SYLVANIA NEWS
TECHNICAL SECTION

JANUARY, 1946 EMPORIUM, PENNA. VOL. 13, NO. 1

HOW TO USE VOLTAGE REGULATOR TUBES

We have had a few inquiries from servicemen who wish to use one or more of the voltage regulator tubes, as for example, to keep an oscillator stable. Those who design their own vacuum tube voltmeters and other test equipment can always get a little more stable performance by incorporating a voltage regulator tube to control the critical voltages.

This article will attempt to explain the proper design procedure for those who are not familiar with this device.

Voltage regulator tubes, sometimes called glow regulator tubes, consist of two elements one of which has a large area, enclosed in a bulb containing a gas such as argon or neon under low pressure. The kind of gas and the pressure are almost entirely responsible for the voltage characteristics as the element spacings affect the operation only slightly. The current rating is limited by the area of the large electrode (cathode) and by the bulb size. It is characteristic of such a construction that after sufficient voltage has been applied to ionize the gas it is impossible to greatly increase the voltage drop across the tube even at currents much above the maximum rated value.

FUNDAMENTAL CIRCUIT

Figure 1 shows the fundamental circuit for use with one voltage regulator tube.

Table 1 lists the characteristics of all the VR tubes available on the market at present whether SYLVANIA manufacture or not and the tube selection will be based on the output voltage and current required. Any tube selected may be used similarly by taking the proper figures from the table.

A SIMPLE EXAMPLE

Example: Suppose you wish to use a 50Z6G or similar rectifier to supply 20 ma to an oscillator at constant voltage of 90 volts; the procedure is as follows:

(1) From the table of available regulator types select the tube

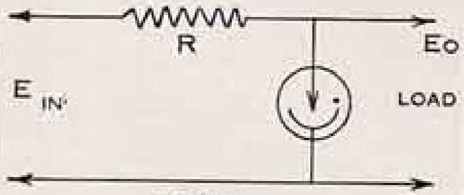


FIGURE 1

meeting the voltage output requirement—in this case we will take the OB3/VR90.

(2) Check the current rating. Since the desired load will be 20 ma an equal amount could be taken by the regulator tube and adequate control would be provided for line voltage changes of 10 to 15% or load changes of almost 100%. More difficult cases where the load current is high with respect to the regulator tube current will be discussed later.

(3) From the load curve given for type 25Z6 on page 168 of the "Sylvania Manual" we can find the voltages which will be available at 20 ma load before the regulator tube lights and at 40 ma normal center of operation. The 8 mfd curve looks promising so from it we read and note E in (20 ma) = 140, E in (40 ma) = 116 Volts.

(4) Find the value of R at normal operating centre with 20 ma through load and 20 ma through regulator,

Drop across R = 116 − 90 = 26 volts
Current through R = 40 ma.

$$\text{Resistance} = \frac{26}{.040} = 650 \text{ ohms}$$

(5) Use this value of R to see if the value of Eo when the regulator tube is out will be sufficient to start the discharge.

$$\text{Eo} = \text{E in (20 ma)} - \text{I} \times \text{R}$$
$$= 140 - (.020 \times 650)$$
$$= 127$$

This is ok since the starting voltage listed is 125 volts max. therefore the values selected will give good regulation and stable operating conditions.

TUBES IN SERIES

Perhaps the voltage required at the load is not the simple output voltage of one tube however. In that case see if you can get two or more regulator tubes having the sum of their operating voltages close to the desired voltage. This would be worked exactly the same as the simple case given before using the sum of the regulated voltages as Eo; the current through the tubes can be taken as midway between the upper and lower limits of the tubes selected. Starting voltage however does not have to be the sum of all the starting voltages, just enough more to start one tube will be sufficient. The reason for this is that an absolutely even distribution of voltage is unlikely—one always will fire first which leaves enough starting voltage available to start the next one and so on. If desired this condition can be obtained by shunting each regulator tube by a 1/10 to 10. meg resistor—no two resistors being the same. Leakage resistance across the sockets is erratic enough that this is probably unnecessary.

ANOTHER EXAMPLE

Let's take a more difficult case. Suppose you are having trouble with a large amplifier in a location where the line voltage varies from 90 to 120 volts and wish to stabilize operation. Let us assume a total drain of 200 ma at 360 volts and see

(Continued on page 4)

RESISTANCE COUPLING DATA

The inside pages of this issue are devoted to a reproduction of the charts we have had prepared to show the correct resistor values for use with Types 7A4 and 7B4. Where more than one circuit is recommended values are given for each method. We suggest that you file these in your data book for easy reference as this will be very useful when you rebuild that amplifier.

The use of these charts is not restricted to the Lock-In types on which the data were taken. The type 7A4 corresponds to Type 6J5GT and Type 7B4 corresponds to Type 6F5GT and 6SF5. Corresponding double triodes are 6SC7GT and 12SN7GT.

HOW TO USE VOLTAGE REGULATOR TUBES *(Continued)*

what we can do about getting stable operation. If the transformer has 450 volts each side of centre for normal line voltage (117) it will deliver only 345 volts where the line voltage drops to 90 so from the output curve for the 5Z3 we find that at the minimum condition there will only be 320 volts available at 200 ma. Since we don't wish to change the transformer we decide that this will give enough output. Three type OC3/VR105 adding up to 315 volts will probably be close enough.

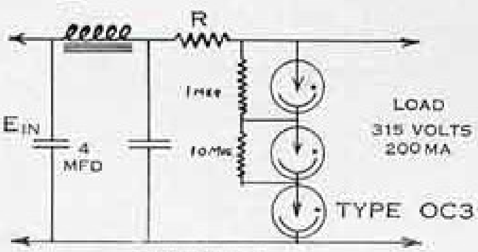


FIGURE 2

Since the line voltage has been stated as varying from 90 to 120 volts we will set up our equations for the centre value, 105 volts, and check later to see if it is correct for the extreme conditions.

$$E \text{ per plate} = \frac{105}{117} \times 450 = 405 \text{ volts}$$

From 5Z3 curve:
E in = 390 volts at 220 ma load (200 for amplifier, 20 for the OC3)
Dro in R = 390 − 315 = 75 volts

$$R = \frac{75}{.220} = 340 \text{ ohms}$$

Note: this includes the D.C. resistance of the choke.

At the high line condition:

$$E \text{ per plate} = \frac{120}{117} \times 450 = 462 \text{ volts}$$

From the 5Z3 curves E in = 455 volts @ 240 ma load. Assume 40 ma for the regulators, if it doesn't check we will have to change it.
Drop in R = 455 − 315 = 140 volts
But since R has been set at 340 ohms and the current will be 240 ma. the drop should also be 82 volts.

Since these figures don't check within a few volts it shows that the circuit will not work as planned. We will have to make some new assumptions, change the circuit or decide we didn't need to cover such a large range of line voltage anyway. Before giving up, however, we could check the low line voltage condition to see if perhaps a slight shifting of the VR tube current would allow a reasonable working range to be obtained. In this case it is so far off that it doesn't seem worth trying.

TABLE I

Type	Regulating Voltage	Maximum Current	Minimum Current	Maximum Starting Voltage	Regulation Volts
OA3/VR75	75	40	5	100	5 Max.
OB3/VR90	90	30	10	125	6 Max.
OA4G*	70	25	5	90	Not rated
OC3/VR105	105	40	5	127	4 Max.
OD3/VR150	150	40	5	180	5.5 Max.
874	90	50	10	130	7 Max.
OA2	150	30	5	185	2 Max.
OB2	108	30	5	133	2 Max.

* Starter anode tied to anode through 10,000 to 100,000 ohm resistor.

TUBES IN PARALLEL

Another string of three VR105's placed in parallel so that 80 ma. instead of 40 can be absorbed would seem to be the obvious answer but this unfortunately will not work. The reason is that in a parallel combination the voltage rises until one tube is ionized. This one prevents the voltage from rising high enough to fire any other in parallel with it.

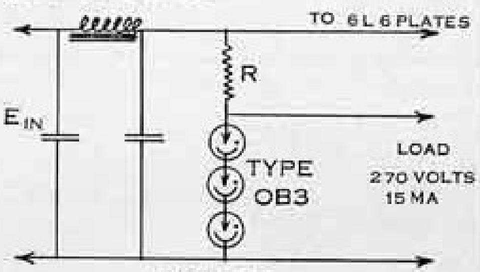


FIGURE 3

There are various tricks that can be used in cases like the above where the straight-forward solution does not give a workable answer. The best way is to divide up the load into smaller units regulating each one separately with the required tubes. In this case it might give adequate control if the plates of the output tubes were left unregulated and the screens and earlier stages regulated at their desired values, say 270 volts. Three type OB3/VR90 would do this very nicely so let's draw up a circuit, go through the calculations and see what comes out.

At 105 volts, 225 ma. total drain (25 ma. for the regulators).

$$E \text{ per plate} = \frac{105}{117} \times 450 = 405 \text{ volts}$$

Ein = 392 volts
Assume choke resistance = 50 ohms
Then drop in choke = 11 volts
Drop in
R = 392 − 11 − 270 = 111 volts

$$R = \frac{111}{.040} = 2750 \text{ ohms}$$

At 120 volts, 240 ma. total drain. (Since the screen voltage is held constant the plate current will be practically the same, even if the plate voltage goes to 450 volts.)

$$E \text{ per plate} = \frac{120}{117} \times 450 = 462 \text{ volts}$$

Ein = 440 volts
Drop in
choke = 50 × .240 = 12 volts
Drop in R = 440 − 12 − 270 = 158
also drop = 55 × 2750 = 151 volts, which is close enough.

We can check the 90 volt condition also as follows:

$$E \text{ per plate} = \frac{90}{117} \times 450 = 347 \text{ volts}$$

Ein = 335 (Current will be 200 ma. to amplifier, 10 ma. to regulator.)
Drop in choke = 10 volts
Drop in R = 335 − 10 − 270 = 55 volts
also drop = 2750 × 25 = 69 volts.

This is close enough to be a good check and shows that very satisfactory operation over this wide voltage range could be obtained in this manner.

We still have to see if there will be voltage available to start the regulator tubes under low voltage conditions. Imagine the VR tubes removed under 90 volt line conditions, then:
Total Drain = 200 ma.
Ein = 335 volts
Drop in choke = 200 × .050 = 10 volts
Drop in resistor = 2750 × .015 = 41
Voltage at regulator tubes
= 335 − 10 − 41 = 284 volts
Voltage required
= 90 + 90 + 125 = 305 volts

This doesn't look as though the tubes would start but actually they would work alright because the rectifier being a filament type would deliver power before the 6L6G's were ready to take it. This could cause trouble, however, if the voltage went below 90 volts momentarily putting the regulators out, which then would not start until the voltage had risen to about 100 volts. If the possibility of this is serious some correction could be obtained by connecting R ahead of the big choke using a separate choke if necessary to reduce hum.

We hope the above explanation of the procedure employed in using regulator tubes will be clear enough that any serviceman who wishes to do so will be able to use them successfully. The calculations for the examples are shown in detail so as to be easy to follow.

Plate and Screen Dissipation Ratings

Their Relation to Tube Performance and Life

Editor's Note: Numerous requests have been received for information concerning dissipation ratings. It is hoped that this article will provide helpful information on this subject and that it will encourage attention to and respect for published tube 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.

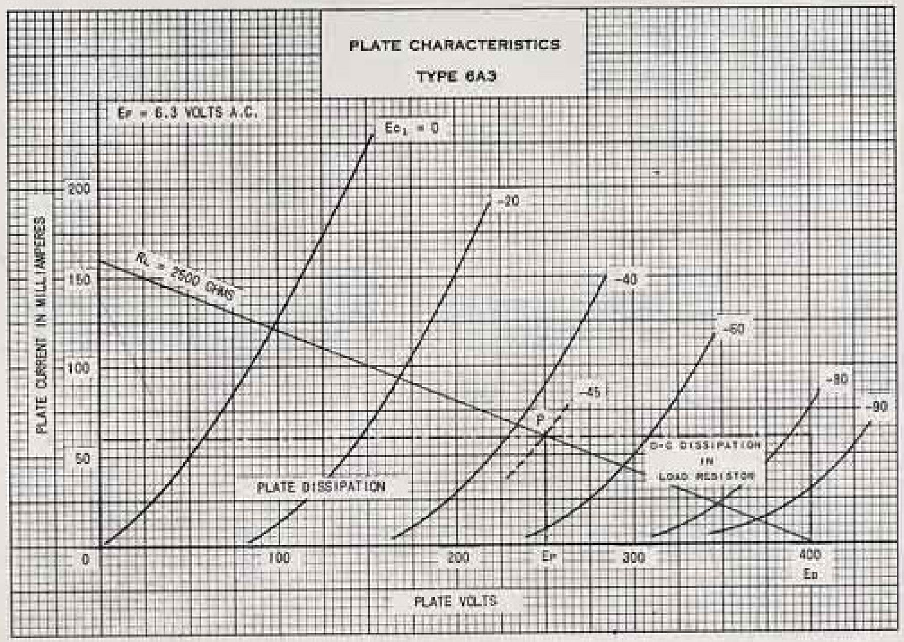
The interpretation of tube ratings published in the Sylvania Technical Manual and other Sylvania technical literature are in accordance with RMA standards and the conditions outlined in the introductory section of the manual for the plate and screen are:

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 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 indicates 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 $I^2 R_L$ 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, this 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

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PLATE AND SCREEN DISSIPATION RATINGS
THEIR RELATION TO TUBE PERFORMANCE AND LIFE

(Continued from page 2)

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 $250 \times 0.045 = 11.25$ Watts

Zero output screen dissipation is $250 \times 0.0045 = 1.125$ Watts

Full output plate dissipation is $(250 \times 0.047) - 4.5 = 7.25$ Watts

Full output screen dissipation is $250 \times 0.007 = 1.75$ 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.

A recent issue of Sylvania News (Vol. 9 No. 10 June 1942) carried an article entitled "Tracking Down Grid Emission" in which appeared the precaution that excessive heat is the factor that must be avoided to prevent grid emission troubles. It is suggested that you review that article since it contains valuable information which is closely related to the present subject.

VOLTAGE REGULATOR TUBES
Sylvania Tubes 0B3/VR90 and 0D3/VR150

(Continued from page 1)

145 to 160 volts. For either type of tube the operating voltage will be less than that required for breakdown.

Regulation Characteristic

The operating voltages are also dependent upon the current passing through the tube, generally being several volts higher at high current drains than at low values of current. This difference in operating voltage on any particular tube is a measure of the regulation for that tube. For Type 0B3/VR90 the maximum regulation is 6 volts over the operating range of 10 to 30 ma. For Type 0D3/VR150 the maximum regulation is 7.5 volts over the operating current range of 5 to 40 ma. On an ideal tube the regulation would have a zero slope and for such a case the operating voltage would be constant over the operating current range. This condition is rarely obtained in actual practice. The regulation tends to improve during the life of a tube.

Possible Tube-To-Tube Differences

One very important factor which should be noted is that individual tubes may not deliver identical voltages to the load. For example, if a given 0B3/VR90 tube is checked and found to deliver 88 volts to the load and this tube is replaced with another 0B3/VR90 this tube might deliver 92 volts or some other voltage to the load. Nevertheless, the voltage should always be within the specified limits for operating voltage which would be 80 to 100 volts for the 0B3/VR90, and the regulation 6 volts or less; while for the 0D3/VR150 the voltage will be between 145 volts and 160 volts and the regulation would be 7.5 volts or less.

Series Operation

Two or more regulator tubes of the same type may be connected in series to obtain higher voltages which are multiples of the drop for a single tube. Voltage taps may be taken from the junction points of the regulator tubes as indicated in the circuit diagram. A Type 0B3/VR90 and an 0D3/VR150 cannot be used in series principally because of the difference in breakdown voltage required and because of the differences which exist in the operating ranges for the two regulator tubes.

Old Tubes for New

A rule requiring owners of radio sets to turn in their old tubes when they buy new ones is being worked out by the WPB and will probably go into effect soon. The tube turn-in regulation is intended to control the number of tubes distributed. It also will permit the salvaging of tube bases which, in some cases, can be refabricated. Watch our next issue for more information.

TRACKING DOWN GRID EMISSION

CAUSES AND CURES FOR TROUBLE-MAKING "BUG"

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

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

Perhaps you have tested tubes, condenrs and resistors, yet you found everying to be normal. Try though you may, ou have never located the cause of these mplaints, although you may have effect-l a cure by the cut and try method. Of ourse, you know that the cathode of a dio tube is designed to emit electrons; ıt this is not true of the grid. Grid nission, as the name implies, means that ıe GRID gives off or emits electrons. Then electrons flow there is also a flow current, (as can be seen if we place a illiameter in series with the cathode) ıd current flowing through coils and high alue resistors in the grid return circuit, ill produce a voltage drop detrimental to ood circuit performance.

Why do we have grid emission? Well, uring the process of evacuation of a radio ibe a small portion of the cathode emitng material is sometimes unavoidably plashed on to the grid with the result ıat should the grid become sufficiently eated during operation, it will emit ectrons.

To reduce this disturbing effect every recaution is taken in the design of ylvania radio tubes to keep the grid as ool as possible. Copper grid supports re used because copper, being a good heat onductor, carries the heat away from the rid. Grid radiators are attached to the rid to give a greater heat radiation area. olloidal graphite is sprayed on plates and ulbs to increase the heat radiation to ıe outside away from the grid,—all to eep the internal tube structure cool.

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

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

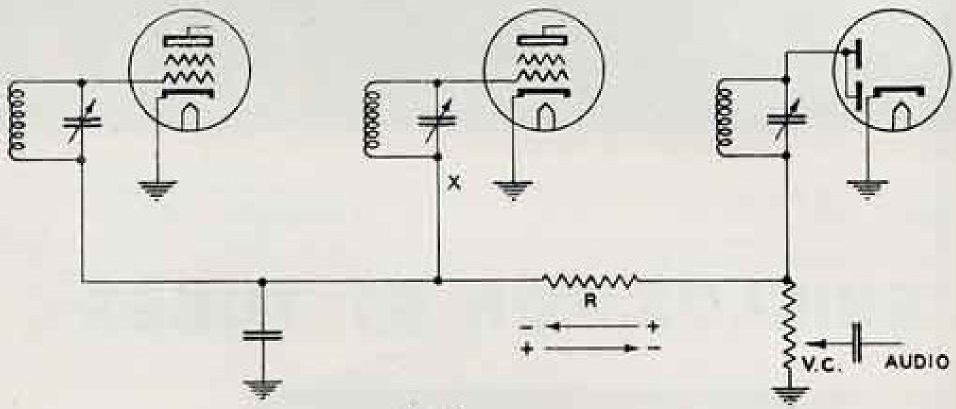


FIG. 1

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 DC resistance in the grid returns are 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 produces 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[1]. You and I know that we cannot use positive voltage on control grids. It must be negative!

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.

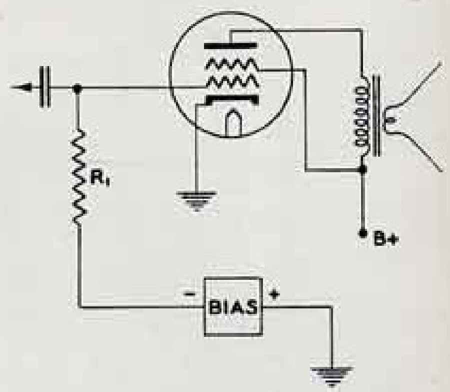


FIG. 2

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.

(Continued on page 4)

TRACKING DOWN GRID EMISSION

(Continued from page 2)

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 DC 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, automatic bias. Above all, make sure that the values of voltages and grid resistors are within the ratings of the tubes.

W. R. JONES TAKES OVER

During Lieutenant Merkle's absence on duty, Walter R. Jones, Director of the Sylvania Commercial Engineering Department, will act as Associate Technical Editor. As a frequent speaker at service meetings, and as author of many Sylvania News technical articles, Mr. Jones is equally well-known to servicemen. Under his direction the Technical Section will continue to supply authentic, up-to-date information to its readers.

SELL AND SWAP SERVICE

This service is offered without charge for the purpose of helping jobbers and servicemen in the exchange of needed radio parts and equipment that are hard to obtain due to war conditions. We reserve the right to refuse any ads that do not serve this purpose. Sylvania News will not undertake to answer inquiries or assume responsibility for transactions.

RULES

1. **Ads must not be over thirty-five words, exclusive of name and address.**
2. **Ads must deal with radio merchandise only.**
3. **The advertiser agrees to answer all inquiries, and to be fair and honest in completing transactions.**
4. **Ads must be submitted on a separate sheet (preferably a business letter-head) with complete address.**
5. **Address ads to Department SS, Sylvania News, Emporium, Pa.**
6. **Ads must be in by the 25th of the month preceding issue. Those received later will be published the following month.**

Wanted—Data and prices on Neobeamo'scope parts, tubes, motors, mirrors for late models. Please write us if you have parts and data for sale, stating condition of items.—Mesmer Radio Service, 544 W. 4th St., Ottumwa, Iowa.

* * *

Wanted—R. C. A. Chanalyst, Rider Manuals, "A" eliminator, modern test equipment and tools.—Metairie Radio Shop, 341 Metairie Road, New Orleans, La.

* * *

Wanted—Short-wave factory built receiver, age or condition not important. Prefer communication type Hammarlund, National, Patterson, Scott, or similar. Also interested in test apparatus, books, manuals.—Glenn Watt, Chanute, Kansas.

* * *

Wanted—Used refrigeration manuals and Rider Manuals 4 to 12.—G.Reis, 333 E. Saratoga, Ferndale, Mich.

* * *

Will Sell or Swap—16 inch D. C. ventilating fan with 1/20 H. P. motor, $5.00; Superior VTVM signal tracer, $20.00; check protector, $5.00.—G. Reis, 333 E. Saratoga, Ferndale, Mich.

* * *

Swap or Sell—Portable CW-Phone 6 volt transmitter, parmetal case, see photo page 371, 1939 handbook. Hammarlund; National, 160 coil; Thordarson T19-M-13: Bliley LD-2; Triplett. Low Power osc. 6F6, PA6F6, SA6J7, 6C5, 6F6 small genemotor. High power 6F6, 807, 6L6 or 6N7, 250V, 100MA genemotor. Both genemotors fully filtered. Other tubes may be used.—Bob Eubank, 1227 Windsor Ave., Richmond, Va.

* * *

Want—Test equipment, audio oscillator, VTVM, etc.—Bob Eubank, 1227 Windsor Ave., Richmond, Va.

* * *

Wanted—Good factory built short wave or all wave receiver. State model, condition and best cash price.—Oliver F. Klein, 2235 N. 39th St., Milwaukee, Wisc.

* * *

Sell or Swap—Remington 10 Shot Automatic .22 rifle, Model 24, and double barrel shotgun both in excellent condition like new, Service Manuals, etc.—Oliver F. Klein, 2235 N 39th St., Milwaukee, Wisc.

* * *

Swap—One new Triplett Model A Volt-Ohm Milliameter set tester never used will trade for late model tube tester, must be in good shape. This cost (and is new) $28.00. Have no use for it, was given as present.—M. E. Kilpatrick & Son, 3434-36 Penn. Ave., Indiana Harbor, Indiana.

* * *

Sell or Swap—One 250 volt d. c. to 110 volt a. c. Rotary Converter, 200 watts output. One 088 Philco Signal Generator, Philco 048 Set Tester. One 250 volt d. c. Watthour Meter. All types of parts, battery sets, etc. One 250 volt d. c. soldering iron.—Alvin Walker, R. F. D. #1, Ashland, Ky.

* * *

For Sale—Will sell cheap, 60 watt Webster sound system, complete with 4 speakers with baffles, 2 microphones, 2 speed turn table. Also 110 volt a. c. power plant all in A-1 shape. Used very little.—Adolph E. Johnson, Warren Radio Service, Warren, Minn.

Wanted—Factory built television receiver. Prefer large screen. State lowest cash price.—Jacks Electric Radio Ser., 296 Wainwright St., Newark, N. Jersey.

* * *

For Sale—New and used receiving and transmitting parts and equipment. What can you use? Send stamp for list.—Herman Yellin, 351 New Lots Ave., Brooklyn, N. Y.

* * *

Wanted—Good photo enlarger.—Herman Yellin, 351 New Lots Ave., Brooklyn, N. Y.

* * *

Wanted—Rider's Manuals, 1 to 12, with index and supplements; all or part. State lowest cash price.—Forest Park Radio Service 12½ S. Euclid Avenue, St. Louis, Missouri.

* * *

For Sale—Rider's Manuals, No. 1 (old edition), 3, 4, 5, 6, 7, 8 with Index. One 189 Supreme Signal Generator, one 385 combination tube checker and diagnometer. All in first class condition. What is offered?—Arthur R. Weaver, 907 E. Main St., Morristown, Tenn.

* * *

Swap or Sell—Dependable 305 tube and condenser tester. Norge panel mounting 8 inch electric test clock calibrated 0-660 minutes. Fine for checking intermittent jobs and enhances any test panel.—R. R. Nichols, Nichols Radio & Elec. Co., Hamilton, Missouri.

* * *

Cash—For Supreme 561 Signal Generator, LCR bridge, resistance boxes, C-D condenser decade box CDB-3 or 5, General Radio Experimenter Aug. 1935 and Sept. 1936, Aerovox Research Worker, Jan., Feb., March, 1928.—J T Lipani, 157 Leverett St., Boston, Mass.

* * *

For Sale—First 8 Vol. Rider's Manuals, like new. $5.00 for 1-6 and $7.50 each for 7-8. Half cash with order, balance after examining.—Henry Benner, RFD #1, Cowiche, Wash.

* * *

Will Sell or Exchange—Radio Course, Rider's Manuals, Meissner Analyst, Multitester, Tube Tester, C-B Signal Generator, Radio Books, etc —Kay Radio Service, 319 Main St., Niagara Falls, N. Y.

* * *

For Sale—Readrite Model 430 tube tester, Electrovoice (Airline) Velocity mike, Jewell Model 199 Analyzer, Western Electric telephone handset, also desk stand. Large radio transmitting tubes, various types; also various types meters. Cash only—make offer.—E. D. Nuttall, Box 215, Overton, Texas

* * *

Swap or Sell—$97 Rembler broadcast station condenser microphone with 2-stage 864 preamplifier built into standard floor stand. Complete with 25 feet heavy shielded cable. Use on batteries or power supply of amplifier. Sell $15, or trade. Make offer.—Bob Eubank, 1227 Windsor Ave., Richmond, Va.

* * *

For Sale—50 assorted speakers, 5 to 15 inch, P-M and Electro Dynamics. Mostly brand new. Send stamp and state type wanted. Prices will be forwarded.—Ideal Radio Shop, 1713 Larrabee St., Chicago, Ill.

TUBE DATA

(Continued from first page)

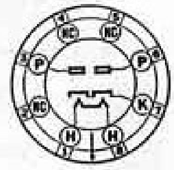
TYPE 14H7 (Continued)

Operating Conditions and Characteristics:

Class A_1 Amplifier

Heater Voltage	12.6	12.6 Volts
Heater Current	0.150	0.150 Ampere
Plate Voltage	100	250 Volts
Screen Voltage	100	150 Volts
Grid Voltage	−1	−2.5 Volts
Suppressor and Internal Shield	0	0 Volt
Plate Current	8.2	9.5 Ma.
Screen Current	3.3	3.5 Ma.
Plate Resistance	0.25	0.8 Megohm
Mutual Conductance	3800	3800 μmhos
Grid Voltage for Mutual Conductance of 35 μmhos (Approx.)	−12	−19 Volts

Sylvania Type 14Y4 Full-Wave Rectifier



5-AB

Sylvania Type 14Y4 is a full-wave rectifier of "Lock-In" construction. It is practically the same as the 7Y4 except for heater ratings and output current which is slightly higher for Type 14Y4. The conventional full-wave circuit may be used, while for half-wave service the two plates may be tied together at the socket.

CHARACTERISTICS

Heater Voltage (Nominal) AC or DC	14.0 Volts
Heater Current (Nominal)	0.320 Ampere
Bulb	T9-G
Base—"Lock-In" 8-Pin	5-AB
Mounting Position	Any

RATINGS:

Heater Voltage (Nominal) AC or DC	14.0 Volts
Heater Current (Nominal)	0.320 Ampere
A-C Voltage Per Plate (RMS) Condenser Input	325 Volts Max.
A-C Voltage Per Plate (RMS) Choke Input	450 Volts Max.
Peak Inverse Voltage	1,250 Volts Max.
D-C Heater to Cathode Voltage	450 Volts Max.
Steady-State Peak Plate Current Per Plate	210 Ma. Max.
D-C Voltage Drop at 60 Ma. Per Plate	22 Volts

Operating Conditions and Characteristics:

FULL-WAVE RECTIFIER

Condenser Input to Filter

Heater Voltage	12.6 Volts
Heater Current	0.3 Ampere
A-C Plate Voltage per Plate (RMS)	325 Volts
D-C Output Current	70 Ma. Max.
Plate Supply Impedance per Plate#	150 Ohms Min.

Choke Input to Filter

Heater Voltage	12.6 Volts
Heater Current	0.3 Ampere
A-C Plate Voltage Per Plate (RMS)	450 Volts
D-C Output Current	70 Ma. Max.
Minimum Value of Input Choke	8 Henrys

#When filter condensers larger than 40 mfds. are used, it may be necessary to add additional plate supply impedance.

• • •

Discontinued Types

The last Technical Section gave information on eight Sylvania tube types that had been discontinued. Since then, thirteen additional regularly listed types have been withdrawn. It may be that some of these types are still available from your Sylvania Jobber, but only until his supply is exhausted. The discontinued types are as follows:

00A	Special Detector
2	Plug-In Resistor
3	Plug-In Resistor
4	Plug-In Resistor
5	Plug-In Resistor
6	Battery Ballast
7	Plug-In Resistor
8	Plug-In Resistor
9	Plug-In Resistor
40	Voltage Amplifier
46A1	Plug-In Resistor
46B1	Plug-In Resistor
401	Detector-Amplifier

A CHAT WITH ROGER WISE

Chief Tube Engineer
Hygrade Sylvania Corporation

The increased acceptance being won by "Lock-In" tubes among set and equipment manufacturers is very gratifying, coming as it does at a time when conditions are unsettled and new trends are appearing. In many cases a step-up in performance is obtained when a "Lock-In" complement replaces other types. A gain of this kind is particularly important at a time when changes in materials entering into set design may be necessary due to current shortages.

While "Lock-In" tube quality is well seasoned through several years of production and field experience, they do represent the most modern and up-to-date line of radio tubes available today. The many novel features secured by the radical improvements incorporated in them include those features stressed in advertising copy—the single-end construction, short lead length, elimination of soldered connections, internal shielding, locking lug, sturdy construction, etc. The circuit conditions may be such that one of these features will be helpful in securing improved performance, or several may be of importance.

The high frequency performance of many of the "Lock-In" types is especially good, and the standard design can also be modified to advantage in some cases by comparatively simple changes which extend the operating range still higher. With the trend toward the use of higher and higher frequencies being accelerated by defense requirements, these design advantages become especially important. Very interesting results under severe vibration and shock have been secured, again due to "modern design."

The slogan which designates the "Lock-In" tube as the tube which "has all the answers" does not seem to be an exaggeration in view of the advantages secured in this ultra-modern radio tube.

• • •

THE CAUSE AND CURE OF FILAMENT FAILURES

FRANK D. LANGSTROTH, Comm. Eng. Dept. Sylvania Tube Division

"It's only an open filament! All you need is a new tube!"

How many times have you said that to a customer? Perhaps a great many, for it is true that a large number of service calls are due to open filament tubes.

It was easy for you to slip in a new tube and let it go at that; but, when you heard the tone of your customer's voice a short time later informing you that the very same thing had happened all over again, were you embarrassed?—We suppose that depended on how much you charged the customer!

Had you realized that in the majority of cases, open filaments do not "JUST HAPPEN" but are "CAUSED" you would not have merely been satisfied with replacing a tube, but you would have found the cause and cured it—for certainly you value your reputation as a serviceman and the good will of your customers!

It is therefore the purpose of this article to present a few of the filament problems encountered in radio servicing, hoping to make them recognizable and to suggest simple cures which will enable you, the serviceman, to have a better understanding of what have appeared to be complications in the past.

Modern radio tubes are indeed very rugged when one considers the exacting requirements under which they must function in their various applications. However, there are a few problems which must be given careful consideration if long life and best results are to be assured.

One of these problems is the importance of OPERATING AND MAINTAINING the filament voltage within the published ratings of the tubes!

This problem sounds very simple—so simple in fact that we ignore it. We take it for granted that if a series of 1.4 volt tube filaments total six volts and we place six volts across it everything is perfect; or if a 150 ma. series adds up to the line voltage, why not put it directly across the line? Well, why not? We will take this problem first.

We will say that one of your customers has an ac–dc receiver, with a filament circuit like that in Figure 1, in which he continues to find open filament tubes—sometimes it is the 12SQ7, sometimes it is the 12SK7. Your customer is vexed over the whole situation. You have tested the voltage across the various filaments and they are within the published limits. The total filaments in series adds to 121 volts and your line voltage is only 115 volts. Everything

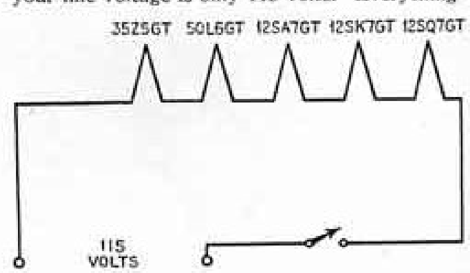


FIGURE 1

looks good to you. Why in "Sam Hill" do they "pop" out? Well, suppose we start taking measurements on this set again and place a voltmeter across the filament of one of the 12 volt tubes and turn the set on—Wow! For a few seconds the filament voltage goes up to 26 volts and then gradually goes down to 12 volts. It is this initial surge voltage that causes the filaments to open! But why do we have this condition?

The filament circuit of a typical ac-dc receiver is shown in Figure 1. There are five tubes having their filaments in series so that the total voltage will equal the line voltage across which the series string is connected.

(Continued on page 4)

THE CAUSE AND CURE OF FILAMENT FAILURES

(Continued from page 2)

FRANK D. LANGSTROTH, Comm. Eng. Dept. Sylvania Tube Division

If we visualize each filament as being a resistor, we can better understand the functions of this circuit. In other words, the filaments of the first, second, third, and fourth tubes act as a resistor to cut the voltage down to its proper value for the fifth tube, while the first, second, third and fifth filament is the dropping resistor for the fourth tube, and so on. We always have four filaments acting as the ballast resistor for the fifth as shown in Figure 2.

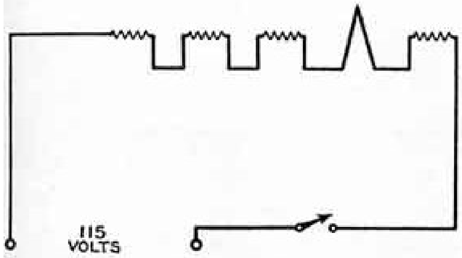


FIGURE 2

According to Ohm's Law everything should work fine with this circuit, and it would if it were not for one condition. The resistance of the filaments which we are using as dropping resistors is variable—it varies with temperature.

When the filaments are first turned on the resistance is low because the tubes are cold and as they become hot, the resistances increases to a steady value.

This would not be a bad condition at all, providing all the filaments reached their steady value at the same time; but we have tubes of various voltages in the series string, and the higher voltage filaments have a greater mass to heat, thus causing them to have a slower heating time than the low voltage filaments.

The result is that we do not have sufficient ballast for the low voltage tubes which have already reached their operating temperature. This causes a higher voltage to appear across their filaments until the resistance of the high voltage filaments have reached their steady or high value. The heating time of the high voltage filaments is further reduced because the high resistance of the now too hot low voltage filaments reduces the voltage applied to the higher voltage tubes.

It can be seen, therefore, that something is necessary to keep the line voltage reduced until the tubes are warmed up. This can be easily done by inserting a small resistor in series with the line voltage and the filament string.

This protective resistor tends to function automatically. As the resistance of the series filament string is very low when the receiver is first turned on, there will be a high current drain through the resistor which will cause a large voltage drop, thereby reducing the voltage applied across the filaments. When the tubes are hot the resistance of the filaments increases, thus reducing the current through the resistor and allowing more voltage for the series filaments.

The application of this protective resistor will naturally drop the filament voltage a few volts, but this should in no way affect the functioning of the receiver, as the loss of voltage will be distributed amongst the five filaments.

The increasing popularity of the battery-operated receiver has no doubt caused you numerous headaches.

We often find open filament tubes and continue to wonder why, especially when some of these tubes have been replaced two or three times.

In sets designed for both battery and ac-dc operation, it is usually necessary that the filaments of the tubes be operated in series during operation from the power line. Series operation is also frequently employed for battery operation to simplify switching.

There appears to be nothing wrong with this type of circuit. We see no reason why we cannot series operate tube filaments providing, of course, their currents are the same. Here again, however, there exists a condition which was not always taken into consideration in early receiver designs of this kind. The fact that the tubes have plate and screen voltages applied to them was often ignored. The total "B" current consumed by the tubes must return to "B"— and the only way that it can take place is by passing through the filament string, thus adding additional current, which at times is sufficient to cause the tube filaments to open.

In series connected filaments, therefore, the difference between the filament current at each end of the string must be the total "B" current, most of which is contributed by the power output tube which is placed at the positive end of the string so that its bias may be obtained by returning the grid to the negative end of the filament string.

The way the "B" current divides between the "A+" and the "A−" circuits depends upon the resistance of these circuits.

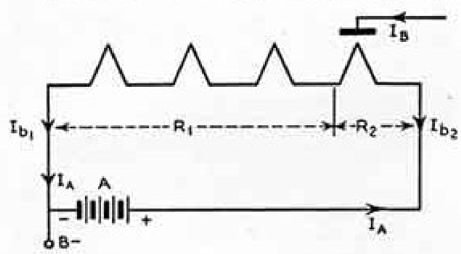


FIGURE 3

For the circuit in Figure 3, this division of the "B" current can be expressed as:

$$\text{Percent } I_b \text{ in A+ circuit} = I_b \frac{(R_1)}{R_1+R_2}$$

$$\text{Percent } I_b \text{ in A− circuit} = I_b \frac{(R_2)}{R_1+R_2}$$

It is apparent that in a-c operation where "A+" is connected through a large dropping resistor, practically all of the current flows out of the negative end of the filament string.

Therefore, during a-c operation it is desirable to shunt the "B" current of the power tube around the other tube filaments, especially if a tube of high "B" current is used.

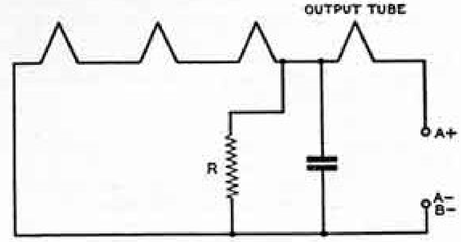


FIGURE 4

This may be done by a suitable resistor "R" as shown in Figure 4. This shunting resistor will equalize the current in the tube filaments for both line and battery operation.

To provide complete protection, the last "A" filter condenser should be placed directly across the shunting resistor. Thus the resistor also serves as a "bleeder" upon the last filter condenser in the "A" filter circuit and prevents this condenser from being subjected to excessive voltage when a tube is removed from the set while operating on a-c for, if the condenser is not damaged, the charge accumulated is sometimes sufficient to burn out several tubes when the filament circuit is again established upon the insertion of a tube. Although this connection allows some a-c ripple to flow through the output tube filament, the amplification is not high enough to render it objectionable.

The filter condenser serves two purposes when used in this position, one as the "A" filter and the other to prevent modulation currents of the output tube from passing through the filament string into the r-f tubes. This condenser must be of high capacity, from 100 to 200 mfd. in order to effectively by-pass the audio component of the total plate, screen and filament current of the output tube.

In receiver designs where the output tube is of the double filament type, extreme care should be taken to see that each 1.4 volt section carries an equal share of the total cathode current. Generally the negative section receives the greatest amount. This will necessitate the use of a resistor of approximately 250 ohms parallel with the negative section or a suitable resistor may be used between the filament center tap and −A to secure equalization.

In order to provide more power output when a-c operated, a separate output tube is sometimes used whose cathode current is returned through the remaining 1.4 volt tubes and thus provides their filament current. Some of these sets subject the 1.4 volt tubes to a severe surge of filament current if the set is switched suddenly from a-c to battery operation. This results from the fact that the cathode of the a-c power output tube remains hot long enough to provide additional current from the "B" battery to flow through the 1.4 volt filaments which are now being supplied from the "A" battery.

Although the 1.4 volt tubes will operate over a wide range of filament voltages, care should be exercised to see that the filament circuits are equalized in order to prevent excessive surges.

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