10.0*	R-F Amp.	135	1.5	67.5	3.7	1.3	250,000	500	125	....	....	22
24A 24S	ST-14	Tetrode	5E-0-3 5E-4-3	Cathode	2.5	1.750	.007m	5.3	10.5	R-F Amp. Detector	180 250	3.0 3.0	90 90	4.0 4.0	1.7 1.7	400,000 600,000	1,000 1,050	400 630	....	....	24A 24S
25A6 25A6GT	Metal T-9	Power Pent.	7S-1-0 7S-0-0	Cathode	25.0	0.300	....	....	....	Power Amp.	95 135 160	15.0 20.0 18.0	95 135 120	20.0 37.0 33.0	4.0 8.0 6.5	45,000 35,000 42,000	2,000 2,450 2,375	....	4,500 4,000 5,000	900 2,000 2,200	25A6 25A6GT
25A7GT	T-9	Diode Pent.	8F-0-0	Cathode	25.0	0.300	....	....	....	H-W Rect. Power Amp.	117 A-C Volts Per Plate, RMS, 75 Ma. Output Current. 100	15.0	100	20.5	4.0	50,000	1,800	.....	4,500	770	25A7GT
25AC5GT	T-9	Triode	6Q-0-0	Cathode	25.0	0.300	....	....	....	Power Amp. Coupled Amp.	110 165	+15 Bias from 6AE5GT/G 46.0 Dynamic Coupled with 6AE5GT Driver.	.....	45.0	....	15,200	3,800	58	 2,000	 2,000	25AC5GT
25AV5GT	T-9	Beam Pent.	6CK-0-0	Cathode	25.0	0.300	0.7*	14.0*	7.0*	Horiz. Defl. Amp.	Characteristics Same as Type 6AV5GT.										25AV5GT
25AV5GA	T-11 or T-12	Beam Pent.	6CK-0-0	Cathode	25.0	0.300	0.5*	14.0*	7.0*	Horiz. Defl. Amp.	Characteristics Same as Type 6AV5GA.										25AV5GA
25AX4GT	T-9	Diode	4CG	Cathode	25.0	0.300	....	....	....	T.V. Damper	P.I.V. = 4,000 Volts Max. D.C. Plate Current = 125 Ma. Max.										25AX4GT
25B5	ST-12	Duotriode	6D-0-0	Cathode	25.0	0.300	....	....	....	Power Amp.	Characteristics Same as Type 25N6G.										25B5
25B6G	ST-14	Beam Pent.	7S-0-0	Cathode	25.0	0.300	....	....	....	Power Amp.	105 200	16.0 23.0	105 135	48.0 62.0	2.0 1.8	15,500 18,000	4,800 5,000	....	1,700 2,500	2,400 7,100	25B6G
25B8GT	T-9	Pentode Tri.	8T-0-1	Cathode	25.0	0.150	.02 2.2	5.5 5.0	10.0 4.6	Pent. Amp. Tri. Amp.	100 100	3.0 1.0	100	7.6 0.6	2.0	185,000 75,000	2,000 1,500	370 112.5	(Pentode Section) (Triode Section)		25B8GT
25BK5	T-6½	Beam Pent.	9BQ	Cathode	25.0	0.300	0.6	13.0	5.0	Power Amp.	Same as 6BK5.										25BK5
25BQ6GA 25BQ6GT	T-11 T-9	Beam Pent.	6AM-0-0	Cathode	25.0	0.300	0.6*	15.0*	7.5*	Horiz. Defl. Amp.	Characteristics and Ratings Same as Type 6BQ6G. Characteristics Same as Type 6BQ6GT.										25BQ6GA 25BQ6GT
25BQ6GTB	T-9	Beam Pent.	6AM-0-0	Cathode	25.0	0.300	0.6*	15.0*	7.5*	Horiz. Amp.	Characteristics Same as Type 6BQ6GTB.										25BQ6GTB
25C5	T-5½	Beam Pent.	7CV	Cathode	25.0	0.300	0.6*	13.0*	8.5*	Power Amp.	120	8	110	49	4.0	10,000	7,500	.....	2,500	2,300	25C5
25C6G 25C6GA	ST-14 T-12	Beam Pent.	7S-0-0	Cathode	25.0	0.300	....	....	....	Power Amp.	Characteristics Same as Type 6Y6G.										25C6G 25C6GA
25CA5	T-5½	Beam Pent.	7CV-0-0	Cathode	25.0	0.300	0.5*	15.0*	9.0*	Power Amp.	Characteristics Same as Type 6CA5.										25CA5
25CD6G 25CD6GA	ST-16	Beam Pent.	5BT-0-0	Cathode	25.0 25.0‡	0.600 0.600	1.0m*	26.0m*	10.0m*	Horiz. Defl. Amp.	Characteristics Same as Type 6CD6G. (25CD6GA Designed for Series String TV Receivers).										25CD6G 25CD6GA

25CD6GB	T-12	Beam Pent.	5BT-0-0	Cathode	25.0X	0.600	1.1*	22.0*	8.5*	Horiz. Defl. Amp.	Characteristics Same as Type 6CD6GA. (25CD6GB Designed for Series String TV Receivers).										25CD6GB
25CR5	T-6½	Beam Pent.	9HC-0-0	Cathode	25.0	0.300	0.32*	12.9*	6.9*	Horiz. Defl. Amp.	Characteristics Same as Type 6CR5.										25CR5
25CU6	T-12	Beam Pent.	6AM-0-0	Cathode	25.0	0.300	0.55*	15.0*	7.0*	Horiz. Defl. Amp.	Characteristics Same as Type 6BQ6G, Except Max. D.C. Plate Supply = 550 Volts.										25CU6
25D8GT	T-9	Diode Triode Pentode	8AF-0-1	Cathode	25.0	0.150	2.5* .015m	3.7* 5.2	4.5* 10.0	Det. Amp. R-F Amp.	100 100	1.0 3.0	 100	0.5 8.5	.... 2.7	91,000 200,000	1,100 1,900	100	....	....	25D8GT
25DN6	T-12	Beam Pent.	5BT-0-0	Cathode	25.0X	0.600	0.8*	22.0*	11.5*	Horiz. Defl. Amp.	Peak Positive Pulse Plate Voltage = 6,600 Volts Max. D.C. Cathode Current = 200 Ma. Maximum Plate Dissipation = 15 Watts. Maximum Screen Dissipation = 3.0 Watts. (25DN6 Designed for Series String TV Receivers).										25DN6

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate; RF Input, Mixer Output.
X Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



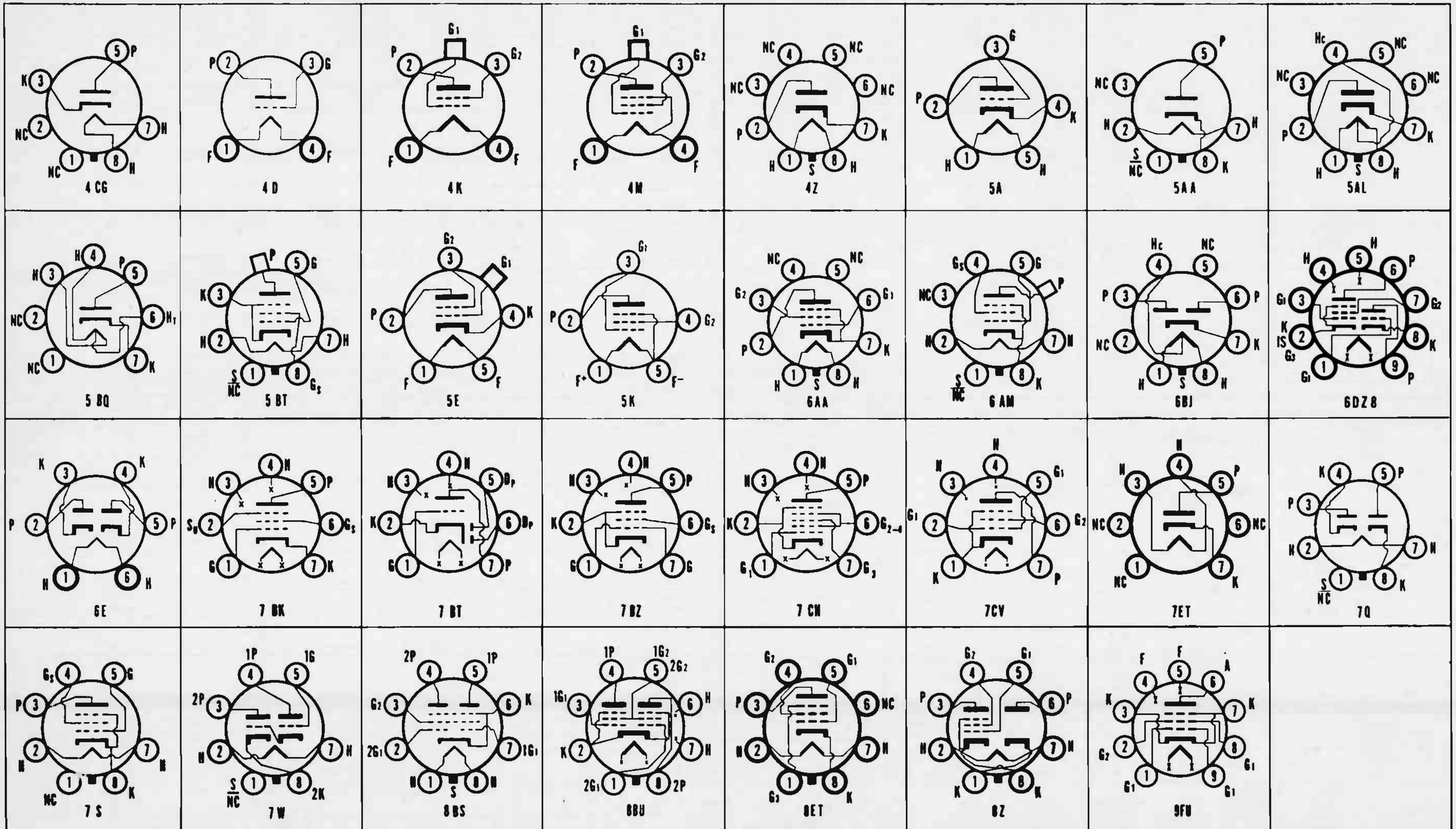
SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection, DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (1) (2) Capacitances in μμf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Power Output Milliwatts	Type
25DQ6	T-12	Beam Pent.	6AM-0-0	Cathode	25.0	0.300	0.55*	15.0*	7.0*	Horiz. Defl. Amp.	Characteristics Same as Type 6DQ6.										25DQ6
25EH5	T-5½	Beam Pent.	7CV	Cathode	25	0.300	0.65*	17*	9*	S.T. A1 Amp.	Characteristics Same as Type 6EH5.										25EH5 50EH5
25F5	T-5½	Beam Pent.	7CV	Cathode	25.0	0.150	0.57*	12.0*	6.0*	Power Amp.	110	8.0	110	70	7.5	......	.....	.....	4,500	2,900	25F5
25L6 25L6GT	Metal T-9	Beam Pent.	7S-0-0	Cathode	25.0	0.300	....	....	....	Power Amp.	110 200	7.5 180■	110 125	49.0 46	4.0 2.2	13,000 28,000	8,000 8,000	....	2,000 4,000	2,100 3,800	25L6 25L6GT
25N6G	ST-12	Duotriode	7W-0-0	Cathode	25.0	0.300	....	....	....	Power Amp.	110 180	0 0	110 100	45 46	7.0 5.8	(Direct Coupled)	2,200 2,300	....	2,000 4,000	2,000 3,800	25N6G
25S	Now Known as Type 1B5																				25S
25W4GT	T-9	Diode	4CG-0-0	Cathode	25.0	0.300	....	....	....	H-W Rect.	350 A-C Volts RMS, 125 Ma. D-C Output. Condenser Input to Filter										25W4GT
25W6GT	T-9	Beam Pent.	7S	Cathode	25.0	0.300	0.5	15.0	9.0	Power Amp.	110 225**	-7.5 -30	110	50 22**	4.0	13,000 1,600♦**	8,000 3,800**	..... 6.2**	2,000	2,100	25W6GT
25X6GT	T-9	Duodiode	7Q-0-0	Cathode	25.0	0.150	....	....	....	H-W Rect. Doubler	125 Volts RMS Per Plate, 60 Ma. D-C Output Per Plate. 125 Volts RMS Per Plate, 60 Ma. D-C Output.										25X6GT
25Y5	ST-12	Duodiode	6E-0-0	Cathode	25.0	0.300	....	....	....	Doubler H-W Rect.	117 A-C Volts Per Plate, RMS, 75 Ma. Output Current. 235 A-C Volts, RMS, 75 Ma. Output Current Per Plate.										25Y5
25Z4	Metal	Diode	5AA-1-0	Cathode	25.0	0.300	....	....	....	H-W Rect.	117 A-C Volts Per Plate, RMS, 125 Ma. Output Current. Condenser Input to Filter. 235 A-C Volts Per Plate, RMS, 125 Ma. Output Current. Condenser Input to Filter.										25Z4
25Z5	ST-12	Duodiode	6E-0-0	Cathode	25.0	0.300	....	....	....	Doubler	Characteristics Same as Type 25Z6GT.										25Z5
25Z6 25Z6GT	Metal T-9	Duodiode	7Q-1-0 7Q-0-0	Cathode	25.0	0.300	....	....	....	Doubler H-W Rect.	{117 A-C Volts Per Plate, RMS, 75 Ma. Output Current. {235 A-C Volts, RMS, 75 Ma. Output Current Per Plate.										25Z6 25Z6GT
26	ST-14	Triode	4D-0-0	Filament	1.5	1.050	8.1*	2.8*	2.5*	Amplifier	90 135 180	7.0 10.0 14.5	....	2.9 5.5 6.2	....	8,900 7,600 7,300	935 1,100 1,150	8.3 8.3 8.3	....	....	26
26A6	T-5½	Pentode	7BK-0-2	Cathode	26.5	0.070	.0035	6.0	5.0	R-F Amp.	26.5 250	Self 125■	26.5 250	1.7 10.5	0.7 4.0	250,000 1 Meg.	2,000 4,000	(Grid Leak Bias = 2 Meg.)			26A6
26A7GT	T-9	Duo. Beam Pent.	8BU-0-0	Cathode	26.5	0.600	1.2*	16.0*	13.0*	Power Amp.	26.5	4.5	26.5	20.0#	1.9#	1,500#	5,700#	.....	1,500#	180#	26A7GT
26BK6	T-5½	Duodiode Tri.	7BT-0-2	Cathode	26.5	0.070	....	....	....	Det. Amp.	100 250	1.0 2.0	....	0.5 1.2	....	80,000 62,500	1,250 1,600	100 100	....	....	26BK6
26C6	T-5½	Duodiode Tri.	7BT-0-0	Cathode	26.5	0.070	2.0	1.8	1.4	Amplifier	26.5 250	2 Meg. 9.0	....	1.1 9.5	....	15,500 8,500	1,100 1,900	17 16	....	....	26C6
26CG6	T-5½	Pentode	7BK-0-2	Cathode	26.5	0.070	.008m	5.0	5.0	R-F Amp.	Characteristics Same as Type 6CG6.										26CG6
26D6	T-5½	Heptode	7CH-0-0	Cathode	26.5	0.070	0.3	7.5	14.0	Converter Oscillator	100 250 100	1.5 1.5 0	100 100 100	2.8 3.0 27.0	8.0 7.8	500,000♦ 1 Meg.♦	455▲ 475▲ 7,200	 22	....	....	26D6
27 27S	ST-12	Triode	5A-0-0 5A-0-4	Cathode	2.5	1.750	3.3*	3.2*	2.3*	Amplifier	90 135 180	6.0 9.0 13.5	....	3.0 4.7 5.0	....	10,000 9,000 9,000	900 1,000 1,000	9.0 9.0 9.0	....	....	27 27S
28D7 28D7W (3)	Lock-in	Duo. Beam Pent.	8BS-L-0	Cathode	28.0	0.400	....	....	....	Amplifier (per section) P.P.A2 Total	28 28 28	.... 3.5 0	28 28 28	9.0 12.5 64.0	0.7 1.0 4.0	...... 4,200	(Rk = 390 Ohms) 3,400		4,000 4,000 1,500¶	80 100 600	28D7 28D7W (3)
28Z5	Lock-in	Double Diode	6BJ-L-0	Cathode	28.0	0.240	....	....	....	F-W Rect.	325 A-C Volts Per Plate, RMS, 100 Ma. Output Current. Condenser Input to Filter. 450 A-C Volts Per Plate, RMS, 100 Ma. Output Current. Choke Input to Filter.										28Z5
30	ST-12 T-9	Triode	4D-0-0	Filament	2.0	0.060	6.0*	3.0*	2.2*	Det. Amp.	90 135 180	4.5 9.0 13.5	....	2.5 3.0 3.1	....	11,000 10,300 10,300	850 900 900	9.3 9.3 9.3	....	....	30
31	ST-12	Triode	4D-0-0	Filament	2.0	0.130	....	....	....	Power Amp.	135 180	22.5 30.0	....	8.0 12.3	....	4,100 3,600	925 1,050	3.8 3.8	7,000 5,700	185 375	31
32	ST-14	Tetrode	4K-0-3	Filament	2.0	0.060	.015m	5.3*	10.5*	R-F Amp. Detector	135 180 180	3.0 3.0 6.0♦	67.5 67.5 67.5	1.7 1.7 (Plate Current to be adjusted to 0.2 Ma. with no Input Signal)	0.4 0.4	950,000 1.2 Meg.	640 650	610 780	....	....	32
32L7GT	T-9	Diode Beam Pent.	8Z-0-0	Cathode	32.5	0.300	....	....	....	H-W Rect. Power Amp.	125 RMS Volts Per Plate, 60 Ma. Output Current. Condenser Input to Filter. 110	 7.5	 110	 40	 3.0	 15,000	 6,000	 81	 2,600	 1,000	32L7GT
33	ST-14	Power Pent.	5K-0-0	Filament	2.0	0.260	1.0*	8.0*	12.0*	Power Amp.	135 180	13.5 18.0	135 180	14.5 22.0	3.0 5.0	50,000 55,000	1,450 1,700	70 90	7,000 6,000	700 1,400	33
34	ST-14	Pentode	4M-0-4	Filament	2.0	0.060	.015m	6.0*	11.0*	R-F Amp.	67.5 135 180	3.0 3.0 3.0	67.5 67.5 67.5	2.7 2.8 2.8	1.1 1.0 1.0	400,000 600,000 1 Meg.	560 600 620	224 360 620	....	....	34
EL34/6CA7	T-10 (SP)	Beam Pent.	8ET	Cathode	6.3	1.500	....	....	....	S.T. A1 Amp. P.P.AB1 Amp.	250 430	13.5 235■	250 425	100 125-140†	15 10-15†	15,000	11,000 Ultra-Linear Circuit	....	2,000 6,600¶	11,000 37,000	EL34/6CA7
35/51 35S/51S	ST-14	Tetrode	5E-0-3 5E-4-3	Cathode	2.5	1.750	.007m	5.3*	10.5*	R-F Amp. A-F Amp.	180 250 250*	3.0 3.0 1.0	90.0 90.0 45 to 67.5	6.3 6.5 0.5	2.5 2.5	300,000 400,000 2 Meg.	1,020 1,050	305 420	....	....	35/51 35S/51S
35A5	Lock-in	Beam Pent.	6AA-L-0	Cathode	35.0	0.150	....	....	....	Power Amp.	110 200	7.5 180■	110 110	40.0 43.0	3.0 2.0	14,000♦ 34,000♦	5,800 6,100	....	2,500 5,000	1,500 3,000	35A5
35B5	T-5½	Beam Pent.	7BZ-0-0	Cathode	35.0	0.150	0.4*	11.0*	6.5*	Power Amp.	110	7.5	110	40.0	3.0	......	5,800	.....	2,500	1,500	35B5
35C3	T-5½	Diode	7ET	Cathode	35.0	0.150	....	....	....	H-W Rect.	117 Volts RMS Per Plate, 100 Ma. D.C. Output. Condenser Input to Filter.										35C3
35C5	T-5½	Beam Pent.	7CV-0-0	Cathode	35.0	0.150	0.6	....	....	Power Amp.	110	7.5	110	40	3.0	......	5,800	.....	2,500	1,500	35C5
35CD6GA	T-12	Beam Pent.	5BT	Cathode	35.0‡	0.450	1.1*	22.0*	8.5*	Horiz. Defl. Amp.	Characteristics Same as Type 6CD6GA. (35CD6GA Designed for Series String TV Receivers).										35CD6GA

35D5	T-6½	Beam Pent.	9FU	Cathode	35	0.150	0.3	13.7	6.7	S.T.A1 Amp.	110 170	200■ 190■	110 170	30 52	2.5 3	18,000 20,000	8,000 9,500	....	2,500 2,500	1,600 4,800	35D5
35DZ8	T-6½	Tri. Beam Pent.	6DZ8	Cathode	35	0.150	....	....	....	A-F Voltage Amp. and Power Amp.	Characteristics Same as Type 6DZ8. (35DZ8 Designed for Series String Receivers).										
35L6GT	T-9	Beam Pent.	7S-0-0	Cathode	35.0	0.150	0.8*	13.0*	9.5*	Power Amp	110 200	7.5 8.0	110 110	40.0 43.0	3.0 2.0	14,000♦ 34,000♦	5,800 6,100	....	2,500 5,000	1,500 3,000	35L6GT
35W4	T-5½	Diode	5BQ-0-0	Cathode	35.0	0.150	....	....	....	H-W Rect.	117 A-C Volts, RMS, 60 Ma. Output Current with Panel Lamp. 117 A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp.										35W4
35Y4	Lock-In	Diode	5AL-L-0	Cathode	35.0	0.150	....	....	....	H-W Rect.	235 Max. A-C Volts, RMS, 60 Ma. Output Current with Panel Lamp. 235 Max. A-C Volts, RMS, 100 Ma. Output Current without Panel Lamp.										35Y4

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate; RF Input, Mixer Output.
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
ɪ Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
♯ Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection. DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

SYLVANIA TUBES—AVERAGE CHARACTERISTICS

Type	Construction			Emitter			Note (¹) (²) Capacitances in μμf.			Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Undistorted Power Output Milliwatts	Type
	Bulb Size or Style	Class	Basing Diag.	Type	Volts	Amps.	Cgp.	Cin.	Cout												
35Z3	Lock-in	Diode	4Z-L-0	Cathode	35.0	0.150	....	....	....	H-W Rect.	235 Max. A-C Volts Per Plate, RMS, 100 Ma. Output Current. Condenser Input to Filter.										35Z3
35Z4GT	T-9	Diode	5AA-0-0	Cathode	35.0	0.150	....	....	....	H-W Rect.	117 A-C Volts, RMS, 100 Ma. Output Current. Condenser Input to Filter.										35Z4GT
35Z5GT	T-9	Diode	6AD-0-0	Cathode	35.0	0.150	....	....	....	H-W Rect.	Characteristics Same as Type 35Y4.										35Z5GT
35Z6G	ST-14	Duodiode	7Q-0-0	Cathode	35.0	0.300	....	....	....	Doubler H-W Rect.	117 A-C Volts Per Plate, RMS, 110 Ma. Output Current. 235 A-C Volts Per Plate, RMS, 110 Ma. Output Current Per Plate.										35Z6G
36	ST-12	Tetrode	5E-0-3	Cathode	6.3	0.300	.007m	3.7*	9.2*	R-F Amp. Detector	135 180 250 250	1.5 3.0 3.0 6.0♦	67.5 90.0 90.0 20 to 25	2.8 3.1 3.2 (Plate Current to be adjusted to 0.1 Ma. with no Input Signal.)	Not Over ½ of Plate Ma.	575,000 500,000 550,000	1,000 1,050 1,080	475 525 595	....	....	36
37	ST-12	Triode	5A-0-0	Cathode	6.3	0.300	2.0*	3.5*	2.9*	Amplifier	135 180 250	9.0 13.5 18.0	....	4.1 4.3 7.5	....	10,000 10,200 8,400	925 900 1,100	9.2 9.2 9.2	....	....	37
EL37	Curved Bulb	Beam Pent.	7S	Cathode	6.3	1.400	1.0*	17.5*	9.0*	S.T. A1 Amp. P.P.AB1 Amp.	250 400	13.5 36	250 400	100 100-276†	13.5 12-72†	13,500	11,000	....	2,500 3,250¶	11,500 69,000	EL37
38	ST-12	Power Pent.	5F-0-0	Cathode	6.3	0.300	0.3*	3.5*	7.5*	Power Amp.	135 180 250	13.5 18.0 25.0	135 180 250	9.0 14.0 22.0	1.5 2.4 3.8	130,000 110,000 100,000	925 1,050 1,200	120 120 120	13,500 11,600 10,000	550 1,000 2,500	38
38A3	T-6½	Diode	9BM	Cathode	38	0.100	....	....	....	H-W Rect.	250 A.C. Volts, RMS, 110 Ma. Max. Output Current.										38A3
39/44	ST-12	Pentode	5F-0-4	Cathode	6.3	0.300	.007m	3.5*	10.0*	R-F Amp. A-F Amp.	90 180 250 250	3.0 3.0 3.0 1.0	90.0 90.0 90.0 67.5	5.6 5.8 5.8 0.5	1.6 1.4 1.4	375,000 750,000 1 Meg. 2 Meg.	960 1,000 1,050	360 750 1,050 Eb thru 0.25 Meg Res.	....	....	39/44
40	ST-14	Triode	4D-0-0	Filament	5.0	0.250	8.0	2.8	2.2	Amplifier	135 180	1.5 3.0	....	0.2 0.2	....	150,000 150,000	200 200	30 30	....	....	40
40A1	T-9	Ballast	8ES	....	....	....	....	....	....	Horiz. Reg.	Avg. Operating Current—0 Ma. at 20 Volts; 150 Ma. at 40 Volts; 155 Ma. at 60 Volts.										40A1
40B2	T-9	Ballast	8ES	....	....	....	....	....	....	Horiz. Reg.	Avg. Operating Current—140 Ma. at 20 Volts; 150 Ma. at 40 Volts; 155 Ma. at 60 Volts.										40B2
40Z5/45Z5GT	T-9	Diode	6AD-0-0	Cathode	45.0	0.150	....	....	....	H-W Rect.	Characteristics Same as Type 35Y4.										40Z5/45Z5GT
41	ST-12	Power Pent.	6B-0-0	Cathode	6.3	0.400	....	....	....	Power Amp.	Characteristics Same as Type 6K6GT.										41
42	ST-14	Power Pent.	6B-0-0	Cathode	6.3	0.700	....	....	....	Power Amp.	Characteristics Same as Type 6F6G.										42
43	ST-14	Power Pent.	6B-0-0	Cathode	25.0	0.300	....	....	....	Power Amp.	Characteristics Same as Type 25A6GT.										43
45	ST-14	Triode	4D-0-0	Filament	2.5	1.500	7.0*	4.0*	3.0*	Power Amp.	180 250 275	31.5 50.0 56.0	....	31.0 34.0 36.0	....	1,650 1,610 1,700	2,125 2,175 2,050	3.5 3.5 3.5	2,700 3,900 4,600	830 1,600 2,000	45
45B5	T-6½	Beam Pent.	9CV	Cathode	45.0	0.100	0.6*	12.0*	6.0*	Power Amp.	100 170	6.7 12.5	100 170	43.0 70.0	3.0 5.0	23,000 23,000	9,000 10,000	....	2,400 2,400	1.9 5.6	45B5
45Z3	T-5½	Diode	5AM-0-0	Cathode	45.0	0.075	....	....	....	H-W Rect.	117 A-C Volts Per Plate, RMS, 65 Ma. Output Current.										45Z3
45Z5GT	Now Known as Type 40Z5/45Z5GT																				45Z5GT
46	ST-16	Power Tet.	5C-0-0	Filament	2.5	1.750	....	....	....	Power Amp.	250 300 400	33.0 0.0 0.0	Tie Gs to P Tie Gs to G Tie Gs to G	22.0 4.0# 6.0#	....	2,380 (Class B Operation) (Class B Operation)	2,350	5.6	6,400 5,200¶ 5,800¶	1,250 16,000 20,000	46
47	ST-16	Power Pent.	5B-0-0	Filament	2.5	1.750	1.2*	8.6*	1.3*	Power Amp.	250	16.5	250	31.0	6.0	60,000	2,500	150	7,000	2,700	47
48	ST-16	Power Tet.	6A-0-0	Cathode	30.0	0.400	....	....	....	Power Amp.	95 125	20.0 22.5	95.0 100	52.0 52.0	12.0 12.0	4,000 11,000	3,900 3,900	15.6 43	1,500 1,500	2,000 3,000	48
49	ST-14	Power Tet.	5C-0-0	Filament	2.0	0.120	....	....	....	Power Amp.	135 180	20.0 0.0	Tie Gs to P Tie Gs to G	6.0 2.0#	....	4,175 (Two Tubes Class B Operation)	1,125	4.7	11,000 12,000¶	170 3,500	49
50	ST-16	Triode	4D-0-0	Filament	7.5	1.250	7.1*	4.2*	3.4*	Power Amp.	300 350 400 450	54.0 63.0 70.0 84.0	....	35.0 45.0 55.0 55.0	....	2,000 1,900 1,800 1,800	1,900 2,000 2,100 2,100	3.8 3.8 3.8 3.8	4,600 4,100 3,670 4,350	1,600 2,400 3,400 4,600	50
50A1	T-6½	Ballast	9CM	....	....	....	....	....	....	Fil. Ballast	Avg. Operating Current—52 Ma. at 30 Volts; 54 Ma. at 50 Volts; 56 Ma. at 65 Volts.										50A1
50A5	Lock-in	Beam Pent.	6AA-L-0	Cathode	50.0	0.150	....	....	....	Power Amp.	110 200	7.5 8.0	110 110	49.0 50.0	4.0 1.5	13,000♦ 28,000♦	8,000 8,000	....	2,000 4,000	2,100 3,800	50A5
50AX6G	ST-14	Duodiode	7Q-0-0	Cathode	50.0	0.300	....	....	....	F-W Rect.	Characteristics Same as Type 6AX6G.										50AX6G
50B5	T-5½	Beam Pent.	7BZ-0-0	Cathode	50.0	0.150	0.6*	13.0*	8.5*	Power Amp.	120	8	110	49	4.0	10,000	7,500	.....	2,500	2,300	50B5
50BK5	T-6½	Beam Pent.	9BQ-0-0	Cathode	50.0	0.150	0.6*	13.0*	5.0*	Power Amp.	250	5.0	250	35	3.5	0.1 Meg.♦	8,500	.....	6,500	3,500	50BK5
50BM8	T-6½	Tri. Pentode	9EX	Cathode	50	0.100	4.2* 0.3*	2.7* 9.3*	4.3* 8.0*	A-F Tri. Amp. Power Amp.	100 100 200	0 6 16	..... 100 200	3.5 26 35	.... 5 7	28,000 15,000 20,000	2,500 6,800 6,400	70	.... 3,900 5,600	.... 1,050 3,500	50BM8
50C5	T-5½	Beam Pent.	7CV-0-0	Cathode	50.0	0.150	0.6*	13.0*	8.5*	Power Amp.	120	8	110	49.	4.0	10,000	7,500	.....	2,500	2,300	50C5
50C6G 50C6GA	ST-14 T-12	Beam Pent.	7S-0-0	Cathode	50.0	0.150	....	....	....	Power Amp.	Characteristics Same as Type 6Y6G.										50C6G 50C6GA
50CA5	T-5½	Beam Pent.	7CV	Cathode	50	0.150	0.5*	15*	9*	Power Amp.	Characteristics Same as Type 6CA5.										50CA5
50DC4	T-5½	Diode	5BQ	Cathode	50	0.150	....	....	....	H-W Rect.	117 A.C. Volts Per Plate, RMS, 110 Ma. Output Current. Heater Top Voltage (Pin 4 to Pin 6) = 7.5 Volts.										50DC4
50EH5	T-5½	Beam Pent.	7CV	Cathode	50	0.150	0.65*	17*	9*	S.T. A1 Amp.	Characteristics Same as Type 6EH5.										50EH5
50L6GT	T-9	Beam Pent.	7S-0-0	Cathode	50.0	0.150	....	....	....	Power Amp.	Characteristics Same as Type 25L6GT.										50L6GT
50X6	Lock-in	Duodiode	7DX-L-0	Cathode	50.0	0.150	....	....	....	H-W Rect. Doubler	235 Volts RMS Per Plate, 75 Ma. D-C Output Per Plate. 117 Volts RMS Per Plate, 75 Ma. D-C Output.										50X6
50Y6GT	T-9	Duodiode	7Q-0-0	Cathode	50.0	0.150	....	....	....	F-W Rect.	Characteristics Same as Type 25Z6GT.										50Y6GT
50Y7GT	T-9	Duodiode	8AN-0-0	Cathode	46.0	0.150	....	....	....	Doubler H-W Rect.	117 A-C Volts, RMS, 65 Ma. Output with Panel Lamp. 150 A-C Volts, RMS, 65 Ma. Output Per Plate with Panel Lamp. 235 A-C Volts, RMS, 65 Ma. Output Per Plate with Panel Lamp.										50Y7GT

50Z6G	ST-12	Duodiode	7Q-0-0	Cathode	50.0	0.300	....	....	....	F-W Rect.	235 Volts RMS Per Plate, 250 Ma. D-C Output.										50Z6G
50Z7G	ST-12	Duodiode	8AN-0-0	Cathode	50.0	0.150	....	....	....	Doubler H-W Rect.	117 A-C Volts Per Plate, RMS, 65 Ma. Output Current. With Current passing thru Panel Lamp Section. 235 A-C Volts, RMS, 65 Ma. Output Current Per Plate.										50Z7G
EF50	Metal Glass	Pentode	9C-L-5 & 8	Cathode	6.3	0.300	.007m	8.0	5.0	R-F Amp.	250	160■	250	10.0	3.1	600,000	6,300	.....			EF50
52	ST-14	Power Tet.	5C-0-0	Filament	6.3	0.300	....	....	....	Class A Amplifier	110	0	.....	43	G2 to P	1,750	3,000	5.2	2,000¶	1,500	52
										Class B	180	0	.....	1.5#	G1 to G2	Two Tubes in P.P.			10,000¶	5,000	
VT52	S-17	Triode	4D-0-0	Filament	7.0	1.180	7.7	5.0	3.0	Amplifier	220	43.5	.....	29.0	....	1,650	2,300	3.8	3,800	1,000	VT52
53	ST-14	Duotriode	7B-0-0	Cathode	2.5	2.000	....	....	....	Power Amp.	Characteristics Same as Type 6A6.										53
55 55S	ST-12	Duodiode Tri.	6G-0-5 6G-5-5	Cathode	2.5	1.000	1.5*	1.5*	4.3*	Det. Amp.	Characteristics Same as Type 6V7G.										55 55S

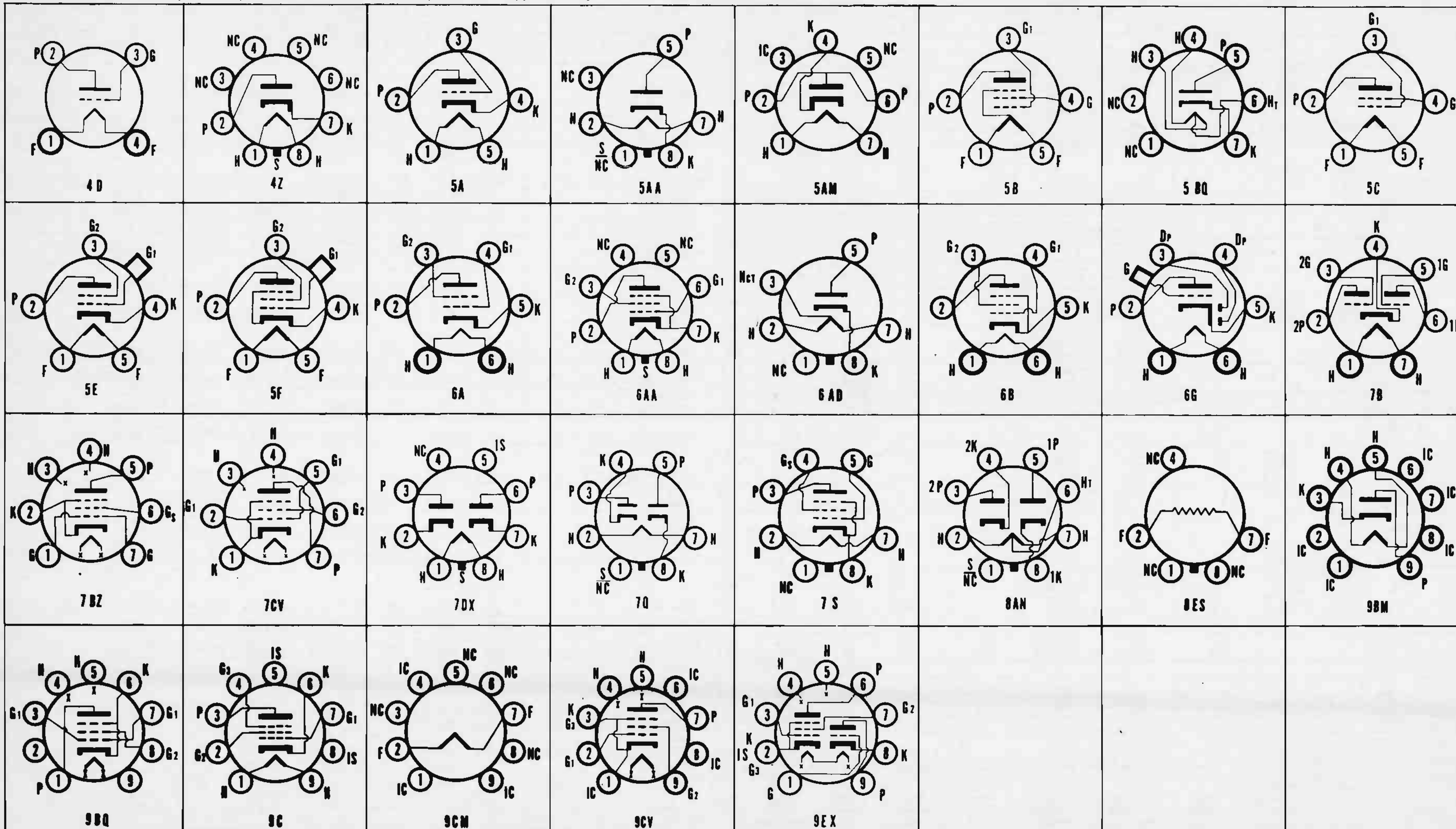
(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate; RF Input, Mixer Output.
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
⌛ Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)

\# Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.

□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.

¶ Plate to Plate.
♦ Approximate.

m maximum.
■ Cathode Resistor (ohms).



SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection, DO NOT USE, J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

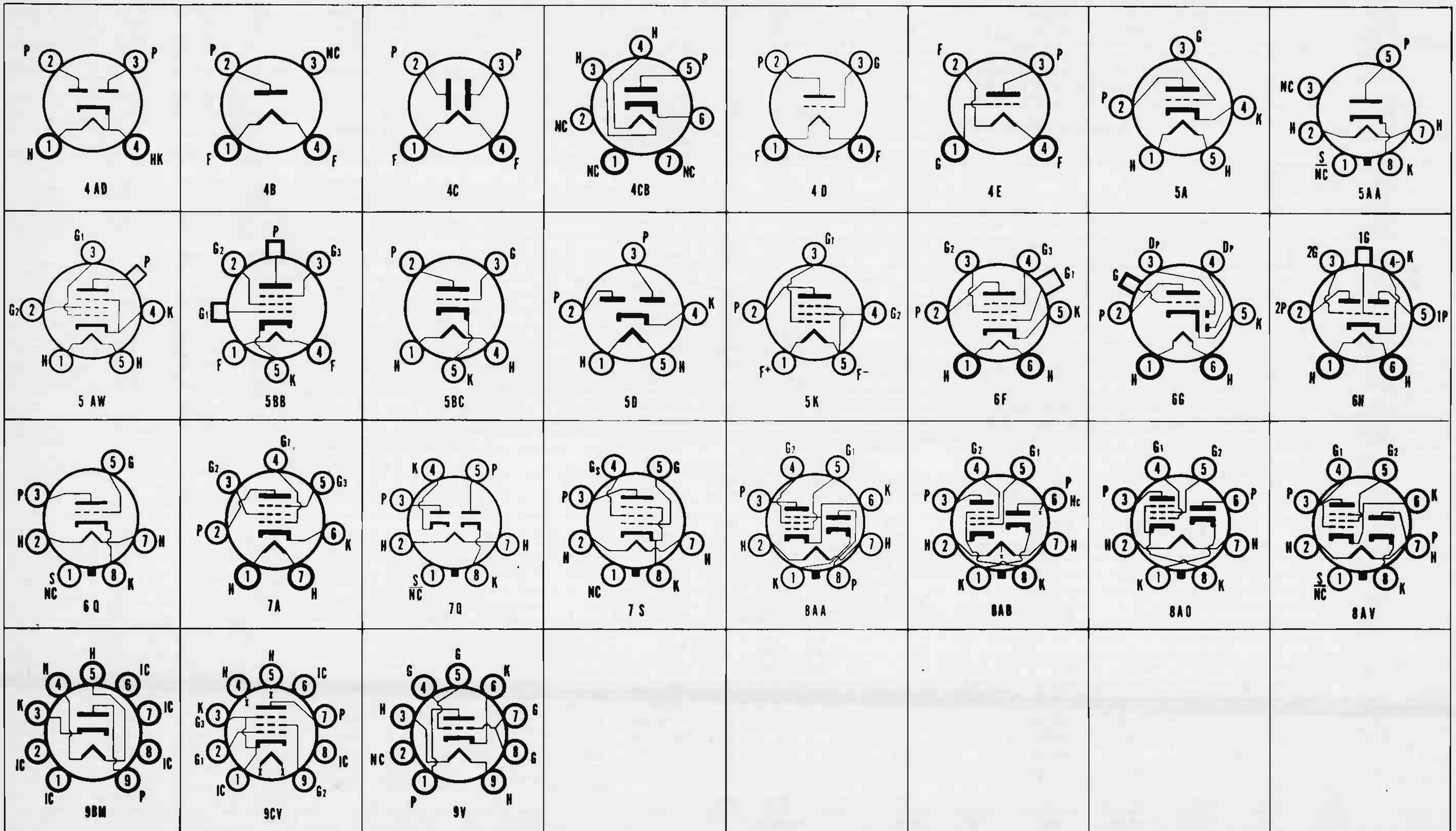
SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction			Emitter			Note (1) (2) Capacitances in $\mu\mu f$.			Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Undistorted Power Output Milliwatts	Type
	Bulb Size or Style	Class	Basing Diag.	Type	Volts	Amps.	Cgp.	Cin.	Cout												
55N3	T-6½	Diode	9BM	Cathode	55	0.100	....	....	....	H-W Rect.	250 A.C. Plate Volts, R.M.S., 180 Ma. Output Current. Condenser Input to Filter.										55N3
56 56S	ST-12 T-9	Triode	5A-0-0 5A-4-0	Cathode	2.5	1.000	3.2*	3.2*	2.4*	Amplifier Detector	250	13.5	.....	5.0	....	9,500	1,450	13.8	....	....	56
56AS	ST-12	Triode	5A-4-0	Cathode	6.3	0.400	2.8*	3.5*	2.5*	Amplifier	Characteristics Same as Type 56.										56AS
57 57S	ST-12	Pentode	6F-0-5 6F-5-5	Cathode	2.5	1.000	.007m	5.0*	6.5*	R-F Amp. Detector	100 250	3.0 3.0	100 100	2.0 2.0	0.5 0.5	1 Meg. 1 Meg.>	1,185 1,225	....	....	....	57 57S
57AS	ST-12	Pentode	6F-5-5	Cathode	6.3	0.400	.007*	5.0*	6.5*	R-F Amp.	Characteristics Same as Type 57.										57AS
58 58S	ST-12	Pentode	6F-0-5 6F-5-5	Cathode	2.5	1.000	.007m	4.7*	6.0*	R-F Amp.	100 250	3.0 3.0	100 100	8.0 8.2	2.2 2.0	250,000 800,000	1,500 1,600	....	....	....	58 58S
58AS	ST-12	Pentode	6F-5-5	Cathode	6.3	0.400	.007*	4.7*	6.0*	R-F Amp.	Characteristics Same as Type 58.										58AS
59	ST-16	Power Pent.	7A-0-0	Cathode	2.5	2.000	....	....	....	Power Amp.	250** 250 300** 400**	28.0 18.0 0.0 0.0	Tie Gs to P 250 Tie Gs to G and Su to P	26.0 35.0 20.0 26.0	....	2,300 40,000 (Class B Operation Two Tubes) (Class B Operation Two Tubes)	2,600 2,500	6.0 100	5,000 6,000 4,600¶ 6,000¶	1,250 3,000 15,000 20,000	59
KT66	Curved Bulb	Beam Pent.	7S	Cathode	6.3	1.270	1.1*	16*	11.5*	S.T. A1 Amp. P.P.AB1 Amp.	250 450	15 250 ■	250 415	85 104-125†	6.3 5-18†	22,500	6,300	....	2,200 8,000¶	7,250 30,000	KT66
70A7GT	T-9	Diode Beam Pent.	8AB-0-0	Cathode	70.0	0.150	....	....	....	H-W Rect. Power Amp.	125 A-C Volts Per Plate, RMS, 60 Ma. Output Current. 110	7.5	110	40	3	......	5,800	.....	2,500	1,500	70A7GT
70L7GT	T-9	Diode Beam Pent.	8AA-0-0	Cathode	70.0	0.150	....	....	....	H-W Rect. Power Pent.	117 A-C Volts, RMS, 70 Ma. Output Current. Condenser Input to Filter. 110	7.5	110	40	3.0	15,000	7,500	.....	2,000	1,800	70L7GT
71A	ST-14	Triode	4D-0-0	Filament	5.0	0.250	7.5*	3.2*	2.9*	Power Amp.	90 135 180	16.5 27.0 40.5	....	10.0 17.3 20.0	....	2,170 1,820 1,750	1,400 1,650 1,700	3.0 3.0 3.0	3,000 3,000 4,800	125 400 790	71A
75 75S	ST-12	Duodiode Tri.	6G-0-5 6G-5-5	Cathode	6.3	0.300	1.7*	1.7*	3.8*	Det. Amp.	250	2.0	.....	0.9	....	91,000	1,100	100	....	....	75 75S
76	ST-12	Triode	5A-0-0	Cathode	6.3	0.300	2.8*	3.5*	2.5*	Amplifier Detector	250 250	13.5 20.0♦	....	5.0 (Plate Current to be adjusted to 0.2 Ma. with no Input Signal.)	....	9,500	1,450	13.8	....	....	76
77	ST-12	Pentode	6F-0-3	Cathode	6.3	0.300	.007m	4.7*	11.0*	R-F Amp.	100 250	1.5 3.0	60.0 100	1.7 2.3	0.4 0.5	600,000♦ 1.0 Meg.>	1,100 1,250	....	....	....	77
78	ST-12	Pentode	6F-0-5	Cathode	6.3	0.300	.007m	4.5*	11.0*	R-F Amp.	90 180 250	3.0 3.0 3.0	90.0 75.0 100	5.4 4.0 7.0	1.3 1.0 1.7	300,000♦ 1 Meg.♦ 800,000♦	1,275 1,100 1,450	....	....	....	78
79	ST-12	Duotriode	6H-0-0	Cathode	6.3	0.600	....	....	....	Power Amp.	180 250	0.0 0.0	....	7.5# 10.5#	....	(Class B Operation) (Class B Operation)		.....	7,000¶ 14,000¶	5,500 8,000	79
80	ST-14	Duodiode	4C-0-0	Filament	5.0	2.000	....	....	....	F-W Rect.	350 A-C Volts Per Plate, RMS, 125 Ma. Output Current. Condenser Input to Filter. 500 A-C Volts Per Plate, RMS, 125 Ma. Output Current. Choke Input to Filter.										80
81	ST-16	Diode	4B-0-0	Filament	7.5	1.250	....	....	....	H-W Rect.	700 A-C Volts Per Plate, RMS, 85 Ma. Output Current. Condenser Input to Filter.										81
82	ST-14	Duodiode	4C-0-0	Filament	2.5	3.000	....	....	....	F-W Rect.	450 A-C Volts Per Plate, RMS, 115 Ma. Output Current. Condenser Input to Filter.										82
83	ST-16	Duodiode	4C-0-0	Filament	5.0	3.000	....	....	....	F-W Rect.	450 A-C Volts Per Plate, RMS, 225 Ma. Output Current. Condenser Input to Filter.										83
83V	ST-14	Duodiode	4AD-0-0	Cathode	5.0	2.000	....	....	....	F-W Rect.	375 A-C Volts Per Plate, RMS, 175 Ma. Output Current. Condenser Input to Filter.										83V
84/6Z4	ST-12	Duodiode	5D-0-0	Cathode	6.3	0.500	....	....	....	F-W Rect.	325 A-C Volts Per Plate, RMS, 60 Ma. Output Current. Condenser Input to Filter.										84/6Z4
EL84/6BQ5	T-6½	Beam Pent.	9CV	Cathode	6.3	0.760	0.5m*	10.8*	6.5*	S.T. A1 Amp. P.P. AB1 Amp.	250 300	135■ 130■	250 300	48 72-92†	5.5 8-22†	38,000	11,300	....	5,200 8,000¶	5,700 17,000	EL84/6BQ5
85	ST-12	Duodiode Tri.	6G-0-5	Cathode	6.3	0.300	1.5*	1.5*	4.3*	Det. Amp.	Characteristics Same as Type 6V7G.										85
85AS	ST-12	Duodiode Tri.	6G-5-5	Cathode	6.3	0.300	1.5*	1.5*	4.3*	Det. Amp.	250	9.0	.....	4.5	....	16,000	1,250	20	....	....	85AS
KT88	ST-16	Beam Pent.	7S	Cathode	6.3	1.800	....	....	....	P.P.AB1 Amp.	450	65	450	100-240†	(Plate and Grid No. 2 Current). Ultra-Linear Circuit				3,800¶	65,000	KT88
89	ST-12	Power Pent.	6F-0-0	Cathode	6.3	0.400	....	....	....	Power Amp.	160** 180 180	20.0 18.0 0.0	Gs & Su to P 180	17.0 20.0 3.0#	.... 3.0 Class B Operm. Tie Su to P & Gs to G (Two Tubes)	3,300 80,000	1,425 1,550	4.7 125	7,000 8,000 9,400¶	300 1,500 3,500	89
VR-90-105-150				Cold						Now Listed as OB3, OC3 and OD3.											VR-90-105-150
V-99	T-8	Triode	4E-0-0	Filament	3.3	0.063	3.5*	2.5*	2.2*	Det. Amp.	90	4.5	.....	2.5	....	15,500	425	6.6	....	....	V99
X99	T-9	Triode	4D-0-0	Filament	3.3	0.063	3.5*	2.5*	2.2*	Det. Amp.	90	4.5	.....	2.5	....	15,500	425	6.6	....	....	X99
117L7/M7GT	T-9	Diode Beam Pent.	8AO-0-0	Cathode	117	0.090	....	....	....	H-W Rect. Power Amp.	117 A-C Volts, RMS, 75 Ma. Output Current. Condenser Input to Filter. 105	5.2	105	43	4.0	17,000♦	5,300	.....	4,000	850	117L7/M7GT
117N7GT	T-9	Diode Beam Pent.	8AV-0-0	Cathode	117	0.090	....	....	....	H-W Rect. Power Amp.	117 A-C Volts, RMS, 75 Ma. Output Current. Condenser Input to Filter. 100	6.0	100	51	5.0	16,000♦	7,000	.....	3,000	1,200	117N7GT
117P7GT	T-9	Diode Beam Pent.	8AV-0-0	Cathode	117	0.090	....	....	....	H-W Rect. Power Amp.	117 A-C Volts Per Plate, RMS, 75 Ma. Output Current. 105	5.2	105	43	4	17,000	5,300	.....	4,000	850	117P7GT
117Z3	T-5½	Diode	4CB-0-0	Cathode	117	0.040	....	....	....	H-W Rect.	117 Volts Per Plate, RMS, 90 Ma. D-C Output.										117Z3
117Z4GT	T-9	Diode	5AA-0-0	Cathode	117	0.040	....	....	....	H-W Rect.	117 A-C Volts Per Plate, RMS, 90 Ma. Output Current.										117Z4GT
117Z6GT	T-9	Duodiode	7Q-0-0	Cathode	117	0.075	....	....	....	Volt. Dblr.	117 A-C Volts Per Plate, RMS, 60 Ma. Output Current.										117Z6GT
182B/482B	ST-14	Triode	4D-0-0	Filament	5.0	1.250	....	....	....	Power Amp.	250	35.0	.....	20.0	....	2,500	2,000	5.0	4,500	1,350	182B/482B
183/483	ST-14	Triode	4D-0-0	Filament	5.0	1.250	....	....	....	Power Amp.	250	65.0	.....	20.0	....	2,000	1,500	3.0	4,500	1,800	183/483
210-T	ST-16	Triode	4D-0-0	Filament	7.5	1.250	7.0*	4.0*	3.0*	Power Amp.	(Standard Type 10 with Ceramic Base, See Type 10 Characteristics.)										210-T
417A	T-6½	Triode	9V	Cathode	6.3	0.300	0.48*	9*	1.8*	UHF R-F Amp.	Characteristics Same as Type 5842.										417A
485	ST-12	Triode	5A-0-0	Cathode	3.0	1.250	....	....	....	Det. Amp.	180	9.0	.....	5.8	....	8,900	1,400	12.5	....	....	485
807 807W	ST-16 T-12	Beam Pent.	5AW-0-0	Cathode	6.3	0.900	0.2m	12.0*	7.0*	P.P.AB1 Amp. P.P.AB2 Amp. P.P.AB2 Amp.	400 400 600	45 25 30	..... 300 300	60-140† 90-240† 60-200†	.... 2-15† 0.7-16†	(Current and Output for Two Tubes) (Current and Output for Two Tubes) (Current and Output for Two Tubes)			3,000 3,200 6,400	15,000 55,000 80,000	807 807W

864	T-9	Triode	4D-0-0	Filament	1.1	0.250	5.3*	3.3*	2.1*	Det. Amp.	90 135	4.5 9.0	....	2.9 3.5	....	13,500 12,700	610 645	8.2 8.2	....	....	864
884	ST-12	Gas Triode	6Q-0-0	Cathode	6.3	0.600	6.0*	2.0*	0.6*	Relay Tube	300	30	.....	75	For Relay Operation Limit Time to 30 Secs. 300 Ma. Peak Current. 16 Volt Tube Drop.						884
885	ST-12	Gas Triode	5A-0-0	Cathode	2.5	1.500	6.0*	2.0*	0.6*	Relay Tube	Characteristics Same as Type 884.										885
950	ST-14	Beam Pent.	5K-0-0	Filament	2.0	0.120	....	....	....	Power Amp.	135	16.5	135	7.0	2.0	125,000	1,000	125	13,500	575	950
954	Acorn	Pentode	5BB-0-0	Cathode	6.3	0.150	.007m	3.4	3.0	R-F Amp.	90 250	3.0 3.0	90 100	1.2 2.0	0.5 0.7	1 Meg. 1 Meg.>	1,100 1,400	....	....	....	954
955	Acorn	Triode	5BC-0-0	Cathode	6.3	0.150	1.3	1.0	0.4	Osc. Amp.	250 90	7.0 2.5	....	6.3 2.5	....	11,400 14,700	2,200 1,700	25 25	....	....	955

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate; RF Input, Mixer Output.
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
χ Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)

\# Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).

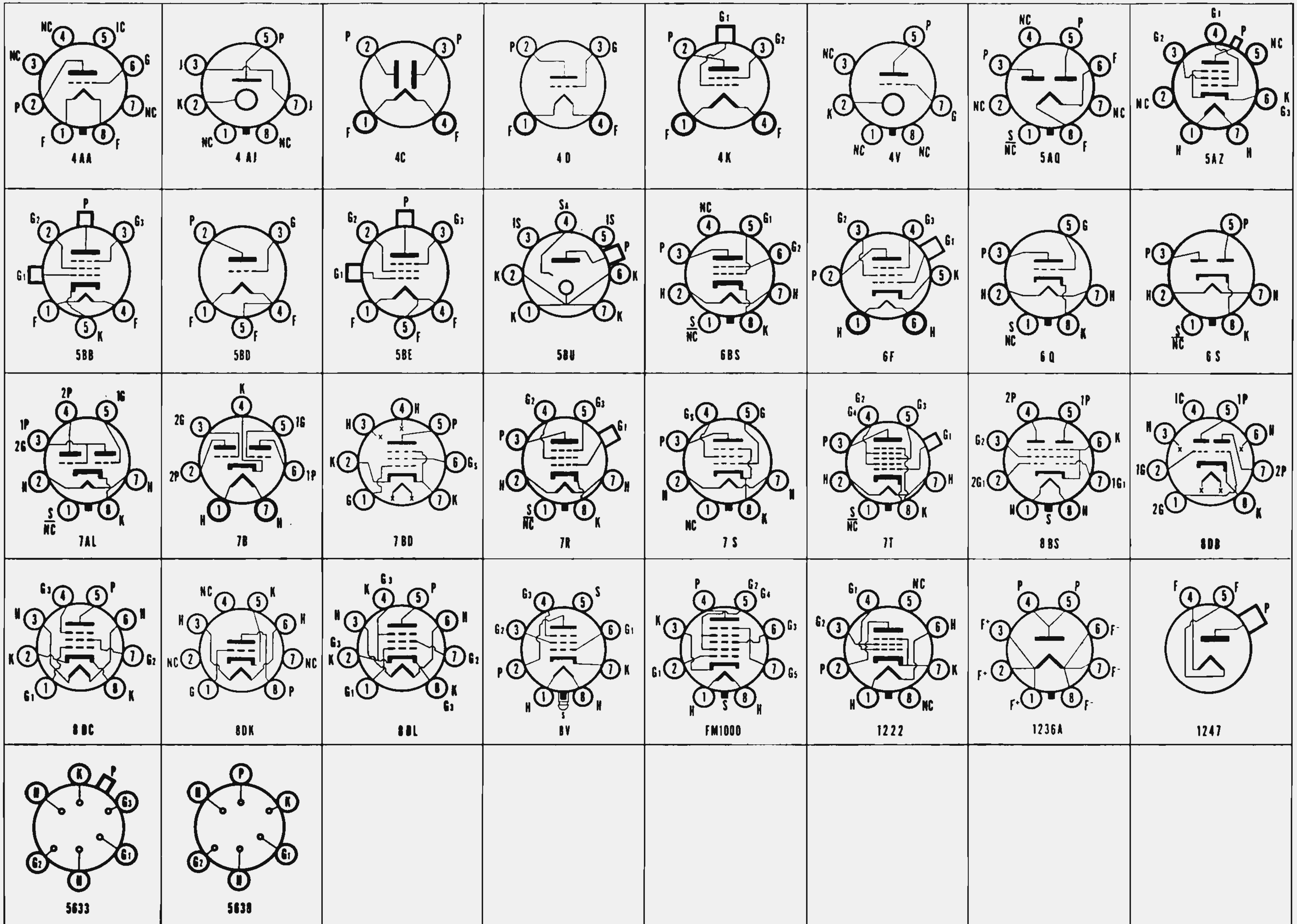


SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection. DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (1) (2) Capacitances in μμf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Undistorted Power Output Milliwatts	Type
956	Acorn	Pentode	5BB-0-0	Cathode	6.3	0.150	.007m	3.4	3.0	R-F Amp.	250	3.0	100	6.7	2.7	700,000♦	1,800	....	....	....	956
957	Acorn	Triode	5BD-0-0	Filament	1.2	0.050	1.2	0.3	0.7	Osc. Amp.	135	5.0	.....	2.0	....	20,800♦	650	12	....	....	957
958-A	Acorn	Triode	5BD-0-0	Filament	1.25	0.100	2.6	0.6	0.8	Osc. Amp.	135	7.5	.....	3.0	....	10,000	1,200	12	....	....	958-A
959	Acorn	Pentode	5BE-0-0	Filament	1.25	0.050	.015m	1.8	2.9	R-F Amp.	135	3.0	67.5	1.7	0.4	800,000♦	600	....	....	....	959
FM1000	Lock-In	Heptode	FM1000	Cathode	6.3	0.300	....	....	....	F-M Det.	....	....	.....	....	....	......	....	....	....	....	FM1000
1005/CK1005	Metal	Gas Duodi.	5AQ-0-1	Filament	6.3	0.100	....	....	....	F-W Rect.	450 Max. Peak Inverse V., 210 Ma. Max. Peak Current, 70 Ma. Avg. Current D-C. Avg. Tube Drop = 20.										1005/CK1005
1201	Now Known as Type 7E5																				1201
1203-A	Now Known as Type 7C4																				1203-A
1204	Now Known as Type 7AB7																				1204
1206	Now Known as Type 7G8																				1206
1221	ST-12	Pentode	6F-0-5	Cathode	6.3	0.300	....	....	....	Amplifier	Special Non-Microphonic Tube, Characteristics Same as Type 6C6.										1221
1222	ST-14	Beam Pent.	1222	Cathode	6.3	0.900	....	....	....	Power Amp.	Characteristics Similar to Type 6L6GA.										1222
1223	ST-12	Pentode	7R-0-0	Cathode	6.3	0.300	....	....	....	Amplifier	"G" Equivalent of Type 1221 Above.										1223
1229	ST-12	Tetrode	4K-0-0	Filament	2.0	0.060	....	....	....		Special Type 32. Made for Low Grid Current Application.										1229
1230	T-9	Triode	4D-0-0	Filament	2.0	0.060	6.0*	3.0*	2.1*		Special Type 30. Made for Low Grid Current Applications.										1230
1231	Lock-In	Pentode	8V-L-5	Cathode	6.3	0.450	.015m	8.5	6.5	R-F Amp. Tet. Amp.	300 300	200■ 200■	150 150	10.0 12.0	2.5 0.5	700,000 540,000	5,500 6,500	3,850 3,500	....	....	1231
1232	Now Known as Type 7G7																				1232
1236A	T-9	Diode	1236A	Filament	1.9	0.450	....	....	....	Regulator	Plate Voltage = 330 Volts (Abs. Max.). D.C. Current = 0.8 Ma. (Abs. Max.). Plate Current = 0.63 Ma. Plate Load Resistance = 0.25 Meg.										1236A
1238	T-9	Duo. Beam Amplifier	8BS-L-0	Cathode	28.0	0.400	....	....	....	Amplifier	Characteristics Similar to 28D7.										1238
1247	T-3	Diode	1247	Filament	0.7	0.065	....	....	....	R-F Probe	300 A-C Volts RMS, 0.4 Ma. D-C Plate Current.										1247
1265	ST-12	Diode	4AJ-0-0	Cold K	....	....	....	....	....	Voltage Reg.	Starting Voltage = 135, Operating Voltage = 90, Operating Current = 5 to 30 Ma.										1265
1266	T-9	Diode	4AJ-0-0 No Jumper	Cold K	....	....	....	....	....	Regulator	Voltage Regulator Similar to Type OB3/VR-90-30, Except Regulating at 70 Volts.										1266
1267	T-9	Gas Triode	4V-0-0	Cold K	....	....	....	....	....	Relay Tube	Similar to Type OA4G.										1267
1273	Lock-In	Pentode	8V-L-5	Cathode	6.3	0.300	.004m	6.0	6.5	Amplifier	Characteristics Same as Type 14C7 (Special Non-Microphonic Tube)										1273
1274	T-9	Duodiode	6S-0-0	Cathode	6.3	0.600	....	....	....	F-W Rect.	Characteristics Same as Type 7Y4.										1274
1275	ST-16	Duodiode	4C-0-0	Filament	5.0	1.750	....	....	....	F-W Rect.	Similar to Type 5Z3.										1275
1276	ST-16	Triode	4D-0-0	Filament	4.5	1.140	....	....	....	Power Amp.	Similar to Type 6A3.										1276
1280	Lock-In	Pentode	8V-L-5	Cathode	12.6	0.150	.004m	6.0	6.5	Amplifier	Characteristics Same as Type 14C7 (Special Non-Microphonic Tube).										1280
1284	Lock-In	Pentode	8V-L-5	Cathode	12.6	0.150	.01	5.0	6.0	R-F Amp.	250	3	100	9.0	2.5	800,000	200	.....	....	....	1284
1291	Now Known as Type 3B7																				1291
1293	Lock-In	Triode	4AA-L-0	Filament	1.4	0.110	1.7	1.7	3.0	Oscillator	90 90	0 20	....	5.2 13.25	.... 120 Mc. Oscillator Rg = 10,000 Ohms.	......	1,500	15	....	....	1293
1294	Now Known as Type 1R4																				1294
1299	Now Known as Type 3D6																				1299
1612	Metal	Heptode	7T-1-0	Cathode	6.3	0.300	.001m	7.5	11.0	Mixer Amp.	Characteristics Same as Type 6L7.										1612
1614	T-10 Sp.	Beam Pent.	7S	Cathode	6.3	0.900	0.4m*	10*	12*	P.P.AB1 Amp.	360 530	22.5 36	270 340	88-132† 60-160†	15† 20†	....	....	....	6,600 7,200	26,500 50,000	1614
1625	ST-16	Beam Pent.	5AZ	Cathode	12.6	0.450	0.2m*	11*	7*	P.P.AB1 Amp. P.P.AB2 Amp.	**Characteristics Same as Type 807.										1625
1626	ST-12	Triode	6Q-0-0	Cathode	12.6	0.250	4.4*	3.2*	3.4	Oscillator	250	70	.....	25	Class C, Oscillator or Amplifier.					4,000	1626
1629	T-9	Electron Ray	7AL-0-0	Cathode	12.6	0.150	....	....	....	Indicator	Characteristics Same as Type 6E5.										1629
2050	ST-12	Gas Tetrode	6BS-0-0	Cathode	6.3	0.600	0.26*	4.2*	3.6*	Relay Tube	400 220	5.0 4.0	0 0	100 75	For Relay Operation Limit Time to 30 Secs. 1 Amp. Peak Current, 8 Volts Tube Drop.						2050
2051	ST-12	Gas Tetrode	6BS-0-0	Cathode	6.3	0.600	0.26*	4.2*	3.6*	Relay Tube	220	4.0	0	75	For Relay Operation Limit Time to 30 Secs. 375 Ma. Peak Current, 8 Volts Tube Drop.						2051
5517/CK1013	T-5½	Gas Diode	5-BU	Cold K	....	....	....	....	....	H-W Rect.	2800 Max. Peak Inverse V., 50 Ma. Max. Peak Current, 6 Ma. Avg. Current D-C, Avg. Tube Drop = 100.										5517/CK1013
5590	T-5½	Pentode	7BD-0-0	Cathode	6.3	0.150	.01	3.4	2.9	R-F Amp.	90	820■	90	3.9	1.4	300,000	2,000	600	....	....	5590
5591	T-5½	Pentode	7BD-0-0	Cathode	6.3	0.150	.02	4.0	2.8	R-F Amp.	120 150 180	200■ 330■ 200■	120 140 120	7.5 7.0 7.7	2.5 2.2 2.4	340,000 420,000 690,000	5,000 4,300 5,100	1,700 1,800 3,500	....	....	5591
5608-A	ST-14	Duotriode	7B-0-0	Cathode	2.5	2.000	....	....	....	Amplifier‡	250 300	5 6	....	5.0 6.0	....	14,000 13,000	2,200 2,450	31.5 32	....	....	5608-A
5633 (3)	T-3	Pentode	5633	Cathode	6.3	0.150	.01m	4.0	2.8	R-F Amp.	100	150■	100	7.0	2.8	200,000	3,400	.....	....	....	5633 (3)
5634 (3)	T-3	Pentode	5633	Cathode	6.3	0.150	.01m	4.4	2.8	R-F Amp.	100	150■	100	6.5	2.5	240,000♦	3,500	.....	....	....	5634 (3)
5635 (3)	T-3	Duotriode	8DB-0-0	Cathode	6.3	0.450	1.2	2.6	1.6	Amplifier	100	100■	.....	4.8	....	10,000	3,800	38	....	....	5635 (3)
5636 (3)	T-3	Pentode	8DC-0-0	Cathode	6.3	0.150	.015m	4.0	3.4	Mixer	100	150■	100	3.6	5.3	320,000	1,280▲	.....	....	....	5636 (3)
5637 (3)	T-3	Triode	8DK-0-0	Cathode	6.3	0.150	1.3	2.8	3.2	Amplifier	100	820■	.....	1.4	....	26,000	2,700	70	....	....	5637 (3)
5638 (3)	T-3	Pentode	5638	Cathode	6.3	0.150	0.19	4.0	6.5	Amplifier	100	270■	100	4.8	1.25	150,000	3,300	.....	....	....	5638 (3)
5639 (3)	T-3	Beam Pent.	8DL-0-0	Cathode	6.3	0.450	0.1m	9.5	7.5	Power Amp.	150	100■	100	21	4	50,000	9,000	.....	....	1,000	5639 (3)

(1) Values are given shielded unless marked with (*).
(2) Converter tube capacitances given are signal grid to plate, RF Input, Mixer Output.
‡ Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
‡ Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection, DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; ☐—Tap Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (1) (2) Capacitances in μμf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transcon-ductance Micromhos	Ampli-fication Factor	Ohms Load for Stated Power Output	Power Output Milli-watts	Type
5640 (3)	T-3	Beam Pent.	8DL-0-0	Cathode	6.3	0.450	.09	9.0	6.5	Power Amp.	100	270■	100	31.0	2.2	15,000	5,000	.....	3,000	1,250	5640 (3)
5641 (3)	T-3	Diode	6CJ-0-0	Cathode	6.3	0.450	....	....	....	H-W Rect.	117 A-C Volts Per Plate, RMS, 45 Ma. D-C Output. Condenser Input to Filter. 235 A-C Volts Per Plate, RMS, 45 Ma. D-C Output. Condenser Input to Filter.										5641 (3)
5642	T-3	Diode	5642	Filament	1.25	0.200	....	....	0.6*	H-W Rect.	Pulse Type Rectifier for Television Service, 10,000 Volts Peak Inverse.										5642
5643 (3)	T-3	Gas Tetrode	8DD-0-0	Cathode	6.3	0.15	0.1	1.7	1.6	Relay Tube	150	5 A-C	0	20	(Grid Bias Voltage 180°, Out of Phase with Anode Voltage)						5643 (3)
5644 (3)	T-3	Gas Diode	4CN-0-0	Cold K	....	....	....	....	....	Voltage Regulator with Starting Voltage at 130, Operating Voltage 95, Operating Current 5 to 25 Ma.											5644 (3)
5645 (3)	T-2	Triode	5646	Cathode	6.3	0.150	1.2	2.4	3.4	Amplifier	100	560■	.....	5.0	....	7,400	2,700	20	....	....	5645 (3)
5646 (3)	T-2	Triode	5646	Cathode	6.3	0.150	1.2	2.4	3.4	Amplifier	100	820■	.....	1.4	....	29,000	2,400	70	....	....	5646 (3)
5647 (3)	T-1	Diode	5647	Cathode	6.3	0.150	....	....	....	Detector	117 Volts RMS Plate, 9 Ma. D-C Output.										5647 (3)
5651	T-5½	Gas Diode	5BO-0-0	Cold K			....	....	....	Volt Ref.	Starting Voltage = 115 Volts Max. Operating Voltage = 92 Volts Max. Operating Current = 3.5 Ma. Max.										5651
5654/6AK5W (3)	T-5½	Pentode	7BD-0-2&7	Cathode	6.3	0.175	.02m	4.0	2.9	R-F Amp.	120	200■	120	7.5	2.5	340,000	5,000	.....	....	....	5654/6AK5W (3)
5670 (3)	T-6½	Duotriode	8CJ-0-5	Cathode	6.3	0.350	1.1	2.2	1.0	H-F Amp. ♯	150	240■	.....	8.2	....	6,370♦	5,500	35	....	....	5670 (3)
5679	Lock-in	Duodiode	7CX-L-5	Cathode	6.3	0.150	....	....	....		Characteristics Same as Type 7A6. For VTVM Use.										5679
5686 (3)	T-6½	Beam Pent.	9G-0-0	Cathode	6.3	0.350	.08m	6.5	8.5	Power Amp.	250	12.5	250	27	5.0	......	3,100	.....	9,000	2,700	5686 (3)
5687	T-6½	Duotriode	9H-0-0	Cathode	6.3 12.6	0.900 0.450	3.8*	4.0*	0.45*	Amplifier♯	250 180	12.5 7.0	....	12 23	....	3,000 2,000	5,400 8,500	16 17	....	....	5687
5691 (3)	T-9	Duotriode	8BD-0-0	Cathode	6.3	0.600	3.6* 3.6*	2.4* 2.7*	2.3* 2.6*	Amplifier	250	2	.....	2.3	....	44,000	1,600	70	....	....	5691 (3)
5692 (3)	T-9	Duotriode	8BD-0-0	Cathode	6.3	0.600	3.5* 3.3*	2.3* 2.6*	2.5* 2.7*	Amplifier	250	9	.....	6.5	....	9,100	2,200	20	....	....	5692 (3)
5693 (3)	Metal	Pentode	8N-1-0	Cathode	6.3	0.300	.005m	5.8	6.8	R-F Amp.	250	3	100	3.0	0.85	......	1,650	.....	....	....	5693 (3)
5694 (3)	ST-14	Duotriode	8CS-0-0	Cathode	6.3	0.800	....	....	....	Amplifier	250 294	5 6	....	6 7	....	11,300 11,000	3,100 3,200	35 35	....	....	5694 (3)
5702	T-3	Pentode	5702	Cathode	6.3	0.200	.03m	4.4	3.5	R-F Amp.	120	200■	120	7.5	2.5	340,000	5,000	.....	....	....	5702
5703	T-3	Triode	5703	Cathode	6.3	0.200	1.15	2.7	2.1	H-F Osc.	120	220■	.....	9.0	....	......	5,000	25	....	....	5703
5704	T-2	Diode	5704	Cathode	6.3	0.150	....	....	....	VHF Det.	150 Volts, RMS Plate, 9 Ma. D-C Output Current.										5704
5718 (3)	T-3	Triode	8DK-0-0	Cathode	6.3	0.150	1.3	2.4	2.4	Amplifier	100 150	150■ 180■	....	8.5 13.0	....	4,650 4,150	5,800 6,500	27 27	....	....	5718 (3)
5719 (3)	T-3	Triode	8DK-0-0	Cathode	6.3	0.150	0.8	1.9	2.2	Amplifier	150	680■	.....	1.85	....	30,500	2,300	70	....	....	5719 (3)
5722	T-5½	Diode	5CB-0-0	Filament	4.9	1.600	....	....	1.5	Noise Diode	200	For Noise Generator Service Ib 35 Ma. Max.									5722
5725 (3)	T-5½	Pentode	7BD-0-0	Cathode	6.3	0.175	.01	3.9	3.0	Amplifier	120	2	120	5.2	3.5	3,200		.....	....	....	5725 (3)
5726/6AL5W (3)	T-5½	Duodiode	6BT-0-6	Cathode	6.3	0.300	....	....	....	Rectifier	117 Volts RMS Plate, 9 Ma. D-C Output Current Per Plate.										5726/6AL5W (3)
5731	Acorn	Triode	5BC-0-0	Cathode	6.3	0.150	1.3*	1.0*	0.4*	A-F Amp. Osc. Amp.	90 135 180 180	2.5 3.75 5 35	....	2.5 3.5 4.5 7.0	.... (Class C Operation)	14,700 13,200 12,500	1,700 1,900 2,000	25 25 25	.... 20,000	.... 135 500	5731
5744	T-3	Triode	5744	Cathode	6.3	0.200	0.8	2.7	2.4	A-F Amp.	250	500■	.....	4	....	......	4,000	70	....	....	5744
5749/6BA6W (3)	T-5½	Pentode	7BK-0-2	Cathode	6.3	0.300	.0035m	5.5	5.5	Class A Amplifier	100 250	68■ 68■	100 100	10.8 11.0	4.4 4.2	250,000♦ 1.0 Meg.♦	4,300 4,400	....	....	....	5749/6BA6W (3)
5751 (3)	T-6½	Duotriode	9A-0-0	Cathode	6.3 12.6	0.350 0.175	1.4*	1.4*		A-F Amp.	Characteristics Same as Type 12AX7. For Reliable Operation. Cout Sec. 1 = .46 μμf.*										5751 (3)
5783	T-3	Gas Diode	5783	Cold K	....	....	....	....	....	Voltage Regulator with Starting Voltage at 115 Volts, Operating Voltage 85, Operating Current 1.5 to 3.5 Ma.											5783
5784	T-3	Pentode	5784	Cathode	6.3	0.200	.03m	3.9	3.0	Amplifier	120	2	120	5.2	3.5	......	3,200	.....	....	....	5784
5785	T2x3	Diode	5785	Filament	1.25	0.015	....	....	....	H-W Rect.	1235 Volts, RMS Plate, 100 ua D-C Output Current.										5785
5787	T-3	Gas Diode	5783	Cold K	....	....	....	....	....	Voltage Regulator with Starting Voltage at 135 Volts, Operating Voltage 100, Operating Current 5 to 25 Ma.											5787
5814 (3) 5814A (3)	T-6½	Duotriode	9A-0-0	Cathode	6.3/ 12.6	0.350/ 0.175	1.5* 1.5*	1.6* 1.6*	0.5* 0.4*	Class A Amplifier ♯	100 250	0 8.5	....	11.8 10.5	....	6,250♦ 7,700♦	3,100 2,200	19.5 17.0	....	....	5814 (3) 5814A (3)
5823	T-5½	Gas Triode	4CK-0-0	Cold K			....	....	....	Relay Tube	Peak Cathode Ma. = 100 Max. D.C. Cathode Ma. = 25 Max. Starter Anode Volt Drop = 61 Volts. Anode Drop = 62 Volts.										5823
5824 (3)	ST-14	Beam Pent.	7S-0-0	Cathode	25.0	0.300	....	....	....	Power Amp.	135	22	135	61	2.5	15,000♦	5,000	.....	1,700	4,300	5824 (3)
5838 (3)	T-9	Duodiode	6S-0-0	Cathode	12.0	0.600	....	....	....	F-W Rect.	300 A-C Volts Per Plate RMS, 65 Ma. Output Current, Condenser Input to Filter. 400 A-C Volts Per Plate RMS, 60 Ma. Output Current, Choke Input to Filter.										5838 (3)
5839 (3)	T-9	Duodiode	6S-0-0	Cathode	26.5	0.285	....	....	....	F-W Rect.	Characteristics Same as Type 5838.										5839 (3)
5840 (3)	T-3	Pentode	8DL-0-0	Cathode	6.3	0.150	.015m	4.2	3.4	R-F Amp.	100	150■	100	7.5	2.4	280,000	5,000	.....	....	....	5840 (3)
5842	T-6½	Triode	9V	Cathode	6.3	0.300	0.55*	9*	1.8*	UHF R-F Amp.	150	62■		26	....	1,800	24,000	43	....	....	5842
5844	T-5½	Duotriode	7BF-0-0	Cathode	6.3	0.300	2.6* 2.6*	2.6* 2.6*	0.5* 0.4*	Class A1 Amplifier ♯	100	470■	....	4.8	....	7,550♦	3,700	28	....	....	5844
5845	T-5½	Duodiode	5CA-0-0	Filament	5.0m	0.435	....	....	0.8	Control Diode	300m	....	.....	2.0m	....	......	.....	.....	....	....	5845
5847	T-6½	Pentode	9X-0-3 & 4	Cathode	6.3	0.300	.04m	7.1	2.9	R-F Amp.	150	110■	150	13	4.5	......	12,500	.....	....	....	5847
5851 (3)	T-3	Pentode	6CL-0-0	Filament	1.25 2.50	0.110 0.055	.055	2.5	3.0	R-F Amp.	125 180	7.5 7.0	125 135	5.5	0.9	175,000	1,600	....	....	 650	5851 (3)
5852 (3)	T-9	Duodiode	6S-0-0	Cathode	6.3	1.200	....	....	....	F-W Rect.	Characteristics Same as Type 5838.										5852 (3)
5871 (3)	T-9	Beam Pent.	7S-0-0	Cathode	6.3	0.450	0.7*	9.5*	7.5*	Power Amp.	Characteristics Same as Type 6V6GT.										5871 (3)

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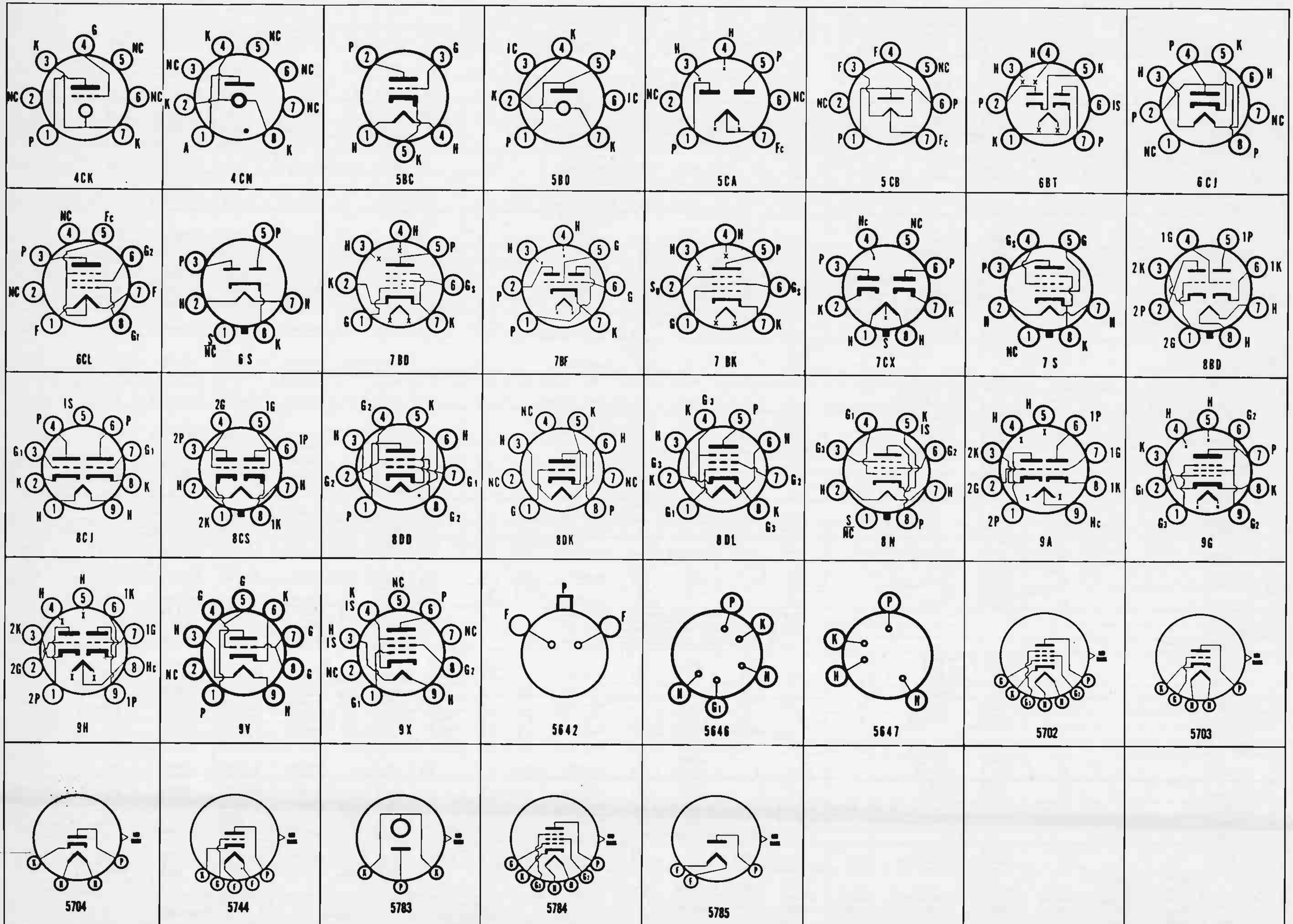
(3) Has special mechanical and/or life characteristics.
(4) Average Contact potential bias developed across specified grid resistor.
Ɪ Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)
♯ Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
☐ Applied through 20,000 ohms.
▲ Conversion Transconductance.
•• Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection, DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (1) (2) Capacitances In μμf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Undistorted Power Output Milliwatts	Type
5879	T-6½	Pentode	9AD-0-0	Cathode	6.3	0.150	0.11m*	2.7	2.4	R-F Amp.	250 250	3 8	100 **	1.8	0.4	2,000,000 ♦ 13,700	1,000 1,530	 21	....	....	5879
5881	T-11	Beam Pent.	7S-0-0	Cathode	6.3	0.900	....	....	....	Power Amp.	Characteristics Same as Type 6L6G.										5881
5889	T-3	Pentode	5889	Filament	1.25	7.5Ma	....	....	....	Amplifier	12	2.0	.....	.005	.005	1.8 Meg.	(For Low Grid Current Applications)				5889
5896 (3)	T-3	Duodiode	8DJ-0-4	Cathode	6.3	0.300	....	....	....	F-W Rect.	150 Volts RMS Per Plate, 18 Ma. D-C Output Current.										5896 (3)
5897 (3)	T-3	Triode	8DK-0-0	Cathode	6.3	0.150	1.3	2.4	2.4	R-F Osc.	100 150	150 ■ 180 ■	....	8.5 13.	....	4,650 4,150	5,800 6,500	27 27	....	....	5897 (3)
5898 (3)	T-3	Triode	8DK-0-0	Cathode	6.3	0.150	0.8	1.9	2.2	Amplifier	100 150	1500 ■ 680 ■	....	0.73 1.85	....	41,000 30,500	1,700 2,300	70 70	....	....	5898 (3)
5899 (3)	T-3	Pentode	8DL-0-0	Cathode	6.3	0.150	.015m	4.4	3.4	R-F Amp.	100	120 ■	100	7.2	2.2	260,000	4,500	.....	....	....	5899 (3)
5900 (3)	T-3	Pentode	8DL-0-0	Cathode	6.3	0.150	.015m	4.4	3.4	R-F Amp.	Characteristics Same as Type 5899.										5900 (3)
5901 (3)	T-3	Pentode	8DL-0-0	Cathode	6.3	0.150	.015m	4.2	3.4	R-F Amp.	100	150 ■	100	7.5	2.4	280,000	5,000	.....	....	....	5901 (3)
5902 (3)	T-3	Pentode	8DL-0-0	Cathode	6.3	0.450	0.2m	6.5	7.5	Power Amp.	110	270 ■	110	30	2.2	15,000	4,200	.....	....	1,000	5902 (3)
5910	T-5½	Pentode	6AR-0-5	Filament	1.4	0.050	.008m	3.6	7.5	R-F Amp.	90	0	90	1.6	0.45	1,500,000 ♦	900	.....	....	....	5910
5915 5915A (3)	T-5½	Dual Control Heptode	7CH-0-0	Cathode	6.3	0.300	.08* .35*	5.4* 6.9*	7.6*	Computer	150□ 150□ 150□	0 10.0 0	75 75 75	5.8 0 0	9.0 0 14.0	Grid No. 3 Voltage = 0 Grid No. 3 Voltage = 0 Grid No. 3 Voltage = —10			....	....	5915 5915A
5930 (3)	T-12	Triode	4D-0-0	Filament	2.5	2.500	....	....	....	Power Amp.	Characteristics Same as Type 2A3.										5930 (3)
5931 (3)	T-12	Duodiode	5T-0-0	Filament	5.0	3.000	....	....	....	F-W Rect.	Characteristics Same as Type 5U4G.										5931 (3)
5932 (3)	T-12	Beam Pent.	7S-0-0	Cathode	6.3	0.900	....	....	....	Power Amp.	Characteristics Same as Type 6L6G.										5932 (3)
5963 (3)	T-6½	Duotriode	9A-0-0	Cathode	6.3 12.6	0.300 0.150	1.5* 1.5*	1.9* 1.9*	0.5* 0.35*	Computers	67.5 150	0 0	....	8.5 5.4	....	6,600 (Rb = 20,000 Ohms)	3,200	21	....	....	5963 (3)
5964 (3)	T-5½	Duotriode	7BF-0-0	Cathode	6.3	0.450	1.3*	2.1*	0.4*	Computers	100 150	50 ■ 0	....	9.5 5.0	....	6,500 (Rb = 20,000 Ohms)	6,000	39	....	....	5964 (3)
5965	T-6½	Duotriode	9A-0-0	Cathode	6.3/ 12.6	0.450/ 0.225	3.0* 3.0*	4.0* 4.0*	0.5* 0.36*	Computer ƒ	150	220 ■	.....	8.5	....	7,000 ♦	6,700	47	....	....	5965
5968	T-3	Duotriode	8DQ	Filament	1.25	0.120	2.3*	0.9*	0.9*	VHF Mixer	45	0	....	0.7	....	.....	1,300	50	....	....	5968
5969	T-3	Duotetrode	8DR	Filament	1.25	0.200	0.3*	2.5*	2.5*	VHF Amp. or VHF Osc.	135 Class A Ratings	3.0	45	6.0	0.6	....	1,700	....	....	....	5969
5970	T-3	Duo Pentode	8DS	Filament	1.25	0.160	0.1*	3.3*	2.4*	VHF Amp.	45	5 Meg.⁴	45	3.0	0.9	170,000	1,850	....	....	....	5970
5977 (3)	T-3	Triode	8DK-0-0	Cathode	6.3	0.150	1.3	2.0	2.2	Amplifier	100	270 ■	.....	10.0	....	3,650	4,500	16	....	....	5977 (3)
5987 (3)	T-3	Triode	8DM-0-0	Cathode	6.3	0.450	3.2	3.2	5.0	Amplifier	100	18	.....	9.0	....	....	1,850	4.1	....	....	5987 (3)
6004	T-9	Duodiode	5T-0-0	Filament	5.0	2.000	....	....	....	F-W Rect.	375 Volts RMS Per Plate, 120 Ma. D-C Output. Condenser Input to Filter.										6004
6005 (3)	T-5½	Beam Pent.	7BZ-0-0	Cathode	6.3	0.450	....	....	....	S.T. Class A1 S.T. Class A1 P.P. Class AB1	180 250 250	8.5 12.5 15	180 250 250	29. 45. 70-79†	3.0 4.5 5-13†	58,000 52,000 Current and Output for Two Tubes	3,700 4,100	....	5,500 5,000 10,000¶	2,000 4,500 10,000	6005 (3)
6021 (3)	T-3	Duotriode	8DG-0-0	Cathode	6.3	0.300	1.4	2.1		U-H-F Amp. ƒ	100	150 ■	.....	6.5	....	6,480 ♦	5,400	35	Cout Sec. 1 = 1.3 μμf.		6021 (3)
6028	T-5½	Pentode	7BD	Cathode	20	0.050	.02	4.0	2.8	Amplifier	120	180 ■	120	7.5	2.5	300,000	5,000	.....	....	....	6028
X6030	Lock-in	Diode	X6030	Filament	3.0m	0.600	....	....	....	Noise Diode	90 250 1400	....	....	4.0m 3.0m .535m	....	....	....	....	....	....	X6030
6045	T-5½	Duotriode	7BF-0-0	Cathode	6.3	0.350	1.3* 1.3*	2.0* 2.0*	0.45* 0.34*	VHF Amp.	100 Cout Sec. 1 = 0.45 μμf.	50 ■	.....	9.0	....	5,940 ♦	6,400	38	.... Cathodes Tied Together	....	6045
6049 (3)	T-3	Pentode	8DL-0-0	Cathode	6.3	0.150	.009m	3.6	3.8	UHF Amp.	100	150 ■	100	7.5	2.5	400,000	3,550	.....	....	....	6049 (3)
6052 (3)	T-3	Duodiode	8DJ-0-4	Cathode	6.3	0.300	....	....	....	Detector	150 Volts RMS Per Plate, 18 Ma. D-C Output. Condenser Input to Filter.										6052 (3)
6053 (3)	T-3	Duodiode	8DJ-0-4	Cathode	26.5	0.075	....	....	....	Detector	150 Volts RMS Per Plate, 18 Ma. D-C Output. Condenser Input to Filter.										6053 (3)
6055 (3)	T-3	Triode	8DK-0-0	Cathode	26.5	0.045	1.8*	2.2*	0.8*	Amplifier	26.5	Self	.....	3.0	....	......	5,000	19.	(Rg1 = 2.2 Megs.)		6055 (3)
6056 (3)	T-3	Pentode	8DL-0-0	Cathode	26.5	0.045	.015m	4.0	3.4	Amplifier	26.5	Self	26.5	2.7	1.1	100,000	3,000	.....	(Rg1 = 2.2 Megs.)		6056 (3)
6080	T-12	Duotriode	8BD	Cathode	6.3	2.500	8*	6*	2.2*	Passing Tube For V.R. Service	135	250 ■	.....	125ƒ	....	280	7,000	2	....	....	6080
6080WA	T-12	Duo Power Triode	8BD	Cathode	6.3	2.500	8.4*	6.2*	2.2*	Passing Tube For V.R. Service	135	250 ■	.....	125ƒ	....	......	7,100	2.0	....	....	6080WA
6082A	T-12	Duo Power Triode	8BD	Cathode	26.5	0.600	....	....	....	Power Amp.ƒ	135	250 ■	.....	125	....	280	7,000	2	13 Watts Plate Dissipation		6082A
6097	T-5½	Duodiode	6BT	Cathode	6.3	0.300	....	....	....	F-W Rect.	Characteristics Same as Type 5726/6AL5W.										6097
6110 (3)	T-3	Duodiode	8DJ	Cathode	6.3	0.150	....	....	....	UHF Det.	Peak Inverse Voltage = 460 Volts. Peak Anode Current = 26.4 Ma. Per Plate.										6110 (3)
6111 (3)	T-3	Duotriode	8DG	Cathode	6.3	0.300	1.5	1.9	0.28 0.32	Med. Mu Amp.	100	220■	.....	8.5	....	4,200	4,750	20	....	....	6111 (3)
6112 (3)	T-3	Duotriode	8DG	Cathode	6.3	0.300	1.0	1.7	0.23 0.28	High Mu Amp.	100 150	1500■ 820■	....	0.8 1.75	....	38,900 28,000	1,800 2,500	70 70	....	....	6112 (3)
6118 (3)	Metal	Duodiode Tri.	7V-1-1	Cathode	6.3	0.300	1.4	5.0	3.8	Det. Amp.	100 250	1.0 3.0	....	0.8 1.0	....	58,000 58,000	1,200 1,200	70 70	....	....	6118
6145	T-9	Pentode	8V-0-5	Cathode	6.3	0.600	.06m	14.0	7.5	Computer	150	0	100	34	8.0	0.1 Meg.	9,700	.....	....	....	6145
6146	T-12	Beam Pent.	7CK-8-1, 4, 6	Cathode	6.3	1.250	0.24*	15.9*	10.6*	P.P.AB1 Amp. P.P.AB1 Amp. P.P.AB2 Amp.	600 500 600	45 44 44	180 175 165	26-200† 27-242† 22-207†	1-23† 0.7-18† 0.6-17†	(Current and Output for Two Tubes) (Current and Output for Two Tubes) (Current and Output for Two Tubes)			7,000¶ 4,600¶ 6,800¶	82,000 ♦ 83,000 90,000	6146

6147	T-3	Power Pent.	6CL	Filament	1.25	0.125	.055	2.6	3.0	VHF Power Amplifier	125	7.5	125	5.5	0.9	175,000	1,600	....	....	....	6147
6205 (3)	T-3	Pentode	8DC-0-2&8	Cathode	6.3	0.150	.015	4.2	3.4	U-H-F Amp.	100	150 ■	100	7.5	2.4	0.26 Meg.	5,000	.....	....	....	6205 (3)
6206	T-3	Pentode	8DC	Cathode	6.3	0.150	.015	4.2	3.4	U-H-F Amp.	100	120 ■	100	7.5	2.0	0.26 Meg.	4,500	Semi-Remote Cutoff.			6206 (3)
6287 (3)	T-6½	Beam Pent.	9CT-0-0	Cathode	6.3	0.600	1.1m	8.0	9.0	Audio Amp.	250	12.5	250	46	5.0	55,000	4,100	.....	6,000	4,500	6287 (3)
6308 (3)	T-3	Gas Diode	8EX-0-0	Cold K	....	....	....	....	....	Voltage Regulator with Starting Voltage at 115 Volts, Operating Voltage at 87 Volts and Current at 3.5 Ma. Max.											6308 (3)
6336A	TT-16	Duo Power Triode	8BD	Cathode	6.3	5.000	21.8*	16.7*	3.8*	Passing Tube For V.R. Service	190 RK =	200 ■ 200 Ohm Per Section, RG = 500 Ohm Per Section.	....	182#	....	300 ♦	13,500	2.7	30 Watts Plate Dissipation#		6336A
6350	T-6½	Duotriode	9CZ-0-0	Cathode	6.3 12.6	0.600 0.300	3.2*	3.6*	0.6*	Computer #	150	5.0	.....	11.0	....	3,900	4,600	18	....	....	6350

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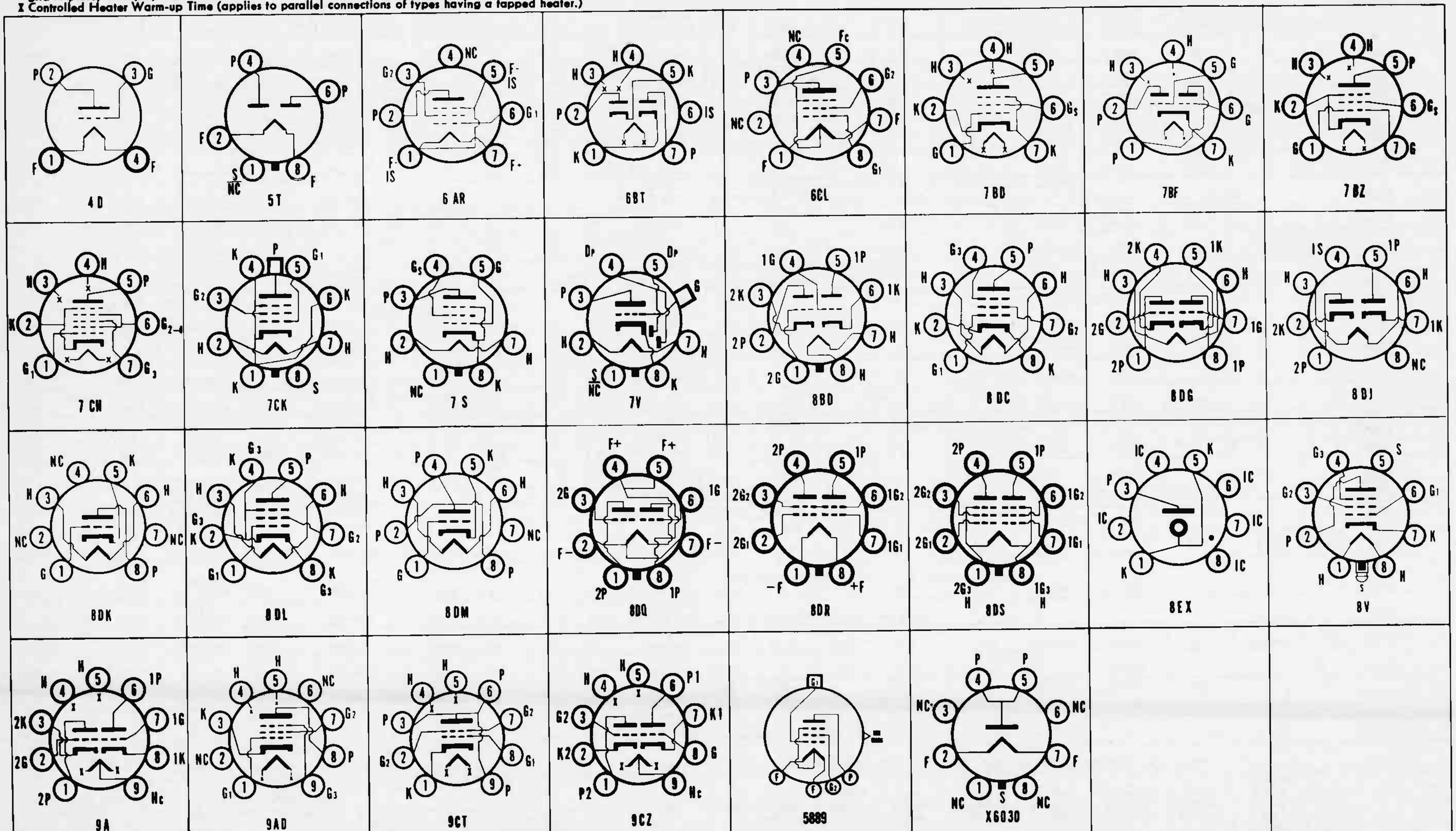
(4) Average Contact potential bias developed across specified grid resistor.
ɪ Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)

Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.

□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.

¶ Plate to Plate.
♦ Approximate.

m maximum.
■ Cathode Resistor (ohms).



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SYLVANIA TUBES — AVERAGE CHARACTERISTICS

Type	Construction: Bulb Size or Style	Construction: Class	Construction: Basing Diag.	Emitter: Type	Emitter: Volts	Emitter: Amps.	Note (1) (2) Capacitances in μμf.: Cgp.	Cin.	Cout	Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Power Output Milliwatts	Type
6352	T-3	Duodiode	8EY-0-0	Filament	3.0 Series	0.360 Series	....	....	....	Regulator	Temperature Limited Diode. Max. Ef. = 4.0. Max. Eb. = 275. Max. Ib. = 1.1 Ma.										6352
6394A	TT-16	Duo Power Triode	8BD	Cathode	26.5	1.300	21.8*	16.7*	3.8*	Passing Tube For V.R. Service	Characteristics Same as Type 6336A.										6394A
6463	T-6½	Duotriode	9CZ-0-0	Cathode	6.3/ 12.6	0.600/ 0.300	5.0* 5.0*	3.0* 3.0*	0.6* 0.5*	Computer ƒ	200 250	11.0 620■		1.0 14.5	....	...... 3850♦	5200	20	....	....	6463
6486A	T-6½	Pentode	9DV	Cathode	6.3	0.250	.04	4.4	3.7	Dual Control Pentode	120	2	120	3.5	3.3	....	3,250	....	....	....	6486A
6516	T-5½	Beam Pent.	6CH	Cathode	6.3	0.200	0.3m	4.25	6.5	VHF/AF Power Amp.	250	13.5	250	16.0	2.25	150,000	2,550	....	16,000	1,400	6516
6520	T-16	Duo Power Triode	8BD	Cathode	6.3	2.500	9.4*	8.4*	2.2*	Passing Tube for V.R. Serv.	Characteristics Same as Type 6AS7G.										6520
6528	ST-16	Duo Power Triode	8BD	Cathode	6.3	5.000	23.8*	17.8*	2.9*	Passing Tube For V.R. Service	100 Plate Dissipation (Per Section) = 30 Watts Abs. Max.	4	....	185	....	245	37,000	9	....	....	6528
6550	ST-16	Beam Pent.	7S-0-0	Cathode	6.3	1.600	0.85*	14.0*	12.0*	S.T.A1 Amp. P.P.AB1 Amp.	400 600	16.5 33	225 300	87.0 100-280†	4.0 3-33†	27,000 (Current and Output for Two Tubes)	9,000		3,000 5,000	20,000 100,000	6550
6582A	T-6½	Pentode	9EJ	Cathode	6.3	0.250	.03	4.5	3.0	R-F Pent.	120	180■	120	7.5	2.5	.5 Meg.♦	4,500	....	....	....	6582A
6626	T-5½	Gas Diode	5BO-0-0	Cold K			....	....	....	Voltage Reg.	Starting Voltage = 165. Operating Voltage = 148. Operating Current = 5 to 30 Ma.										6626
6627	T-5½	Gas Diode	5BO-0-0	Cold K			....	....	....	Voltage Reg.	Starting Voltage = 130. Operating Voltage = 108. Operating Current = 5 to 30 Ma.										6627
6690 (3)	T-3	Duotriode	8GQ-0-0	Cathode	6.3	0.300	2.1m 2.1m	3.2m 3.2m	1.8m 2.2m	Video Amp.ƒ	100	100■	.....	8.0	....	......	4,800	35	....	....	6690 (3)
6788	T-3	Pentode	8DL	Cathode	6.3	0.175	.032	2.4	3.3	Audio Amp.	100	1500■	100	0.7	0.1	1.2 Meg.	1,100	.....	....	....	6788
6814	T-3	Triode	8DK	Cathode	6.3	0.150	1.3	2.4	2.4	Computer	100	0	.....	10	....	4,800	6,000	29	....	....	6814
6832	T-3	Duotriode	8DG	Cathode	6.3	0.400	....	....	....	D.C. Amp.	100	3000■	....	0.8	....	....	1,050	....	....	....	6832
6840	T-6½	Duotriode	9CZ	Cathode	12.6 6.3	0.400 0.800	5.5* 5.5*	4.0* 4.0*	0.7* 0.7*	Computer	250	620■	....	14	....	3,400	7,100	20	....	....	6840
6851	T-6½	Duotriode	9A	Cathode	6.3	0.250	1.4* 1.4*	1.6* 1.6*	0.46* 0.36*	Amplifierƒ	250	3100■	....	1.0	....	60,000	1,200	70	....	....	6851
6854	T-6½	Duotriode	9FV	Cathode	6.3	0.500	1.7* 1.7*	2.4* 2.4*	1.1* 1.1*	Amplifierƒ	150	240■	....	8.2	....	6,500	5,225	35	....	....	6854
6870	T-6½	Beam Pent.	9BF	Cathode	6.3 12.6	0.600 0.300	.025m*	8.5*	7.0*	VHF Power Amp.	250	120■	250	25.0	3.5	230	8,500	....	....	....	6870
6877	T-6½	Power Triode	9GB	Cathode	6.3	0.800	....	....	....	Power Amp.	150	12	....	75	....	2,000	6,500	3.75	....	12,000	6877
6883	T-12	Beam Pent.	7CK-8-1,4,6	Cathode	12.6	0.625	0.24*	13.5*	8.5*	Power Amp.	Characteristics Same as Type 6146.										6883
6893	T-9	Beam Pent.	7CK-8-1,4,6	Cathode	12.6	0.400	0.2*	12.5*	7.0*	Power Amp.	Characteristics Same as Type 2E26.										6893
6900	T-6½	Duo Power Triode	9H	Cathode	6.3 12.6	0.900 0.450	4.0* 4.0*	4.0* 4.0*	0.6* 0.5*	Power Amp.	120	2	....	36	....	2,000	11,500	17.5	4.2 Watts Plate Dissipation		6900
6913	T-6½	Duotriode	9A-0-0	Cathode	12.6 6.3	0.300 0.600	3.4*	3.6*	0.5*	Computer	150	5.0	.....	11.0	....	3,900	4,600	18	....	....	6913
6919	T-5½	Duodiode	6BT	Cathode	6.3	0.200	....	....	....	F-W Rect. Computer	Maximum Inverse Peak Plate Voltage = 300 Volts. Maximum Peak Plate Current = 30 Ma. Maximum D.C. Output Current = 10 Ma. (Design Max. Values).										6919
6922	T-6½	Duotriode	9DE	Cathode	6.3	0.300	1.4* 1.4*	3.3* 3.3*	1.75* 1.65*	VHF Amp.	90	120■	.....	12	....	2,800	11,500	33	....	....	6922
6943	T-3	Pentode	8DC	Cathode	6.3	0.175	.015	3.0	3.0	R-F Amp.	100	150■	100	8	2.3	300,000	3,600	....	....	....	6943
6944	T-3	Pentode	8DC	Cathode	6.3	0.175	.015	2.9	3.1	R-F Amp.	100	150■	100	7	2.1	280,000	3,200	....	....	....	6944
6945	T-3	Beam Pent.	8DL	Cathode	6.3	0.350	0.13	5.0	5.5	Power Amp.	100	270■	100	25	1.5	20,000	3,500	....	3,000	800	6945
6946	T-3	Triode	8DK	Cathode	6.3	0.175	1.0*	1.6*	0.75*	Amplifier	100	270■	....	9.0	....	....	3,800	16.5	....	....	6946
6947	T-3	Duotriode	8DG	Cathode	6.3	0.350	1.2* 1.2*	1.6* 1.6*	0.2* 0.25*	Amplifierƒ	150	270■	....	6.5	....	....	4,000	35	....	....	6947
6948	T-3	Duotriode	8DG	Cathode	6.3	0.350	0.75* 0.75*	1.6* 1.6*	0.2* 0.25*	Amplifierƒ	100	1500■	....	0.8	....	....	1,650	70	....	....	6948
6954	T-5½	Pentode	7CM	Cathode	6.3	0.300	.0035m*	6.0*	5.0*	Dual-Control Computer	150	1.0	150	5.8	6.6	50,000	2,050	Grid No. 3 = −3.0 Volts			6954
6955	T-6½	Duotriode	9A	Cathode	6.3 12.6	0.350 0.175	1.4* 1.4*	1.5* 1.5*	0.5* 0.4*	Amplifierƒ	100 250	0 8.5	....	13.0 11.5	....	5,800♦ 7,000♦	3,500 2,350	21.3 16.5	....	....	6955
6968	T-5½	Pentode	7BD	Cathode	6.3	0.175	.02	4.0	2.85	VHF Amp.	Characteristics Same as Type 6AK5.										6968
6973	T-6½	Beam Pent.	9EU	Cathode	6.3	0.450	0.4	6	6	S.T. A1 Amp. P.P. AB1 Amp. P.P. AB1 Amp.	250 300 350	15 230■ 22	250 300 280	46 80-96† 58-106†	3.5 6-14† 3.5-14†	73,000	4,800	....	.... 5,500 7,500	.... 15,000¶ 20,000¶	6973
7001	T-5½	Beam Tetrode	7EJ	Cathode	6.3	0.450	0.1m	7.0	8.75	Power Amp.	120 Maximum Plate Dissipation = 5.5 Watts.	250■	120	35	4	......	4,800	.....	....	....	7001
7025	T-6½	Duotriode	9A	Cathode	12.6 6.3	0.150 0.300	1.7* 1.7*	1.6* 1.6*	0.46 0.34*	Audio Amplifier	Characteristics Same as Type 12AX7, except Controlled for Noise and Hum.										7025
7027	T-12	Beam Pent.	8HY	Cathode	6.3	0.900	1.5*	10*	7.5*	P.P.AB1 Amp.	330 400 450 400 380 410	24 25 30 200■ 180■ 220■	330 300 350 300 380 410	122-184† 102-152† 95-194† 112-128† 138-170† 134-155†	5.6-18.5† 6-17† 3.4-19.2† 7-16† 5.6-20† (Cathode Current) Ultra-Linear Circuit.	....	....	....	4,500¶ 6,600¶ 6,000¶ 6,600¶ 4,500¶ 8,000¶	31,500 34,000 50,000 32,000 36,000 24,000	7027

7036	T-5½	Heptode	7CH	Cathode	6.3	0.300	.08* .35*	5.4* 6.9*	7.6*	Dual Control Computer	Characteristics Same as Type 5915A.										7036
7044	T-6½	Duotriode	9H	Cathode	6.3 12.6	0.900 0.450	6.0 6.0	4.8 4.8	0.65 0.55	Computer	120	2.0	....	36	....	1,900	10,000	19	....	....	7044
7077	Ceramic and Metal	Triode	7077	Cathode	6.3	0.240	1.0*	1.9*	.10*	UHF R-F Amp.	250 EB = 250 Volts Through 18,000 Ohm Resistor.	82■	....	6.4	....	8,900	9,000	80	....	....	7077
7105	T-12	Duo Power Triode	8BD	Cathode	12.6	1.250	8.4*	6.2*	2.2*	Passing Tube For V.R. Service	Characteristics Same as Type 6080WA.										7105
7137	T-5½	Triode	7BQ	Cathode	6.3	0.225	1.7	6.0	4.5	VHF Amp.	150	100■	....	13.5	....	....	8,500	40	....	....	7137

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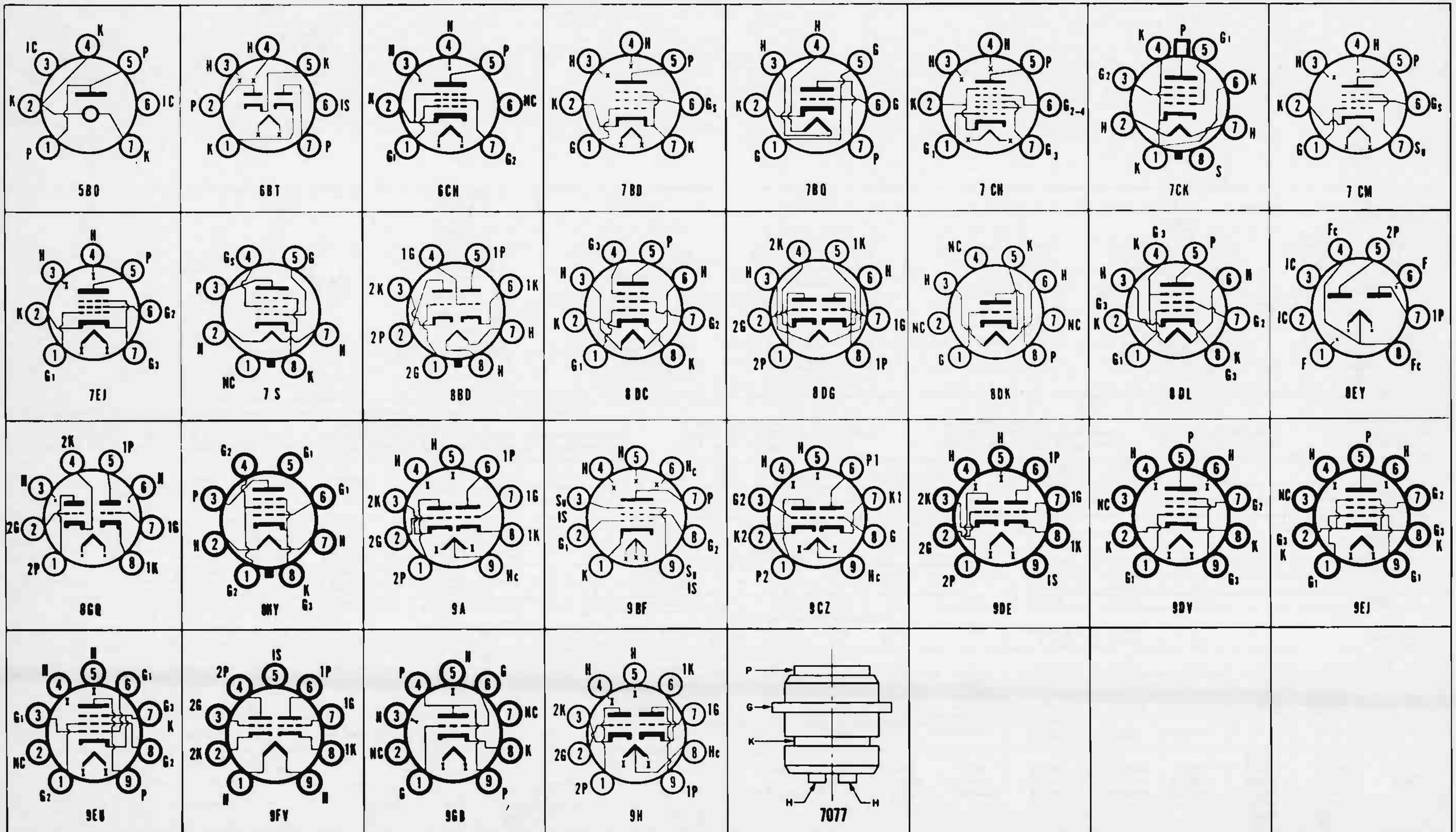
I Controlled Heater Warm-up Time (applies to parallel connections of types having a tapped heater.)

∮ Per Tube or Section.
§ Plate and Target Supply Voltage.
† Maximum Signal.
□ Applied through 20,000 ohms.
▲ Conversion Transconductance.
** Triode Operation.
¶ Plate to Plate.
♦ Approximate.
m maximum.
■ Cathode Resistor (ohms).



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SYLVANIA TUBES—AVERAGE CHARACTERISTICS

Type	Construction			Emitter			Note (1) (2) Capacitances in μμf.			Use	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current Ma.	Screen Current Ma.	Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Ohms Load for Stated Power Output	Undistorted Power Output Milliwatts	Type
	Bulb Size or Style	Class	Basing Diag.	Type	Volts	Amps.	Cgp.	Cin.	Cout												
7167	T-5½	Tetrode	7EW	Cathode	13.5	0.090	.03m	4.4	2.74	VHF Amp.	250	1.0	80	10	1.4	125,000	8,000	.....	....	....	7167
	Similar to Type 6CY5, Except Designed for Mobile Applications.																				
7212	T-12	Beam Pent.	8EC	Cathode	6.3	1.250	0.24m*	13.5*	8.5*	P.P.AB1 Amp. P.P.AB1 Amp. P.P.AB2 Amp.	600 500 600	45 40 44	180 185 165	26-200† 57-215† 22-207†	1-23† 2-25† 0.6-17†	....	....	....	7,000 5,500 6,800	82,000 70,000 90,000	7212
7244	T-5½	Duotriode	7BF	Cathode	6.3	0.450	1.4* 1.4*	3.0* 3.0*	0.34* 0.28*	Amplifier	100	50 ■	.....	9.0	....	6,300	6,000	38	....	....	7244
	(Frame—Grid Construction).																				
7258	T-6½	Tri. Pentode	9DA	Cathode	13.5	0.210	1.5* .04*	2.0* 7.0*	0.26* 2.4*	Tri. Amp. Pent. Amp.	150 125	3 56 ■	 125	15 12	.... 3.8	4,700 170,000	4,500 7,800	21	....	....	7258
	(Designed for Mobile Operation).																				
9001	T-5½	Pentode	7BD-0-7	Cathode	6.3	0.150	.01	3.6	3.0	R-F Amp.	250	3.0	100	2.0	0.7	1 Meg.>	1,400	.....	....	....	9001
9002	T-5½	Triode	7BS-0-0	Cathode	6.3	0.150	1.4	1.2	1.1	Amplifier	250	7.0	.....	6.3	....	11,400	2,200	25	....	....	9002
9003	T-5½	Pentode	7BD-0-7	Cathode	6.3	0.150	.01m	3.6	3.0	R-F Amp.	250	3.0	100	6.7	2.7	700,000	1,800	.....	....	....	9003
9004	Acorn	Diode	4BJ-0-0	Cathode	6.3	0.150	....	....	....	H-W Rect.	117 Volts RMS Plate, 5 Ma. D-C Output.										9004
9005	Acorn	Diode	5BG-0-0	Cathode	6.3	0.150	....	....	....	H-W Rect.	117 Volts RMS Plate, 1.0 Ma. D-C Output.										9005
9006	T-5½	Diode	6BH-0-0	Cathode	6.3	0.150	....	....	....	H-W Rect.	270 Volts RMS Plate, 5 Ma. D-C Output.										9006
XXD	Now Listed as 14AF7/XXD																				XXD
XXFM	Now Known as Type 7X7																				XXFM
XXL	Lock-In	Triode	5AC-L-0	Cathode	6.3	0.300	....	....	....	Amplifier	100 250	0.0 8.0	....	10.0 8.0	....	7,000 8,700	3,600 2,300	25 20	....	....	XXL

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♦ Approximate.
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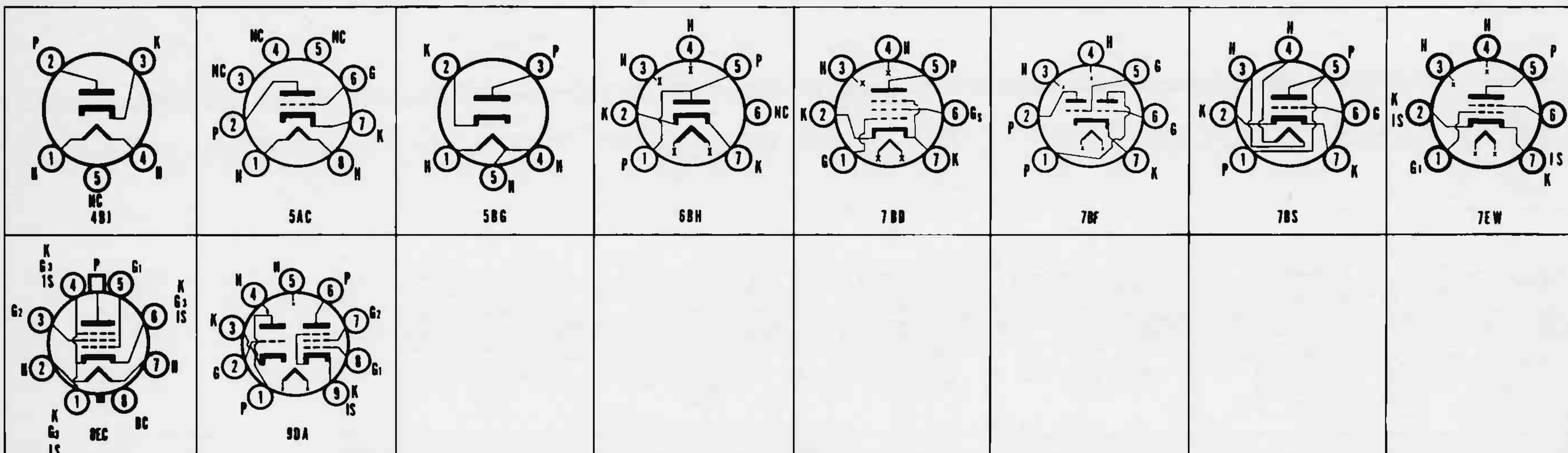


SYMBOLS FOR BASE DIAGRAMS: Dp—Diode Plate; F—Filament; Fc—Filament Center; G—Grids numbered according to their position from the cathode; H—Heater; Hc—Heater Center; Ht—Heater Tap; IC—Internal Connection, DO NOT USE; J—Jumper; K—Cathode; NC—No Connection; P—Plate; Rc—Ray Control; S-Metal Shell; SA—Starter Anode; T—Target; XS—External Shield; □—Top Cap; ■—Locating Key.

LESSON 10

Radio Frequency Amplification
Superheterodyne Principles

The actions of tuned circuits and of vacuum tubes are utilized to select and increase the weak signals received by the antenna. The amplification in any modern radio set is accomplished at radio frequencies before detection, and at audio frequencies after detection. I.F. used is considered radio frequencies.

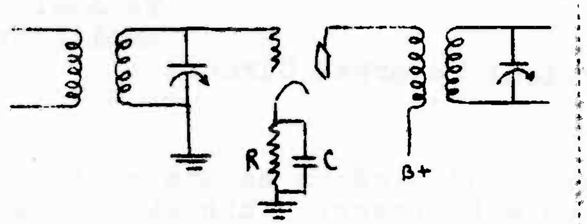
SELECTIVITY A radio receiver must separate the signals of any station wanted from the signals of all remaining operating stations. The degree of selectivity is the ability of the receiver to perform this function. Since the broadcast band stations are separated by 10 KC., selectivity that is sufficient to separate stations 10 KC. apart is employed.

SENSITIVITY The receiving set must also amplify the incoming signal voltage to a sufficient degree to operate the loud-speaker. The sensitivity of a receiver is the measurement of overall amplification from the antenna input to the loudspeaker connections. Sensitivity should be as large as practical; it is possible to over do this in modern high gain sets.

All noise collectively picked up by the receiver is known as the noise level. If the wanted signal has less strength than the strey impulses forming the noise level, that station cannot be received successfully. Therefore, a radio set that can "go down" to the noise level is as sensitive as is required.

FIDELITY The exactness with which the receiver reproduces speech and music is an indication of its fidelity. The radio receiver should not distort, add, change, or alter the original broadcasted sound (audio frequencies) in any way.

T. R. F. A tuned radio frequency amplification stage consists of an input tuned transformer and an output tuned transformer which also serves as the means of input for the next stage. It is possible to use a number of such T.R.F. stages preceding the detector to obtain the needed sensitivity and selectivity. The condensers used to tune the transformers are usually ganged together for single dial control. Each condenser section is identical and about .000365 mfd. capacity. Small trimmer condensers shunt each section and are adjusted to make up for the differences in capacity, etc.



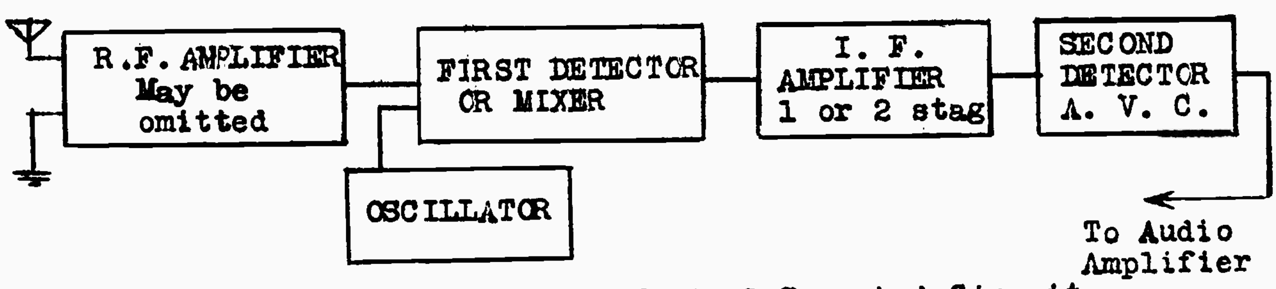
TRIODE T. R. F. STAGE

VOLUME CONTROL REPLACEMENT A large number of radio repairs center around the volume and tone control replacement. Every radio set has a volume control and a great many have tone controls. These units receive about as much handling and mechanical motion as the tuning dial and consequently do wear out with time. A volume control fault is easily detected even by the non-technical owner of the radio. It is bad practice to attempt to repair the original control, but in a few cases replacement resistor strips are available and are easily installed. For best results and time economy, a bad volume control should be replaced. To detect the fault notice if the volume change is gradual; if it is sudden, the arm does not make good contact or the resistance is worn out in spots. Another positive test is to short the different terminals of the control; if no change is noticed, the unit is at fault. Either there is an internal short, or an open circuit

The replacement of a volume control is about the easiest task servicemen come across. Look the set up in a volume control manual (available from any manufacturer of volume controls or the jobbers), obtain proper control, remove old control, install the new unit.

THE SUPERHETERODYNE PRINCIPLE

Present day receivers use in majority of cases the superhet circuit. In a superheterodyne the high carrier frequency of a desirable station is changed to a lower fixed frequency and amplified at that frequency. By a proper arrangement, it is possible to select any one station and change with the tuning equipment the frequency of that station or any other station on the same band to the same fixed frequency known as the intermediate frequency or I.F. Since the I.F. is constant, the amplifier used can be of the fixed type (no variable condensers used for tuning) and can be made more efficient (higher gain) than similar R.F. types.



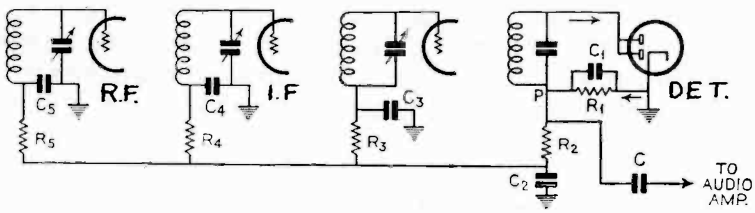
Diagramatical Illustration of a Typical Superhet Circuit

The R.F. stage or the antenna tuned circuit separates to a limited degree the wanted signal from all others. This signal is mixed with the local oscillator signal to form the I.F. signal. The I.F. amplifier suppresses all unwanted signals and amplifies the desirable signal. A high gain may be obtained from a single I.F. stage (a gain of 75 is common).

If two different frequencies are mixed in a suitable tube, signals will be produced that are equal to the sum and to the difference of the original frequencies. For example, 650 KC. and 475 KC. will produce 650 + 475 = 1,125 KC. and 650 — 475 = 175 KC. Now suppose we are considering an actual case in a radio set where the I.F. amplifier is designed to pass 175 KC. (plus and minus 5 KC.) and we wish to receive a station transmitting on 650 KC. By simply adjusting the R.F. input stage to 650 KC. and the oscillator to produce a frequency of 475 KC., we will obtain 175 and 1,125 KC. frequencies. Of course, the I.F. amplifier will pass and amplify only the 175 KC. signal and the 1,125 KC. frequency will not be used. When a different station is selected, the oscillator frequency is correspondingly changed to produce the required 175 KC. I.F. signal.

AUTOMATIC VOLUME CONTROLS

There are numerous varieties of automatic volume control (A.V.C.) circuits, but they all work on the same principle. The A.V.C. arrangement is intended to maintain nearly constant the strength of the signal arriving at the detector, thus compensating for different signal strengths of different stations and for fading. It does this by varying the sensitivity of the R.F. and I.F. amplifiers. Actually A.V.C. changes the bias on these amplifier tubes to obtain this action. The actual volume is of course not kept constant because it depends on the percentage of modulation at the transmitter.



The schematic above illustrates an A.V.C. system often used in up-to-date sets. Forgetting for the moment the grid return resistors in the R.F. circuits, let us begin with the detector. The signal is rectified by a diode. Current can flow only when the diode becomes positive and the coil must then be considered as the generator. This will perhaps help to explain why the resistor R_1 will carry current in the direction of the arrow, making the point P negative with respect to the cathode and the chassis. This seems to be difficult to understand by many. 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 radio frequency currents and the audio frequency component is taken off to be applied to the grid 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, but the A.F. component must be filtered out and precautions for interstage coupling should be taken. This latter requirement is accomplished by the network of resistors and condensers.

The advantage of a superhet circuit comes from the use of pre-adjusted single frequency amplifiers (I.F. amplifiers) and means must be provided in such sets to convert the frequency of the station received to this intermediate frequency. This conversion is accomplished by generating a radio frequency higher than the signal and differing from it by the frequency of the I.F., and mixing this new frequency and the signal frequency in a non-linear impedance which can be provided by a vacuum tube operated over a non-linear part of its characteristic curve.

From this review, it is clear that an oscillator is needed to produce this new frequency and a mixer is required to combine these two frequencies. In the early types of superheterodyne receivers, a triode served as a local oscillator and another triode was used as the mixer. Since the mixer in such sets was operated as detector to obtain the non-linear characteristics, this tube in some literature is called the first detector while the detector used to "remove" audio signals is called the second detector.

Pentagrid converter tubes (of which 1A7, 6A7 and 6A8 are commonly encountered examples) have the electron stream influenced by both the signal and oscillator frequencies. A common cathode serves both the oscillator and mixer sections. The output is taken from the main plate. The oscillator grid is next to the cathode and the next grid serves as the oscillator anode. These elements form a triode which is connected to the oscillator coil and effects the current passing between the cathode and the main plate. Grids three and five are connected together to serve as the screen, while grid four is between them and is the control grid for the signal frequency.

Tubes of the single-ended types such as 6SA7 and 12SA7 have their elements connected somewhat differently from pentagrid converters we have just considered. Grid one nearest the cathode is here also used as the oscillator grid, but grids two and four are tied together and used as the screen, grid three is the R.F. input grid, and grid five nearest the plate is the suppressor. The oscillator coil used with such single-ended converter tubes has a single tapped winding.

Tubes such as 6J8 and 6K8 are really dual tubes, having some of their elements connected internally to provide required converter action.

REVIEW QUESTIONS

1. How is it possible to increase the sensitivity but not the selectivity of a radio receiver?

2. In a radio receiver having a 456 KC. I.F., when tuning in a station at 670 KC., what is the frequency of the oscillator?

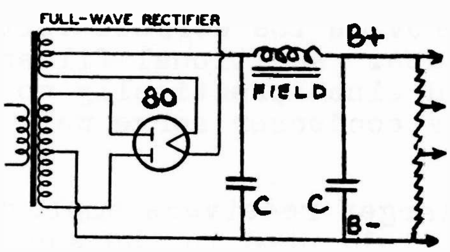
3. Can a different AVC voltage be applied to each tube of two separate circuits? How?

LESSON 11

Power Supplies

A radio receiver requires a source of power for heating the filaments and for supplying the plate potential and grid bias. In a battery operated radio the power required is obtained from batteries of the correct voltages and capacities. The majority of the present day sets, however, are operated from power lines and require a special power supply unit incorporated into the radio chassis.

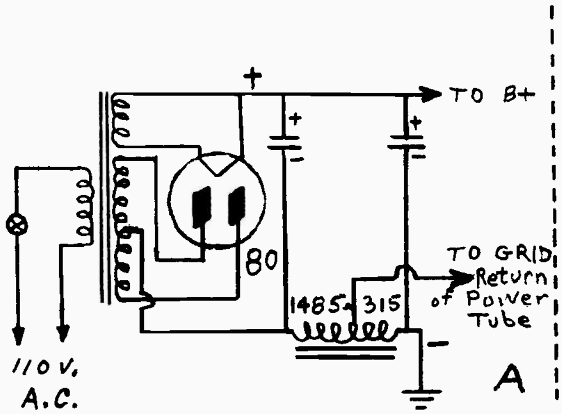
The primary function of a power supply is to furnish the required A.C. or D.C. voltages to the tubes' filaments, and also properly filtered plate supply so as to avoid hum and have satisfactory regulation. Usually the power supply also provides the necessary current for one or more speaker fields. There are power supplies for A.C. only and designed to be operated at the voltage and frequency of the supply, others for D.C. only, and still others for A.C. and D.C. combined.



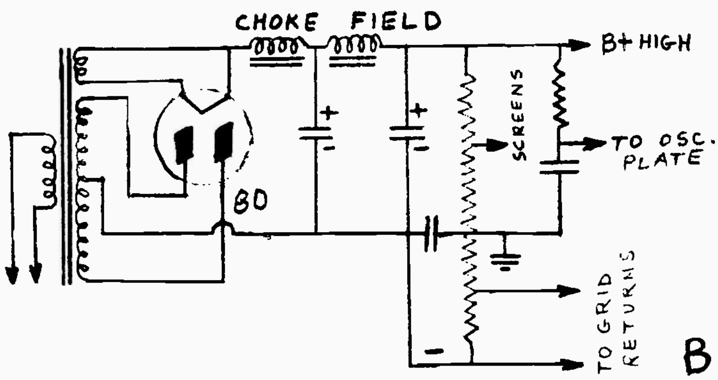
The essential parts that are employed in the simplest A.C. operated power supply are a power transformer to step the voltage up or down as needed, a rectifier tube, and one filter section consisting of a choke and two electrolytic condensers. Generally the choke can be the speaker field. The figure shows such a circuit which has become very popular. The resistance of the choke must be correctly chosen so that the total current drawn by the receiver is just sufficient to produce the required excitation in the electromagnetic field of the speaker.

This arrangement is probably the most economical one for small receivers. It is generally used with sets of relatively low sensitivity because there is only one filter section and any hum which reaches any of the early amplifying stages has only a limited amount of audio amplification. So, if this amplification is not too much, the hum in the speaker can be kept at a negligible level. Some small receivers will also be found to employ some form of hum-bucking coil in the voice coil circuit.

Note that a voltage divider consisting of high resistance units of the carbon type is used. The heavy bleeder of a few years ago is used very little now days. It is, of course, well known that in cases where a heavy bleeder is absent, the voltage of the "B" supply will vary considerably with the current drain. The largest variation in drain is usually caused by the A.V.C. circuit which changes the bias on several tubes. In one case the plate voltage on the R.F. amplifier was 240 volts with a strong signal coming in, but dropped to 225 volts without signal. The result may be a slight shift in the oscillator frequency. Servicemen should keep these facts in mind when servicing such receivers.



A

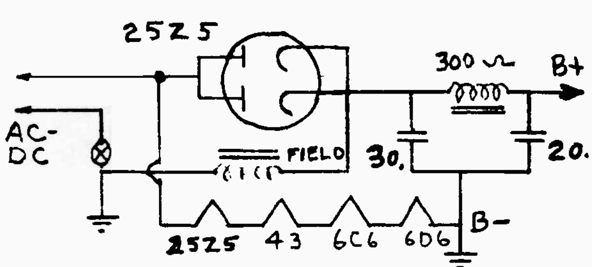


B

It is seen that if there is a drop of 105 volts across the speaker field; consequently when the specifications for the power transformer are made up, 105 volts must be added to the required plate voltage. This voltage drop can be utilized by placing the choke in the negative leg of the power supply and using a part of the supply for C bias. This is illustrated, next page. A tap on the field coil has been so chosen as to provide the correct voltage drop for the grid bias of the power tube. Additional filtering for the bias supply is easily provided since practically no current is taken. A high resistance and a condenser serve well for this purpose.

In B, a typical power supply for larger receivers employing two filter sections and with the speaker field used in the second section is illustrated. The filter stage ahead of the speaker field greatly reduces the hum introduced by the field itself besides lowering the hum level of the plate supply. The voltage divider serves as a bleeder to deliver semi-fixed bias to the driver stage. The output stage, however, as well as all other tubes are self biased.

<u>AC-DC CIRCUITS</u>



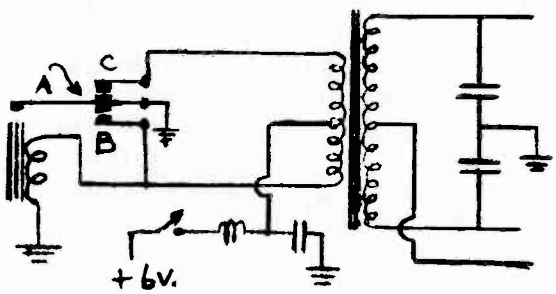
AC-DC sets employ tubes of either the 0.15 or 0.3 ampere filament current drain. The voltages vary, however, some are of the 6.3 volt type, others of the 25 volt, etc. The tubes are connected in series and a resistor is added so as to provide the required additional voltage drop. This resistor may be placed in the power cord so as to remove the heat from the chassis.

The B supply has only about 120 volts A.C. to start, so it is not possible to employ high resistance chokes. Consequently, the speaker field (if a dynamic speaker is used) cannot serve as a filter choke and is connected across the B supply. Filtering a 60 cycle supply is twice as hard as removing a 120 cycle ripple in full wave rectifiers. Reactances of the chokes are only half as much as for 120 cycles and reactances of condensers are twice as high offering a poorer path for the ripple voltage. One filter section is usually employed; large condensers are used and the choke can have larger inductance due to a relatively lower current.

Another problem with such AC-DC sets is the fact that the chassis, if tied to the B- side, becomes one side of the line and this may be the side that is not grounded. Accidental grounding of the chassis or the antenna wire would result in a short circuit. The last danger is circumvented by placing a series condenser in the antenna lead and making no provisions for a ground connection.

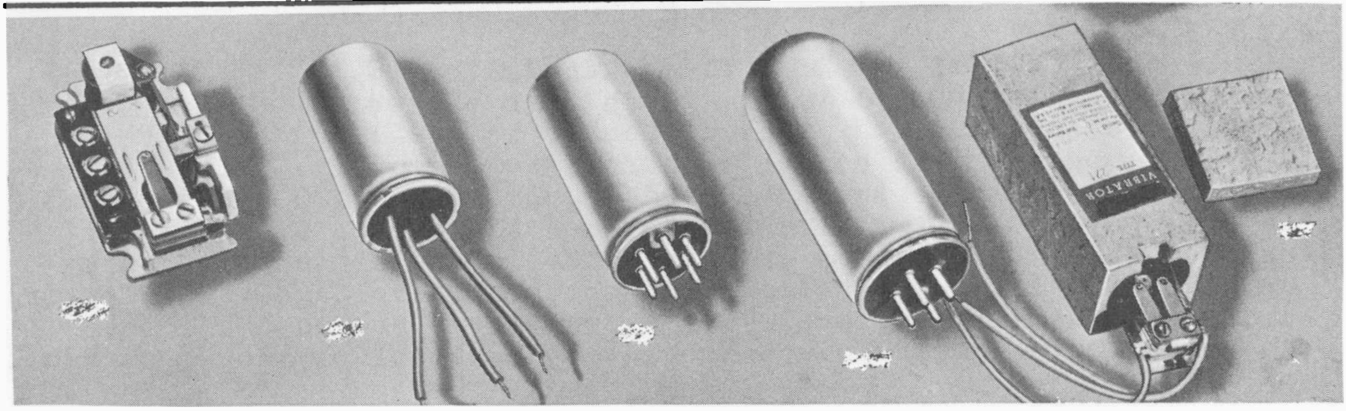
Newer type AC-DC sets that meet Fire Underwriters requirements, do not connect B- (plate voltage return) to the chassis in any direct way, but couple it to the chassis through a condenser, a resistor, or both.

While auto radio sets are battery operated in the sense that they secure their power from the 6 or 12-volt storage battery of the car, a power supply similar to the type we explained is still needed. By using 6.3 or 12-volt tubes, filament requirements can be obtained directly. But to obtain much higher plate voltage, the low battery voltage must be changed to interrupted D.C. (which has a behavior somewhat like A.C.), and then handled in the manner of familiar A.C. power supply.

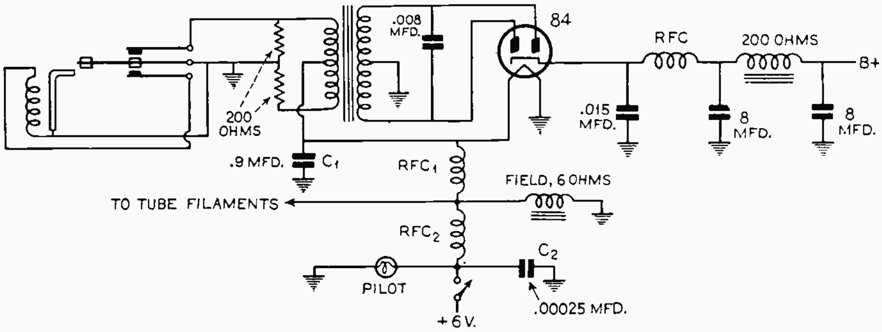


In connection with the operation of auto sets' power supplies we must carefully study the action of vibrators. The non-synchronous vibrator consists of an armature which is kept in vibration by an electromagnet on the same principle as the buzzer.

This diagram shows only the vibrator itself with the transformer and R.F. filter. When the switch is closed, current will flow through the lower half of the transformer primary and then through the magnet windings. The armature is then attracted and contact A will touch contact B, thereby short circuiting the electromagnet. The armature is then released again and swings back until contact A touches contact C. Meanwhile the electromagnet is attracting it again so that it keeps on vibrating at its own natural frequency and alternately touching contacts B and C. Now when contacts A and B are closed, the lower half of the primary is directly across the battery, which will result in a heavy current from the center tap downwards. When A touches C, the upper half of the primary is across the battery and a heavy current will flow from the center tap upwards. These two impulses

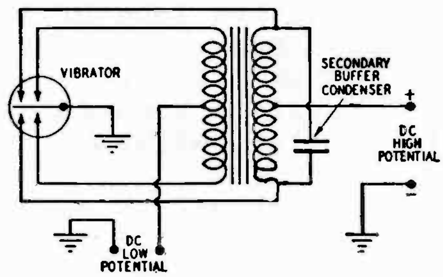


may be considered an alternating current although not of a perfect sine wave form. An alternating voltage will be induced in the secondary. Because of the turn ratio, the secondary voltage may be made of any required value.



There are some special precautions to be taken in the design of vibrator systems. When the contacts A and B close, there is such a sudden increase of current that a high voltage peak is induced in the secondary. The same is true when the other contacts close. 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. 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 B supply filter may contain an R.F. filter in addition to the regular A.F. 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. A typical circuit of an automobile power supply using a non-synchronous vibrator is shown below. This circuit includes the center-tapped resistor across the primary and the usual buffer condenser across the secondary. Sometimes two condensers are connected across the secondary with the center tap grounded. The values of these condensers should be about .01 mfd. They must also have high voltage rating.

SYNCHRONOUS VIBRATORS 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. Buffer condensers are again employed in the secondary to improve the wave form. The usual R.F. filters and A.F. filter are used like in the other vibrator system.



The most common fault with auto radio sets and with house sets employing vibrators, is vibrator trouble. The best procedure is to replace the unit with an exact duplicate.

Usually the vibrators are of the plug in type may be easily replaced.

A few practical service tests for A.C. operated power supplies will now be given. Determine if the power supply voltage reaches the transformer. This can be done by testing for voltage (A.C.) at the primary connections of the power transformer. Lack of voltage will suggest broken cord, poor connection at the socket, or defective switch. Next test for filament voltage, using your voltmeter or simply momentarily shorting one of the low filament windings and watching for a spark. Lack of voltage on any secondary will suggest a burned out primary winding, and this winding can be tested with an ohmmeter while the power is shut off.

Further tests may be conducted by breaking the B+ lead at the filament or cathode of the rectifier tube and measuring the amount of current consumed by the radio. If this current is very high, one filter condenser may be disconnected at a time and observing the effects produced. In case you are told by the owner of the radio that the rectifier tube needed replacements many times, suspect the input filter condenser.

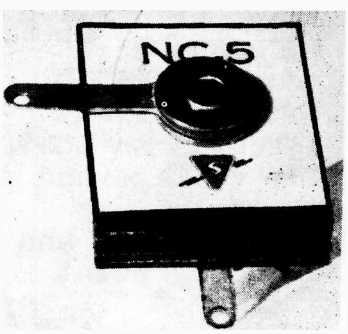
The successful design of radio tubes with high voltage filaments and efficient operation with relatively low plate voltages permitted extensive use of AC-DC power supplies. In the older sets of this type, the heater voltage added up to a value considerably below the line voltage of 110 volts, and a voltage drop was produced with a line cord resistor or ballast tube. In more modern AC-DC sets, the tubes are selected so that the heater voltage adds up to the value of the line voltage and no dropping resistor is necessary. For the plate supply, use was made of half-wave rectifier or voltage-doubler circuits, and each of these will be treated from an advanced servicing point of view.

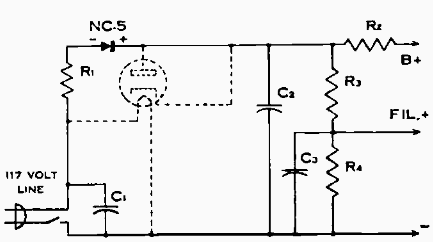
For a brief analysis of the half-wave rectifier power supply, let us first consider the action at the rectifier tube and input condenser which is made quite large in practice. While the plate of the rectifier tube is negative, it does not conduct and the current for the radio is supplied by the condenser which has been charged during the previous positive half of the cycle. When the alternating line voltage passes through the zero point and begins to supply an increasing positive potential to the plate, no conduction takes place until the sine wave positive value rises above the voltage-charge remaining in the filter condenser. Once started, this conduction lasts until the peak of the positive lobe of the sine wave is passed. When the sine wave value drops below the charge-voltage remaining in the condenser, and this occurs a short fraction of the cycle after the peak, the tube stops conducting although the positive half of the cycle is still in effect.

From this explanation, we can realize that the tube conducts over a small fraction of the cycle near the maximum point of the positive cycle. Fluctuations in the output voltage from the first condenser are less pronounced with large capacity, but a large condenser places a higher momentary load on the rectifier tube. The peak current through the rectifier tube may be many times the average of the D.C. current you may measure with a milliameter. less than 20 mfd. in the first section of the filter when carrying out a repair. Also, condenser of metal can construction will radiate heat more efficiently than a cardboard unit. Placement away from parts which radiate heat should be your guide. The 150-volt condensers are adaptable for AC-DC supplies operated from 60 cycle A.C., but for 25 cycle use 200-volt or higher working voltage condensers will provide required safety factor.

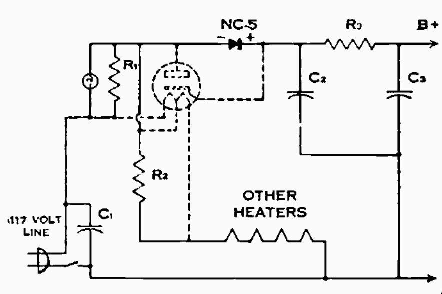
The newly developed selenium rectifier is a natural replacement for half-wave rectifier tubes and presents several advantages. The technical facts about this new rectifier have been taken from a description of Sylvania type NC-5, but units of other makes are very similar. The actual size of the unit is 1-1/4 inches square and 11/16 inches thick and it mounts anywhere on the chassis by one bolt. Selenium rectifiers are similar in construction and performance to the copper-oxide disc rectifiers.

The figures below show changes required when substituting a selenium rectifier for an ordinary rectifier tube in half-wave power supplies.





(A)



(B)

In Figure A, the heater circuit of the former 117 volt tube can be completely removed and the + side of the selenium rectifier connected to the cathode terminal and the minus side to the plate terminal. It is important to increase the value of the resistor R1 to restore the voltage on the tube filaments to the proper value. It would be inadvisable in this case to connect the resistor in such a place as to use additional plate voltage since the tubes are already being operated at the maximum rated voltage. The added resistance should be about 25 to 30 ohms, but may require adjusting slightly for different sets. The best way of making this adjustment is to use a 1000 ohm-per-volt meter to read the voltage across a 1.4 volt tube when the line voltage is exactly 117 volts. Adjust the resistance to get 1.3 volts under this standard condition.

Figure B shows the changes required when using the Sylvania type NC-5 as a replacement for a 35Z5 or 35Y4 rectifier tube. The important item here is R2 which must replace the rectifier tube heater in the series string. Be sure to place this so as not to overheat other parts as it will dissipate considerable heat. Table I gives the values of R2 recommended for the most common rectifier tubes.

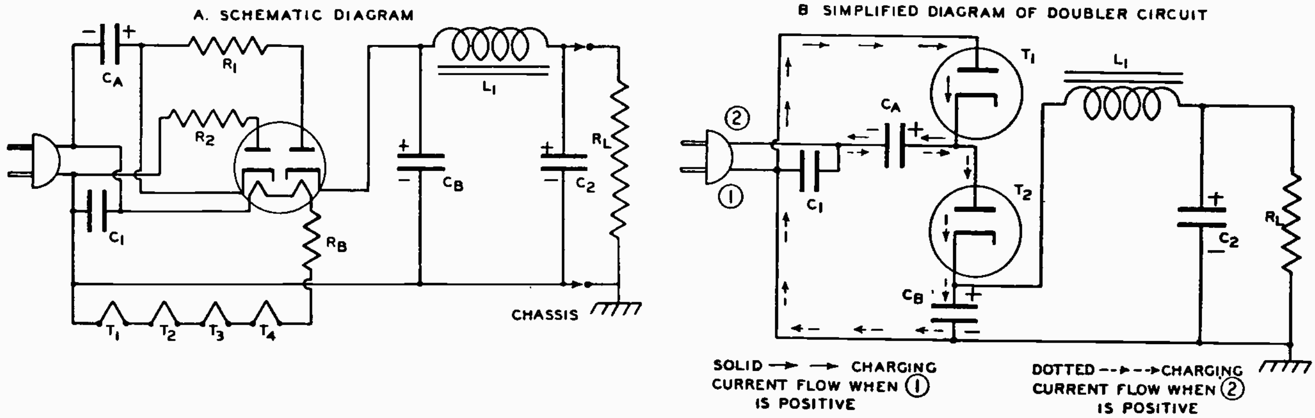
TABLE I

Type	Heater Current	R2 Ohms	Watts	R1 Ohms
25Z5	.300	85	15	Not required
25Z6	.300	85	15	Not required
35W4	.150	200	10	10 to 25
35Y4	.150	200	10	10 to 25
35Z3	0.150	230	10	Not required
35Z4GT	0.15	230	10	Not required
35Z5GT	0.15	200	10	10 to 25
45Z5GT	0.15	270	10	10 to 25
50Y6GT	0.15	330	15	Not required
50Z7GT	0.15	300	15	10 to 25

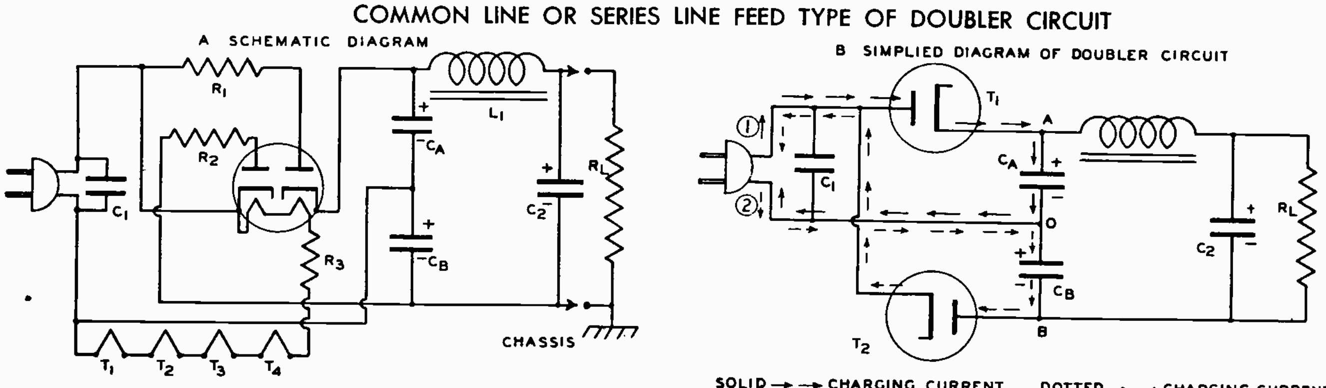
Voltage doubler rectifier circuits have been used in many popular models. Basically there are two different circuits which produce a D.C. voltage approximately twice the A.C. line voltage. In the symmetrical type, two large capacity condensers are connected in series across the input to the filter section. Each of these condensers is also connected to a separate diode section (may be a part of 25Z5, or a separate diode rectifier) in such a manner that each half-cycle charges a different condenser. For best results, the two condensers employed should be of equal capacity or a strong 120 cycle hum will be noticed. To test for equality, shunt one condenser at a time with a 4 mfd. electrolytic and see if 120 cycle hum is reduced. If the original condensers in the set are balanced, any added capacity will increase the hum level. For added future safety when you are repairing a voltage doubler of the symmetrical type, add 25 ohm resistors in series with plate leads.

In power supplies of this type, there exists a potential difference between every cathode and heater even if one tube in the set has one filament connection grounded. Any cathode leakage in a tube will create much more trouble in a set using a voltage doubler circuit.

SYMMETRICAL OR BALANCED TYPE OF VOLTAGE DOUBLER



COMMON LINE OR SERIES LINE FEED TYPE OF DOUBLER CIRCUIT



Courtesy P. R. Mallory & Co.

REVIEW QUESTIONS

1. Name several important reasons why batteries are not used for radio power in localities where electrical power is available.

2. What is the function of the power transformer? On what factors does the size of the transformer depend?

3. Why is the field coil of a dynamic speaker often used as the filter choke?

4. What advantage does an A.C. transformer type set have over the AC-DC radio?

5. Why are buffer condensers used in a vibrator power supply circuit? Notice that these condensers are placed in the secondary circuit at times, or sometimes connected in the primary circuit.

6. What advantage does a synchronous vibrator give?

7. What happens to the radio's response and the function of the different circuits, when the vibrator points become badly worn?

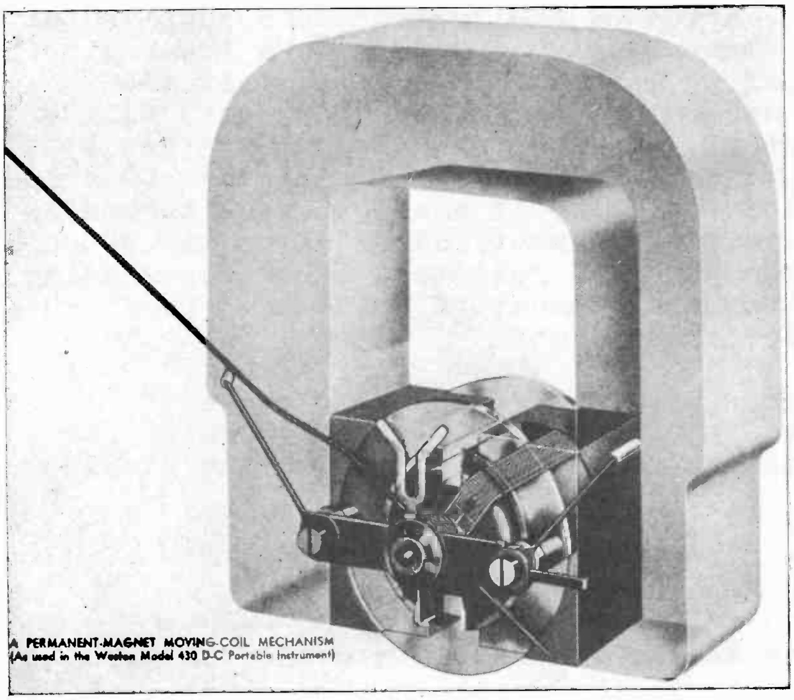
LESSON 12

Meters, Multitesters, and Tube Testers

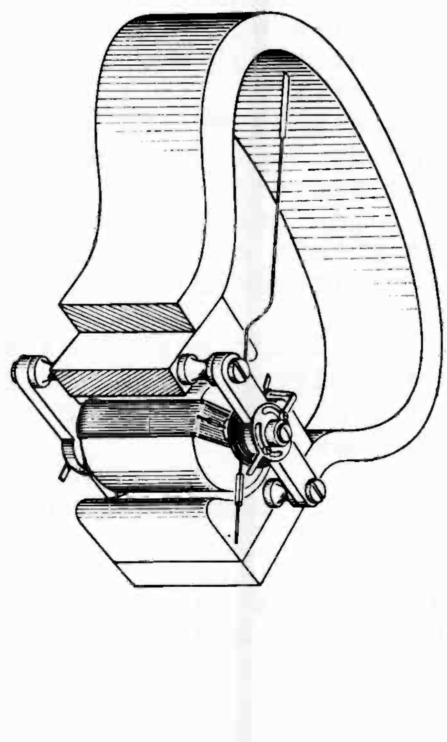
Radio servicemen use meters as an aid in discovering faults or making adjustments in radio equipment. Knowledge of circuits permits the technician to foretell what electrical values may be expected at various sections or parts under test. Considerable variation in the values of these measurements suggest the existance of a fault which is isolated with further tests.

Electric current operates all meters and, therefore, it is current that is measured. The amount of current passing through the meter, however, is a function (depends upon) other electrical quantities (voltage, for example), and the meter scale may be calibrated directly in terms of voltage, resistance, capacitance, etc. We will review some essential fundamentals of meter construction, operation, basic circuits, and scale accuracy, before we proceed to study a few popular commercial volt-ohm-milliammeters and analyzers.

The majority of today's direct current meters use D'Arsonnal type movement. This movement is sometimes called the permanent-magnet moving-coil type because of the components employed. In the two cut-away illustrations, you will notice that a large horse-shoe magnet forms the bulk of the unit. Between the pole



A PERMANENT-MAGNET MOVING-COIL MECHANISM
(As used in the Weston Model 430 D-C Portable Instrument)



pieces, a light movable coil is suspended on pivots. The springs in front and behind the coil tend to turn the coil in opposite directions and, thereby, balance the coil and the pointer in a definite position. These springs are also used to conduct current to the coil from fixed terminals.

When the meter is used for measuring and current flows in the movable coil, an electromagnetic field is produced. This field of the electromagnet is of such a polarity that it bucks the field of the fixed horse-shoe magnet. This causes the coil to rotate to the right until the magnetic force is just balanced by the additional tension produced by the springs. The intensity of this rotating (electromagnetic) effort is proportional to the current. The actual amount of rotation, of course, depends on the design of the meter besides the amount of current present. Since the same amount of current will always rotate the coil and its attached pointer needle to a specific position, a calibrated scale can be mounted on the meter frame, behind the pointer, and used to indicate the actual value of the current present.

The movement is very finely balanced and very thin wire is used for the coil, so that little current is needed for even the maximum rotation. A great many meters used in radio testers require 1 ma. for maximum deflection. For special applications, where very minute currents must be measured or circuits must not be upset, meters of greater sensitivity, 50 micro-ampere movement, are employed.

Sensitivity of a milliammeter can be decreased by connecting shunts — resistors in parallel with the meter. The D.C. resistance of a milliammeter is marked on the instructions supplied with the instrument or can be measured with a bridge or a low-resistance ohmmeter which uses a separate meter. You know that if two resistors of equal value are connected in parallel, each will pass one-half of the total current. Let us assume our meter has a D.C. resistance of 100 ohms. We parallel it with a resistor 100 ohms and connect the combination to a circuit where we want to measure the current. The same amount of current indicated on the meter is also passing through the parallel resistor. Whatever reading we obtain on the meter, the total amount of current in the circuit under test is twice this value.

Shunt resistors are usually selected on the basis of multiplying the current scale by a factor of ten, or multiples of ten. The shunt resistor value is found by using the simple formula

$$\text{Shunt resistance} = \frac{\text{Meter resistance}}{(n-1)}$$

where n is the multiplying factor wanted to increase the current reading scale.

Scales of meters are marked off in suitable divisions to help you estimate the reading obtained. Take time to read values obtained, especially on unfamiliar meters. Even experts have wasted hours on repair jobs because of such errors.

To produce the maximum deflection in a current-measuring meter a definite voltage will be needed. This voltage, of course, will be equal to the product of the meter internal resistance and the current required for a full scale deflection. In the case where the internal resistance of the meter is 100 ohms, and the meter has zero-to-one-milliampere movement, this voltage is 1/10 volt. (100 x .001; this second figure is one milliampere expressed in amperes).

To make this meter suitable for measuring much higher voltages, series resistors of suitable sizes are connected. If 50 volts are to be measured, as a maximum, a suitable scale is incorporated in the meter and the test prods are connected to the meter in series with a resistor of 50,000 ohms. The meter resistor of 100 ohms can be ignored since it is so small when compared to 50,000 ohms. Notice that 50 volts will just cause a current of one milliampere to pass through the circuit. This circuit has the meter and the meter will in this instance indicate full deflection. Other value resistors used with a suitable switching method will permit the same meter to be used for many additional measurements.

The same meter incorporating a battery (or other D.C. voltage source) and a series resistor which will produce full scale deflection upon the shorting of the test prods form a high resistance ohmmeter. For example, a 4½ volt battery may be used with an adjustable potentiometer which can provide an average value of 4,500 ohm resistance.

With this arrangement, when the prods are shorted, the circuit is completed. The meter shows maximum current, but the resistance between the prods is zero. So the point of maximum current (usually at the right) is marked 0 ohms on the ohmmeter scale. If a 4,500 ohm resistor is being measured by being connected between the prods, the current will drop to one half its previous value since the series circuit will be double its previous resistance. The meter needle will stop at the half-way mark. This point will correspond to 4,500 ohms.

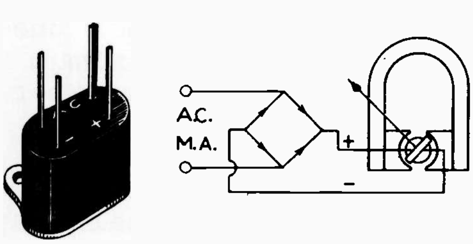
An ohmmeter scale is more spread out at the right for low values and is very congested for extremely high values. The ohmmeter we described can be read for values up to about 500,000 ohms, after that the total space of the scale remaining before the infinity mark is reached is so small that no accurate reading is possible. Some ohmmeters, of course, are made to read up to several megohms. This is accomplished by using meters of greater sensitivity or by connecting higher voltage battery. If you have an ohmmeter, for example, employing a 4½ volt battery, replacing it with 45 volt battery and connecting an additional resistor of 40,000 ohms in series will multiply your scale (on high ohms, only) by a factor of 10.

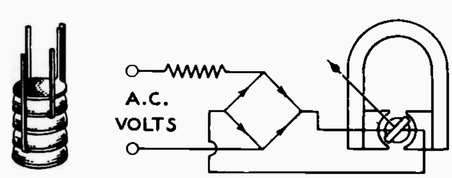
For low resistance measurements, under 50 ohms, a shunt arrangement is used. This will be explained further as we study a few commercial units.

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.

Always use the lowest value scale which will permit measuring values obtained. It is obvious that 7 volts can be read more accurately on a 0-10 volt scale than on the 0-100 volt scale. The meter itself is usually more accurate in the center of the scale than at the edges.

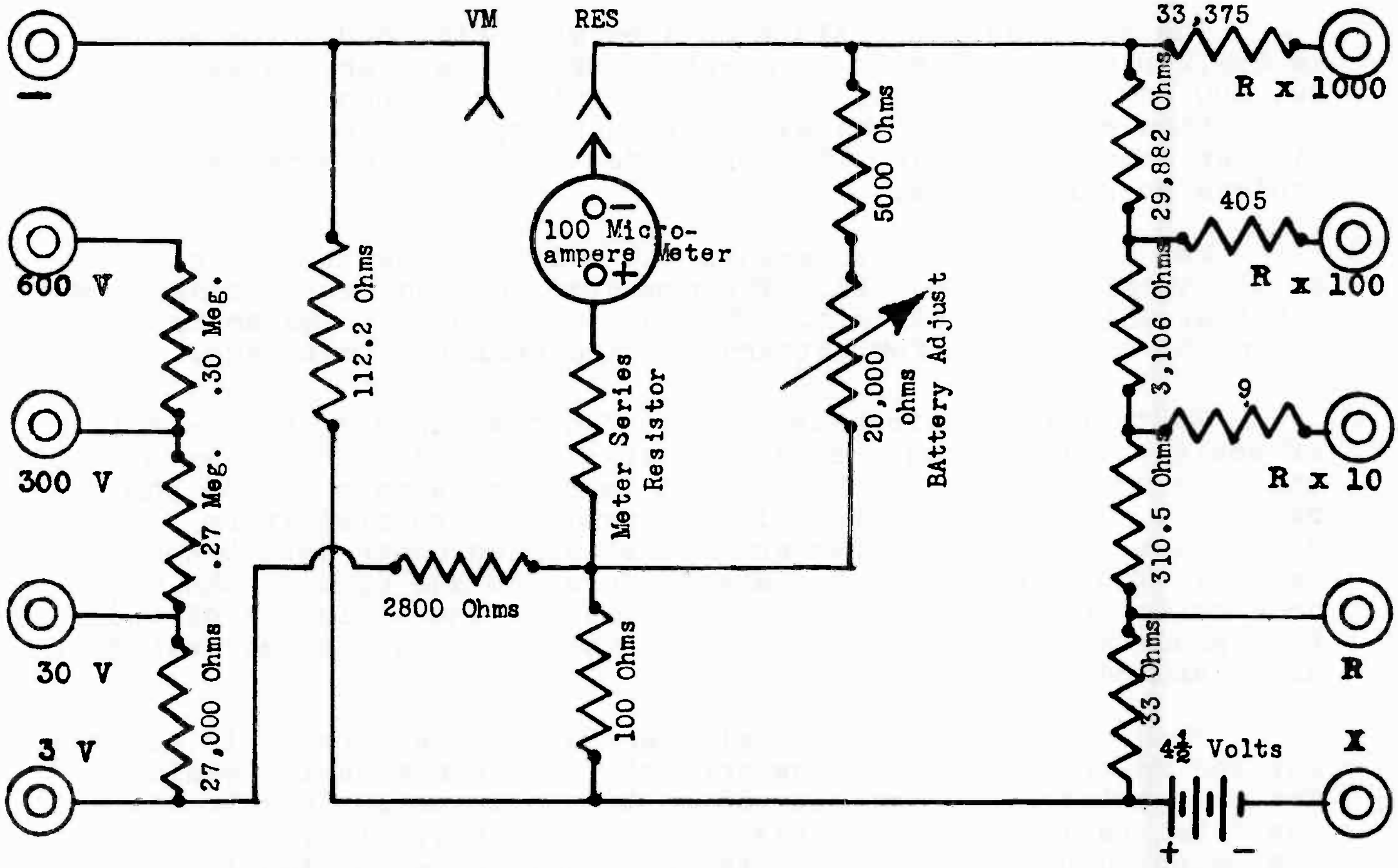
The meters we have discussed so far can be used with D.C. only. It is possible to use a regular D.C. meter for measuring alternating current or voltage with the aid of a rectifier unit. The rectifier changes A.C. to D.C. and the value of A.C. voltage or current is measured on special scales. Usually these scales are calibrated for a given A.C. frequency, and considerable variation in frequency will cause additional errors. The rectifier elements are made of copper oxide and the current is permitted to pass only in one direction.





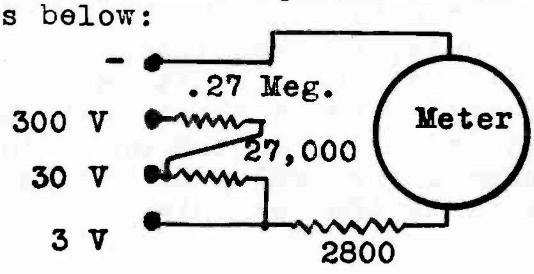
Several diagrams showing the method for connecting a four element bridge of copper oxide discs are shown on the left. These illustrations are reproduced through the courtesy of Weston Electrical Instrument Corp. It is important to realize that the sensitivity of the meter is reduced when a rectifier is used and different scales must be employed for A.C. and D.C. measurements. Any rectifier meter reads average values but is calibrated in terms of R.M.S.

A sensitive D.C. meter may be used with a thermocouple to measure alternating currents up to R.F. The current to be measured heats a small wire which is placed near a junction of two different metals. When a point of contact of two different metals is heated, a slight D.C. voltage is produced.



Because the Supreme Instruments Corp. Model 537 volt-ohmmeter uses an easy to trace circuit, we will introduce it first. The meter used is of 100 micro-ampere movement and for voltage measurements is switched to the left terminal marked VM. For all voltage measurements, the negative prod is inserted in the upper left hand terminal marked "—" minus. Let us consider the circuit when it is being used for measuring 300 volts maximum and the positive prod is connected to the jack marked 300 V. With this application, the .30 meg. resistor is not functioning, while the resistors marked .27 meg., 27,000 ohms, 2,800 ohms, "Meter Series Resistor," and the meter itself are connected in series to the prods. The meter series resistor is of a value to match the meter and give a total of 2,000 ohms. The resistors marked 100 ohms and 112.2 ohms (themselves connected in series) are in parallel with this meter circuit total resistance of 2,000 ohms. The equivalent resistance to this combination (using parallel resistance formula) is 175 ohms. The equivalent sensitivity for voltage measurements is in the order of one milliampere — if you want the exact figure it is 1.043 milliamperes.

A simplified equivalent circuit of what we are analyzing appears below:



The meter is considered as incorporating the associated resistors and acts as the equivalent resistor of 175Ω.

The total series resistance when measuring 300 volts maximum is 299,975 ohms, but with permissible errors may vary between 294,000 and 306,000 ohms, so that 300 volts will produce full scale deflection well within the over all accuracy of 3% to 5%. In a similar manner, the circuits formed for other voltage ranges produce proper results.

For resistance measurements the switch is set to the right, to the terminal marked RES. The ohmmeter section uses a ring-type parallel adjustment circuit. The 20,000 ohm potentiometer is needed to compensate for battery voltage variation with age.

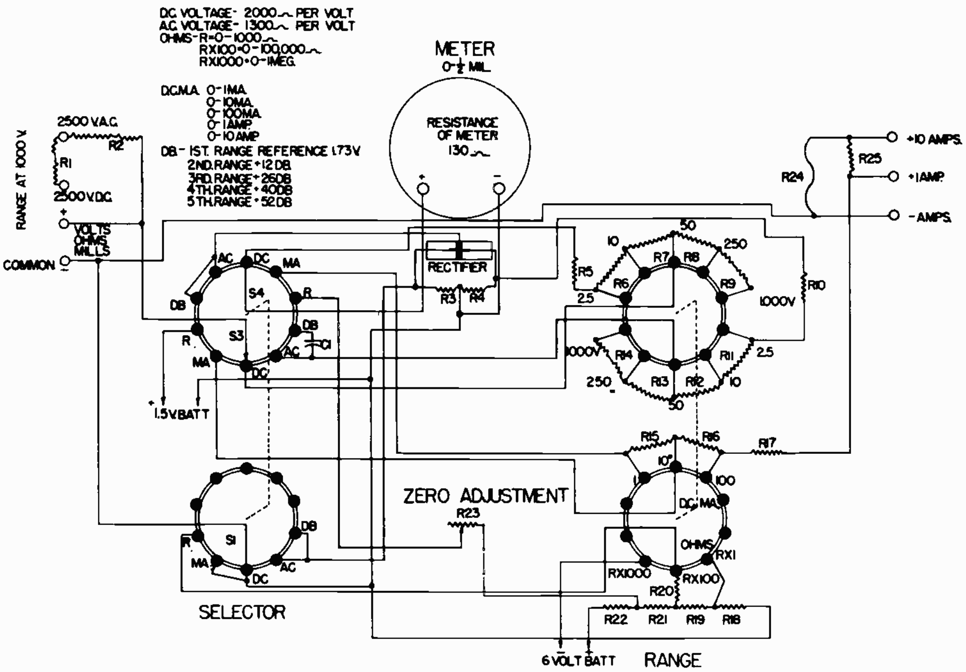
To test for resistance values of a few hundred ohms, middle of scale about 35 ohms, use jacks marked "R" and "X." Observe that the $4\frac{1}{2}$ volts of the battery is impressed across the 33 ohm resistor. The total voltage if the prods are shorted (zero resistance), smaller values as the resistance under test becomes larger. The other resistors are of value to add up with the meter network to produce full scale deflection on short circuit of the test prods and corresponding correct reading when various resistors are measured.

When other resistance scales are used, the circuit is altered, but the re-arrangement is now correct for the new scale reading. The change introduces an alteration in the meter series circuit and the total resistance in series with the battery. If you calculate the meter current for each of the setting, you will find it can be made 100 micro-amperes for zero ohm testing on any scale and other correct values for other test considerations. The slight variations are compensated with the Battery Adjustment which alters the meter equivalent sensitivity and always has a minor effect on the total series resistance. The adjustment mentioned must be used to set zero ohms each time a new scale is used for measurements. The advantage of an ohmmeter circuit of this type lies in its adaptability in providing a single scale for several ranges.

The circuit of another multimeter is shown on the next page. This circuit is similar in some respects to the diagram just discussed, but there are several important differences.

Analyzers were popular some years ago and were intended primarily to save time in permitting the serviceman to test and discover the possible fault in a defective receiver without actually removing the chassis from the cabinet. In majority of cases, in order to make the repair, the chassis had to be removed anyway, this instrument is no longer popular and majority of servicemen make the needed tests by making contact with prods of a simpler multi-tester directly to the points in the radio chassis.

In order to use test instruments, the serviceman must have a clear notion concerning the function of the circuit he is testing and some knowledge as to the expected correct electrical values. Voltage values can be obtained by referring to the operating conditions for the different vacuum tubes employed. Resistance values can be estimated for some parts (for example, paper condensers will show infinite resistance, coils 5 to 100 ohms) and, in the case of resistors, compared with actual markings as given. If the set is "dead," resistance tests are recommended. These usually will point to the place where the circuit is broken and prevents operation. If a radio which is being repaired has voltages at some points, the test for voltage at other points may lead to the fault which is preventing proper operation.



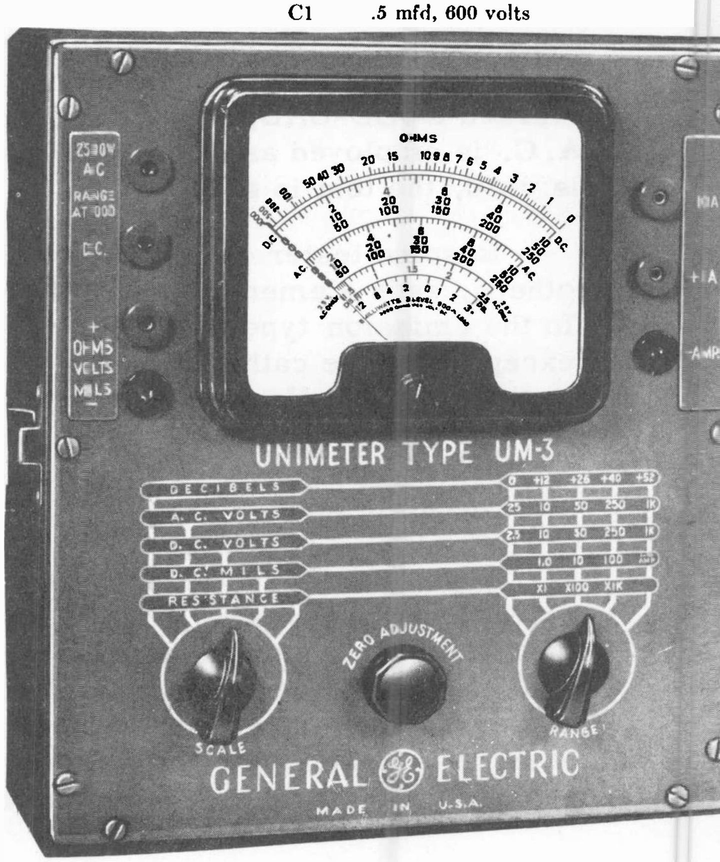
Symbol	Description
R1, R14	1 megohm, 1 watt, ±2%
R2	2 megohms, 3 watts, ±2%
R3, R4	2000 ohms, ½ watt, ±2%
R5	5000 ohms, ½ watt, ±2%
R6	15,000 ohms, ½ watt, ±2%
R7	80,000 ohms, ½ watt, ±2%
R8	400,000 ohms, ½ watt, ±2%
R9	1.5 megohm, 1 watt, ±2%
R10	1000 ohms, ½ watt, ±2%
R11	10,000 ohms, ½ watt, ±2%
R12	53,000 ohms, ½ watt, ±2%
R13	265,000 ohms, ½ watt, ±2%
R15	117 ohms, ½ watt, ±2%
R16	11.7 ohms, ½ watt, wirewound, ±2%
R17	1.17 ohms, ½ watt, wirewound, ±2%
R18	11 ohms, ½ watt, wirewound, ±2%
R19	1134 ohms, ½ watt, ±2%
R20	431 ohms, ½ watt, ±2%
R21	1137 ohms, ½ watt, ±2%
R22	10860 ohms, ½ watt, ±2%
R23	2000 ohms
R24	.013 ohm, wirewound, ±2%
R25	.117 ohm, wirewound, ±2%
C1	.5 mfd, 600 volts

Unimeter, type UM-3, is a portable unit designed for simplicity, attractive appearance and rugged construction, for the rapid and accurate measurement of volts, ohms, current and decibels as encountered in the repair of electronic equipment.

For operation in the normal ranges the test prods are plugged in the + and — jacks. Red test lead to +, black test lead to —. The most used ranges are changed by two selector switches. The left or SCALE switch selects the type of measurement desired. The right or RANGE switch selects the range of the desired type of measurement.

The SCALE and RANGE switch settings *must* not be changed while the test prods are in contact with the external circuit. This is particularly important in AC and Db. (Output) measurements and on DC above 100 volts. Rotating the range switch may cause transient voltages to be set up that are capable of ruining the rectifier, even though the duration of the voltage peak is so short that it doesn't show on the meter. *Never* change switch settings with 1000 or 2500 volts AC or DC applied to the test prods.

A .5 mf 600 V capacitor is switched in series with the test leads for output measurements when the SCALE switch is set to decibels.



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. The more accurate and the more sensitive a tube tester is, the better it will test the tubes and there will not be any chance of a tube in bad condition getting into the set to spoil the operation.

Occasionally when a tube tests defective, it will work quite well in the receiver tuned to a powerful local station. It is a rather difficult matter to convince the owner that this tube needs replacing when he can hear the receiver apparently working fine.

To convince the receiver owner that the tube in question is really defective, simply place a new tube in place of the one not testing GOOD. Tune in a rather weak distant station. Now replacing the BAD tube in the set will probably stop the reception of the weak station completely.

Different test methods are used by the various tube manufacturers. Tube checkers and testers are usually A.C. operated and employ four to as many as twenty-five sockets. The grid shift method is commonly used in the testers. The grid voltage is altered a small amount which in turn causes a corresponding change in the plate current. This change in the plate voltage is the index by which we judge the condition of the tube and this current is indicated on the meter. The tube tester meter is usually marked GOOD-BAD, so that the public can understand the results. If A.C. is employed as the grid voltage, the test is called dynamic. If D.C. is used, the test is static.

In some testers the majofity of the elements are tied together; in others, each element receives a relatively correct potential for the test. In the emission type tester all the elements are tied together with the exception of the cathode and the filament. A positive potential is then applied to the collection of the remaining elements and the current passing is measured. Obviously, if the screen grid prong of a tube is completely missing, the tube may still test GOOD and this is why the grid shift dynamic testers are superior and do detect such faults.

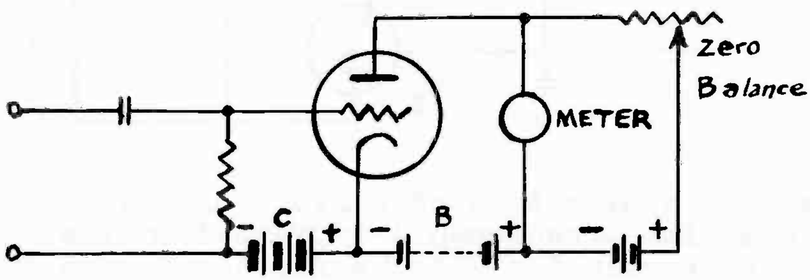
The emission type tester is much simpler and is much cheaper in price than the dynamic type. For practical requirements, the emission test is accurate enough and does serve the purpose. Besides low emission, about the only other common defect that occurs in a tube is a short circuit between some elements. Modern tube testers of all makes incorporate a short test, placing a voltage between the different elements and using a sensative neon bulb as the indicator.

LESSON 13

Vacuum Tube Voltmeters

As the name implies, a vacuum tube voltmeter uses a radio tube and is primarily an instrument for measuring voltage. This type of instrument falls into several different classes, each using a different basic circuit, but every type providing the main advantage of very high input impedance.

The high input impedance permits the use of the vacuum tube voltmeter for practically all voltage tests in radio equipment without upsetting the voltage values existing at these points previous to the test. For example, the exact voltage at the plate of a resistance coupled tube can be obtained. Or A.V.C. voltages can be measured accurately. If the unit is designed to measure R.F., the oscillator voltage can be measured. And, of course, all normally measurable voltages can also be measured with a vacuum tube voltmeter.

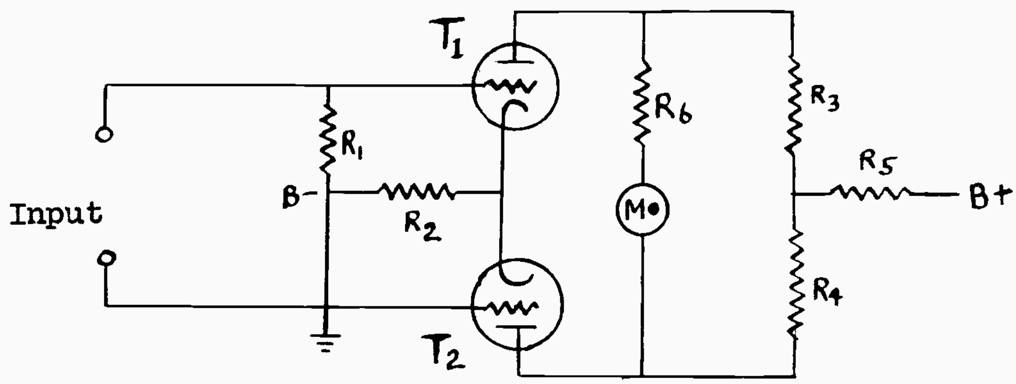


One type of vacuum tube voltmeter (VTVM) employs a vacuum tube (triode or pentode) which is operated over its curved characteristic as a detector. Under such operation, the D.C. plate current will depend on the A.C. voltage applied to the control grid. It is possible, therefore, to calibrate a milliammeter placed in the plate circuit (and which will measure the plate current) in terms of the input grid voltage. The value of plate current present when the input grid voltage is zero, can be balanced out with another, separate battery and a variable resistor circuit also connected to the same meter, but passing current in reverse. A zero adjustment is made with this circuit. A basic circuit of this type is indicated. Batteries are shown for simplicity but the same general circuit can be made to operate from a single power supply.

This type of VTVM is intended primarily for A.C. voltage measurements. It can be calibrated at some practical frequency (60 cycles for example) and will give accurate results even when used to measure R.F.

Many special arrangements are possible to secure advantages such as increased sensitivity, stability against changes due to tube's age or voltage variations, or to obtain response in a logarithmic ratio, but these circuits are not of especial interest to a radio serviceman. We shall discuss vacuum tube electronic multimeters which are special kinds of vacuum tube voltmeters designed to provide measurements of voltage, current, and resistance values commonly encountered in radio repair work.

Almost all electronic type volt-ohmmeters designed for use by radio servicemen employ a balanced vacuum tube circuit designed to measure D. C. voltages. The basic vacuum tube circuit employed is illustrated below. Here two similar triodes are employed in what, at first, appears to be a peculiar arrangement.



Consider the application of a D.C. voltage (of value permitted by the bias arrangement) impressed on the input terminals. For simplicity of explantion, let us further assume that the positive prod is connected to the upper terminal. This voltage will be impressed across the grid resistor R_1 of vacuum tube T_1. The grid of this tube will become positive by the amount of this voltage. Notice that the grid of T_2 remains at ground potential at all times.

For the moment, let us return to the time just before any voltage is impressed on the input. Since there is no grid current (tubes biased negatively), each grid is essentially at ground potential — resistor R_1 simply completes the circuit to ground. The steady state plate (or cathode) current passes through R_2 and produces a voltage drop here. This voltage makes the control grids of both tubes negative with respect to the corresponding cathodes, as is required. If identical tubes are selected, the operating condition described, plus the exact similarity of plate resistors R_3 and R_4, guarantees equal plate currents in each tube. If equal plate currents pass through equal plate resistors R_3 and R_4, the voltage drop across each of these two resistors will be equal. These equal drops will subtract from the power supply voltage, B+, and the voltage present at the plate of each tube used will be equal. Perhaps this value will be 80 volts in a practical circuit. If a sensitive meter M is connected to these points, as shown in the diagram, under the open input-terminal conditions described, no current will be present in the meter circuit. A difference of voltage, you understand, must exist to pass current through the meter.

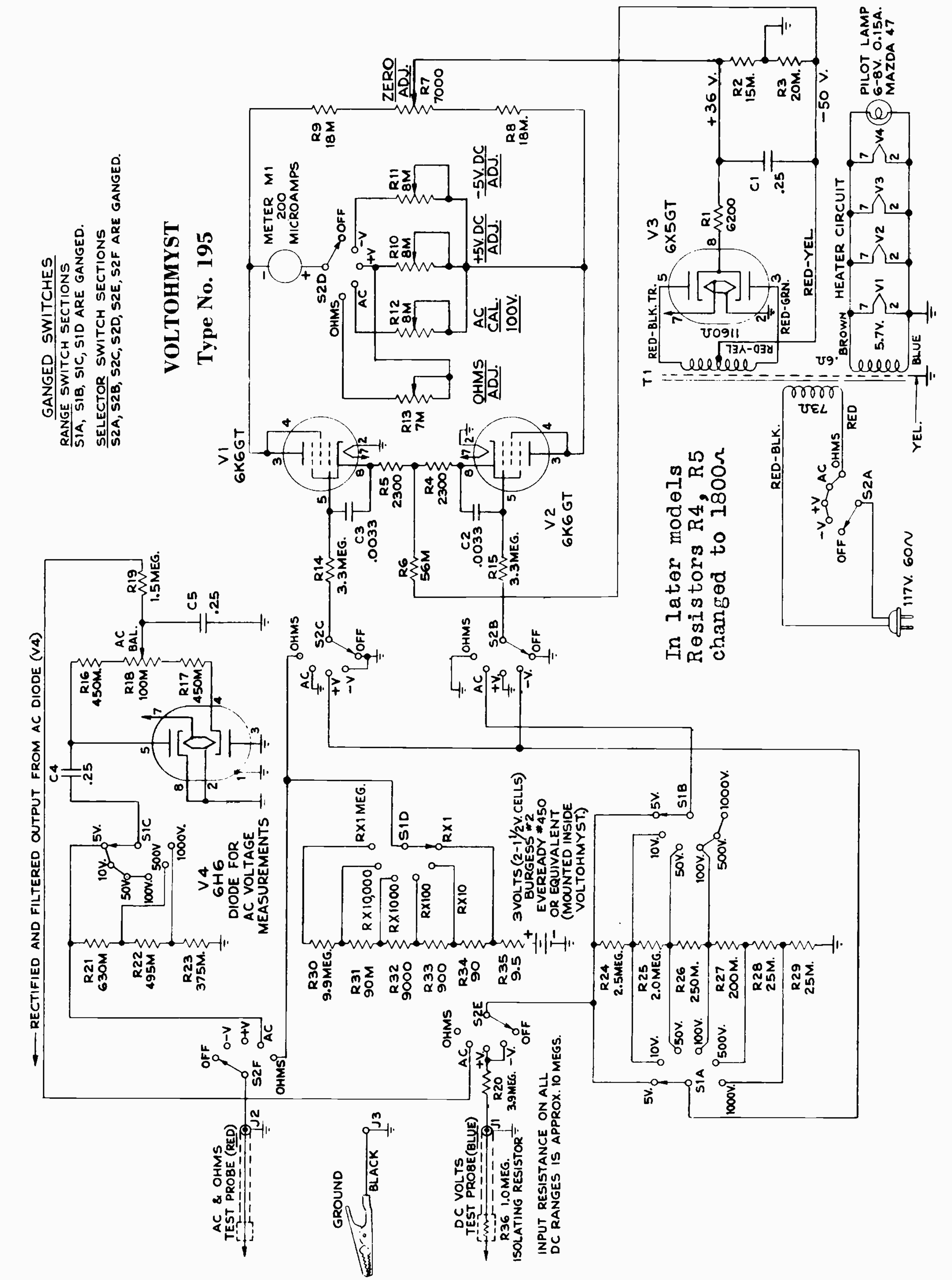
After you clearly understand the conditions existing with no input voltage, we can proceed to consider the effects of the input voltage we mentioned before. This "positive" voltage will make the grid of T_1 less negative than it was before. This tube T_1 will pass greater current. A larger drop will occur across the plate resistor R_3, leaving a smaller voltage at the plate of this tube — perhaps only 78 volts.

This is not all that happens. The plate current passes through the cathode resistor R_2, and since the plate current is larger, the voltage drop across it will also be larger. This action will have a degenerative effect on the input voltage since it will produce an additional small negative bias which to a degree will nullify the application of positive input voltage to the grid of T_1.

Also, with this increase in the cathode resistor voltage, the grid bias for T_2 will become more negative and, thereby reduce its plate current. This action in turn will have a further degenerative effect (reducing) on the amount of change produced in the voltage across the cathode resistor. Reduction in plate current of T_2 will also cause a smaller drop in the plate resistor R_4, increasing the voltage at the plate of T_2, perhaps to 81½ volts. We now have a voltage difference across the meter circuit and it will indicate some new value. Resistor R_6 is used to limit the current through the meter and the meter is calibrated in terms of the input voltage.

The meter reads zero initially and is connected with proper polarity to correspond to the polarity use of the input. In some testers of this type, the meter has a center zero, and no polarity of the test prods need be observed. In other units the terminals of the meter can be reversed with a switch so that either polarity of the test prods may be used provided the corresponding setting of the switch is made.

The effect of each portion of the circuit on others was mentioned as if final conditions were affected but once, actually these actions are inter-related and cause results in a multitude of ways. Although the complete analysis of the action is difficult, equalibrium is reached instantaneously for each change, and the current through the meter is directly related to the input voltage. The degenerative effects present and the use of a balanced circuit eliminate, to a large degree, the error introduced by supply voltage variations. Observe that a change in plate voltage supply will have but little effect on the operation of the circuit.


VOLTOHMYST
Type No. 195
GANGED SWITCHES
RANGE SWITCH SECTIONS
S1A, S1B, S1C, S1D ARE GANGED.
SELECTOR SWITCH SECTIONS
S2A, S2B, S2C, S2D, S2E, S2F ARE GANGED.
In later models
Resistors R4, R5
changed to 1800Ω
METER M1
200
MICROAMPS
ZERO
ADJ.
R7
7000
R9
18M
R8
18M.
R11
8M
R10
8M
R12
8M
R13
7M
-5V. DC
ADJ.
+5V. DC
ADJ.
AC
CAL.
100V.
OHMS
ADJ.
V1
6K6GT
V2
6K6 GT
R5
2300
R4
2300
C3
.0033
C2
.0033
R14
3.3MEG.
R15
3.3MEG.
R6
56M
V3
6X5GT
R1
6200
C1
.25
R2
15M.
R3
20M.
+36 V.
-50 V.
RED-YEL.
RED-BLK. TR.
RED-GRN.
RED-YEL
1160Ω
.6Ω
T1
73Ω
RED-BLK.
RED
YEL.
BROWN
BLUE
5.7V.
HEATER CIRCUIT
PILOT LAMP
6-8V. 0.15A.
MAZDA 47
117V. 60∿
RECTIFIED AND FILTERED OUTPUT FROM AC DIODE (V4)
R19
1.5MEG.
C5
.25
AC
BAL.
R16
450M.
R18
100M
R17
450M
C4
.25
V4
6H6
DIODE FOR
AC VOLTAGE
MEASUREMENTS
R21
630M
R22
495M
R23
375M.
RX1MEG.
RX10,000
RX1000
RX100
RX10
RX1
R30
9.9MEG.
R31
90M
R32
9000
R33
900
R34
90
R35
9.5
3VOLTS (2-1½V. CELLS)
BURGESS #2
EVEREADY #450
OR EQUIVALENT
(MOUNTED INSIDE
VOLTOHMYST)
R24
2.5MEG.
R25
2.0MEG.
R26
250M.
R27
200M.
R28
25M.
R29
25M.
R20
3.9MEG.
AC & OHMS
TEST PROBE (RED)
GROUND
BLACK
DC VOLTS
TEST PROBE (BLUE)
R36 1.0MEG.
ISOLATING RESISTOR
INPUT RESISTANCE ON ALL
DC RANGES IS APPROX. 10 MEGS.

In order to use the same circuit for measuring a wide range of voltages, a voltage divider network is incorporated in the input. Resistance measurements are made by introducing the unknown resistor in series with a small dry battery across one of the voltage inputs. Since the voltage impressed on the input circuit will depend upon the resistor value under test, additional scales can be provided to indicate the value of resistors to be tested.

To measure alternating voltage a rectifier must be provided. This may be in the form of a copper-oxide unit with correspondingly reduced sensitivity. In fact, if a copper-oxide unit is used, it is usually used directly with the meter (without the tube circuit) for A.C. measurements. In the majority of commercial instruments, a diode tube is incorporated in a special probe and serves as the rectifier. The use of a diode permits voltage measurements at high radio frequencies and preserves the advantage of high impedance input.

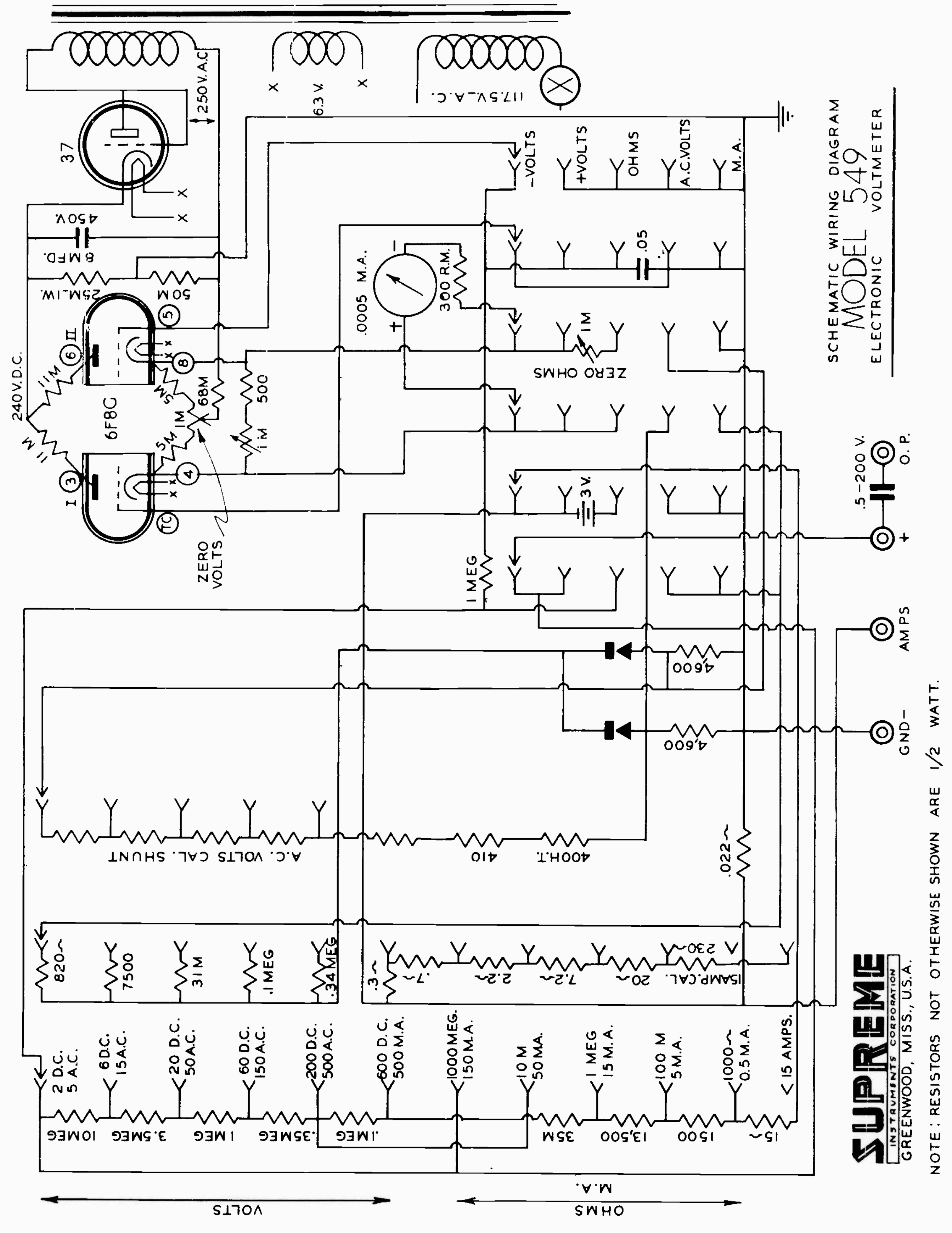
We will now discuss several popular commercial units which will help us to understand and apply the basic theory presented.

An instrument using the basic circuit we just studied is employed in the R.C.A. VoltOhmyst. We illustrate this circuit and will call your attention to a few special features.

As you will observe, this instrument uses a D.C. electronic vacuum tube voltmeter circuit which is characterized by excellent linearity and stability. Two type 6K6-GT tubes are linked by means of a common high resistance (R_6) and because of this coupling any change in the input voltage to the grid of one tube changes the cathode bias of the other and, as a result, the change in the plate current of one is accompanied by a simultaneous opposite change in the plate current of the other. The differential voltage this action develops across the load resistors R_8 and R_9 is applied to the meter which is calibrated in terms of the voltage applied to the grid, and in terms of resistance when the instrument is being used as an ohmmeter.

The provision of individual balance adjustments permits the switching from range to range without the need for resetting in each instance. The zero adjustment controlled by the potentiometer R_7 is employed for the initial zero setting of the meter and need be only adjusted once each time the instrument is used, unless, of course, there is considerable voltage variations.

The switching circuits at the left of the diagram employ resistance networks to provide the ranges obtainable from this instrument. Please note that the resistors in the bottom group are intended for use with D.C. ranges. The middle set of resistors is used with a small battery for resistance (ohmmeter) measurements. The circuit in the upper left hand section provides a voltage divider network to give various ranges and this circuit is


SCHEMATIC WIRING DIAGRAM
MODEL 549
ELECTRONIC VOLTMETER
SUPREME
INSTRUMENTS CORPORATION
GREENWOOD, MISS., U.S.A.
NOTE: RESISTORS NOT OTHERWISE SHOWN ARE 1/2 WATT.
VOLTS
OHMS
M.A.

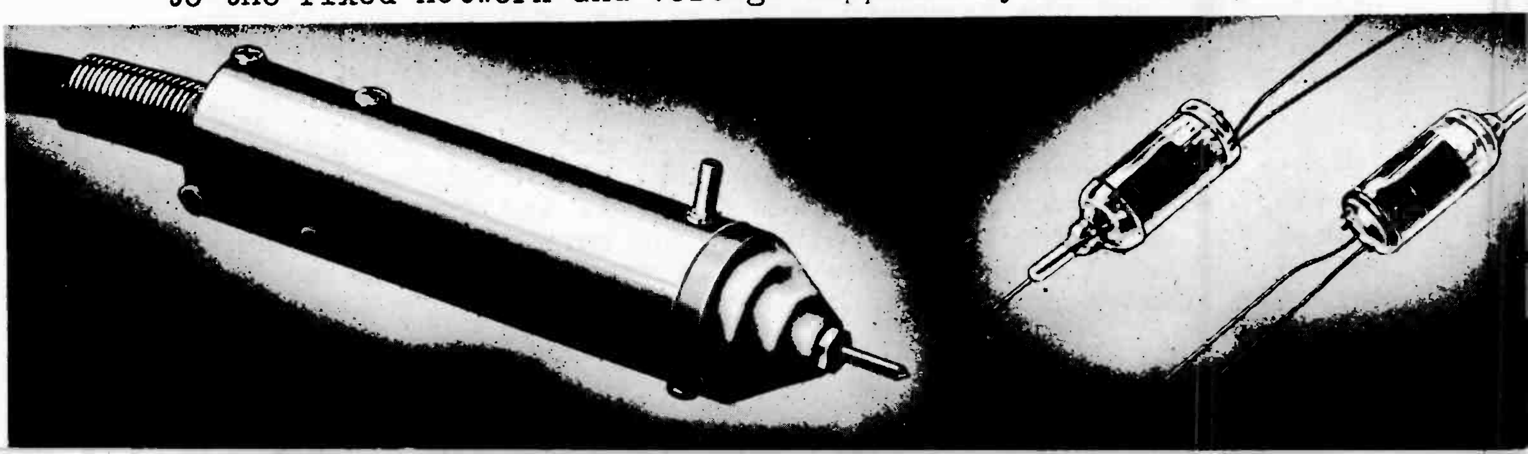
used for A.C. power and audio frequency measurements. The diode 6H6 tube rectifies the alternating voltage input and places the resulting rectified voltage upon the same basic VTVM circuit which, as you recall, is intended for measuring D.C. only.

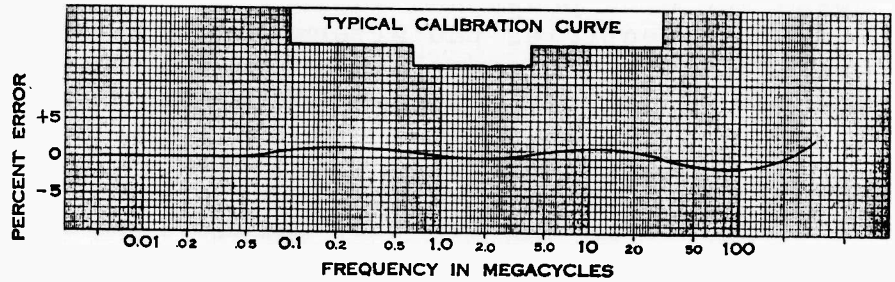
Another electronic multimeter is the Supreme Instrument Corp. Model 549. In this unit, the meter used for measuring the voltage differences in the two tube balanced circuit is placed across the cathodes. This action, however, is essentially the same as in the basic circuit we have described.

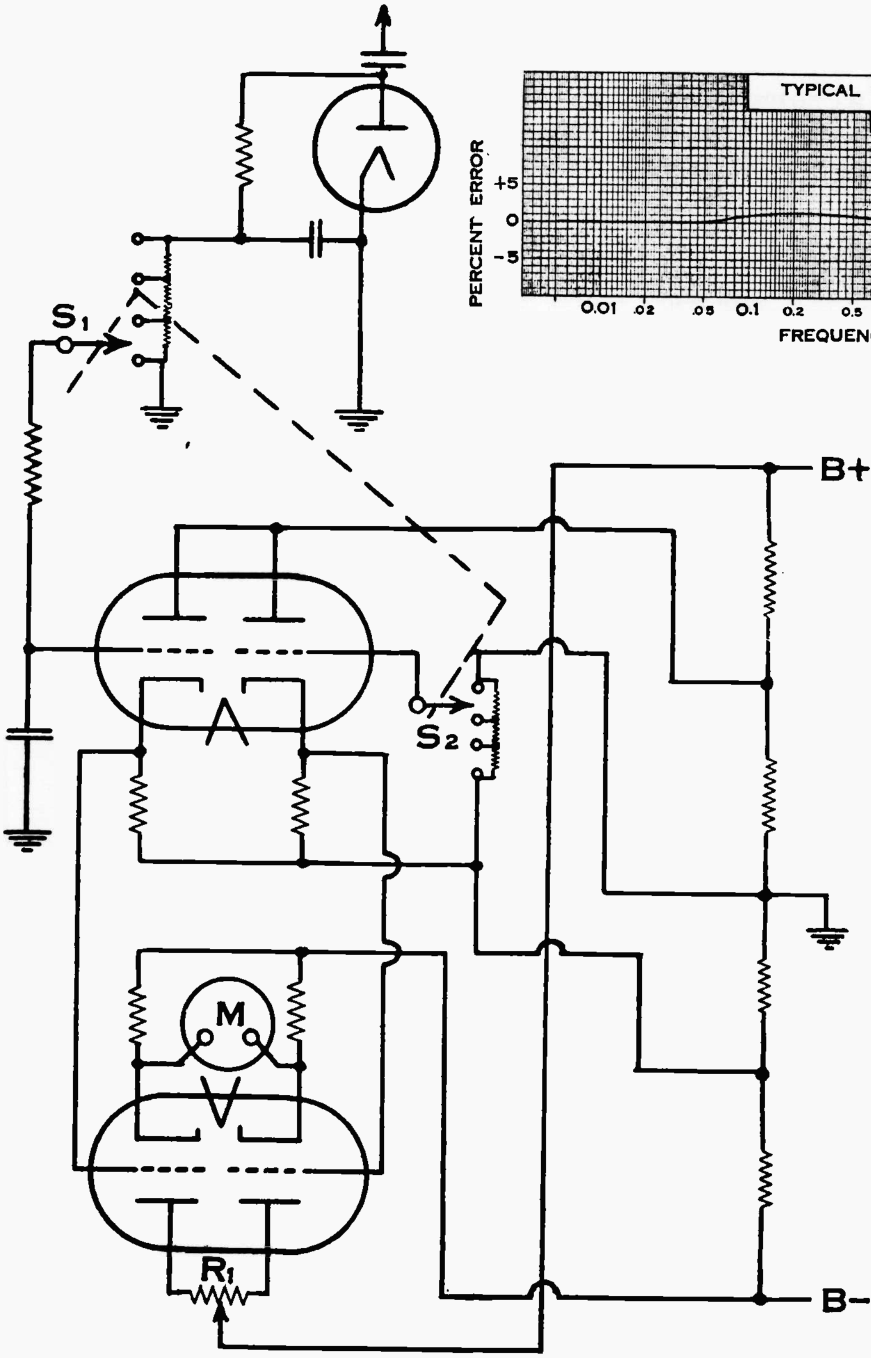
You will note in studying this circuit that it is similar and the primary singular exception is the use of copper-oxide rectifiers for A.C. measurement. For these measurements, the meter is connected directly to the voltage divider network marked A.C. VOLTS CAL. SHUNT. The electronic network is not used for these measurements. The switch elements at the right bottom of the circuit are moved in tendem "up and down" to make connections for various applications of the unit.

Sylvania Electric offers to servicemen an instrument called a Polymeter which uses an electronic VTVM basic circuit of the type we discussed. A simplified circuit of this unit is shown on page 124, and you will onserve certain important differences. The diode included is intended for A.C. measurements and can be used with a good degree of accuracy up to frequencies of 300 MC. This makes this instrument of value in television servicing as well. The curve on the next page indicates the accuracy obtainable at various frequencies. The D.C. voltage obtained from the diode is impressed on a balanced electronic circuit of the type we have described. The voltage differential resulting in this instance, however, is not impressed on the meter, but instead is applied to another dual function tube in a very similar circuit. A much greater voltage differential is obtained from this second set of triodes and is in turn impressed upon the meter used.

The ohmmeter circuit is formed from the basic voltage input circuit with the aid of a small battery which is used to supply a voltage to the unknown resistor and the associated network. The meter reading will show the value of the unknown resistance since its scale is calibrated with consideration to the fixed network and voltage supplied by the battery.







FUNDAMENTAL PROBE CIRCUIT

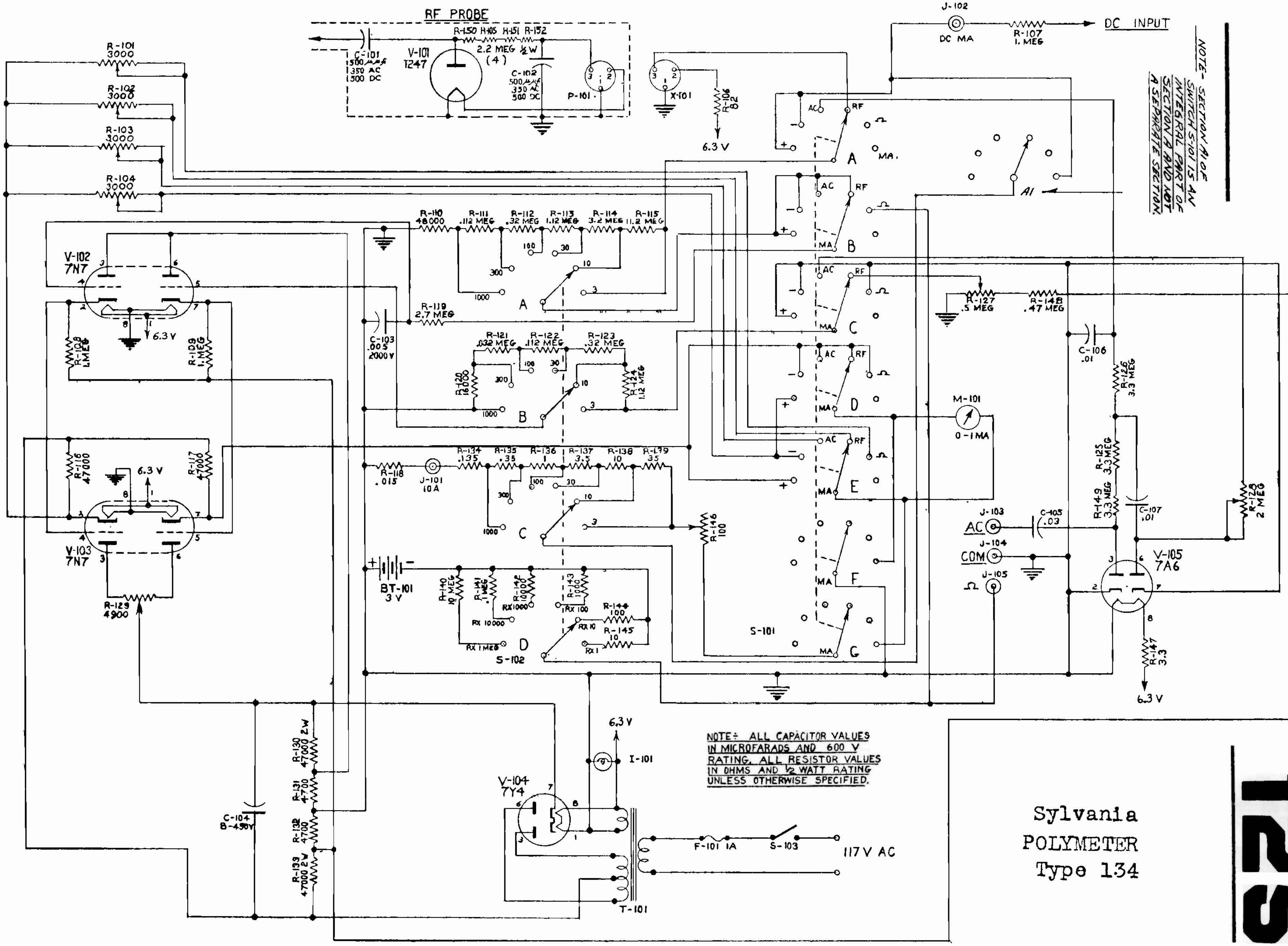
Table

D. C. Voltages	Ohms per volt	Accuracy
0-3	5,333,333	
0-10	1,600,000	
0-30	533,333	± 3% of full scale
0-100	160,000	
0-300	53,333	
0-1000	16,000	
A. C. Voltages:	**Audio (capacity 40 uuf.)**	
0-3	900,000	
0-10	270,000	± 5% of full scale
0-30	90,000	
0-100	27,000	± 7% of full scale
0-300	9,000	
A. C. Voltages:	**R.F. (at frequencies up to 300 mc with probe capacity of 3 uuf.)**	
0-3	900,000	± 5% of full scale
0-10	270,000	
0-30	90,000	± 7% oi full scale
0-100	27,000	
0-300	9,000	± 10% of full scale
Current	**Resistance**	
0-10 amps	.015 ohms	± 5% of full scale
0-1000 ma	.150 ohms	
0-300 ma	.50 ohms	
0-100 ma	1.5 ohms	± 3% of full scale
0-30 ma	5.0 ohms	
0-10 ma	15.0 ohms	
0-3 ma	50.0 ohms	
Resistance	**Current Required**	
0-1000 ohms	300 ma @ 0 ohms	
0-10,000 ohms	30 ma @ 0 ohms	± 6%°on
0-100,000 ohms	3 ma @ 0 ohms	first half
0-1 Meg.	0.3 ma @ 0 ohms	of scale
0-10 Meg.	30 ua @ 0 ohms	
0-1000 Meg.	0.3 ua @ 0 ohms	

NOTE—RF accuracy from 100 to 300 mc is 5% greater than the above figures.

A table indicating the scales available, the sensitivity obtainable, and the accuracy expected, is included to give you an idea of the results that are possible with instruments of this type.

After this preliminary study, you can refer to the general circuit. Here you will note the addition of various voltage divider networks to give the needed ranges and the switching method for changing the circuit for the measurement and range wanted. Current readings are taken directly on the meter with suitable shunt resistances, but, for this purpose, the electronic



NOTE- SECTION A1 OF SWITCH S-101 IS AN INTEGRAL PART OF SECTION A AND NOT A SEPARATE SECTION.

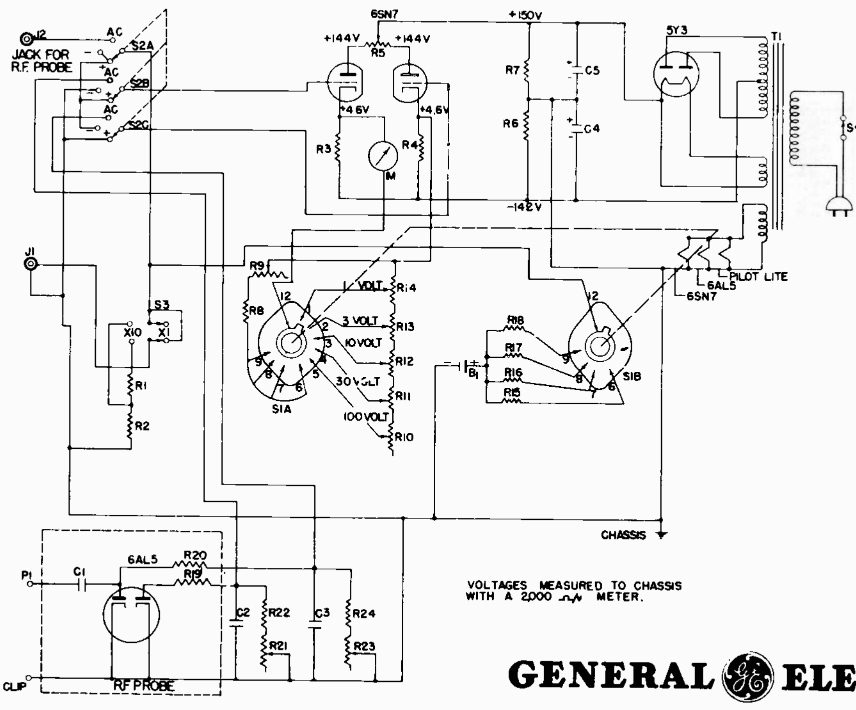
NOTE: ALL CAPACITOR VALUES IN MICROFARADS AND 600 V RATING. ALL RESISTOR VALUES IN OHMS AND ½ WATT RATING UNLESS OTHERWISE SPECIFIED.

Sylvania
POLYMETER
Type 134

section of the unit is not employed. As you realize, the R.F. probe is employed for all A.C. measurements. Since it is not practical to design a single probe circuit to serve for high radio frequencies and at the same time measure power frequencies without error, this unit is not adaptable for A.C. frequencies below the audio spectrum.

The input impedance of 16 megohms for D.C. measurements was selected as the best compromise between the erratic behavior which may be caused through the use of a much higher value and the too low an impedance giving poor sensitivity as used in some of the earlier models of vacuum tube voltmeters. Notice that in the table the ohms-per-volt sensitivity varies with the scale used. This is not the case with some other instruments of this nature, but is of little consequence in radio service work.

The General Electric electronic volt-ohmmeter type PM-17 circuit and parts list are next presented for your study.



GENERAL ELECTRIC

A 6AL5 tube mounted in a probe is used for audio and radio frequency voltage measurements from 200 cycles to beyond 100 megacycles. Response drops below 200 cycles to a value of 5% low at 60 cycles. In audio frequency measurements the probe can be mounted in the top of the case and the test leads from the panel used instead. An ohmmeter circuit is included for convenience in measuring high and low ohmic values of resistance.

SPECIFICATIONS

D-C VOLTS: ×1 range—0-1, 3, 10, 30, 100 volts. Input impedance from 30 to above 200 megohms. ×10 range—0-10, 30, 100, 300, 1000 volts. Input impedance constant at 10 megohms. Input capacity on both ×1 and ×10 ranges 2 mmf.

A-C VOLTS: 0-1, 3, 10, 30, 100 volts. Input capacity, using test leads, approximately 100 mmf. Usable at audio and low radio frequencies. Response drops below 200 cycles to a value of 5% low at 60 cycles.

R-F VOLTS: 0-1, 3, 10, 30, 100 volts. (Same as a-c scale.) R-f measurements made using the r-f probe. Input capacity using the r-f probe is 6.6 mmf at 70 megacycles.

OHMS: R×1, ×100, ×10K, ×100K (K=1000). Basic scale .2 to 1000 ohms, 10 ohms center scale. Applied voltage, all ranges, 1.5 volts.

POWER SUPPLY: 105-120 volts, 60 cycles, 30 watts input.

ACCESSORIES: (Supplied) Two alligator clips. Two pairs of leads and an r-f probe.

CASE: Steel, 8½" by 8" by 8". Sloping panel of aluminum. Instrument accessible as a unit by removing panel screws.

WEIGHT: 15 pounds.

LIST OF ELECTRICAL COMPONENTS

Symbol	Description	Rating	Tolerance
B1	No. 2 Flashlight battery	1.5 volt	
C1	Capacitor	.01 mfd	
C2	Capacitor, paper	.05 mfd, 400 volt	
C3	Capacitor, paper	.05 mfd, 400 volt	
C4	Capacitor, electrolytic	8 mfd, 250 volt	
C5	Capacitor, electrolytic	8 mfd, 250 volt	
R1	Resistor, carbon precision	1 w. 8 megohm	2%
R2	Resistor, carbon precision	1 w. 1 megohm	2%
R3	Resistor, carbon	1 w. 51K ohm	5%
R4	Resistor, carbon	1 w. 51K ohm	5%
R5	Potentiometer (zero set)	5K ohm	
R6	Resistor, carbon	1 w. 47K ohm	5%
R7	Resistor, carbon	1 w. 51K ohm	5%
R8	Resistor, carbon	½ w. 8.2K ohm	10%
R9	Potentiometer (ohms adjust)	5K ohm	
R10	Potentiometer	750K ohm	
R11	Potentiometer	350K ohm	
R12	Potentiometer	50K ohm	
R13	Potentiometer	50K ohm	
R14	Potentiometer	15K ohm	
R15	Resistor, carbon precision	½ w. 9 ohm	2%
R16	Resistor, carbon precision	½ w. 1K ohm	2%
R17	Resistor, carbon precision	½ w. 100K ohm	2%
R18	Resistor, carbon precision	¼ w. 1 megohm	2%
R19	Resistor, carbon	¼ w. 3.3 megohm	5%
R20	Resistor, carbon	¼ w. 3.3 megohm	5%
R21	Potentiometer (AC zero)	10 megohm	
R22	Resistor, carbon	½ w. 6.8 megohm	10%
R23	Potentiometer	10 megohm	
R24	Resistor, carbon	½ w. 6.8 megohm	10%
R25	Resistor, carbon precision (in DC test prod)	1 megohm	2%
M	Meter	100 microammeter	2% accuracy
T1	Power transformer		

Due to the self-balancing type of circuit and the high degree of degeneration, fluctuations in line voltage and changing of tubes has little or no effect on calibrations.

In all AC-DC volts and ohms measurements, the test leads are plugged in the jack on the front panel. The 6AL5 probe is used for R.F. measurements. All functions of the instrument are obtained through the use of two selector switches. The polarity switch controls the polarity of the test prods and also switches the instrument to the ohms and A.C. circuits. The range switch selects the range of the desired measurement.

Other controls are: a zero adjustment knob to set the instrument pointer to zero, an ohms adjustment knob to set the instrument pointer to full scale on the ohms ranges, a toggle switch which acts as a power switch.

The toggle switch in the lower right corner of the panel controls the 10 to 1 voltage divider which is switched across the input to secure the higher ranges of D.C. volts. This voltage divider also provides a convenient means of securing a grid return when D.C. loading of this instrument is obtained by using an open grid input on D.C. volts X1. The grid return is through the circuit being measured.

Voltage measurements made between two points, both above ground potential, should be made using the following procedure. Measure each point separately to ground, then subtract to find the difference in potentials. This method of measuring causes no appreciable disturbance in the circuit being measured. If the negative lead, which is grounded to the instrument case, were connected to a point above ground, inaccurate readings would result due to the A.C. loading effect of the chassis and the test leads. There is also the possibility of shorting to ground.

The automatic volume control voltage developed in a receiver by the incoming signal can be measured at a number of places. Most common places are the grids of the IF amplifier tubes and the signal grid of the converter tube. This D.C. voltage, if measured anywhere along the grid return circuit on the AVC line, is a convenient output indication during receiver alignment. Resonance will produce the highest negative voltage. Polarity will be negative with respect to ground.

The D.C. voltage developed by the oscillator is always directly proportional to the strength of the oscillation. This D.C. voltage can be measured readily at the oscillator grid of the converter tube. Polarity will be negative with respect to ground.

All voltages encountered in radio service work, of course, can be measured with electronic voltmeters. Even bias cell voltage can be measured -- a thing which cannot be accomplished with an ordinary voltmeter.

The discriminator voltage developed in radio receivers employing automatic frequency control can be measured directly at the discriminator and also at the grid of the oscillator control tube.

By switching to the regular D.C. voltage ranges and connecting to the limiter grid circuit, a useful means of indicating proper antenna orientation and position as well as adjusting antenna matching sections may be found. Maximum readings indicate proper antenna positions and correct matching.

The instrument is useful for measuring the D.C. voltage developed in the picture channel of a television receiver across the second detector load resistor. This measurement is most useful when adjusting antenna orientation and position as well as when adjusting antenna matching sections. Maximum readings indicate proper antenna position and correct matching.

The effect of a gassy tube is to put a positive charge on its control grid instead of the negative charge or no charge at all that would normally be found between grid and ground. A gassy tube will cause the entire AVC system to run positive, resulting in loss of sensitivity. You can measure the voltage directly at the control grid of the tube to determine the polarity of the charge.

The R.F. probe is useful in tracing an R.F. signal from the antenna through to the diode detector plate. After rectification by the diode tube, only the audio frequency component of the signal is left, but the R.F. probe can still be used to trace the signal through to the loud speaker. Gains or losses between stages can readily be measured.

As an example of what might be expected in the R.F. portion of a small AC-DC receiver, the following figures are given. With 100,000 microvolts of R.F. fed to the receiver through a standard I.R.E. dummy antenna, AVC voltage on the control grid of the 12SA7 tube was 5.8 volts D.C. R.F. appeared on the various tubes as follows:

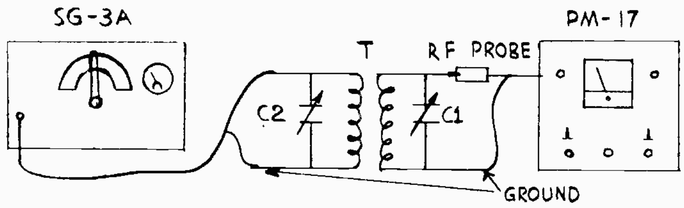
12SA7 converter grid	.13 volts R.F.
12SA7 converter plate	.7 volts R.F.
12SK7 IF grid	.2 volts R.F.
12SK7 IF plate	6.4 volts R.F.
12SQ7 diode plate	3.6 volts R.F.

These figures will, of course, vary with different receivers and circuits, but in general, a minimum of 3 volts should always be found at the diode plate of the second detector.

With the aid of an R.F. signal generator, such as the General Electric SG-3A, the relative merit of similar IF., R.F. and ANT. coils and wave traps, or the frequencies to which they will tune can easily be determined.

The PM-17 electronic VTVM is set up to measure R.F. voltage and is connected to the signal generator and coil as shown in the circuit. The circuit is drawn showing an IF. coil "T." R.F. and ANT. coils are connected in the same manner.

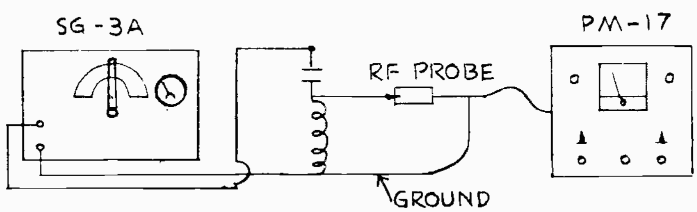
If the frequency of the coil is known, the signal generator is set on that frequency and adjusted to give an output of from 1 to 2 volts. Adjust trimmer C_1 on the coil to give the highest reading on the meter of VTVM. This reading should be noted.



Trimmer C_2 will have little or no effect on the frequency, so it can be disregarded. By connecting another similar coil in place of "T," and keeping the signal generator settings the same and peaking C_1 on the second coil, the relative merits of the two coils can be determined and the better one selected. The coil with the best "Q" produces the highest reading on the meter.

If the frequencies of the coils are unknown, connect the apparatus as before and tune the signal generator until the highest reading is obtained on the meter. The frequency can then be read on the scale of the signal generator.

The frequency or relative merit of wave traps can be determined by connecting it as shown in the circuit below and tuning the signal generator until the highest reading is obtained. The frequency of the wave trap can then be read directly on the scale of the signal generator.



By adjusting the trimmers on various coils and wave traps from minimum to maximum capacity and readjusting the signal generator to obtain the highest reading, the frequency range to which the coils can be tuned can easily be determined.

REVIEW QUESTIONS

1. What are some of the advantages of a vacuum tube voltmeter over the conventional type?

2. Why is the sensitivity of a VTVM much greater than the sensitivity of the meter employed?

3. How is it possible to measure resistance with the basis circuit used for VTVM?

4. What additional circuit parts are needed to measure radio frequencies with an ordinary VTVM?

LESSON 14

POINT-TO-POINT SERVICING

While the presence of correct voltage values at all points cannot guarantee the proper operation of the radio under examination, a wide discrepancy of even a single voltage value may suggest the cause of the existing fault. This is true in equipment which has been properly operating up to the time of the failure, and a singular fault may be rightly expected to be the cause of the trouble.

When a radio set is properly operating, it may be considered to consist of several separate inter-connected stages, each stage operating in a correct fashion. For a stage to give expected operation, certain voltage values must exist at various points. Many faults commonly causing radio failure also have a pronounced effect upon voltages present at associated junction points. The existance of these facts permits the successful application of voltage point-to-point servicing technique.

Power line frequency A.C. voltages may need checking (measurement) in the power supply input and at filament terminals — the only places where these voltages exist in most A.C. operated sets. Measurements from 2½ to 450 volts may be needed. Radio frequency measurements are helpful in determining the degree of oscillation in a superhet, the signal strength, the stage gain, and the power output.

The preference of voltage point-to-point servicing over other methods depends on many factors which in turn depend on equipment available, fault suspected after a preliminary examination, and your personal choice. Further, a change to this servicing method may be made after another technique of radio fault finding did not lead to any conclusive results and suggested voltage point-to-point method as being more adaptable in this instance.

In general, it is best to start voltage tests by determining if correct plate voltage exists at the output of the rectifier. The various types of power supplies are discussed in a later lecture and we will, at this time, only mention at what points this test can be made and what value of voltages can be expected.

The negative prod of your voltmeter (this applies to all types) is in contact with the most negative point — this is usually the chassis. An alligator clip is handy for making this connection to the negative side, and there are clips of this type which hook into regular phone-tips of the test prods.

In some A.C. and automobile sets, the most negative point may not be the chassis. This matter may be checked easily by noting where the center-tap of the high-voltage winding is connected. This center-tap, of course, is the negative point. In the more modern AC-DC radios, the chassis is not connected directly to the negative side of the power supply. In such sets (and also in all other AC-DC types), the negative prod of your voltmeter may be connected to the power switch which is usually on the side of the power line used as the negative side. However, this is not always the case and in some sets the switch is on the positive side. The side of the line in AC-DC sets which leads to the plate of the rectifier tube is positive, so the other side of the line is negative. In battery sets, the negative B battery lead is used as the point for attaching the negative voltmeter prod. If you know that A+ is connected to B-, use A- terminal for this purpose.

The most positive point is at the cathode of the rectifier. In directly heated tubes, the filament serves as the cathode, and one side of the filament is used as the positive point before the filter. In battery sets, B+ of the battery is the point. Test at these points to determine if proper voltage is being delivered by rectifier. Here is a list of typical voltages to be expected:

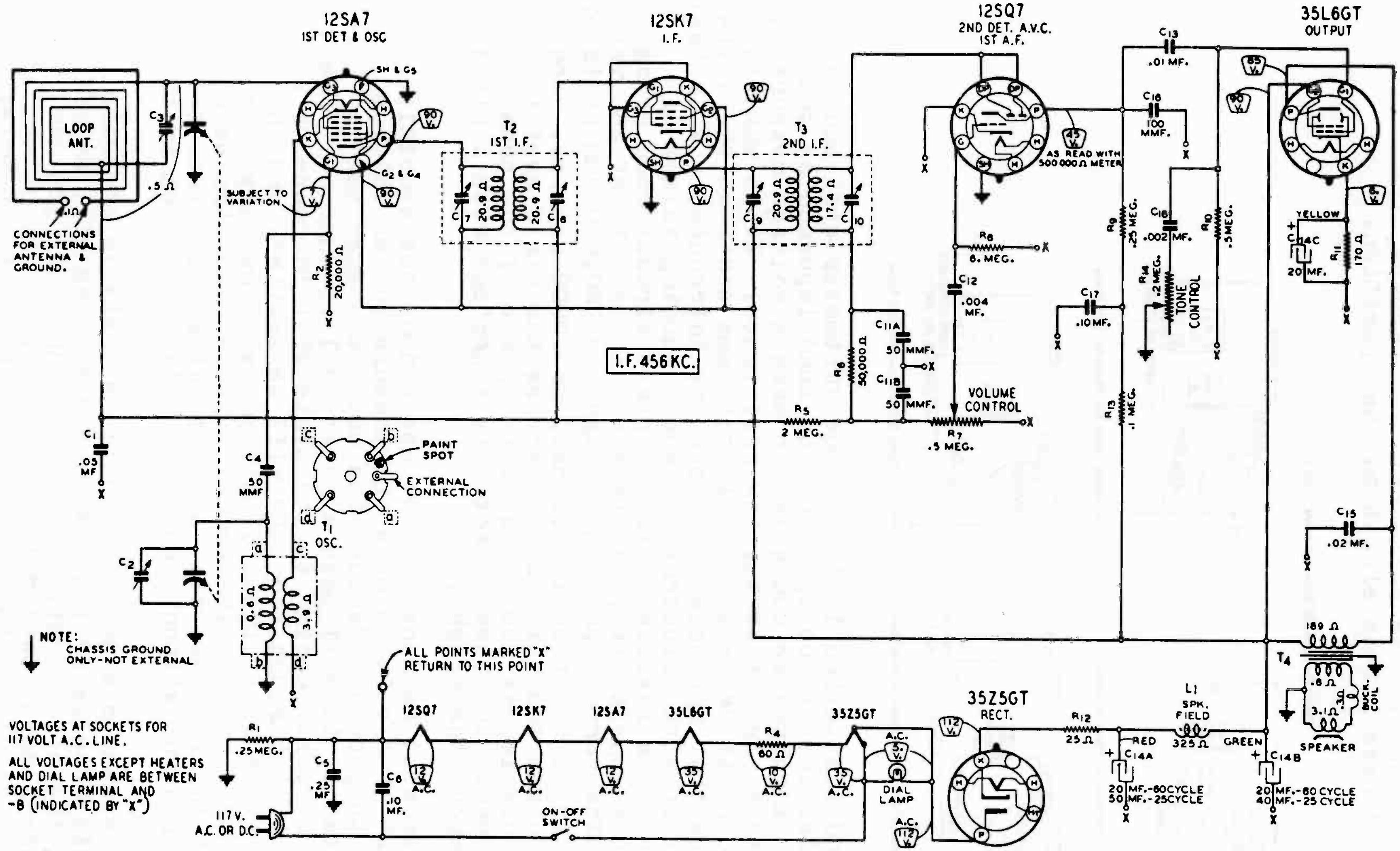
Old style A.C. sets	300 to 400 volts
Recent A.C. and Auto sets	250 to 325 volts
AC-DC sets (half-wave rectifier)	115 to 135 volts

Now we can go further. Test for voltage after filter and then proceed to each tube testing for voltage at various terminals. Values expected become familiar to you from experience. A tube manual is of great help since it gives ordinary operating voltages under various conditions. Circuit diagrams include data on voltages to be expected at points used for tests.

To be efficient in using the point-to-point voltage tracing technique, you must watch for two limitations of this method and overcome them with collaborating tests or use another test technique. One limitation is wide variation in permissible values. If 200 to 300 volts is correct for a certain point in the circuit and you obtain a reading of 200, is this value to be accepted as correct? Perhaps, the set was designed to give 300 volts at the point considered, but you do not know this fact; you know that 200 to 300 is commonly used.

An answer to this type of problem is found in making further voltage measurements. If the voltage is low, something is causing it to be so, and probably voltages in the associated circuits will be definitely on the low side.

Another way to analyze this question is to ask yourself: "If this voltage really should be 300, but now measures only 200,

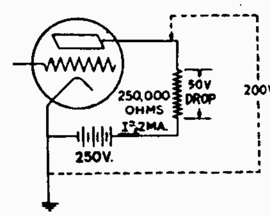


The circuit of Series 5A25-S, Wells-Gardner receiver is illustrated. You will note the helpful voltage values given at various points which can be used as a guide in conducting point-to-point voltage tests. You will observe that these values are measured between the points indicated, and any point marked X. A.C. socket voltages are measured between the terminals, as indicated.

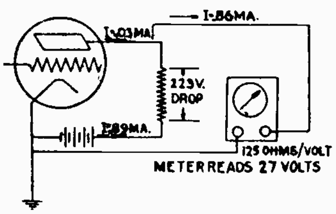
Besides voltage values indicated, others can be measured, but it is not probable that they will give any additional aid not offered by the suggested tests. In measuring unknown voltage, a high enough voltage scale should be selected so that no damage results even if the maximum possible voltage is encountered. If the voltage is smaller than expected, a lower scale may be selected for more accurate measurement.

would the set show the faults which exist?" Perhaps, this voltage difference should have little effect on the operation.

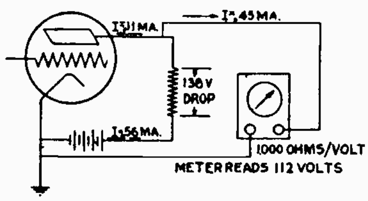
Meter Range—250 Volts Full Scale in All Cases



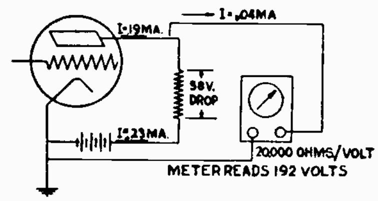
Normal Operation No Meter In Circuit



Conditions Using 125 Ohms Per Volt Meter



Conditions Using 1.000 Ohms Per Volt Meter



Conditions Using 20.000 Ohms Per Volt Meter

The second limitation is due to the voltmeter used and causes the circuit under test to be upset by the load imposed by the meter network. A voltmeter connected to make a voltage measurement is always across a circuit containing resistance. It is when the value of this circuit resistance is in the same order as the voltmeter resistance that appreciable errors are introduced. This fact will be made clear with illustrations above showing values of voltage measured in a resistance loaded plate circuit when using meters of various sensitivity. 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.

A.C. measurements are made in testing the power supply or the existence of continuous filament circuits. In A.C. sets, voltages of various secondaries may be measured. The primary connections should indicate about 115 volts. In the "on" position, no voltage should be present across the switch; in the "off" position, you will obtain a reading almost equal to the line voltage. Filament voltage readings may be taken at the socket terminals. The voltage values should be as expected, but may be slightly higher with tube(s) out of sockets.

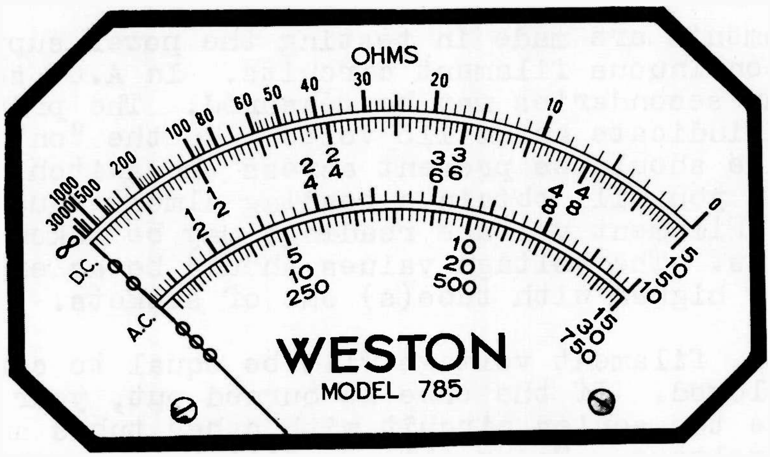
In AC-DC sets, filament voltage will be equal to correct value for tube employed. If the tube is burned out, your voltmeter will complete the series circuit with other tubes and will indicate the line voltage. Under this condition, the voltmeter relatively high resistance is not across any smaller resistance (filament of a tube), and almost the total drop will be across the voltmeter.

The process of translating an incorrect voltage indication to the actual fault which produces it, requires extensive understanding of the function of components included in the circuit. Normally, every component leading to the point under test is suspected and those components which could produce the results indicated by the measurement are individually tested to determine if they are the items at fault. Sometimes voltage tests at other points can be utilized for this additional testing. At other times, the parts in question may have to be tested by other methods or replaced with new components in an effort to locate the actual fault. In general, voltage point-to-point testing is best adaptable when the fault is suspected to lie in those sections of the receiver where D.C. voltage actually exists. The effect of such faults is to produce a "dead" receiver.

Resistance point-to-point testing is especially useful in determining the source of trouble in case voltage is not present in some particular section. This method, however, is adaptable for radio fault finding under other conditions and is a basic technique. The failure of a part or circuit to function properly is accompanied with a pronounced change of some resistance value. Therefore, the finding of a considerable variation from normal in a resistance measurement usually suggests what item is at fault.

To use resistance servicing method successfully, knowledge of expected resistance values for various circuit elements and their combinations is essential. Realization of equivalent resistance values obtained with elements in series and parallel must also be known. These subjects will be discussed.

An ohmmeter is employed for resistance point-to-point testing, and, for safety sake, the power in the radio under test should be shut off (or batteries disconnected) when this testing is conducted. Actually, many tests could be made with an ohmmeter while the radio power is on, but there is always a possibility of making contact across points of voltage difference and thereby damaging the meter.



FACSIMILE SCALE

An ohmmeter should provide means for determining values commonly encountered in radio service work. However, the more popular instruments will not measure accurately above 1/2 megohm, and higher values if present cannot be tested.

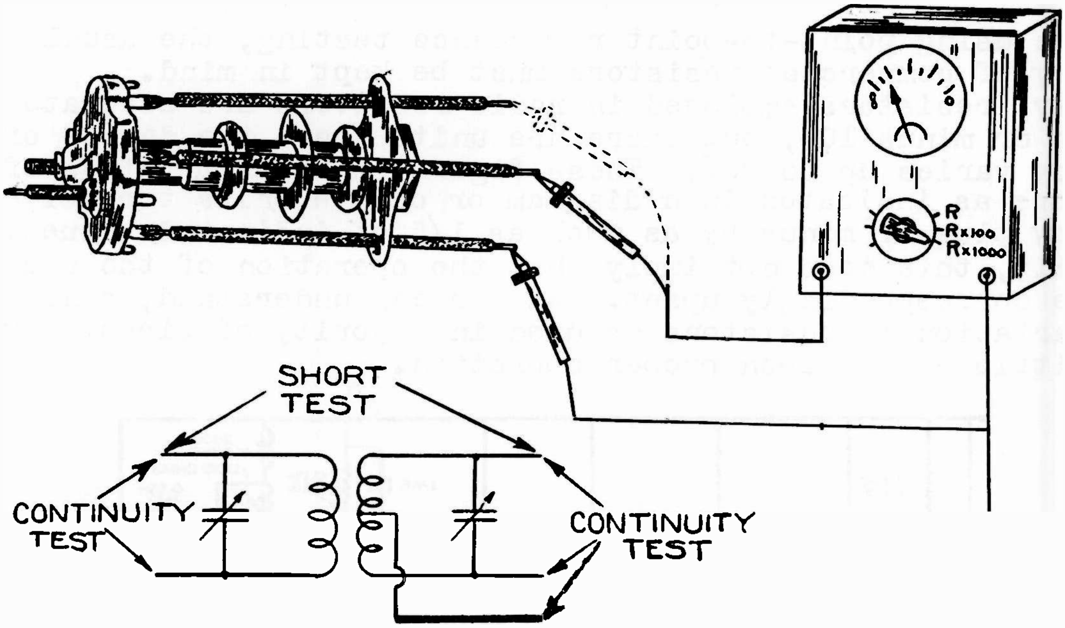
Let us review what values of resistance various components used in radio receivers will indicate when tests are made. Resistors, of course, should indicate their correct values within the expected accuracy of about 10%. You should exercise care in making certain that the resistor you are measuring is not actually shunted by others, for in that case, the combination is in parallel and an entirely different value may be obtained. This subject of parallel effects will be discussed in greater detail. If you are not certain concerning possible shunts, disconnecting one side of the resistor to be tested will eliminate this possibility.

A volume control (potentiometer) can be measured from the center tap to each side. The two values so obtained for any one setting should add up to the total resistance of the control. A control may also be tested for proper operation by connecting the ohmmeter to the center tap and one side, and rotating the shaft. The resistance should vary as the control is adjusted.

Paper and mica condensers should indicate infinite resistance implying open circuit for D.C. At times, if you test a condenser in a circuit shortly after shutting off the set, the condenser still may have a charge and will cause the meter needle to move. However, this movement will be of a temporary nature and an open circuit condition should be indicated shortly thereafter.

Variable condensers are usually shunted by coils of small resistance and will require wires to be disconnected if high resistance range of the ohmmeter is to be used for test purposes. If low resistance range is employed, you will be able to tell if the condenser is shorted (zero resistance) or if you are obtaining the value of the resistance of the coil connected in parallel.

Polarity must be observed in testing electrolytic condensers. The probe wired closest to the positive terminal of the ohmmeter



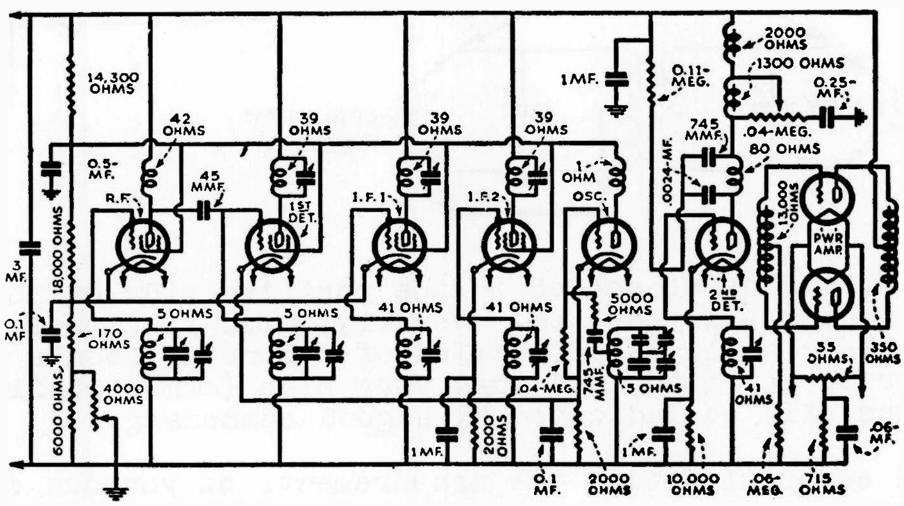
battery should be connected to the positive side of the electrolytic condenser being tested. Usually, upon first being connected, there will be a slight inflection of the meter needle while the condenser is charging, and then very high (almost infinity) resistance will be indicated by a good condenser.

In connection with the measurements of various coil and transformer windings, we are presenting below a table which gives values that may be expected in majority of cases. There are, you understand, exceptions to these values, and the table is given only to serve as a guide.

R.F. Coils, Primaries	10 to 65 ohms
Secondaries	1 to 10 "
Antenna Coils, Primaries	3 to 50 "
Secondaries	1 to 10 "
I.F. Coils, Primaries	20 to 200 ohms
Secondaries	20 to 200 "
Power Transformer, Primary	1 to 15 ohms
H.V. Winding ...	200 to 600 ohms
Filament Winding	Very low
Output Transformers, Primaries	300 to 800 ohms
Secondaries ..	1/5 to 8 ohms

A radio tube in good operating condition will give a value of resistance approximately equal to its filament voltage rating, divided by its current rating. The information to compute this can be obtained from your tube manual. Tests between the different tube elements should indicate open circuit, unless, of course, some of these elements are connected directly with each other or through other parts in the circuit.

In using point-to-point resistance testing, the usual accuracy of commercial resistors must be kept in mind. Normally, resistors employed in radio receivers are accurate to plus or minus 10%, but there are units where the degree of accuracy varies up to 20%. These figures mean that values of resistors as indicated in a diagram or on the units themselves may vary plus or minus by as much as 1/5 of indicated values. Naturally, this does not imply that the operation of the receiver will be correspondingly upset. As you can understand, considerable variation in resistors as used in majority of circuits will have little effect upon proper operation.



The understanding of these facts, however, is important, since when you are actually measuring resistors, you must realize that variations mentioned are normal and do not indicate possible faults. You must further understand that certain resistors may vary even a greater amount due to other causes, but even a larger variation in some circuits will not influence proper operation. In particular, resistors used in plate, grid, filter, and AVC circuits are not critical.

In proceeding to test a radio receiver, the ohmmeter should be located for easy visibility and you should hold one prod in each hand. In this manner, you can quickly make the needed contacts, and firmly holding the tips of the prods in place, observe the indication on the ohmmeter. We again caution you to watch for round about paths which may shunt the item you are intending actually to measure and may introduce errors in reading.

The circuit included above on this page is an illustration of values obtained in a typical radio set. You will note that the values of actual resistors are indicated. In the case of measuring a parallel combination, such as the 6,000 ohms fixed resistor, and the 4,000 ohms potentiometer (both located in the lower left hand corner of the schematic), one of these items has to be disconnected in order to obtain individual values and not a value for the two units in parallel.

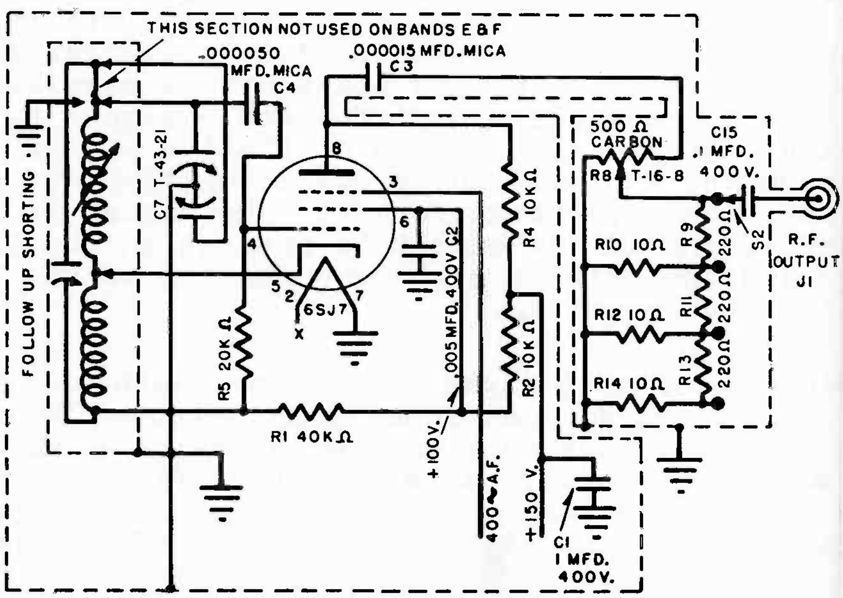
LESSON 15

SIGNAL GENERATORS AND SIGNAL TRACERS

A signal generator is essentially a small transmitter designed to produce various frequencies required for service and laboratory work. Primarily a signal generator is used by a radio serviceman for alignment, but it is also adaptable for solving other service problems.

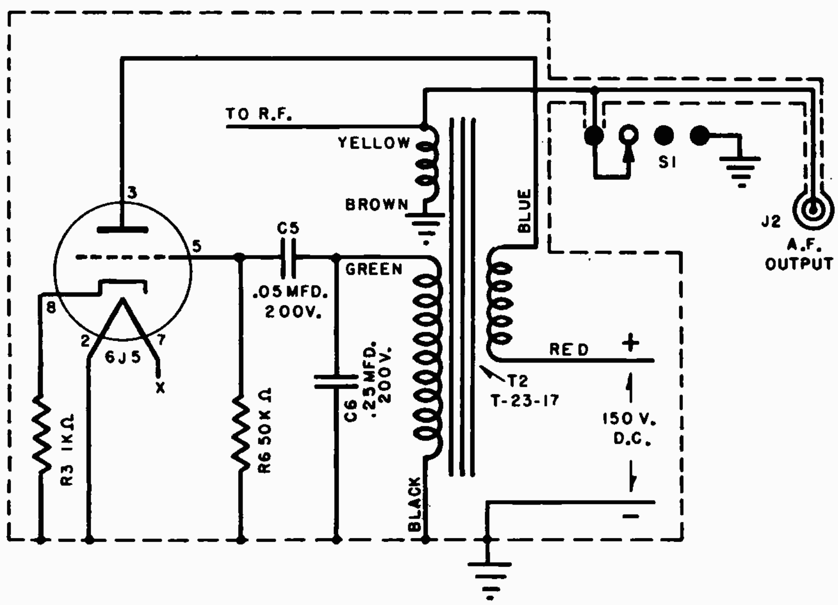
To mention briefly, a signal generator may be used for localizing the source of trouble in a radio receiver, detecting the stage producing distortion, testing individual parts, measuring gain, various audio and fidelity tests, and many other applications which can be used to simplify the job of a radio serviceman.

In a R.F. signal generator, an electron-coupled oscillator circuit is employed to produce adjustable radio frequencies. With this type of oscillator, the variations in the load have little effect upon the frequency. Tuning (adjustment of the frequency produced) is accomplished with a variable condenser. The tuning condenser control dial is carefully calibrated and is usually accurate to within 1%. The frequencies available are generated with several different coil-arrangements which are selected and connected to the tuning condenser of the circuit by means of a band-switch. A practical R.F. signal generator may cover frequencies from 100 KC. to 90 MC. This includes all I.F. frequencies used and also the usually employed communications frequencies. The coverage may be obtained in six or seven steps.



Simplified R. F. Oscillator Circuit

In most units, the higher frequencies are not actually generated as fundamentals, but are obtained as harmonics of the highest frequency band for which L-C is actually provided.



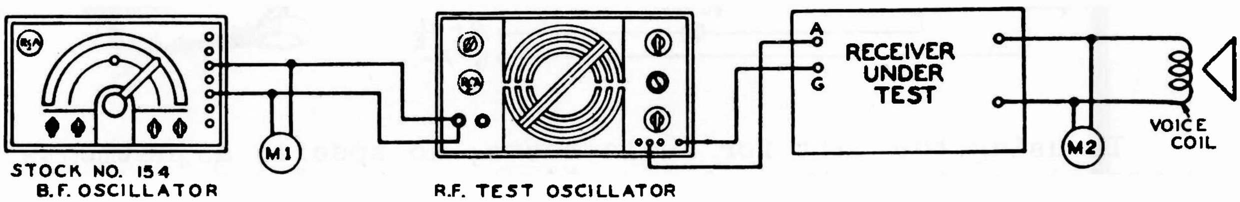
Simplified A. F. Oscillator Circuit

A separate audio signal generator circuit is usually included in conjunction with the R.F. signal generator circuit. The audio signal produced may be of a single frequency (400 cycles commonly used), or several different frequencies may be available for selection. The intensity of the audio signal superimposed on the R.F. carrier may be controlled. This is known as the percentage of modulation and 30% is popular. Also the audio frequency output may be used separately.

A signal generator may be used for locating faults in radio receivers and as an aid for properly aligning all types of 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 of the first I.F. transformer. The signal is applied to any one stage, and if the output is present in the loudspeaker, this stage and the balance of stages leading to the speaker may be assumed to be operating.

With the aid of a signal generator, each stage of a radio receiver can be tested individually and distortion can be detected. A higher accuracy in judging results can be obtained with the aid of an oscilloscope connected first to the signal generator direct and then to the output of the stage to observe effects produced on the signal. If intead of an oscilloscope, a vacuum tube voltmeter is used, stage gain can be measured.

Radio receiver audio fidelity tests are used to determine the over-all electrical fidelity characteristics of the complete receiver. This test is accomplished by applying a modulated R.F. signal to the input of the receiver and measuring the output voltage (at various modulating audio frequencies) across the loudspeaker voice coil. See sketch below which is reproduced through the courtesy of R.C.A. Manufacturing Company.



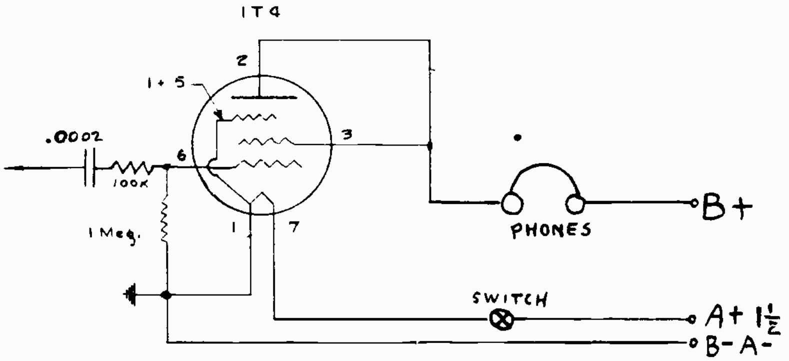
Connections for Radio Receiver Fidelity Measurements

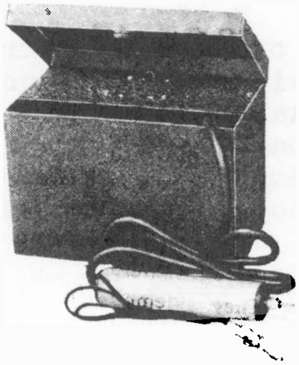
Audio frequency signal generators are designed to produce signal frequencies between 30 to 15,000 cycles per second. Some of these units employ standard type of oscillators with the components designed to produce the required audio frequencies. Suitable inductors and capacitors for this purpose would be quite large and could be made variable only with the greatest difficulty. However, it is possible to produce audio frequencies by beating (combining in a non-linear impedance) two radio frequencies differing in frequency by the number of cycles required to produce the audio frequency. In practice, two R.F. signal generators and associated equipment are built-in a single case. One generator circuit produces a fixed R.F., while the second has its frequency variable and easily altered with a regular tuning condenser. If the frequencies of the two R.F. generators, for any one adjustment, differ (for example) by 800 cycles, then an 800 cycle audio signal is produced.

Signal Tracing Techniques

In 1945, simplified versions of signal tracing instruments were released. These lower priced instruments permitted one to listen to the existing signal at various points in the radio under test, and either incorporated a meter or had provisions for connecting a meter for comparative measurements.

The Feiler Model TS-1 is a very simple instrument and an examination of its basic schematic below will suggest its mode of operation. The capacitance-resistance input network will not upset or de-tune the circuit under test. When operated at R.F. or I.F. frequencies, this network provides correct values to convert the type 1T4 (pentode connected as a triode) to a grid leak type detector. Because of the small value condenser, the unit will produce louder signals from higher frequencies. This is just what is wanted since by operating more efficiently at R.F. than I.F., the unit can automatically adjust for the greater signal level of I.F. signal obtained from a radio under test.

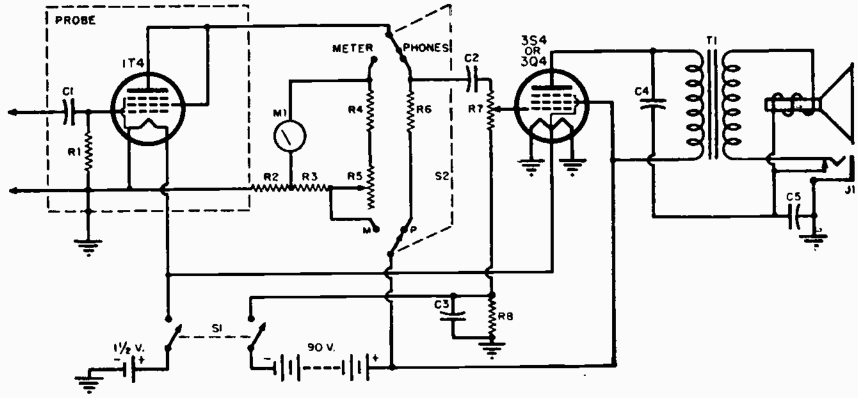




In using the unit for audio tests, no special adjustments are needed; in fact, there is no adjustments needed for any test and the probe can be touched safely to any point of the circuit. In this application, the impedance of the grid condenser and grid leak form a voltage divider network, and only a fraction of the strong incoming audio signal is impressed on the grid. The impedance of a small condenser at audio frequencies is very high; for example, at 1,000 cycles, a .0002 mfd. condenser will have an impedance of about 750,000 ohms. This automatic action is also what is wanted and the signal is reduced to a value that can be handled by the tube with its very small bias obtained from a voltage drop in the filament and from contact potential voltage.

The output from this single stage (when used with a 67½ volt plate battery) is sufficient to operate a pair of head-phones. In this manner, it is possible to test for the signal at all points of a radio receiver without any adjustments at all and without risk of damaging the test unit or the radio.

The Superior Model CA-12 signal tracer was described in a past issue of RADIO NEWS and we reproduce the schematic of this unit through the courtesy of this magazine. The input arrange-ment is similar to the unit we just described. A meter is in-

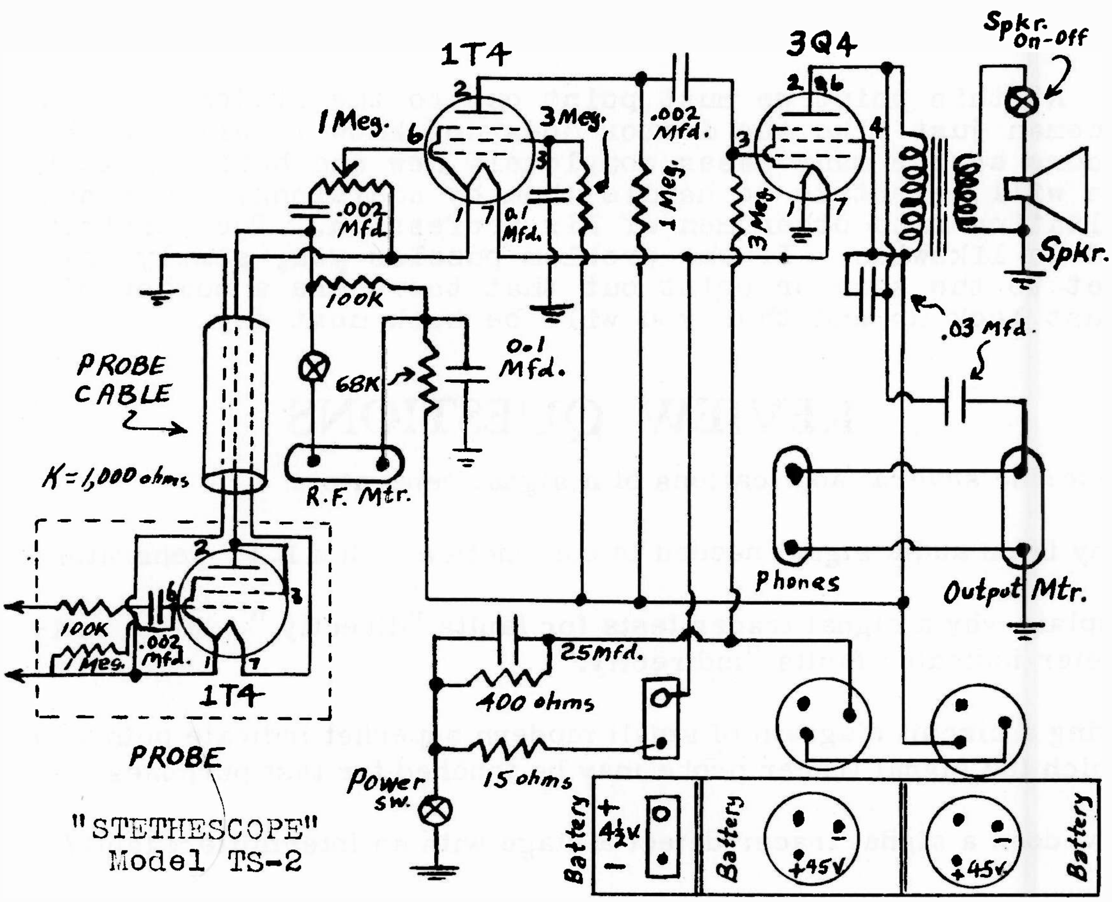


R_1—20 megohm, ½ w. res.
R_2—20,000 ohm, ½ w. res.
R_3—1000 ohm, ½ w. res.
R_1, R_8—500 ohm, ½ w. res.
R_5—500 ohm rheostat
R_6—50,000 ohm, ½ w. res.
R_7—500.000 ohm pot.
G_1—.0002 µfd. mica cond.
C_2, C_4—.025 µfd., 200 v. cond.
C_3—4 µfd., 10 v. elec. cond.
C_5—.002 µfd., 200 v. cond.
S_1—S.p.d.t. sw.
S_2—2-pole, 2-pos. sw.
M_1—0-1 d.c. milliammeter
T_1—Output trans., 10,000 ohms plate to voice coil
J_1—Closed circuit jack
1—1T4 tube
1—3S4 or 3Q4 tube
1—4" PM Speaker

corporated in the plate circuit and permits the use of the instrument as a vacuum tube voltmeter to measure input signal strength. To obtain audio output from the loudspeaker of the tester or separate phones, a double-pole double-throw switch is used to connect the output of the probe-tube to an audio amplifier stage employing either a 3S4 or 3Q4 pentode.

From the schematic diagram of the Feiler "Stethescope" Model TS-2, you will observe that the unit incorporates the probe section and an additional two-stage audio amplifier to produce the output from the loudspeaker included. The unit is battery operated and, in this way, is self-contained and is adaptable for portable use. There is also an A.C. model which has a built-in power supply. A regular 0-1 ma. meter can be connected for observing the intensity of the R.F. signal. Phone terminals are also provided.

We will now outline the general servicing procedure in using signal tracers of the type described. With the aid of a signal tracer it is possible to locate quickly the section of the radio receiver which is causing the difficulty. For this purpose, the ground lead of the tester is connected to the radio chassis and the probe is touched to points where signal is expected, progressing from antenna to speaker. The point beyond which the signal is no longer obtainable is in the section which contains the fault.



"STETHESCOPE"
Model TS-2

As you progress with the test suggested, the signals should become stronger. Should any of the tests indicate a weakening of the signal, the stage preceeding this point is not operating properly and is producing a loss instead of a gain.

To locate an intermittent fault, the probe is placed on points where signal is to be expected, progressing from antenna to speaker. For each test made, try to obtain the intermittent failure, so that you can determine where the fault producing this failure lies ahead of the point under test or beyond this point. For example, if you are testing at the plate of the first I.F. tube, the turning the set on and off, shaking it, touching and pushing various parts, or doing similar things which ordinarily produce the intermittent condition, in this case do not cause the intermittent to appear in the output of the signal tracer, you can form the following deduction. Since in the test described, portions of the radio set ahead of the point under test were in the circuit serving the signal tracer output, but did not produce any intermittent indication, then these sections (ahead of the point) must be in good operating condition. The fault lies beyond the point at which you are testing. Further, tests after this point will isolate the stage and suggest the parts that may be at fault.

Test for noise, hum, or distortion is carried out in a similar manner. In alignment work, a signal tracer may be employed as the audio output indicator.

At this point we must point out to the student that a radio serviceman just like the doctor does not know it all. A physician will come across many cases completely new and baffling to him, but he will undertake to handle them by additional study and consultation with other men of his profession. The serviceman should do likewise. If the problem puzzles you, simply take the set to the shop or point out that there are a number of facts you must look up and that you will be back next day.

REVIEW QUESTIONS

1. Describe several applications of a signal generator.
2. Why is an audio signal needed in conjunction with a R.F. generator?
3. Explain why a signal tracer tests for faults "directly," while a voltmeter indicates faults "indirectly."
4. Using a circuit diagram of small modern superhet indicate points to which the signal tracer probe may be touched for test purposes.
5. How does a signal tracer detect a stage with an intermittent fault?
6. Can you think of a radio fault that could not be found with a tracer?

LESSON 16

USING AN OSCILLOSCOPE FOR SERVICING

The cathode ray oscilloscope is an indispensable tool for the radio laboratory and can be a valuable aid to a radio serviceman in performing repair work. The heart of the unit is the cathode ray tube. This we will discuss first. The need for the associated circuits then will become obvious. Sweep circuits, flat-response amplifiers, focusing arrangements will be explained before we review the technique of operating a cathode ray oscilloscope and interpretation of visual results obtained.

A cathode ray tube is a vacuum tube so designed that electrons emitted from a cathode (located at one end) are concentrated into a narrow beam. This beam is influenced by electrostatic or magnetic fields and is caused to impinge upon a screen at the opposite (wide) end of the tube. This screen becomes fluorescent at the place where the electron beam makes the impact and, as the beam varies from side to side and up and down, the image produces a pattern. The nature of the pattern depends on changes of intensity taking place in the associated electrostatic or magnetic fields.

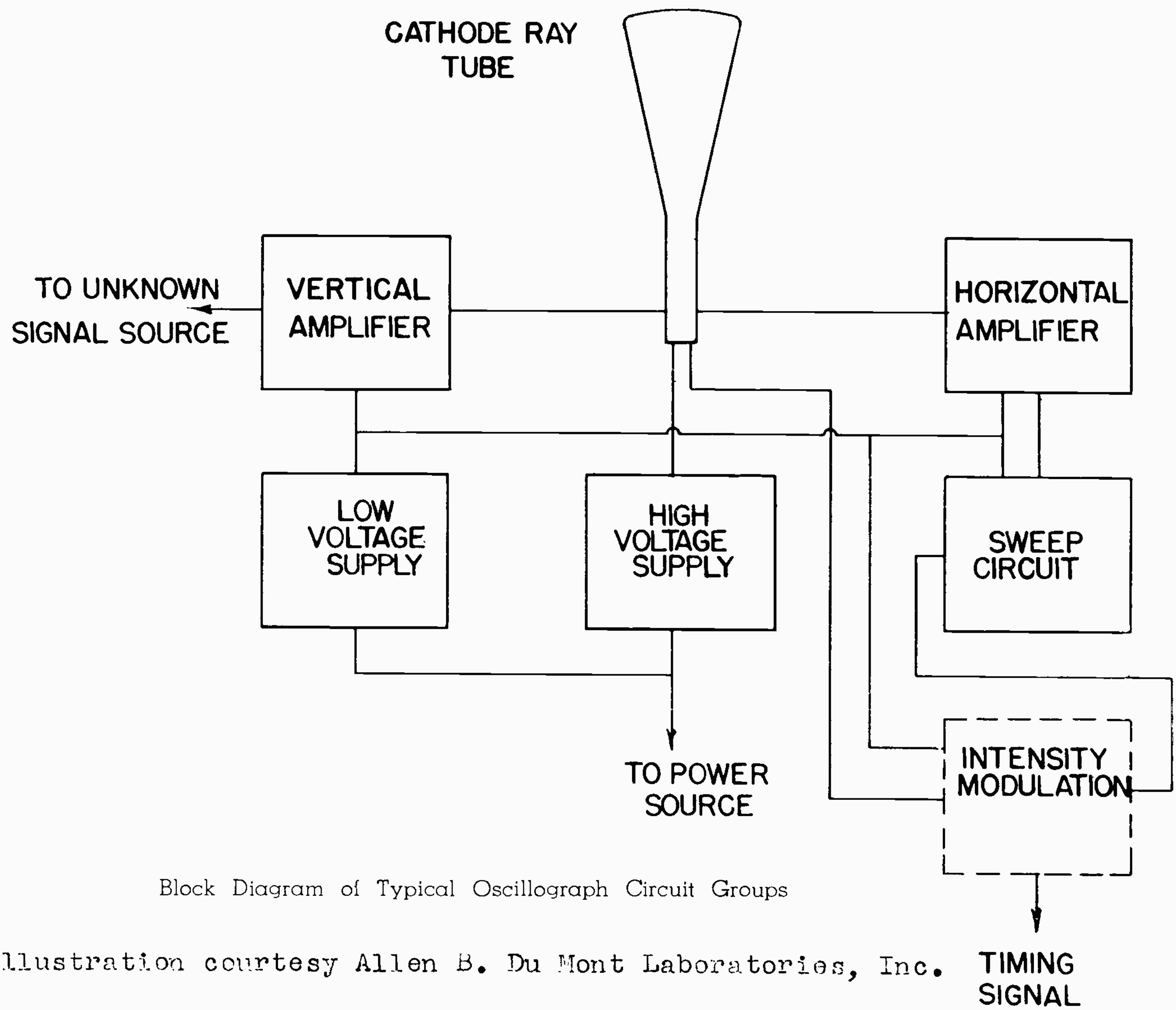
A cathode ray tube in itself is not a complete indicating device. In order to produce a simple spot on the fluorescent screen, the proper high voltages must be applied to the various electrodes. Usually a single power transformer is used with two separate power supplies; one of conventional type and another to supply high voltages needed for the cathode ray tube.

As pointed out in the "Reference Manual" copyrighted by Allen B. Du Mont Laboratories, a source from which we will quote at length on the subjects of sweep circuits and amplifiers, the combination of the cathode ray tube and suitable power supply is enough to form the indicator element. Since the cathode ray tube is relatively an insensitive device requiring potentials of several hundred volts for full deflection, a suitable amplifier is needed to increase the usual input voltage of much lower magnitude to acceptable value.

While the amplifier will permit the study of small voltages, it will also impose limitations on the character of signals that can be transmitted by the amplifier. With the unknown signal applied directly to the deflection plates, the maximum amplitude observable will be limited only by the full scale deflection of the beam; the maximum frequency which can be applied is limited by the transit time of the beam passing between the deflection plates, and also by the shunt capacitance between deflection plate terminals.

Applying a direct current voltage to the plates will deflect the beam proportionally to the magnitude of that voltage, and the beam will remain fixed in its deflected position until that D.C. deflection voltage is removed. Therefore, there is no low frequency limitation when direct connection is used. In fact, it is the application of a direct current voltage, controllable in magnitude, that is used to position the beam in both horizontal and vertical directions in the complete oscillograph unit.

When an amplifier is interposed between signal source and deflection plates, the signal will be faithfully reproduced only if the limitations of the amplifier are not exceeded. These limitations include frequency discrimination both in the amplifier and input attenuator circuits, phase distortion, and the



Block Diagram of Typical Oscillograph Circuit Groups

Illustration courtesy Allen B. Du Mont Laboratories, Inc.

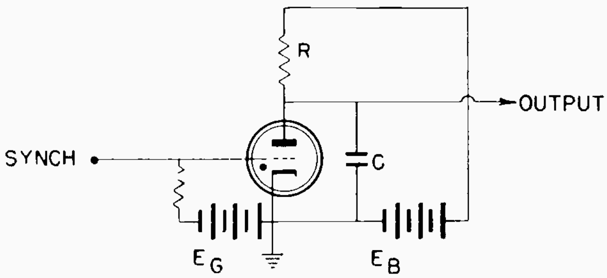
maximum allowable direct current and peak input voltages. The minimum signal voltage is determined by the least amount of beam deflection which can be tolerated for effective study, and therefore by the gain of the deflection amplifier. The maximum voltage which can be applied is limited by the voltage rating of any input coupling capacitances and the voltage range of the input amplifier stage. Of course, a radio frequency signal will not be passed by an audio frequency amplifier, nor will a direct current signal be amplified by an alternating current amplifier. Attention must also be directed towards the gain or attenuation control, since the effects of the variable distributed capacitance depending on the setting of the rotor in a high resistance potentiometer can cause extreme phase and frequency distortion.

A very important consideration in choosing an oscillograph is the frequency response characteristic of the vertical axis amplifier. Many applications of an oscillograph require the observation of pulses, square waves and other non-sinusoidal waveforms. Therefore, not only must the sinusoidal response be uniform, but the transient response must permit undistorted amplification of irregular wave shapes.

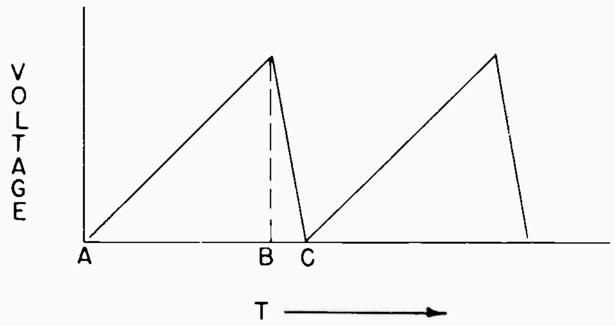
This amplifier discussion thus far has been restricted largely to the vertical axis. Similarly, these considerations apply to the horizontal amplifier. For most applications, the signal applied to the horizontal deflecting plates provides for the movement of the spot at a uniform rate with respect to time. Such a signal provides the time-axis along which is plotted the unknown variable voltage. After the spot has traveled the width of the screen, it snaps back to its starting position and the process is repeated. Without going into a detailed discussion of the generator which supplies the horizontal voltage, it will suffice to say that the waveform of this time-axis deflecting voltage is usually of a saw-tooth nature, and therefore, is rich in harmonic content. Since this saw-tooth voltage is amplified by the horizontal amplifier, the frequency and phase characteristics of that amplifier should permit undistorted amplification of sinusoidal signals of frequencies extending both far above and below the saw-tooth recurrence rates. Frequently, the saw-tooth frequency range is from a few cycles per second to over 50,000 cycles per second, so that quite stringent requirements are imposed on the frequency response characteristic of this amplifier.

It is also desirable for the horizontal and vertical amplifier to have identical phase characteristics to facilitate accurate study of the relationship between two different signals, each being applied to a separate axis.

The linear time-base generator or sweep oscillator is the integral part of the oscillograph unit which generates the saw-tooth voltage producing the linear time-base referred to above. The time-base is not restricted to a linear function, but can also be a sinusoidal, circular or spiral function or any other shape that may be desirable for particular applications.



Basic gas triode sweep oscillator circuit



Linear time-base voltage waveform

The saw-tooth wave is generally developed by a relaxation oscillator in which a gas discharge tube is used.

A feature of the sweep oscillator is its ability to synchronize its frequency of oscillation with the frequency of the unknown signal so that in cases of recurrent phenomena the spot begins its excursion each period at the same point on the wave of the unknown. The resulting luminescent pattern is a stabilized wave. With the pattern "locked in," the rapid retrace of the wave many times a second will give the appearance to the human eye of a "still photograph" because of the persistence of the fluorescent-phosphorescent screen on the cathode-ray tube coupled with the persistence of human vision.

The subject of blanking or intensifying the beam naturally brings to mind the application of beam intensity modulation for other purposes. In the case of television, the grid of the cathode ray tube is modulated by a voltage which causes the spot or trace to become lighter or darker in accordance with the voltage variations. This same principle may be used in oscillographs to provide timing demarcations, or reference points on the trace or pattern. These timing marks can be provided by an external oscillator or pulse generator whose frequency is known. Other times, the signal available for beam modulation is less than that needed for extinguishing the beam, and therefore, an amplifier is needed. This amplifier is commonly known as the Z-axis amplifier. A further use for this provision is to intensify the beam over portions of the trace where the writing rate of the spot is so great that the fluorescent screen is not sufficiently excited. Thus, the intensity is more uniform throughout the entire trace and photographic exposure is facilitated. Furthermore, the portion of the trace which is most interesting is often the least visible. This provision will prevent burning and damage to the fluorescent-phosphorescent screen caused by operation of the intensity control at maximum (i. e., zero bias) in an attempt to improve the total visibility.

Focusing of the fluorescent spot is accomplished by varying the ratio of the voltages applied to the two anodes. Regulation of the spot size and intensity is accomplished in some tubes through the variation of anode current of one of the plates. Variation in the bias voltage applied to the control grid will permit this adjustment. In practical equipment, of course, these adjustments are made by means of variable resistors (potentiometers) mounted on the control panel.

We will now talk about the actual operation and application of a commercial oscilloscope. For this purpose we will discuss Supreme Corp. Model 546 unit.

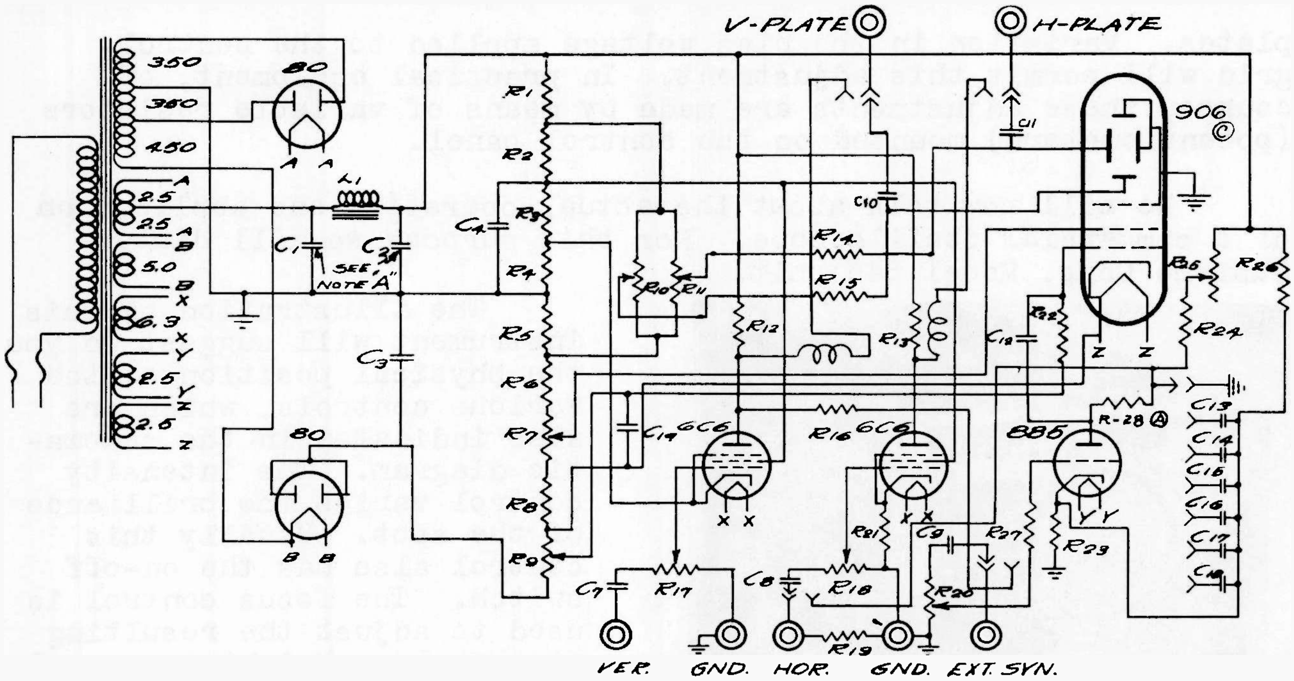
The illustration of this instrument will suggest to you the physical position of the various controls, which are also indicated in the schematic diagram. The intensity control varies the brilliance of the spot. Usually this control also has the on-off switch. The focus control is used to adjust the resulting picture to a bright image and is dependent on the adjustment of anode voltages for proper electron-optical focus.

Bearing in mind that any picture or trace obtained consists of a moving dot of light, you can understand that it may be required to shift the position of the dot or the complete picture. For this purpose, the vertical position and horizontal position controls are employed. These adjustments are accomplished by varying D.C. voltages applied to both sets of deflecting plates; potentiometers R_{10} and R_{11} are used for this purpose.

The gain controls are potentiometer voltage divider networks at the input to the vertical and horizontal amplifiers. These parts are marked R_{17} and R_{18}. In the unit described, these controls are not connected unless the respective amplifier gain controls are placed in operation.

Means are provided for using the internal sweep or for changing the circuit so that an external sweep can be employed. Provisions are also incorporated for eliminating the horizontal amplifier when external sweep is employed.

In using the internal sweep, a special saw-tooth oscillator becomes connected to the circuit and produces a changing voltage which sweeps the beam across at an adjustable frequency and returns the beam from extreme right to left in a very short fraction of the total cycle. Since it is not practical to produce all frequencies in the saw-tooth oscillator with a one set of components, in the oscilloscope described, six steps are employed



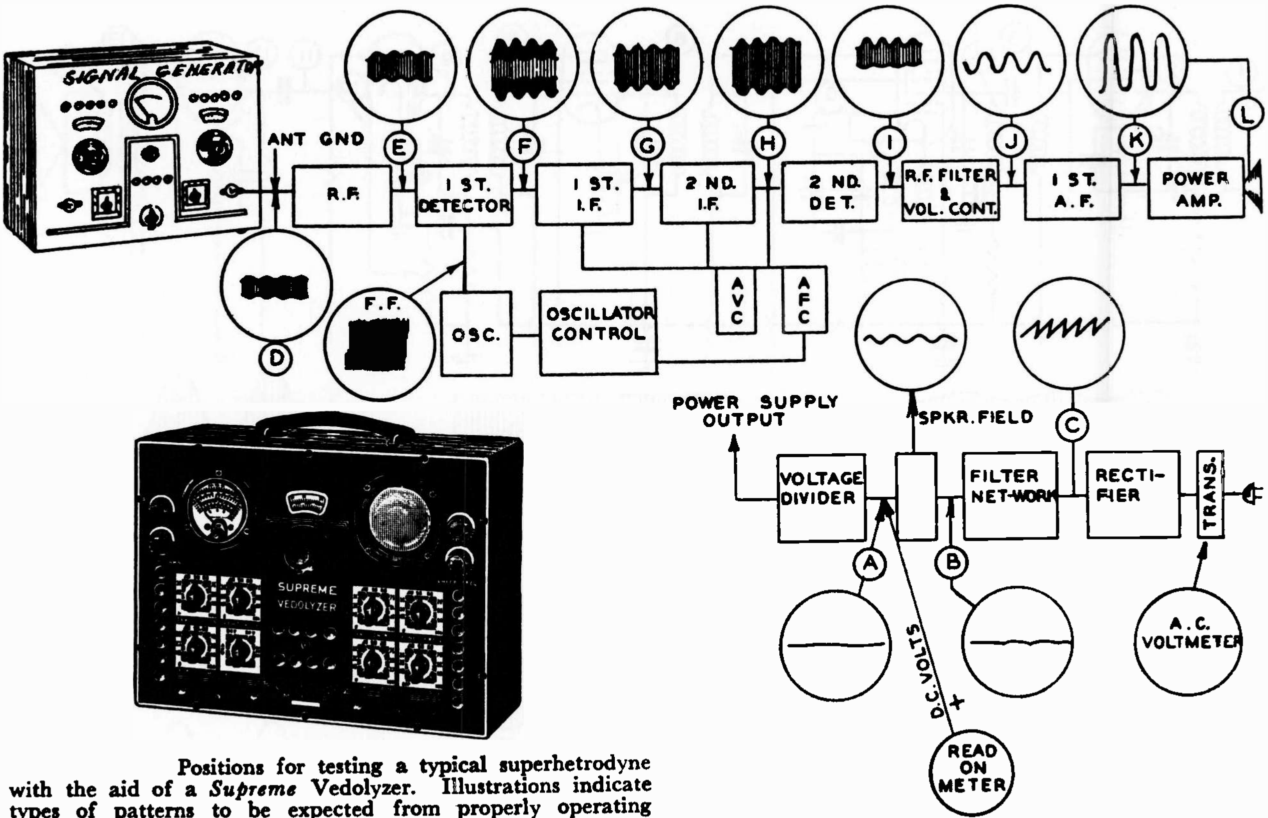
Symbol	Ohms	R-9	200,000	R-18	4 megohms	R-23	1,000	Symbol	Mfd.		
R-1	25,000	R-10	4 megohms	R-19	1 megohm	R-24	1 megohm	C-3	0.5	C-12	50 mmfd.
R-2	10,000	R-11	4 megohms	R-20	15 megohms	R-25	4 megohms	C-4	8.0	C-13	0.37
R-3	10,000	R-12	50,000	R-21	1,000	R-26	100,000	C-7	0.1	C-14	0.04
R-4	220	R-13	100,000	R-22	500,000	R-27	100,000	C-8	0.1	C-15	0.01
R-5	250,000	R-14	1 megohm			R-28	500	C-9	0.05	C-16	0.0025
R-6	750,000	R-15	500,000			Symbol	Mfd.	C-10	0.5	C-17	600 mmfd.
R-7	500,000	R-16	1 megohm			C-1	4.0	C-11	0.25	C-18	200 mmfd.
R-8	100,000	R-17	1 megohm			C-2	4.0			C-19	0.5

covering from 15 to 30,000 cycles per second and overlapping each other for easy adjustment. Once the band of sweep frequencies, which include the frequency required is selected, the fine frequency control (potentiometer R_{25}) is used to achieve the exact adjustment.

The understanding what the various controls do will permit you to make the necessary adjustment to view any pattern obtainable from equipment under test. It is important to have the spot moving at all times in order not to burn out the fluorescent screen.

For a serviceman, a cathode ray oscilloscope is especially useful for checking voltage wave forms, as an aid in alignment, as a peak voltmeter, for measuring phase shift, for detecting and measuring distortion, for frequency measurements, and as a visual indicator in signal tracing. We will briefly describe these applications.

To study a wave form, the source of voltage is connected to the vertical amplifier and a sweep frequency is selected that will permit the viewing of a single cycle or several cycles. By eliminating the horizontal sweep from operating, the voltage input to the vertical amplifier can be measured. The actual height of the "line" produced will be in proportion to twice the peak voltage impressed. By comparing this height to some other known value of A.C. voltage, the unknown peak voltage can be estimated. In using D.C. voltage for comparison purposes, please



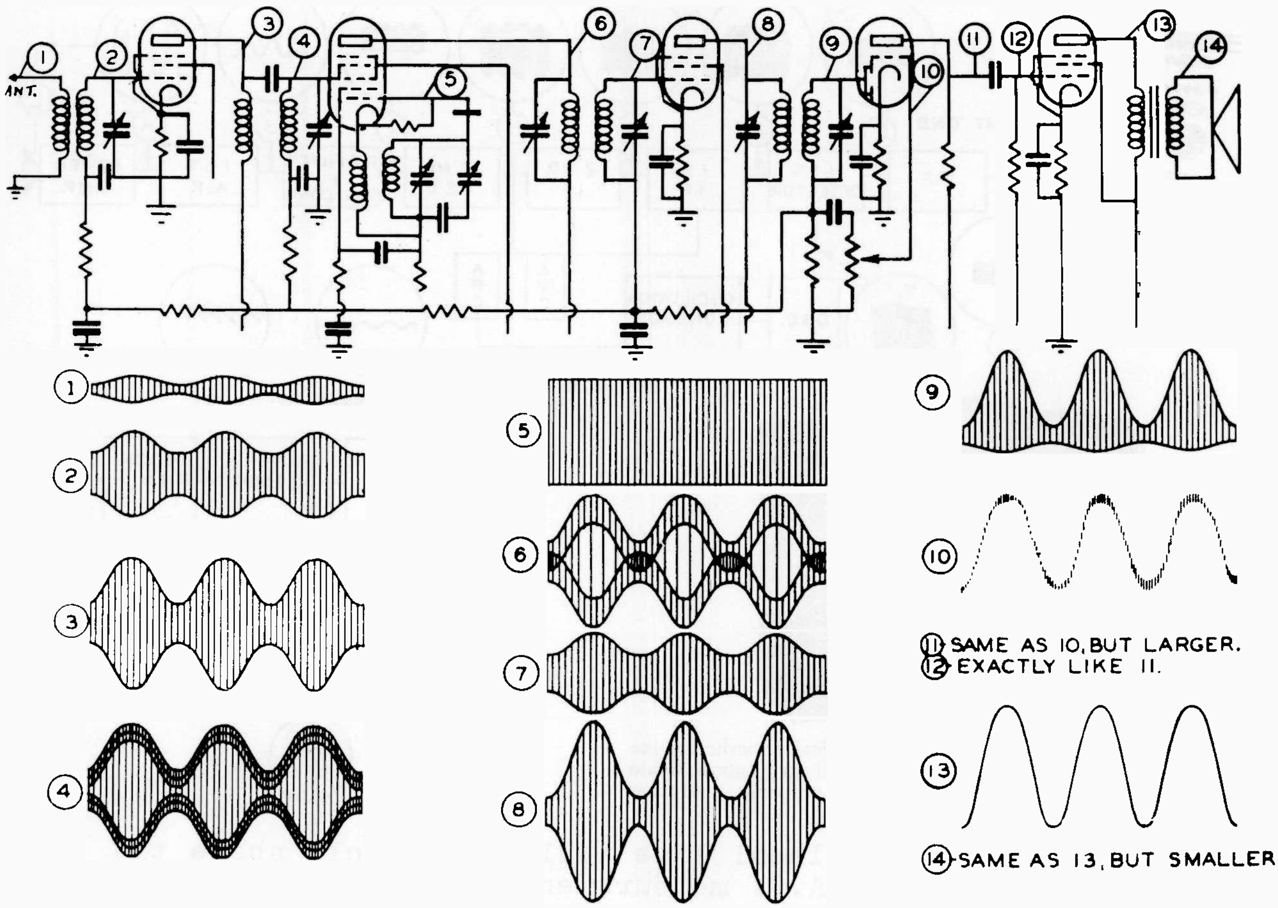
Positions for testing a typical superhetrodyne with the aid of a *Supreme* Vedolyzer. Illustrations indicate types of patterns to be expected from properly operating circuits.

bear in mind that the visual line will appear only above the center mark, while for A.C. measurements, the line appears above and below and actually gives twice the height as compared to the same value D.C. A signal can be examined with the aid of a cathode ray oscilloscope before it enters a piece of equipment, and a further visual examination of this signal from the output of the equipment will indicate any changes or distortion produced by the equipment. For this purpose, special apparatus is available that will permit the examination of both patterns at the same time and, thereby, simplify the comparison.

In alignment work, with the aid of a proper sweep arrangement, the response curve can be viewed on the scope and exact adjustments carried out for best operation. This type of alignment is especially beneficial in high fidelity radio receivers and in frequency modulation equipment.

While the majority of signal tracers depend on hearing an audio signal or measuring voltage values, as indicated on a tuning-eye tube or a standard meter, additional information can be supplied by a cathode ray oscilloscope used in conjunction with the signal tracer. In fact, Supreme Instruments have built a visual type signal tracer.

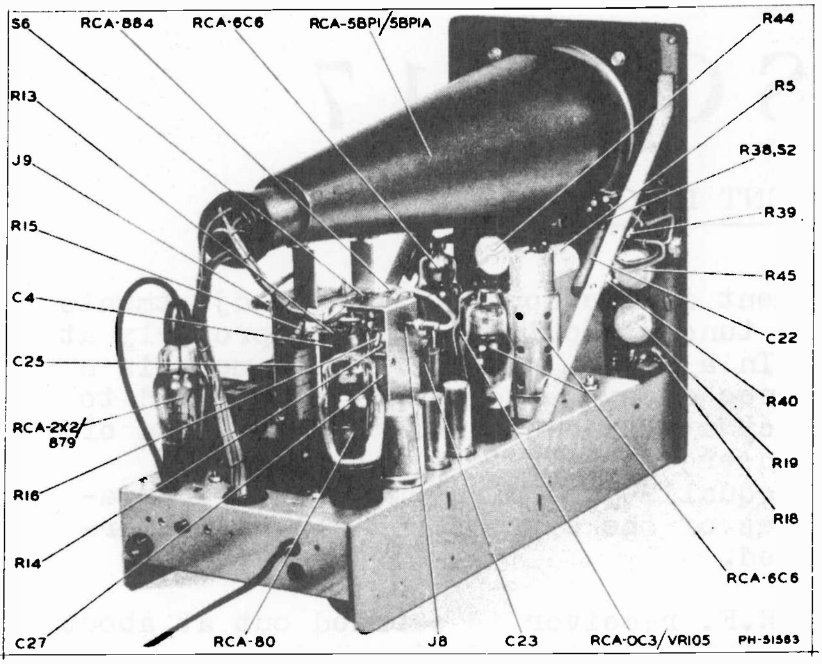
The shape of a pattern obtained on the cathode ray tube depends on the value and phase relationship of the voltages applied to the deflecting plates. These patterns are useful

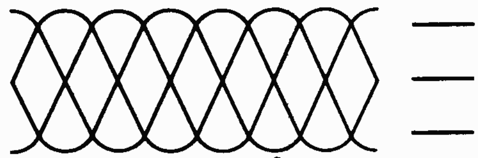


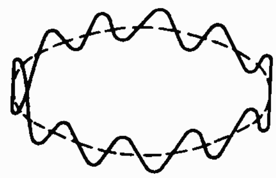
for the study of voltage and phase relationship and supply information about the unknown voltage applied to one set of plates when the character of voltage applied to the other set of deflecting plates is known.

It is important to understand that the electron beam of the cathode ray tube is influenced by both sets of deflecting plates at the same time. For example, if equal sine wave voltages are applied to both sets of plates, the pattern obtained will be a line of 45 degree slope, provided the voltages are in phase. The reason for this result becomes clear, if you bear in mind that the instantaneous values of both voltages are equal at all times and the beam is shifted equally towards one of the horizontal plates and one of the vertical plates.

If two identical voltages of the same amplitude, but out of phase by 90 degrees are used instead, a circle pattern is produced. If the amplitudes are not equal, an ellipse will result. If besides the difference in amplitude, the phase differs by 45 degrees, a figure similar to an ellipse, but slanting to one side, will be produced. Figures so far considered are of the simpler Lissajou's types. From the pattern obtained on the screen of the scope, the frequency and phase relationship of the two voltages can be determined.







As the ratio of the frequencies increase, the pattern obtained becomes more complex. Ratios under 10 to 1, can be determined without difficulty. In general, it is difficult to judge the ratio directly from the picture without the knowledge of some tricks. One such tricky method is to count the number of horizontal lines of intersection, see illustration. Add one to this number and the result is one number of the required ratio. The other number of the ratio is obtained by counting the peaks at the top (or bottom, but not both) of the pattern.

For the study of ratios greater than 10 to 1, the wave form is produced on a circle or ellipse. A phase splitting circuit consisting of a condenser across one set of deflecting plates and a resistor across the other plates will displace the pattern around the ellipse for easy analysis.

REVIEW QUESTIONS

1. How is a pattern produced on the screen of a cathode ray tube?
2. Why must the amplifiers used in a cathode ray oscilloscope have good frequency response characteristics?
3. What are the main applications of an oscilloscope in radio servicing?
4. How is an oscilloscope used as a signal tracer?
5. How can a frequency of an unknown sine wave be determined by comparing it to one of known frequency?

LESSON 17

ALIGNMENT INFORMATION

The process of alignment is the combination of adjustments carried out to permit every tuned circuit to operate properly at each setting of the dial. In a T.R.F. receiver, alignment is a relatively simple matter since every tuned stage is intended to operate at the same frequency at any one time. Each section of a multi-gang variable condenser is shunted by a trimmer and these trimmers are used to equalize the minimum capacity variations due to stray capacities of the circuit and slight differences in inductances employed.

The alignment of a T.R.F. receiver is carried out at about 1,400 KC. and adjustment of trimmers is made to produce maximum signal. Once adjustment is made at this frequency, the receiver tuned circuits will track at lower frequencies since greater amount of capacity of the variable condenser will be in effect and any small additional differences will represent only minute fractions of this capacity.

In a superhet, as you know, the several tuned circuits function at entirely different frequencies but their adjustments are interdependent. For optimum results, the adjustments must be correctly made and carried out in the proper sequence.

The I.F. transformers are usually double tuned and will give maximum gain and best selectivity response when employed at a frequency for which these coils were designed. This frequency varies in radios of various makes and the period in which the sets were produced. In modern sets, the I.F. is between 455 and 470 KC. Some of the older sets used I.F. of 175, 260 KC., and other values.

For correct tracking, the oscillator of a superhet must generate a frequency usually above the signal frequency and differing from it by the I.F. value. When the oscillator frequency is higher, the tuning capacity must be smaller to give the required frequency range. This tuning capacity is made smaller in practical circuits by employing a cut-section condenser or by connecting a padder, which is a small semi-variable condenser, in series with the gang of a regular tuning condenser that is used for the oscillator section.

The antenna and oscillator coils (in some larger sets an R.F. coil is also used) are so designed that with a given cut-section condenser (or regular condenser and correctly adjusted padder) it is possible to adjust the trimmers at the high frequency band and have correct tracking at all other frequencies. This design, of course, is based on the I.F. used, and this is another reason why correct I.F. adjustment must be made.

In the process of tuning a superhet receiver slightly out of alignment, the oscillator section has a much more pronounced effect upon the tuning adjustment since the antenna (and R.F. if used) sections are broad enough to pass the signal of a station even if slightly detuned. Under such conditions, a given station will be received at some incorrect, but not much removed, point on the dial. At this setting, the signal of the station wanted will "ride through" the detuned antenna (and R.F. if used) sections, while the particular adjustment will produce in the incorrectly adjusted oscillator a frequency higher exactly by the I.F. of the set. This suggests that the dial reading is corrected by adjusting the oscillator section trimmer.

In performing alignment, means must exist for comparing the intensity of the output as adjustments are made. Listening to the output is one method, but it is not very reliable since the human ear is not critical to very small changes in sound intensity. If the set is equipped with a tuning indicator such as an electron-ray tube, shadow-meter, or plate milliammeter, these devices can be employed to indicate resonance. A vacuum tube voltmeter may be connected across the A.V.C. junction point and ground; with this arrangement, resonance will be indicated by maximum voltage. An A.C. voltmeter of low range can be connected across the voice coil, or a higher range of such a meter in series with a paper dielectric condenser can be inserted across the primary of the output transformer.

In sets with A.V.C., steps must be taken to nullify this action while carrying out alignment work. If you are able to carry out the alignment while feeding a very weak signal, the A.V.C. will not produce any effect under such a weak signal and the response will be directly related to accuracy of the alignment. When using a weak signal, you should have the volume control of the receiver wide open.

In sets where a stronger signal is needed, the A.V.C. by trying to keep the output intensity constant will prevent you from judging true effects of the adjustments, and in such sets A.V.C. must be prevented from operating during alignment. Where a separate A.V.C. tube is used, this tube may be removed without impairing the operation of the receiver except for lack of automatic volume control action. In other sets, it is permissible and quite a simple matter to ground A.V.C. bus to remove this action. There are sets where this simple means of nullifying A.V.C. cannot be made and in such sets you can disconnect I.F. stages grid returns from the A.V.C. and connect these returns to ground or similar point.

A signal generator is essential if the I.F. stages are out of alignment to a considerable degree. If you have another set properly operating and having the same I.F., you can couple these to carry out the I.F. adjustment without a signal generator. If the I.F. amplifier is not too far out of alignment, a signal generator lead may be connected to the signal input grid of the oscillator. A small mica condenser is wired in series with this lead and also the ground lead. The I.F. trimmers may be adjusted in any order in such case.

In some sets, where the owner may have attempted the repair himself, you may find it impossible to get the signal through both transformers of the I.F. amplifiers. The best procedure under such circumstances is to adjust one transformer at a time. Connect the signal generator to the grid of the I.F. tube preceding the output I.F. transformer and adjust the trimmers of this transformer. You may find it necessary to find a signal generator frequency which will get through. If this frequency is above the correct I.F., turn the trimmers clockwise to increase capacity and lower the adjusted frequency of the I.F. transformer. In this manner, you can approach the correct adjustment. Then return to the converter tube and complete the adjustment of the I.F. amplifier.

There are receivers having the trimmers located apart from the coils of the I.F. transformer. A few transformers you encounter may be triple tuned, while many midgets have the second I.F. transformer of the single tuned type. In all these cases, the alignment practice is as described. As the volume output increases with improvement of gain obtained by adjusting the circuits to resonance, the volume should be reduced with the attenuator of the signal generator and not with the volume control of the set.

In carrying out the alignment of the I.F. amplifier, the turning of every trimmer should have a noticeable effect on the volume of the output or the indicator employed. Lack of such action will suggest an open coil, shorted trimmer, or a stripped adjusting screw. The factory engineers design I.F. coils so that the trimmers can give considerable variation from the optimum I.F. If you find that the trimmer adjusting screw must be tightened completely or left very loose, suspect trouble.

Although high frequency adjustment in most superhets should be performed at 1,400 KC., many manufacturers specify different frequencies and you should watch for such variations. If a station operates in your locality at the very frequency suggested for alignment, a slightly different value should be employed. In a few sets, the manufacturer's instructions give a high frequency at the end of the dial calibration for setting the oscillator trimmer and another high frequency for completing this alignment.

High frequency adjustments are made after the I.F. is aligned. A signal generator set at the correct frequency is connected to the antenna or coupled loosely to the loop of the radio with the aid of three turns of hook up wire about 8 inches in diameter. In alignment work if your signal generator provides for percentage modulation adjustment, a value between 30% and 50% will give best results.

The radio receiver dial is adjusted to a frequency corresponding to the frequency being produced by the signal generator. This is usually about 1,400 KC., but, as we have mentioned, other frequencies may be suggested by a manufacturer for certain radio sets. The adjustment of the oscillator trimmer should permit you to obtain proper response without changing the dial setting. The antenna trimmer need not be touched at this time since this circuit is broad enough to pass the signal frequency even if considerably detuned.

After the oscillator section is adjusted, the antenna trimmer adjustment is made. In radio sets using R.F. pre-selector, this stage is adjusted at the very end. You may find it advisable to go back and recheck all points of alignment including I.F. trimmers. Sometimes slight additional adjustment is possible for further improvement of response.

In superhet receivers using a cut-section condenser, no other adjustment is needed and the set should now work properly at all frequencies. In case you cannot obtain successful results at low frequencies and are certain that the alignment work has been correctly carried out with a good signal generator, adjustment at the low frequency end can be made by bending the outside plates of the variable condenser, which are notched for this purpose. You can understand that bending these plates slightly, no effective change will be produced on your high frequency adjustments, since these plates engage the stationery plates only at the lower frequencies.

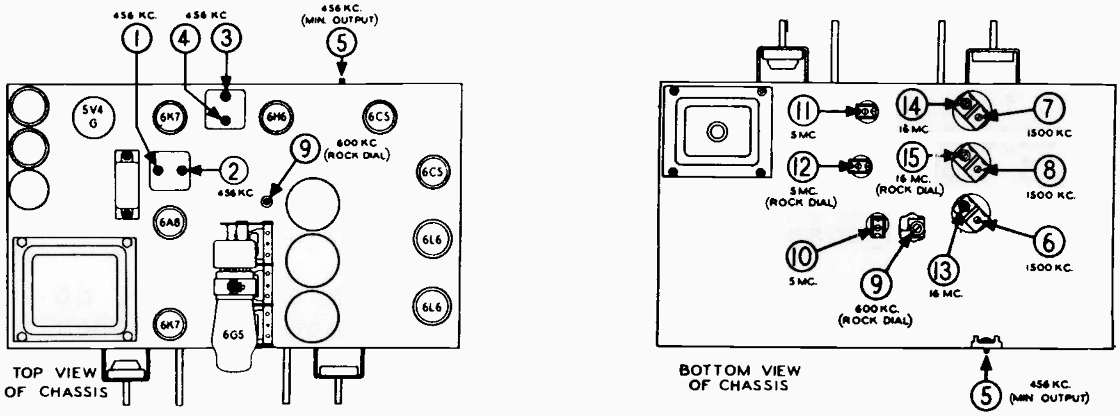
In case an ordinary gang condenser is used, a padder is provided for adjustment at about 600 KC. This frequency is not critical but is recommended by most manufacturers.

In low frequency adjustment, the signal generator is set to produce 600 KC., and while the radio dial is rocked up and back past the 600 KC. point on the dial, the padder is adjusted for maximum signal. The rocking action need not be employed and the adjustment may be carried out at 600 KC. with the objective of having the signal intensity drop above and below this frequency.

A word of caution is in order to those who have not yet handled receivers that incorporated a fixed mica condenser in series with the padder. Many times this fixed condenser is the one that causes the trouble and this difficulty is not easily detected.

In radio sets providing reception on more than one band, the same procedure for adjustment of the I.F. is carried out first of all. Unless there are manufacturer's instructions to the contrary, the broadcast band is aligned next. In multi-band receivers, the trimmers may not be supplied on the variable condenser or, if they are included, may not be employed for alignment. Usually each set of coils has its own separate trimmers mounted near corresponding coils.

If the short wave bands included have "independent" trimmers, these can be adjusted with the lowest frequency band first. In some sets, the adjustment of some one trimmer may effect an adjacent band and in such cases the alignment procedure must be carried out in the proper order.



In general, the alignment of multi-band receivers is involved because it is difficult to find the proper trimmers that correspond to the various bands. Charts similar to that illustrated are provided with circuit diagrams to permit easy location of these trimmers. Another problem is the possibility of adjusting the oscillator to produce an incorrect frequency which nevertheless will have a value that will result in new frequencies (due to harmonics) which may pass through the I.F., but not permit the receiver to operate at its maximum efficiency.

In carrying out alignment on short-wave bands, it is also helpful to know the correct frequencies for the high and low positions of the alignment. If these frequencies are not available, it is usually possible to guess by using the corresponding variable condenser position for each band after the broadcast band, but changing the wavelength switch and adjusting the signal generator to the corresponding frequency.

We will now consider a few possible troubles. The failure of any of the trimmers to have an effect on the response may be due to an open secondary or broken lead to the trimmer. Should you experience an improvement in response as any one trimmer is tightened, but find it impossible to tighten beyond a certain point, this shortcome will suggest that the oscillator trimmer has been tightened too far, and probably the dial scale does not read correctly. Similar trouble may occur at the other extreme when you are forced to loosen the trimmer to a point where the set screw no longer engages the threaded bushing.

LESSON 18

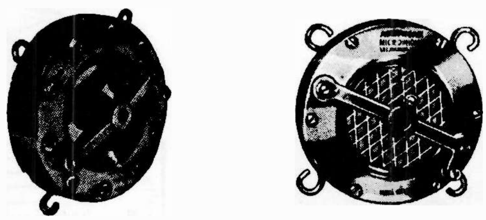
AMPLIFIERS, PUBLIC ADDRESS, AND HIGH FIDELITY

Principles of PUBLIC ADDRESS SYSTEMS

When a large group of people is to be served with a common program, public address equipment finds its application. Most often a speaker's voice is amplified to a suitable volume to make him audible to all present. Radio programs and phonograph records also serve as a means of the input. If the program originates some distance from the amplifier a line is used to connect it to the input. In talking picture work a photo-cell serves as a means of input and requires a special pre-amplifier.

Essentially, a P.A. system consists of one or more of the sources of input mentioned above, the amplifier or any pre-amplifiers necessary, and the output in the form of one or more loud-speakers so placed as to take the greatest advantage of the acoustics. These various parts of P.A. systems will be taken up in detail with additional data on volume controls and measurements of related factors.

CARBON MICROPHONES

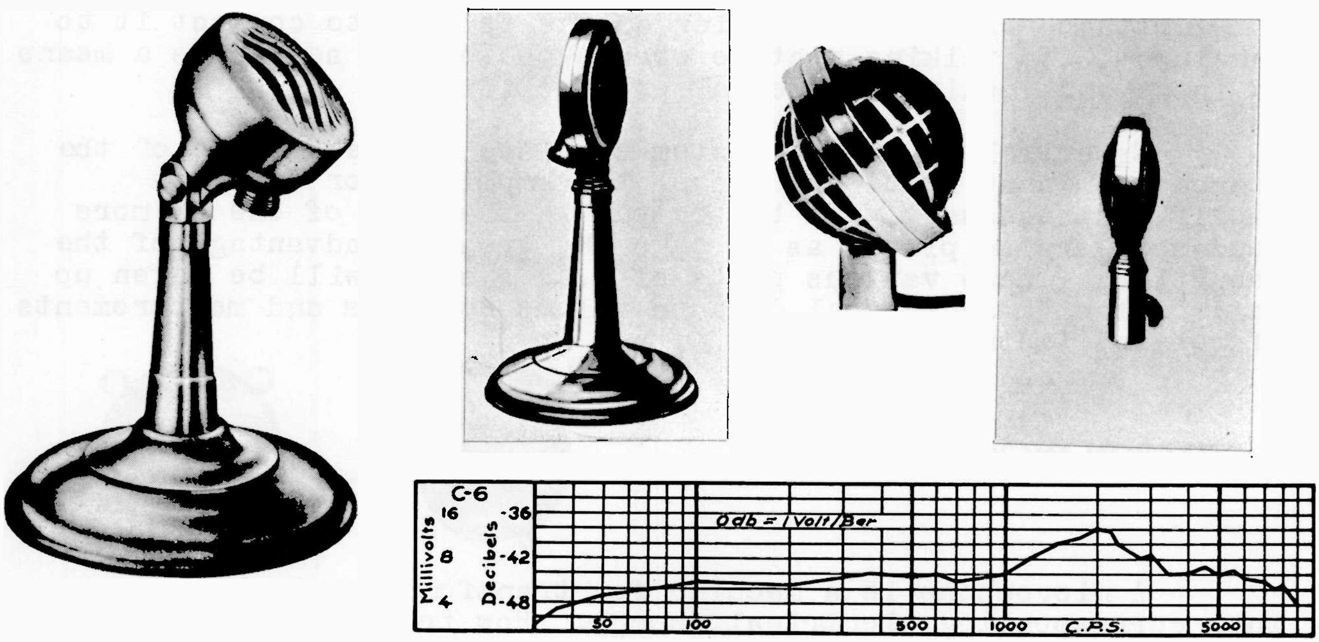


A microphone is a machine for transforming the sound waves into corresponding electrical energy. How truthfully it performs this task is the test of its excellency. Years ago a common microphone in P.A. use was the two-button type. Being a carbon microphone it depends for its operation on the varying resistance of the carbon granules with the pressure of the waves produced by sound which strikes the diaphragm. As the diaphragm fluctuates, corresponding fluctuations in the resistance of the carbon occur and vary the current passing through. In the two-button microphone, one button is placed on each side of the diaphragm and so operate exactly out of phase. This electro-acoustical push-pull arrangement gives better quality.

The thin metal diaphragm will resonate at a certain frequency and cause an increased output at this frequency. The better grade microphones have their diaphragm stretched so that resonance occurs at the upper end of the audible frequency range. This may be further reduced by air damping. The output of a two-button microphone is in the order of −40 DB; and the impedance is commonly 200 ohms per button. A transformer is used to couple this type microphone to the load.

The condenser microphone may be mentioned for its historical interest. If a variable condenser is connected to a source of potential, the charging current will vary with changes in capacity. The diaphragm of a condenser microphone constitutes one of the plates of the condenser, while the back-plate acts as the other plate. The capacity so formed is in the order of 200 micro-micro-farads, and the maximum variation in capacity is only 0.01 per cent.

Into the head of the condenser microphone is built-in a two stage resistance coupled amplifier to bring the output signal strength up to that of a two-button microphone. Batteries are usually employed as the source of condenser potential and for filament and plate supply of the pre-amplifier.



Various types of crystal microphones and a typical response curve.

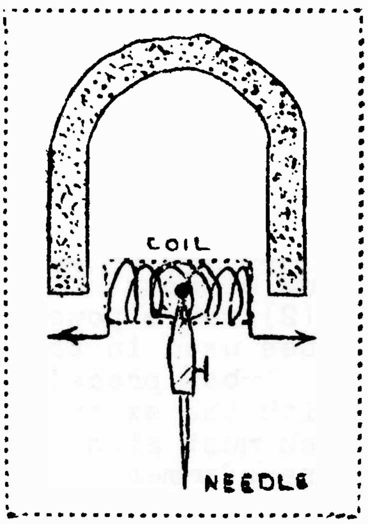
The crystal microphone employs a piezo-electric crystal as a generating element. A crystal when subjected to stresses of sound waves produces corresponding changes in electrical potential generated by the crystal element. The output level of a crystal microphone is, of course, much lower than that of a carbon microphone, usually in the order of —60 DB, and requires either a suitable pre-amplifier or a main amplifier of a high gain type. The crystal microphone has absolutely no background noise and the response is not effected by the position of the microphone nor by reason of moving it about while in use.

The velocity microphone has been more recently developed and because of its excellency over the other types is finding extensive application in better public address equipment. Velocity microphones have an output of about the same value as the output of crystal type and may be obtained in high impedance types for direct coupling to the control grids of vacuum tubes.

The velocity microphone has highly directional qualities and will not pick up background noises. This greatly assists in reducing the possibility of reproducing undesireable noises. This type of microphone further has no internal "hiss noises" and possesses quite flat response characteristics over a wide audio frequency band.

As a means of radio input an ordinary tuner is utilized. This may be of the tuned radio frequency type or a superheterodyne. The latter is preferred because of its better selectivity. An automatic volume control is essential as a powerful local may literary blow the people out of the hall before the manual control is adjusted. The second detector should be of the diode type as no further audio frequency amplification outside of the final P.A. amplifier is needed. If a triode tube is used, the plate should be connected to the cathode for diode operation. Two A.V.C. circuits are illustrated below.

Phonographs records are made for rotation at 33-1/3, 45, and 78 RPM (revolutions per minute). The 78 RPM records have been made for years and are supplied in 10 and 12-inch sizes. (Children's records may be smaller). The 33-1/3 RPM records are "long playing" or LP and are also supplied in the two sizes mentioned. The 45 RPM records are made primarily by RCA and are supplied in 7-inch size. Both manual and automatic record players are available with adjustments to permit the use of a single unit for playing at any of these three speeds. The pickup needed varies for the use at these different speeds. At present it is possible to secure a pickup with a single cartridge to serve at all these speeds. A few years ago crystal pickups of reversible type were employed, and you may even find units with two distinct pickups.

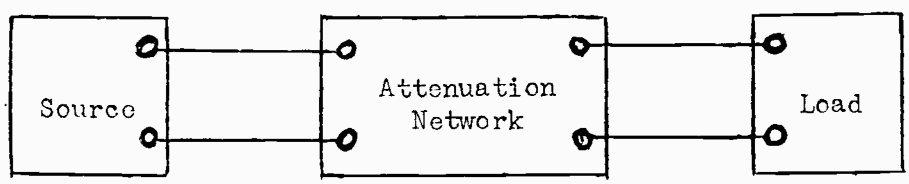


A pickup arm may consist of a permanent magnet within which is pivoted a coil of wire directly connected to the needle. As the needle works along the groove of a record, the uneveness of the grooves sets the needle in vibration. The needle being connected to the coil by mechanical means, the motion is transformed to the coil which in moving cuts the lines of force of the permanent magnet. A current is set up in the coil. This current corresponds to the recorded sound. Crystal pickups working on a different principle are also used.

One of the difficulties encountered in phonograph reproduction is needle-noise. This may be removed to an extent where it may be considered negligent by means of a band filter.

If the source of input is some distance from the amplifier, a line is used for transmission purposes. It is advisable to use shielded cable for this purpose, thereby reducing the chance of picking up stray currents. Usually be means of transformers the impedance of the connecting line is made equal to 500 ohms. This impedance of 500 ohms is used because many standard audio frequency components are made to match this frequency.

Where the audio power must be reduced in the audio amplifier, this is accomplished with the aid of attenuation networks built up of resistive branches. All circuits possess capacity, inductance, and resistance. Of these three, only resistance does not change over wide limits of frequency and, therefore, must be adapted in the circuit for the purpose of controlling the volume. With this in mind, we may consider for practical purposes an attenuation network to consist of a combination of resistance elements, with one or more variable units. These resistance elements are used to introduce a power loss of value between certain limits when placed in the circuit between some fixed values of input and output impedances. Occasionally circuits are encountered where either or both the input and output impedances are in such a relation to the circuit that variations over wide limits in their impedances will not make a material difference in the operation. Under such conditions, one or both of the impedances may be neglected in designing the volume control network.



Relation of Attenuation Network to Source and Load

Irrespective of its application, an audio amplifier is used to amplify the frequencies of the audible range. It is possible without imposing too drastic complications to design public address amplifiers to reproduce faithfully to a marked degree audio frequencies between approximately 50 and 12,000 cycles.

Audio amplifiers are entirely dependent upon the use of the vacuum tube as an amplifier. This use falls into two classes (1) where voltage amplification is the object, and (2) where power output with little distortion is desired. Power tubes used in the last stage of an amplifier are of this latter type. Tubes preceding the power stage are primarily voltage amplifiers, with the exception of the driver stage in class "B" type amplifier which must also supply power to the grids of the last stage. The transformer connected between these stages in class "B" amplifier must be designed carefully and possess high efficiency.

The amplification ability of the tube is due to the nature of the construction which causes a small grid potential change to have the same effect upon the plate current as a much larger plate potential change. The ratio of the change in the plate voltage (E_p) to the change in grid voltage that will vary the plate current (I_p), by an equal amount is called the amplification factor, or the Greek letter μ, as explained in Lesson 9.

The current change in the plate circuit may produce a voltage variation across a resistance, a high impedance, or the impedance of the primary of an audio transformer. With a transformer, it is possible to step up this voltage by a small ratio in the order of 3 to 1, or less. Higher ratios will demand a great deal of inductance for the secondary which will result in large capacity between the turns. This capacity would act as a shunt for high frequencies. Transformers at best can only give partially true reproduction, but may be designed to give only negligent variations in the needed audio range.

With the advent of high gain amplifiers, use of resistance coupling between stages is becoming more and more in vogue, while impedance coupling finds but little present day application. The advantage of "direct coupling" has been surpassed by the high gain tubes. If the plate current is passed through a high resistance connected between the plate and the positive side of the "B" supply, voltage variations are produced in proportion to the changes in the plate current. The voltage drop distributes itself in proportion to the resistance of the tube (r), and the load (R). The voltage amplification is a fraction of μ expressed by the relation:

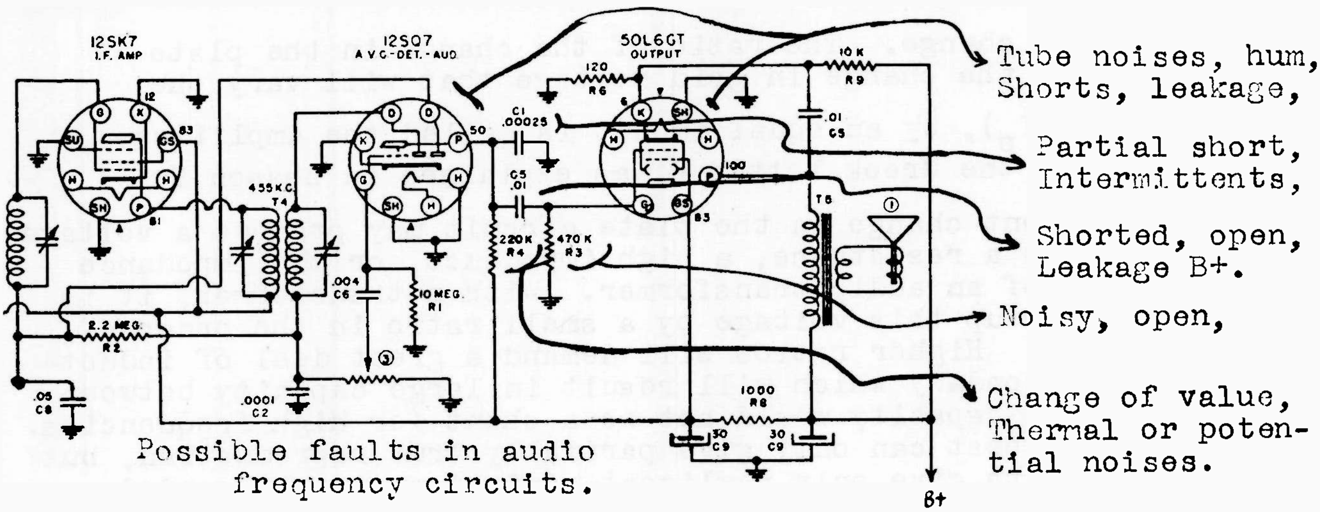
$$\text{Voltage Amplification} = \frac{\mu R}{R + r}$$

From the above relation it is seen that as the load increases, voltage amplification will approach the amplification factor. The value for best results is usually suggested by the tube manufacturer. The voltage variations are coupled to the grid of the next tube through a condenser of suitable size. This size may be found approximately from the formula below, where R_g is the grid coupling resistor of the following tube, other symbols are explained above. All resistances are in ohms.

$$C = \frac{0.04(R + r)}{R_g(R + r) + rR} \text{ farads}$$

The grid resistor serves to release the electrons that may have accumulated on the grid. If this resistor is made small very little voltage will be impressed upon the grid, if unreasonably large, it will not free the electrons and cause blocking. A suitable value is suggested by tube manufacturers.

The grid of a tube is biased sufficiently negative so that from the practical point of view no current flows in the grid circuit and no power is consumed there. The grid resistor does use some power which may be calculated.



Possible faults in audio frequency circuits.

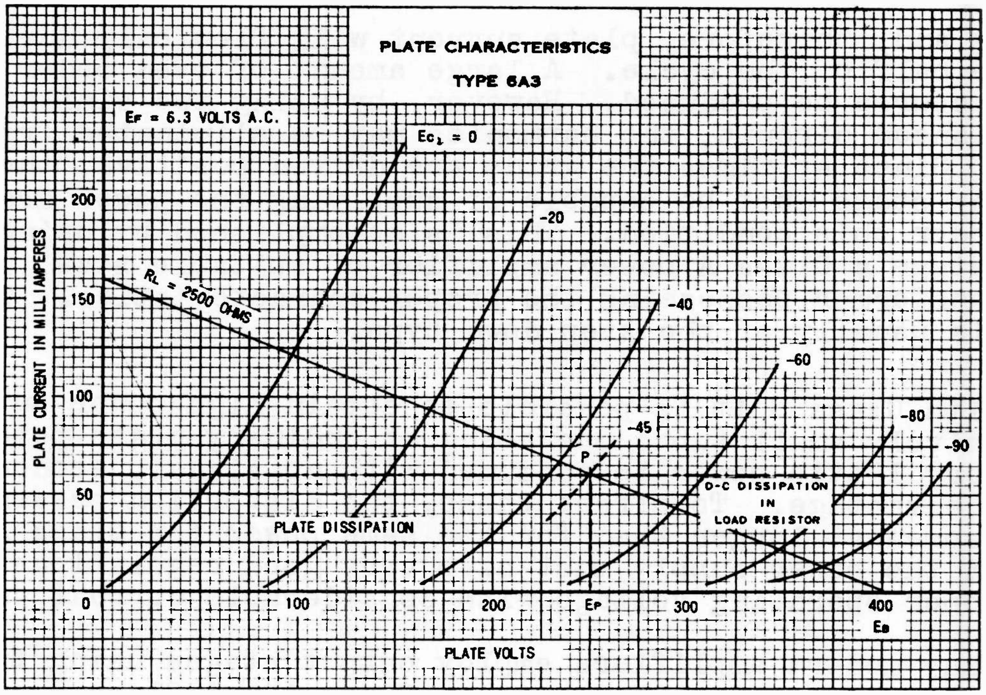
The majority of faults in audio voltage amplifiers lie in the tube itself or in the coupling condenser. Generally, this stage gives little trouble. Plate coupling condensers must be of high quality, since even the slightest amount of leakage may cause the grid of the next tube to become positive.

Since a loudspeaker is an electro-acoustical device, actual power is required to operate it. For this reason, the output stage of a radio receiver uses a tube intended for power amplifier amplification. Such tubes are designed with the object of developing power, in contrast with voltage amplifier tubes in which the object is to obtain as much voltage gain as possible.

Because triode tubes in Class A are commonly used in receivers, and also for reasons of simplicity, we will first consider such an application. For any given operating condition of negative grid bias and a suitable value of plate voltage, the plate current will be of some value that can be measured or found from characteristic curves of the tube under consideration. Without a load in the plate circuit, the plate current would vary as the signal voltage would alter the instantaneous grid potential above and below the fixed bias value. This variation would follow along one of the lines (known as the static characteristic line) of the grid-voltage-plate-current curves.

The connection of a load alters these results. As the grid becomes more negative (on a negative cycle of the signal), the plate current is reduced, but not as much as under the conditions of no load. The reasons for this change is due to the fact that a reduction in the plate current reduces the voltage drop across the load and accounts for a higher voltage at the plate. This higher voltage, of course, to a degree counteracts the plate current reduction. The exact reverse of this action takes place with a positive signal. In such instance, the plate current rises less with a load connected then without.

The effect of a load is to change the operating line to a line called the dynamic characteristic and having a smaller slope.



The dynamic characteristic is also more nearly linear than are the characteristic curves of the tube. This linear factor is important in minimizing distortion produced by the curvature of the characteristic curve.

To keep distortion to a minimum, the practical limiting factors are the excessive curvature of the dynamic characteristic at low plate currents and the need to keep positive peaks of the signal smaller in value than the negative bias used. This latter fact is important, for if the grid is driven positive, grid current will result and will distort the input signal.

In order to obtain the maximum power output without producing distortion for reasons just stated, it is necessary to maintain a careful balance between grid bias, load impedance, plate resistance of the tube, and plate voltage. For the serviceman, this problem has been solved by tube engineers and tube manuals give the operating information required.

Distortion arises primarily from operating the tube over the curved part of its characteristics. It usually resolves itself into harmonics. Of all the harmonics, the second are of the greatest magnitude. The push-pull amplifier by cancellation reduces the even order harmonics to a very negligable figure, requires less filtering of its plate supply, and permits somewhat larger input voltage without causing distortion due to overloading.

In Class B operation the tubes are biased or designed with a sufficiently high amplification factor to cut off the plate current with no input signal. When a signal sufficient to swing the grid is introduced, the negative portion of the cycle will add only to the bias and, therefore, plate current will flow only during the positive half of the cycle. A large amount of even order harmonics will of course be produced. However, by using two similar tubes in a balanced circuit, the harmonics may be eliminated from the output. Since at times the grids are driven positive, the preceding stage must be capable of supplying the power drawn by the grids under this condition. This is accomplished by using for a driver stage a Class A power amplifier of suitable size, coupled by a transformer possessing the proper characteristics. The transformer is usually of the step down type.

With Class B it is possible to obtain high power output with comparatively small tubes operating at ordinary plate potentials. Since very little power is consumed with no signal, economy is another advantage. To offset these, the distortion present is always somewhat larger than for the same power for Class A operation and the power supply must have very good regulations to maintain proper operating voltage with considerable current variations.

Many modern amplifiers employ output stages using tubes in an arrangement intermediary between Class A and Class B commonly called Class A-prime or Class AB. On low signals the circuit behaves as a Class A, while on powerful signals the Class B action allows the handling of large power. In this manner, the advantage of both classes is combined.

Because tubes operated in Class B cannot be self biased, it is an advantage to design these tubes so that they take almost zero current at no-signal. If tubes are employed for this class of operation that do require considerable negative grid bias, a separate power supply for this purpose is recommended. While it is best for this additional power supply to have a separate power transformer, the required power may be obtained from separate windings on the power transformer used in the main supply.

It is very difficult to make audio transformers to have uniform response in the audio band. This was the main limitation and served to hamper the popularity of such interstage arrangement. With the high gain triode or pentode type tubes, a much higher plate load is required, and, therefore, a resistor can be employed. While resistance coupling produces a certain loss of voltage instead of gain, the amount lost is easily made up by the higher gain of the tubes employed, and excellent frequency response is obtainable with a simpler arrangement.

With the use of pentodes in the output stage and with the high gain obtainable in the stages of the radio preceding the detector, very little additional audio voltage amplification is needed. In most of the modern sets, this is obtained with the aid of a single triode having a mu of 20 to 100. This triode may be incorporated with a diode detector in a single tube envelope.

LESSON 19

ADVANTAGES OF INVERSE FEEDBACK

A beam power amplifier to be truly modern should incorporate inverse feedback. It is a commonly recognized fact that low plate resistance tubes such as the 2A3 are superior from the standpoint of low distortion and good quality. With inverse feedback the high plate resistance beam power tube may be made to take on the characteristics of the low-mu triode, yet retain most of its high power sensitivity. The important advantages obtained by the use of inverse feedback are fourfold: first, reduction of wave form distortion; second, improvement of frequency response; third, reduction of hum; and fourth, reduction of "hangover" effect. The only disadvantage of inverse feedback lies in the fact that the gain is considerably reduced.

EXPLANATION OF INVERSE FEEDBACK

In the circuit of Fig. 1, a certain amount of the voltage developed in the plate circuit is fed back out of phase with the signal in the grid circuit. If without inverse feedback a certain voltage E_0 is developed across the output circuit with an input voltage E_1 the gain of the stage is E_0 divided by E_1. If now a certain percentage N of the voltage E_0 is fed back to the grid circuit in such a way that the voltage is out of phase with the input voltage E_1 the total input voltage to obtain an output voltage of E_0 is $(N E_0 + E_1)$ and the gain of the stage is $\frac{E_0}{(N E_0 + E_1)}$. The ratio N is the percentage of the output voltage which is fed back to the input circuit. It may be readily seen that if N is large the gain of the stage depends more upon N than upon the circuit constants.

The ratio reduction in gain by the addition of inverse feedback may be readily determined by dividing the gain without feedback by the gain with feedback.

REDUCTION OF DISTORTION

As was pointed out in the above paragraph, an inverse feedback circuit feeds back a certain portion of the output voltage to the grid circuit. If distortion is introduced in the amplifier stage a certain amount of the distorted voltage will be fed back into the grid circuit and this will tend to cancel out the distortion developed in the amplifier stage. If in the circuit of Fig. 1 a certain amount of distortion voltage B is present in the output circuit the distortion voltage fed into the grid circuit will be N x B and this quantity multiplied by the gain of the stage will give the cancelling effect of the inverse feedback. The total distortion present in the output is then equal to the sum of the distortion without inverse feedback and the distortion cancelled by the inverse feedback. In other words, if b is the distortion without inverse feedback, the total distortion, B, with inverse feedback is equal to (b + B) x N x A, where A is the gain of the stage. Evaluating B gives the quantity $\frac{b}{1 + NA}$. In other words the distortion is reduced by the ratio of $\frac{1}{1 + NA}$.

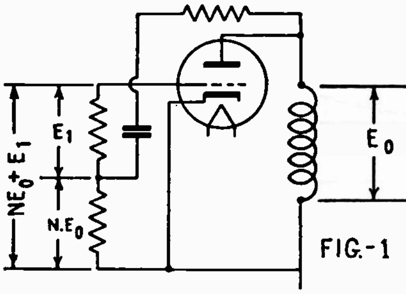


FIG.-1

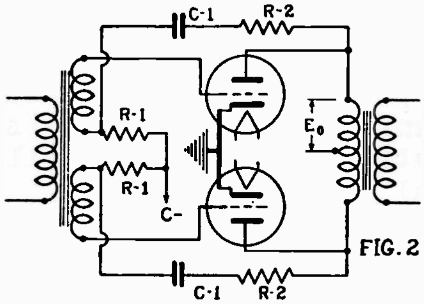


FIG. 2

Fig. 2 shows the ordinary method of obtaining inverse feedback with the resistor-condenser method. The amount of inverse feedback is equal to $\frac{R_1}{R_1 + R_2}$ assuming that the reactance of the condenser C_1 is negligible over the operating frequencies. However, this assumption is not necessarily true especially at the lower frequencies and the circuit of Fig. 3 is much more efficient from this standpoint. In Fig. 3 the feedback voltage is obtained from a tertiary winding on the output transformer. This method also provides a much better overload characteristic since the resistance in the grid circuit is negligible and it is quite possible to operate the tubes in the grid current region.

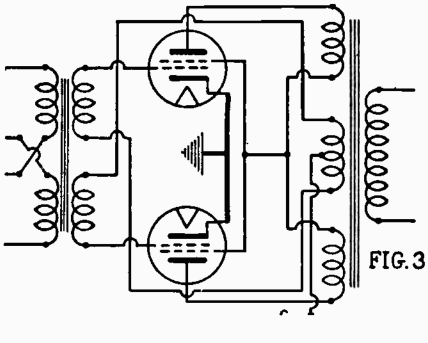


FIG. 3

REDUCTION OF PLATE RESISTANCE

In addition to the reduction in distortion obtained by inverse feedback, there is also a reduction in the plate resistance of the tubes. A high plate resistance is a definite disadvantage in the case of a power tube which operates into a speaker load which is more or less variable depending upon the impedance of the voice coil. In the circuit of Fig. 4, it may be easily seen that the voltage E developed across the load depends a great deal upon the actual value of R_L which is the reflected impedance of the voice coil. This is due to the fact that the signal current depends almost entirely upon the high plate resistance of the tube. Since the load resistance is low in comparison to the plate resistance, the voltage developed across the load is almost directly proportional to the impedance of the load which varies appreciably with change in frequency. In Fig. 5 it may be seen that the voltage across the load does not vary so much since the signal current depends both upon the load and upon the plate resistance of the tube. If the voice coil has an appreciable amount of reactance the impedance rises with the frequency causing distortion and giving an unnatural amount of "highs." The high plate resistance is unsuitable from another view point, that of the amount of low frequency distortion which may be tolerated. This low frequency distortion is not

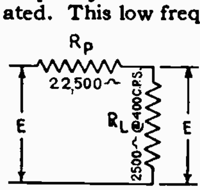


FIG. 4

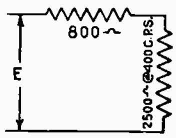
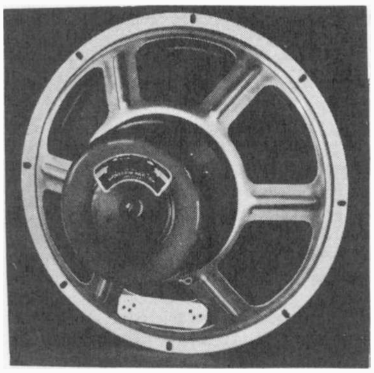


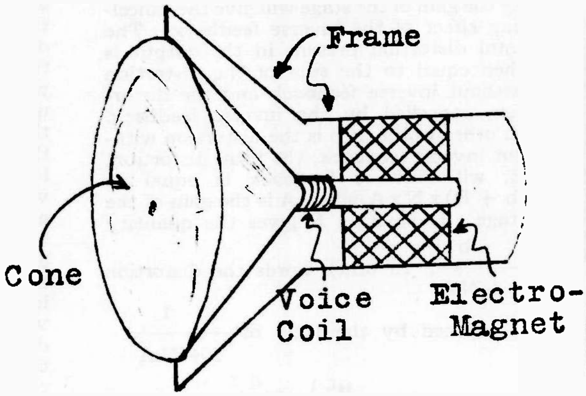
FIG 5

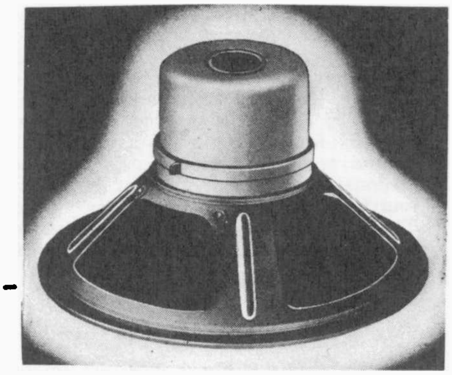
due to the characteristics of the tubes which remain unchanged regardless of the frequency, but depends upon the magnetizing current in the output transformer. The magnetizing current is a distorted nonsinusoidal wave and this current, on flowing through the high plate resistance of the tube, develops a nonsinusoidal voltage drop across the tube which, when subtracted from the input signal, results in a distorted wave across the output. Unfortunately, most amplifiers today are measured for distortion at 400 c.p.s. where the magnetizing current is practically negligible. It is not uncommon to find beam power amplifiers without inverse feedback which have only 25 per cent of the rated power at 40 or 50 cycles. This low frequency distortion is particularly objectionable since all harmonics fall within the audible range. Inverse feedback effectively reduces the plate resistance so that the distorted voltage drop caused by the magnetizing current is exceedingly small with the result that there is very little distortion across the output circuit.

Electrodynamic & Magnetic Speakers

After the audio signal in electrical form is amplified, it must be changed to actual sound. The loudspeaker changes this electrical energy to acoustical energy. A magnetic field is required by all types of modern dynamic speakers and is provided by an electromagnet (field coil) or by a strong fixed magnet in the permanent magnet (P.M.) type speakers.



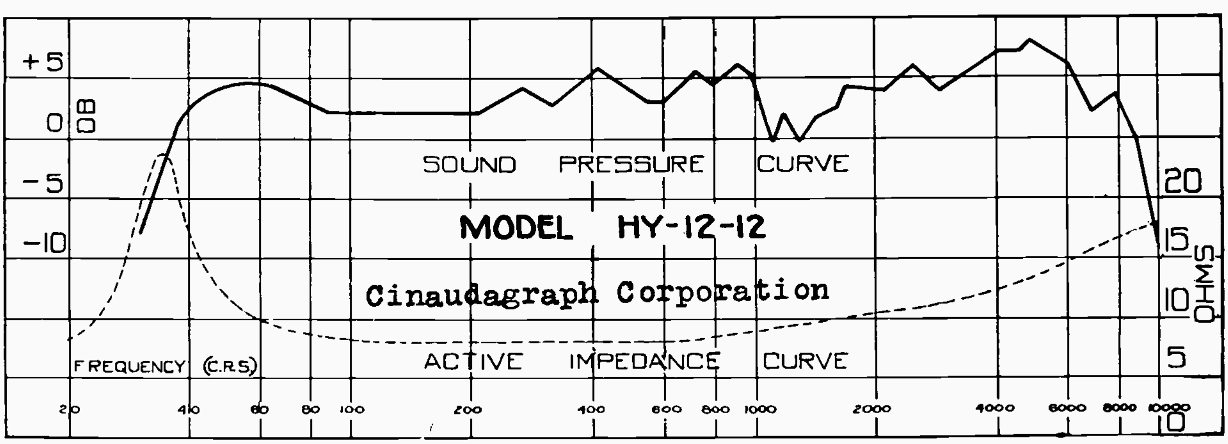




In the dynamic speaker a small cylindrical coil (voice coil) is attached to a paper cone. The coil is suspended in a strong magnetic field and carries the impulses from the radio set's or amplifier's output. The voice coil will move in accordance with the signal and will vibrate.

Minor troubles found in speakers can be repaired. A voice coil that touches the pole piece should be repositioned. Cone cement used can be loosened with acetone or special cement solvent. Small rips or tears in a speaker cone can be patched with cone cement. Scotch tape may be used for a temporary repair.

The chart below will give you an idea of the response of a good quality 12-inch speaker. Also notice the dotted curve which indicates the change of the voice coil impedance.



LOUDSPEAKER SELECTION - PLACEMENT

In all Public Address installations, loudspeakers are more than just an accessory of the system; they must be considered as the all important devices used to convert the electrical audio output to the needed acoustical energy — sound. The speakers of any well matched sound system are selected with care so that the response characteristics and power handling ability will give the desired results with the associated equipment. But the proper placement of the speakers and the use of correct baffles or directional horns is necessary to permit the P.A. engineer to secure the best results from the sound system in any particular installation. Just as poor placement of speakers may ruin the response from the highest quality equipment, so can moderate cost equipment be made to perform wonders when the speaker placement is correctly made along scientific lines.

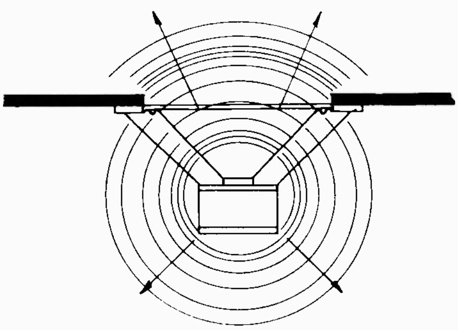


Figure 1. A cross section of a speaker mounted in a baffle. Note how the baffle prevents the inter-action of the waves set up by the front and rear of the cone.

The speakers must always be used with some form of baffle to prevent the tendency of the front and rear sound waves from cancelling-out each other. (Fig. 1) If the baffle were omitted, sound compression produced in front of the speaker cone, when the cone moves forward, would cause the air to rush around the edges and relieve the rarefaction in the rear. To be equally effective to the middle and lower frequencies a baffle must be fairly large. In practice a 6" or 8" speaker will require a baffle with 40 inch sides.

A speaker mounted in a flat baffle made of ply-wood, celotex, or masonite will radiate sound almost uniformly in all directions. If the installation requires the projection of the sound forward, directional flares or special horn baffles must be employed. The Oxford Exponential Horn XA22 is ideal for this purpose. It gives the desirable directional effect, and has great volume-handling ability. (These exponential horns are supplied with either Permag or electro-dynamic trumpets).

NUMBER OF SPEAKERS TO USE

In average installations it is best to use one or two speakers. A single speaker such as Oxford type 110C or 11WMP will serve in class rooms, hallways, small stores, and in almost all other installations requiring less than 10 watts of power. For auditoriums, churches, gymnasiums, dance halls, two speakers of good quality should be able to handle the audio volume from amplifiers supplying 15 to 35 watts. These speakers must have a conservative power handling capacity of at least 18 watts each. For use with amplifiers supplying greater power, employ directional trumpet speakers or at least four well made 12 or 14 inch dynamics.

PLACEMENT FOR NATURAL RESPONSE

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. (Fig. 2) This is why two speakers are used in auditoriums and dance halls,

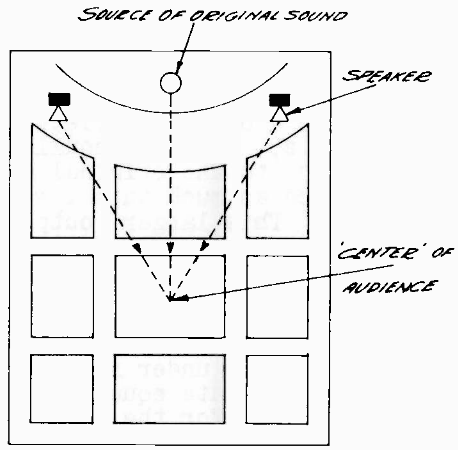


Figure 2. The speakers should be placed so that the majority of the listeners will hear the original and reinforced sound at the same instance.

one on each side of the stage. This type of installation permits the original sound to be supplemented or reinforced by the amplified output. It certainly would not do to have a single speaker in the back section of a long and narrow hall. Under such a condition, the listeners sitting in the first front rows and those in the extreme rear would hear the original sound and the amplified sound at a considerable time interval.

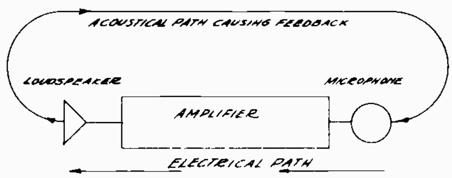


Figure 3. The acoustical return of sound causes feedback.

FEEDBACK PROBLEM

In all installations, some of the sound emitted by the loudspeakers will reach the microphone of the system. Feedback will result if the sound reaching the microphone is greater in intensity than the original sound input. (Fig. 3) Consider for example a typical auditorium with an orchestra playing. A definite sound level produced by the instruments of the orchestra is picked up by the microphone. After amplification, a correspondingly higher power level of sound is emitted by the loudspeakers. Of course, the actual ratio of the input to the output power is the net gain of the amplifying equipment at the volume control setting employed. Now if the sound coming back to the microphone, either through direct radiation or by reflection from walls, is about equal in intensity to the original input, twice as much output will result. This larger output will in turn cause twice as much sound energy to be returned to the microphone and again the output level will be doubled. This doubling process will continue, under such condition, at a rate equal to the time required for the sound to pass acoustically from loudspeaker to microphone and electrically through the amplifying equipment. In several seconds the amplifier will be overloaded, and a continuous loud whistle will be the only output present.

Should the sound returning to the microphone be greater in intensity than the original, the feedback action will start just so much faster. If the sound intensity is but a little less than the original input, a hang-over effect or echo will be present. All these conditions are equally bad and can successfully be eliminated.

Reduction of amplification will always solve the feedback problem. But this is a poor solution, since the output in majority of cases must be reduced to so low a point that the sound system no longer serves its purpose. In some installations certain groups of frequencies are the only cause of feedback. Perhaps this is due to greater amplification at these frequencies or to the resonant effect of the room. Tone control adjusted to reduce the gain at these frequencies will eliminate the feedback due to this cause. But this, too, is a make-shift solution, for the tone control adjustment not only may solve the feedback problem, but also may distort the natural qualities of the program.

The way to eliminate feedback is to prevent sound from the speakers reaching the microphone of the system. If the speakers are focused in a direction away from the microphone, direct feedback will be

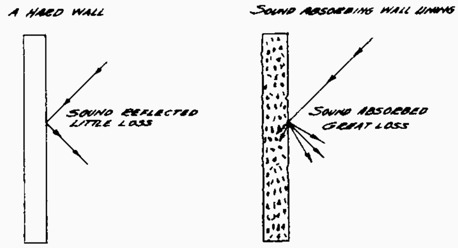


Figure 4. To prevent sound emitted by the speakers from reaching the microphone, sound absorbing materials are used.

eliminated. However, sound reflected from walls, ceiling, and floor will reach the microphone. The sound in being reflected, loses some of its energy, so that in striking several walls in its return path to the microphone, the sound intensity may be reduced to a low value where it will no longer create any feedback. (Fig. 4) Since sound-absorbing materials deaden the sound and absorb its energy, the use of carpets, heavy curtains and drapes, and special sound-absorbing materials strategi-

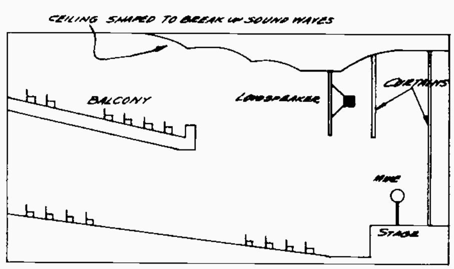


Figure 5. In an auditorium the speakers should be above and in front of the microphone. The curtains should be down as much as possible to serve as sound traps.

cally placed will permit the use of the Public Address system at the required volume level without encountering feedback.

Practically every school auditorium is or soon will be equipped with sound amplifying equipment. Here the correct placement of speakers is a simple matter. Two speakers of the 12 inch size should be used.

These speakers should be placed on the two sides of the stage, and directed outwards. The speakers should be well in front of the microphone and should be enclosed in suitable baffles. (Fig. 5) The sound should be emitted in front only. If the auditorium is small, non-directional baffles will serve. The curtain in back of the stage should be lowered to eliminate sound reflection. If the walls are of hard material and this type of installation does not completely eliminate the feedback problem, a directional microphone may be used or the speakers may be moved a little more forward and the front curtain lowered a little.

A well decorated square shaped room, 40 by 60 feet, serves as a dine-and-dance club. On a stage placed alongside one of the longer walls is the orchestra. When the orchestra plays softly, the

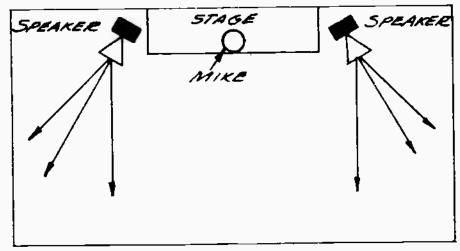


Figure 6. This simple but correct installation solved the problem of the night-club.

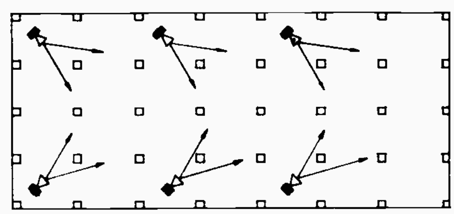


Figure 7. Even a factory paging system can present difficulties unless the speakers are correctly placed.

music cannot be heard in the extreme corners away from the stage. Loud playing proves uncomfortable for the patrons near the stage. (Fig. 6) Experimentation with a small 8 watt sound system shows that speakers placed in the far corners facing the stage create feedback. By using two semi-directional speakers placed above the stage and faced towards the extreme opposite corners, the problem is solved.

In a large factory located on a single floor, speakers used in a paging system were spread out at random. Difficulty was experienced in understanding the calls and announcements. This was caused by the sound from several of the speakers reaching the same individuals. By using directional speakers, and facing them in such directions that the sound from any two did not interfere, the difficulty was eliminated. (Fig. 7)

LESSON 20

MATCHING SPEAKERS TO THE P. A.

The correct selection of the speakers for any public address installation depends on the equipment used, results required, and the acoustics and size of the location. These determining factors are closely inter-connected and must be considered together in selecting the type and number of loud speakers to be employed.

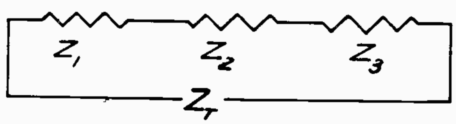
The number of speakers used will depend primarily on the installation; perhaps only two speakers will be needed in a school auditorium, but several dozen may be used in a complex paging system. In any one enclosed hall or room, as few speakers as practical should be used. This suggestion, however, cannot always be followed, since the speaker efficiency is highest when the speaker is operated well under its maximum rating. Also, at times the installation calls for so much power that a great many speakers must be used. Bearing in mind that no one rule will really serve in all cases, the P.A. specialist may depend on the table given for correct information for every regular installation. (See Table 1.)

No matter if you use a single speaker or have a complicated network, the speaker load should be correctly matched to the amplifier output. For maximum power transfer and minimum added distortion, the load impedance, Z, must equal the output impedance of the amplifying system. Two forms of mismatch may occur -- the load may be higher in value, or the load may be lower. In both instances a power loss will occur — less than the maximum amplifier power output will reach the speakers, and there will also be a loss of quality.

Small errors in matching are not important as is evident from Table 2.)

The commercial amplifiers provide several different output impedances in the most commonly required ranges. For example, one unit may have taps at 4, 8, 16, and 500 ohms. When speakers are used at a distance from the amplifier, the speaker line is usually connected to the 500 ohm tap, and the speakers with line transformers are connected together to match this impedance. If the speaker is near by, within 50 feet, the voice coil may be directly connected to the nearest value tap. Let us now consider the problem where several similar speakers are to be connected together.

In connecting impedances in series, the individual impedance values are simply added. (See Chart 1.)

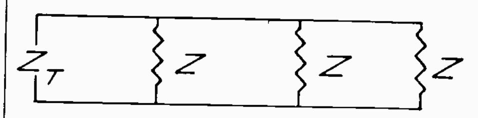


$$Z_T = Z_1 + Z_2 + Z_3 + \text{----} +$$

Chart No. 1.

In connecting several equal impedances in parallel, the resulting impedance is found from the formula (See Chart 2.) where Z is the value of one of the impedances used and X is the number of impedances in parallel.

In using two 8 ohm voice coil speakers, the connections



$$Z_T = \frac{Z}{X}$$

Chart No. 2.

may be made in series or in parallel. In the series circuit the resulting impedance is 16 ohms; in parallel, 4 ohms. It is better to use parallel connection, as an open voice coil in a single speaker in the series circuit will stop the entire service of all speakers.

TABLE 1.

Type Of Application	Room Size Cu. Ft.	People Present	Noise Level	Power Needed (Watts)	Number Of Speakers Needed	Size Of Speakers	Oxford Type	Type Of Baffel
Hospital Room-Paging	4,000	6	Very Quiet	1/4	1	6½"	6XMC	Cabinet
School Room	8,000	48	Quiet	1	1	8"	8WMC	Cabinet
Office Inter-Comm.		1	Average	1	1	5"	5XMP	Cabinet
Small Restaurant	10,000	25	Noisy	3	1	12"	12WMP	In Grill Work
Funeral Home	25,000	100	Quiet	3	2	12"	12WMP	Flat Baffels
Window Ballyhoo	Open Air	25	Noisy	8	1	12"	12DMP	Semi-Directional
Factory Paging	150,000	50	Noisy	25	4	8"	8WMC	Cabinets
Auditorium	150,000	600	Quiet	25	2	14"	14DMP	Semi-Directional
Street Advertising	Open Air		Very Noisy	30	2	Horn	6DMP	Directional Horns
Large Stadium		10,000	Noisy	60 to 100	8	14"	14DMP	Direction Horn and Baffels

Speakers may also be connected in series-parallel arrangement, so that the resulting impedance will match one of the output taps. For example, four 8 ohm voice coil speakers may be connected in a fashion to give the equivalent impedance of 8 ohms. (See Chart 3.)

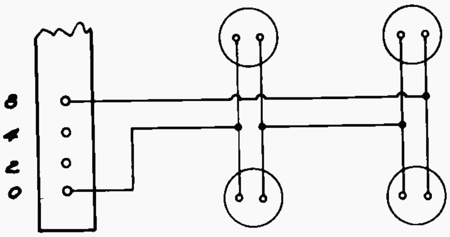
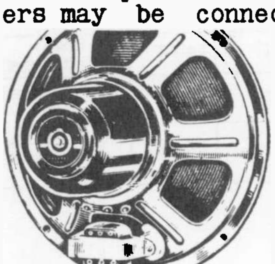


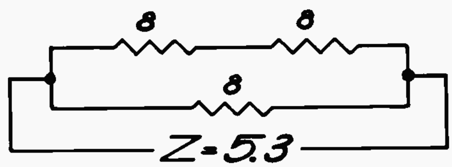
Chart No. 3.

So far, we were mainly interested in properly matching the output to the speakers employed and we assumed that the volume level at all speakers was to be the same. There are installations, however, that, while using speakers of one type, must have the speakers operate at different volume levels. For example, the speakers of a paging system must have their volume level of intensity to serve the different locations -- and probably every place has a different noise level. Just how can this variation of sound intensity be accomplished and yet match the network to the amplifier output?

The first important rule to remember is that it is immaterial how the speakers are connected; if the equivalent impedance is correct, good matching will result. As an example, we may consider a food market installation with two 8 ohm voice coil speakers inside, and another similar speaker outside. The outside speaker is to be operated at about four times the power level of either inside speaker. To accomplish this the speakers may be connected in the following manner. The speakers used indoors are connected in series, giving the equivalent 16 ohms. This combination in turn is connected in parallel with the 8 ohm speaker placed outside, and gives the equivalent 5.3 ohms. The 4 ohm impedance tap of the amplifier used will give good results as there will be only a trivial loss. (See Chart 4.)



The complete line of electro-dynamic and P.M. type speakers includes 14 inch Auditorium Models, also many smaller sizes especially designed for P.A. work. From these, the sound engineer can at all times select the best reproducer for the job.



$$\frac{16 \times 8}{16 + 8} = \frac{128}{24} = 5.3$$

Chart No. 4.

It is evident that the voltage across each branch is the same, but the current through the single speaker will be twice as great as the current present in the branch having two similar speakers. Therefore, the single speaker placed outside of the store will have twice the power of the two other speakers combined -- or four times the power of each speaker placed inside.

The speakers used, of course, need not be all the same. For another example, consider the school installation with 8 inch speakers in eight different school rooms, two 14 inch Oxford 14DS-TLL speakers in the auditorium, and one exponential horn in the gymnasium -- all speakers equipped with Universal 500-1000 ohm transformers. The sound level needed in each of the rooms is $1\frac{1}{4}$ watts, in the auditorium 20 watts total, and in the gymnasium 10 watts where the exponential horn trumpet will serve. The units may be hooked-up in the manner shown, and a study of the circuit will show that the right match with the required power at each point is obtained. The amplifier, of course, must supply 40 watts.

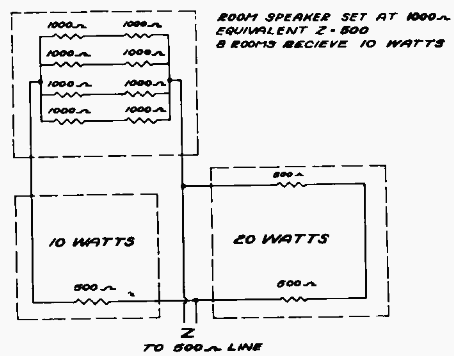


Chart No. 5.

In a similar manner any complex speaker installation may be designed to give optimum results and produce just the right amount of audio power at each speaker.

TABLE 2

ERROR IN MATCHING OUTPUT Z / LOAD Z	APPROXIMATE LOSS OF POWER IN DB	APPROXIMATE LOSS OF POWER IN %	APPROXIMATE EFFECT ON QUALITY AND SENSITIVITY
.5	.5	11	NOTICEABLE
.6	.35	7	SLIGHTLY NOTICEABLE
.7	.2	4	BARELY NOTICEABLE
.8	.1	2	BARELY NOTICEABLE
.9	.05	1	NEGLIGABLE
1.0	0	0	NONE
1.25	.05	1.5	NEGLIGABLE
1.50	.2	4	BARELY NOTICEABLE
1.75	.35	7	SLIGHTLY NOTICEABLE
2.0	.5	11	NOTICEABLE

EFFECT OF MISMATCHING SPEAKERS TO AMPLIFIER OUTPUT

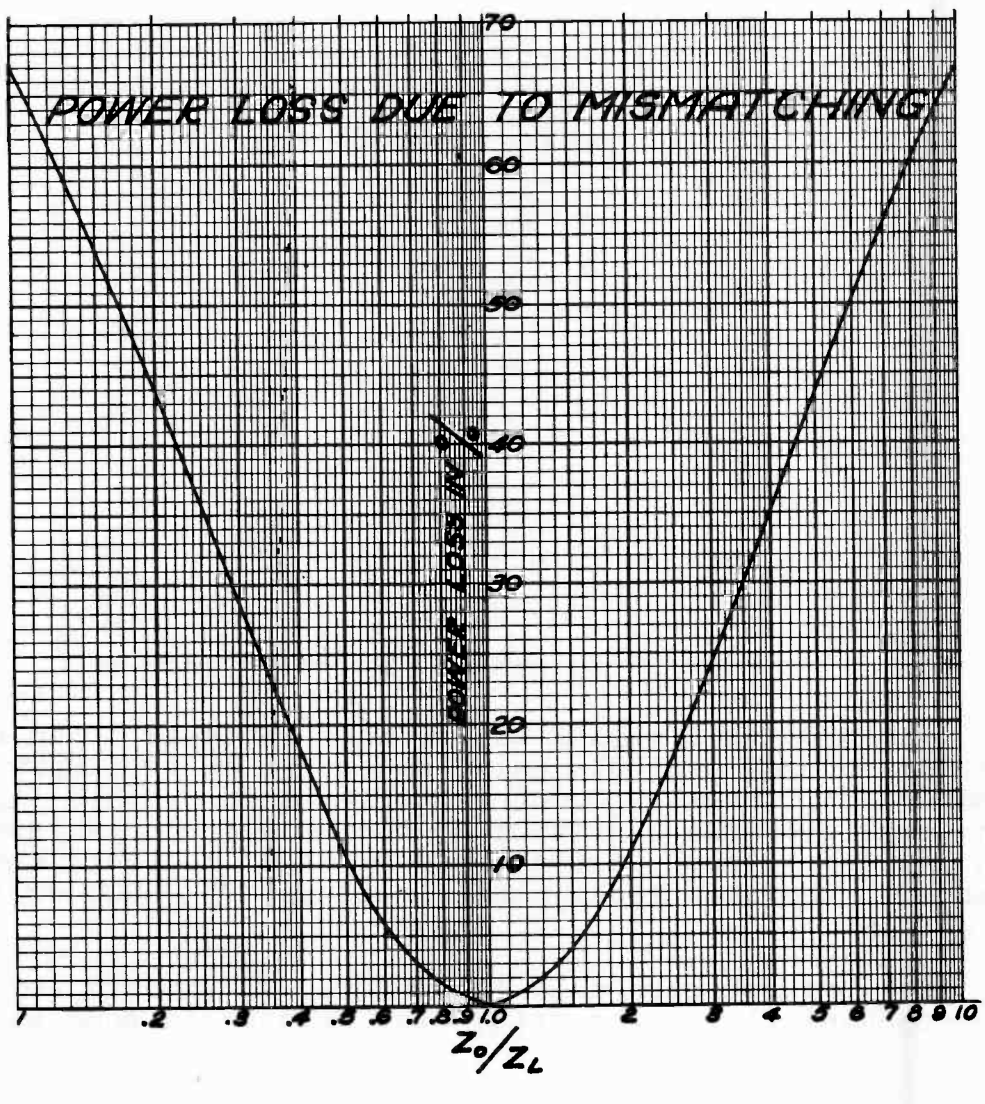
A great deal of stress has been placed on the necessity of exact matching from source to load. While this generally holds true when the mismatching is considerable, a slight mismatch is not serious. This is quite obvious by referring to the chart.

In order to properly determine correct matching, the impedance of the voice coil must be known. This impedance is not a constant figure, but varies with frequency. For all general applications, however, the impedance is measured at 400 cycles. In the event that the impedance of a speaker is not known, the approximate value can be obtained by multiplying the DC resistance by a factor of 1.25.

To consider the usefulness of the graph, let us take the problem where the only speaker available is one with a 6 ohm voice coil, and the amplifier output is available in either a 4 ohm or 8 ohm tap. The question in this case is what tap on the amplifier will give the best results. The ratio of $\frac{Z \text{ output}}{Z \text{ load}}$ in the case of the 4 ohm tap is .666, and in the case of the 8 ohm tap is 1.33. In checking these figures on the graph, we find that in the case of the 4 ohm tap where the ratio is .666, the loss is approximately 4%, and similarly, on the 8 ohm tap, the loss is only 2½%. It is quite obvious that the best results will be obtained if the speaker is connected to the 8 ohm tap. Generally, the results are better if the speaker is mismatched to a higher rather than a lower impedance.

However, if the speaker has only a 2 ohm voice coil, and the only tap available on the amplifier is 8 ohms, the ratio of the two impedances is 4. From observation on the graph, the loss is 35%, which is quite serious and this mismatching is not recommended.

Courtesy Oxford-Tartak Radio Corp.



THE DECIBEL

Of all units in radio the least understood and most often misused is the decibel. The decibel, abbreviated as DB, is a unit of comparison of two powers and under proper consideration may be used to compare currents and voltages. It is the transmission unit used to measure power related in some way to the auditory sense. The DB is a logarithmic unit in so much as it varies as the log of the ratio of the two powers in comparison.

$$DB = 10 \log_{10} \frac{P_1}{P_2}$$

The mathematical formula above states the relation that the log to the base ten of the ratio of the two powers, multiplied by ten will give the difference between the two powers in decibels.

The difference in decibels may also be found from the table below if the ratio of the two powers under consideration is known.

Gain in DB	Power Ratio	Loss in DB	Power Ratio
40	10,000	0	1.
35	3,162	1	.8
30	1,000	2	.6
29	800	3	.5
26	400	4	.4
23	200	5	.32
20	100	6	.25
15	32	7	.2
12	16	8	.16
10	10	9	.12
9	8	10	.1
8	6.3	11	.08
7	5	13	.05
6	4	15	.03
5	3.2	17	.02
4	2.5	20	.01
3	2	25	.003
2	1.6	30	.001
1	1.3	35	.0003
0	1	40	.0001

Since DB is always a ratio, when we speak of an amplifier as having so many decibels gain, we assign an arbitrary level of comparison. Usually 0.006 watts is taken as this figure. If one amplifier has a gain of 75 decibels in comparison with a given arbitrary level, while another has 60 decibels when compared to the same level, the first has (75 — 60) or 15 DB more gain.

The transmission unit is employed to express any ratio of power, mechanical loss or gain, etc. related in some way to the auditory sense.

LESSON 21

FREQUENCY MODULATION

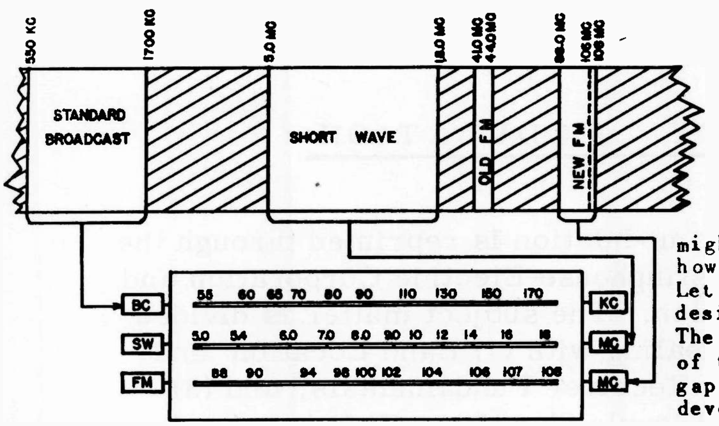
This material on frequency modulation is reprinted through the courtesy and cooperation of Westinghouse Electric Corporation and is copyrighted by that organization. The subject matter is divided into three convenient sections dealing with (1) Band Location and VHF Characteristics, (2) F.M. Receiver Fundamentals, and (3) F.M. Receiver Alignment and Trouble Shooting. This is a good way for treating this subject from a serviceman's point of view.

As an introduction to F.M., let us review briefly the difference between amplitude and frequency modulation. In amplitude modulation, as you brobably know, there are two side bands. At any one instance, if the transmitter is amplitude modulated with a single frequency sine-wave at that 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 by an equal number of cycles. Since both 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, in opposite directions, from moment to moment as the modulating audio frequency changes.

Now let us consider 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 produced 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 (i.e. 1 KC.) would have side bands at 1,001, 1,002, 1,003, etc., as well as at 999, 998, 997 KC., etc. When the carrier is being swung, for instance 10 KC. to either side, the side bands situated between 990 and 1,010 KC. only are of importance, the others above and below these extremes 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 frequencies transmitted.

The material on F.M. Band Location and Very High Frequency Behavior begins on page 207.

PORTION OF THE RADIO SPECTRUM



SLIDE 1

H-119 DIAL

(1-1) The present carrier frequency band assigned to FM extends from 88 to 106 megacycles. The 106 to 108 megacycle range, which also is included on our FM receivers, is set aside for facsimile and is, so far as we are aware, not in general use at this time. Slide 1 shows the spectrum location of the new VHF FM and facsimile bands with respect to the standard broadcast and short wave band. The old prewar FM band from 41 to 44 megacycles also is shown in the spectrum chart for comparison purposes. The dial scale shown in this slide is that of the Westinghouse Model H-119 AM-FM radio and phonograph which is to be discussed in this lecture.

(1-2) As slide 2 shows, at this very-high-frequency range, propagation of radio waves tend to follow more or less optical laws as compared with the standard broadcast range from 540 to 1600 kilocycles used in present-day AM systems. Briefly, this means that the radio waves act somewhat like light waves and "line-of-sight" wave propagation plays an important part. Under ideal conditions the terrain between the transmitting and receiving antennas should have no continuous obstructions such as large buildings, hills, etc. In actual practice ideal conditions are seldom realized. Frequently, very good FM reception may be obtained under conditions which according to the "line-of-sight" theory would make reception impossible.

According to the accepted theory, the electric field intensity of the FM wave varies inversely with the *square* of the distance from the transmitting antenna to the receiver. For production of a *true frequency modulated* signal to be passed on to the discriminator in the receiver, a good husky signal at the limiter grid is an absolute necessity. Unless there is a signal of sufficient strength to saturate the limiter, amplitude signals will be passed on to the discriminator, resulting in very poor tone quality and distorted output. This requirement practically dictates the use of a good, well-elevated outside antenna.

(1-3) FM Antenna Fundamentals.
At first glance the design of a suitable antenna for receiving FM waves might seem a very simple problem. Actually, however, a number of factors are involved. Let us examine these factors from the practical design standpoint.

The antenna input impedance determines the value of the r-f voltage developed across the dipole gap (load impedance) inasmuch as the voltage developed is determined by the values of the current flowing and the load impedance at that particular instant. It may be expressed mathematically by ohm's law for alternating current:

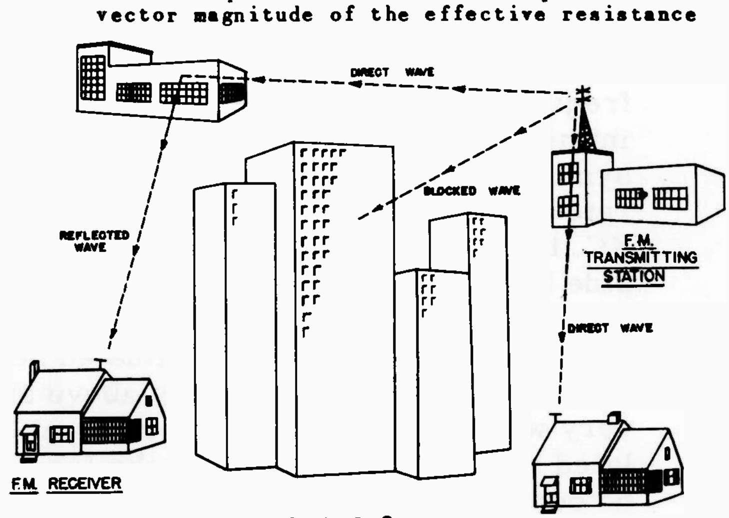
$$E = IZ \qquad (1)$$

Where E and I are the r-f voltages and currents, respectively, and Z is the impedance at the center of the dipole at any given instant. The impedance may be expressed as

$$Z = \sqrt{R^2 + X^2} \qquad (2)$$

Where R and X are the antenna input resistance and reactance, respectively.

In a half-wave antenna, *resonant to a fixed frequency*, the current is a maximum at the center and zero at the ends, while the voltage is a maximum at the ends and a minimum at the center. For this half-wave *resonant* dipole, then, the impedance varies along the antenna and is minimum at the center and maximum at the ends. For a half-wave dipole, *resonant* and *isolated in free space*, the impedance at the center is approximately 73 ohms and approximately 2500 ohms at the ends. The intermediate points between the center and each end have intermediate values of impedance. The 73 ohms impedance at the center represents the vector magnitude of the effective resistance



SLIDE 2

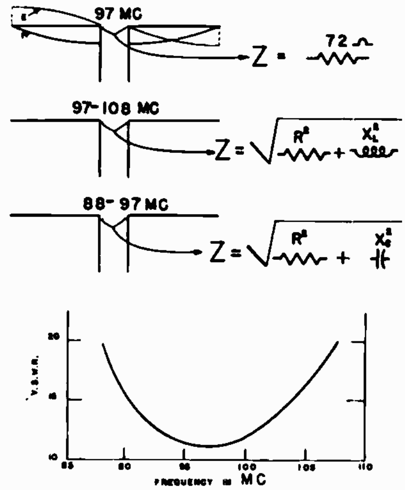
and a small residual reactance; however, for all practical purposes it may be considered a pure resistance. For *single, fixed frequency operation*, then, the transmission line should present a characteristic impedance to the center of the dipole, equal to the dipole center impedance, or, in other words, the characteristic impedance of the transmission line should be 73 ohms. But wait! Don't jump to any conclusions! We are now talking about a half-wave antenna resonant to a single frequency. For FM we have entirely different conditions.

The FM signal is constantly shifting in frequency with applied modulation. So far as the impedance value is concerned, the effect is exactly the same as would be encountered if the frequency were fixed and the length of the dipole were varied. At frequencies higher than the resonant frequency of the antenna, the dipole acts an inductive reactance and at frequencies lower than its resonant frequency it acts as a capacitive reactance. Remember that the center impedance value is equal to the square root of the sum of the squares of the resistance *and the reactance*. In short, as the signal frequency swings back and forth across resonance, the impedance value "travels" up and down its scale of values for the single FM signal. Furthermore, we are not interested in receiving only *one* FM station--we wish to receive stations all the way across the FM band. Various schemes have been brought forth for leveling out the extreme impedance values encountered at the band edges but most of these systems are too costly for anything other than certain commercial applications. For ordinary FM reception, a good compromise can be effected by making the dipole elements large in diameter, overlapping them slightly at the center and selecting the correct resonant frequency length.

(1-4) Determination of FM antenna length. If reception of programs from only *one* FM station is desired, the dipole elements would be cut to a half-wave length at the center or unmodulated carrier frequency according to the formula:

$$\text{Length of half-wave (inches)} = \frac{5540}{\text{Freq. (mc)}} \quad (3)$$

In a practical installation, however, reception of more than one FM station is desired. This means that the length of the elements must be cut to some intermediate frequency which will give a satisfactory response at the extreme ends of the band and yet keep the standing wave ratio (mis-match) of the transmission line between the dipole and the receiver input, to the minimum. In general, the frequency to which a broadly resonant antenna is cut, is equal to the geometric mean of the frequency extremes of the band to be covered.



VOLTAGE STANDING WAVE RATIO VS FREQUENCY
WESTINGHOUSE STRATOVISION
F.M. ANTENNA

SLIDE 3

For the 88 - 106 megacycle band, the frequency at which the antenna should equal one half-wave is

$$\text{Frequency in Megacycles} = \sqrt{88 \times 106} = 97 \text{ mc.} \quad (4)$$

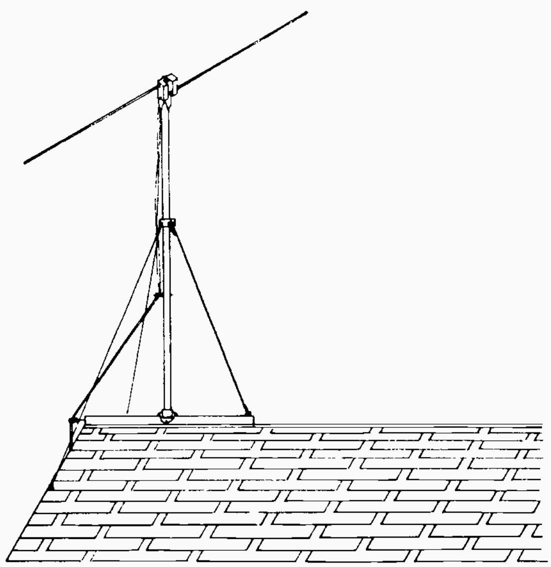
The actual length of the elements, in inches, according to the above formula, is

$$\text{Length} = \frac{5540}{97} = 57.1 \text{ inches}$$

Like most other practical applications of electrical theory, however, it is necessary to modify the actual element length for maximum efficiency across the FM band. In order to obtain a semi-broad-band characteristic in the Westinghouse Stratovision FM antenna, the two elements overlap at the center insulator. It was found necessary to increase the overall dipole length, end to end, to 62 inches to compensate for this physical characteristic.

(1-5) FM dipole antenna transmission line characteristic impedance. As mentioned above, the impedance at the center of an FM receiving dipole antenna cannot be stated as any given value. In actual practice it varies anywhere from 68 ohms to 1000 or 1500 ohms depending upon the length and diameter of the dipole elements and the portion of the FM band to which the receiver is tuned. It is obvious that no fixed value of transmission line impedance can be selected and matched to the center of the antenna. It is necessary to select some "happy medium" value which will operate most efficiently over the entire FM band. Due to the rather high standing wave ratios encountered at the band extremes, the transmission line must present very low-loss characteristics in the VHF range. Recent developments in low-loss transmission lines include a spaced, polyethylene-insulated, two-wire line of 300 ohms characteristic impedance. In tests with the Westinghouse Stratovision FM antenna, it was found that maximum signal level at the receiver input terminals was obtained with this new "twin-lead" line as compared with standard 50 and 70 ohm coaxial and twisted pair lines. In extremely noisy locations, however, the 300 ohm line will pick up slightly more noise than the coaxial type. In making installations in such very noisy areas, the coaxial-type transmission line may be used with some sacrifice of signal strength at the receiver input.

(1-6) Installation of the FM Antenna.



SLIDE 4

The FM antenna should be installed as high as possible and in the clear. It should be kept away from close proximity to metal roofs, eaves and other metallic objects. The dipole antenna is slightly directional and is most sensitive to FM signals when rotated to a position broadside to the FM station. The antenna can usually be mounted on a roof top or other high projection and then rotated to the position which gives best signal pickup on the various stations across the band. As the sensitivity pattern of the dipole is that of a figure 8, it will be necessary to rotate the antenna only 90° for changing from minimum to maximum sensitivity. Tests have proved that in most cases little difference in signal strength is noticed when the antenna is rotated, provided that the signal is strong. In most installations the antenna will be orientated to provide best reception on desired weak stations and left in that position.

The 300-ohm transmission line is fairly sensitive to metallic objects. The Westinghouse Stratovision FM antenna is supplied with a stand-off insulator to prevent the transmission swinging or rubbing against the metal mast. The three-foot section of transmission line between the stand-off insulator and the center of the dipole should be twisted *three times* and drawn tight through the insulator. The purpose in twisting the transmission line between the dipole center and the stand-off insulator is to maintain electrical balance between each wire of the transmission line and the metal mast. This nullifies the effect of the metal mast in the transmission line field, thus preventing loss of the r-f signal energy.

The section of transmission line between the stand-off insulator and the FM receiver, input terminals should be kept flat and drawn fairly tight. Do not permit the line to swing or rub against roof edges, walls or shrubbery. The transmission line may be dressed against a *dry* wooden baseboard or wall and the line secured by driving a small metal brad through the center of the plastic dielectric and into the wood. The brads should be spaced about one or two feet apart. Do not use thumb or carpet tacks; The large metallic head may short circuit the two wires of the line or may cause serious signal losses due to a change in the characteristic impedance of the line.

Use just sufficient length of line to reach the antenna terminals without coiling; any excess line should be cut away. At these extremely high frequencies, tests have shown that two or three turns or loops in the transmission line are sufficient to reduce the received signal strength 25 to 50 percent.

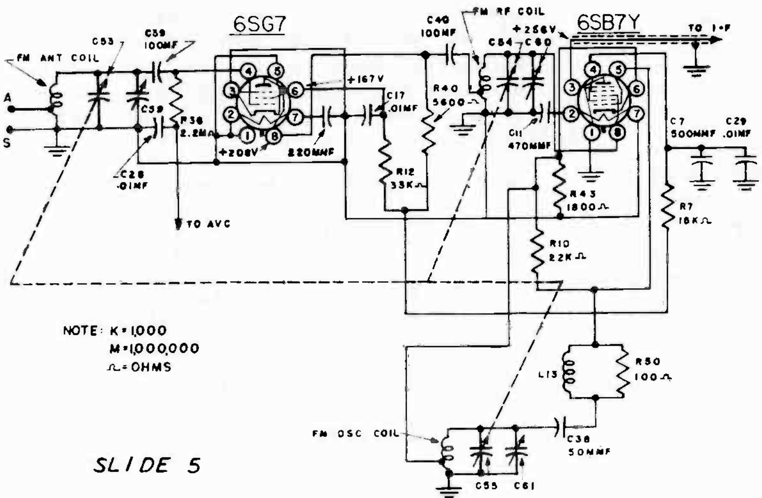
SECTION II
FM RECEIVER FUNDAMENTALS

(2-1) General - The design of a receiver for FM is similar in many respects to that employed in AM practice, but is somewhat more complex. The superheterodyne circuit is standard, but the 88 - 106 megacycle tuning range brings in some variations from the usual AM practice, and, of course, we have the special FM circuit features such as limiters, discriminators, etc. In this discussion we shall start at the FM antenna input terminals of the Westinghouse Model H-119 receiver and discuss the major differences between the FM and AM circuits.

(2-2) R.F., Mixer and Oscillator Circuits, H-119.

The r-f end of an FM receiver has somewhat the same functions to perform as in an AM receiver. I-F rejection is of less importance as the 10.7 mc. i-f is comparatively interference free. Image rejection is not a major problem as the high i-f places images of FM stations outside the band. *The major function of the r-f end of the receiver is to add as much as possible to the gain of the set so that a good signal-to-noise ratio will be obtained.*

Slide 5 shows the r-f amplifier, mixer and oscillator circuits of the Westinghouse Model H-119 AM-FM receiver. Only the FM portion of the circuit is shown; all band switches and components associated with AM have been deleted for the sake of simplicity in following the FM operation. It will be noticed that one wire of the two-wire transmission line from



SLIDE 5

R-F MIXER OSC STAGE H-119

the antenna, is connected to chassis ground; the other wire is connected to a tap on the antenna coil. The tap location has been selected for maximum signal voltage delivery to the 6SG7 r-f amplifier grid and is correct for use with transmission line impedances of from 50 to 300 ohms. The tuned circuits, both physically and electrically, are more or less conventional, as compared with regular AM circuits, except for the size of the tuning capacitors and coils. One and one-half volts of negative bias for the 6SG7 r-f amplifier tube is obtained from the voltage drop across a regiator in series with the power transformer high-voltage winding center tap and additional bias from the AVC circuit. The r-f energy from the 6SG7 plate is fed to a tap on the mixer r-f coil in order to obtain the proper impedance match between the 6SG7 plate and the 6SB7Y signal grid.

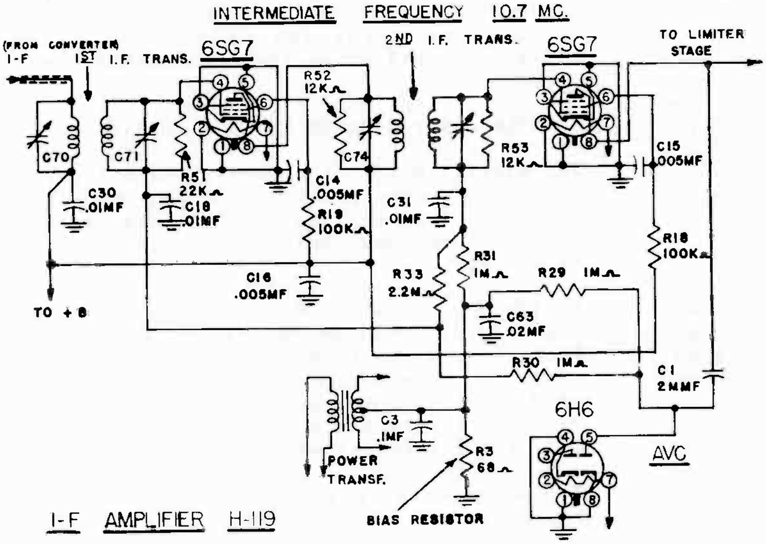
This mixer-oscillator tube is a 6SB7Y which is a special metal-shell type developed for converter service on the new 88 - 106 mc. FM band. The circuit and connections are similar to those of the ordinary 6SA7 type; however, the interelectrode capacitance of the 6SB7Y is much lower than that of the 6SA7 and the 6SB7Y is fitted with a low-loss base. The oscillator circuit is a conventional tapped-coil Hartley type. The coil and resistor network, L13 and R50, is a parasitic suppressor circuit. When the 14-tube chassis was designed it was found that a spurious oscillation appeared near the 1600 kilocycle point on the regular AM broadcast range. The coil and resistor combination effectively eliminates this condition.

(2-3) Intermediate Frequency Amplifier Circuits, H-119.

Electrically, the i-f amplifier circuits of the H-119 are more or less conventional. The 10.7 mc. i-f transformer windings are connected in series with the regular 455 kc. AM i-f windings. Due to the wide difference between the two intermediate frequencies, no interaction or ill effects are encountered. The gain and other characteristics are about the same as when separate transformers are used, In tuning such composite i-f units, the AM or 455 kc. trimmers are adjusted first and the FM or 10.7 mc. trimmers last.

It will be noticed that a 22,000 ohm loading resistor is connected across the secondary winding of the first i-f transformer and 12,000 ohm resistors across the primary and secondary windings of the second i-f transformer. The higher value of resistance in the grid circuit of the first i-f stage is used because of the comparatively low signal level at this point. If the resistance value is made very low the loss in signal level would be too great. The purpose of the resistors is to permit "peaking" of the i-f circuits; unless resistor loading is used, it would be necessary to "flat-top" the i-f circuits in order to obtain proper band-pass characteristics. There is some curvature, of course, in the top portion of the resistance-loaded frequency response curve but the limiter acts to clip off this curvature providing, in effect, a wide-band flat-top response at the discriminator input.

INTERMEDIATE FREQUENCY 10.7 MC.

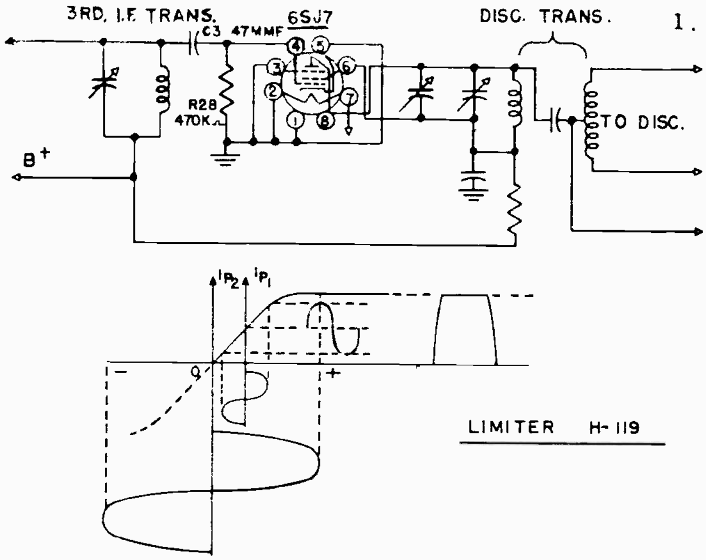


I-F AMPLIFIER H-119

SLIDE 6

This slide shows the 68 ohms voltage dropping bias resistor in the power transformer high-voltage center tap. Note that the signal for the AVC rectifier is taken directly from the plate of the 6SG7 second i-f tube through a 22 mmf fixed capacitor. This permits the same AVC circuit to function on both AM and FM without becoming involved in complex switching arrangements. In every other respect the i-f amplifier is strictly conventional. We shall now discuss the operation of the limiter stage.

(2-6) The limiter circuit, H-119



SLIDE 7

a. *The limiter is an i-f amplifier stage designed to "saturate" at a certain signal level.* It acts somewhat like a tank, which allows the water level to rise to the outflow pipe and then keeps that level constant no matter how much water is poured in.

b. In the FM set the purpose of the limiter is:

1. *To remove all amplitude variations in the i-f amplifier system ahead of the limiter.* It should pass on to the discriminator a signal of constant amplitude and varying frequency.

2. *To enable the FM set to discriminate between two stations on the same frequency* as long as the signal strength of one station is two times that of the other. (Similar to AVC.)

3. *To reject static,* both natural and man-made.

c. Operation of the limiter:

1. *The limiter works on the grid rectification principle.* A grid condenser and grid leak are used in the same manner as the "square law" detectors used in the radios of 15 or 20 years ago.

2. *No negative bias is supplied to the grid.* The grid swings positive and grid current flows at the moment a signal is applied. Grid current flows through the 470,000 ohm grid resistor, R28, from grid to cathode of the 6SJ7 tube. The voltage drop across R28 has a polarity which makes the grid negative with respect to cathode. The stronger the signal, the greater the bias voltage. This "automatic" bias reduces the gain of the tube and maintains a constant output.

d. The step by step operation of the limiter follows:

1. A *strong* signal is impressed on the 6SJ7 grid. The 47 mmf capacitor, C3, rapidly charges up to nearly the peak signal amplitude.

2. *The capacitor then discharges through the 470,000 ohm resistor R28.*

3. *The values of the resistor and capacitor are critical.* The discharge rate through the resistor will be *slower* than the charging rate through the tube. This results in a steady negative bias voltage being built up on the grid.

4. *This negative voltage is almost equal to peak of the signal.* The grid will swing positive only on signal peaks and for a very short period of time. The length of these periods is determined by the time constant of the grid capacitor, C3, and the grid resistor, R28.

5. Under these conditions the 6SJ7 tube then will "squash" down any changes in the strength or amplitude of the signal. From its plate circuit it will deliver a constant amplitude signal to the discriminator.

e. **Precautions**

Limiter tube voltages are quite critical. When replacing the grid condenser or the grid and plate resistors, the exact value specified by the manufacturer must be used.

(2-7) The Discriminator Circuit, H-119

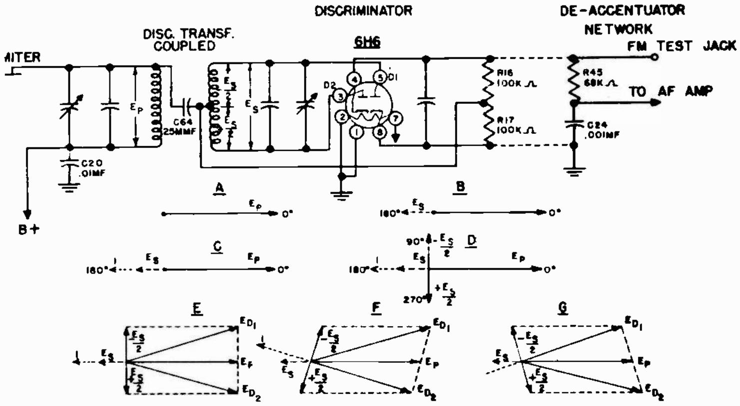
a. *The discriminator is a device which changes frequency variations into a varying audio voltage.* This varying audio voltage corresponds to the sound being transmitted by the FM station.

b. In the Westinghouse Model H-119 a more or less conventional center-tapped i-f transformer and a 6H6 tube comprise the discriminator. This circuit utilizes the phase shift between the primary and secondary voltages across the i-f transformer to produce a differential audio voltage.

c. The step by step operation of the H-119 discriminator is as follows:

1. The i-f signal voltage appears across the tuned primary of the discriminator transformer (condition A)

2. An *induced* voltage is produced across the secondary winding. This voltage is 180° out of phase with the primary voltage (condition B).



SLIDE 8

3. At resonance the *induced* secondary voltage causes an in-phase current to flow through the coil and its tuning condenser (condition C).

4. This in-phase current flows through the coil and produces a *reactive voltage drop* across the coil and condenser. This reactive voltage is out of phase with the secondary current by 90° (condition D).

5. If the resistance of the secondary winding is low, the reactive voltage drop across the secondary tuning capacitor will be many hundreds of times greater than the induced voltage due to transformer action. This "gain" is similar to that of an ordinary TRF stage when it is tuned and for all practical purposes, we can forget the induced secondary voltage and assume that the secondary voltage is equal to the reactive voltage drop across the coil and condenser.

6. The current through the secondary winding may be assumed to flow from bottom to top of the coil. One half of the reactive voltage drop appears between the center tap and the bottom of the coil; the other half appears between the center tap and the top of the coil. For purposes of explanation, we will designate the upper half of the voltage drop as "minus" Es/2 and the lower half as "plus" Es/2.

7. The primary voltage is also coupled to the *center--point of the secondary winding through the capacitor C64.* This voltage appears across resistor R17, and is the same as that across the primary winding.

8. *The resultant signal voltage which appears at diodes No. 1 or No. 2 is the vector sum* of the series voltage drop across R17 plus the upper half of the secondary voltage, or the vector sum of the series voltage plus the lower half of the secondary voltage.

9. *When the signal voltage frequency is equal to the resonant frequency* of the tuned primary and secondary discriminator transformer circuits, the signal voltages appearing at the two diode plates are equal, and equal and opposite rectified voltages will appear across resistors R16 and R17 (condition E).

10. *The audio frequency output under the conditions just mentioned,* will be zero. This would be a condition of no modulation at the FM transmitter.

11. *As the frequency varies with modulation, the voltages applied to the two diodes become unequal.*

12. *At frequencies higher than the resonant frequency of the tuned circuits,* the secondary winding presents an inductive reactance causing the current to lag the secondary voltage. As a result the voltage at diode No. 1 is greater than at diode No. 2 (condition F).

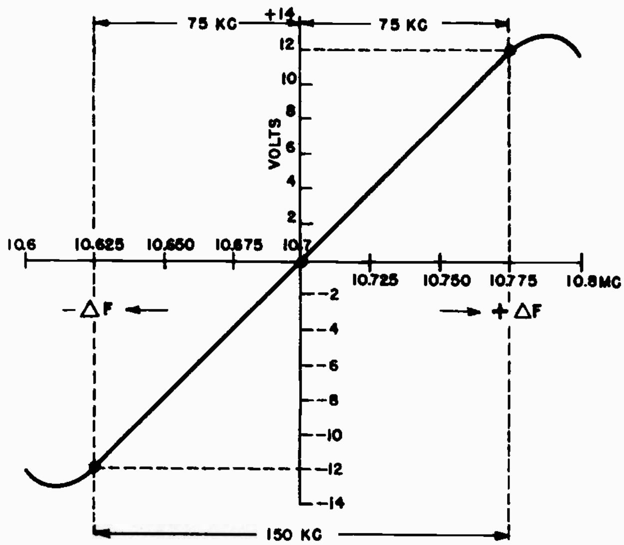
13. Diode No. 1 passes current which flows from the cathode mid-point connection through R16. The voltage drop across R16 is now greater than the drop across R17. The voltage output at the discriminator test jack will be equal to the algebraic difference between the voltage drops across R16 and R17 and will have a definite polarity, plus or minus, with respect to ground.

14. *At frequencies below resonance,* the conditions are the direct opposite of those just described. The tuned circuit now presents a capacitive reactance, the secondary current leads the voltage and the voltage at diode No. 2 is now greater than that at diode No. 1 (condition G).

15. Diode No. 2 accordingly passes current which flows from cathode midpoint connection through R17 causing a greater voltage drop across that resistor.

16. As the frequency swings from one side of resonance, through resonance and to the other side of resonance, the audio voltage output from the discriminator, will decrease to zero, reverse polarity and rise to a peak. If the voltage values appearing across R16 and R17 are plotted against the impressed frequency, a curve such as that shown in slide 9 will be obtained. The straight portion of the curve must, at least, extend over the band width covered by the FM signal.

(2-8) **Deaccentuation Network H-119.** The a-f accentuator is used at the FM transmitter network to raise the amplitude of the audio



SLIDE 9

frequencies in the upper range. At 10,000 cycles the amplitude of the audio signal is up to 15DB. The actual signal, as taken from the discriminator output is therefore distorted. It is necessary to utilize this arrangement in order to prevent the transmission of noise from the FM transmitter.

At the receiver, the a-f amplifier must be designed to present a response the direct opposite of that at the transmitter. This means that the a-f amplitude at 10,000 cycles must be *down* 15DB in order to realize reproduction of the original sound. This is accomplished by the insertion of a network of resistance and capacitance at the input of the a-f amplifier. The time constant of this network is from 70 to 100 micro-seconds and the values are quite critical. When replacing these components, be certain that the values are identical with those specified by the manufacturer.

SECTION III
FM RECEIVER ALIGNMENT AND TROUBLE SHOOTING

(3-1) Voltmeter Alignment H-119

a. Test Equipment Required:

1. Standard signal generator with provision for removal of modulation and capable of providing 10.7 mc. and 88 - 106 mc. output.

2. Vacuum tube voltmeter, such as RCA Voltohmist or Hickok 125 (must have a scale of around 2.5 volts D.C.). A 20,000 ohms per volt D.C. voltmeter, such as Simpson Model 260, may be used. However, the VTVM is recommended.

b. R-F and I-F Alignment.

1. Connect vacuum tube voltmeter across limiter grid resistor.

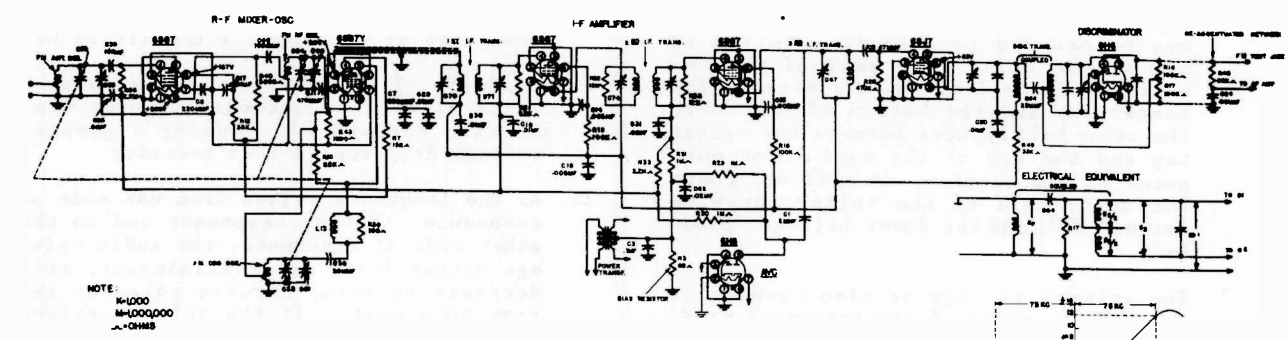
2. Connect unmodulated output signal voltage from signal generator to stage under alignment (if aligning i-f generator should be adjusted for 10.7 mc. center i-f; if aligning r-f, generator should be adjusted to some frequency in the 88 - 106 mc. band.)

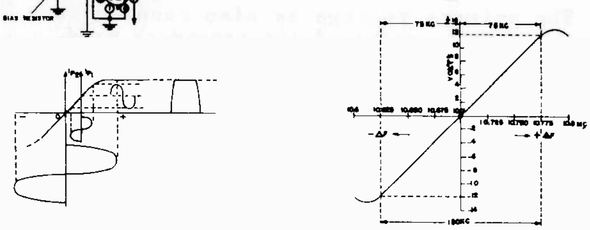
3. Adjust i-f or r-f trimmers for maximum voltage indication on vacuum tube voltmeter.

NOTE: Maintain a good common ground connection between the receiver, the vacuum tube voltmeter and the signal generator.

c. Discriminator Alignment.

1. Connect signal generator to receiver limiter grid. Keep output of signal generator *low* so that grid current will not be drawn.





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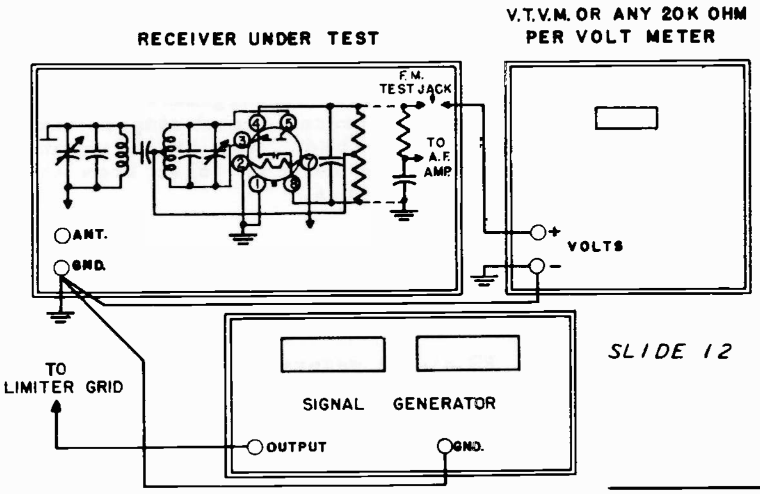


F. M. BAND ALIGNMENT

Connect a 10,000 ohms-per-volt or Vacuum Tube Voltmeter between the Discriminator Test Jack and the chassis.

With the volume control set for maximum output and the signal from the generator attenuated to avoid A.V.C. action, proceed as follows

STEP	CONNECT SIGNAL GENERATOR TO--	SIGNAL GENERATOR FREQUENCY	RADIO DIAL SETTING	ADJUST
1	Set Phono-Band switch to "F.M."			
2	Detune secondary trimmer of discriminator transformer.			
3	6SG7, 2nd i-f, control grid through a .01 mfd mica capacitor	UNMODULATED 10.7mc	88 mc	10.7 mc primary trimmer of 3rd i-f trans. for maximum voltage.
4	6SG7, 1st i-f, control grid through a .01 mfd mica capacitor	UNMODULATED 10.7 mc	88 mc	10.7 mc secondary and primary trimmers of 2nd i-f trans. for maximum voltage.
5	Fixed plates of the FM converter tuning capacitor through a .01 mfd mica capacitor	UNMODULATED 10.7 mc	88 mc	10.7 mc secondary and primary trimmers of 1st i-f transformer for maximum voltage.
6	Fixed plates of the FM converter tuning capacitor through a .01 mfd mica	UNMODULATED 10.7 mc	88 mc	carefully "peak" all 10.7 mc i-f trimmers for maximum voltage.
7	FM antenna terminal through a non-inductive 300 ohm resis.	UNMODULATED 105 mc	105 mc	FM oscillator trimmer for maximum voltage.
8	FM antenna terminal through a non-inductive 300 ohm resistor	UNMODULATED 105 mc	105 mc	FM r-f and ANT trimmers for maximum voltage.
9	Fixed plates of the FM converter tuning capacitor through a .01 mfd mica capacitor	UNMODULATED 10.7 mc	88 mc	Primary trimmer of discriminator transformer for maximum voltage.
10	Fixed plates of the FM converter tuning capacitor through a .01 mfd mica capacitor	UNMODULATED 10.7 mc	88 mc	Secondary trimmer of discriminator transformer for zero voltage. The voltage will change polarity as the trimmer is tuned through resonance. Tune carefully for zero voltage.
11	Re-check steps 9 and 10.			

2. Connect vacuum tube voltmeter to discriminator output (FM test jack in H-119).

3. Detune discriminator transformer secondary trimmer.

4. Adjust discriminator transformer primary trimmer for maximum voltage indication on the VTVM.

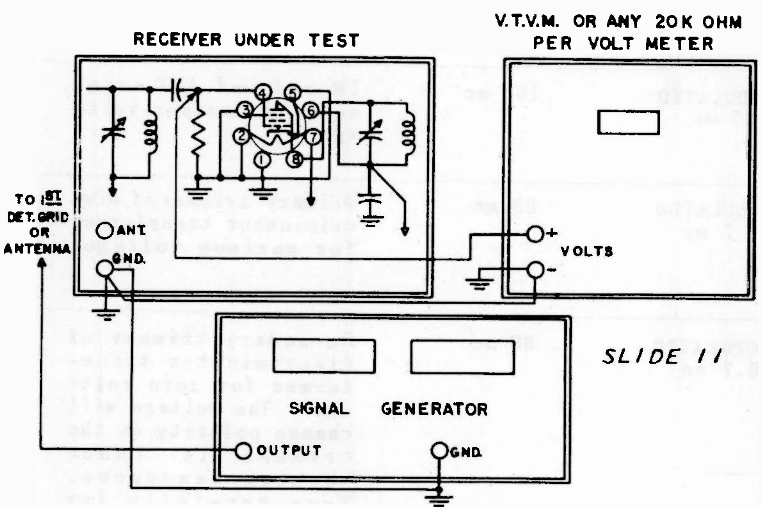
5. Adjust discriminator transformer secondary trimmer for *zero* voltage indication on the VTVM.

NOTE: As the secondary trimmer passes through resonance, the voltage indication will decrease to zero, reverse polarity, and again increase to a peak. Adjust as accurately as possible to the zero value.

6. Swing signal generator frequency to 10.775 mc. Note discriminator voltage value as indicated on VTVM.

7. Swing signal generator frequency to 10.625 mc. Note discriminator voltage value as indicated on VTVM. This voltage indication will be of opposite polarity to that observed under step 6. The two readings should be of the same value within ± 10% of the highest value.

8. If the two voltage readings are not within the tolerance specified under step 7, a slight readjustment of the primary trimmer may be necessary. The primary trimmer controls the amplitude and linearity of the discriminator output; the secondary trimmer controls the location of the zero reference point on the discriminator characteristic curve.



d. FM Alignment H-119

Service Department laboratory tests showed that the Model H-119 FM alignment could be carried out by a procedure much simpler than that just described. The FM alignment chart reproduced here is taken from the H-119 Service Notes.

(3-2) **Visual Alignment H-119**

a. Test Equipment Required:

1. FM signal generator, such as Hickok 288-X, capable of providing 10.7 mc and 88 - 106 mc output. Should supply synch sweep voltage for oscilloscope trace.

2. Oscilloscope, such as RCA Model 155C.

b. R-F and I-F Alignment

1. Connect oscilloscope vertical input across limiter grid resistor.

2. Connect synch sweep voltage from signal generator to horizontal input of oscilloscope.

3. Connect output signal voltage from signal generator to stage under alignment (if aligning i-f, generator should be adjusted for 10.7 mc. center i-f; if r-f, generator should be adjusted to somewhere in 88 - 106 mc. band).

4. Adjust i-f or r-f trimmers until oscilloscope pattern is similar to "A" in slide.

NOTE: Maintain a good ground common connection between the receiver, the oscilloscope and the signal generator.

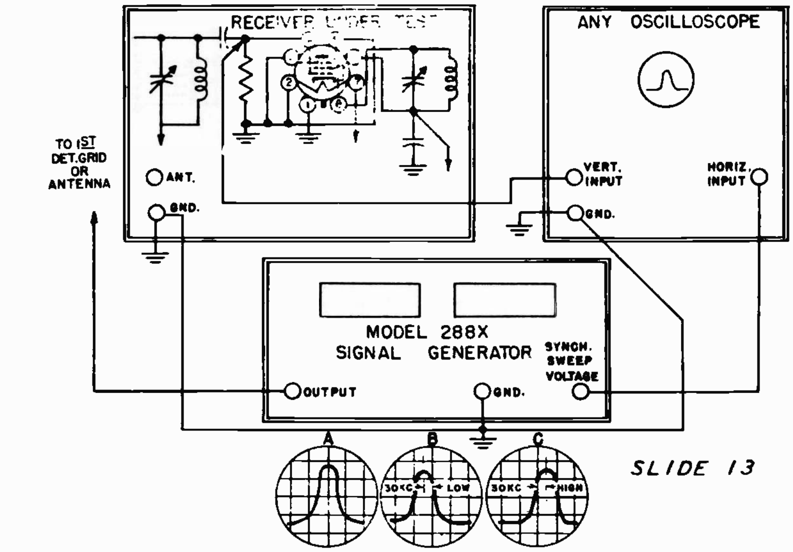
Visual Alignment Discriminator

1. Connect signal generator to receive limiter grid and to oscilloscope as outlined above.

2. Connect vertical input of oscilloscope to discriminator output (FM test jack in H-119).

3. Adjust discriminator primary trimmer for *maximum pattern amplitude*.

4. Adjust discriminator secondary trimmer until pattern is correctly centered about the horizontal axis. The positive and negative peaks should be equal in amplitude and the trace between the two peaks should be linear, at least over the frequency response of the r-f and i-f circuits.



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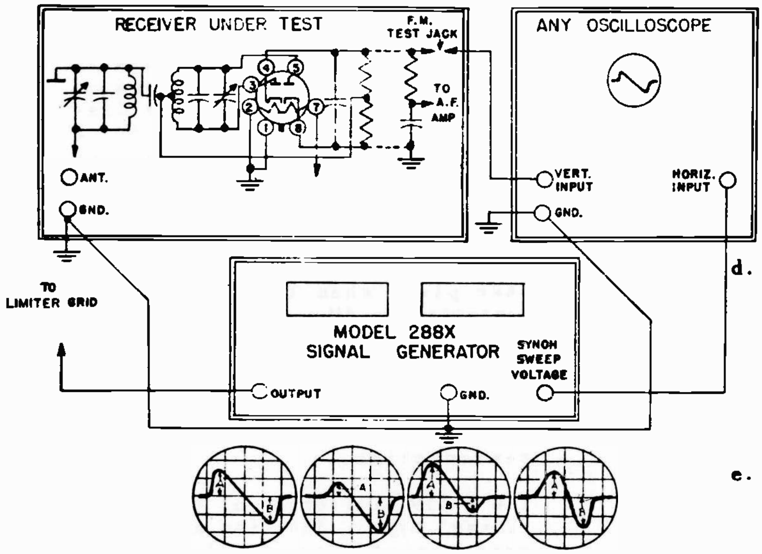

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5. It may be necessary to alternately readjust the discriminator primary and the secondary trimmers to obtain linearity and symmetry in the output. The primary trimmer controls the overall amplitude and the linearity of the pattern; the secondary trimmer controls the distribution of the pattern around the horizontal axis or zero reference line.

(3-3) FM Trouble Shooting

a. Noise and Hiss

1. Noisy r-f or converter tube
2. Defective antenna system
3. Excessive plate voltage on limiter
4. Regeneration

b. Regeneration

1. Improper lead dress
2. Incorrect alignment
3. Defective shield or ground straps
4. Open bypass condenser (r-f or i-f circuits)

c. Distortion and poor Tone Quality

1. Limiter not functioning due to
   - a. Bad 6SJ7 limiter tube
   - b. Incorrect limiter voltage
   - c. Limiter circuit not properly aligned
   - d. I-F circuits not properly aligned
   - e. Bad i-f amplifier tube
   - f. Open loading resistor across i-f winding
   - g. Open bypass condenser, i-f circuit
   - h. Incorrect voltages on i-f tubes
2. Bad resistors or capacitors in de-accentuator network.
3. Insufficient signal for limiter saturation due to
   - a. R-F circuits out of alignment
   - b. Bad r-f tube
   - c. Inefficient antenna system

d. Dynamic Range or Reproduction Poor

1. Limiter not functioning properly
2. Regeneration in i-f due to open bypass condenser or open loading resistor across i-f transformer
3. I-F circuits, limiter or discriminator not properly adjusted.

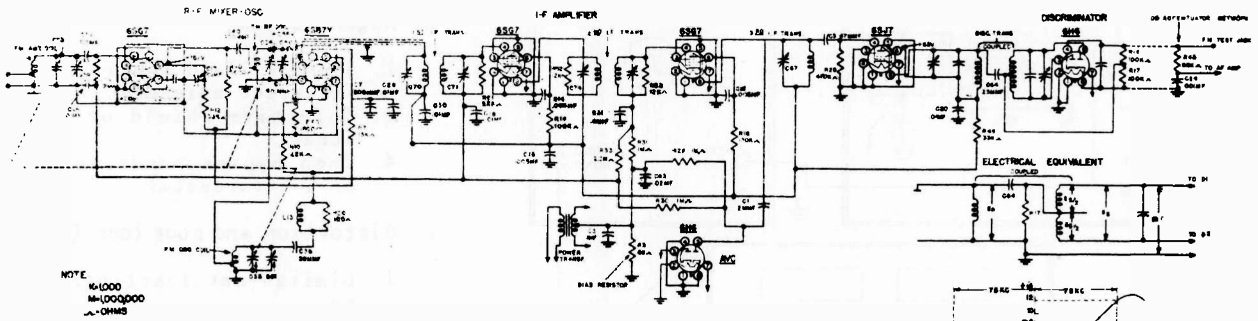
e. Lack of Highs on FM Stations

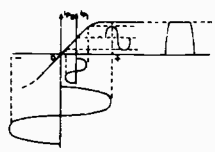
1. Check resistance-capacitance values in de-accentuator network.

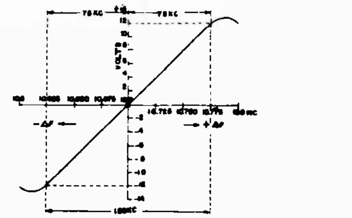
f. Trouble Shooting in the Discriminator

Trouble: Severe Amplitude Distortion During High Audio Signal Levels.

Remedy: This trouble is frequently due to poor discriminator alignment. High level audio signals correspond to wide frequency deviations around the center intermediate frequency. If the discriminator is far out of alignment, the widely deviated signal, which corresponds to a loud noise, will go over the "hump" of the characteristic curve and distortion will result. If the discriminator is only slightly out of alignment, the audio quality will be good except on the very loud passages where the response leaves the linear portion of the curve and passes over to the peak.







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To correct, realign the discriminator transformer primary and secondary trimmers.

Another possibility is that one-half of the discriminator transformer secondary winding may be open; or, the phasing condenser between the primary and secondary windings may be open. Either of these troubles will cause loss of one reference voltage and thereby introduce distortion.

g. Trouble Shooting in the Limiter

Trouble: Distortion in Discriminator A-F Output

The same basic operating principle is involved in all present-day limiter circuits. In the Westinghouse H-119, a 6SJ7 sharp cut-off pentode is operated so that grid swing conditions between cut-off and zero grid volts is of the order of 3 or 4 volts. The plate and screen voltage is maintained at approximately 63 volts. Under such operating conditions, with a strong signal applied to the limiter grid, plate current saturation is quickly reached.

The most frequent trouble in limiter circuits, with the possible exception of tube trouble, is a change in plate voltage due to changes in the value of the plate load resistor or to partial short-circuit of the plate circuit bypass condenser. If the plate and screen voltages are too high, the "threshold" voltage may change as much as 50 to 150 microvolts or more. This means that the limiter will function as an i-f amplifier and little or no limiting action will take place. As the signal frequency swings with modulation, it passes over the slope of the i-f characteristic curve generating an AM signal which can be passed on to the discriminator. The discriminator will respond to AM as one-half of the 6H6 tube can act as a diode rectifier. Unless the limiter removes the AM response, this condition will occur. The i-f response curve is not linear, so considerable distortion will take place when the FM signal is converted to AM. This is not normal FM reception and the conditions just described are due to a lack of limiter action. This condition can be readily recognized by noisy and somewhat distorted reproduction.

The H-119 limiter is of the "peak-riding" type. The bias across the grid resistor is developed from current flow during the peaks of the r-f grid voltage swing. This grid current charges the capacitor and the capacitor, in turn, discharges through the grid resistor. If the grid resistor became open, there would be no leakage path for the condenser charge. A burst of noise or a strong signal will charge the grid capacitor to a large bias voltage. If the resistor is open, however, there would be no condenser discharge other than the loss leakage across the dielectric and the accumulated charge holds the 6SJ7 grid below the cut-off value. This condition will cause sharp clicks of signal or noise similar to a motor-boating effect. If the capacitor dielectric has a very low leakage factor, the set may appear dead for fairly long periods of time.

LESSON 22

The Radio Servicing Business

Obtaining Radio Repair Jobs

Servicemen forget that they live in a highly-competitive society. They expect Mr. Radio Owner to come to them when he has radio difficulties, to beat a path to their door, and to search high and low for their addresses if necessary. Of course, this does not happen and the fellow down the street gets the job. If you want more business, if you want the business of people who never heard of you, you must let them know of your existence, your good points, your special abilities to serve them. You must approach them many times in many different ways. Advertising does this and advertising pays!

Money invested in advertising is far from being foolishly spent. Not only do you expect to receive back every dollar spent on advertising, but on every dollar you expect a certain definite return in the form of increased business and greater profits. You will get these successful results if you plan your advertising wisely and correctly.

Among the various forms of advertising suitable for radio service business, advertising in publications such as local newspapers and telephone books is most common. When advertising is sent directly to the prospect, either by mail or messenger, this method of advertising is called direct mail.

Posters, window displays, and signs are very effective ways of obtaining additional business. See the sample illustrated. There are also certain unique methods of advertising salesmanship that get business.

Advertising in any form must get attention. Unless an advertisement or a sign attracts attention, it is not present as far as the prospective reader is concerned and it is useless. Attention is obtained in various ways. Sheer size, black type, white space, color, novelty, illustration, and catch-phrases serve to get attention.

Once attention is arrested in any suitable manner, the interest of the reader must be held. The story, the picture, the idea must "get the reader," compel him to read on. In other words, it is not merely enough to notice an advertisement, but the advertisement must actually prove interesting. With the reader expressing a not personally realized interest in your advertisement, the next step is to create a desire. A desire for a better set, a new set of tubes, or better reception.

SAMPLES OF CLASSIFIED ADS

Service, Repair, Etc.

RADIO SERVICE—WORK GUARANteed. No set too complicated. Experienced men, Radio Center, 19 Yes St. BRyant 9-0558.

$3 TV SERVICE $3
Day, night, Sunday; N. and N. W. TRU VUE GRaceland 7-5772

E-Z TERMS ON ALL RADIO REPAIR, wash. mach. vacuum cleaners. BRyant 9-0558.

$3—POWER TV SERVICE—$3
Day, night, Sun. Parts guar. No job too little or too big. 1 hour service. North and South. LAkeview 5-1409

Once the desire is aroused, the reader must be impressed with conviction that your tubes, your service, or your appliances are what he wants. Your items and service must appear to him as the logical solution of his desires.

At this stage, the reader is convinced that your service or products are what he wants and needs, but you must make him act. Action will make him pick up the 'phone and call you up or stop in to have his tubes tested. Do not merely tell your story in your advertisements. Finish up with action that will make the reader exclaim: "I'll phone that service man right now," and not "Well, my radio hasn't been playing right, I'll get it fixed one of these days."

In larger cities, a small advertisement in the want-ad section of the daily newspaper brings excellent results. Some outstanding points about your service must be featured. Note the few examples shown. The feature of the first ad is the fact that no set is too complicated and the work is guaranteed. In smaller city papers and in weeklies it is best to take display space, two or three inches.

The principles in the preparation of the advertising copy are therefore well defined, and of course the main objective is sales. It may seem a far cry from a two-line classified advertisement to a well-considered plan of copy preparation. Perhaps it is. The name, nature of business, solicitation, address and telephone number may take up half the space. Not much theory need be applied to creation of the seven words constituting the extra line of type. But there are at least two factors that justify exercise of skill and care, even under the extremely restricted condition outlined. First, the habit of doing things right is just as important to your grandest one, and large advertising agency businesses have been developed for handling only classified advertisements because of specialized skill; second your advertising space will grow with you, and the principles applicable to copy and art creation are in general the same for all sizes of advertising space. So address yourself to these purposes:

1. Arouse interest.
2. Create desire.
3. Impress conviction.
4. Induce action.

Telephone book advertisements offer excellent possibilities. A large number of people turn to the 'phone book when they are in need of some special commodity or service. The two examples shown demonstrate the two possibilities of such advertisements. Notice that the upper ad has much copy or reading matter. On the other hand, the second ad has white space and but a few words. Both methods have their advantages, but a happy medium will be best.

SAMPLES OF DISPLAY ADS

RADIO SERVICE CENTER
Calls Made Day and Night
HONEST - RELIABLE SERVICE
Any Make Set—10 Years in Business
Accurate Tube Test in Home
Most Modern Test Equipment
Member, Radio Service Institution
FREE ESTIMATE IN SHOP
Parts in Stock for All Sets
19 Yes St. BRyant 9-0558

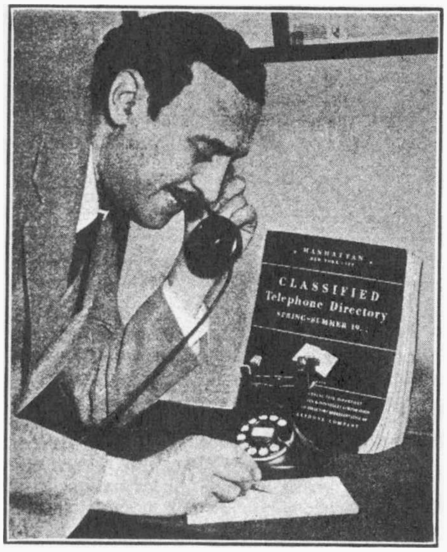
SOMEONE'S RADIO SHOP
Prompt
EXPERT REPAIRS
On
ALL MAKES
Free Estimates — Work Guaranteed
19 Yes St. BRyant 9-0558

Telephone-book advertisements.

Dreams will not create successful advertisements or bring business to your store. Good advertising should make things easy for your customers.

Every serviceman should have a complete mailing list of the people he has served. Occasional mailing should be made, suggesting free check-up service on tubes, or other offer. New names may also be used for this publicity.

Publicity via the telephone is also adaptable for selling service. If Mr. Brown had his radio repaired ten months ago, a telephone call some evening should be made. Here is a typical conversation:



"Hello, Mr. Brown. I repaired your radio some time ago. How does it work now? .... I am glad to know that it works fine. Does your television set need any adjustment? .... Perhaps you do not know that I also repair all types of electrical appliances."

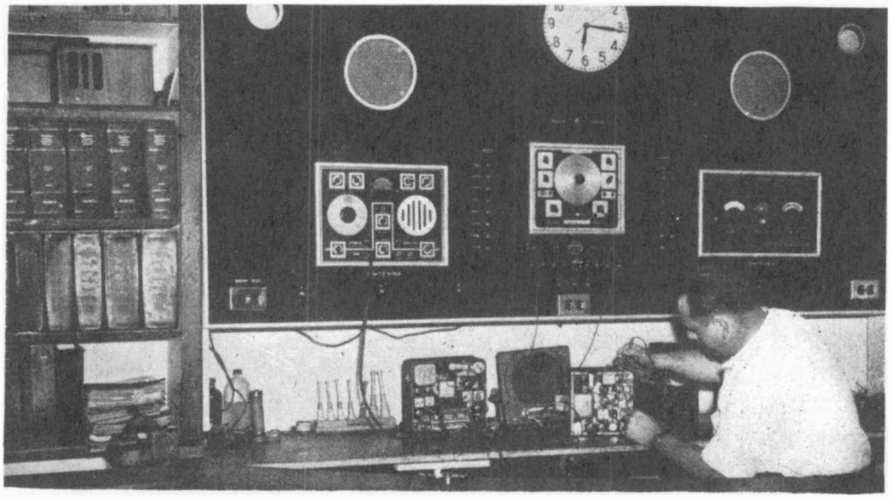
These various suggestions should result in some work for you. But even if not one of your questions brings a call for service, you have reminded an old customers of yourself and are now more certain to receive the next service job. At times, your customer may tell you of a friend who needs a radio repaired or a television adjusted.

When a day comes along without service calls and you find idle time on your hands (this can happen in the busiest of shops), use the telephone to call "cold" prospects in your locality. This is a good way to get service jobs and find new customers.

If you drive a car or a small truck, be sure to have an advertising message painted on a panel or a sign placed in a window which will tell of your service and give your address and telephone number. During slack times, it is worth while to ring the bell of a neighbor where you worked and explain: "I have just repaired a radio next door. Perhaps your radio or television set needs adjustment or repair. You will save on my travel charges since I am already at your door." This approach will result in a repair job if work is needed by this neighbor. In any case, you should leave your card in case a serviceman is needed at some future date.

Window display advertising can be very effective. It is of prime importance, where you have a street front, to have the window dressing not only neat and orderly, but interesting. This is an art in itself and large outfits either have professional window dressers on their payroll or hire them as needed. A small operator has to do his own work, probably. So the fellow who started out as a service man finds he has to be an advertising writer of sorts, a window dresser, a bookkeeper, a buyer, a clerk, and finally a service man.

Help in a plan of window display may be obtained from the women folk. Mother, sister, or wife can suggest that "touch" a man handy with soldering iron is not likely to have.



The usual displays as received from manufacturers may serve well on counters and in windows, but the most effective method is one invoking originality. Then one's window becomes distinctive. Services that incur movement are impelling. Anything that evokes an interesting contrast is valuable for its attention value. All ideas should be definitely associated with a sales appeal. The object is to sell. Everything else is only the means.

One fellow got six dead transmitting tubes from a station and put these giants next to six receiver tubes. He cited the fact the station checked tubes hourly. Why should not the listener have his tubes checked twice a year, also for the same reason — best quality performance? The transmitting tubes cost $1,500. The six receiver tubes could be bought for less than $8.

"Let us check your tubes" is the sales appeal, because if any tubes are bad or weak, a tube sale is made, and if the tubes are in good condition, the set may not be. Or, if everything is all right, some accessory may be sold to make reception better than just "all right," or to introduce a new service from the receiver, as in the case of the phonograph pickup attachment.

Another dealer attracted large crowds of real radio prospects by offering $10 prize for the owner of the oldest radio set. Certainly the person who thinks he has the oldest radio in a community is a good prospect for a new set.

The Question of Rates and Charges

The subject of the rate per hour can be calculated by considering all expenses including overhead for a period of one year and dividing this sum by the total number of productive hours in this period. This high-brow accounting technique is better suited for larger corporations. You better figure on a flat fee based on amounts others have found satisfactory. You should not make less than $2.25, but try to average $3.00 per hour. This is not too much when you consider the hours spent in travelling, buying parts, possible adjustments, holidays, and other hours spent in your business without direct earning.

I do not recommend, however, that an hourly charge is made to the customer. A charge should be made for the complete repair since this is what your customer wishes to purchase — they do not want to buy time. Parts used, at retail price which is about 66% above your cost, should also be added to the bill.

You should use the hourly charge suggestion in computing the probable charge. An estimated charge can be given in advance — make this on the high side, this will prove a good idea if the actual cost comes out about the same or lower. Charge the actual price as computed when the job is finished. If an exact price is wanted, take a guess. Make it high enough to be safe. Charge this price for the job no matter if it turns out higher or lower. Now let us consider how the price can be determined.

Brief tests to localize the source of trouble in a radio set will require about one-half to one hour. Much will depend on the difficulty of getting the chassis out of the cabinet. In the shop, the cost of time to find the fault will average between $3.00 and $4.00. If you know the fault is an intermittent, play safe with a cost figure of $6.00. To do the work in the home about $2.00 must be added to cover travel time.

The actual repair may take from a few minutes to replace a resistor to over an hour for replacing an I.F. transformer and completing the alignment. About $3.50 will cover most cases. Parts for an average job will cost $1.50, you figure $2.50. These figures indicate that an average job in your shop will be billed between $6.10 and $7.10. This gives you a figure to use if a price is wanted completely in advance; make it $10.00 for safety. If you are permitted to give the set a brief examination (your charge is $2.00 to $3.00 anyway if your customer does not want the work completed), you can give a more accurate estimate. Add a small amount anyway as a safety factor.

Be careful to quote what you believe are the correct figures. State the amount in a clear voice, make the customer realize by your actions and speech that you carefully considered the price and your quote is fair and final. If the customer wishes to think the matter over, permit him to do so, but make a record of your quotation for future reference. If the situation permits, you can go into some detail in explaining how you obtained your charge. This suggestion applies both to the occasion when you are furnishing a quotation and when you are presenting the actual bill.

Each job should be covered by a bill where labor appears as one item (no hours need be shown), and every single part used should be listed together with the net price to your customer. Any damaged parts removed from the radio should also be presented at this time. If you are told to junk these parts, try to break or mar them in some way while the customer is still present.

Another

Supreme Publications

Service Manual