LABORATORY DATA SHEET

WESTERN ELECTRIC

VACUUM TUBES

THREE ELEMENT COLD CATHODE

313C 313CB 313CC 333A 346B 353A 359A 372A 376A 395A 727A

Classification

Double gap, cold cathode gas filled tubes for use as relays, rectifiers, or voltage regulators.

The elements of these tubes consist of a cathode, a control anode and a main anode. The conduction path between the cathode and the control anode is known as the control gap. The conduction path between the cathode and the main anode is known as the main gap. In some types a resistor is mounted in the base and is included in a control anode lead.

The glass bulb of some of the tubes has been given an opaque coating so that the discharge is not visible while the tube is operating.

The 395A and 727A vacuum tubes are similar with the exception that the 395A tube is designed to withstand high mechanical shock.

Mounting

The tubes may be mounted in either a vertical or horizontal position.

The following three types of bases are employed: a four prong base suitable for use in a standard four prong thrust type vacuum tube socket; an octal base suitable for mounting in any standard octal type vacuum tube socket; a four prong base suitable for stud mounting on a special bracket.

The base dimensions are shown on Figures 2, 3, 5, 7, 10 and 12.

The 359A, 395A and 727A vacuum tubes are unbased and designed for wiring into the circuit by soldering to the lead out wires. These tubes should be supported by a suitable clamp or holder in such a manner that no high local pressure will be exerted against the glass envelope.

Definitions

Control-gap breakdown voltage is the positive control anode potential required to initiate ionization and thereby start conduction in the control gap.

Control-gap sustaining voltage is the voltage drop across the control gap when current is flowing. It is approximately independent of current. It is this property which permits the tube to be used as a voltage regulator.

Main-gap breakdown voltage is the positive main anode potential required to start conduction in the main gap when no ionization is occurring in the control gap.

Main-gap working voltage is the voltage impressed between the main anode and the cathode. This voltage must be less than the main-gap breakdown voltage in order that operation of the tube may be controlled by the control-gap.

Main-gap sustaining voltage is the voltage drop across the main gap when current is flowing. It is approximately independent of current when the current passes through the tube in the normal direction. When current passes through the tube in the reverse direction the sustaining voltage increases rapidly with current. It is this asymmetry in the properties of the main gap which enables the tube to be used as a rectifier. Current-voltage characteristics of the main gap are shown in Figure 16.

Transfer current is the control-gap current required to start conduction in the main gap. The value of the transfer current is determined by the anode voltage and the tube design, it is zero at the main-gap breakdown voltage and approaches infinity at the main-gap sustaining voltage. The transfer current varies considerably from tube to tube and during the life of a given tube but will, in general, be well below the rated maximum value.

Deionization time is the time during which the voltage must be removed from the tube in order that the discharge shall not be reestablished when the voltage is restored. This time is greatly affected by the potentials applied to the tube electrodes during the deionization period. The deionization time increases with increasing applied voltage and with increasing current through the tube before the deionization period. To specify the deionization time completely a family of curves are required. For comparative purposes, however, the time is quoted as that required when a current of 20 milliamperes has been flowing through the tube and the reapplied potential is 130 volts in the main gap, or 5 volts above sustaining voltage in the control gap.

Transfer time is the time during which the control-gap must be energized in order that the discharge may transfer to the main-gap. This time increases with decreasing

control-gap current and with decreasing main-gap voltage. The transfer time varies considerably from tube to tube and through the life of a given tube. For main-gap voltages of 130 or more and for control-gap currents equal to or greater than the maximum rated transfer current the transfer time is in general less than 100 microseconds.

Current Ratings

The life of cold cathode tubes is determined primarily by the current at which they are operated. In the event that the tube is employed in intermittent service there is no deterioration during the idle periods. Since the life varies with the current through the tube and since in many applications the service is highly intermittent the tubes are given a number of current ratings so chosen as to yield a number of different expected current passing hours life. These ratings represent the average life to be expected from a group of tubes operating at the stated currents. Individual variations are considerable and may be expected to be of the order of plus or minus 50% of the stated figures. The tube life is considered to be ended when either the control gap breakdown voltage or the main gap sustaining voltage exceeds the maximum value specified for new tubes by 5%.

Inverse current is the maximum peak value of current which may be drawn in the reverse direction, i.e. with the anode negative. This rating is intended for use in circuit design and must be met by including a suitable resistor in the circuit. The value of the inverse current is set by sputtering of anode material. Excessive values of inverse current result in short tube life.

Operation Notes

Stability of breakdown voltages. The control gap breakdown voltage is subject to variation during shelf life. Thus, a tube which has been passing current and which has a given breakdown voltage may not have the same breakdown voltage after a period of standing. After passing current for a few seconds the control gap breakdown voltage will revert to its original value. The change in breakdown voltage due to shelf aging will depend upon the standing time but the full change may be expected to occur in one week. That is, tubes which stand longer than one week are not expected to show a greater change in breakdown voltage than those tubes which have stood for only one week. For this reason circuits should be so designed as to provide adequate voltage margins.

In general the variation in control gap breakdown voltage due to shelf aging will be less than ± 3 volts.

Tubes which are not subject to shelf aging but which pass current frequently may also show changes in the control gap breakdown voltage. The variation in control gap breakdown voltage during repeated operation of the tube is in general less than ± 1 volt.

Variation of breakdown voltage with life. The breakdown voltage varies but little with life during the first 75% of the expected life for the current drawn. It may be expected to remain constant within ± 3 volts during this period. During the last 25% of the life of the tube the breakdown voltage rises gradually.

Effect of light. The effect of strong illumination of tubes without the opaque coating is to reduce the breakdown voltage. In the control gap this reduction may amount to 1 or 2 volts but in the main gap it may amount to 50 volts. The values of breakdown voltage given in the tables apply to normal room illumination.

Variation of control gap breakdown voltage with frequency. The control gap breakdown voltage varies with frequency. An increase in frequency gives rise to an increase in breakdown voltage as shown in Figure 13. In consequence of this fact higher input levels must be used at higher frequencies.

Breakdown time. The control gap breakdown time is the time required for the control gap to break down after a voltage in excess of the breakdown voltage has been applied to the control gap. The time required will depend upon the voltage applied, the conditions of illumination, and the length of time the tube has been idle.

If the tube has been standing idle and is in total darkness, breakdown times of the order of 1 to 20 milliseconds may be expected with control gap voltages five volts greater than the breakdown voltage. On subsequent operations the breakdown time will be less than one millisecond.

The breakdown time after standing depends upon the length of time the tube has been standing but the maximum breakdown time will be found within 24 hours of standing.

Normal room illumination will be sufficient to reduce the breakdown time to one millisecond or less regardless of the time the tube has been standing idle.

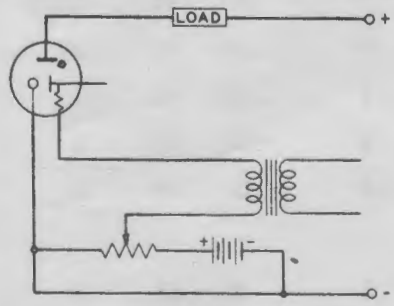
Effect of Ambient Temperature. The breakdown and sustaining voltages are independent of ambient temperature changes in the range of -40°C to +60°C.

Typical Circuits

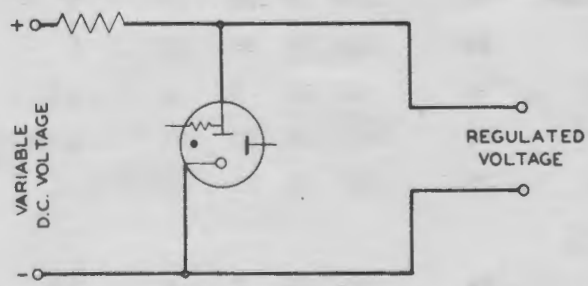
Circuit A shows a circuit using a cold cathode tube as a relay. The supply voltage should be intermediate between the main-gap breakdown and sustaining voltages and the control anode may be biased at any desired potential less than the control-gap sustaining voltage. The resistance in the control anode circuit may be of the order of 100,000 ohms. This circuit possesses a "lock-in" feature, since the anode potential must be removed momentarily to restore the tube to a non-conducting condition. When supplied from alternating current this circuit does not possess a "lock-in" feature unless the frequency of the supply voltage is so high that the tube is not allowed a sufficient interval to deionize.

Circuit B shows a circuit using a cold cathode tube as a rectifier. The rectifying properties of the main-gap are used but the control anode should be connected into the circuit as indicated, through a high resistance. This will cause conduction in the forward direction to begin at a voltage much below the main-gap breakdown voltage. It is important to note that as a rectifier this tube possesses a unique property not common to other rectifiers in that its impedance is infinite for voltages below the control-gap breakdown voltage. In many applications this is of importance since the tube may be used to pass current at the higher potentials without placing a bridge across the line for signals of lower voltage.

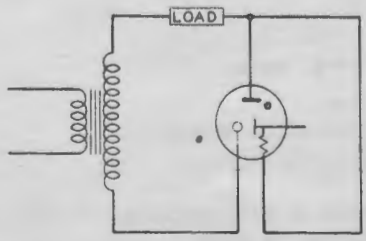
Circuit C shows a circuit using the control gap of a cold cathode tube as a voltage regulator.



CIRCUIT A



CIRCUIT C



CIRCUIT B

CHARACTERISTICS AND RATINGS

Code No.	Outline Drawings	✻Control-Gap Breakdown Voltage, d-c Min	Nom	Max	Control-Gap Sustaining Voltage, d-c At 20 ma Min	Nom	Max	Recommended Maximum Main-Gap-Working Voltage, d-c	Main-Gap Sustaining Voltage, d-c At 20 ma Min	Nom	Max
313C	Figs. 1 & 2	65	70	85	55	60	70	150	68	75	85
313CB	Figs. 1 & 2	65	70	85	55	60	70	170	74	76	78
313CC	Figs. 1 & 2	69	72	74	55	60	70	150	68	75	85
333A ■	Figs. 4 & 5	65	70	85	55	60	70	150	68	75	85
346B ■	Figs. 6 & 7	65	70	85	55	60	70	225	75	80	85
353A ■	Figs. 8 & 7	65	70	85	55	60	70	150	68	75	85
359A	Figs. 9 &10	70 §	75 §	85 §	55†	60†	70†	165	68†	75†	85†
372A ■	Figs. 4 & 3	65	70	85	55	60	70	150	68	75	85
376A	Figs 11 &12	65	75	90	55	60	70	275	65	70	80
395A 727A	Figs 9A &10 Figs 9B &10	74 §	77 §	80 §	55†	60†	70†	140	68†	75†	85†

Code No.	Transfer Current At 130V µa Max.	Typical Fig.	Forward Current ma, d-c For Life Of 10 hrs	100 hrs	1000 hrs	10000 hrs	Nominal Deionization Time Millisec Control-Gap	Main-Gap	Peak Inverse Current ma Max.	Cathode Current Max. peak ma	ave. ma, d-c	tave⊕ sec
313C	5	14	100	35	20	10	3	10	5	100	35	2
313CB	5	14	50	18	10	5	3	10	5	50	18	2
313CC	5	14	50	18	10	5	3	10	5	50	18	2
333A	5	14	100	35	20	10	3	10	5	100	35	2
346B	200✻✻	15	100	35	20	10	2	8	5	100	35	2
353A	5	14	100	35	20	10	3	10	5	100	35	2
359A ♦	50	14	40	15	8	4	2†	8†	1	40	15	1
372A	5	14	100	35	20	10	3	10	5	100	35	2
376A	300	15	50	18	10	5	0.5	2	5	50	18	2
395A ♦ 727A ♦	5	14	35	13	7	4	3†	10†	1	35	13	1

Note: Codes in **BOLD FACE TYPE** have same electrical characteristics.

✻ For further information see Operation Notes.

✻✻ at 110 volts.

† at 10 milliamperes, d-c.

♦ Control gap peak inverse current 1 milliampere.

■ 120,000 Ohms, 1/2 Watt resistance in base.

§ These breakdown limits refer to those obtained just after tube has been conducting.

⊕ tave = maximum averaging time for cathode current.

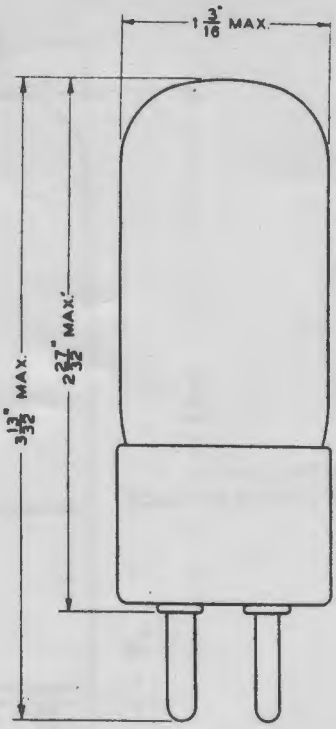


FIG. 1

R.M.A. M8-071
STANDARD SMALL
4-PIN BASE

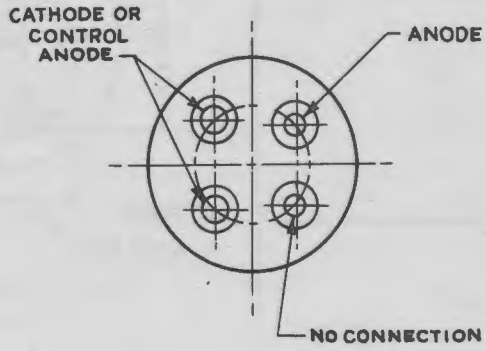


FIG. 2

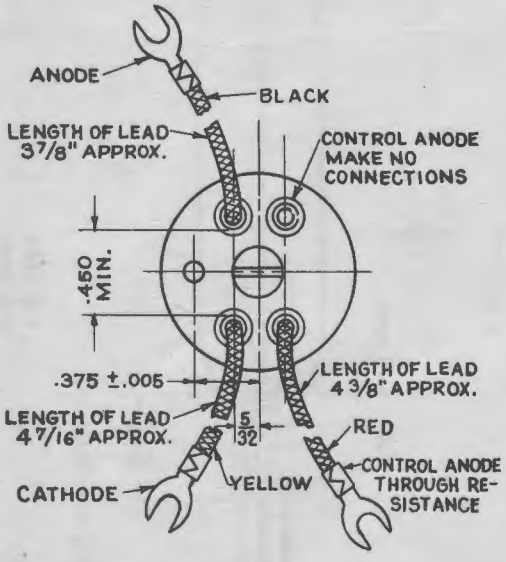


FIG. 3

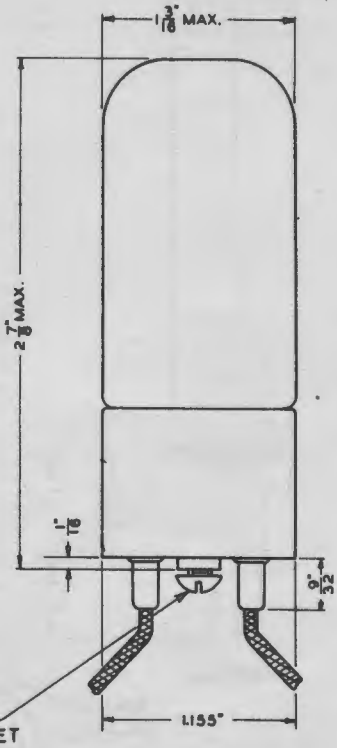


FIG. 4

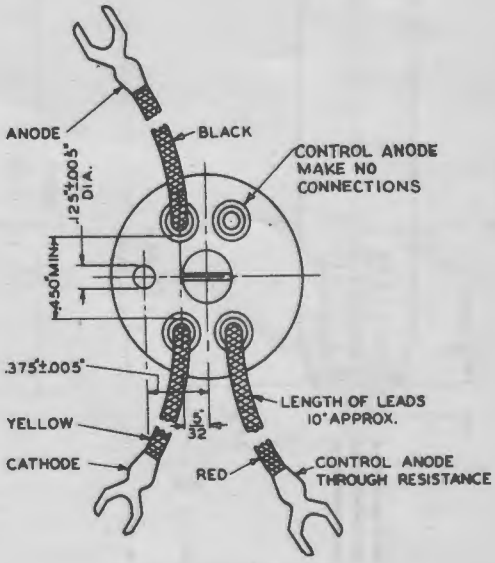


FIG. 5

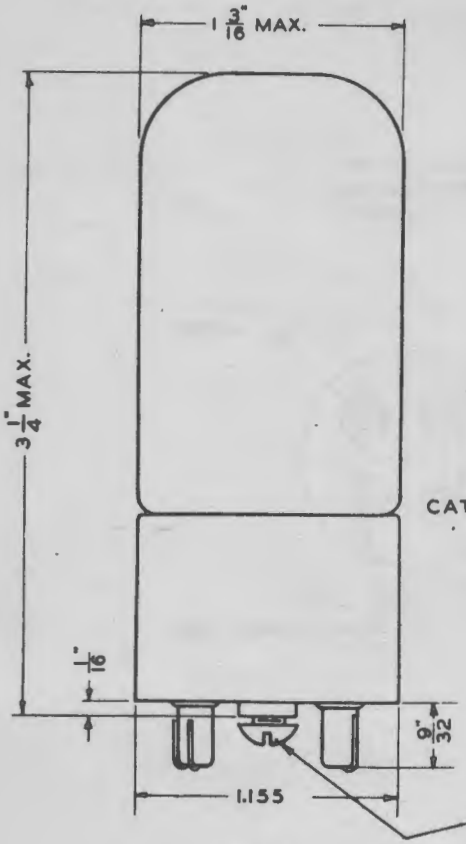


FIG. 6

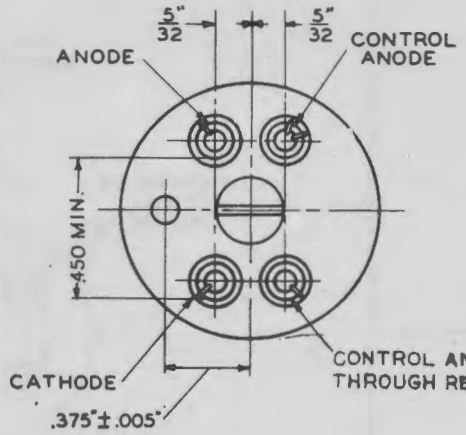


FIG. 7

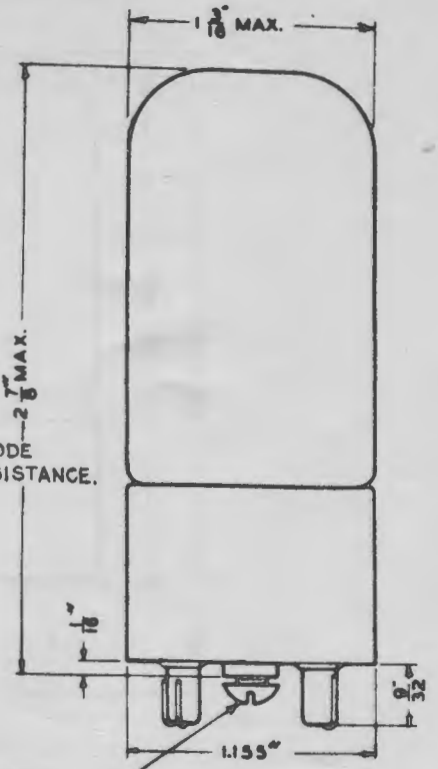


FIG. 8

.164-32 X 3/16" SCREW FOR MOUNTING ON BRACKET 3/64" THICK.

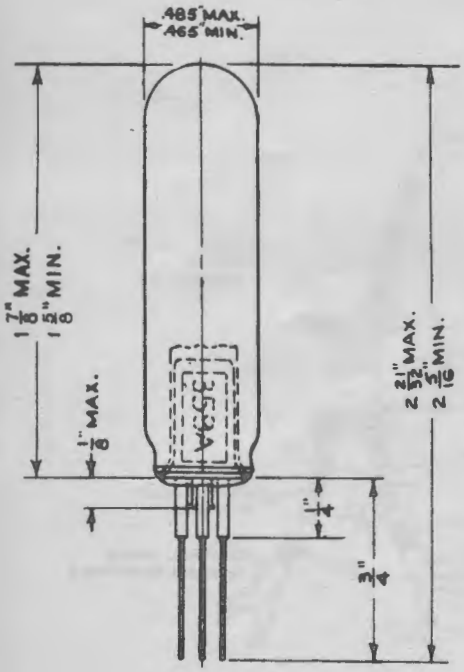


FIG.9

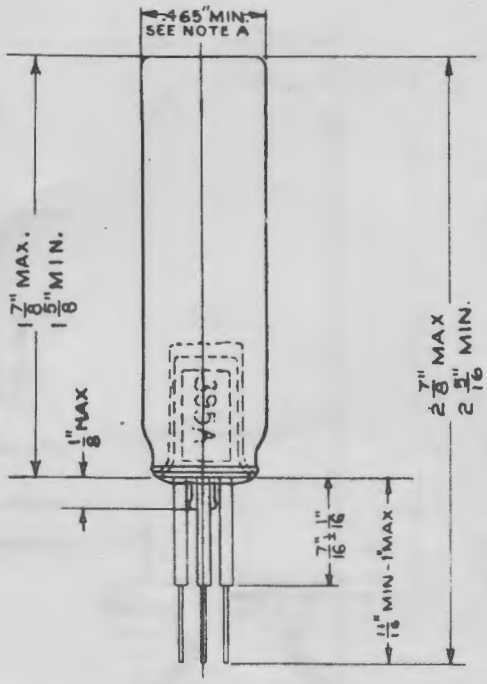


FIG.9A

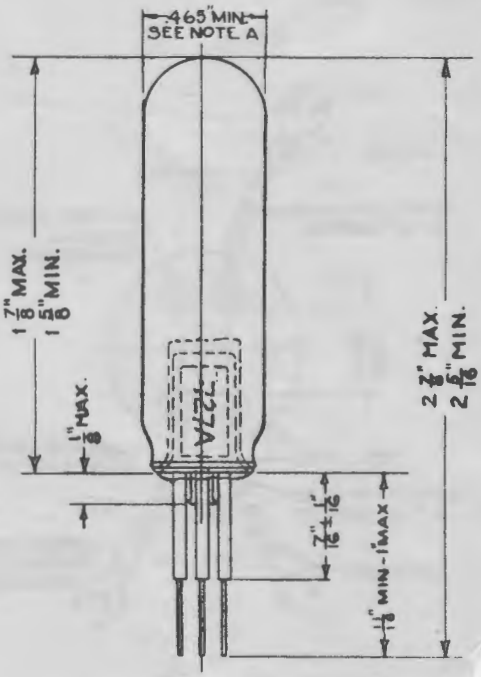


FIG.9B

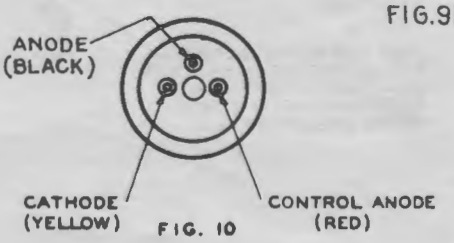


FIG. 10

NOTE A
THE TUBE SHALL BE CAPABLE OF BEING PASSED THROUGH A GAUGE OF .500 MAX. DIA. 1/2 INCH MIN. LENGTH.

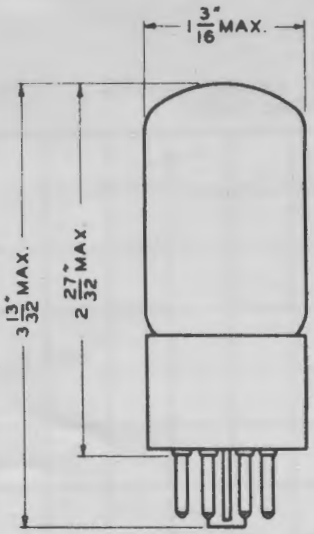


FIG. 11

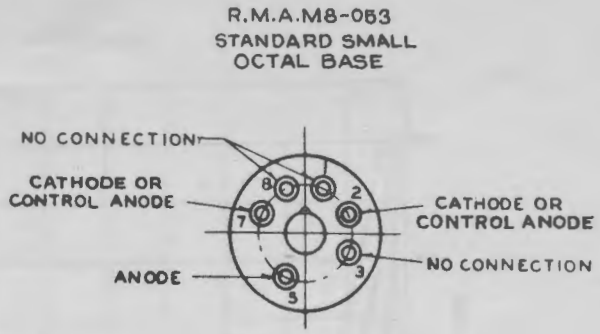


FIG. 12

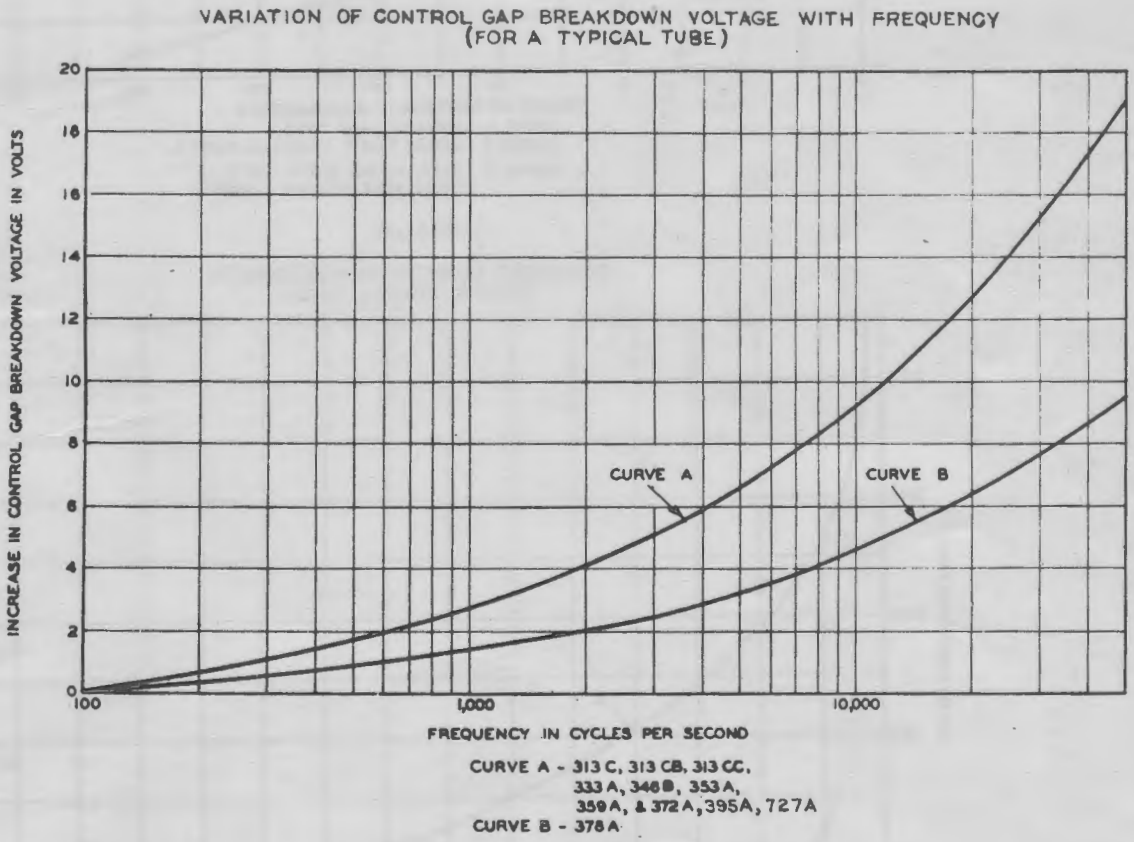
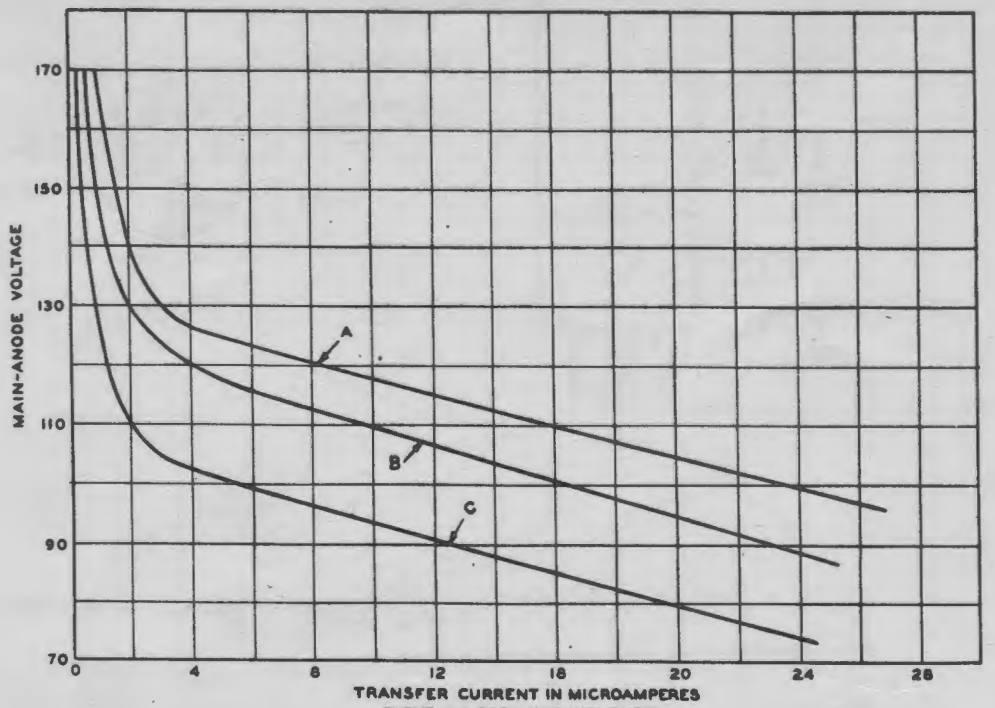


FIG. 13

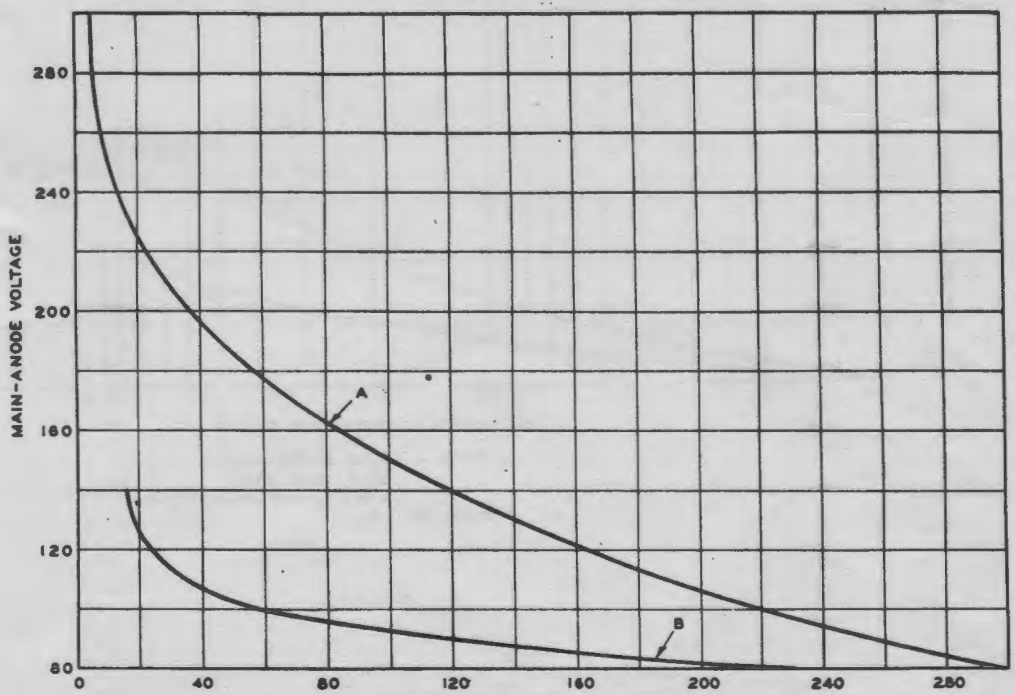
TRANSFER CURRENT CHARACTERISTIC
(FOR A TYPICAL TUBE)



TRANSFER CURRENT IN MICROAMPERES
CURVE A - 359A VACUUM TUBE
CURVE B - 395A, 727A VACUUM TUBES.
CURVE C - 313C, 313CB, 313CC, 333A, 353A, 372A VACUUM TUBES

FIG 14

TRANSFER CURRENT CHARACTERISTIC
(FOR A TYPICAL TUBE)



TRANSFER CURRENT IN MICROAMPERES
CURVE A - 376A VACUUM TUBE
CURVE B - 346B VACUUM TUBE

FIG. 15

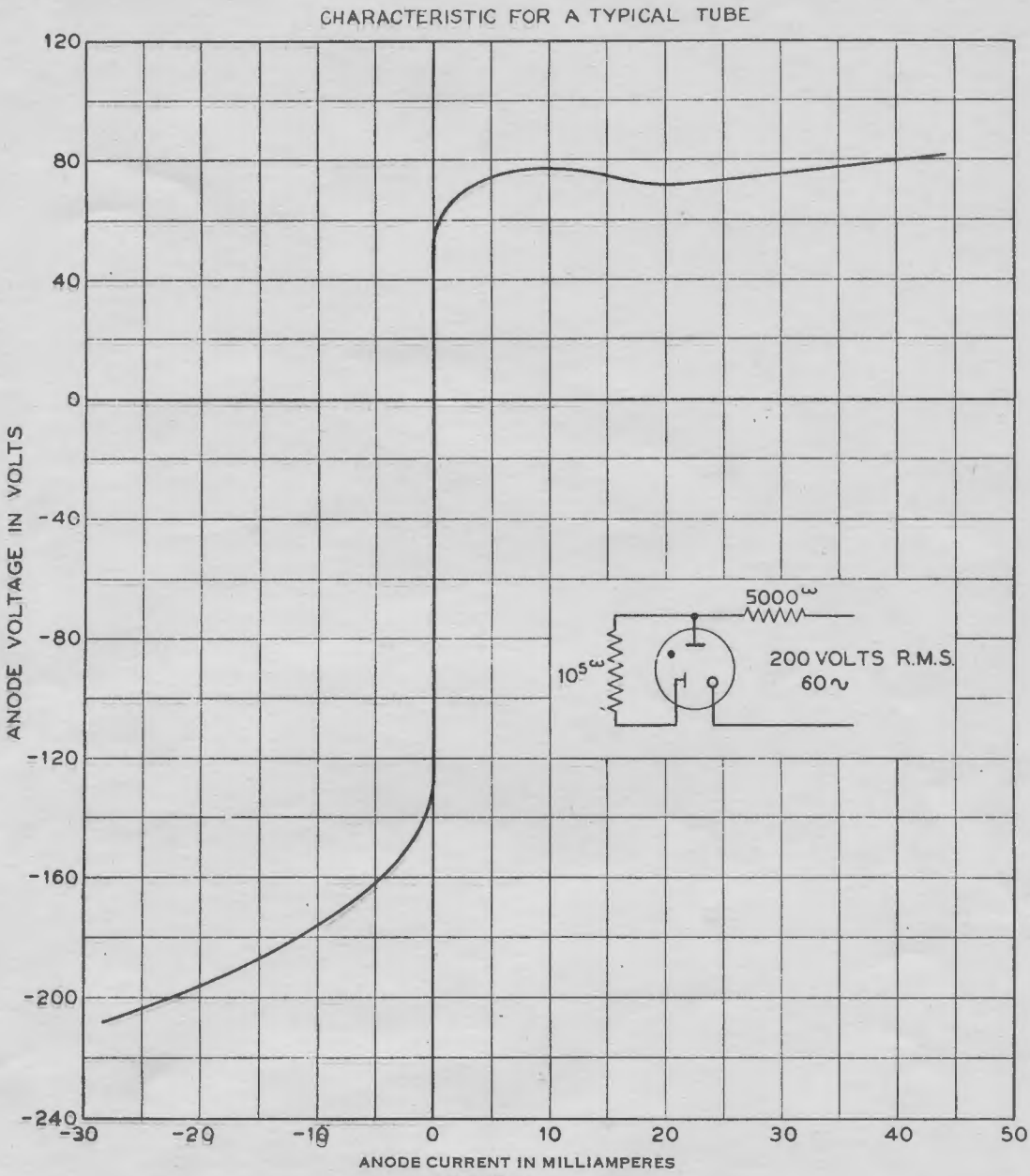

CHARACTERISTIC FOR A TYPICAL TUBE
120
80
40
0
-40
-80
-120
-160
-200
-240
ANODE VOLTAGE IN VOLTS
-30
-20
-10
0
10
20
30
40
50
ANODE CURRENT IN MILLIAMPERES
5000ω
10⁵ω
200 VOLTS R.M.S.
60∿

FIG. 16