Westinghouse

GRID-GLOW TUBE

TYPE KU-610

INSTRUCTIONS

Westinghouse Electric & Manufacturing Company

East Pittsburgh Works, East Pittsburgh, Pa.

I. L. 1936

DESCRIPTION

The KU-610 Grid-Glow Tube is a grid controlled rectifier of the hot-cathode gas filled type. Like the ordinary three electrode vacuum tube, it contains an anode, a cathode and a grid. Unlike the vacuum tube, however, the KU-610 contains neon gas at such a pressure that electrons in flowing from cathode to anode ionize the gas atoms and produce positive ions of neon. These positive ions neutralize the negative space charge of the electrons and thereby permit the passage of large currents with a very low potential drop across the tube.

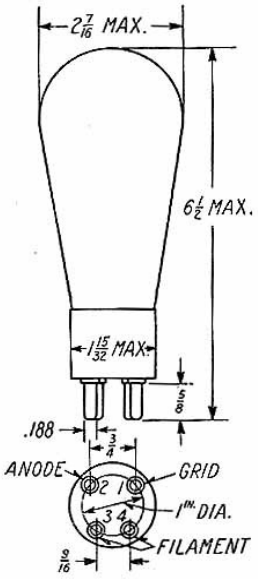

FIG. 1

The function of the grid is to control the potential at which the anode current begins. A sufficient negative bias on the grid will make the starting potential very high. Once the discharge is started, however, the grid has no appreciable effect in controlling the current. The grid will regain control in a very short time if the anode current is interrupted.

On a-c. the anode current passes through zero during each cycle, thereby giving the grid an opportunity to regain control so that the starting potential on the next half cycle can be varied. By thus controlling the point on the a-c. wave at which current starts to flow, the average rectified output of the tube may be varied from essentially zero to a maximum value. This control may be effected by either changing the magnitude of the grid potential or its phase with respect to the anode to cathode potential.

RATINGS

Maximum Crest Inverse Plate Voltage	1500
Maximum Crest Forward Voltage	750
*Maximum Crest Plate Current i_p	0.8 amp.
*Maximum Average Plate Current $I_{ave.}$	0.4 amp.
*Time Constant T	10 sec.
Cathode Type	Oxide Coated Filament
Cathode Volts E_f	2.5
Cathode Amperes I_f	7.0

Filament Heating Time	10 sec.
Average Tube Voltage Drop	22 volts
Maximum Overall Length	$6\frac{1}{2}''$
Maximum Diameter	$2\frac{7}{16}''$
Base (Industrial)	S#411
Type of Cooling	Air
Gas	Neon

*Two factors determine the current rating of Grid-Glow Tubes: Maximum electron emission of the filament and the heat capacity of the tube parts.

i_p =maximum crest current. This is the maximum value of current the filament can supply even for a very short time without damage. This value usually is *not* 1.4 times the r.m.s. value. If the maximum crest current demanded of the tube in a certain application cannot be estimated, it should be determined by means of an oscillograph or a reliable crest ammeter.

$I_{ave.}$ =maximum average current over a period. This is the maximum *continuous* average current rating if the current is constant as read on a d-c. meter. It applies to operation on commercial frequencies and d-c. This current is further defined as the maximum average current over any period of T consecutive seconds. (T is referred to as the time constant.)

The average current over any period of T consecutive seconds must not exceed I_{ave} and under no conditions must the crest current exceed i_p even for surges of very short duration.

INSTALLATION

The KU-610 Grid-Glow Tube is fitted with a four-prong base especially designed for heavy duty. (1) The tube may be operated in any position, although in general the vertical position with the base downward is recommended.

If the tube is to be subjected to appreciable shock or vibration, the socket should be mounted on a good shock-absorbing medium.

To obtain best results the circuit and tube must be shielded from high frequency surges, excessive commutator ripple, etc., and protected from dirt and moisture which would cause excessive circuit leakage.

(1) A specially designed socket is available for use with these tubes. It should be ordered as "Industrial Tube Socket S#766732". Industrial tube socket contacts S#777737 are available for those who wish to assemble sockets directly on the panel.

OPERATION

Cathode Circuit—The filament should preferably be operated from a-c. When the filament has attained an equilibrium temperature, the voltage measured at the pins of the base should be exactly 2.5 volts. The tube is designed, however, to operate satisfactorily at 5% above or below this value, although maximum life will be obtained at the rated voltage. The cathode should always reach

equilibrium temperature before the plate potential is applied. If this is not done, the cathode is bombarded during the heating period and the emission decreased. Repeated bombardment of this kind will eventually destroy the tube.

The return leads from the plate and grid circuits should be connected to a mid tap on the secondary of the filament heating transformer, or if d-c. is used, to the negative side of the filament.

Plate Circuit—There are four fundamental limits to be observed in the operation of the KU-610 Grid-Glow Tube. These are the maximum crest forward voltage, maximum crest inverse voltage, maximum crest plate current and maximum average plate current.

The current ratings have been previously defined. The maximum crest voltage limits are given to avoid arc back and loss of grid control. It should be kept in mind that very short surges of voltage may be responsible for such failures. It is necessary in many cases to use a crest voltmeter or oscillograph to determine the actual crest voltages present.

The KU-610 has a deionization period of about 1000 micro seconds and is therefore limited to use on 500 cycles or less. If the frequency is higher than 500 cycles, the residual ionization after the passage of current will be sufficient to make the grid ineffective in controlling breakdown on the next half cycle of voltage.

The voltage drop between anode and cathode is of the order of 22 volts, varying to some extent from tube to tube. It will also vary in a given tube with life and with filament temperature.

Means, either automatic or manual, should be provided in the anode circuit for allowing the cathode to reach operating temperature before the anode potential is applied.

A filament heating period of 10 seconds is recommended.

It is very important in order that the tube shall give reasonable life, that the load present in the plate circuit shall be such as to limit the crest current to not more than .8 ampere and the average current as previously defined to not more than .4 ampere.

Grid Circuit—To protect the grid from excessive current and to stabilize its characteristic, it is recommended that wherever possible a resistance of $\frac{1}{10}$ megohm be used in series with the grid.

With the constant shown in Figure 2, the typical starting characteristic curve of anode volts E_p as a function of grid volts E_G is obtained. This curve shows d-c. values of

potential. The a-c. r.m.s. curve may be obtained by dividing the d-c. values by 1.4 provided the a-c. voltage is a good sine wave free from harmonics and the two voltages are exactly in phase. By way of clarification, the starting characteristic curve may be explained by saying that current flows at any condition lying to the right and above the curve and that no current flows at points below and to the left of the curve. In other words, at any given value of grid bias E_g, current will not flow unless the anode potential E_p equals or exceeds the value corresponding to that point on the starting characteristic curve.

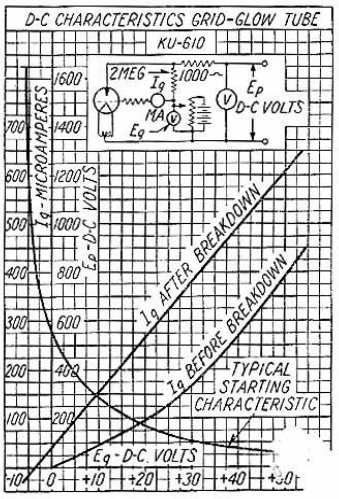

FIG. 2

The lower I_g curve shows the grid current in mico amperes flowing at the instant the tube is just ready to start, and the upper curve shows the current after the discharge has started and current is passing through the tube.

If the grid and anode potentials are not in phase, the d-c. characteristic may be considered as instantaneous points on the a-c. waves and the condition for discharge thus predicted.

The starting characteristic varies considerably with individual tubes so that wherever possible it is recommended that an excess of grid potential be used and the phase shift method of control employed.

If the tube is to be used only as a relay or contactor for on and off control, it is very easy to use sufficient bias that all tubes will operate alike.

MAINTENANCE

The KU-610 gives an intense red or orange glow when it is operating.

In installations where service is not to be interrupted, a crest voltmeter or an oscillograph may be used to check the anode to cathode drop at regular intervals.

If a regular increase in drop above 27 volts is noted on successive observations, the tube should be removed from service.

If further information is desired on the tube itself or circuits in which it is to be used, communicate with the agency from which the tube was purchased.

TYPICAL CIRCUITS

Circuits employing KU-610 tubes may be divided into three general classes according to output; namely, half wave rectifiers, full wave rectifiers and a-c. or symmetrical circuits as shown in Figures A, B and C respectively.

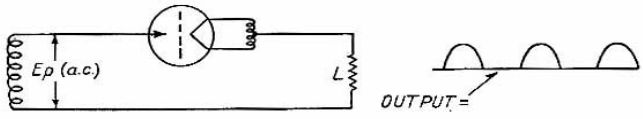

FIG. A

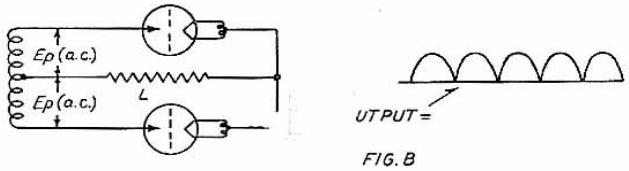

FIG. B

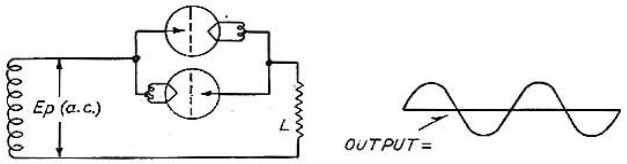

FIG. C

The output shown in these three figures is for the condition where current passes during the entire half cycle. This is the case only when the tube is used as a relay or as an ordinary rectifier.

The discharge passing through these tubes may be controlled by varying the magnitude or the phase of the grid voltage and thus determining the point in the cycle at which current will start to flow.

The output shown in Figure D, then results, for full wave rectification for example; thus by varying the phase of the grid potential, the average current output may be controlled over a wide range.

The operation of the circuit may be better understood by redrawing the starting characteristic (Figure 2) as shown in Figure E. Here E_p is the anode potential, assumed to be a sine wave, and E_g the grid bias, positive above and negative below the line, that will just allow the tube to start at the corresponding value of E_p. V_g is a sine wave of voltage applied to the grid and varied in phase with respect to E_p. Current starts at the earliest point in the cycle at which V_g Intersects E_g (P for the condition shown in Fig. E).

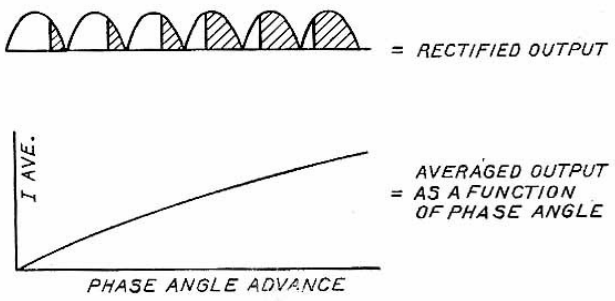

FIG. D

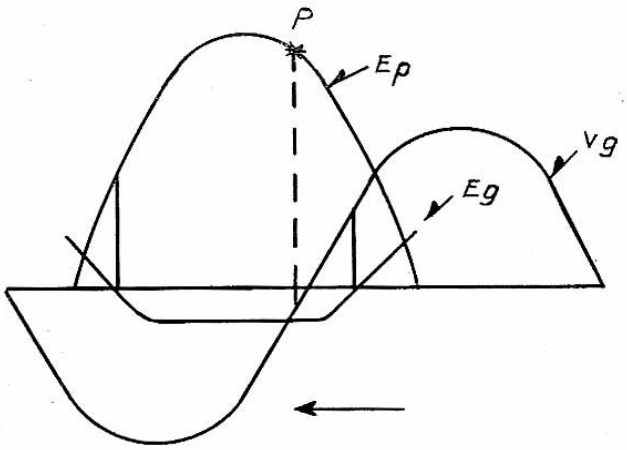

FIG. E

If the phase of the grid potential is advanced as shown by the arrow, the starting point P advances also, and the average current output is increased. The phase of the grid voltage may be varied by any of the well known methods such as resistance—capacity circuits, capacity—inductance circuits or wound rotor machines. Specific circuits employing phase control are shown in Figures F and G. It is understood, of course, that the same control methods may be applied to full wave rectifier circuits or to the a-c. symmetrical circuit shown in Figure C. In Figure F, the resistance R and the capacity C in conjunction with the mid-tapped transformer T constitute the phase shift circuit. The grid potential is obtained by connecting directly onto the latter.

In Figure G the grid potential phase is controlled by an entirely separate circuit and the potential fed to the grid through a transformer. The principle is the same, but allows for greater flexibility. For example, several tubes may be operated in unison from the same control circuit.

To obtain the best results, consult the following table which gives recommended values for the grid voltage Eg at various anode potentials Ep, for both Figure F and Figure G. Both values are a-c. r.m.s. volts.

Ep	Eg
110	75 to 220
220	40 to 220
440	40 to 160

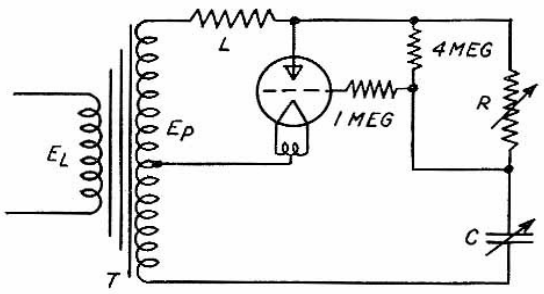

FIG. F

Contact Control—Figure H shows a circuit in which the opening or closing of a delicate contact causes the tube to operate. With the circuit as shown closing the contact starts the tube. If the resistor R and the contacts are interchanged, the closing of the contacts will stop the tube.

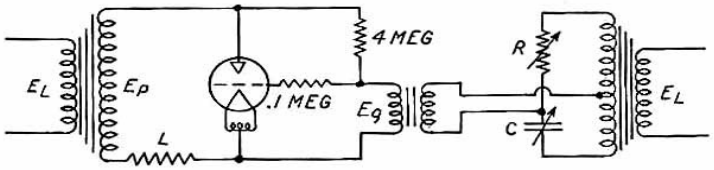

FIG. G

The recommended values of E+ and E— for various values of Ep are shown in the following table:

Ep	E+	E—
110	57	0
220	20	15
440	0	18

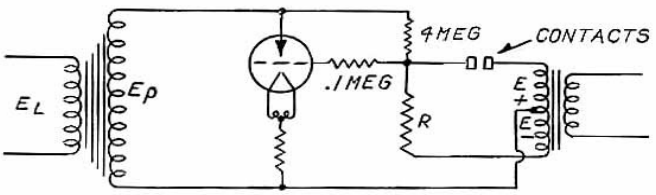

FIG. H

The foregoing circuits are intended only to illustrate the types of applications for which the KU-610 may be used rather than to give exact design data. If undue difficulty is experienced in obtaining the operation desired from these or other similar circuits, communicate at once with the agency from which the tube was purchased.