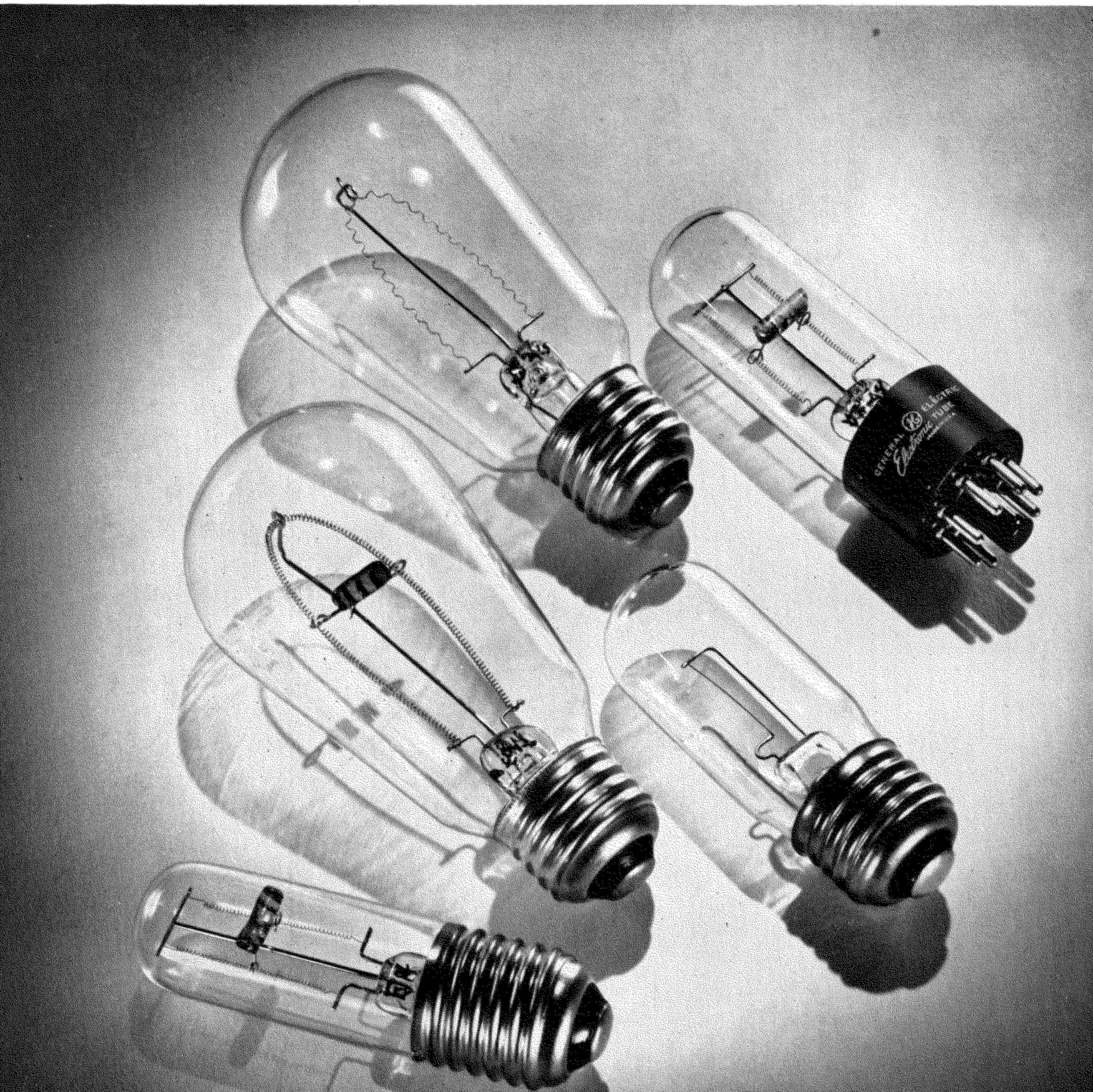
GENERAL ELECTRIC

BALLAST TUBES



DESCRIPTION

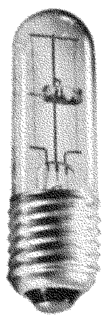
A ballast tube is essentially a constant-current device. It is a resistor whose resistance, at a certain critical temperature, varies with temperature so rapidly that, as the voltage across the tube varies, the current remains practically constant. The operation is the same on either alternating or direct current. Its function is to maintain a constant average current.

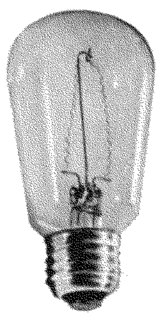
All ballast tubes now manufactured have been designed for a specific application and, as a result have non-uniform ratings. Because of the wide range of voltage and current ratings possible, no attempt has been made to manufacture a standard line. Ballast tubes may, however, be used in parallel or with shunting resistors across the load to increase or decrease the current rating, or with series resistors to increase the voltage rating. These methods are described under the section titled "Operation."

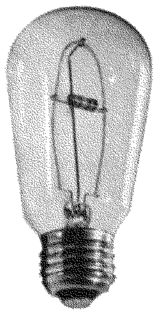
RATINGS AND DATA

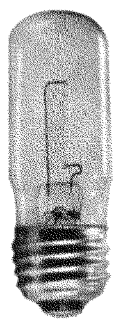
In rating a ballast tube, the voltage range over which the current is nearly constant is given together with a maximum and minimum current. The upper limit of the voltage range is to be considered the maximum voltage at which the tube may be operated. Over the voltage range the current may vary two per cent above or below its average value. The average current of individual tubes may be as much as two per cent above or below the average current of the entire production. Therefore, considering change of current with life and any other factors which may enter, the variation of current in a circuit using ballast tubes may be as much as five per cent above or below the average. The limits given in the tube ratings cover these factors.

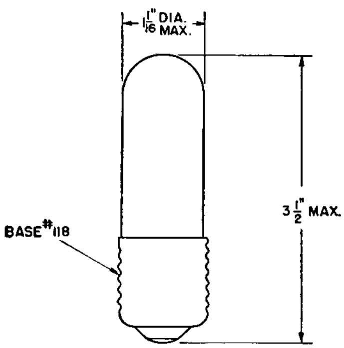
TUBE TYPE NO.	VOLTAGE RANGE IN VOLTS		CURRENT IN AMPERES	
	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
B-6	15	21	0.95	1.01
B-25	7	16	1.07	1.16
B-46	8	18	2.70	3.25
B-47	8	18	2.05	2.35
FB-50	5	8	0.225	0.275



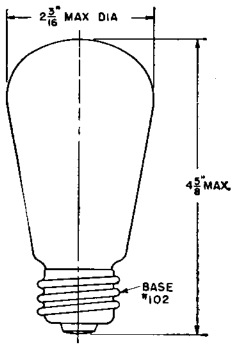




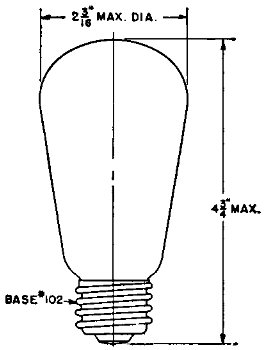




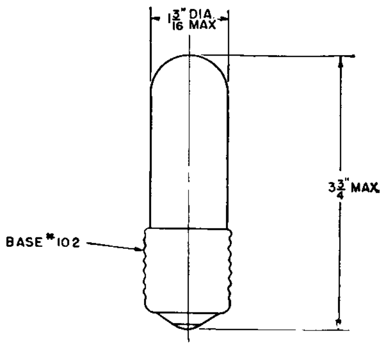
Outline
B-6 Ballast Tube
K-5182058 7-1-44



Outline
B-25 Ballast Tube
K-4955995 7-1-44



Outline
B-46, B-47 Ballast Tube
K-5185216 8-10-44



Outline
FB-50 Ballast Tube
K-8639322 7-1-44

INSTALLATION

The ballast tube should be mounted, with the base down, in an enclosure rigid enough to stop flying glass since, should the tube develop an air leak, the mixture of oxygen with the hydrogen contained in the tube might become of the right proportion to explode. The envelope becomes quite hot during operation, and free circulation of air must be allowed in order to keep the temperature of the air near the tube below 150 F. Marked changes in envelope temperature will cause a change in the current. Since the entire load current must pass through the ballast tube, the socket and connections to it must be clean and make good contact to prevent heating at these points.

OPERATION

The operation of the tube is shown by the characteristic curves in Fig. 1. As the voltage across the filament rises from zero, the resistance of the tube increases slowly in the same manner as most metals. As the lower end of the operating range is reached, the resistance of the filament increases quite rapidly with temperature, so that further increase in voltage causes practically no further increase in current. As the upper end of the operating range is reached, the resistance again becomes nearly constant. A still further increase in voltage causes an almost proportional increase in current as illustrated in the curves of Fig. 1.

This operation of the tube can be seen by observing the filament. As the voltage across the tube is increased from zero and approaches the lower end of the operating range, a small section in the middle of the filament will become red hot. As the voltage is increased further, the length of this red-hot section increases until the entire filament is visibly hot. This represents the end of the operating range and any increase in voltage will overheat and damage the tube. Operating the tube above the upper limit of voltage will result in excessive expansion and contraction of the filament as the voltage varies; this will cause the wire to stretch out the coils of the filament or to knot, which will increase the current and speed up the destructive process already started, resulting, shortly, in filament burn-out.

If a steady voltage of a value in the middle of the operating range is applied to the tube continuously, its life will be tens of thousands of hours. Opening and closing the circuit with the resulting lengthen-

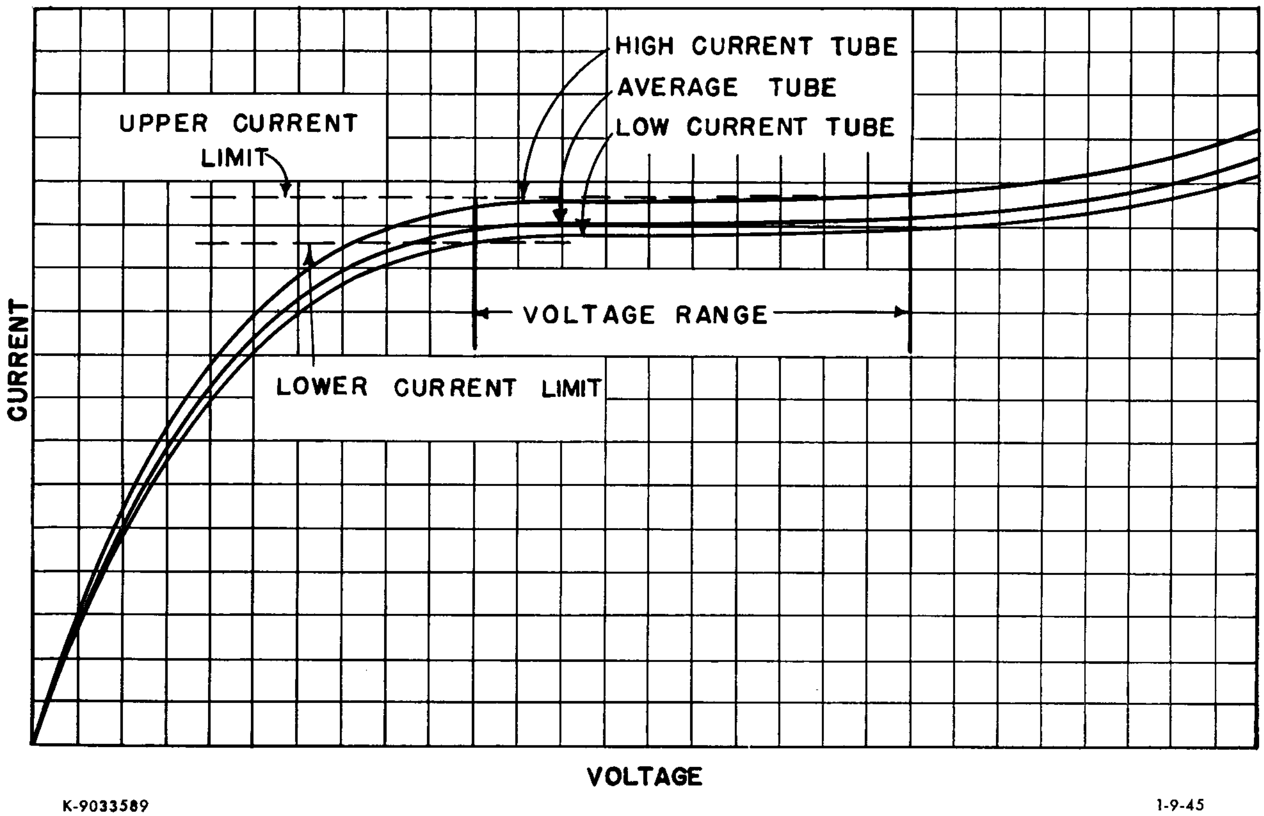


Fig. 1—Typical Ballast Tube Characteristics

ing and shortening of the filament greatly reduces the life of the tube. If full voltage is applied to the tube, the circuit may be opened and closed only a few hundred times before the current is outside the limits or the filament is burned out. Thus the life of the tube will be determined entirely by its duty cycle.

Because of the large thermal inertia of the tube, the temperature does not reach its final value immediately when the circuit is closed or when the voltage changes. Since the cold resistance of the filament is quite low, when the circuit is first closed the initial current may be several times the final value.

After a few seconds, however, the current will have fallen to within 25 per cent of the final value, and from 15 seconds to several minutes, depending upon the size of the tube, will be required for the current to reach a steady state. The real function of a ballast tube is to maintain a constant average current.

In Fig. 1 three curves are given to show the variation to be expected between tubes of a given rating. By choosing the proper coordinates, these curves are approximate for any ballast tube. Individual tubes may maintain the current to less than the range shown, but in any particular application variations up to plus or minus five per cent of the average may be expected. Typical characteristic curves indicating the limits of ballast action for the various types of ballast tubes are shown in Fig. 1A at the right.

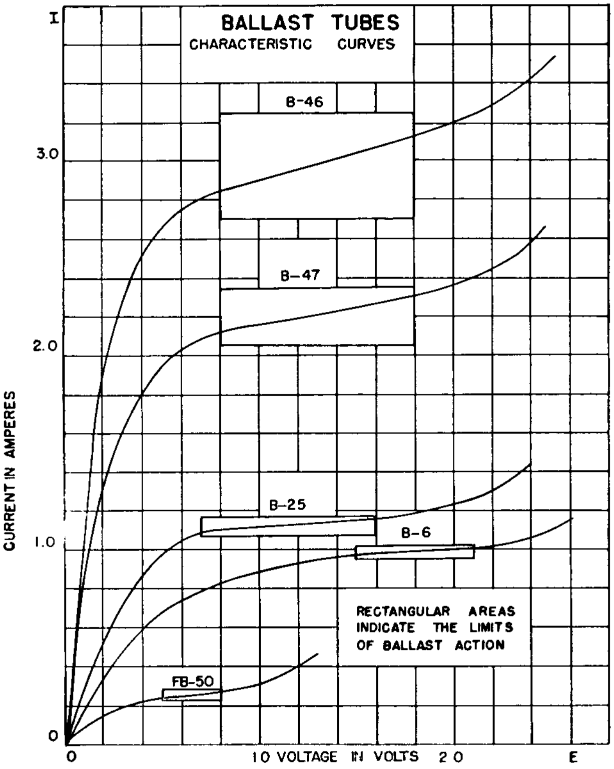


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Fig. 1A

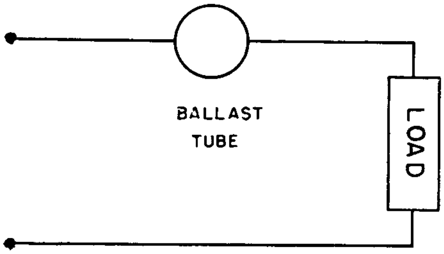
APPLICATION CIRCUITS#

The commonest use of the ballast tube is to place it directly in series with the load as shown in Fig. 2 and Fig. 3.

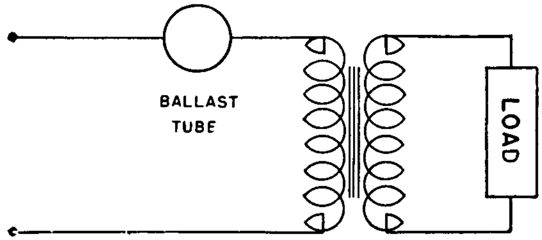
The graphical representation of the current and voltages in the circuit is shown in Fig. 4.

When voltage is applied, the current which flows is determined by the intersection of the load characteristic and the tube characteristic. As the supply voltage varies the current remains practically constant. The load voltage remains practically constant because the tube voltage varies by an amount proportional to the supply-voltage variation. The tube used should have a voltage range equal to the variation in supply voltage.

#Circuits shown in ETI-194 are examples of possible tube applications and the description and illustration of them does not convey to the purchase of tubes any license under patent rights of General Electric Company



K-9033575 Fig. 2—Connection for A-c or D-c Circuit 12-30-44



K-9033578 Fig. 3—Connection Using a Transformer 1-1-45

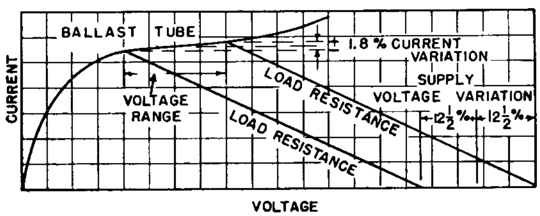


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Fig. 4—Ballast Tube in Series with Load

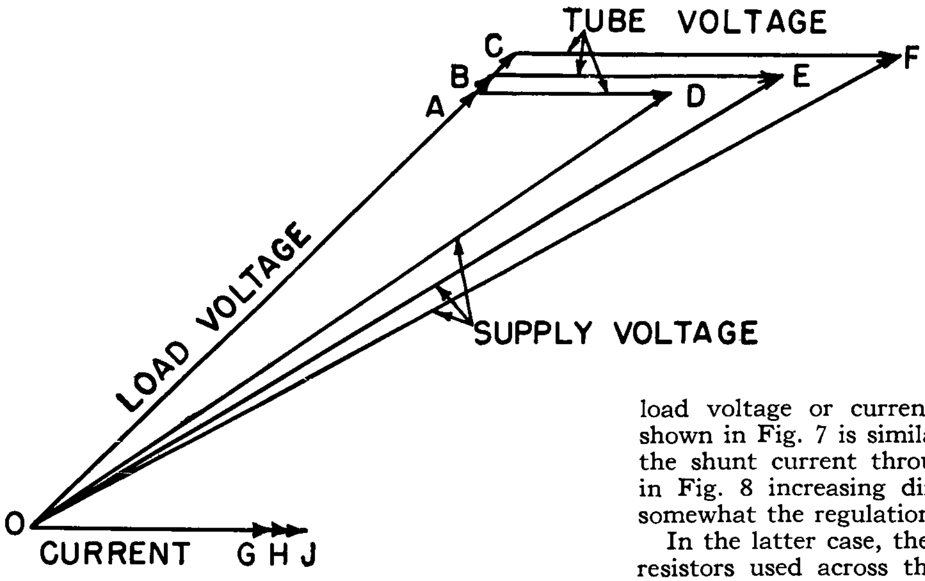

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Fig. 5—Vector Diagram For Inductive Load

A ballast tube may be used with inductive loads as well as with pure-resistance loads. Fig. 5 shows the vector diagram for such a load. The vector *OE* represents the normal supply voltage, while the vectors *OB* and *BE* represent the normal load and ballast-tube voltages, respectively. *OH* is the normal current. As the supply voltage decreases to *OD* or increases to *OF*, the ballast-tube voltage decreases to AD or increases to CF. This maintains the load voltage between OA and OC and the current between OG and OJ.

If it is necessary to use a tube whose current rating is too high or too low, either the load or the tube, as the case may be, may be bridged with a resistor to carry the excess or additional current. Figs. 6 and 7 show these two connections.

The operation of the circuit shown in Fig. 6 is identical with that shown in Fig. 2, the resistor being considered part of the load. This circuit is also recommended where close adjustment of the load voltage or current is required. The circuit shown in Fig. 7 is similar in operation except that the shunt current through the resistor, as shown in Fig. 8 increasing directly with voltage, spoils somewhat the regulation of the tube.

In the latter case, the higher the value of shunt resistors used across the ballast tube, the better the regulation. This connection is not recommended except in cases where close regulation is unnecessary.

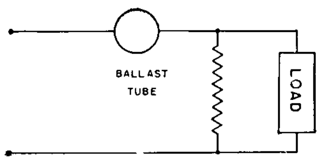

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Fig. 6—Circuit Using Tube with Too Large a Current

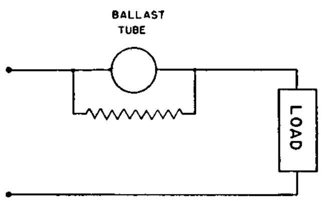

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Fig. 7—Circuit Using Tube with Too Small a Current (Not recommended)

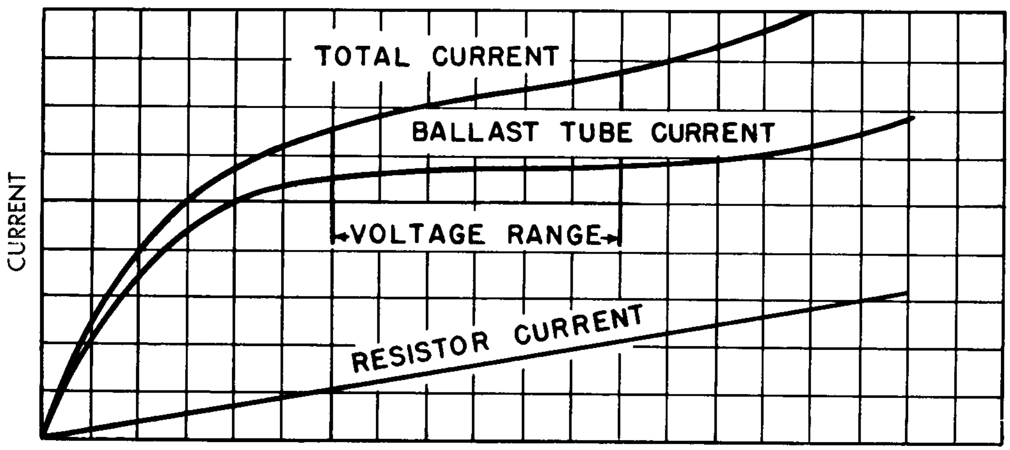

Fig. 8—Resistor Across Ballast Tube

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APPLICATION CIRCUITS (Contd.)

The ballast tube may be used to maintain constant current in a circuit requiring variation of the load. A suggested circuit is shown in Fig. 9.

Since the voltage across the ballast tube will vary with both the line voltage and load resistance (the potentiometer being considered part of the load) a greater voltage range will be required, and the ballast tube will use a greater percentage of power See Fig. 10 below.

The minimum voltage across the ballast tube will occur with minimum supply voltage and with the load adjusted to the minimum point on the potentiometer. The maximum voltage across the ballast tube will occur with the maximum supply voltage and with the load adjusted to the maximum point on the potentiometer. Since this circuit draws a constant current from the line, varying the potentiometer will not cause a variation in supply voltage to other apparatus on the line.

Ballast tubes may be used in parallel provided their voltage ranges are equal or nearly so. If their voltage ranges are unequal, good ballasting will occur only over that part of the voltage range which is included by both tubes. The current for any voltage will be the sum of the currents in both tubes at that voltage.

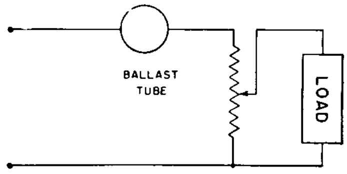

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Fig. 9—Circuit for Varying Load Voltage

Ballast tubes cannot be used in series unless their current-voltage characteristics are identical. This can be shown by referring to Fig. 1. If two tubes, one having the maximum current and one the minimum for a particular rating, are used in series the current will be the same in both tubes at all times. At the value at which the higher-current tube starts to ballast, the lower-current tube is operating above its ballasting range and hence is over-loaded. Thus, the safe operating range of the combination is only that of the lower current tube.

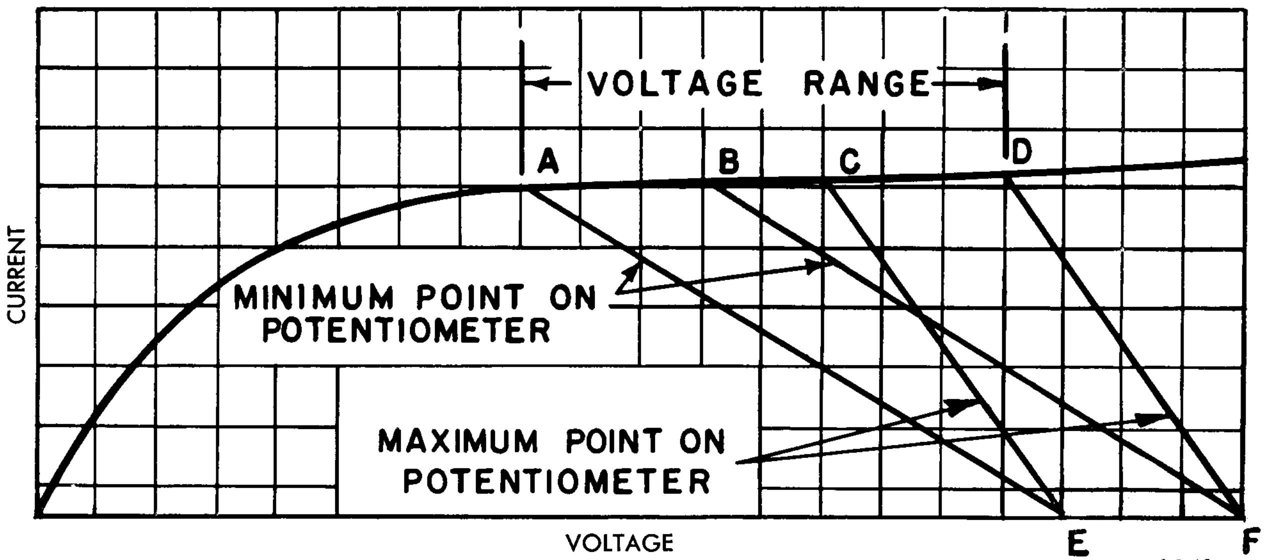

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Fig. 10—Ballast Tube in Series with Potentiometer, Load Across Potentiometer

Electronics Department

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