AB46.439A
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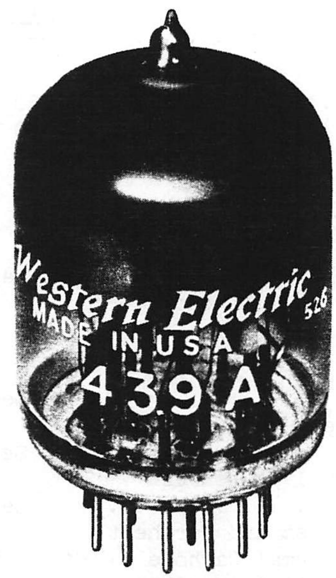
A.T.&T. Co. Standard

ELECTRON TUBE DATA SHEET

WESTERN ELECTRIC 439A ELECTRON TUBE



DESCRIPTION

The 439A is a ten-stage cold-cathode gas-discharge stepping tube designed for continuous counting or registration of pulses at pulse rates up to 1000 pulses per second. Design features permit both visual and electrical registration of input pulses. The tube can be operated in decade chains or can be used to drive other electronic devices for the purpose of timing, pulse counting, pulse generation, and similar operations.

File: Cold Cathode Section
Issue 1, 6-57

RATINGS, Absolute Values

Cathode Current	
Maximum Peak	10 milliamperes
Maximum Average	3 milliamperes
Minimum Average	1 milliampere
Maximum Averaging Time	0.5 second
Maximum Inverse Anode or Auxiliary Anode Current	0.0 milliampere
Ambient Temperature Limits	-55° to +60° centigrade

ELECTRICAL DATA[1]

	Min.	Bogey	Max.	
Anode Voltage Drop	---	110	---	volts
Anode Breakdown Voltage				
Normal Cathode	150	225	275	volts
Output Cathodes (K1 - K10)	180	225	300	volts
Stepping Cathodes (B1 - B10)	150	190	250	volts
Auxiliary Anode				
Voltage Drop to Cathode K10	---	112	---	volts
Breakdown Voltage	260	300	---	volts
Transfer Voltage[2] to Cathode K10	See curves - Fig. 1			
Transfer Voltage [2, 3], to any Cathode except K10	260	290	---	volts
Cathode				
Forward Transfer Voltage [4, 9]	See curves - Fig. 2			
Double Transfer Voltage between Output Cathodes [5,8,9]	See curves - Fig. 3			
Transfer Voltage from Normal to Nearest Output Cathodes [6,8,9]	See curves - Fig. 4			
Transfer Voltage from Nearest and Farthest Output Cathodes to the Normal Cathode [7,8,9]	See curves - Fig. 5			
Temperature Sensitivity-Cathode Transfer Voltage[6]	See curves - Fig. 6			

MECHANICAL DATA

Mounting Position	Any
Socket	(Equivalent to or) Cinch#54A17538
Bulb	T9

Dimensions and pin connections shown in outline on Page 10.

Note 1 All data are based on operation of the tube within average current ratings at the time of stepping or transfer of the discharge.

Note 2 Voltage, with respect to an operating cathode, at which conduction occurs from the auxiliary anode to cathode indicated.

Note 3 Measured with maximum K10 voltage of +50 volts with respect to the operating cathode.

Note 4 Voltage, with respect to an operating cathode, applied to the adjacent forward cathode to transfer the discharge to that cathode.

Note 5 Voltage, with respect to an operating output cathode, applied to an adjacent non-operating output cathode, which may cause transfer of the discharge to the non-operating output cathode.

Note 6 Voltage, with respect to the normal cathode, applied to one or both of the output cathodes K1 or K10, which may cause transfer of the discharge from the normal cathode to K1 or K10.

Note 7 Transfer from an output cathode to the normal cathode is the voltage, with respect to an operating output cathode, applied to the normal cathode, which will cause transfer of the discharge to the normal cathode.

Note 8 Values shown are measured under static conditions. The values represent absolute limits on output voltage for circuits in which resistive loads are connected to the output cathodes. See also Notes on Operating Principles and Applications, sections captioned (1) Cathode Output Characteristics, (2) Frequency Characteristics.

Note 9 The transfer characteristics shown in Figs. 2, 3, 4, and 5 apply only at an ambient temperature of 25°C. The transfer characteristics which apply at other ambient temperatures can be obtained by adding the correction voltages shown in Fig. 6 to the curves of Figs. 2, 3, 4, and 5. At ambient temperatures below 25°C the absolute value of the transfer voltage is reduced, and at ambient temperatures above 25°C the absolute value of the transfer voltage is increased.

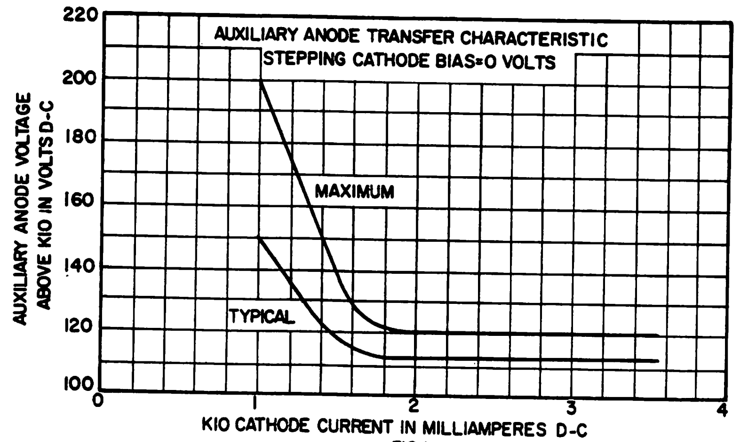


FIG. 1

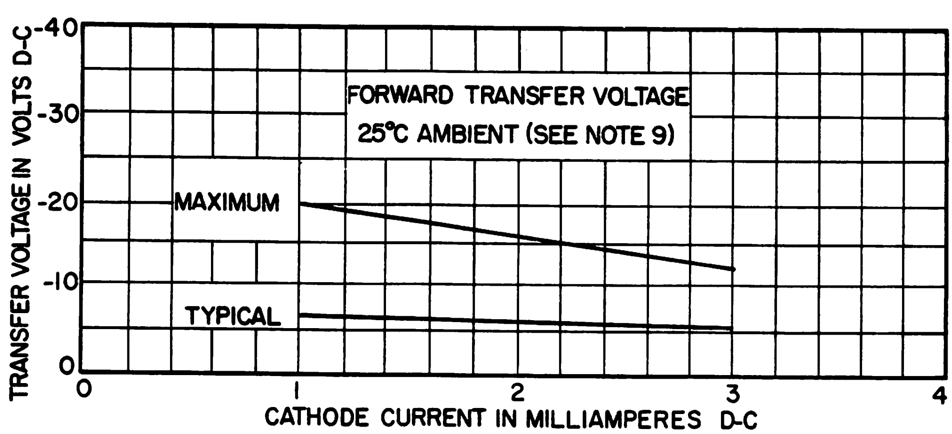


FIG. 2

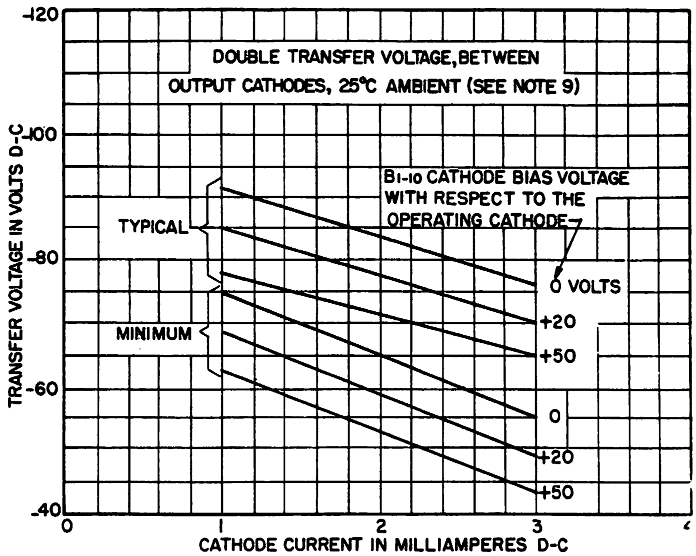

DOUBLE TRANSFER VOLTAGE, BETWEEN
OUTPUT CATHODES, 25°C AMBIENT (SEE NOTE 9)
B1-10 CATHODE BIAS VOLTAGE
WITH RESPECT TO THE
OPERATING CATHODE
TYPICAL
MINIMUM
0 VOLTS
+20
+50
0
+20
+50
TRANSFER VOLTAGE IN VOLTS D-C
-120
-100
-80
-60
-40
0
1
2
3
CATHODE CURRENT IN MILLIAMPERES D-C

FIG. 3

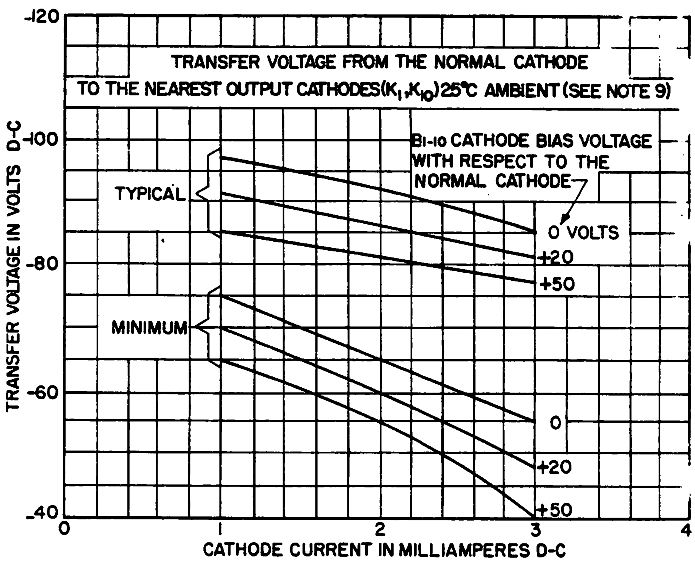
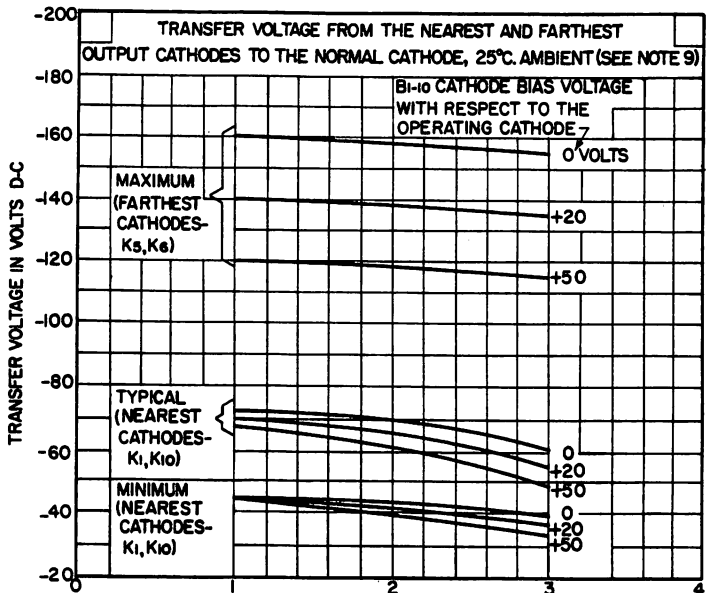
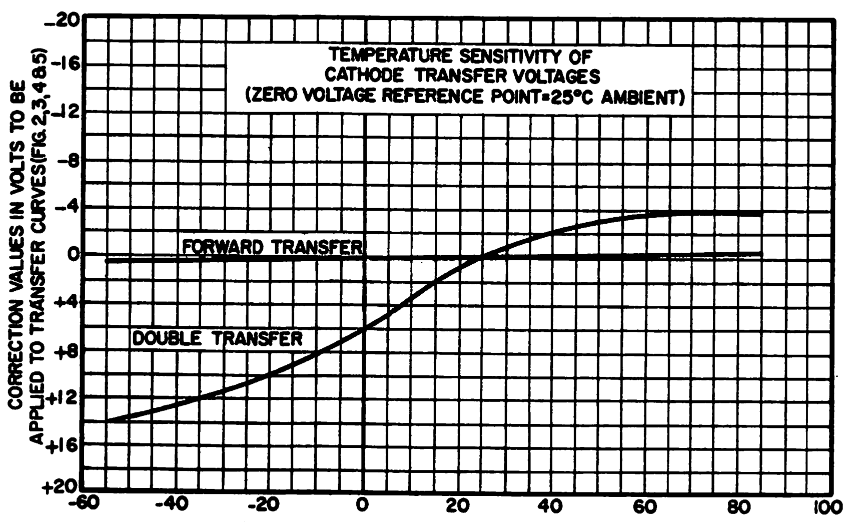

TRANSFER VOLTAGE FROM THE NORMAL CATHODE
TO THE NEAREST OUTPUT CATHODES(K_1,K_{10}) 25°C AMBIENT (SEE NOTE 9)
B1-10 CATHODE BIAS VOLTAGE
WITH RESPECT TO THE
NORMAL CATHODE
TYPICAL
MINIMUM
0 VOLTS
+20
+50
0
+20
+50
TRANSFER VOLTAGE IN VOLTS D-C
-120
-100
-80
-60
-40
0
1
2
3
4
CATHODE CURRENT IN MILLIAMPERES D-C

FIG. 4


TRANSFER VOLTAGE FROM THE NEAREST AND FARTHEST
OUTPUT CATHODES TO THE NORMAL CATHODE, 25°C. AMBIENT (SEE NOTE 9)
B1-10 CATHODE BIAS VOLTAGE
WITH RESPECT TO THE
OPERATING CATHODE
0 VOLTS
+20
+50
MAXIMUM
(FARTHEST
CATHODES-
K5,K6)
TYPICAL
(NEAREST
CATHODES-
K1,K10)
0
+20
+50
MINIMUM
(NEAREST
CATHODES-
K1,K10)
0
+20
+50
TRANSFER VOLTAGE IN VOLTS D-C
-200
-180
-160
-140
-120
-100
-80
-60
-40
-20
0
1
2
3
4
CATHODE CURRENT IN MILLIAMPERES D-C
FIG. 5


TEMPERATURE SENSITIVITY OF
CATHODE TRANSFER VOLTAGES
(ZERO VOLTAGE REFERENCE POINT=25°C AMBIENT)
FORWARD TRANSFER
DOUBLE TRANSFER
CORRECTION VALUES IN VOLTS TO BE
APPLIED TO TRANSFER CURVES (FIG. 2,3,4 & 5)
-20
-16
-12
-8
-4
0
+4
+8
+12
+16
+20
-60
-40
-20
0
20
40
60
80
100
AMBIENT TEMPERATURE IN DEGREES CENTIGRADE
FIG. 6

NOTES ON OPERATING PRINCIPLES AND APPLICATIONS

GENERAL DESCRIPTION

The essential features of the tube are shown in Fig. 7. Twenty cathodes surround the common anode. Alternate cathodes are called K or output cathodes and B or stepping cathodes respectively. Each of the ten K cathodes is connected to an external lead for output purposes. The B cathodes are internally connected in two groups of five; for most circuit applications these two groups are tied together externally.

A "normal" cathode, located outside the main ring of cathodes near cathode B_1, can be used to reset or normalize the tube.

The tube also has an auxiliary anode which can be used to produce an output signal on every tenth step.

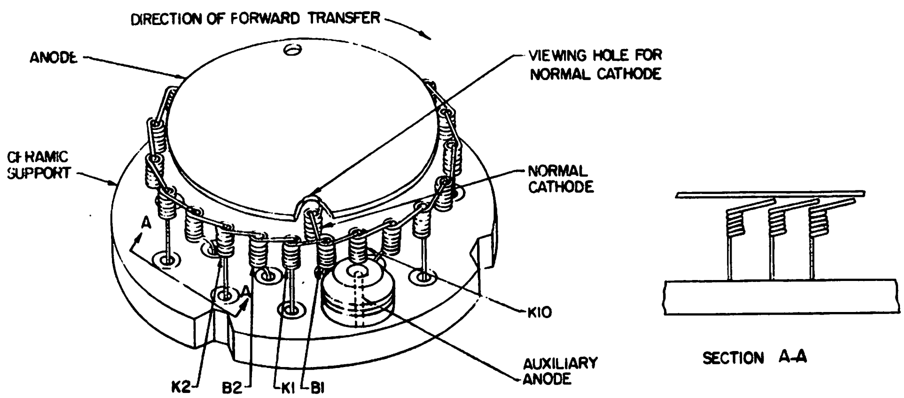


FIG. 7 CATHODE-ANODE STRUCTURE

STEPPING MECHANISM

Figure 8 shows three stages of a stepping tube with a discharge established between K_1 and the anode. If the B cathodes are at the same potential as K_1 or higher, the discharge remains in the gap between K_1 and the anode. However, if the potential of the B cathodes is depressed sufficiently below that of the K cathodes, the discharge transfers to one of the adjacent B cathodes. This causes the anode potential to fall below that needed to sustain the discharge to K_1, so that the discharge to K_1 extinguishes. If the B cathodes are then made more positive than the K cathodes, a similar transfer takes place, this time from the operating B cathode to an adjacent K cathode. By virtue of a built-in preference mechanism, the transfer always takes place in one direction (from left to right in Fig. 8). It follows that by biasing the B cathodes positively with respect to the K cathodes and by superimposing large negative pulses on the bias voltage, the discharge can be caused to step from K cathode to K cathode, the position of the discharge advancing one K cathode to the right for each pulse.

The preference in the direction of transfer is accomplished by making each cathode with a low-efficiency portion and a high-efficiency portion. The cathodes consist of a coil of wire forming a "hollow" and a wire extension, called a "pick-up tab" (see Fig. 7). The discharge is more efficient in the hollow than on the tab and the sustain voltage in the hollow is lower. The tab extends into the region of ionization of the preceding cathode. This facilitates transfer of the discharge to the cathode on the right when the potential of the right-hand cathode is sufficiently below that of the operating cathode. The discharge at first transfers to the tab, but since the discharge is relatively inefficient there, it travels immediately to the hollow portion. Curves of typical and maximum transfer voltage are shown in Fig. 2.

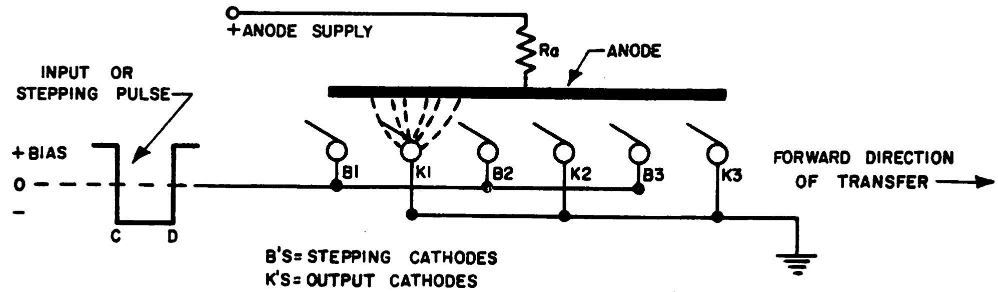


FIG. 8 3-STAGE STEPPING SYSTEM

NORMALIZING

The glow discharge can be transferred from any output cathode to the normal cathode by applying a sufficiently large negative voltage to the normal cathode. The magnitude of voltage needed to accomplish the transfer is given by the curves shown in Fig. 5. From Fig. 7 it can be seen that the stepping cathode B_1 has two pick-up tabs which enable it to transfer the discharge from normal to K_1 or from K_{10} to K_1. Hence, once the discharge is established on the normal cathode, the next stepping pulse transfers the discharge to K_1.

AUXILIARY ANODE OUTPUT

The auxiliary anode is located directly underneath output cathode K_{10} and is shielded from all other cathodes (see Fig. 7). At voltages below the breakdown limits shown in the data, the auxiliary anode remains at its supply voltage except when the discharge is on K_{10}. When the discharge steps to K_{10}, both the auxiliary anode and the main anode conduct to K_{10} and an output voltage can be detected by means of suitable circuitry connected to the auxiliary anode. Fig. 1 shows the minimum voltage which must be applied to the auxiliary anode for transfer to take place.

A typical auxiliary anode circuit is shown in Fig. 9. Shortly after the main discharge steps to K_{10} the auxiliary anode conducts to K_{10} in addition to the main anode. The resulting voltage drop appears across R as a negative signal which can be used to drive a succeeding stage or to operate other devices. If the components are properly chosen, the auxiliary anode discharge can be extinguished by stepping the main discharge to B_1. If R_{aa} and C are sufficiently large and R is sufficiently small, the circuit shown in Fig. 9 may function as a relaxation oscillator, giving output pulses at regular intervals as long as the discharge remains on K_{10}. However, such a circuit may be useful if the discharge is stepped out of K_{10} before the second output pulse is generated by the oscillator.

Time delay T, shown in the waveform of Fig. 9, represents the time required for the discharge to travel along the K_{10} pick-up tab, fill the hollow, and transfer conduction to the auxiliary anode. Its length is of the order of 100 to 200 microseconds, depending on cathode current and auxiliary anode voltage.

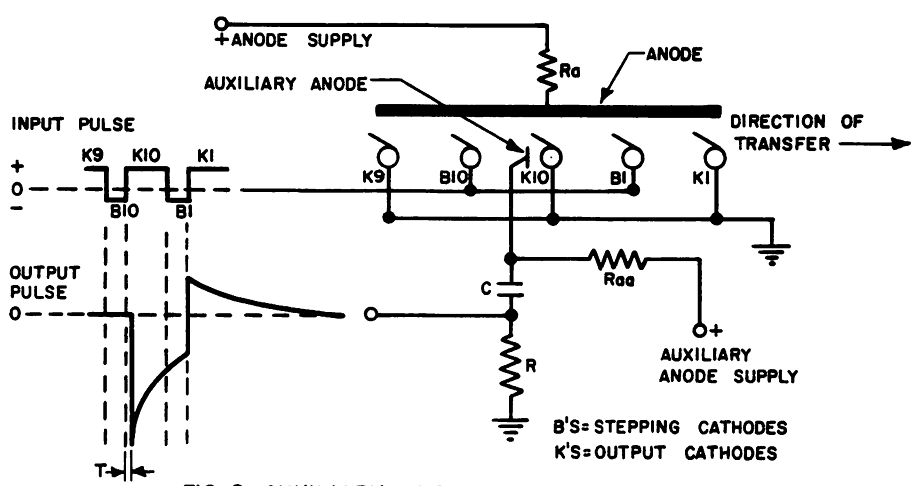


FIG. 9 AUXILIARY ANODE OPERATION

CATHODE OUTPUT CHARACTERISTICS

The position of the discharge can be readily observed from the top of the tube. If visual output is not adequate, an output signal may be taken from any desired K cathode by inserting resistors in series with the cathode leads. Fig. 10 shows a possible circuit. In such a circuit, greater peak-to-peak voltage must be applied to the B cathodes to accomplish the stepping function. To assure that the discharge to the K cathodes will be extinguished when the stepping pulse is applied, the negative swing of the stepping pulse must fall at least 10 volts below the K cathode return voltage. On the other hand, to assure that the discharge to the B cathodes will be extinguished when the stepping pulse is removed, the B cathodes must be biased at least 10 volts above the potential of the operating cathode, i.e., 10 volts above the output voltage developed across the cathode resistor. Therefore, the driving voltage necessarily exceeds the output voltage in magnitude.

In general, the magnitude of the output voltage is limited by the double transfer to either another output cathode or the normal cathode (see notes 5 and 7). The voltage curves which set these limits are shown in Figs. 3, 4, and 5.

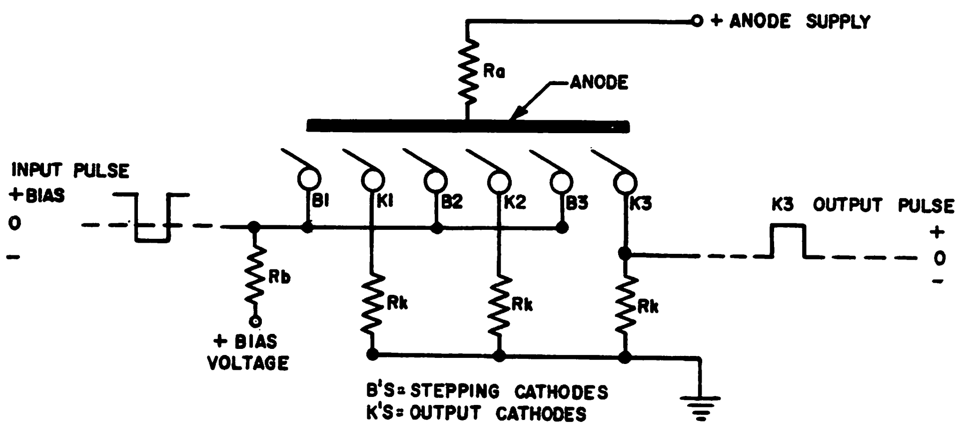


FIG. 10

FREQUENCY CHARACTERISTICS

At frequencies above about 1000 cycles per second, the deionization time of the gaps becomes a limit on available output voltage. To avoid back-transfer at high frequencies because of residual ionization in the preceding gap, it may be necessary to reduce the output voltage. It is also helpful to apply a square wave input pulse. This speeds up the transfer of the discharge into the hollow, thereby allowing more time for deionization of the preceding gap.

The circuit shown in Fig. 11 can be used to obtain greater output voltage at higher frequencies. In this circuit, a capacitor C_k across the output resistor R_k holds the output cathode being deionized positive to prevent back-transfer. In the particular case illustrated, transfer to the next K cathode (K_n + 1) takes place as soon as the discharge has traveled down the pick-up tab of B_n + 1, because K_n + 1 is appreciably more negative than B_n + 1. K_n, on the other hand, is held positive by its capacitor, so that transfer can only take place in the forward direction. Because the rise of the K_n + 1 voltage is delayed by the capacitor, the discharge to B_n + 1 is extinguished at the same voltage level at which transfer occurred. The required driving voltage is therefore smaller than in the all-R circuit. In this circuit the B cathodes are said to be "unstable" because the discharge remains on them for only a portion of the stepping pulse. The driving signal need only go from the bias voltage (V output + 10v) to a voltage which is below the output voltage by the maximum forward transfer voltage. The output voltage in turn must be greater than twice the forward transfer voltage. The time constant R_kC_k should be so chosen that C_k discharges almost completely by the time the same cathode is to conduct again.

The time required for transfer from K cathode to K cathode (t_2 - t_1) is less for higher output voltages. This results in an increased frequency limit. However, since the B cathodes are all connected together, no capacitor preference mechanism can be applied to them, and the ultimate frequency limit is determined by the condition that the spacing between B pulses be greater than the B-gap deionization time. The driving frequency limit for the circuit of Fig. 11 is approximately 5000 cps.

Other RC circuits can be constructed in which:

(1) B and K cathodes are stable
(2) B cathodes are stable, K cathodes are unstable
(3) B and K cathodes are unstable

Each of these modes has somewhat different design requirements.

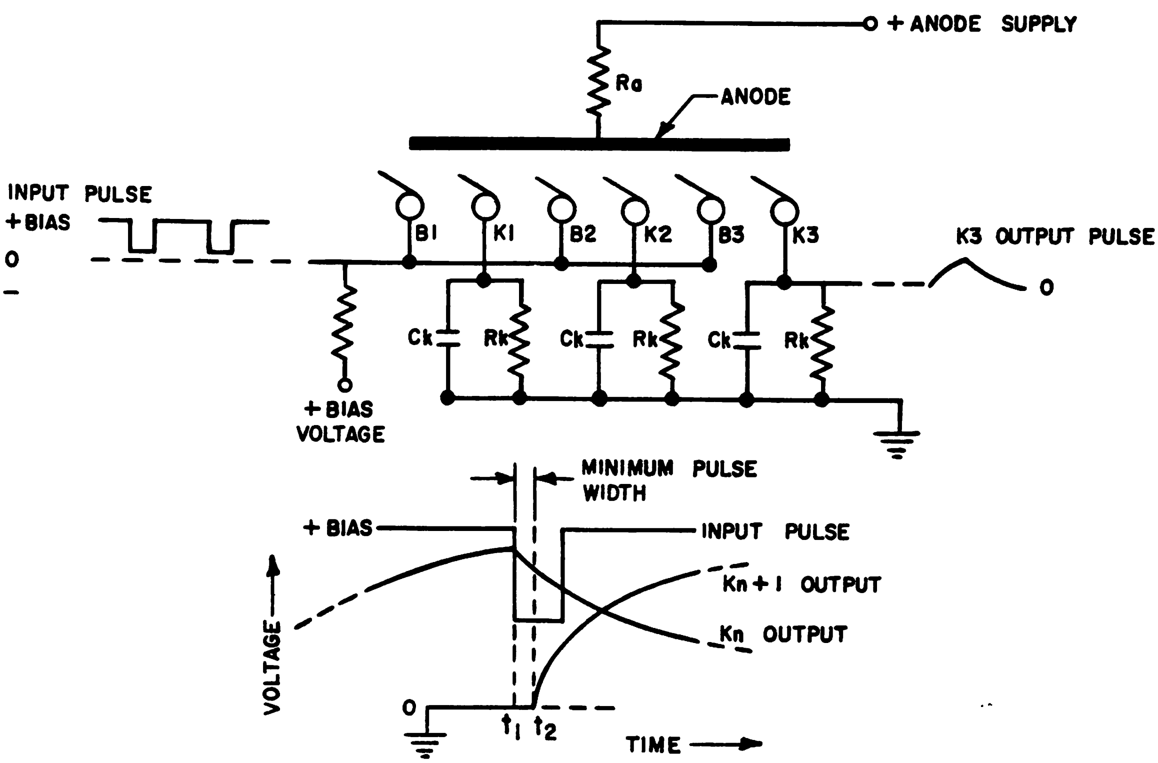
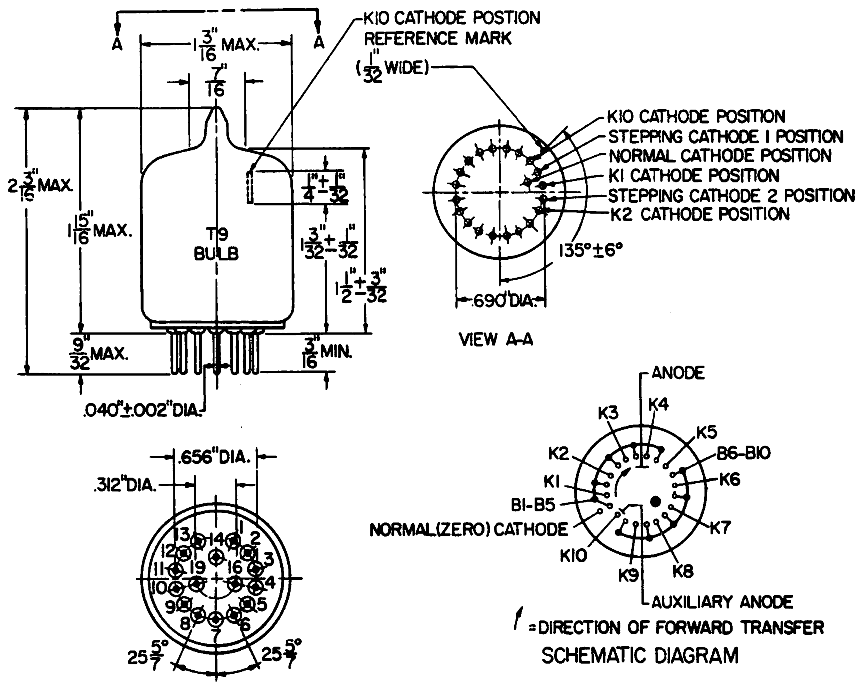


FIG. 11



PIN 1. OUTPUT CATHODE (K3)
PIN 2. OUTPUT CATHODE (K2)
PIN 3. OUTPUT CATHODE (K1)
PIN 4. OUTPUT CATHODE (K10)
PIN 5. AUXILIARY ANODE
PIN 6. (IC) INTERNAL CONNECTION
PIN 7. OUTPUT CATHODE (K9)
PIN 8. OUTPUT CATHODE (K8)
PIN 9. OUTPUT CATHODE (K7)
PIN 10. OUTPUT CATHODE (K6)
PIN 11. STEPPING CATHODES B6-B10
PIN 12. OUTPUT CATHODE (K5)
PIN 13. OUTPUT CATHODE (K4)
PIN 14. STEPPING CATHODES B1-B5
PIN 16. NORMAL CATHODE
PIN 19. ANODE

NOTE:- BASE PIN NO. 6 MARKED "INTERNAL CONNECTION" SHOULD NOT BE CONNECTED TO ANY PORTION OF AN EXTERNAL CIRCUIT. FAILURE TO OBSERVE THIS PRECAUTION MAY RESULT IN IMPROPER OPERATION OF THE TUBE.

A development of Bell Telephone Laboratories, the research laboratories of the American Telephone and Telegraph Company and the Western Electric Company