Radio Tube Hints

VOLUME ONE

COMPILED AND PUBLISHED BY

SYLVANIA
ELECTRIC PRODUCTS INC.

RADIO TUBE HINTS

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COMPILED AND PUBLISHED BY
SYLVANIA ELECTRIC PRODUCTS INC.
MANUFACTURERS OF
Sylvania Radio Tubes, Fluorescent Lamps and Fixtures,
Incandescent Lamps, Electronic Devices

EMPORIUM, PENNA.
PLANTS IN PENNSYLVANIA AND MASSACHUSETTS

FIRST EDITION
THIRD PRINTING

No patent liability is assumed with respect to the commercial use of the circuits and tube information contained in this booklet.

FOREWORD

This book is not intended to be a complete treatise on the subject of radio tubes but rather a handy reference book of generally helpful information and data for radio servicemen. If this little booklet helps make their work more pleasant and more profitable, it will have fulfilled its mission.

SYLVANIA ELECTRIC PRODUCTS INC.

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Converter Tube Design Features

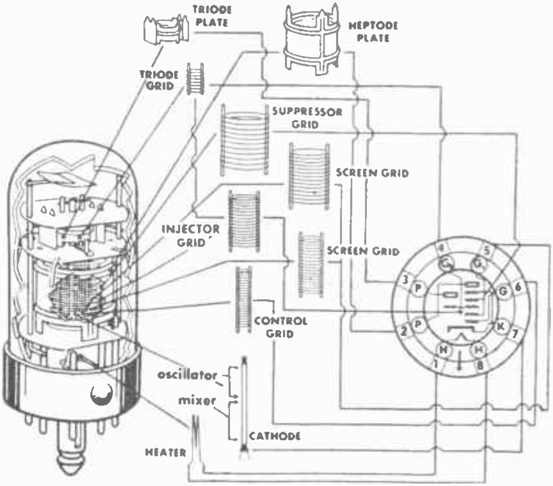
Service problems related to converter tubes may often be clarified through knowledge of the tube design of the particular type in question. Numerous converter tube types have been employed in superheterodyne receivers. Five principal designs are in general use and these will be briefly described as to their constructional features and the functions associated with the various grid structures. Several typical performance curves are also discussed.

TRIODE-HEPTODE CONVERTERS

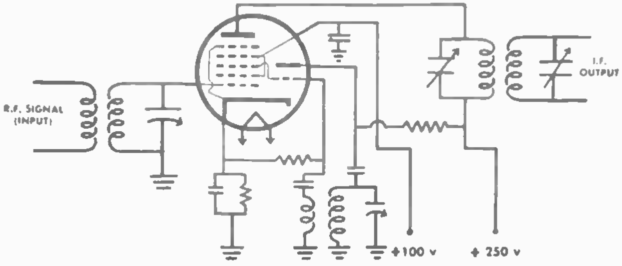
Types 7J7, 7S7, 14J7, 14S7, 6J8G

The superheterodyne receiver requires a converter tube whose function is to mix or beat (heterodyne) the incoming signal frequency with a locally generated frequency to obtain an intermediate frequency. If the output from a conventional triode oscillator is suitably coupled to a tuned r-f voltage amplifier, the pentode plate circuit will contain four frequencies: the signal frequency, the oscillator frequency, and the sum and the difference frequencies of these two. The latter are obtained by beating the first two frequencies mentioned. Since more gain is secured at lower frequencies in the i-f amplifier stages, the difference frequency (called the i-f frequency) is the one desired. This can be obtained when the tuned circuits in the pentode plate are designed to resonate at the i-f frequency, in which case they will reject the other three frequencies.

Such a circuit can be simplified considerably by combining the triode oscillator with the mixer tube in one bulb. Furthermore, improved efficiency and stability can be secured by adding an injector grid in the mixer section which is connected directly to the grid of the oscillator section, thereby permitting both the mixer control grid and the injector grid to control the electron stream. This provides true electron coupling. An illustration of such a tube is the



triode-heptode Type 7J7 shown above. The diagram indicates that the cathode is common to both units, the upper portion being associated with the triode oscillator and the lower section with the heptode mixer. A typical circuit diagram is shown wherein plate-tuning of the oscillator is indicated. Grid-circuit tuning is also widely



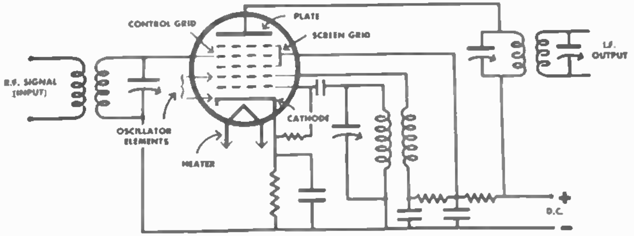
employed with triode-heptode tubes, in which case the oscillator circuit resembles that shown for the pentagrid converter described on page 8.

THE PENTAGRID CONVERTER

Types 1LA6, 1A7GT/G, 7A8, 7B8, 6A8G, and others

Pentagrid Converter is the name applied to a tube having five grids in addition to the cathode and plate and intended for frequency conversion in superheterodyne radio receivers. Such tubes combine the functions of oscillator, mixer and amplifier within one structure. The No. 1 and No. 2 grids are used as the oscillator grid and oscillator plate respectively. Electrons passing through grids No. 1 and No. 2 are further controlled by the signal input grid No. 4. This grid is shielded from the oscillator section by grid No. 3 and from interaction with the plate by grid No. 5. Screen grids No. 3 and No. 5 are connected together internally. The circuit on the next page illustrates the use of the pentagrid converter, such as Type 7B8. Voltages of signal and oscillator frequency reaching the plate are bypassed to ground, since the tuned circuit in the plate is resonant only to the beat or intermediate frequency (I.F.) which is to be further amplified.

The pentagrid converter may be considered as operating very much like a conventional variable-mu tetrode first detector with an associated triode oscillator, except that the oscillator triode grid is located next to the cathode which is common to both the first detector variable-mu tetrode and the oscillator triode. Electrons emitted from the cathode surface are influenced by the various grid and plate voltages and divide up so that grid No. 1 receives about 3 to 6 per cent of the electrons, the oscillator anode receives about 40 per cent of the electrons, grids 3 and 5 (screen grid) receive about 25 to 30 per cent of the electrons, and the plate receives the remaining electrons emitted. Because of the oscillator grid's strategic position next to the cathode, any oscillator voltage on this grid will modulate the entire electron stream regardless of the ultimate destination of the electrons. Referring to the diagram, it is interesting to observe the action that takes place within the tube when it and the associated circuit components are operating normally. When the set is first turned on, the No. 1 grid is at zero potential because it is tied to the cathode by the 50,000 ohm grid leak. As the cathode heats up and starts to emit electrons, the feedback between oscillator anode and grid causes regeneration which immediately starts the triode circuit to oscillating. When the oscillator circuit is oscillating. the No. 1 grid is driven alternately positive and negative. While the grid is positive, grid current flows through the grid leak in such a direction as to make the No. 1 grid negative with respect to the cathode. This grid swing may make the grid negative by as much as 30 to 40 volts, and this becomes the grid bias point about which the grid varies in amplitude alternately in a positive and then a negative direction under the influence of plate circuit feedback. From this it can be seen that the maximum instantaneous negative voltage on the No. 1 grid may be 60 to 80 volts.



Electrons from the cathode are accelerated through the No. 1 grid by the positive oscillator plate and the positive screen grid. The oscillator plate actually consists of a pair of side rods but no grid wires are strung on these rods. Many of the electrons approaching the oscillator plate possess high velocities so that they shoot past the oscillator plate and for the most part through the screen grid No. 3 and approach grid No. 4. The No. 4 grid has a negative potential which therefore retards the oncoming electron stream. This cloud of retarded electrons between grids No. 3 and No. 4 constitute a virtual cathode for the tetrode section of the tube. Electrons may be drawn away from this source (virtual cathode) in a manner quite analogous to that by which they were originally accelerated away from the regular cathode.

If grid No. 1 is only slightly negative or even somewhat positive, then the virtual cathode has an ample electron supply for the tetrode section of the tube. Whenever grid No. 1 swings to more negative values, the number of electrons arriving at the tetrode plate is temporarily reduced or possibly cut off. Pulses of current are therefore supplied to the tetrode section at oscillator frequency and the electron stream to the tetrode plate is modulated by the r-f signal voltage on the No. 4 grid. Thus, the oscillator can modulate the signal in the tetrode section and produce the i-f beat note in the plate circuit of the tetrode section.

The current necessary to have sustained oscillations is controlled by the oscillator grid and not by the signal grid, the latter being incapable of producing cutoff in the oscillator section. The gain of the tube can be controlled over a considerable range by a variable negative bias on grid No. 4 without substantially affecting the oscillator section.

THE PENTAGRID MIXER

Types 6L7 and 6L7G

Type 6L7G pentagrid mixer is used with a separate oscillator tube. Type 6L7G has the No 1 grid as the signal grid, grids No. 2 and No. 4 connected internally as screen grids, grid No. 3 as the oscillator injector grid and the No. 5 grid as the suppressor (connected internally to cathode). Thus, Type 6L7G is quite similar to the mixer section of Type 7J7.

THE TRIODE-HEXODE

Types 6K8, 6K8G and 6K8GT

Such converters have a rather unconventional structure. The oscillator plate is so located that it is completely removed from the cathode to mixer plate electron stream. The oscillator plate and mixer plate are on opposite sides of the cathode. Grid No. 1 completely surrounds the cathode so that the side towards the oscillator plate acts as the oscillator grid, while the other side is associated with the mixer and modulates the cathode to mixer plate electron stream at oscillator frequency. With this construction a single grid suffices to screen the oscillator grid from the signal grid as well as to screen the signal grid from the mixer plate. The signal control grid is made in the form of a flat wound grid with one-half of the windings (those facing the oscillator plate) removed. Specially designed metal shields suitably connected to the cathode prevent stray electrons from producing undesirable couplings and also serve to isolate the oscillator and mixer sections. In addition, they cause a potential minimum to exist between the screen and plate. Sufficiently high plate resistance is obtained so that a suppressor grid is not required.

THE PENTAGRID CONVERTER 6SA7 TYPE

Types 6SA7, 6SA7GT/G, 7Q7, 12SA7GT/G, 14Q7

This construction, as exemplified by Types 6SA7, 6SA7GT/G and 7Q7, is somewhat like 6L7G except that the functions of grids No. 1 and No. 3 are interchanged. Grid No. 1 is the oscillator grid and grid No. 3 is the signal grid, the latter having a remote cutoff characteristic. The side rods for grid No. 3 are located 90° from the plane of the other side rod supports and are therefore directly in the center of the electron stream. The negative voltage on the signal grid repels some of the electrons traveling to the plate back towards the cathode. However, these electrons will not affect the space charge near the cathode since most of the electrons turned back are intercepted by collector plates fastened to the side rods of the No. 2 screen grid. Hence, the collector plates of the screen provide isolation of the cathode space charge and the signal grid so that changes in signal grid voltage produce little change in the cathode current. Any changes in plate current due to signal grid voltage changes are offset by opposite and nearly equivalent changes in screen current. Screen grids No. 2 and No. 4 are connected internally. Grid No. 5 is the suppressor and serves to increase the plate resistance of the converter.

DEFINITIONS

Conversion Conductance (g_c) is defined as the ratio of the intermediate frequency component of the plate or output current of the converter tube in a superheterodyne receiver to the radio frequency component of the signal voltage applied to the control grid. The value is expressed in micromhos. With reference to the performance of a frequency converter, it is employed in the same manner as mutual conductance is used in single frequency amplifier computations.

Conversion Gain is the ratio of the intermediate frequency voltage developed across the load to the radio frequency voltage applied to the control grid. When tube and circuit constants are known the conversion gain may be computed from the formula:

$$\text{Conversion Gain} = \frac{g_c\, r_p\, R_L}{r_p + R_L}$$

Where g_c is the conversion conductance, r_p the plate resistance and R_L the resonant impedance of the i-f transformer measured across the primary terminals.

Several curves may prove helpful in illustrating performance characteristics of converters. Fig. A shows how the conversion conductance for a typical triode-heptode converter varies with the negative control grid (heptode) voltage. The recommended control grid voltage would be approximately −3 volts, under which conditions the tube has a conversion conductance of about 300 micromhos. The curve also indicates the cutoff characteristic, since the conversion conductance is reduced to only a few micromhos when the control grid voltage reaches −16 volts.

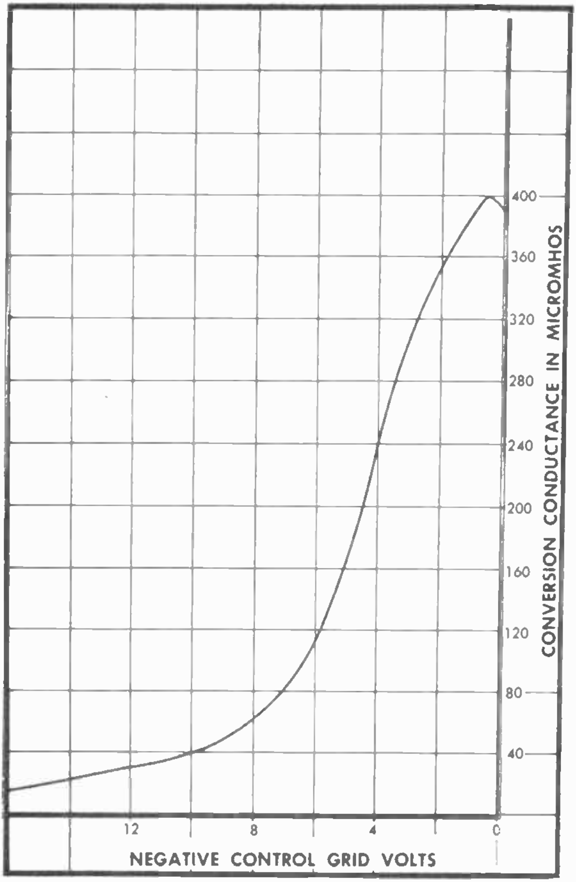

400
360
320
280
240
200
160
120
80
40
CONVERSION CONDUCTANCE IN MICROMHOS
12
8
4
0
NEGATIVE CONTROL GRID VOLTS

Fig. A

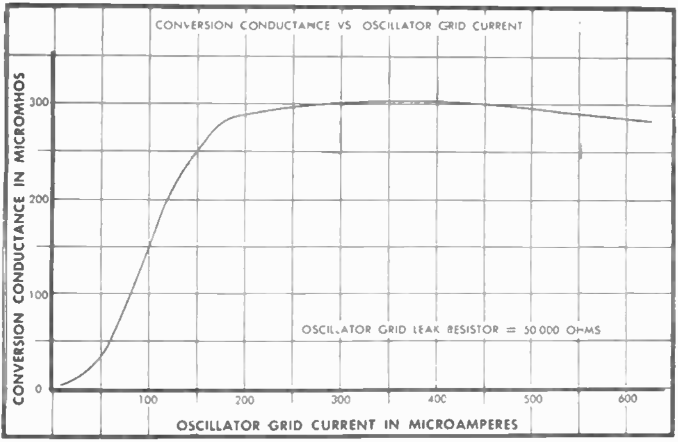


Fig. B

For optimum receiver performance too much emphasis cannot be placed on the curve of Fig. B. This gives the variation in conversion conductance for oscillator grid current thru a specified grid leak resistance. It shows how important it is to keep the minimum oscillator strength above the "knee" of the curve. Attention is called to the fact that beyond the knee of the curve the uniformity is excellent over a wide range of oscillator voltage. The developed oscillator voltage is given by the product of the oscillator grid current and the grid leak resistance. For example, 200 microamperes through 50,000 ohms gives a developed oscillator voltage of 10 volts.

Since converter tubes of different constructions, such as those already discussed, have different ratings and electrical characteristics it is natural that performance characteristics also differ from type to type. Although conversion gain is a function of conversion conductance, the gain also depends upon the load impedance (R_L) of the converter section. For example, a pentagrid converter may have a higher rated conversion conductance than a triode-heptode converter, but if due consideration is given to the load impedance the conversion gain of the triode-heptode will not be reduced in the ratio of the respective conversion conductances of the types involved. Considering that the rated oscillator voltage is obtained from each type, Fig. C shows gain curves calculated for both types using the gain formula specified. Verification of the performance characteristics mentioned above is indicated by these curves.

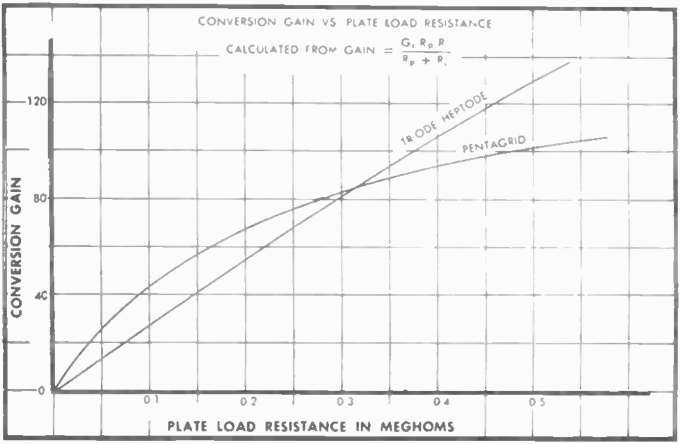


Fig. C

Three Reasons for Blue Glow

Many inquiries are received relative to the blue glow which is present in a number of Sylvania Tubes. Most of these are based on the misunderstanding of the different types of glow that may be present in a tube. There are three different types of blue haze that may appear while tubes are in operation. They are classed as: Fluorescent glow: Mercury Vapor Haze; Gas.

The fluorescent glow is usually of violet color, and is noticeable around the inside surface of the glass bulb. This glow is a phenomenon caused by electronic bombardment taking place within the tube. This glow changes with the intensity of the signal and may at times become quite brilliant. Fluorescent glow has absolutely no affect on the operation of a receiver. In fact, tubes with this characteristic are particularly good as regards gas content.

Mercury vapor haze is a blue glow which is noticeable between the plate and filament in Types 82 and 83 rectifier tubes. These are the only types of Sylvania receiving tubes in which this type of haze appears. The perfect operation of Types 82 and 83 is dependent upon a mercury vapor which comes from free mercury that has been placed in the bulb during the exhaust period. Therefore this type of blue haze is in no way detrimental to the operation of these tubes.

Gas is a blue haze which is usually confined to the vicinity of the plate and filament structure. Its presence, when of large content, affects the operation of a receiver to the extent that erratic performance is noticeable. Gassy tubes should always be replaced with new tubes.

Testing for the above conditions can be best accomplished by actual operation in a receiver. It is not necessary to test for the blue glow evident in Types 82 and 83, since this is characteristic of these two tubes.

When in doubt as to the blue content of other types of tubes a sure test can be made by using a strong magnet next to the bulb. A gassy tube will not be affected in any way by the presence of the magnet, while the fluorescent glow, which has no affect on the performance of the tube, will shift about as the magnetic field is shifted.

Tuning Indicators
Type 6E5 vs Type 6G5

The Type 6E5 tube became quite popular as a visual tuning indicator. After the novelty of this type of tube wore off, it was found that the tube had some disadvantages over the regular tuning meter which had previously been employed, to indicate the visual tuning. These disadvantages mainly were that either the indication of weak signals was unsatisfactory or that on strong signals the shadow closed entirely.

This tube consists of a triode and a target and a deflecting plate. The triode is intended to function as a d-c amplifier. The electron ray section of the tube consists of a portion of the heated cathode as a source of electrons which are attracted to a target that has a positive potential on it. The shaded or unlighted sector which is used as the indicating means is produced by the shadow of a control electrode or deflecting plate attached to the plate of the triode.

By referring to the schematic diagram shown in Figure 1 we will get a better picture of the action taking place when Type 6E5 is used in circuit applications. We will assume Ec is variable by means of control A. If 250 volts is applied to the target, electrons will be attracted to it and will cause it to glow. The deflecting plate is connected to the triode plate as is indicated in the diagram. These two elements are connected to the target through a 1 megohm resistor. If we now apply zero bias to the triode, the maximum plate current will flow to the triode plate. The current flows through the 1 megohm resistor, producing a voltage drop between the target and the deflecting plate.

Since the plate is negative with respect to the target, it will reduce the number of electrons reaching the target. Because of the shape

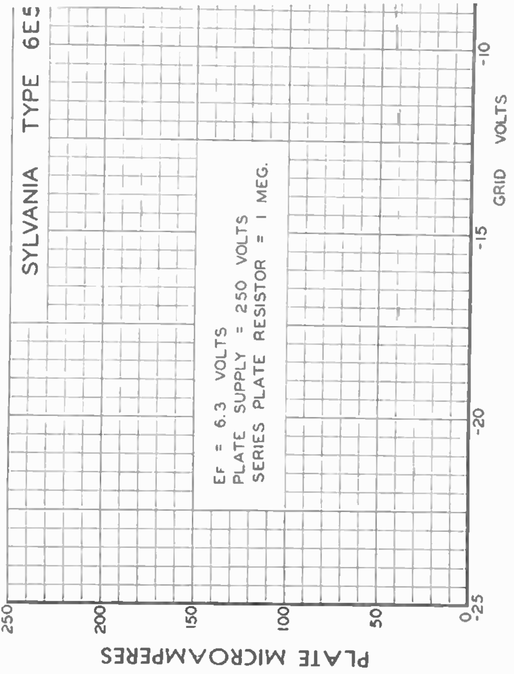


FIG. 2

and location of the deflecting plate a shadow will be cast around the target. The shadow angle will be about 100 degrees. If the bias is increased slightly to approximately 2 volts, the plate current will decrease somewhat, decreasing the voltage difference between the target and the deflecting plate resulting in the shadow angle closing

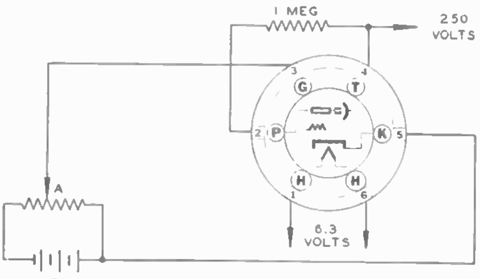


Fig. 1

in since not as many electrons are repelled as before. After 2 volts bias is applied, the shadow angle change per volt bias applied to the grid increases somewhat and remains constant until about 6 volts bias is applied. From 6 to 8 volts the rate of change slows up some

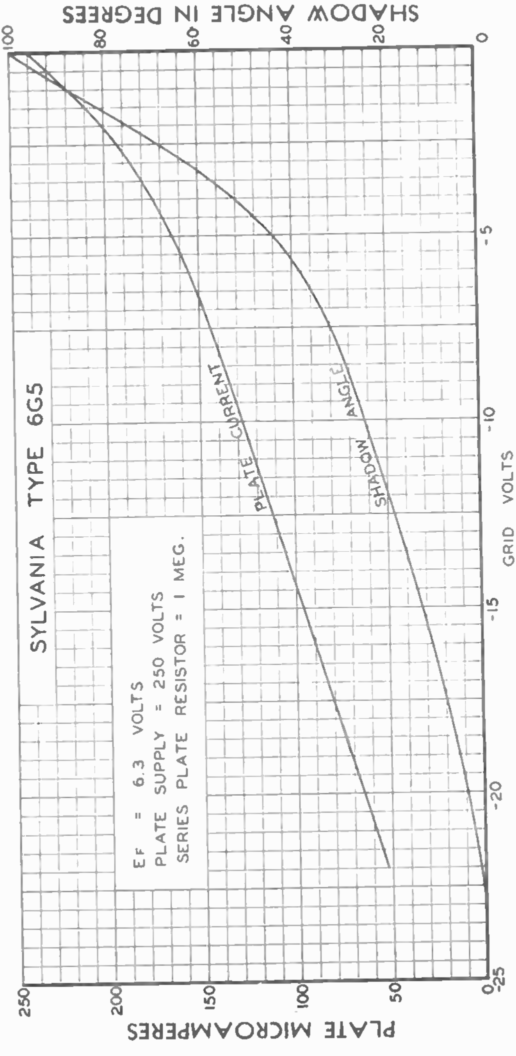


FIG. 3

reduce the indication for weak signals, since if we develop 2 volts of a-v-c, instead of applying it to the triode, we will use only the same fraction of voltage employed on strong signals, with the result that the indication is greatly reduced. It can readily be seen that this type of performance is not wholly satisfactory.

The Sylvania Type 6G5 tube was introduced to correct the difficulties mentioned above. The triode grid has been changed somewhat so that the plate current cut-off occurs around −22 volts instead of −8 volts as in Type 6E5. Figure 3 shows two curves on the Type 6G5 corresponding to those shown in Figure 2 for Type 6E5. It will be noted from the curves that it will be possible to use all of the developed a-v-c voltage with this tube with the result that the indications of weak signals are as large as possible while the strongest signals will not quite close the shadow.

Type 6G5 can be used to replace Type 6E5 in nearly all applications where difficulty is experienced due to the closing of the shadow. Usually no circuit changes will be required. Where the difficulty does not exist due to the closing of the shadow, increased weak signal indications can be obtained, if only a portion of the a-v-c voltage is now being used, by applying the total a-v-c voltage and substituting a Sylvania Type 6G5.

Tube Mysteries Explained

In the open forums held after Sylvania Service Meetings, servicemen in all parts of the country bring up the same problems regarding tubes. There appears to be some mystery in the way these tubes act in tube testers and in actual operation, and servicemen who have experienced this trouble have had considerable difficulty in finding the true answer.

Some of these problems are: 1. Why does a power output tube test OK in some types of testers and still not sound good, while replacing the power output tube with a new one cures the poor tone quality? 2. Why does a rectifier tube test OK in a tester and yet the plate voltage available to the set is low until replaced by another rectifier? 3. Why do tubes test OK in tube checkers and yet cause the set to stop playing after a few minutes of operation?

1. A power amplifier tube requires a fairly large plate current in order to operate properly. If the proper emission is not available to supply this plate current, then poor quality may result. Many so-called emission testers give an indication of "good" for power output tubes if an emission current of only a very few milliamperes flows. This is obviously much less than is drawn in set operation. Thus, the serviceman does not replace tubes which actually need replacing. Although high current is required for power output tubes it is very important that not too much current flows when testing diodes and low plate current tubes or else they will be damaged. Most of the newer testers of this general type employ various loads for use in the circuit to limit the current to a safe value. The proper load is indicated on the chart covering settings for testing the various tubes. If any doubt exists as to whether the tube tester is testing power output tubes properly, a simple check may be made by connecting a d-c milliammeter in series with the cathode of the tube being tested.

This meter will read the total cathode current. It should correspond approximately to the rated plate current for the tube operating under rated conditions.

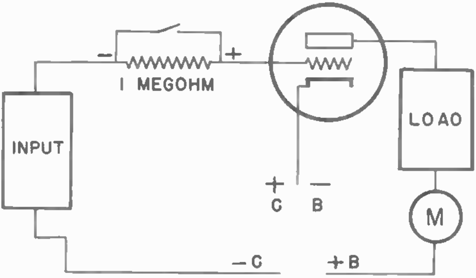
2. A rectifier tube often tests "good" in some testers when it actually delivers voltages much lower than normal. This is also caused by lack of sufficient emission to support normal plate current. The tester may require only a small amount of plate current to test "good" and this amount is much lower than required for satisfactory operation in the receiver. The same sort of test, as recommended above, may be made to determine if everything is as it should be. The meter should read so that the current passed is comparable with that required in a normal receiver.

3. Considerable difficulty is experienced in the field with receivers refusing to play after being in operation for a short while. This may be due to gassy tubes. It is necessary for the tubes to become thoroughly warmed before this difficulty will show up. Some tube testers are provided with a gas test but most are not. A very simple one which will locate gassy tubes is shown. This can be connected to any tube in the receiver or a separate unit may be constructed. When self-bias is employed, the indication will not be as sharp as when fixed bias is employed.

The circuit essentially is as shown. Input and output systems are indicated in block form as these may vary depending on the circuit the tube is used in. The supply voltages for the plate and grid are indicated as +B and −C.

A meter is connected in the plate circuit so as to read plate current. A one megohm resistor is connected in the grid circuit so it may be shorted out. The operation simply consists of opening and closing the switch across the one megohm resistor and noting the change in plate current. A gassy tube or bad tube will show a greater change than will a good one. In fact, most good tubes should not cause much, if any, change in plate current. This test is equally good for power output tubes or any other type. It is important that the tubes be warmed before being tested for gas, especially if they are power output types.

The theory involved in this test is simple and might be of some interest. If any gas current is present in the tube, this current flowing through the resistor will produce a voltage which will subtract from the bias, resulting in an increase in plate current. If one microampere of gas flows, this will decrease the bias by one volt when the switch is opened. If the mutual conductance of the tube is 1000 micromhos this one volt change of grid bias will increase the plate current by one milliampere.



Type 35Z5G and Type 35Z5GT Trouble

A large number of inquiries have been made relative to open filaments in Types 35Z5G and 35Z5GT, before the tubes have been put into use. After a thorough investigation of this it has been found that the majority of the trouble is caused by improper testing in the field. This has been brought about by using improper settings on the testers and by inserting the tube before proper settings have been made.

This type of tube has a 35 volt heater which is tapped to permit the operation of a panel lamp across pins #2 and #3. Thus, it is very easy to apply improper voltages or to short this section of the heater, causing damage to it. **When making any tests on this tube, be sure the correct settings are made before inserting the tube in the tester.**

In receiver operation the heater tap on pin #3 is normally connected to pin #5 for the purpose of permitting the plate current to pass through the tapped section of the filament. This eliminates the initial surge voltage on the panel lamp when the receiver is first turned on and results in a higher level of illumination. Therefore, after the tube has been put into service there are certain precautions that should be followed. Short circuits in the B supply may cause a large drain on the rectifier, resulting in a burn-out in the panel lamp section of the tube. Any type of short to the panel lamp circuit should be avoided; or the use of an improper type of panel lamp is not recommended. Also a load current greater than that recommended should never be placed on the tube.

Tube tester manufacturers have been very co-operative in supplying complete test data on all their instruments that will test this type of tube. These data are shown below. If you do not have the correct tube test settings for your tester, and they do not appear below, they may be obtained from the manufacturer. Check the figures and make changes wherever there is a difference on your chart, as these are the correct current settings.

CLOUGH BRENGLE CO.

Model 225:

Fil.	1	2	3	4	5	6	7	8	9	IN.	SH.
m	F*	H*	X*	R	:	:	:	:	:	91	9

Fil.	IN	CIRCUIT
Model 125-B:		
Mt	91	5-50
Model 125-R:		
Mt	8	5-50

Caution: Do not use new addenda sheets in connection with testers which have not been modernized. (This caution is printed on the addenda sheets.)

DAYTON ACME CO.

Model 303:

Fil. & Cir.	Sel. 1	Sel. 2	Sel. 3	Slide Switches
..	10	32	9	AC*

*Note—Push A & C to "UP" position before placing tube in socket and do not return A & C to normal position until tube has been removed. This tube normally shows SHORTED.

Model 302:*

9-3	46	Q	..	..

*Switch A "UP"

Model 301:

J, 1 & 8	46	Q	..	..

Model 501:*

30	..	10	Q-3	..

*Sel. 1 at "G" before placing tube in socket.

Model 22C:

. .	25.0	37	3	AC*

*Note—Toggles A & C must be thrown to "UP" position before placing tube in socket and left up until tube has been removed. This tube normally shows a SHORTED condition.

Model 200:

25.0	37	3	AC*

*Note—Toggles A & C must be thrown to "UP" position before placing tube in socket and left up until tube has been removed. This tube normally shows a SHORTED condition.

HICKOK ELEC. INSTRUMENT CO.

Models AC-51, 51-X, T-53, 510-X, 530:

A-11; B-1; Fil.—35; L-40—R-0. Press Rect. Standard Button. Testers having serial number below 500,000 which have not been modernized, set "L" on 76 instead of 40.

JACKSON ELEC. INSTRUMENT CO.

Advice from Jackson is that all late type testers which will test this tube have the correct data appearing on their charts. For new charts or data on modernizing, write directly to Jackson.

PRECISION APPARATUS CO.

Models 910, 912, 915, 920, 922:

A	B	C	D	E	F	Depress
7	10	0	1	11	9*	D

(Fil. Cont.—Depress J* then B.)

Precision advises that Series 500, 500-A, 510, 510-A, 600, 700, 800, 800-A, 815, 815-A, 900 and 900-A, have complete new test data available upon request. The latest supplement bears the date 2/15/40. Series 910, 912, 915, 920 and 922, all have test charts bearing the date 1/20/40 which supersedes all previous charts for this series.

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*Indicates changes made over original chart.

SUPREME INSTRUMENTS CORPORATION

Model 385, 89 Series:

Fil. Volts	25
Fil. Return	7
But'n down	8
Qual. Sel. (R)	43
Qual. Sel. (S)	30

Neon lamp glows on F & 3 as A5 & 12Z5 switch up.

Models 500, 505, 585:

Fil. Volts	25
Fil. Return	7
Switches Up	238
Met. Ckt	C
Load Sel	90
Shunt Sel	3
Qual. Sel	50

When making filament open test, neon bulb should light on both #2 and #3.

Model 400:

Fil. Volts	25
Fil. Return	7
Switches Up	238
Met. Ckt	E
Qual. Sel	4

When making filament open test, neon bulb should light on #2 and #3.

Model 594:

Fil. Volts	25
Fil. Term	E
Meter Ckt	A
But'n. Down	38
Qual. Sel	75

#8 shows short.

Models 501, 502:

Fil. Volts	25
Fil. Return	7
Switches Up	5
Meter Ckt.	A
Qual. Sel.	37

When making filament open test, neon bulb should light on #2 and #3.

Models 503, 504:

Fil. Return I	7
Fil. Volts II	10
Qual. Sel. III	17
Meter Ckt. IV	3
Elements V	5

When making filament open test, neon bulb should light on #2 and #3.

Model 506:

Fil. Volts I	9
Fil. Return II	2
Fil. Return III	7
Meter Ckt. IV	0
Shunt Sel. V	7
Shunt Sel. VI	0
Shunt Sel. VII	0
Elements Out	3-8

Depress #3 when making leakage test. #3 shows short.

Tracking Down Grid Emission

Among the many "bugs" that find their way into a radio circuit, there is one that has caused untold grief and confusion to the serviceman. Its common name is GRID EMISSION.

Although it starts life as a tiny electron, it soon grows to huge proportions. It is elusive in its ways, and much valuable time may be lost merely in determining its presence. After that, more time is consumed in solving the serious problems that it creates. No doubt, you are familiar with some of the following complaints: blocking, loss of sensitivity, lack of selectivity, distortion, burned out plate and screen resistors, low emission rectifier and power tubes, and hum. These are a few of the problems of grid emission and they are generally reported to take place after the receiver has been in operation long enough to become overheated.

Perhaps you have tested tubes, condensers and resistors, yet you found everything to be normal. Try though you may, you have never located the cause of these complaints, although you may have effected a cure by the cut and try method. Of course, you know that the cathode of a radio tube is designed to emit electrons; but this is not true of the grid. Grid emission, as the name implies, means that the GRID gives off or emits electrons. When electrons flow there is also a flow of current, (as can be seen if we place a milliameter in series with the cathode) and current flowing through coils and high value resistors in the grid return circuit, will produce a voltage drop detrimental to good circuit performance.

Why do we have grid emission? Well, during the process of evacuation of a radio tube a small portion of the cathode emitting material is sometimes unavoidably splashed on to the grid with the result that should the grid become sufficiently heated during operation, it will emit electrons.

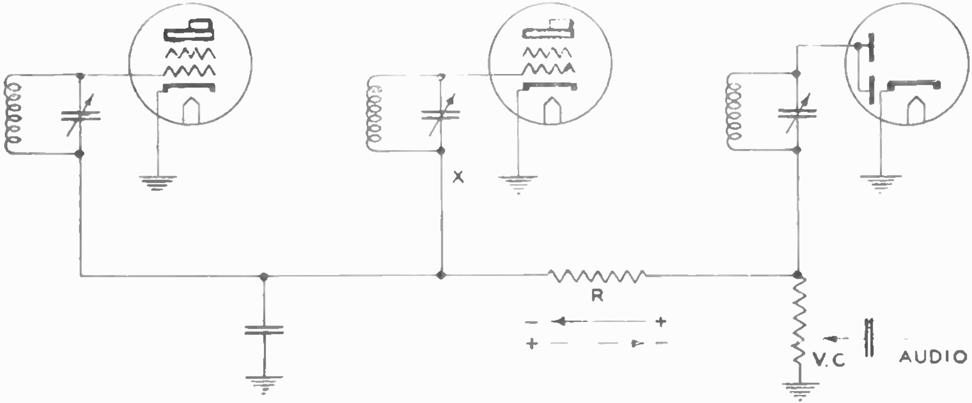

Fig. 1

To reduce this disturbing effect every precaution is taken in the design of Sylvania radio tubes to keep the grid as cool as possible. Copper grid supports are used because copper, being a good heat conductor, carries the heat away from the grid. Grid radiators are attached to the grid to give a greater heat radiation area. Colloidal graphite is sprayed on plates and bulbs to increase the heat radiation to the outside away from the grid,—all to keep the internal tube structure cool.

We conclude, therefore, that excessive heat is the factor that must be avoided if we are to keep away from grid emission.

More recent tube types are of higher mutual conductance than those of the earlier days and in order to obtain this increase in mutual, the spacing between the grid and cathode has been greatly reduced. As a result, the grid is close enough to the cathode so that excessive heater voltage, or cathode current will heat the grid to the emission point.

Another recent factor aiding the evil of grid emission is the trend toward the zero-bias type of receiver operation. In this type of circuit the d-c resistance in the grid returns is generally very high. This results in a higher disturbing-voltage drop, and at the same time fails to produce a negative bias voltage which would be helpful in opposing the disturbing voltage.

The r-f circuit shown in Fig. 1 represents a typical zero-bias arrangement which we will use to follow the actions of grid emission.

Let us assume that the initial bias on the tubes derived from the contact potential of the diode is -1 volt. We will also assume that the receiver has been in operation long enough to become sufficiently over-heated to stimulate grid emission. The excessive heat may be caused by improper ventilation, high line voltage, or the exceeding of the voltage ratings of the tubes.

The grid of any one of the tubes, being overheated, will now give off electrons and current will flow. To start with, this current is very very small, being only about one microampere. However small though it may be, it must return to ground. Therefore, it flows through the r-f coil, through the a-v-c resistor R, on through the volume control to ground. During its course to ground the current had to pass through the a-v-c resistor R whose value is three megohms, and, according to Ohms Law, current flowing through a resistance must produce a voltage drop. As E=IR we then have a voltage developed across R equal to 3 volts. The polarity of this voltage drop is the HARMFUL factor. Current flowing from the diode to the grid produced a negative voltage at point X, but current going from the grid to ground produces a positive voltage. Therefore, at point X we have +3 volts developed by the grid current flow, minus the −1 volt of bias caused by contact potential, leaving a +2 volts. This means that at the grid of each tube on the a-v-c string, there are 2 volts of positive voltage. You and I know that we cannot use positive voltage on control grids. It must be negative!

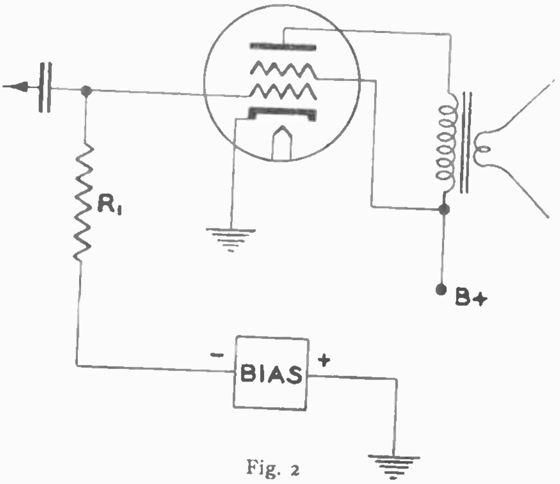

Fig. 2

plate circuit will show a rise in current

heated if grid emission is present.

Practical cures for this ailment may be effected by a diode gate, a resistor in series with the filament to slightly reduce the filament voltage, proper ventilation, or automatic bias. Above all, make sure that the values of voltages and grid resistors are within the ratings of the tubes.

With positive voltage on the grid, the plate current increases, causing more heat within the tube, thus liberating more electrons from the grid. This continues in a vicious circle until the positive voltage at the grid becomes high enough to block the tube. Plate and screen resistors may burn out, rectifier tubes are overloaded, and sensitivity falls off, due to the change of characteristics brought about by grid emission.

Fig. 2 represents a typical power output stage. Here grid emission is more troublesome, due to the greater amount of heat generated within the power tube. The grid current flowing in R_1 can become sufficiently high to cause enough positive voltage to cancel out the negative bias thereby producing bad distortion. At the same time the resultant heavy plate current will in a short time liberate gases from the over-heated elements. With the ionization of the gas the cathode is bombarded by positive ions and its emission is destroyed.

To prevent the possibility of such destructive effects, tube manufacturers issue specifications as to the maximum permissable voltage ratings that may be applied to each tube; also the values of permissable d-c resistance in the grid-cathode circuit. These values must be adhered to at all times for satisfactory tube operation.

The effects of grid emission are to some extent minimized by the employment of automatic or self-bias in which grid bias is derived from a resistance in the cathode or filament return. An increase in plate current tends to increase the effective negative bias applied to the grid, thus opposing the cumulative effects of the positive voltage

Filament-Grid Short Circuits

Recently we have received a considerable number of complaints on battery type tubes which indicated that commercial tube checkers were showing up tubes as having grid-filament shorts. In many instances it was reported to us that the tubes worked perfectly satisfactory in equipment. In other instances tubes were sent back to us for analysis. Our analysis showed that there were no short circuits between filament and grid. An investigation was made of several commercial tube checkers in which these defects were being noted to ascertain the cause for such indicated shorts, when in reality no shorts were present.

When one stops to analyze just what is occurring, it is fairly easy to see the reason for the discrepancy. In a commercial tube checker, for simplicity reasons, it is usually a practice to make available only one supply voltage. For most types of tubes the value of this voltage is not too important and consequently a value usually above 150 volts is employed. When filament-grid shorts are being checked, however, on any kind of a tube, since the spacing between these elements is very close, the voltage gradient is very high and a considerable electrostatic attraction exists. In the case of 1.4 volt tubes this force is sufficient to attract the filament over to the grid. This results in a grid-filament short being indicated since the filament may actually touch the grid under these conditions. With the proper equipment it is possible to actually see the filament being attracted to the grid structure. In manufacturing these tubes a great deal of difficulty was experienced with this condition until it was recognized that the voltage between grid and filament must be kept at a low enough value so that the filament did not become distorted. This can readily be accomplished by reducing the value of this voltage without any attendant harm since the maximum voltage applied between grid and filament in most battery types will be under 25 volts.

The next time you are testing battery tubes for short circuits and run into grid-filament shorts and the tubes appear to be otherwise alright, it is suggested that you measure the voltage between filament and grid and if it exceeds 50 volts that you disregard the grid-filament short indication.

Generally a real grid-filament short circuit occurs because the filament has been opened up and the hook tension has been sufficient to pull the loose end of the filament up so that it comes in contact with the grid wires thus causing a short circuit. Whenever this occurs, of course, the filament continuity will be broken and this can readily be determined. Under these conditions, the tube will be inoperative and should be discarded for an open filament rather than a short circuit.

This information is being passed on so that tubes will not be falsely accused of having grid-filament shorts when in reality these short circuits do not exist under service conditions.

Plate and Screen Dissipation Ratings

Vacuum tube ratings provide an accurate guide to assist the engineer or serviceman in securing efficient tube performance. The use of this information, coupled with careful attention to circuit considerations and proper installations will generally pay dividends in acceptable operating efficiency. Among the important factors included in tube data are the ratings of maximum plate and maximum screen dissipations. The discussion which follows deals primarily with dissipation considerations.

The interpretation of tube ratings published in the Sylvania Technical Manual and other Sylvania technical literature are in accordance with RMA standards and the conditions outlined in the introductory section of the manual for the plate and screen are:

A-C or D-C Power Line: The maximum ratings of plate and screen voltages and dissipations given on the tube type data sheets are Design Maximums. For equipment designed for use in the United States on nominal power-line services of 105 to 125 volts, satisfactory performance and serviceability may be anticipated, provided the equipment is designed so as not to exceed these Design Maximums at a line voltage of 117 volts.

Storage Batteries: Automobile battery operated equipment should be designed so that when the battery voltage is 6.6 volts, the plate voltage, the plate dissipation, the screen voltage, the screen dissipation, and the rectifier load current will not exceed 90% of the respective recommended Design Maximum values given in the data for each tube type.

"B" Batteries: Equipment operated from "B" batteries should be designed so that under no condition of battery voltage will the plate voltage, the plate dissipation, the screen voltage, and the

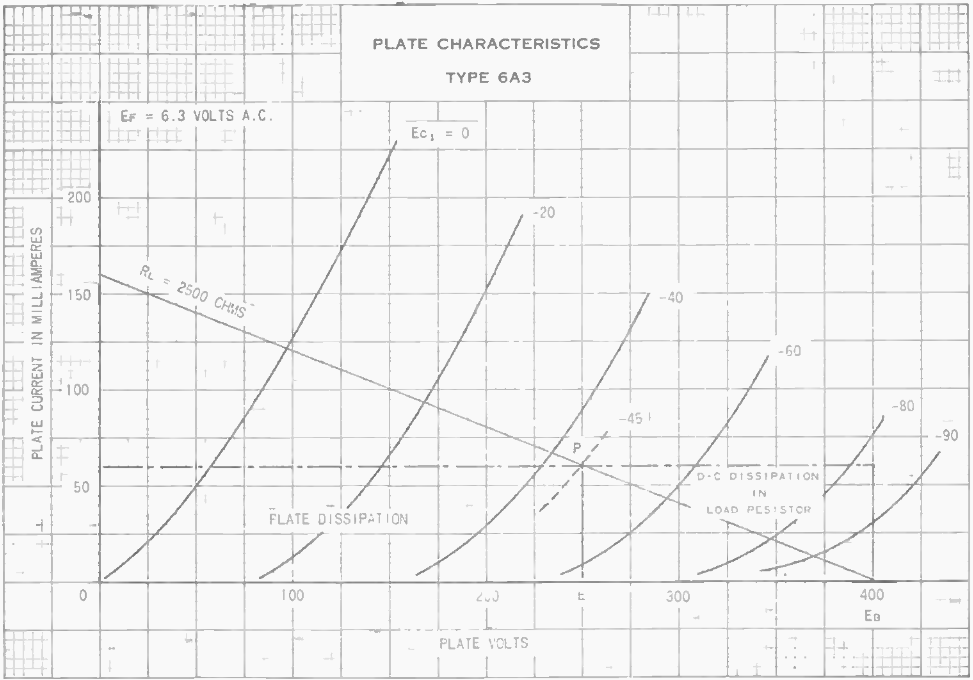
PLATE CHARACTERISTICS
TYPE 6A3
EF = 6.3 VOLTS A.C.
Ec1 = 0
-20
-40
-45
-60
-80
-90
RL = 2500 OHMS
P
D-C DISSIPATION
IN
LOAD RESISTOR
PLATE DISSIPATION
PLATE CURRENT IN MILLIAMPERES
200
150
100
50
0
100
200
E
300
400
EB
PLATE VOLTS

screen dissipation ever exceed the recommended respective maximum values shown in the data for each type by more than 10%.

In general, electrode dissipation is the power dissipated in the form of heat by an electrode as a result of electron and/or ion bombardment. Each tube type must have maximum ratings assigned, these being dependent upon the tube design, its component parts and the kind of service it is to perform. Experience has shown that when maximum ratings are exceeded, particularly for an appreciable time, the performance capabilities may be impaired and the tube life shortened.

The total power dissipated by the tube consists of plate and grid losses plus the power used in heating the cathode. All of this heat must be carried away from the tube, principally through the envelope of the tube. A major proportion of the energy which is dissipated in tubes having glass bulbs is produced at the plate of the tube. Consequently, the plate has to be capable of radiating all the heat generated at its surface, and also the heat radiated to the plate by the cathode and other elements, without damage or adverse results. Any excessive heat, above that stipulated by the maximum dissipation ratings, can produce very detrimental effects. These will be covered in more detail later.

TRIODE CLASS A POWER AMPLIFIERS

As a first example, consider a triode power amplifier such as a Type 6A3, operated resistance-coupled, under the rated Class A conditions. The accompanying plate characteristic indicated that with 250 volts applied to the plate, -45 volts grid bias and the recommended load of 2500 ohms, the rated plate current is 60 ma. This requires a plate supply voltage of 400 volts for with 60 ma. flowing through the load resistor of 2500 ohms there will be a voltage drop across R_L of 0.06 ma. x 2500 ohms or 150 volts, and hence an applied voltage of 250 volts. The d-c power dissipated in the load resistor will be I^2R_L or $(E_b - E_p)$ I watts. Using the latter expression this gives 150 volts x 0.06 ampere or 9 watts, and this power is represented on the diagram by the rectangle at the right. The plate dissipation of the tube will be EpI or 250 volts x 0.06 ampere which equals 15 watts. This is represented by the rectangle at the left as designated. These values only apply when no input signal is applied to the grid.

When an alternating voltage is impressed on the grid, the voltage at the plate of the tube will also fluctuate since it will differ from the supply voltage by the drop in the load impedance. With the signal on the positive half cycle, the plate current will increase, thus causing a larger drop in R_L so that the plate potential will be less than its value at the operating point. On the negative half cycle the instantaneous grid voltage will be more negative than −45 volts, the instantaneous plate current will be less than the average value and the drop in R_L will be reduced Consequently the instantaneous plate voltage is higher during the negative half cycle.

With an impressed input signal whose peak voltage equals the bias voltage, the a-c power developed in the load is rated at 3.2 watts. This a-c power is dissipated in R_L in addition to the d-c power dissipation of 9 watts mentioned above. The plate dissipation is therefore reduced by the amount of the power output. This decrease in plate dissipation under dynamic operating conditions is a characteristic of all class A amplifiers. Hence, Class A power amplifiers should be so designed that the dissipation under static conditions will not be exceeded.

The RMA ratings for Type 6A3 specify a maximum plate voltage of 325 volts and a maximum plate dissipation of 15 watts. Since a plate current of 60 ma. is obtained when 250 volts are applied to the plate with a grid bias of −45 volts, it is apparent that if a higher plate voltage is employed, the maximum plate dissipation will be exceeded unless more bias is provided to reduce the plate current to a safe value. In general, the allowable plate dissipation will determine the maximum operating plate current for a given plate voltage. For some tube types the allowable dissipation may be high enough so that the operating point and load resistance may be based upon considerations of distortion, flow of grid current and desired power output

PENTODES AND BEAM TUBES

With pentodes and beam tubes additional factors must be taken into consideration. The total B-supply input power will be the power in the plate circuit plus the power dissipated in the screen circuit. With an input signal whose peak voltage equals the bias, the power delivered to the plate circuit is the product of the maximum signal plate current and the corresponding plate voltage. The heat dissipated by the plate will be the power supplied to the plate circuit less the power delivered to the load.

Screen dissipation increases quite rapidly with applied signal voltage and may be several times greater at the maximum signal condition than when the signal is zero. The increase in d-c screen current with signal occurs because of the influencing effect of plate potential on screen current and is particularly noticeable when a high value of load resistance is employed. This condition should be avoided, not only to maintain the screen dissipation within limits but also to keep the distortion at an acceptable value.

TYPICAL EXAMPLE

As a second illustration of zero-output and rated-output screen and plate conditions we will survey the ratings for Type 7C5, or the octal-based equivalent Type 6V6GT/G, when employed as a single-ended Class A amplifier Maximum ratings are:

Plate Voltage....................................	315 Volts
Screen Voltage..................................	250 Volts
Plate Dissipation..............................	12 Watts
Screen Dissipation............................	2 Watts

Recommended operating conditions are:

Heater Voltage	6.3	6.3	Volts
Plate Voltage	250	315	Volts
Screen Voltage	250	225	Volts
Grid Voltage	−12.5	−13	Volts
Peak Input Signal	12.5	13	Volts
Plate Current (Zero Signal)	45	34	Ma.
Plate Current (Max. Signal)	47	35	Ma.
Screen Current (Zero Signal)	4.5	2.2	Ma.
Screen Current (Max. Signal)	7.0	6.0	Ma.
Load Resistance	5000	8000	Ohms
Power Output	4.5	5.5	Watts
Total Distortion	8	12	Per Cent

For the 250 volt condition the dissipation values computed from the above figures show:

Zero output plate dissipation is 250X0.045=11.25 Watts
Zero output screen dissipation is 250X0.0045=1.125 Watts
Full output plate dissipation is (250X0.047)−4.5=7.25 Watts
Full output screen dissipation is 250X0.007=1.75 Watts

We see, therefore, that as the output goes from zero to 4.5 watts the plate dissipation drops from 11.25 watts to 7.25 watts while the screen dissipation increases 0.625 watt.

Similar computations could be made for the 315 volt condition. It is to be noted that the recommended operating conditions have been designated so as not to exceed the maximum dissipation ratings. One should bear in mind that published ratings represent average tubes and that any particular tube when measured may differ to some extent from these figures for plate and screen values, power output and distortion.

SPECIAL PRECAUTIONS

It has been pointed out that because of the reduction of minimum plate voltage which occurs with increase in load, the average and maximum values of screen current increase with load resistance. Hence, permissible screen dissipation limits the maximum load that can be employed. This justifies the precaution that the load should never be removed from the output transformer secondary of a pentode or beam tube since the effective load impedance will increase and the resulting excessive screen dissipation will damage the tube.

Removing the plate voltage, without also removing the screen voltage, gives rise to abnormally high screen currents even though rated screen voltage and rated bias are normal. This means excessive screen dissipation will be encountered and the tube soon ruined if operation continues.

Dissipations higher than the specified maximum values generally result in detrimental effects such as secondary emission, high gas currents, warpage of tube elements and actual tube destruction.

SERVICE TO SERVICEMEN

The Service Helps shown on the following pages are only a few of the generous assortment of Sylvania Sales and Service Helps made available by Sylvania Electric Products Inc., most of which are free upon request. Semi-technical literature for the serviceman such as Characteristic Sheets, Tube and Base Diagram Charts, Tube Correlation Charts, the Tube Complement Book at 35c and the Technical Manual at 35c, are in constant demand. Window displays, streamers and transparencies, price literature, circulars, book matches, electric signs, mailing cards, newspaper mats, and plain or imprinted tube stickers are provided generously as an assistance to dealers and servicmen. All items shown are typical—styles and prices are subject to change without notice.

Sylvania News, a regular monthly publication featuring a separate Technical Section, items of trade interest, personal interviews, and service helps, is available to everyone. Further information about Sylvania News, Sylvania Radio Tubes, and any of the sales or service helps, may be obtained from your local Sylvania Distributor, or by addressing your inquiries to Sylvania Electric Products Inc., Emporium, Pa.

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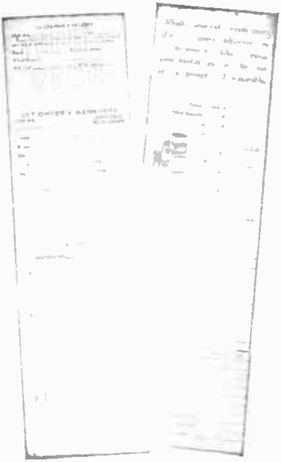

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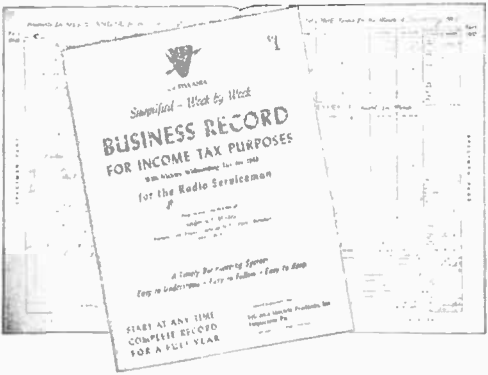

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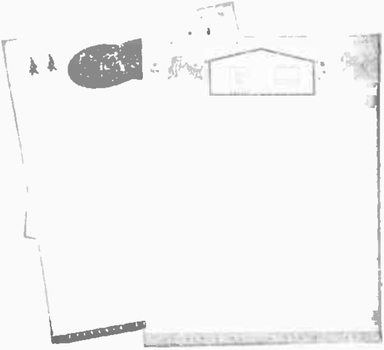

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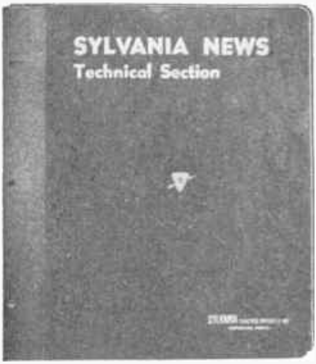

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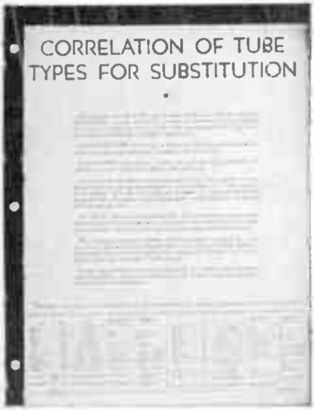
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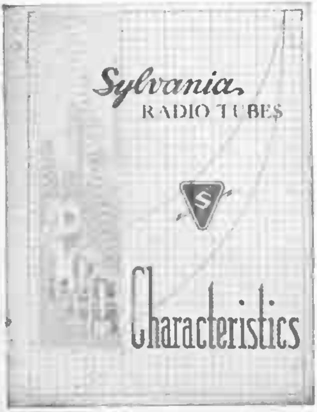
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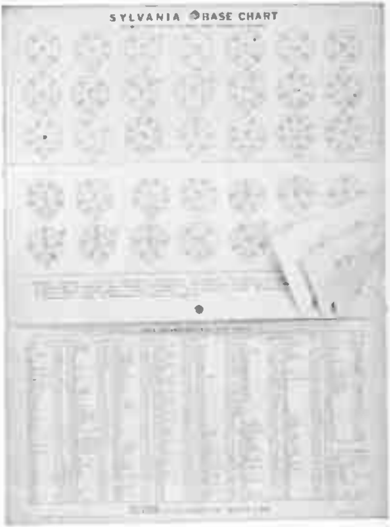
SYLVANIA BASE CHART

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BASE CHART

Base views for Sylvania tubes. Cross indexed by types and bases

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FIRST EDITION
THIRD PRINTING

FOREWORD

This compilation of radio equipment hints is dedicated to the thousands of radio servicemen who conscientiously render good service and thereby make an important contribution to the radio industry.

The equipment described in this booklet can be a very important addition to every radio man's service bench and will save much time and effort in tracing and locating radio receiver troubles.

Sylvania Electric Products Inc.

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Slide-Back Vacuum Tube Voltmeter

A vacuum tube voltmeter for use in service work should be as rugged as possible and do away with the necessity of calibration. Since the plate current of a vacuum tube depends upon the grid voltage, for a fixed plate voltage, the slide-back type of vacuum tube voltmeter shown on the accompanying sketch is especially suitable for service work in measuring voltages where the current drain of a voltmeter would materially change the readings. The chief uses which a serviceman will find for this piece of equipment will be:

(a) Measuring the d-c voltages developed across the diode load resistor.

(b) Measuring voltage at the plate of resistance coupled amplifier tubes.

(c) Measuring voltage at the screen of amplifier tubes.

(d) Measuring any d.c. voltage in the system where no current drain can be tolerated.

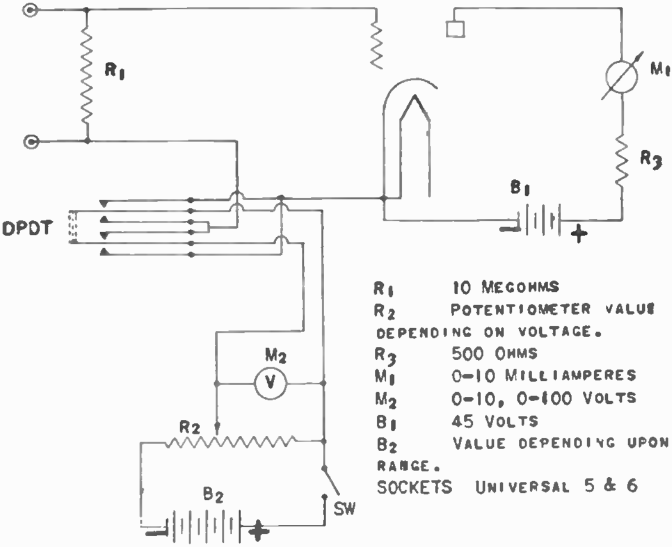
(e) Measuring A.C. voltages such as filament voltage in AC-DC receivers.

The apparatus required consists of a universal five and six contact socket connected as shown on the wiring diagram; a 10 megohm resistor; a double-pole double-throw switch (which is connected as a reversing switch); a potentiometer whose resistance is suitable for the amount of voltage used in the grid circuit; and an on-off switch for that potentiometer. In addition, the necessary filament supply will have to be provided. A grid voltage is required whose value is considerably greater than the highest voltage to be measured. A plate voltage of 45 volts, which may be obtained from a B battery, and two meters will be required: first, a voltmeter which is calibrated in d-c volts, possibly having two scales—0 to 10 and 0 to 100, depending upon the range of voltages used; and second, a milliammeter with a 0 to 10 milliampere range. A power supply operated from the a-c line may be incorporated. This unit is described in another article. Since most receivers on which these measurements will be made operate from a power line, there is no point in operating the test equipment from batteries. The universal socket is recommended so that a Type 57, 77, 6C6 or a 56, 76, 37, 27 may be used, depending upon the sensitivity required. To employ a Type 57, 77, or 6C6 in the six contact socket, the tubes should be connected as triodes by connecting the screen and suppressor grids to the plate terminal at the socket. As such, they will give an amplification factor of about 20. If less sensitivity is required, a Type 56 or 76 tube may be inserted in the five pin socket. With either of these tubes a voltage amplification factor of approximately 12 may be obtained. If less sensitivity is desired, a Type 27 or 37 may be used in the same socket. The purpose of the 10 megohm resistor is to make certain that the grid circuit is closed for d.c. at all times, so the plate meter will not be driven off scale if the tube is lighted and the input circuit is not closed.

The operation of the device is as follows:

The proper tube is placed in its socket and with no voltage applied to the grid of the tube, the potentiometer supplying grid bias is adjusted so the meter in the plate circuit reads at some predetermined point, for example: in the center of the scale. The d-c voltage to be measured is then applied across the input terminals, and if that voltage has polarity such that the positive side is connected to the grid of the tube, the plate current flowing in the meter circuit will increase due to a decrease in bias. The potentiometer is then adjusted until the plate current is restored to its original value. The difference in voltmeter readings between the initial setting and the new setting is the value of d-c voltage which was being supplied across the input terminals. If the polarity is in the opposite direction, then the plate current will decrease as voltage is applied to the input circuit and the potentiometer should be readjusted to restore the plate current reading to its original setting.

Slide-Back Vacuum Tube Voltmeter



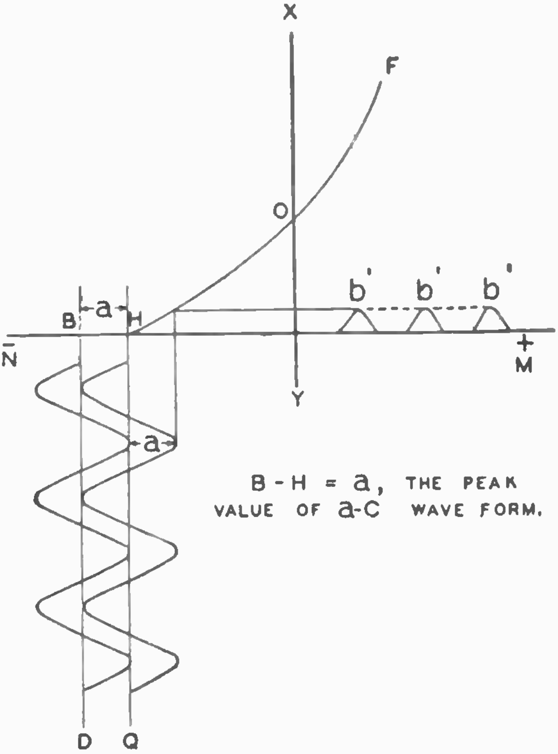
If voltages higher than 10 volts are to be measured, the negative terminal should always be connected to the grid to prevent burning out the plate meter. In this case, a reference set at maximum scale reading instead of center of scale would give greatest precision.

It will be noted that no specific values of voltage are given, since that depends upon the range of voltages which are to be measured. In general, the voltage across the potentiometer must be equal to the largest voltage it is expected to measure plus the bias which will be on the tube when no signal is being received.

The slide-back type of vacuum tube volt meter may be used for measuring peak values of a-c voltage if a slightly different procedure than previously outlined is employed. If the wave form is irregular, it is to be borne in mind that this meter will still read the peak voltage, but unless the wave form being measured is sinusoidal, the peak voltage will not necessarily be 1.4 times the RMS value which would be read on an ordinary meter.

The accompanying sketch indicates the procedure which is to be followed in making these measurements. The curve "HOF" represents the plate current curve for the tube being used in the vacuum tube volt meter. The vertical line "XY" represents plate current, while the horizontal line "YM" represents grid bias in a positive direction, and the line "YN" represents grid bias in a negative direction. At a point "H" on the curve "HOF" no plate current flows, since this curve crosses the horizontal line "NY" at this point. If, therefore, we apply such a bias to the tube in the voltmeter that its plate current goes to zero, that is, no indication is given on the plate current meter, and if we apply an a-c voltage at this point, which is represented by a sine wave about the line "HQ", then it will be seen that voltage peaks to the left of "HQ" will not produce any plate current; while those current peaks appearing to the right of "HQ" will produce pulses of plate current, as shown at b'. If, now, we increase the grid bias in a negative direction until these plate current indications again cease, we will find that if the amplitude of the wave being measured is "a", then the bias will have been increased by an amount equal to "a". The new position for a peak voltage of "a" will be along the line "BD" instead of "HQ", which is to the left of "HQ" by an amount equal to "a". In other words B minus H equals "a", which is equal to the peak value of the a-c wave form.

The procedure to be followed is simply this: with no voltage to be measured and applied to the terminals of the vacuum tube volt meter, the grid bias is adjusted so that the plate current just goes to zero. (In general greater accuracy can be assured if the "zero" point is actually a small finite reading on the plate meter.) The voltage to be measured is now applied to the grid and the bias is again adjusted until plate current just disappears. The difference in the two grid biases will be equal to the peak voltage which was applied to the grid of the tube. Thus, the slide-back type of vacuum tube voltmeter may be used to indicate peak a-c voltages as well as direct current voltages which may appear in a given circuit.



Power Unit for Slide-Back Vacuum Tube Voltmeter

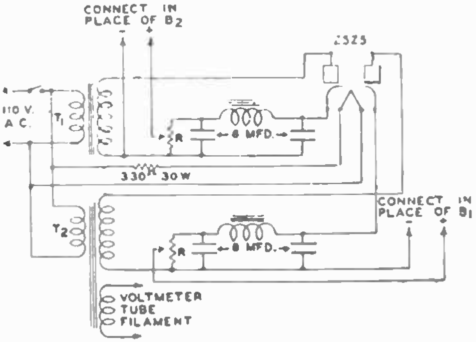
The power supply for the vacuum tube voltmeter is designed to be very flexible, so all ranges of voltages may be obtained to accommodate the various voltages being measured.

It is extremely important that the voltage supply be entirely independent of grounds since often the voltages being measured will be grounded. This requires the use of transformers.

In order that the reversing switch for the "C" battery, which was shown in the first issue, may still be usable it is necessary that a rectifier tube having two separate cathodes be employed. The type 25Z5 tube has been chosen for this purpose. In addition to the rectifier tube itself, it will be necessary to have two separate transformers having high voltage secondaries; one at least having in addition a 2.5 or 6.3 volt winding for lighting the filament of the voltmeter tube. The voltage depends, of course, upon the type of tube being used in the voltmeter unit. Transformers most commonly available for this use will have a center tapped secondary. Only one-half of this secondary is to be used. The plate of the rectifier tube is to be connected to the center tap and the return circuit will be connected to one end of the transformer winding. Thus, one section of the tube will supply plate voltage while the other section will be used to supply grid bias. It will be necessary to include an inductance capacity filter, as shown on the diagram, which will consist of a small choke and two 8 microfarad condensers for each supply. The voltage rating of the condensers must be chosen so that they will be sufficient for the voltages employed. The filament of Type 25Z5 tube will be lighted directly from the 110 volt power supply. In order to limit the current, it will be necessary to insert a 30 watt, 330 ohm resistor in series with the filament, as shown on the drawing. The value of the potentiometers "R" employed to vary the voltages applied to both plate and grid supply will be determined by the total voltage available. In any case, these potentiometers should be of the wire wound type.

This power supply is quite flexible and will permit the vacuum tube voltmeter to be used without any alterations except to connect the four power supply terminals to the meter unit in place of the B batteries and to plug the primaries of the transformer unit into a light socket.

It is to be noted that this type of supply is not suitable for use with d-c line voltage. Most of the parts specified are standard parts and will probably be found in the work shop of every service man.



A Simple Peak Voltmeter

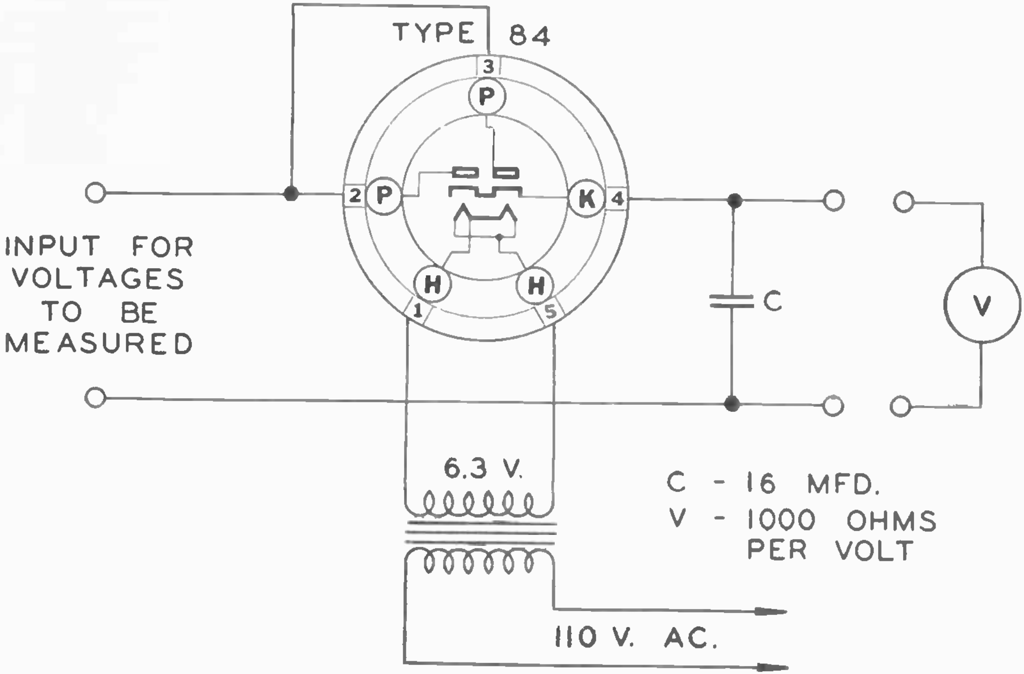
A simple peak voltmeter useful for measuring d-c, a-c, or pulsating voltages from about 10 volts up to any value desired is a valuable piece of service equipment. This article will describe such an instrument which can be made at a reasonable cost.

The accompanying schematic diagram shows a circuit of this voltmeter consisting of a Type 84 tube together with a suitable transformer for lighting the filament and 16 microfarads of condenser which must have a voltage rating as high as the largest peak voltage which is to be measured.

A thousand ohms per volt voltmeter having the proper voltage range for the voltages to be measured is connected across the 16 microfarad condenser, which in turn is connected in series between the cathode of the tube and one side of the voltage which is to be measured. The voltmeter can be the one that is commonly used in service analyzers, providing it is of the 1000 ohms per volt type. The meter should not be used on a scale range less than the 100 volt scale. This should be done so that at least 100,000 ohms of resistance will always be shunting the electrolytic condenser. If the condenser is shunted with less than this value, a slight error will result. A pair of pin jacks can be provided across the terminals of the condenser into which the meter may be connected. It is to be remembered in measuring a-c voltages that the peak voltage will be 1.4 times the r.m.s. voltage as measured on an a-c voltmeter, if the wave form is sinusoidal. For example: if the line voltage measures 100 volts, the peak voltage will be 140 volts. This is the reading obtained when using a peak voltmeter.

This device requires absolutely no adjustments, and is useful in measuring voltages developed across filter condensers, especially the

Simple Peak Voltmeter



first filter condenser. It is important that service men have an instrument to measure such voltages, since they are often called upon to make a replacement of condensers of unknown ratings. Unless the peak voltage across a filter system is known, a condenser with improper voltage rating may be used which will probably result in another defective condenser and a dissatisfied customer. The working voltage rating of a condenser should be somewhat higher than the voltage which is measured on this peak voltmeter.

The average serviceman will find a great many uses for this small voltmeter, not only as outlined above, but also for measuring a-v-c voltages, screen grid voltages and other voltages where the drain of a voltmeter might give incorrect readings.

The unit is also very useful in measuring output voltages obtained from a receiver. It may be connected directly across the primary of the output transformer and will serve as a very fine output indicator.

It must be remembered that this unit will measure peak voltage and not r.m.s. voltages.

The Vacuum Tube Voltmeter As a Service Tool

This article describes the theory, construction, calibration and use of vacuum tube voltmeters in service work. An instrument of this type, capable of measuring d-c voltages or a-c voltages of any frequency encountered in modern receivers, is becoming increasingly necessary in service work—not only because it can measure voltages across high impedance circuits without drawing current from the circuit, but because it may be used to measure resistance, inductance, capacity, leakage, transformer ratios, stage gain, power output, percentage of modulation and coil "Q"—or virtually everything the serviceman must know about a receiver or any of its component parts. Its versatility is only limited by the skill of the operator.

The servicing of a radio receiver may be considered as consisting of circuit repairs and adjustments to permit the tubes in a set to function properly. In the final analysis the radio tubes do all the work of amplifying the signal; providing a locally generated signal which—beating with the incoming signal--changes its frequency; amplifying this intermediate frequency; and removing the a-f component, and in turn amplifying this to the point that will operate the loud speaker. The balance of the parts in the set serve to couple the tubes together and to supply them with the recommended heater, plate and various grid voltages.

Because of the long life of tubes and the ease with which they may be removed from the set, tested and replaced, few tough problems are encountered in this connection. However, it is much more difficult to give most of the other parts of the receiver a thorough test. To be accurately tested, all parts should be checked in the chassis at their operating frequency—which will be between 25 cycles per second and 25 megacycles for the average "all-wave" receiver, and over 90 megacycles for a television receiver. The latter requirement must be kept in mind when building test equipment if we wish to be sure that it will not become obsolete in the future. Since the parts should be tested in the chassis at their operating frequency, it is certainly logical that the best instrument to test them with is a vacuum tube voltmeter since the V.T.V.M. has essentially the same characteristics as the tube usually associated with the part under test. Not all V.T.V.M. circuits are well suited for service work, however. Some are not sensitive enough, others draw too much current from the circuit under test, several types are too complicated or unstable, and some require such delicate meters that they are too costly to purchase and keep in repair for service work. Before deciding on any one type we will consider the more important basic types, and give detailed construction data on the one best suited for service work.

THE DIODE VACUUM TUBE VOLTMETER

The first vacuum tube voltmeter was of the Diode type, and dates back beyond the age of radio to the year of 1883 when Thomas A. Edison placed a plate in one of his first carbon filament lamps and noticed that—when the plate was made positive with respect to the filament—a current would flow between plate and filament. This was called the "Edison effect" after its discoverer. For over twenty years its use was limited to laboratory experiments in rectification until Fleming introduced it to replace the crystal detector, in which function it was called the "Fleming Valve." The reason for calling it a valve is obvious since it will pass current only in one direction—when the plate is positive—and shut it off as the plate is made negative. Since that time, all radio tubes are "valves" to the British experimenter and servicemen. The Greeks of course gave us a word for it—"Diode"—meaning dual element. The diode is used today in most radio receivers as a second detector and source of a-v-c, a-f-c and volume expansion control voltage. The diode vacuum tube voltmeter shown in figure 1A is possibly the simplest type, which is about its only virtue. Any glass or metal type of tube may be used as the rectifier, provided it will stand the maximum peak a-c voltage to be measured. If batteries are to be used for a source of heater voltage, a tube of the 1A4T type is a good choice because the control grid is brought out to the top cap and this can be used as the diode

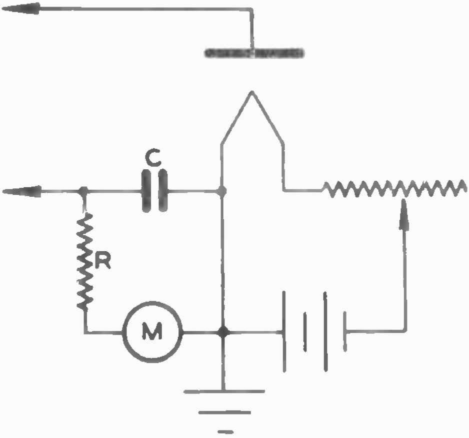


FIG. 1A

plate. The screen grid and plate in this case may be grounded and will serve as an internal shield to minimize external pickup. The capacity of the condenser "C" must be large enough to present a very low reactance to the lowest frequency to be measured—or we can say there should be no a-c voltage drop across this condenser at the lowest frequency we expect to measure. This requires a good paper condenser of at least 4 mfd. with a voltage rating equal to the largest peak voltage to be measured. The resistor "R" and meter "M" may be a standard 1000-ohms-per-volt voltmeter with its internal multiplier.

When the V.T.V.M. is connected across a circuit through which an alternating current is flowing, the plate will of course be alternatingly positive and negative by an amount equal to the a-c voltage flowing in the circuit under test. When the plate is positive it will attract electrons from the filament and a d-c current will flow through the external circuit under test and back through the meter and multiplier resistor to the filament You will notice that the meter circuit will contain only d-c voltage since the a-c voltage is by-passed by the condenser "C". During that portion of a cycle when the plate is negative, no d-c current will flow because its negative potential will

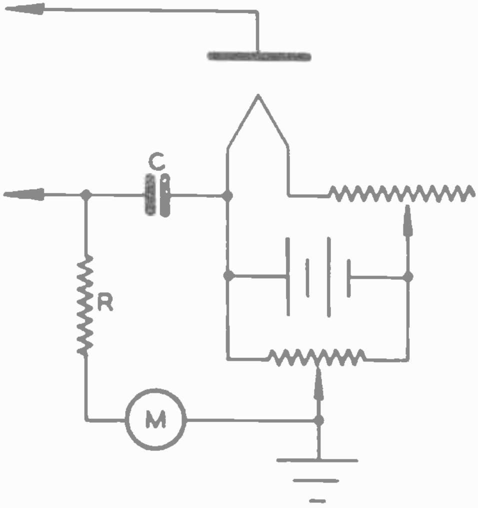


FIG. 1B

repel the negatively charged electrons being emitted from the filament. From this we can see that our diode V.T.V.M. will not draw current from the circuit under test when the plate is negative, so we can say it has infinite resistance during this portion of the cycle. When the plate is positive, however, the resistance of the diode will drop so that it may have a resistance of 1000 ohms or less, depending on the tube used. We can see from this that the diode V.T.V.M. will draw almost as much current from the circuit under test as a direct current voltmeter of similar sensitivity when measuring a d-c voltage. The obvious way to avoid this serious current drain is to use a more sensitive meter such as a 0-10 microammeter, which, with a multiplier resistor "R" of 500,000 ohms, would give us a meter resistance of 100,000-ohms-per-volt for the 5 volt range. Such a meter however is both expensive and delicate, and is not very practical for general service work. Moreover, even if we decided to use such a meter we would find another difficulty when we attempted to measure below 0.5 volt. In this range we might find that a point would be reached where no indication would be secured on the meter even though we knew that an a-c voltage existed in the circuit under test. Or, on the other hand, we might find that the meter would read 0.5 volt or less with the test prods short circuited. This error is due to "contact potential," which because of electronic action makes the plate appear as though it had an initial d-c potential of approximately plus 0.5 volt or minus 0.5 volt on it. To avoid this difficulty we can use the circuit shown in figure 1B and with the test prods short circuited adjust the potentiometer until the meter just reads zero. This will enable us to read more accurately below 0.5 volt.

So far we have said little about the main advantage of the diode V.T.V.M.—the fact that it is self-calibrating. This is a considerable advantage in that a d-c voltmeter is used for indication and the a-c voltage is read directly on the d-c voltmeter scale. The accuracy of this reading, however, is subject to considerable error, especially on the low voltage range because the diode resistance may be an important percentage of the meter multiplier resistance—and as a consequence the two will act as a voltage divider across the d-c generated voltage. Were it not for this source of error, which may be minimized by the use of a very high resistance voltmeter, we would find that the readings on the d-c meter would correspond to the average a-c voltage across the circuit under test, provided the current drawn from the circuit did not introduce a further error. At higher d-c voltages the diode V.T.V.M. d-c meter may read nearer to RMS values of a-c voltage, and at still higher a-c voltage ranges—because of the higher meter multiplier resistance—a value nearer to the peak a-c voltage may be indicated. No law can be given for this action because it depends upon the frequency as well as the a-c voltage, which is the penalty we pay for having a condenser in the input circuit across which d-c current must flow. This effect is the same as that called "time constant" in a-v-c and resistance coupled amplifier circuits. There are two methods of surmounting this difficulty. One is to follow the diode with another tube so that no current will be drawn from the diode circuit, and use this tube as a d-c amplifier with a milliameter in its plate circuit to indicate plate current change. The other is to use a "slide back" diode voltmeter such as the circuit shown in figure 1C. The first method will be discussed further under "Triode V.T.V.M.," and the second method depends upon a system of bucking out the d-c voltage generated by the diode. This is called a "slide-back" diode V.T.V.M. As shown in figure 1C a potentiometer is used across the filament battery to correct for "contact potential" and an additional battery is supplied to furnish the "bucking voltage." In operation the test prods are first short circuited and the filament potentiometer varied until the current through the meter is just reduced to zero with the meter switch in the No. 1 position and the sliding arm of the bucking battery potentiometer adjacent to the ground terminal. The test prods may then be connected to the circuit to be tested, and the slide back potentiometer adjusted until the meter again reads zero. The meter switch is then thrown to the No. 2 position and the d-c voltage read on it will be equal to the peak a-c voltage measured. Resistor

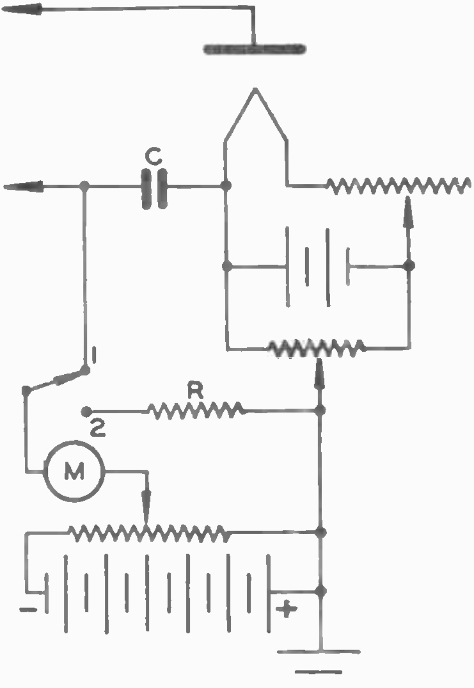


FIG. 1C

"R" will, of course, be the meter multiplier resistor and condenser "C" should be a 4 mfd. or larger paper condenser. The only trouble with this circuit is the difficulty of locating the exact zero current point and the necessity of having available a bucking voltage equal to the peak voltage to be measured. It is, however, recommended as the best diode type of V.T.V.M. because in the truest sense of the word it is self-calibrating, and because it does not draw current from the circuit under test. This last advantage follows from the fact that when the negative bucking voltage is exactly equal to the peak positive voltage applied to the plate, the V.T.V.M. circuit will have an infinite resistance to the a-c voltage and no current will flow in the diode from filament to plate (with the exception of the very small current drawn to charge the plate to filament capacity of the diode—which we may ignore for service work). We have mentioned "average," "RMS" and "peak" volts a-c and it may be well before going

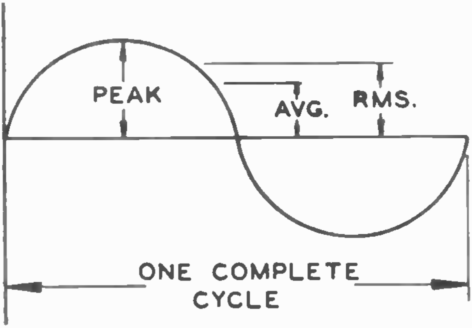


FIG. 1D

further to show how these three terms are related for a sine wave type of wave form. The peak voltage of course means the voltage between the zero potential point and the very peak of the a-c wave; RMS volts is equal to .707 times this value; and average volts is equal to .604 times the peak voltage. This relationship is shown graphically in figure 1D. In service work it is not important which of these readings we secure, for most applications, as long as we know what it is. Since all of our service meters are calibrated in RMS volts and we must use RMS volts in measuring power, it is somewhat of an advantage to have our V.T.V.M. calibrated in RMS if a choice is to be made.

A further advantage to consider is the use of such a V.T.V.M. circuit as will permit us to use the tube on a cable so that it can be connected to the circuit under test with very short leads. This will permit us to measure high frequencies with the minimum amount of error due to standing waves on the leads and capacity between leads because the V.T.V.M. tube can be placed very close to the circuit part to be tested, and in most applications the leads need be only 2 or 3 inches long. To reduce still further r-f losses, a tube having a grid connection brought out the top should be selected. If a diode type of V.T.V.M. circuit is being used, this grid as mentioned before can be employed as the diode plate.

THE GRID RECTIFYING TRIODE V.T.V.M.

One of the most sensitive triode types of V.T.V.M. is the grid leak detector type shown in figure 2A. This type of detector was very popular before the introduction of the power detector and the more recent diode detector. It may be considered a combination diode detector followed by a d-c amplifier. When an a-c signal is applied to the grid, rectification takes place during the positive half cycle, and the rectified grid current flowing through the grid leak biases the grid negative. This negative grid bias reduces the plate current and a milliammeter in the plate circuit may be calibrated to read the a-c voltage appearing on the grid. It is one of the most sensitive types of V.T.V.M. besides having the advantage that the meter in the plate circuit reads maximum with no signal applied, and therefore the meter cannot be damaged by the application to the grid of too large an a-c signal. The grid leak may be made very large (on the order of 5 to 10 megohms) so the loading on the circuit under test will be small. A further advantage derived from the use of a high resistance grid leak is that the grid condenser may be smaller in capacity and therefore also smaller physically. This type of V.T.V.M. is usually equipped with a single pole double throw switch so that

la

dc

ci

th

pl

is first short circuited

position the slide back potentiometer is adjusted to give some convenient plate current value such as 1 ma. The meter switch is then thrown to the "A" position and the grid bias voltage is measured. The a-c voltage to be measured is now applied across the test prods and with the switch in "B" position the potentiometer is adjusted until the meter again reads 1 ma. The switch is then thrown to the "A" position and the new bias voltage read. The

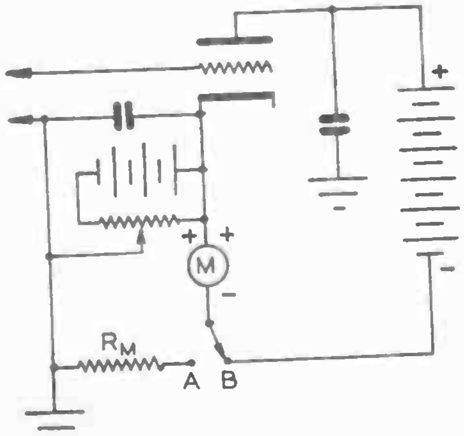


FIG. 2B

the grid leak may be used in parallel with the grid condenser for measuring d-c voltages, or between grid and ground for a-c measurements. When the grid leak is connected from grid to ground, the condenser will block d-c voltages and permit only a-c voltages to reach the grid. The main disadvantages of this type are that it does load the circuit under test somewhat; it has to a small extent frequency discrimination (due to the use of R and C in the input circuit); and it has a rather limited voltage range unless a voltage

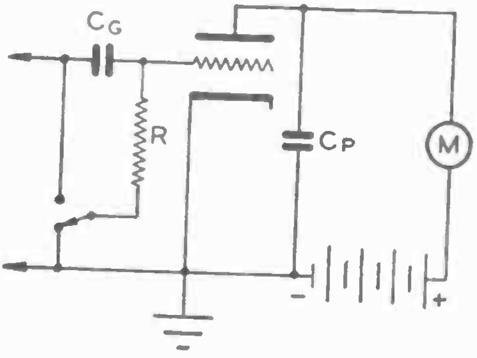


FIG. 2A

course introduces

difference between the first and second bias voltages is the value of peak a-c voltage across the test prods. Resistor RM is the meter multiplier resistance.

In general the slide back V.T.V.M. may be considered the best of those types that do not require calibration. Its major disadvantage is that a relatively large slide-back voltage must be provided if the instrument is to be used for radio service work, and this requires an additional switching system to insert different values of meter multiplier resistors in the circuit if good meter accuracy is to be realized. A-C and d-c voltages between .25 and 15 volts may be measured with the circuit shown in figure 2B with good accuracy.

The plate current variation for a given input voltage on the grid is proportional to the mutual conductance of the tube type used. In choosing the tube type for this purpose other factors such as shielding, input capacity, plate to grid capacity and position of the grid lead must be considered. Screen grid types may also be used as triodes by connecting plate, screen and suppressor grids together.

THE REFLEX TYPE V.T.V.M.

The circuit shown in figure 2C will be more familiar to servicemen as the power detector in which connection it was used very extensively as a detector for t-r-f sets and as a second detector for early model super-heterodyne receivers between 1927 and 1931. It is called a "Reflex type V.T.V.M." because the plate current is made to return to the cathode through a resistor which is common to both the grid and plate circuits. The effect of this resistor is to increase the bias with an increase in plate current. As a consequence the instrument as a V.T.V.M. or as a second detector can handle a larger signal without over-loading or drawing grid current. This is valuable in a V.T.V.M. because it gives the instrument a greater voltage range without recourse to the use of voltage divider resistors. If the proper type of tube is used it will add very little capacity and no resistance load to the circuit under test. The cathode resistor and the plate must be well by-passed to ground with paper or mica

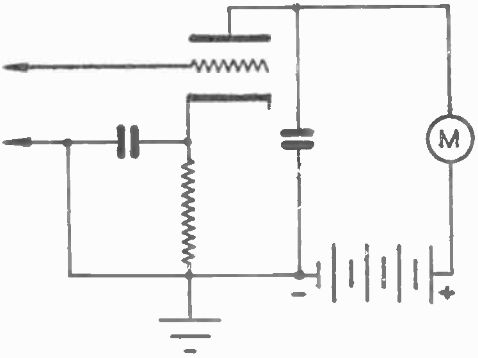


FIG. 2C

condensers large enough to have very small reactance at the lowest frequency to be measured—usually 30 cycles per second.

The reflex type V.T.V.M. circuit shown in figure 2D has provision in the plate circuit to reduce the no signal plate current to zero. This permits the use of a more sensitive meter and makes it possible to read smaller plate current changes, which means that smaller voltages may be measured with the instrument. With a 0-200 microammeter in the plate circuit, a-c voltage as low as 0-1 volt applied to the grid will produce a 1 to 5 microampere plate current change—depending upon the type of tube used. The plate current change with applied a-c grid voltage is not uniform over the entire meter range, so consequently this type of V.T.V.M. must be calibrated. It has so many other advantages, however, that it is probably the most popular type of V.T.V.M. circuit in use today. A large number of circuit variations are possible with this basic type.

The three types of V.T.V.M. circuits mentioned so far (the Grid rectifying, Slide-back and Reflex) are the most important basic ones

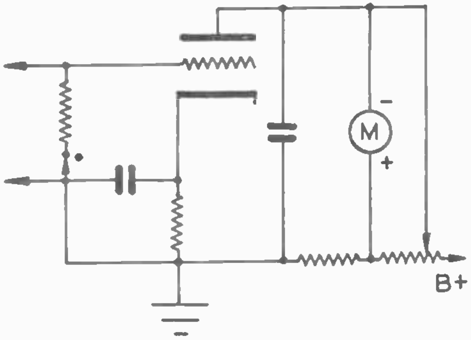


FIG. 2D

using a triode type of tube. There are three other types, however, which we will include here because they are interesting from a circuit standpoint and very useful for special applications.

THE INVERTED TRIODE TYPE V.T.V.M.

As the name implies, the inverted type V.T.V.M. employs the plate of the triode as the control element and the grid is used as the electron accumulating element. The instrument employs a low drain filament type tube with a 0-200 or 0-500 microammeter. A small positive potential is applied to the grid as shown in figure 2E, and the rheostat is adjusted to give a zero signal grid current of 200 or 300 microamperes. This also adjusts the filament voltage to the correct value. If an unknown d-c voltage is now applied to the plate with the plate connected to the negative terminal of the unknown voltage source, this negative potential will prevent some of the electrons from reaching the grid and will thus reduce the grid current. The use of a series condenser and high resistance leak from plate to ground will also permit this type of V.T.V.M. to be used for measuring a-c voltages.

The necessity of using a sensitive meter in the grid circuit of this type of instrument is a serious disadvantage for service work. It must of course be calibrated before it can be used.

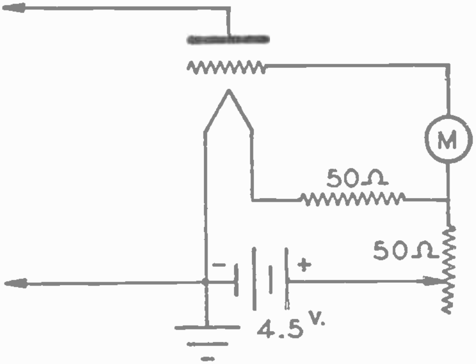


FIG. 2E

THE MOULLIN TYPE V.T.V.M.

One of the earliest types of V.T.V M. to become popular was the Moullin type, the circuit of which is shown in figure 2F. It was for some time the standard for laboratory use and the term "Moullin Voltmeter" was used to indicate vacuum tube voltmeters in general.

Although it requires too sensitive a meter to be useful for general radio service work, it has the advantages common to the inverted type of V.T.V.M.—i.e., adjusting the meter to zero with the rheostat automatically adjusting both the filament and plate voltages to the correct value. The response of the plate current meter to applied grid voltages is linear for most of the scale, but the effect of the tube's space-charge introduces non-linearity at the low voltage end that makes it necessary to calibrate the instrument. The effective plate voltage is usually on the order of one or two volts, so that the voltage range of the V.T.V.M. is rather limited.

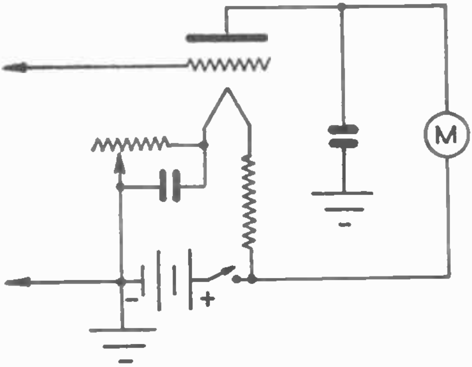


FIG. 2F

THE INFINITE IMPEDANCE DIODE V.T.V.M.

The infinite impedance diode V.T.V.M. shown in figure 2G is really another version of the reflex type or power detector circuit. The main difference between the reflex type and the infinite impedance diode is that the by-pass condenser is eliminated from the cathode.

This permits a large degree of degeneration since the cathode resistor is really the plate load, and being common to both plate and grid circuits permits the tube to handle very large input signals without over-loading. This advantage is secured by sacrificing some of the low voltage sensitivity of the instrument, however. Another disadvantage is the fact that there exists a-c currents in the cathode circuit, (these are eliminated by the by-pass condenser in the reflex type V.T.V.M.) that makes it very difficult, if not impossible, to use the tube on the end of a cable so that the tube may be used with very short leads for high frequency work. This fact must be kept in mind if the V.T.V.M. is to be useful for television work.

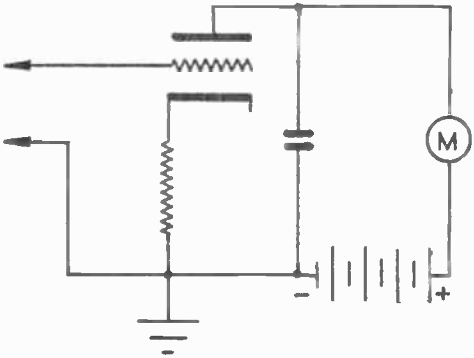


FIG. 2G

The Electric Eye Vacuum Tube Voltmeter

There are many good types of vacuum tube voltmeters on the market made by reputable manufacturers whose products would be valuable additions to the test equipment of any radio service shop. These units are rather expensive, however, because good workmanship and a sensitive meter are necessarily costly. In order to make available to the serviceman an accurate, rugged low cost vacuum tube voltmeter which the serviceman can build and calibrate himself at a very low cost, the following constructional article is published. No meter is required for this instrument so it will withstand a great deal of abuse both electrically and mechanically with little fear of damage. Most of the parts required for this vacuum tube voltmeter are available from the average serviceman's parts stock. The time required to build this instrument is small and servicemen will find it a useful device to assist them in the diagnosis of many radio receiver troubles.

The vacuum tube voltmeter to be described is a modification of the reflex type employing a calibrated potentiometer and a type 6E5 tuning indicator tube in place of the usual microammeter. In addition to reducing the cost of construction, this circuit provides a very important advantage in that the low voltage end of the scale most used and where greatest accuracy is desirable is spread out so that the range from 0 to 3 volts occupies approximately one half the scale and the balance of the range occupies the other half.

The voltage range of the V.T.V.M. is from 0.1 volt to between 100 and 200 volts depending upon the plate voltage of Type 6F5 tube. In service use it will be found more practical to make use of voltage divider resistors across the input of the tube to extend the voltage range, since the calibrations become crowded above 50 volts.

The frequency range of the instrument is from below 60 cycles per second to some higher frequency which will depend upon the length of the leads from the prod tube to the voltage source, the capacity between these leads and the impedance across which the voltage is being measured. To eliminate the effect of standing waves on the input leads and the capacity between them the prod tube is placed on the end of a cable so the tube may be used very close to the voltage source with correspondingly short leads and low r-f loss. This permits voltages on the order of 18 to 20 megacycles to be measured with accuracy more than sufficient for general service work. At frequencies above this figure the loading effects of the tube's input capacity and the effect of electron transit time will introduce an error that is a function of the voltage source impedance. For service work this error is not unreasonably large, however, at any frequency encountered in radio receivers since in most instances the V.T.V.M. prod tube will be used across a tuned circuit to measure voltages in place of a tube having an equal loading effect.

The photographs show front view, and the chassis view of an Electric Eye Vacuum Tube Voltmeter. The simplicity of the circuit together with the fact that the location of parts and leads is not critical makes it very easy to build this V.T.V.M. into any type of cabinet that may be at hand. R-F currents are confined to the prod tube and socket assembly so it is not necessary to employ a shielded case for the main unit. The sloping panel has much to recommend it from a standpoint of ease of operation and convenience in reading the calibration.

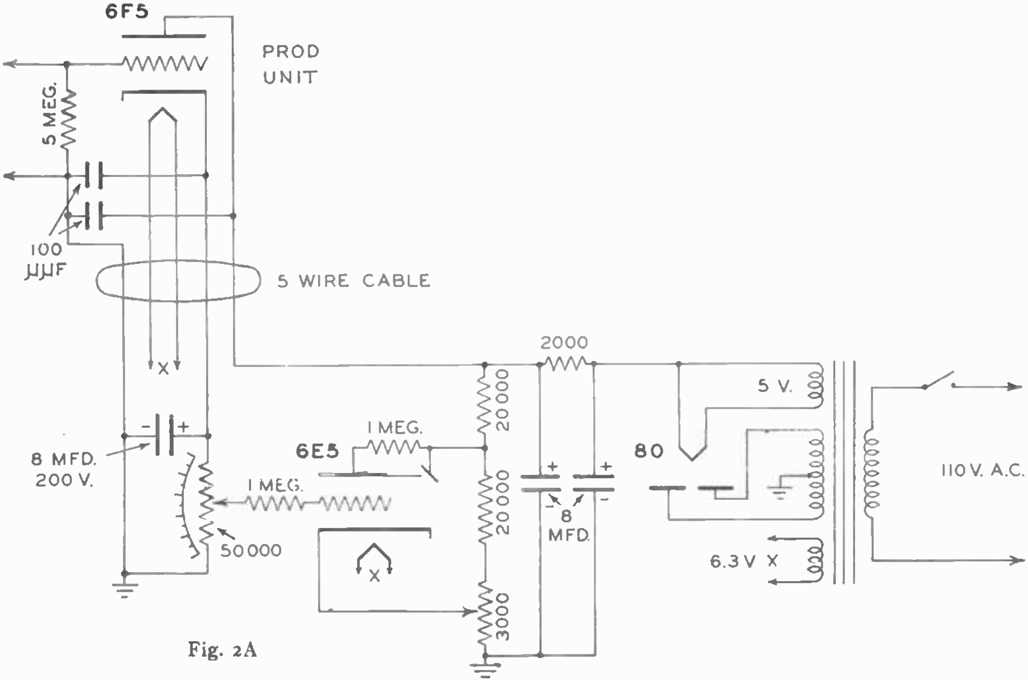

6F5
PROD UNIT
5 MEG.
100 µµF
5 WIRE CABLE
X
8 MFD. 200 V.
-
+
50000
1 MEG.
6E5
1 MEG.
X
20000
20000
3000
2000
+
+
-
-
8 MFD.
80
5 V.
6.3 V X
110 V. A.C.

Fig. 2A

The V.T.V.M. consists of a power supply; simple resistance-capacity filter, voltage divider net work, electric eye indicator tube, calibrated potentiometer and Type 6F5 prod tube mounted on the end of a 5 wire cable. The power transformer consists of a primary; 6.3 volt secondary to supply 0.6 ampere of current for Types 6F5 and 6E5 heaters; 5 volt secondary for the Type 80 rectifier tube and a 650 volt center tapped high voltage secondary rated at 40 ma. This is the standard 4-tube midget transformer and because only 50% of its maximum power capabilities is being used it will run very cool in operation. The two 8 mfd. electrolytic condensers shown in the diagram should be rated at 450 working volts to insure long life and good performance. The filter resistor may be either a 2-watt carbon or wire wound type. The 20,000 ohm resistors in the voltage divider net work should also be rated at 2 watts. The two 1 megohm and the 5 megohm resistors may be of the ⅓ or ¼ watt carbon type. Wire wound potentiometers should be used to insure long life and accuracy of the voltage calibration. The two 100 uuf mica condensers used at the socket of the prod tube must be soldered to the proper terminals with the shortest possible leads, to eliminate high frequency error. These two condensers keep the high frequency currents out of the 5-wire cable and make it unnecessary to use a shielded cable.

THEORY OF OPERATION

When the instrument is first turned on the input leads to the prod tube are short circuited and the Type 6F5 cathode potentiometer is turned so that the sliding arm is adjacent to the Type 6F5 cathode. The pointer should then be at the lower left hand end of the scale if the potentiometer has been connected properly. The shadow of the Type 6E5 is then adjusted by varying the 3000 ohm potentiometer so that it just closes and leaves only a hair line of darkness between the two "wings" of light. Under these conditions the Type 6F5 plate current flowing through the 50,000 ohm cathode potentiometer will make the cathode 3.5 to 4.0 volts positive with respect to ground. The Type 6F5 grid will therefore have a 3.5 to 4.0 volt negative bias.

We know that the Type 6E5 requires approximately 8 volts negative grid bias to close the "wings" and since it is connected to a potential source of say 4 volts positive the cathode of the Type 6E5 must then be 4 plus 8 or 12 volts positive. When the two test prods are connected across an a-c voltage source the Type 6F5 rectifies this a-c voltage and the average plate current increases. This produces a greater IR drop across the 50,000 ohm cathode potentiometer which reduces the negative bias on the Type 6E5 causing the wings to open. If the Type 6F5 potentiometer slider is now turned toward the grounded end a point will be found where the Type 6E5 grid will again receive a minus 8 volt bias and the wings will again close. If a known voltage (for example 2 volts) was applied to the grid of the Type 6F5 tube to cause this action, the point on the scale where the eye just closed can be marked 2 volts and thereafter when an unknown voltage makes it necessary to adjust the potentiometer to this point, the operator will know that a 2 volt signal is being measured. The purpose of the 1 megohm resistor in series with the grid of the Type 6E5 tube is to prevent excess grid current from flowing in the event a large a-c signal is applied to the prod tube when the potentiometer is adjusted for a small signal. This safety feature makes it unnecessary to anticipate the approximate amplitude of the unknown voltage.

Direct current voltages are measured by connecting the positive side of the unknown voltage to the grid of the prod tube. This is necessarily true because the tube is self-biased almost to cut-off under normal conditions and if a further negative voltage is applied to the grid there will be little if any change in plate current.

Inasmuch as it is felt that most servicemen will wish to use as many parts as possible from their present stock and will prefer to use many of their own ideas in the construction of this vacuum tube voltmeter no detailed layout specifications are made available. The photographic illustrations tell most of the story, however. The third knob seen in the front view is the on-off switch and the two extra tubes shown on the right hand side of the chassis were included to test out a method of line voltage regulation.

The scale for the V.T.V.M. may be engraved on a hard rubber or aluminum panel, or a heavy paper card may be used and the calibration made with India ink. If the paper card is employed, it should be painted after calibration with clear lacquer or covered with a sheet of celluloid, to keep the scale clean. The diameter of the scale should be made as large as the panel of the instrument will permit to facilitate calibration and for ease in reading. A wire or celluloid pointer long enough to cover the calibration should be fastened to the 50,000 ohm potentiometer knob in such a manner that there is no possibility of it becoming loose and thus giving a false reading.

METHOD OF TESTING V.T.V.M.

Before starting the actual work of calibrating the scale of the V.T.V.M., make the following tests to be sure the instrument is working correctly:

1. Measure the Type 6F5 plate voltage—any value between 270 and 350 volts will give satisfactory operation. Insert resistors in series with 5.0 and 6.3 volt secondaries, if necessary, to secure proper voltage on the tubes. Measure the Type 6E5 target voltage and if necessary change the values of the voltage divider resistors to secure 180 to 250 volts on the target.

2. Ground the Type 6F5 grid and turn the 50,000 ohm potentiometer to the extreme counter-clockwise position (zero voltage position on scale). This should place the sliding contact adjacent to the Type 6F5 cathode terminal, and it should be possible to "close" the electric eye by adjusting the Type 6E5 cathode (3000 ohm) potentiometer. Pick a Type 6E5 tube that gives a clean straight edge to the shadow.

3. With the eye closed as above, remove the ground connection from the Type 6F5 grid. Be sure the grid connection does not touch anything (except the 5 megohm resistor). The position of the two shadows on the Type 6E5 should change very little if at all. Try

several Type 6F5 tubes if necessary to secure this result. Usually an old Type 6F5 that has been used several hundred hours in a radio set will give the most stable operation.

4. Connect the Type 6F5 grid lead to the positive terminal of a dry cell and the negative terminal of the battery to ground. The eye should open and it should take approximately a 60 degree turn of the 50,000 ohm potentiometer to close it.

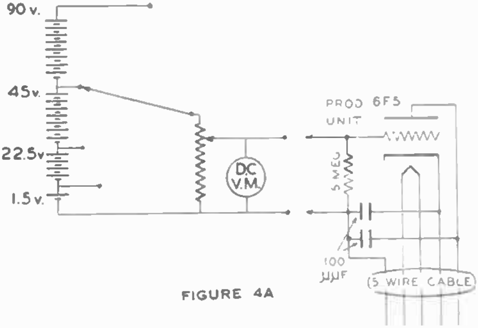


FIGURE 4A

5. With the above set-up and the eye within a hair's width of being closed, disconnect and then reconnect one terminal of the 8 mfd. condenser located in the cathode circuit of the Type 6F5. With a condenser having low leakage there should be very little change in the position of the Type 6E5 shadow.

CALIBRATING D-C SCALE

Connect a series of batteries to a 25,000 or 50,000 potentiometer and multi-range voltmeter as shown in figure 4A. A well filtered "B" supply may be used in place of the batteries, but if any a-c ripple appears on the d-c component a false reading will result—since the V.T.V.M. will measure the combination of the a-c and d-c voltages. Use the low voltage range of the d-c voltmeter and adjust the battery potentiometer to give 0.1 volt reading on the d-c voltmeter. This will cause the eye to open if it has previously been adjusted to zero. Turn the 50,000 ohm potentiometer on the V.T.V.M. until the eye just closes and mark 0.1 on the scale under the pointer. Continue the calibration in 0.1 volt steps up to 5 volts, changing the battery tap and the meter scale when necessary. Calibrate every 0.2 volt up to 10 volts; then every .25 volt up to 15 volts; then every .5 volt up to 20 volts; then every 1.0 volt up to 40 volts; then every 2 volts up to 50 volts; then every 5 volts up to 70 volts; then every 10 volts up to 100 volts; and then every 25 volts up to the maximum voltage capability of the V.T.V.M.—which will depend upon the plate

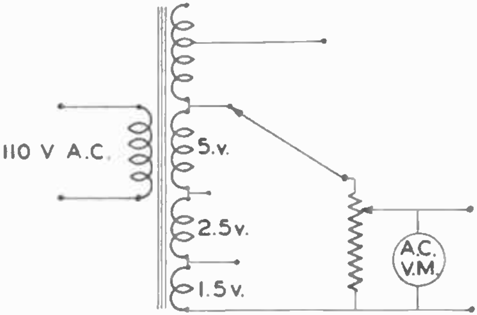


FIGURE 4B

voltage of the Type 6F5 tube. The calibration for d-c voltage should be made on one side of a circular line previously drawn on the panel. The calibration marks should not be drawn so as to cross this line or they will interfere with the a-c calibration marks which are to be made on the other side of this line. In using the various meter scales on the d-c meter always use the scale that will permit the reading to be made as near full scale as possible, as this will give the best accuracy.

CALIBRATING A-C SCALE

The a-c scale is calibrated in the same manner as the d-c scale except a transformer is used across the a-c line as a voltage source, and of course an a-c meter must be used. A good arrangement is shown in figure 4B. A standard power transformer is used with the low voltage secondaries connected in series, and half of the high voltage secondary is used. In connecting the secondaries in series, be sure they are connected so that the voltages add instead of bucking each other. As in the case of the d-c calibration, start with 0.1 volt steps and allow larger voltage steps between calibration points as the scale becomes crowded.

Line voltage variations, if severe, will cause some loss in accuracy. This can be reduced if the Type 6F5 grid is grounded and the 3000 ohm potentiometer adjusted to close the eye when the 50,000 ohm potentiometer is set at zero on the scale several times during the calibration period. This is also a good precaution during long periods of use.

Mark the d-c scale with the letters "D.C." to prevent possible mistakes in the future. A very good method of avoiding confusing the two scales is to use different colors for each—such as white for d-c and red for a-c.

Use of the Electric Eye Vacuum Tube Voltmeter

The vacuum tube voltmeter is one of the most versatile and useful instruments for laboratory and service shop use. It is not, however, a tool that can be used without regard for its limitations, or the results may be subject to serious error. It is less simple and convenient to use for some types of voltage measuring than the moving coil type of voltmeter, and where this latter type of meter can be used, it is to be preferred to the V.T.V.M. For measuring d-c voltages across high resistance circuits where it is not permissable to use an instrument that will draw current from the circuit and for r-f measuring work, the V.T.V.M. is in a class by itself and is in many cases the only instrument that can be used.

It has been so long since most of us learned to use a d-c voltmeter that we tend to forget the number of times we used the wrong scale and either bent the pointer (if nothing worse happened) or got no reading at all, and the number of times we secured a reading that meant nothing to us because we did not know how to interpret it, lacking knowledge on what reading to expect as normal for the voltage condition we were trying to check. The V.T.V.M., by the very nature of its purpose—measuring voltages across high impedances and at radio frequencies—necessitates more care and knowledge in its application than the simple d-c meter. For this reason this series of articles is being concluded with data on the correct use of the V.T.V.M. in service work.

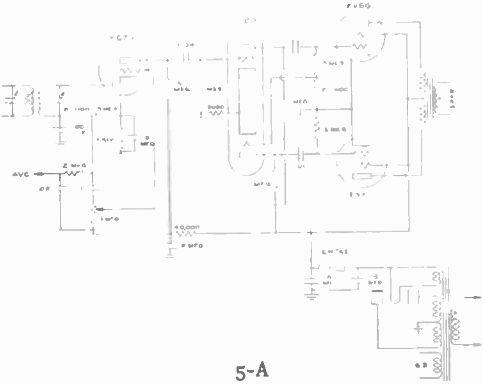
In addition to the study of this material, the serviceman is urged to experiment on several different types of radio sets known to be in good working condition so that he will be familiar with the results to expect when testing a questionable set. It is especially recommended that each suggested test described in the following paragraphs be actually made by servicemen on radio receivers known to be working properly, before an attempt is made to diagnose a receiver in imperfect condition. This will make it much easier to interpret the future readings secured with the aid of the V.T.V.M.

USES AND APPLICATION

The audio frequency end of a radio receiver, because of the lower frequencies involved and the higher voltage available, presents the simplest point at which to start learning the proper use of the V.T.V.M. The circuit shown in figure 5A is typical of what may be encountered in a modern radio receiver, audio section. The following stage by stage measurements will show how this end of the receiver may be analyzed with a V.T.V.M.

TESTING SECOND DETECTOR CIRCUIT

Diode Section The diode rectifier separates the a-f component from the i-f carrier, and since we are interested in only the audio



5-A

circuit for the time being, we wish to determine all possible sources of a-f loss and investigate each one in turn.

(1) I-F Filter:

The purpose of the 50,000 ohm resistor and 100 $\mu\mu$f. condenser ahead of the diode load resistor is to filter the i-f signal from the audio (and a-v-c voltage) to prevent this i-f voltage from reaching the grid of the Type 6Q7G tube. If any quantity of i-f signal reaches the Type 6Q7G grid, it will cause the tube to overload at low audio levels and cause distortion. Likewise, if any of the a-v-c voltage reaches the Type 6Q7G grid, it will bias the tube toward cut-off and cause distortion. To check the effectiveness of the i-f filter (50,000 ohm resistor and 100 $\mu\mu$f. condenser) connect the V.T.V.M. to the control grid of the Type 6Q7G—this demonstrates one convenience of the V.T.V.M. method of testing. Many tests can be made from the top of the chassis. Also, the most important reason for testing at the grid of the Type 6Q7G is because we want to know how much i-f signal is getting through to the grid. We could test at the junction of the 50,000 ohm resistor and the condenser, but even if we found some i-f at this point, it would not prove that the grid was getting i-f voltage because the distributed capacity of the wiring, the .01 mfd. by-pass condenser and the volume control might filter it out (as a matter of fact, in some low priced sets this distributed capacity is depended upon to do this very thing). An **unmodulated** signal from a test oscillator is tuned in on the receiver and any voltage appearing on the V.T.V.M. will be i-f voltage. It is well to listen to the speaker during this test to be sure there is no other signal such as hum or hiss coming through since these false signals will of course reach the grid of the Type 6Q7G and cause a false reading. This is one case where a shielded room is of great value. The effect of noise and hum can be reduced to a large extent by increasing the signal strength at the oscillator so that a large a-v-c voltage is built up to reduce the sensitivity of the receiver. The test prod grid (6F5) of the V.T.V.M. should be connected through a small mica condenser on the order of 250 μμf. capacity to avoid measuring any a-v-c voltage that may be leaking through the .01 mfd. coupling condenser.

(2) A-F Blocking Condenser:

Assuming that the i-f filter is satisfactory, remove the 250 μμf. condenser from the test prod grid of the V.T.V.M. and with a strong signal still applied to the input of the receiver, connect the test prod direct to the Type 6Q7G grid to see if any d-c voltage appears on the Type 6Q7G grid. The ground lead of the V.T.V.M. should be connected to the chassis in each case. To prevent a false reading due to noise, hum, etc., from effecting the readings, connect an 0.5 mfd. paper condenser known to be free from leakage across the input of the V.T.V.M. This will by-pass any a-c and if a few seconds are allowed for the condenser to charge up before a reading is attempted, the d-c voltage will not be affected. A leaky condenser will make the wings of the V.T.V.M. electric eye overlap because the a-v-c voltage will be negative. Even if the leakage is small the condenser should be replaced because a leaky condenser is apt to cause trouble at a later date.

(3) A-V-C Network, A-F Filter:

The .02 mfd. condenser and 2 megohm resistor comprise the a-f filter to prevent any a-f voltage from being fed back along the a-v-c circuit. The effectiveness of this filter can be checked by connecting the V.T.V.M. prod tube grid through an 0.1 mfd. paper condenser to the junction of the .02 mfd. condenser and 2 megohm resistor with a strong modulated signal fed into the receiver from a test oscillator. No voltage should appear on the V.T.V.M. under normal conditions.

TRIODE (OR PENTODE) SECTION

(1) Cathode Resistor and Condenser:

The voltage drop across the cathode resistor may be checked by either a d-c voltmeter or the V.T.V.M. This will indicate the amount of grid bias on the Type 6Q7G tube. The condenser across this resistor may be very easily checked without removing it from the circuit. To check this condenser we need only connect the V.T.V.M. across it and feed a low frequency signal into the grid of the Type 6Q7G tube. A low frequency is specified because a condenser is less effective at the lower frequencies and therefore if the condenser tests satisfactory at the low frequencies it is sure to be effective at the higher frequencies in the a-f band. An easily secured low frequency source is a voltage divider across the 6.3 volt heater winding of the power transformer. Apply a 60 cycle voltage equal to about 50 % of the d-c bias to the grid of the Type 6Q7G. For example, with the constants shown in figure 5A an a-c signal of 0.8 to 1.0 volt is satisfactory and the voltage may be fed to the grid through an 0.5 mfd. condenser to avoid any complications due to the fact that the heater may be operated above d-c ground potential for some biasing purposes. Because we do not want the d-c voltage drop across the cathode resistor to appear on the V.T.V.M. prod tube an 0.5 mfd. condenser should be connected in series with the grid of the V.T.V.M. prod tube. If the cathode by-pass condenser is effective no voltage will be readable on the V.T.V.M.

(2) Screen Grid By-Pass Condenser:

If instead of a Type 6Q7G tube we have a Type 6B7 or Type 6B8G tube as a second detector the screen by-pass condenser may be tested in the same way with the same set-up, since its function is the same; to by-pass any a-c voltage that may appear on the screen grid.

(3) Stage Gain:

Returning to a consideration of the Type 6Q7G circuit, we can test the gain of this stage by introducing a measurable a-c voltage—such as 0.5 volt into the grid circuit from the a-c line just as we did for testing the cathode by-pass condenser, and measuring the a-c voltage appearing across the plate load resistor. A voltage from the a-c line is recommended to avoid the possibility of wave form errors that may result from a poor wave form from a test oscillator.

The output voltage divided by the input voltage is the stage gain. The 0.5 mfd. condenser recommended in the previous test should be used in series with the V.T.V.M. grid to avoid the affect of the d-c plate voltage. The volume control should of course be on "maximum" during these tests.

(4) Plate to Grid Coupling Condenser Capacity:

To check the .004 coupling condenser for capacity, leave the a-c signal on the Type 6Q7G grid as before and move the V.T.V.M. 0.5 mfd. condenser from the plate terminal of the Type 6Q7G to the grid terminal of the Type 6C8G. The gain should be very nearly the same (within 10 to 20 per cent, usually) on most receivers. If a larger condenser is substituted for the .004 mfd. unit to increase the low frequency gain, it may be necessary to place a larger filter condenser in the power pack to keep the overall receiver hum within reasonable limits.

(5) Plate to Grid Coupling Condenser Leakage:

To test the d-c leakage of the .004 mfd. condenser, connect the V.T.V.M. prod tube grid direct (without the 0.5 mfd. blocking condenser) to the grid of the Type 6C8G tube, and remove the Type 6Q7G tube from the socket. Removing the Type 6Q7G tube from the socket does two desirable things; it eliminates any noise, hum or signal, that may be picked up by the receiver, from reaching the V.T.V.M., and it removes the IR drop from the 0.5 megohm resistor caused by the Type 6Q7G plate current. If any voltage appears on the V.T.V.M. the condenser is leaky. As an example, suppose the B supply is 300 volts, the leakage current through the .004 mfd. condenser may be one microampere, the voltage drop across the 1 megohm resistor will then be .000001x1,000,000 ohms = 1 volt (E = IxR). Such a leakage biasing the Type 6C8G grid positive by 1 volt would seriously limit the undistorted signal level that could be amplified, and unbalance the phase inverter circuit. A leakage of one tenth this value is as much as should be permitted.

(6) D-C Plate Voltage:

To measure the d-c voltage on the plate of the Type 6Q7G tube, turn the volume control to "minimum" and connect the V.T.V.M. from plate to ground and read the d-c voltage direct on the V.T.V.M. The Type 6Q7G tube must be in the socket during this test.

(7) Plate Circuit Decoupling Filter:

The 40,000 ohm resistor and 4 mfd. condenser in the plate circuit of the Type 6Q7G forms an additional filter in the B supply to help eliminate hum. To test its effectiveness, measure the a-c voltage appearing between the B supply end of the 40,000 ohm resistor and ground, using an 0.5 mfd. condenser in series with the prod tube grid of the V.T.V.M. to eliminate the B supply d-c voltage. The a-c voltage appearing on the V.T.V.M. should be very small. Then measure the a-c hum voltage under the same circumstances appearing across the 4 mfd. condenser. It should be so small as to be unmeasureable with the V.T.V.M. If an a-c voltage is detected, the 4 mfd. condenser is defective or of too low a value and should be replaced.

(8) Decoupling Condenser Leakage:

To test the 4 mfd. condenser for leakage, remove the Type 6Q7G tube from the socket, and the 0.5 mfd. condenser from the prod tube grid, and measure the d-c voltage between each end of the 40,000 ohm resistor and ground. If there is no leakage in the 4 mfd. condenser the voltage will be the same at both ends of the resistor. With an electrolytic condenser some small leakage is to be expected, and the two voltages will therefore not be equal. Since the "B" supply voltage is higher than the range of the V.T.V.M. it will be necessary to connect a 20 megohm resistor in series with the grid of the prod tube of the V.T.V.M. This 20 megohm resistor in series with the 5 megohm resistor already in the circuit between prod tube and ground will provide a voltage divider network ahead of the V.T.V.M. and the reading of the V.T.V.M. must be multiplied by 5 to secure the proper reading. A little experience in testing various makes of electrolytic condensers will indicate the amount of leakage to be expected as normal with each make.

A glance at the schematic diagram in figure 5A will show that we have now tested every part of the Type 6Q7G circuit under actual operating conditions without removing them from the circuit. The various parts used in the Type 6C8G phase inverter circuit should next be tested in exactly the same way.

TESTING PHASE INVERTER CIRCUIT

The phase inverter circuit shown depends for its correct operation on the fact that an a-c voltage in the plate circuit of a vacuum tube is 180 degrees out of phase with the a-c voltage in the grid circuit. This is one fact in our tests that we may safely assume to be correct (although it too may be tested with a V.T.V.M.). To get the two output tube grids 180 degrees out of phase with each other, the signal from the top output tube is put through an extra tube (or one section of a duo triode, as in this case). Naturally we want the a-c voltage appearing on the two output tube grids to be equal in amplitude as well as being out of phase with each other. To secure this result, only a portion of the signal applied to the top output tube is applied to the second section of the duo triode. The ratio of the voltage applied to the phase inverter tube compared with the total voltage available should equal the voltage amplification of the tube being used as a phase inverter. The voltage amplification figure may be found by actually measuring the gain of the top section of the Type 6C8G tube. The test we are most interested in however is to find if an equal voltage is being fed to each output tube grid. This may be determined by any one of four measurements if all other parts are known to be good. The result of these tests should show that:

A. The a-c signal between each grid of the Type 6C8G tube and ground should be equal.

B. The a-c signal between each plate of the Type 6C8G tube and ground should be equal.

C. The a-c signal between each **grid** of the output tubes and ground should be equal.

D. The a-c signal between each **plate** of the output tubes and ground should be equal.

Only one of the above tests need be made and C is to be recommended as this tells us just what we want to know. A difference of 10 per cent or less in the two a-c output tube grid voltages may be considered as satisfactory since even a 10 per cent unbalance will not cause a noticeable increase in distortion.

POWER SUPPLY

Aside from the B-plus and heater supply voltages, which may be measured with the moving coil type of voltmeter, we are most interested in measuring the amount of a-c ripple appearing across the two filter condensers since this is an indication of their effectiveness. An 0.5 mfd. condenser should be used in series with the grid of the V.T.V.M. prod tube to eliminate the d-c voltage normally across the filter condensers. The a-c voltage appearing across each filter condenser will vary from one make of set to another due to differences in the inductance of the choke coil, power transformer, high voltage secondary voltage and current drain through the choke coil so that experience must be acquired from testing many receivers before this test will be of maximum value. As an example of what a-c voltage may be expected across the filter condenser nearest the rectifier, a typical power supply was measured with different size electrolytic condensers in the first condenser position, and the results are tabulated below:

Capacity of 1st condenser:

4 8 12 16 20 24 mfd.

A-C voltage across condenser:

52 26 18 13 10 8 volts

The second condenser in the above test was 8 mfd., the B-plus voltage 350 d-c volts and the current through the choke was 110 milliamperes d-c. The a-c voltage measured across the second filter condenser will of course be very much less under normal conditions.

If the user has had some experience on audio frequency measuring work with the V.T.V.M., he should have little trouble at higher frequencies providing due care is exercised to keep the V.T.V.M. leads short.

TESTING OSCILLATOR VOLTAGE

The local or heterodyning oscillator in a super-heterodyne receiver is very easy to test from the top of the chassis by connecting the control grid of the V.T.V.M. prod tube to the stator plates of the gang condenser oscillator section. While the V.T.V.M. is connected, rotate the gang condenser and check the voltage continuously on each band. There will be some variations on each band and between bands—this is normal. If a point is observed where no voltage exists or an extremely small voltage is found, the oscillator circuit should be inspected for coupling between coils, for dampness, shorted turns, or other defects. In a few special oscillator circuits a d-c voltage will also be present between the gang condenser stator plates and ground. In these instances it will be necessary to use a mica condenser in series with the V.T.V.M. grid.

MEASURING ANTENNA COUPLER GAIN

The operation of the antenna coil, r-f stage and converter circuits are very important for proper receiver performance. It is these circuits that give the receiver much of its gain, all of its image suppression, and a large percentage of its selectivity. But equally as important, these circuits determine the noise-to-signal ratio of the receiver.

Improper alignment or low efficiency in this end of the receiver will cause the signal to be received with so much hiss that it can not be enjoyed. When this condition exists and proper alignment will not correct it, it will usually save time to start at the antenna and measure the antenna coil gain, r-f stage gain, and converter gain to locate the exact seat of the trouble.

If a test oscillator is connected to the antenna and ground leads of the antenna coil, a voltage can be measured across the secondary if the gang condenser is tuned to the oscillator frequency. This will not give us an idea of the voltage step up in the coil unless we know the voltage appearing across the primary. If we attempt to measure this primary voltage, it will usually be so small that an accurate reading can not be secured.

It is obvious that we either need a higher output from the test oscillator or an amplifier on the V.T.V.M. If we place a t-r-f amplifier ahead of the V.T.V.M. we will find that the gain of this stage will vary with frequency and cause error. A t-r-f amplifier following the test oscillator to build up the output voltage, however, can vary with frequency and it will not affect our results because in every case we will measure the voltage after it has passed through the oscillator amplifier. A further advantage of such an arrangement is that the amplifier will filter out the harmonics of the oscillator.

A two stage r-f amplifier can be built very easily using plug-in coils to change frequency ranges with a Type 6K7G or equivalent type of tubes. The attenuator on the test oscillator will serve as a volume control and with this set-up we can put a convenient value such as 0.2 volt across the antenna coil primary, and then move the V.T.V.M. connection to the secondary and measure the voltage at that point. If, for example, a reading of 4 volts is obtained, the gain of the coil is 4 divided by 0.2 or 20. This measurement can be made in a few minutes from the top of the chassis.

TESTING WAVE TRAP CIRCUIT

Most receivers that operate without an r-f stage use a wave trap in the antenna circuit to reduce the interference caused by unwanted signals at the i-f frequency. If the resonant frequency of this circuit changes, it will not only allow these interfering signals to pass, but may resonate near a desired signal and reduce or eliminate it. To test this circuit use the test oscillator with the t-r-f amplifier connected between the antenna and ground leads of the receiver and the V.T.V.M. connected across the antenna coil secondary. As the test oscillator and t-r-f amplifier are tuned through the i-f frequency of the receiver, the voltage on the V.T.V.M. should go to minimum. If the minimum response is found to be at some other frequency than that of the i-f stage, the wave trap should be retuned so that the proper effect is secured.

MEASURING STAGE GAIN

Stage gain is measured from the grid of one tube to the grid of the succeeding tube. To measure the gain of the r-f stage in a receiver, for example, a predetermined signal such as 0.2 volt may be introduced into the grid circuit of the r-f tube by connecting the test oscillator across the antenna coil secondary. The V.T.V.M. is then connected in place of the converter tube and the resulting voltage at this point, divided by the initial voltage (.2 volt), is equal to the gain of the stage at the frequency to which the test oscillator and receiver are tuned.

Because the test oscillator is not loaded appreciably by this type of test, the average test oscillator will furnish sufficient voltage output to be measured by the V.T.V.M. and the t-r-f amplifier will not be necessary. Because the converter tube is not in the circuit during this test, no a-v-c voltage will be built up to reduce the gain of the r-f stage and the resonant frequency of the circuit will not be changed since the input capacity of the V.T V.M. is essentially the same as the converter tube.

To measure the stage gain of the converter or of the i-f stage, the same procedure is followed. A time saving procedure is to use the t-r-f amplifier with the test oscillator and introduce a known voltage in the antenna coil primary and connect the V.T.V.M. in place of the converter tube. The gain of the complete r-f portion of the receiver can then be taken at the same time the tuned circuits are being aligned to agree with dial calibration.

MEASURING AVC VOLTAGE

When measuring d-c voltages the prod tube of the V.T.V.M. is normally applied to the positive terminal of the voltage source. For a-v-c voltages, which are negative with respect to ground, this would require connecting the V.T.V.M. prod tube grid to ground and the frame of the V.T.V.M. to the a-v-c distribution network. This, however, impresses a 60 cycle voltage on the a-v-c network due to leakage and capacity currents in the power transformer windings of the V.T.V.M. and receiver power supplies. To overcome this source of error the grid of the V.T.V.M. prod tube should be connected to the a-v-c distribution network and the chassis of the V.T.V.M. connected to the chassis of the receiver. A negative a-v-c voltage will cause the V.T.V.M. electric eye to overlap. It can be opened to normal (i.e. with the two shadows just separated by a hair's width of darkness) by turning the zero adjustment 3,000 ohm potentiometer. During this test the 50,000 ohm calibrated potentiometer is not used but left in the zero position.

The 3,000 ohm potentiometer used for this test must be calibrated if an accurate determination of the a-v-c voltage is desired and this is accomplished along the same lines as the previous calibration of the 50,000 ohm potentiometer. Since the 3,000 ohm potentiometer is now serving two purposes, the calibration must be on a sliding disc held in place with a felt washer under the knob. When an a-v-c voltage is to be read the 50,000 ohm potentiometer pointer is placed on "zero," the test prods are short circuited, and the 3,000 ohm potentiometer is adjusted to just close the electric eye.

The calibrated scale under the 3,000 ohm potentiometer knob is now rotated until the zero position is under the index of the knob. If the test prods are now placed across the a-v-c network the eye will overlap. Turning the 3,000 ohm potentiometer will open the eye to normal position and the voltage can be read on the calibration.

During this test the 5 megohm resistor in the input circuit of the V.T.V.M. should be disconnected for greatest accuracy.

MEASURING AFC VOLTAGE

The voltage generated by the discriminator in an a-f-c circuit will be zero when all circuits are properly aligned. The V.T.V.M. furnishes a means of reading this voltage without in any way disturbing the circuit. This is accomplished in exactly the same way that a-v-c voltages are measured except that the a-f-c voltage from the discriminator may be either positive or negative so that it may be necessary to use both the 50,000 ohm and 3,000 ohm calibrated potentiometers to read the voltage.

In most cases, however, it is not necessary to know how much voltage is developed but only whether the opposing voltages are in or out of balance. The prod tube grid for this test is connected to the lead connecting discriminator and oscillator control tube or to the grid cap of the oscillator control tube.

TESTING R.F. EFFICIENCY OF FIXED CONDENSERS

There are many fixed condensers in the r-f and i-f sections of a radio receiver whose function is to by-pass r-f currents to ground. Examples of these are condensers from the low potential end of r-f and i-f coils to ground; across cathode resistors; between screen grid and ground and between a-v-c or a-f-c distribution network and ground. They all have one thing in common and that is their function—to furnish an easy path to ground for the r-f and i-f energy. They can be tested in exactly the same way.

The V.T.V.M. is connected across the condenser under investigation with a small condenser in series with the V.T.V.M. grid and a large signal is introduced into the grid of the stage in which the condenser appears. If the capacity of the condenser is too small or if the condenser is open a voltage will appear on the V.T.V.M. A shorted condenser will show up when the d-c voltage across the condenser is measured.

CONCLUSION

The purpose of this article will have been served if the reader has gained a better understanding of the potential service that a V.T.V.M. can render in radio service work. There are many other tests and measurements possible with this instrument that will suggest themselves to the user as he becomes more familiar with it. As the ever expanding field of electronics develops more fully, it is anticipated that the V.T.V.M. will grow in usefulness.

Know Your Tube Tester

Generally speaking tube testers may be divided into three general types: Those which apply direct current voltages of approximately correct values to the various elements under test; those which apply a-c voltages to the various elements with correct phasing of grid and plate; and those which connect all elements together except the cathode and apply an a-c voltage between the cathode and the other elements, commonly referred to as emission testers. The cost of these instruments decreases in the order named.

The d-c style of instrument requires a rectifier and filter together with a voltage divider to apply proper voltages to the various elements of the tube being tested. This test more closely approximates service conditions and hence is likely to be more accurate than others. This type of tester is usually called a "mutual conductance" type. The indication is obtained either by changing the grid bias and reading the change in plate current, or by introducing an a-c signal on the grid of the tube and reading the signal component of the plate current. The definition of mutual conductance is the change in plate current produced by a change in grid voltage, so that either of the above systems meets the requirements. Obviously this type of tester is more difficult to keep up to date, since new tubes may have added elements and will require added controls or sockets.

The next type of tester mentioned is that which employs a-c voltages on the various elements of the tube, but with proper phase relations so that the grid is negative when the plate is positive. With a tester of this type the indication is usually obtained by changing the grid bias and reading the corresponding plate current change. This is generally known as a grid-shift type of tester. This change is somewhat proportional to mutual conductance, but since a-c voltages are applied, and since the values are not the same as those employed in receiver service, the indications usually do not mean as much as a true mutual conductance reading. This fact is largely overcome, however, by supplying a calibration for various types of tubes with the tester. Intelligent use of this calibration as well as a complete check of the performance of the tester with the different makes of tubes will usually permit quite accurate readings to be obtained. This type of checker usually requires an additional control to set the meter to zero. Otherwise two readings must be taken to obtain the difference in plate current caused by shifting of the bias. In order to properly test all types of tubes a variable grid bias must be provided, which increases the cost of the tester and also further complicates the operation. If, however, these devices are provided it is not difficult to keep the tester up-to-date as new tube types are announced.

At the present time the so-called "emission" type of tester or one of its modifications is most popular. This type of tester usually connects all the elements of the tube together except the cathode, and a-c voltage is applied between the cathode and the other elements. A meter is supplied to read the required current which flows each time the elements are positive with respect to the cathode. The cost of this type of tester is comparatively low since only one value of a-c voltage is usually supplied, in addition to the filament. Since the elements are all connected together, a minimum number of sockets are required for testing. The tester has the further advantage of requiring very few changes to adapt it to new tubes. It is obvious that such tests do not approximate operating conditions. Consequently a set of limits must be run for each type of tube, and perhaps for each make of tube as well.

Most of the difficulty which arises because of failure of tube testers to agree has in the past been due to lack of correlation between various makes of emission testers. This is not hard to understand when one realizes that no two makes of tube tester necessarily employ the same voltages between the cathode and the other elements, or the same circuit impedances. Originally, only one value of circuit resistance was employed, which meant either that most tubes were tested with a very low emission current or a very high value. In the first case this meant that tubes which normally require a large current for satisfactory operation, such as output tubes and rectifiers, might test satisfactorily in the emission tester while actually the cathode was unable to supply the required amount of plate current. If the later condition, that of drawing a very high emission current, was used, then tubes requiring only very small emission current for satisfactory operation, such as 1.4 volt types and some of the early 5 volt tubes such as the 01A, would be ruined if kept in the tube tester for any length of time.

During the past few years the R.M.A. Tube Committee has given considerable thought to these problems. Standard circuits for emission testers have been recommended, so that all emission testers would give the same indication for the same type of tube, whatever the make. The Committee has also specified different load resistances for different types of tubes, so that power output and rectifier tubes may be tested for high emission current, while tubes requiring moderate amounts of emission are tested with a larger load resistor, and battery tubes and diodes are tested with a still greater load resistor to limit the current to a safe value comparable to that required in service.

Ten minutes a day spent in studying the performance of any tube tester, new or old, will bring out many unsuspected variations in results, and will undoubtedly increase your ability to obtain accurate and correct tests. In the long run this will pay both in better tube sales and in your customer's faith in your honesty and technical ability.

SERVICE TO SERVICEMEN

The Service Helps shown on the following pages are only a few of the generous assortment of Sylvania Sales and Service Helps made available by Sylvania Electric Products Inc., most of which are free upon request. Semi-technical literature for the serviceman such as Characteristic Sheets, Tube and Base Diagram Charts, Tube Correlation Charts, the Tube Complement Book at 35c and the Technical Manual at 35c, are in constant demand. Window displays, streamers and transparencies, price literature, circulars, book matches, electric signs, mailing cards, newspaper mats, and plain or imprinted tube stickers are provided generously as an assistance to dealers and servicmen. All items shown are typical—styles and prices are subject to change without notice.

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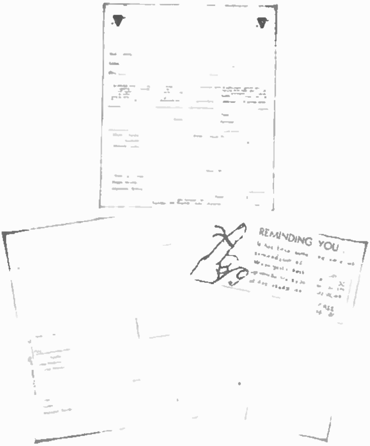

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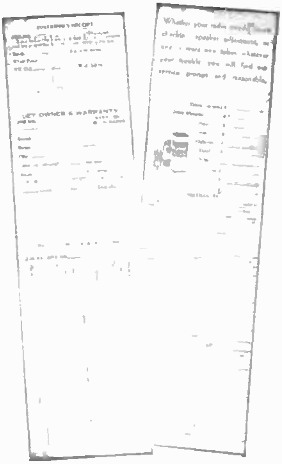

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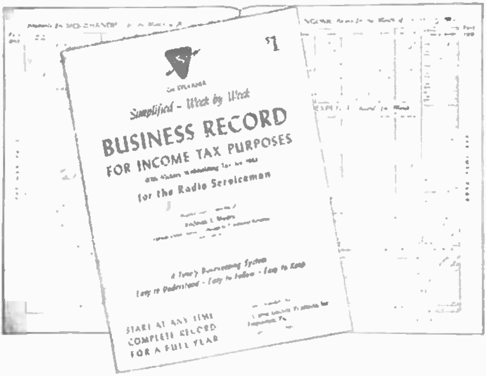

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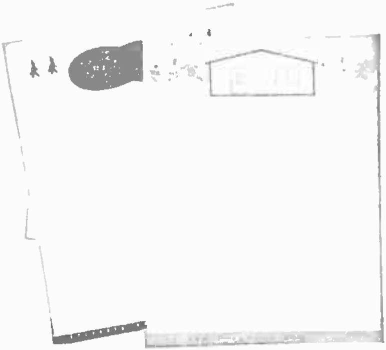

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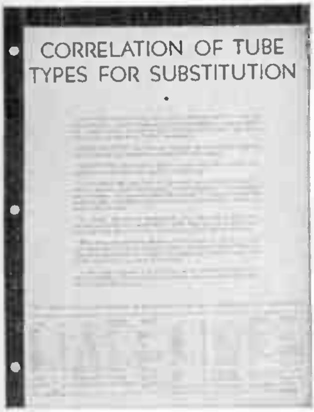

CORRELATION OF TUBE TYPES FOR SUBSTITUTION

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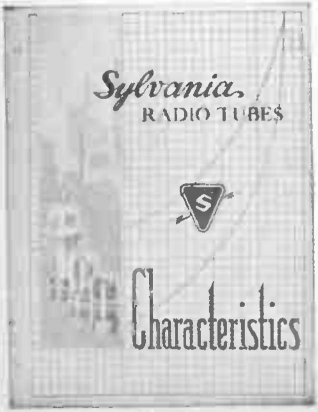

Sylvania RADIO TUBES

Characteristics

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SYLVANIA BASE CHART

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BASE CHART

Base views for Sylvania tubes. Cross indexed by types and bases.

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TUBE CORRELATION CHART

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First Edition
Third Printing

No patent liability is assumed with respect to the commercial use of the circuits and tube information contained in this booklet.

FOREWORD

This book is not intended to be a complete treatise on the subject of radio tubes but rather a handy reference book of generally helpful information and data for radio servicemen. If this little booklet helps make their work more pleasant and more profitable, it will have fulfilled its mission.

Sylvania Electric Products Inc.

Table of Contents

Converter Tube Design Features

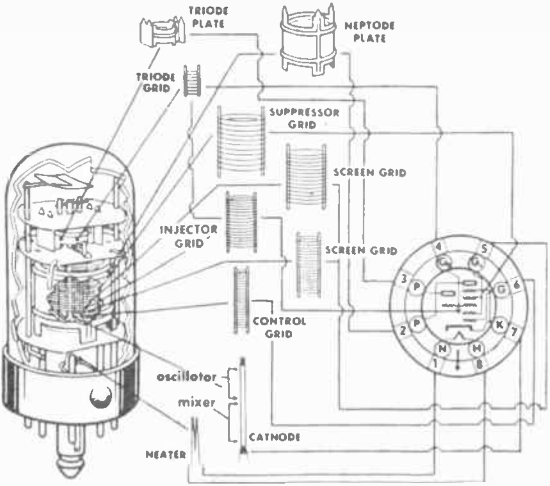
Service problems related to converter tubes may often be clarified through knowledge of the tube design of the particular type in question. Numerous converter tube types have been employed in superheterodyne receivers. Five principal designs are in general use and these will be briefly described as to their constructional features and the functions associated with the various grid structures. Several typical performance curves are also discussed.

TRIODE-HEPTODE CONVERTERS

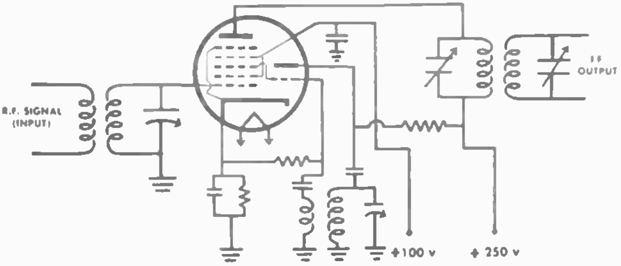
Types 7J7, 7S7, 14J7, 14S7, 6J8G

The superheterodyne receiver requires a converter tube whose function is to mix or beat (heterodyne) the incoming signal frequency with a locally generated frequency to obtain an intermediate frequency. If the output from a conventional triode oscillator is suitably coupled to a tuned r-f voltage amplifier, the pentode plate circuit will contain four frequencies: the signal frequency, the oscillator frequency, and the sum and the difference frequencies of these two. The latter are obtained by beating the first two frequencies mentioned. Since more gain is secured at lower frequencies in the i-f amplifier stages, the difference frequency (called the i-f frequency) is the one desired. This can be obtained when the tuned circuits in the pentode plate are designed to resonate at the i-f frequency, in which case they will reject the other three frequencies.

Such a circuit can be simplified considerably by combining the triode oscillator with the mixer tube in one bulb. Furthermore, improved efficiency and stability can be secured by adding an injector grid in the mixer section which is connected directly to the grid of the oscillator section, thereby permitting both the mixer control grid and the injector grid to control the electron stream. This provides true electron coupling. An illustration of such a tube is the



triode-heptode Type 7J7 shown above. The diagram indicates that the cathode is common to both units, the upper portion being associated with the triode oscillator and the lower section with the heptode mixer. A typical circuit diagram is shown wherein plate-tuning of the oscillator is indicated. Grid-circuit tuning is also widely



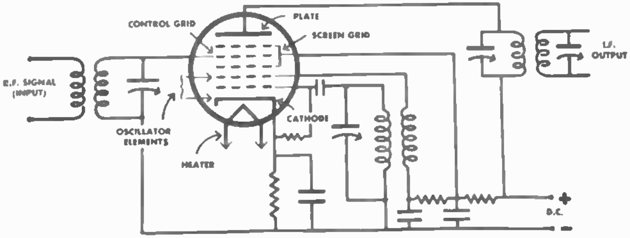
employed with triode-heptode tubes, in which case the oscillator circuit resembles that shown for the pentagrid converter described on page 8.

THE PENTAGRID CONVERTER

Types 1LA6, 1A7GT/G, 7A8, 7B8, 6A8G, and others

Pentagrid Converter is the name applied to a tube having five grids in addition to the cathode and plate and intended for frequency conversion in superheterodyne radio receivers. Such tubes combine the functions of oscillator, mixer and amplifier within one structure. The No. 1 and No. 2 grids are used as the oscillator grid and oscillator plate respectively. Electrons passing through grids No. 1 and No. 2 are further controlled by the signal input grid No. 4. This grid is shielded from the oscillator section by grid No. 3 and from interaction with the plate by grid No. 5. Screen grids No. 3 and No. 5 are connected together internally. The circuit on the next page illustrates the use of the pentagrid converter, such as Type 7B8. Voltages of signal and oscillator frequency reaching the plate are bypassed to ground, since the tuned circuit in the plate is resonant only to the beat or intermediate frequency (I.F.) which is to be further amplified.

The pentagrid converter may be considered as operating very much like a conventional variable-mu tetrode first detector with an associated triode oscillator, except that the oscillator triode grid is located next to the cathode which is common to both the first detector variable-mu tetrode and the oscillator triode. Electrons emitted from the cathode surface are influenced by the various grid and plate voltages and divide up so that grid No. 1 receives about 3 to 6 per cent of the electrons, the oscillator anode receives about 40 per cent of the electrons, grids 3 and 5 (screen grid) receive about 25 to 30 per cent of the electrons, and the plate receives the remaining electrons emitted. Because of the oscillator grid's strategic position next to the cathode, any oscillator voltage on this grid will modulate the entire electron stream regardless of the ultimate destination of the electrons. Referring to the diagram, it is interesting to observe the action that takes place within the tube when it and the associated circuit components are operating normally. When the set is first turned on, the No. 1 grid is at zero potential because it is tied to the cathode by the 50,000 ohm grid leak. As the cathode heats up and starts to emit electrons, the feedback between oscillator anode and grid causes regeneration which immediately starts the triode circuit to oscillating. When the oscillator circuit is oscillating, the No. 1 grid is driven alternately positive and negative. While the grid is positive, grid current flows through the grid leak in such a direction as to make the No. 1 grid negative with respect to the cathode. This grid swing may make the grid negative by as much as 30 to 40 volts, and this becomes the grid bias point about which the grid varies in amplitude alternately in a positive and then a negative direction under the influence of plate circuit feedback. From this it can be seen that the maximum instantaneous negative voltage on the No. 1 grid may be 60 to 80 volts.



Electrons from the cathode are accelerated through the No. 1 grid by the positive oscillator plate and the positive screen grid. The oscillator plate actually consists of a pair of side rods but no grid wires are strung on these rods. Many of the electrons approaching the oscillator plate possess high velocities so that they shoot past the oscillator plate and for the most part through the screen grid No. 3 and approach grid No. 4. The No. 4 grid has a negative potential which therefore retards the oncoming electron stream. This cloud of retarded electrons between grids No. 3 and No. 4 constitute a virtual cathode for the tetrode section of the tube. Electrons may be drawn away from this source (virtual cathode) in a manner quite analogous to that by which they were originally accelerated away from the regular cathode.

If grid No. 1 is only slightly negative or even somewhat positive, then the virtual cathode has an ample electron supply for the tetrode section of the tube. Whenever grid No. 1 swings to more negative values, the number of electrons arriving at the tetrode plate is temporarily reduced or possibly cut off. Pulses of current are therefore supplied to the tetrode section at oscillator frequency and the electron stream to the tetrode plate is modulated by the r-f signal voltage on the No. 4 grid. Thus, the oscillator can modulate the signal in the tetrode section and produce the i-f beat note in the plate circuit of the tetrode section.

The current necessary to have sustained oscillations is controlled by the oscillator grid and not by the signal grid, the latter being incapable of producing cutoff in the oscillator section. The gain of the tube can be controlled over a considerable range by a variable negative bias on grid No. 4 without substantially affecting the oscillator section.

THE PENTAGRID MIXER

Types 6L7 and 6L7G

Type 6L7G pentagrid mixer is used with a separate oscillator tube. Type 6L7G has the No 1 grid as the signal grid, grids No. 2 and No. 4 connected internally as screen grids, grid No. 3 as the oscillator injector grid and the No. 5 grid as the suppressor (connected internally to cathode). Thus, Type 6L7G is quite similar to the mixer section of Type 7J7.

THE TRIODE-HEXODE

Types 6K8, 6K8G and 6K8GT

Such converters have a rather unconventional structure. The oscillator plate is so located that it is completely removed from the cathode to mixer plate electron stream. The oscillator plate and mixer plate are on opposite sides of the cathode. Grid No. 1 completely surrounds the cathode so that the side towards the oscillator plate acts as the oscillator grid, while the other side is associated with the mixer and modulates the cathode to mixer plate electron stream at oscillator frequency. With this construction a single grid suffices to screen the oscillator grid from the signal grid as well as to screen the signal grid from the mixer plate. The signal control grid is made in the form of a flat wound grid with one-half of the windings (those facing the oscillator plate) removed. Specially designed metal shields suitably connected to the cathode prevent stray electrons from producing undesirable couplings and also serve to isolate the oscillator and mixer sections. In addition, they cause a potential minimum to exist between the screen and plate. Sufficiently high plate resistance is obtained so that a suppressor grid is not required.

THE PENTAGRID CONVERTER 6SA7 TYPE

Types 6SA7, 6SA7GT/G, 7Q7, 12SA7GT/G, 14Q7

This construction, as exemplified by Types 6SA7, 6SA7GT/G and 7Q7, is somewhat like 6L7G except that the functions of grids No. 1 and No. 3 are interchanged. Grid No. 1 is the oscillator grid and grid No. 3 is the signal grid, the latter having a remote cutoff characteristic. The side rods for grid No. 3 are located 90° from the plane of the other side rod supports and are therefore directly in the center of the electron stream. The negative voltage on the signal grid repels some of the electrons traveling to the plate back towards the cathode. However, these electrons will not affect the space charge near the cathode since most of the electrons turned back are intercepted by collector plates fastened to the side rods of the No. 2 screen grid. Hence, the collector plates of the screen provide isolation of the cathode space charge and the signal grid so that changes in signal grid voltage produce little change in the cathode current. Any changes in plate current due to signal grid voltage changes are offset by opposite and nearly equivalent changes in screen current. Screen grids No. 2 and No. 4 are connected internally. Grid No. 5 is the suppressor and serves to increase the plate resistance of the converter.

DEFINITIONS

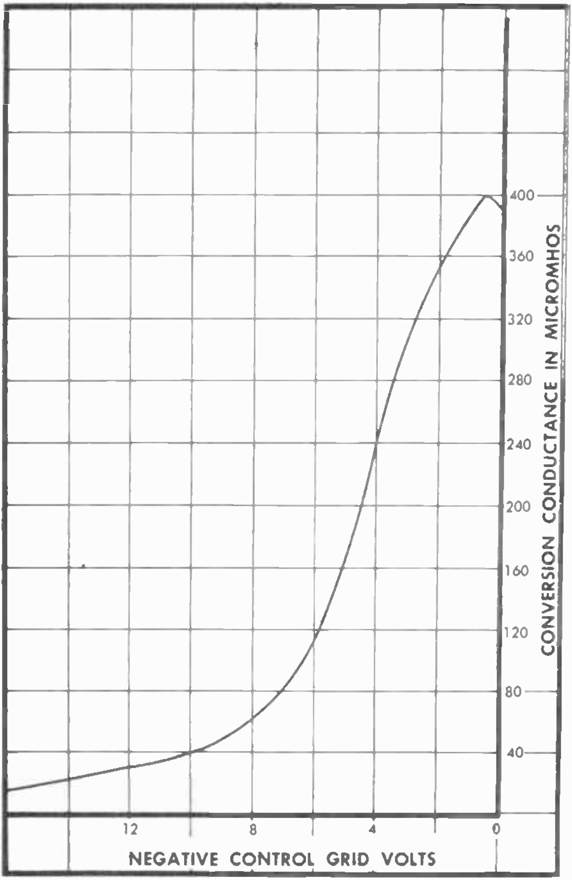
Conversion Conductance (g_c) is defined as the ratio of the intermediate frequency component of the plate or output current of the converter tube in a superheterodyne receiver to the radio frequency component of the signal voltage applied to the control grid. The value is expressed in micromhos. With reference to the performance of a frequency converter, it is employed in the same manner as mutual conductance is used in single frequency amplifier computations.

Conversion Gain is the ratio of the intermediate frequency voltage developed across the load to the radio frequency voltage applied to the control grid. When tube and circuit constants are known the conversion gain may be computed from the formula:

$$\text{Conversion Gain} = \frac{g_c r_p R_L}{r_p + R_L}$$

Where g_c is the conversion conductance, r_p the plate resistance and R_L the resonant impedance of the i-f transformer measured across the primary terminals.

Several curves may prove helpful in illustrating performance characteristics of converters. Fig. A shows how the conversion conductance for a typical triode-heptode converter varies with the negative control grid (heptode) voltage. The recommended control grid voltage would be approximately −3 volts, under which conditions the tube has a conversion conductance of about 300 micromhos. The curve also indicates the cutoff characteristic, since the conversion conductance is reduced to only a few micromhos when the control grid voltage reaches −16 volts.



400
360
320
280
240
200
160
120
80
40
CONVERSION CONDUCTANCE IN MICROMHOS
12
8
4
0
NEGATIVE CONTROL GRID VOLTS

Fig. A

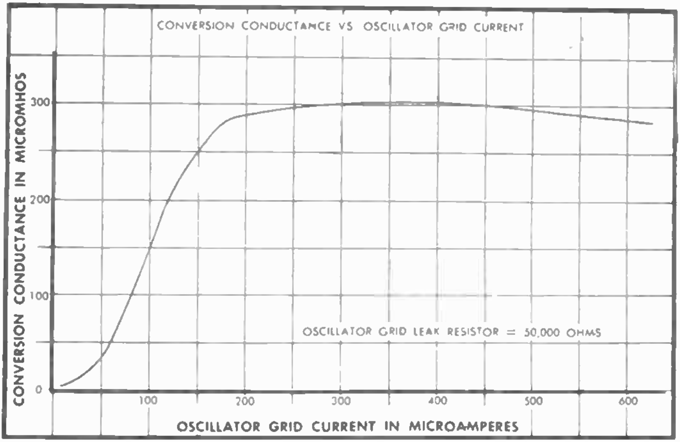


Fig. B

For optimum receiver performance too much emphasis cannot be placed on the curve of Fig. B. This gives the variation in conversion conductance for oscillator grid current thru a specified grid leak resistance. It shows how important it is to keep the minimum oscillator strength above the "knee" of the curve. Attention is called to the fact that beyond the knee of the curve the uniformity is excellent over a wide range of oscillator voltage. The developed oscillator voltage is given by the product of the oscillator grid current and the grid leak resistance. For example, 200 microamperes through 50,000 ohms gives a developed oscillator voltage of 10 volts.

Since converter tubes of different constructions, such as those already discussed, have different ratings and electrical characteristics it is natural that performance characteristics also differ from type to type. Although conversion gain is a function of conversion conductance, the gain also depends upon the load impedance (R_L) of the converter section. For example, a pentagrid converter may have a higher rated conversion conductance than a triode-heptode converter, but if due consideration is given to the load impedance the conversion gain of the triode-heptode will not be reduced in the ratio of the respective conversion conductances of the types involved. Considering that the rated oscillator voltage is obtained from each type, Fig. C shows gain curves calculated for both types using the gain formula specified. Verification of the performance characteristics mentioned above is indicated by these curves.

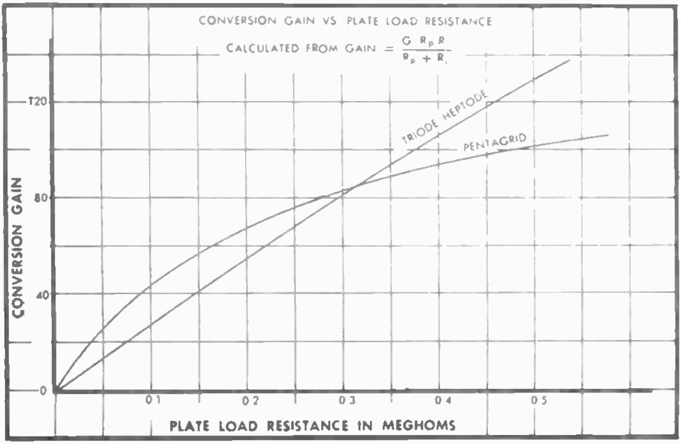


Fig. C

Three Reasons for Blue Glow

Many inquiries are received relative to the blue glow which is present in a number of Sylvania Tubes. Most of these are based on the misunderstanding of the different types of glow that may be present in a tube. There are three different types of blue haze that may appear while tubes are in operation. They are classed as: Fluorescent glow; Mercury Vapor Haze; Gas.

The fluorescent glow is usually of violet color, and is noticeable around the inside surface of the glass bulb. This glow is a phenomenon caused by electronic bombardment taking place within the tube. This glow changes with the intensity of the signal and may at times become quite brilliant. Fluorescent glow has absolutely no affect on the operation of a receiver. In fact, tubes with this characteristic are particularly good as regards gas content.

Mercury vapor haze is a blue glow which is noticeable between the plate and filament in Types 82 and 83 rectifier tubes. These are the only types of Sylvania receiving tubes in which this type of haze appears. The perfect operation of Types 82 and 83 is dependent upon a mercury vapor which comes from free mercury that has been placed in the bulb during the exhaust period. Therefore this type of blue haze is in no way detrimental to the operation of these tubes.

Gas is a blue haze which is usually confined to the vicinity of the plate and filament structure. Its presence, when of large content, affects the operation of a receiver to the extent that erratic performance is noticeable. Gassy tubes should always be replaced with new tubes.

Testing for the above conditions can be best accomplished by actual operation in a receiver. It is not necessary to test for the blue glow evident in Types 82 and 83, since this is characteristic of these two tubes.

When in doubt as to the blue content of other types of tubes a sure test can be made by using a strong magnet next to the bulb. A gassy tube will not be affected in any way by the presence of the magnet, while the fluorescent glow, which has no affect on the performance of the tube, will shift about as the magnetic field is shifted.

Tuning Indicators
Type 6E5 vs Type 6G5

The Type 6E5 tube became quite popular as a visual tuning indicator. After the novelty of this type of tube wore off, it was found that the tube had some disadvantages over the regular tuning meter which had previously been employed, to indicate the visual tuning. These disadvantages mainly were that either the indication of weak signals was unsatisfactory or that on strong signals the shadow closed entirely.

This tube consists of a triode and a target and a deflecting plate. The triode is intended to function as a d-c amplifier. The electron ray section of the tube consists of a portion of the heated cathode as a source of electrons which are attracted to a target that has a positive potential on it. The shaded or unlighted sector which is used as the indicating means is produced by the shadow of a control electrode or deflecting plate attached to the plate of the triode.

By referring to the schematic diagram shown in Figure 1 we will get a better picture of the action taking place when Type 6E5 is used in circuit applications. We will assume Ec is variable by means of control A. If 250 volts is applied to the target, electrons will be attracted to it and will cause it to glow. The deflecting plate is connected to the triode plate as is indicated in the diagram. These two elements are connected to the target through a 1 megohm resistor. If we now apply zero bias to the triode, the maximum plate current will flow to the triode plate. The current flows through the 1 megohm resistor, producing a voltage drop between the target and the deflecting plate.

Since the plate is negative with respect to the target, it will reduce the number of electrons reaching the target. Because of the shape and location of the deflecting plate a shadow will be cast around the target. The shadow angle will be about 100 degrees. If the bias is increased slightly to approximately 2 volts, the plate current will decrease somewhat, decreasing the voltage difference between the target and the deflecting plate resulting in the shadow angle closing

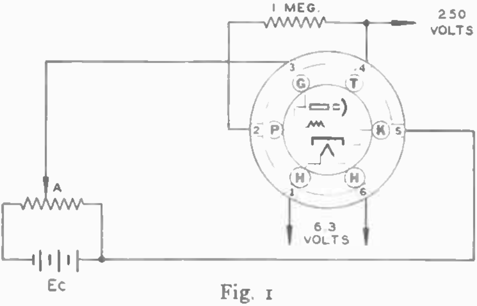


Fig. 1

in since not as many electrons are repelled as before. After 2 volts bias is applied, the shadow angle change per volt bias applied to the grid increases somewhat and remains constant until about 6 volts bias is applied. From 6 to 8 volts the rate of change slows up somewhat but at 8 volts the shadow has usually entirely disappeared. Figure 2 shows how the shadow angles and the plate current of the triode vary if different bias voltages are applied to the triode section.

In an ordinary superheterodyne receiver the d-c voltage developed across the diode load resistor in the a-v-c circuit varies from zero volts at no signal input to a maximum of 25 volts or higher. If we refer to Figure 2, it is evident that the largest bias which may be applied to the triode without completely closing the shadow is about 6.5 volts. This means we can utilize only a fraction of the developed a-v-c voltage in order to prevent complete closing of the shadow on strong signals. By tapping a portion of the a-v-c voltage, we

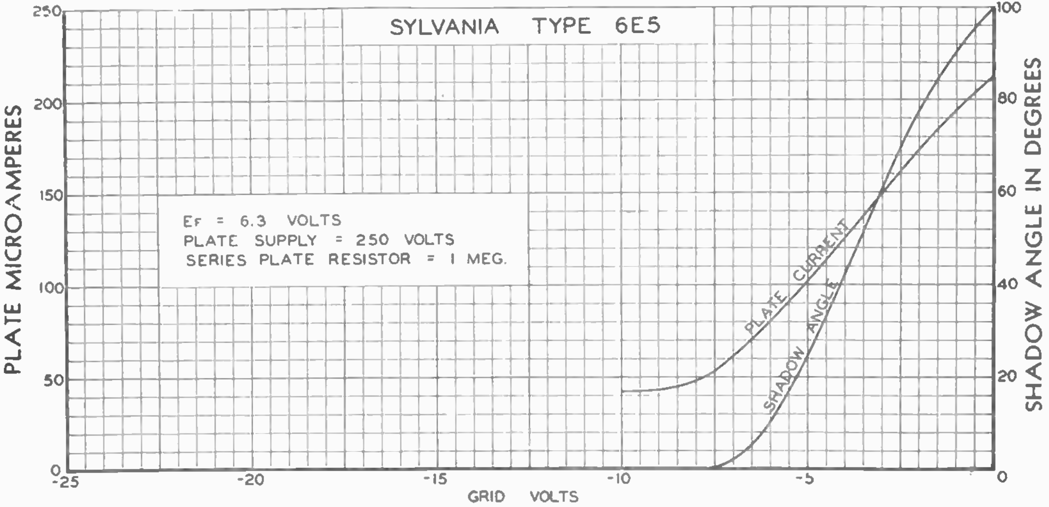

SYLVANIA TYPE 6E5
Ef = 6.3 VOLTS
PLATE SUPPLY = 250 VOLTS
SERIES PLATE RESISTOR = 1 MEG.
PLATE MICROAMPERES
250
200
150
100
50
0
SHADOW ANGLE IN DEGREES
100
80
60
40
20
0
-25
-20
-15
-10
-5
GRID VOLTS
PLATE CURRENT
SHADOW ANGLE

FIG. 2

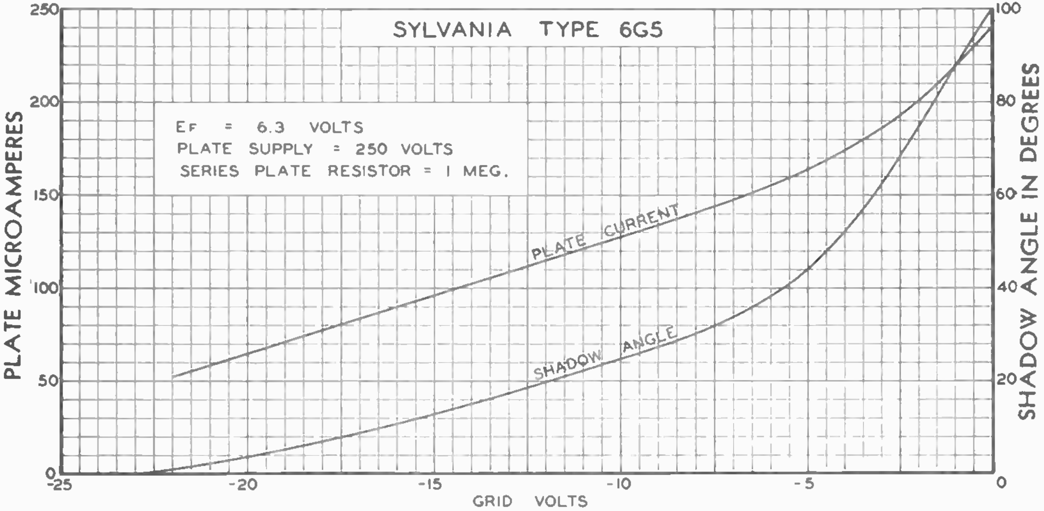

SYLVANIA TYPE 6G5
EF = 6.3 VOLTS
PLATE SUPPLY = 250 VOLTS
SERIES PLATE RESISTOR = 1 MEG.
PLATE CURRENT
SHADOW ANGLE
PLATE MICROAMPERES
SHADOW ANGLE IN DEGREES
GRID VOLTS
250
200
150
100
50
0
100
80
60
40
20
0
-25
-20
-15
-10
-5
0

FIG. 3

reduce the indication for weak signals, since if we develop 3 volts of a-v-c, instead of applying it to the triode, we will use only the same fraction of voltage employed on strong signals, with the result that the indication is greatly reduced. It can readily be seen that this type of performance is not wholly satisfactory.

The Sylvania Type 6G5 tube was introduced to correct the difficulties mentioned above. The triode grid has been changed somewhat so that the plate current cut-off occurs around −22 volts instead of −8 volts as in Type 6E5. Figure 3 shows two curves on the Type 6G5 corresponding to those shown in Figure 2 for Type 6E5. It will be noted from the curves that it will be possible to use all of the developed a-v-c voltage with this tube with the result that the indications of weak signals are as large as possible while the strongest signals will not quite close the shadow.

Type 6G5 can be used to replace Type 6E5 in nearly all applications where difficulty is experienced due to the closing of the shadow. Usually no circuit changes will be required. Where the difficulty does not exist due to the closing of the shadow, increased weak signal indications can be obtained, if only a portion of the a-v-c voltage is now being used, by applying the total a-v-c voltage and substituting a Sylvania Type 6G5.

Tube Mysteries Explained

In the open forums held after Sylvania Service Meetings, servicemen in all parts of the country bring up the same problems regarding tubes. There appears to be some mystery in the way these tubes act in tube testers and in actual operation, and servicemen who have experienced this trouble have had considerable difficulty in finding the true answer.

Some of these problems are: 1. Why does a power output tube test OK in some types of testers and still not sound good, while replacing the power output tube with a new one cures the poor tone quality? 2. Why does a rectifier tube test OK in a tester and yet the plate voltage available to the set is low until replaced by another rectifier? 3. Why do tubes test OK in tube checkers and yet cause the set to stop playing after a few minutes of operation?

1. A power amplifier tube requires a fairly large plate current in order to operate properly. If the proper emission is not available to supply this plate current, then poor quality may result. Many so-called emission testers give an indication of "good" for power output tubes if an emission current of only a very few milliamperes flows. This is obviously much less than is drawn in set operation. Thus, the serviceman does not replace tubes which actually need replacing. Although high current is required for power output tubes it is very important that not too much current flows when testing diodes and low plate current tubes or else they will be damaged. Most of the newer testers of this general type employ various loads for use in the circuit to limit the curreut to a safe value. The proper load is indicated on the chart covering settings for testing the various tubes. If any doubt exists as to whether the tube tester is testing power output tubes properly, a simple check may be made by connecting a d-c milliammeter in series with the cathode of the tube being tested.

This meter will read the total cathode current. It should correspond approximately to the rated plate current for the tube operating under rated conditions.

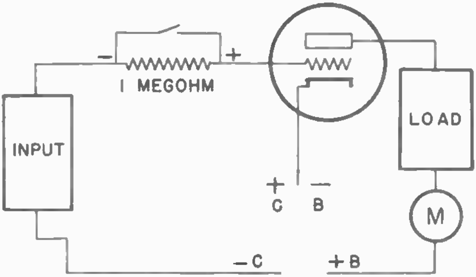
2. A rectifier tube often tests "good" in some testers when it actually delivers voltages much lower than normal. This is also caused by lack of sufficient emission to support normal plate current. The tester may require only a small amount of plate current to test "good" and this amount is much lower than required for satisfactory operation in the receiver. The same sort of test, as recommended above, may be made to determine if everything is as it should be. The meter should read so that the current passed is comparable with that required in a normal receiver.

3. Considerable difficulty is experienced in the field with receivers refusing to play after being in operation for a short while. This may be due to gassy tubes. It is necessary for the tubes to become thoroughly warmed before this difficulty will show up. Some tube testers are provided with a gas test but most are not. A very simple one which will locate gassy tubes is shown. This can be connected to any tube in the receiver or a separate unit may be constructed. When self-bias is employed, the indication will not be as sharp as when fixed bias is employed.

The circuit essentially is as shown. Input and output systems are indicated in block form as these may vary depending on the circuit the tube is used in. The supply voltages for the plate and grid are indicated as +B and −C.

A meter is connected in the plate circuit so as to read plate current. A one megohm resistor is connected in the grid circuit so it may be shorted out. The operation simply consists of opening and closing the switch across the one megohm resistor and noting the change in plate current. A gassy tube or bad tube will show a greater change than will a good one. In fact, most good tubes should not cause much, if any, change in plate current. This test is equally good for power output tubes or any other type. It is important that the tubes be warmed before being tested for gas, especially if they are power output types.

The theory involved in this test is simple and might be of some interest. If any gas current is present in the tube, this current flowing through the resistor will produce a voltage which will subtract from the bias, resulting in an increase in plate current. If one microampere of gas flows, this will decrease the bias by one volt when the switch is opened. If the mutual conductance of the tube is 1000 micromhos this one volt change of grid bias will increase the plate current by one milliampere.



Type 35Z5G and Type 35Z5GT Trouble

A large number of inquiries have been made relative to open filaments in Types 35Z5G and 35Z5GT, before the tubes have been put into use. After a thorough investigation of this it has been found that the majority of the trouble is caused by improper testing in the field. This has been brought about by using improper settings on the testers and by inserting the tube before proper settings have been made.

This type of tube has a 35 volt heater which is tapped to permit the operation of a panel lamp across pins #2 and #3. Thus, it is very easy to apply improper voltages or to short this section of the heater, causing damage to it. **When making any tests on this tube, be sure the correct settings are made before inserting the tube in the tester.**

In receiver operation the heater tap on pin #3 is normally connected to pin #5 for the purpose of permitting the plate current to pass through the tapped section of the filament. This eliminates the initial surge voltage on the panel lamp when the receiver is first turned on and results in a higher level of illumination. Therefore, after the tube has been put into service there are certain precautions that should be followed. Short circuits in the B supply may cause a large drain on the rectifier, resulting in a burn-out in the panel lamp section of the tube. Any type of short to the panel lamp circuit should be avoided; or the use of an improper type of panel lamp is not recommended. Also a load current greater than that recommended should never be placed on the tube.

Tube tester manufacturers have been very co-operative in supplying complete test data on all their instruments that will test this type of tube. These data are shown below. If you do not have the correct tube test settings for your tester, and they do not appear below, they may be obtained from the manufacturer. Check the figures and make changes wherever there is a difference on your chart, as these are the correct current settings.

CLOUGH BRENGLE CO.

Model 225:

Fil.	1	2	3	4	5	6	7	8	9	IN.	SH.
m	F*	H*	X*	R	:	:	:	:	:	91	9

Fil.	IN	CIRCUIT
Model 125-B:		
Mt	91	5-50
Model 125-R:		
Mt	8	5-50

Caution: Do not use new addenda sheets in connection with testers which have not been modernized. (This caution is printed on the addenda sheets.)

DAYTON ACME CO.

Model 303:

Fil. & Cir.	Sel. 1	Sel. 2	Sel. 3	Slide Switches
..	10	32	9	AC*

*Note—Push A & C to "UP" position before placing tube in socket and do not return A & C to normal position until tube has been removed. This tube normally shows SHORTED.

Model 302:*

9-3	46	Q	..	..

*Switch A "UP"

Model 301:

J, 1 & 8	46	Q	..	..

Model 501:*

30	..	10	Q-3	..

*Sel. 1 at "G" before placing tube in socket.

Model 22C:

..	25.0	37	3	AC*

*NOTE—Toggles A & C must be thrown to "UP" position before placing tube in socket and left up until tube has been removed. This tube normally shows a SHORTED condition.

Model 200:

25.0	37	3	AC*

*NOTE—Toggles A & C must be thrown to "UP" position before placing tube in socket and left up until tube has been removed. This tube normally shows a SHORTED condition.

HICKOK ELEC. INSTRUMENT CO.

Models AC-51, 51-X, T-53, 510-X, 530:

A-11; B-1; Fil.—35; L-40—R-0. Press Rect. Standard Button. Testers having serial number below 500,000 which have not been modernized, set "L" on 76 instead of 40.

JACKSON ELEC. INSTRUMENT CO.

Advice from Jackson is that all late type testers which will test this tube have the correct data appearing on their charts. For new charts or data on modernizing, write directly to Jackson.

PRECISION APPARATUS CO.

Models 910, 912, 915, 920, 922:

A	B	C	D	E	F	Depress
7	10	0	1	11	9*	D

(Fil. Cont.—Depress J* then B.)

Precision advises that Series 500, 500-A, 510, 510-A, 600, 700, 800, 800-A, 815, 815-A, 900 and 900-A, have complete new test data available upon request. The latest supplement bears the date 2/15/40. Series 910, 912, 915, 920 and 922, all have test charts bearing the date 1/20/40 which supersedes all previous charts for this series.

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*Indicates changes made over original chart.

Model 385, 89 Series:

Fil. Volts	25
Fil. Return	7
But'n down	8
Qual. Sel. (R)	43
Qual. Sel. (S)	30

Neon lamp glows on F & 3 as A5 & 12Z5 switch up.

Models 500, 505, 585:

Fil. Volts	25
Fil. Return	7
Switches Up	238
Met. Ckt.	C
Load Sel.	90
Shunt Sel.	3
Qual. Sel.	50

When making filament open test, neon bulb should light on both #2 and #3.

Model 400:

Fil. Volts	25
Fil. Return	7
Switches Up	238
Met. Ckt.	E
Qual. Sel.	4

When making filament open test, neon bulb should light on #2 and #3.

Model 594:

Fil. Volts	25
Fil. Term	E
Meter Ckt.	A
But'n. Down	38
Qual. Sel.	75

#3 shows short.

Models 501, 502:

Fil. Volts	25
Fil. Return	7
Switches Up	5
Meter Ckt.	A
Qual. Sel.	37

When making filament open test, neon bulb should light on #2 and #3.

Models 503, 504:

Fil. Return I	7
Fil. Volts II	10
Qual. Sel. III	17
Meter Ckt. IV	3
Elements V	5

When making filament open test, neon bulb should light on #2 and #3.

Model 506:

Fil. Volts I	9
Fil. Return II	2
Fil. Return III	7
Meter Ckt. IV	0
Shunt Sel. V	7
Shunt Sel. VI	0
Shunt Sel. VII	0
Elements Out	3–8

Depress #3 when making leakage test. #3 shows short.

Tracking Down Grid Emission

Among the many "bugs" that find their way into a radio circuit, there is one that has caused untold grief and confusion to the serviceman. Its common name is GRID EMISSION.

Although it starts life as a tiny electron, it soon grows to huge proportions. It is elusive in its ways, and much valuable time may be lost merely in determining its presence. After that, more time is consumed in solving the serious problems that it creates. No doubt, you are familiar with some of the following complaints: blocking, loss of sensitivity, lack of selectivity, distortion, burned out plate and screen resistors, low emission rectifier and power tubes, and hum. These are a few of the problems of grid emission and they are generally reported to take place after the receiver has been in operation long enough to become overheated.

Perhaps you have tested tubes, condensers and resistors, yet you found everything to be normal. Try though you may, you have never located the cause of these complaints, although you may have effected a cure by the cut and try method. Of course, you know that the cathode of a radio tube is designed to emit electrons; but this is not true of the grid. Grid emission, as the name implies, means that the GRID gives off or emits electrons. When electrons flow there is also a flow of current, (as can be seen if we place a milliameter in series with the cathode) and current flowing through coils and high value resistors in the grid return circuit, will produce a voltage drop detrimental to good circuit performance.

Why do we have grid emission? Well, during the process of evacuation of a radio tube a small portion of the cathode emitting material is sometimes unavoidably splashed on to the grid with the result that should the grid become sufficiently heated during operation, it will emit electrons.

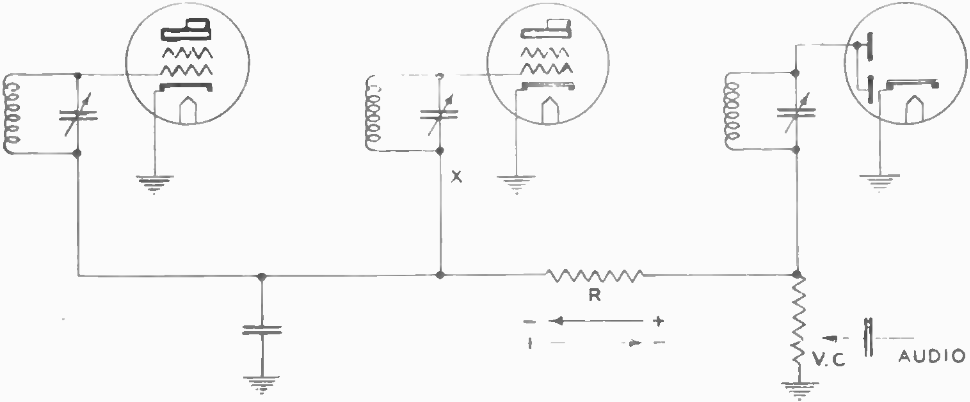


Fig. 1

To reduce this disturbing effect every precaution is taken in the design of Sylvania radio tubes to keep the grid as cool as possible. Copper grid supports are used because copper, being a good heat conductor, carries the heat away from the grid. Grid radiators are attached to the grid to give a greater heat radiation area. Colloidal graphite is sprayed on plates and bulbs to increase the heat radiation to the outside away from the grid,—all to keep the internal tube structure cool.

We conclude, therefore, that excessive heat is the factor that must be avoided if we are to keep away from grid emission.

More recent tube types are of higher mutual conductance than those of the earlier days and in order to obtain this increase in mutual, the spacing between the grid and cathode has been greatly reduced. As a result, the grid is close enough to the cathode so that excessive heater voltage, or cathode current will heat the grid to the emission point.

Another recent factor aiding the evil of grid emission is the trend toward the zero-bias type of receiver operation. In this type of circuit the d-c resistance in the grid returns is generally very high. This results in a higher disturbing-voltage drop, and at the same time fails to produce a negative bias voltage which would be helpful in opposing the disturbing voltage.

The r-f circuit shown in Fig. 1 represents a typical zero-bias arrangement which we will use to follow the actions of grid emission.

Let us assume that the initial bias on the tubes derived from the contact potential of the diode is -1 volt. We will also assume that the receiver has been in operation long enough to become sufficiently over-heated to stimulate grid emission. The excessive heat may be caused by improper ventilation, high line voltage, or the exceeding of the voltage ratings of the tubes.

The grid of any one of the tubes, being overheated, will now give off electrons and current will flow. To start with, this current is very very small, being only about one microampere. However small though it may be, it must return to ground. Therefore, it flows through the r-f coil, through the a-v-c resistor R, on through the volume control to ground. During its course to ground the current had to pass through the a-v-c resistor R whose value is three megohms, and, according to Ohms Law, current flowing through a resistance must produce a voltage drop. As E=IR we then have a voltage developed across R equal to 3 volts. The polarity of this voltage drop is the HARMFUL factor. Current flowing from the diode to the grid produced a negative voltage at point X, but current going from the grid to ground produces a positive voltage. Therefore, at point X we have +3 volts developed by the grid current flow, minus the −1 volt of bias caused by contact potential, leaving a +2 volts. This means that at the grid of each tube on the a-v-c string, there are 2 volts of positive voltage. You and I know that we cannot use positive voltage on control grids. It must be negative!

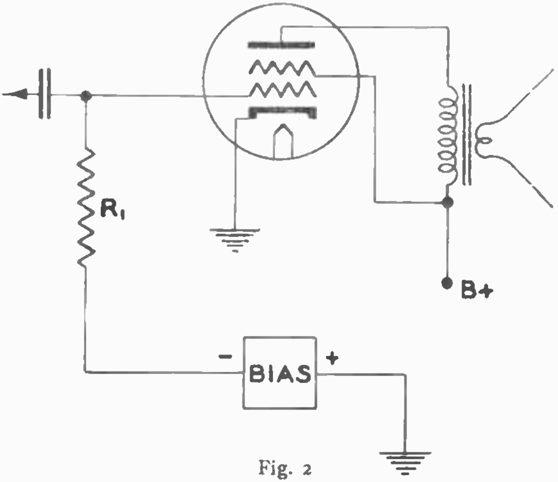


Fig. 2

With positive voltage on the grid, the plate current increases, causing more heat within the tube, thus liberating more electrons from the grid. This continues in a vicious circle until the positive voltage at the grid becomes high enough to block the tube. Plate and screen resistors may burn out, rectifier tubes are overloaded, and sensitivity falls off, due to the change of characteristics brought about by grid emission.

Fig. 2 represents a typical power output stage. Here grid emission is more troublesome, due to the greater amount of heat generated within the power tube. The grid current flowing in R_1 can become sufficiently high to cause enough positive voltage to cancel out the negative bias thereby producing bad distortion. At the same time the resultant heavy plate current will in a short time liberate gases from the over-heated elements. With the ionization of the gas the cathode is bombarded by positive ions and its emission is destroyed.

To prevent the possibility of such destructive effects, tube manufacturers issue specifications as to the maximum permissable voltage ratings that may be applied to each tube; also the values of permissable d-c resistance in the grid-cathode circuit. These values must be adhered to at all times for satisfactory tube operation.

The effects of grid emission are to some extent minimized by the employment of automatic or self-bias in which grid bias is derived from a resistance in the cathode or filament return. An increase in plate current tends to increase the effective negative bias applied to the grid, thus opposing the cumulative effects of the positive voltage caused by grid emission.

The presence of grid emission is usually indicated by distortion, increase in hum, and excessive plate current. It is sometimes difficult to detect the presence of excessive plate current unless the meter is permanently in the circuit during tests, as the switching-off of the tube may allow it to cool sufficiently to restore normal operation. For this same reason grid emission cannot be detected on tube checkers.

In performing tests to determine grid emission the receiver should be thoroughly heated, not by applying excessive line voltage which might damage condensers and other parts, but by placing a box over the chassis so that ventilation is cut off.

A microameter, having a 0-10 scale, connected in series with the grid return circuit is the most practical method of measurement. However, this instrument is expensive and delicate and is not easily obtainable.

A milliameter, which we all have, permanently connected in the plate circuit will show a rise in current after the receiver is sufficiently heated if grid emission is present.

Practical cures for this ailment may be effected by a diode gate, a resistor in series with the filament to slightly reduce the filament voltage, proper ventilation, or automatic bias. Above all, make sure that the values of voltages and grid resistors are within the ratings of the tubes.

Filament-Grid Short Circuits

Recently we have received a considerable number of complaints on battery type tubes which indicated that commercial tube checkers were showing up tubes as having grid-filament shorts. In many instances it was reported to us that the tubes worked perfectly satisfactory in equipment. In other instances tubes were sent back to us for analysis. Our analysis showed that there were no short circuits between filament and grid. An investigation was made of several commercial tube checkers in which these defects were being noted to ascertain the cause for such indicated shorts, when in reality no shorts were present.

When one stops to analyze just what is occurring, it is fairly easy to see the reason for the discrepancy. In a commercial tube checker, for simplicity reasons, it is usually a practice to make available only one supply voltage. For most types of tubes the value of this voltage is not too important and consequently a value usually above 150 volts is employed. When filament-grid shorts are being checked, however, on any kind of a tube, since the spacing between these elements is very close, the voltage gradient is very high and a considerable electrostatic attraction exists. In the case of 1.4 volt tubes this force is sufficient to attract the filament over to the grid. This results in a grid-filament short being indicated since the filament may actually touch the grid under these conditions. With the proper equipment it is possible to actually see the filament being attracted to the grid structure. In manufacturing these tubes a great deal of difficulty was experienced with this condition until it was recognized that the voltage between grid and filament must be kept at a low enough value so that the filament did not become distorted. This can readily be accomplished by reducing the value of this voltage without any attendant harm since the maximum voltage applied between grid and filament in most battery types will be under 25 volts.

The next time you are testing battery tubes for short circuits and run into grid-filament shorts and the tubes appear to be otherwise alright, it is suggested that you measure the voltage between filament and grid and if it exceeds 50 volts that you disregard the grid-filament short indication.

Generally a real grid-filament short circuit occurs because the filament has been opened up and the hook tension has been sufficient to pull the loose end of the filament up so that it comes in contact with the grid wires thus causing a short circuit. Whenever this occurs, of course, the filament continuity will be broken and this can readily be determined. Under these conditions, the tube will be inoperative and should be discarded for an open filament rather than a short circuit.

This information is being passed on so that tubes will not be falsely accused of having grid-filament shorts when in reality these short circuits do not exist under service conditions.

Plate and Screen Dissipation Ratings

Vacuum tube ratings provide an accurate guide to assist the engineer or serviceman in securing efficient tube performance. The use of this information, coupled with careful attention to circuit considerations and proper installations will generally pay dividends in acceptable operating efficiency. Among the important factors included in tube data are the ratings of maximum plate and maximum screen dissipations. The discussion which follows deals primarily with dissipation considerations.

The interpretation of tube ratings published in the Sylvania Technical Manual and other Sylvania technical literature are in accordance with RMA standards and the conditions outlined in the introductory section of the manual for the plate and screen are:

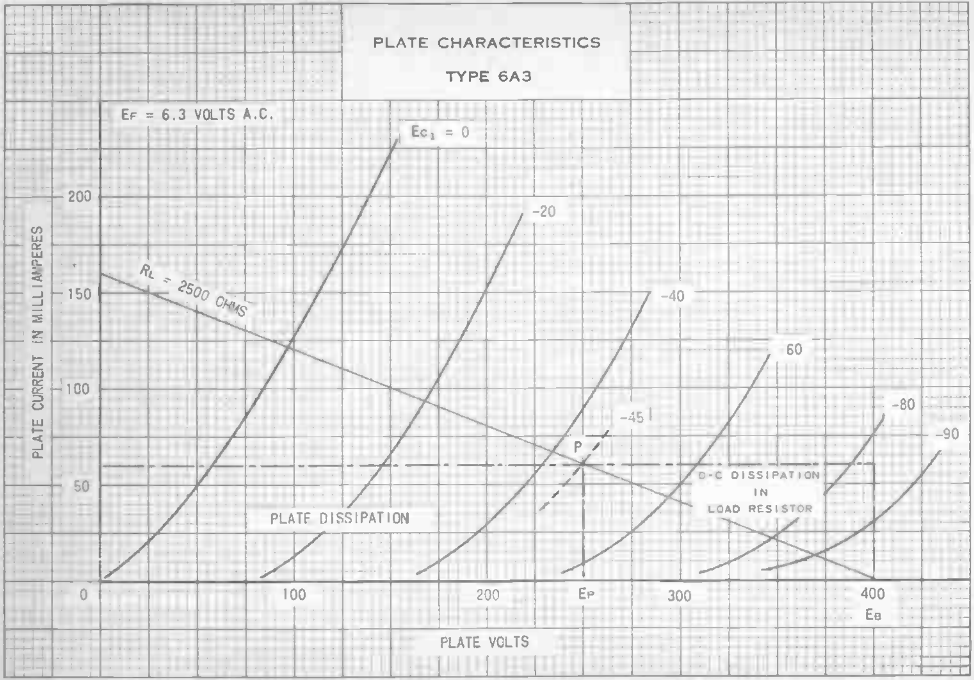
A-C or D-C Power Line: The maximum ratings of plate and screen voltages and dissipations given on the tube type data sheets are Design Maximums. For equipment designed for use in the United States on nominal power-line services of 105 to 125 volts, satisfactory performance and serviceability may be anticipated, provided the equipment is designed so as not to exceed these Design Maximums at a line voltage of 117 volts.

Storage Batteries: Automobile battery operated equipment should be designed so that when the battery voltage is 6.6 volts, the plate voltage, the plate dissipation, the screen voltage, the screen dissipation, and the rectifier load current will not exceed 90% of the respective recommended Design Maximum values given in the data for each tube type.

"B" Batteries: Equipment operated from "B" batteries should be designed so that under no condition of battery voltage will the plate voltage, the plate dissipation, the screen voltage, and the

PLATE CHARACTERISTICS

TYPE 6A3



screen dissipation ever exceed the recommended respective maximum values shown in the data for each type by more than 10%.

In general, electrode dissipation is the power dissipated in the form of heat by an electrode as a result of electron and/or ion bombardment. Each tube type must have maximum ratings assigned, these being dependent upon the tube design, its component parts and the kind of service it is to perform. Experience has shown that when maximum ratings are exceeded, particularly for an appreciable time, the performance capabilities may be impaired and the tube life shortened.

The total power dissipated by the tube consists of plate and grid losses plus the power used in heating the cathode. All of this heat must be carried away from the tube, principally through the envelope of the tube. A major proportion of the energy which is dissipated in tubes having glass bulbs is produced at the plate of the tube. Consequently, the plate has to be capable of radiating all the heat generated at its surface, and also the heat radiated to the plate by the cathode and other elements, without damage or adverse results. Any excessive heat, above that stipulated by the maximum dissipation ratings, can produce very detrimental effects. These will be covered in more detail later.

TRIODE CLASS A POWER AMPLIFIERS

As a first example, consider a triode power amplifier such as a Type 6A3, operated resistance-coupled, under the rated Class A conditions. The accompanying plate characteristic indicated that with 250 volts applied to the plate, −45 volts grid bias and the recommended load of 2500 ohms, the rated plate current is 60 ma. This requires a plate supply voltage of 400 volts for with 60 ma. flowing through the load resistor of 2500 ohms there will be a voltage drop across R_L of 0.06 ma. x 2500 ohms or 150 volts, and hence an applied voltage of 250 volts. The d-c power dissipated in the load resistor will be I^2R_L or $(E_b - E_p)$ I watts. Using the latter expression this gives 150 volts x 0.06 ampere or 9 watts, and this power is represented on the diagram by the rectangle at the right. The plate dissipation of the tube will be EpI or 250 volts x 0.06 ampere which equals 15 watts. This is represented by the rectangle at the left as designated. These values only apply when no input signal is applied to the grid.

When an alternating voltage is impressed on the grid, the voltage at the plate of the tube will also fluctuate since it will differ from the supply voltage by the drop in the load impedance. With the signal on the positive half cycle, the plate current will increase, thus causing a larger drop in R_L so that the plate potential will be less than its value at the operating point. On the negative half cycle the instantaneous grid voltage will be more negative than −45 volts, the instantaneous plate current will be less than the average value and the drop in R_L will be reduced Consequently the instantaneous plate voltage is higher during the negative half cycle.

With an impressed input signal whose peak voltage equals the bias voltage, the a-c power developed in the load is rated at 3.2 watts. This a-c power is dissipated in R_L in addition to the d-c power dissipation of 9 watts mentioned above. The plate dissipation is therefore reduced by the amount of the power output. This decrease in plate dissipation under dynamic operating conditions is a characteristic of all class A amplifiers. Hence, Class A power amplifiers should be so designed that the dissipation under static conditions will not be exceeded.

The RMA ratings for Type 6A3 specify a maximum plate voltage of 325 volts and a maximum plate dissipation of 15 watts. Since a plate current of 60 ma. is obtained when 250 volts are applied to the plate with a grid bias of −45 volts, it is apparent that if a higher plate voltage is employed, the maximum plate dissipation will be exceeded unless more bias is provided to reduce the plate current to a safe value. In general, the allowable plate dissipation will determine the maximum operating plate current for a given plate voltage. For some tube types the allowable dissipation may be high enough so that the operating point and load resistance may be based upon considerations of distortion, flow of grid current and desired power output

PENTODES AND BEAM TUBES

With pentodes and beam tubes additional factors must be taken into consideration. The total B-supply input power will be the power in the plate circuit plus the power dissipated in the screen circuit. With an input signal whose peak voltage equals the bias, the power delivered to the plate circuit is the product of the maximum signal plate current and the corresponding plate voltage. The heat dissipated by the plate will be the power supplied to the plate circuit less the power delivered to the load.

Screen dissipation increases quite rapidly with applied signal voltage and may be several times greater at the maximum signal condition than when the signal is zero. The increase in d-c screen current with signal occurs because of the influencing effect of plate potential on screen current and is particularly noticeable when a high value of load resistance is employed. This condition should be avoided, not only to maintain the screen dissipation within limits but also to keep the distortion at an acceptable value.

TYPICAL EXAMPLE

As a second illustration of zero-output and rated-output screen and plate conditions we will survey the ratings for Type 7C5, or the octal-based equivalent Type 6V6GT/G, when employed as a single-ended Class A amplifier Maximum ratings are:

Plate Voltage	315 Volts
Screen Voltage	250 Volts
Plate Dissipation	12 Watts
Screen Dissipation	2 Watts

Recommended operating conditions are:

Heater Voltage	6.3	6.3	Volts
Plate Voltage	250	315	Volts
Screen Voltage	250	225	Volts
Grid Voltage	−12.5	−13	Volts
Peak Input Signal	12.5	13	Volts
Plate Current (Zero Signal)	45	34	Ma.
Plate Current (Max. Signal)	47	35	Ma.
Screen Current (Zero Signal)	4.5	2.2	Ma.
Screen Current (Max. Signal)	7.0	6.0	Ma.
Load Resistance	5000	8000	Ohms
Power Output	4.5	5.5	Watts
Total Distortion	8	12	Per Cent

For the 250 volt condition the dissipation values computed from the above figures show:

Zero output plate dissipation is 250X0.045 = 11.25 Watts
Zero output screen dissipation is 250X0.0045 = 1.125 Watts
Full output plate dissipation is (250X0.047) − 4.5 = 7.25 Watts
Full output screen dissipation is 250X0.007 = 1.75 Watts

We see, therefore, that as the output goes from zero to 4.5 watts the plate dissipation drops from 11.25 watts to 7.25 watts while the screen dissipation increases 0.625 watt.

Similar computations could be made for the 315 volt condition. It is to be noted that the recommended operating conditions have been designated so as not to exceed the maximum dissipation ratings. One should bear in mind that published ratings represent average tubes and that any particular tube when measured may differ to some extent from these figures for plate and screen values, power output and distortion.

SPECIAL PRECAUTIONS

It has been pointed out that because of the reduction of minimum plate voltage which occurs with increase in load, the average and maximum values of screen current increase with load resistance. Hence, permissible screen dissipation limits the maximum load that can be employed. This justifies the precaution that the load should never be removed from the output transformer secondary of a pentode or beam tube since the effective load impedance will increase and the resulting excessive screen dissipation will damage the tube.

Removing the plate voltage, without also removing the screen voltage, gives rise to abnormally high screen currents even though rated screen voltage and rated bias are normal. This means excessive screen dissipation will be encountered and the tube soon ruined if operation continues.

Dissipations higher than the specified maximum values generally result in detrimental effects such as secondary emission, high gas currents, warpage of tube elements and actual tube destruction.

SERVICE TO SERVICEMEN

The Service Helps shown on the following pages are only a few of the generous assortment of Sylvania Sales and Service Helps made available by Sylvania Electric Products Inc., most of which are free upon request. Semi-technical literature for the serviceman such as Characteristic Sheets, Tube and Base Diagram Charts, Tube Correlation Charts, the Tube Complement Book at 35c and the Technical Manual at 35c, are in constant demand. Window displays, streamers and transparencies, price literature, circulars, book matches, electric signs, mailing cards, newspaper mats, and plain or imprinted tube stickers are provided generously as an assistance to dealers and servicmen. All items shown are typical—styles and prices are subject to change without notice.

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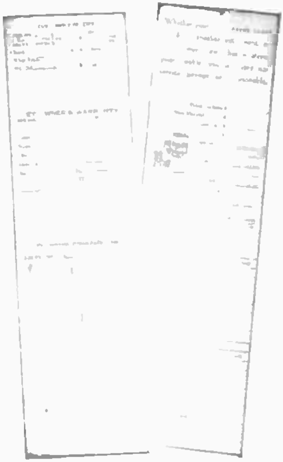

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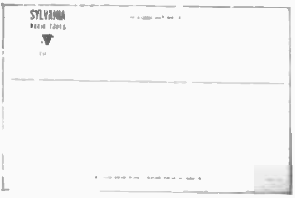

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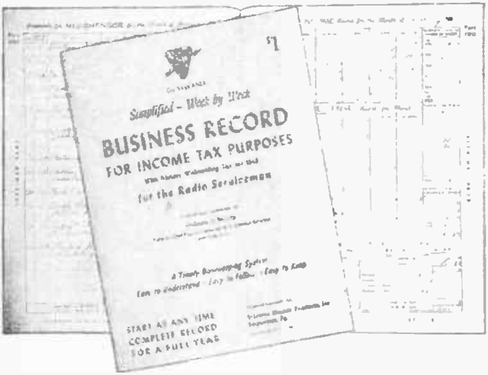

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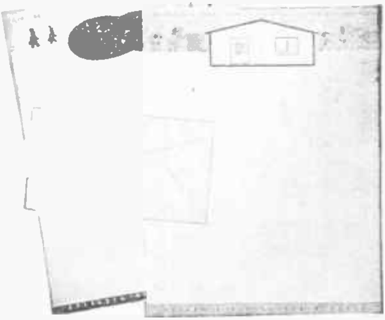

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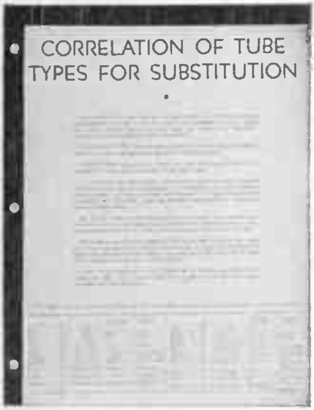

CORRELATION OF TUBE TYPES FOR SUBSTITUTION

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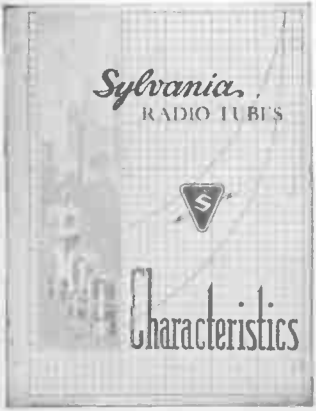

Sylvania RADIO TUBES

Characteristics

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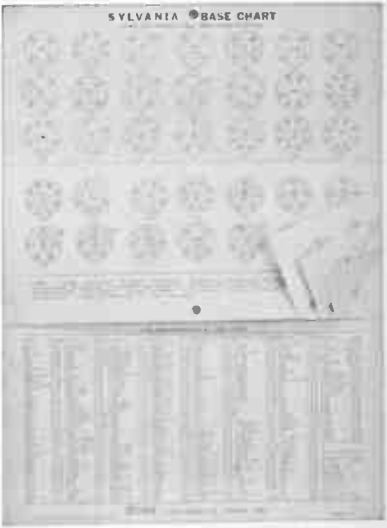

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BASE CHART

Base views for Sylvania tubes. Cross indexed by types and bases

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