RADIOTRONICS

AMALGAMATED WIRELESS VALVE CO. PTY. LTD.

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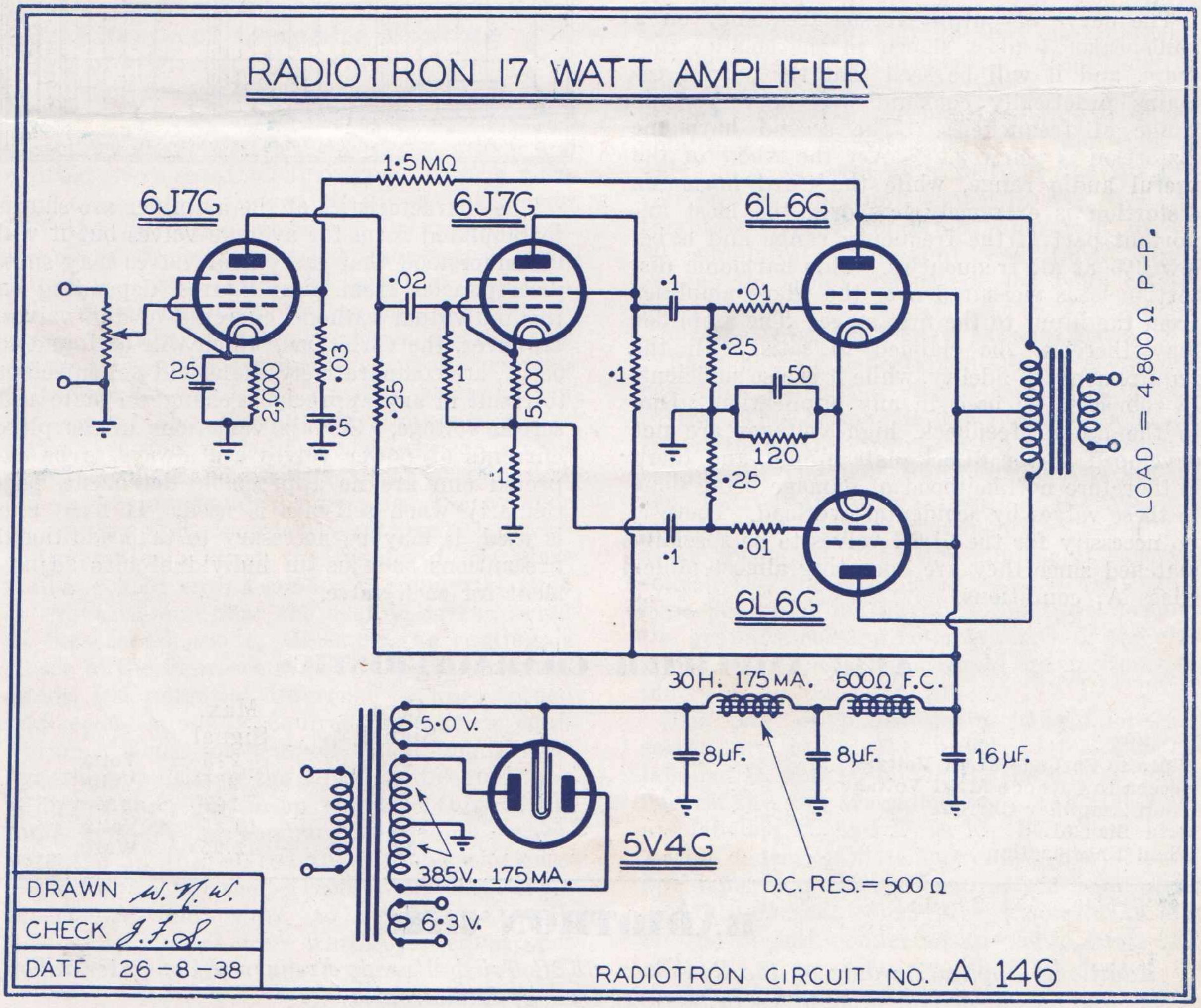
17 WATT 6L6G AMPLIFIER



17 WATT 6L6G AMPLIFIER

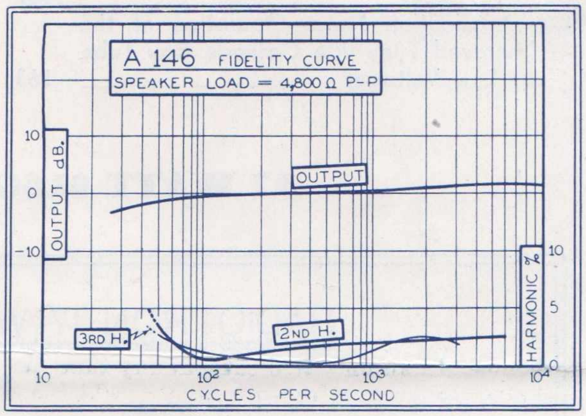
Radiotron Circuit A146

An intermediate size of amplifier is required for numerous applications and Radiotron Circuit A146, giving an output of 17 watts, has been designed to satisfy this demand. Two Radiotron 6L6G valves are used in slightly over-biased Class A_1 push-pull operation, and since self-bias is employed the total current drain only increases from 158 to 167 mA. from no signal to maximum signal. This constancy of current drain enables the field coil to be inserted in series with the filter to give the greatest economy in components. Alternatively, if it is desired to operate the amplifier from a large genemotor, this is quite practicable without the loss of output which tends to occur when the plate current changes to any considerable extent.

Negative feedback of a similar kind to that used in several previous amplifiers has been employed, and the voltage from the plate circuit of the 6L6G stage is fed back through a suitable voltage divider to the screen grid of the first 6J7G stage. The feedback percentage is adjusted so that at full signal output the input voltage to the first stage is 0.24 volt R.M.S., and the gain reduction factor in the 6L6G's is 2.35.

The curve of output versus frequency on a loudspeaker load is shown in the smaller diagram, and it will be seen that the output remains practically constant over a very wide range of frequencies. The second harmonic distortion is below 2.5% over the whole of the useful audio range, while the third harmonic distortion is extremely low over the most important part of the frequency range and is below 3% at all frequencies. This harmonic distortion is as measured over the whole amplifier from the input to the first stage. The amplifier may therefore be claimed to satisfy all the requirements of fidelity, while it is also sufficiently robust to be used in any application. Due to the use of feedback, high voltages are not developed in the 6L6G plate circuit and there is therefore no likelihood of damage being done to these valves by accidental overload. There is no necessity for the 6L6G valves to be specially matched since they are operating almost under Class A_1 conditions.

The power supply incorporates a 385-385 volt 175 mA. transformer and Radiotron 5V4G rectifier. A two-stage filter is necessary and the first filter choke is rated at 30 henries 175 mA. and the second is the field of the loudspeaker. This field will receive energisation to the extent of 12.5 watts at zero signal and reaching just under 14 watts with maximum signal. If the first filter choke has a lower resistance than 500 ohms, it will probably be found necessary to add further resistance in series in order to maintain the plate to cathode voltage of the 6L6G's at 275 volts on maximum signal. The rise of plate voltage at zero signal is quite permissible and does not exceed the plate or screen dissipation of the valves.



The characteristics of the amplifier are shown in tabulated form for average valves but it will be understood that individual valves may show discrepancies from these figures, depending on the individual cathode currents of the valves. However, the variations, which will be found to occur, are comparatively slight and not sufficient to result in any appreciable change in plate and screen voltage. Certain variations in the plate currents of power valves are always to be expected and are no appreciable detriment, particularly when self-bias is used. If fixed bias is used, it may be necessary to take additional precautions such as an individual bias adjustment for each valve.

A146 AMPLIFIER CHARACTERISTICS

	Zero Signal	Max. Signal	
Plate to Cathode 6L6G Voltage	286	275	Volts
Screen to Cathode 6L6G Voltage	286	275	Volts
Total Amplifier Current	158	167	mA.
Grid Bias 6L6G	18.85	19.85	Volts
Field Energisation	12.5	13.95	Watts

RADIOTRON 6K8G

Additional application data on the Radiotron 6K8G Triode-Hexode Frequency Converter will be given in the next issue of Radiotronics.

RCA APPLICATION NOTE

OPERATION OF THE IMPROVED TYPE 906 CATHODE-RAY TUBE AT LOW VOLTAGES

An important low-voltage operating condition for the type 906 cathode-ray tube has been established on the basis of a recent improvement in the design of this tube type. This improvement consists in the use of a graphite coating on the inside of the glass envelope. This coating, which is connected to the second anode inside the tube, in addition to permitting the tube to operate satisfactorily at comparatively low voltages, reduces the loading effects of the vertical deflection plates, reduces spot displacement due to the use of high resistance between a pair of deflection plates, and decreases reflections of the luminescent trace from the inner walls of the tube. Reducing reflections from the inner walls of the tube increases the contrast between dark and luminous areas of the screen. Good spot size, good definition, and high sensitivity can be obtained with only 400 volts on the second anode. This new operating condition is important because it enables a three-inch cathode-ray tube to be used with a low-cost power-supply unit. Typical 400-, 600-, 1200-, and 1500-volt operating conditions for the type 906 are given in Table I.

Effects of Graphite Coating

It is of interest to discuss briefly the manner in which the graphite coating improves performance. In an uncoated cathode-ray tube, the secondary electrons from the screen, which are emitted because of bombardment by the electron beam, are attracted to the second anode and the deflection plates. The removal of secondary electrons from the fluorescent screen causes the potential of the screen to rise to a value which is somewhat less than the second-anode voltage. A steady screen potential is reached when the number of electrons arriving at the screen equals the number emitted from the screen. Thus, for any static operating condition, the potential difference between screen and second anode adjusts itself to maintain an equilibrium condition between the number of primary and secondary electrons.

Suppose now, that the inside of the glass wall is coated with a conducting material, such as graphite, and that the coating is connected to the second anode. Because the coating is closer to the fluorescent screen than the second anode, less potential difference between screen and second anode is required to maintain equilibrium. Thus, for a given second-anode voltage, the potential of the screen in a coated tube is higher than that in an uncoated tube of the same type. The comparatively high screen potential in the coated tube allows the electrons to strike the screen with low beam divergence and, thus, to produce a well-defined spot. In other words, for equal spot definition, a coated tube requires less second-anode voltage than an uncoated tube of the same type.

When the second-anode voltage on a cathode-ray tube is low, the entire screen may become charged due to impact by low-velocity electrons. When the second-anode voltage is increased while the screen is so charged, a value of second-anode voltage is found at which the charge on the screen is neutralized by the beam. The value of this second-anode voltage determines the minimum second-anode voltage for satisfactory operation. This value of voltage is less for the coated type 906 than for the uncoated type, because of the relatively small difference in potential between screen and second anode in the coated-type tube.

Power-Supply Unit

A power-supply unit for low-voltage operation of the improved type 906 is shown schematically in Fig. 1. A type 80 valve is used as a rectifier. A single 1 μf condenser of comparatively low voltage rating provides adequate filtering for most applications.

In some cases, it is desirable to have a spot of better definition than is obtainable under the 400-volt conditions. For such applications, the second-anode voltage may be increased to 600 volts. Typical operating conditions for 600 volts on the second anode are given in Table I. Power-supply data for this operating condition are shown in Fig. 1. The type 80 valve may be used as a rectifier for the 600-volt power-supply unit shown in Fig. 1. Under this low-current condition, operation of the 80 simulates choke-input conditions closely enough to permit the use of 450 volts (RMS) per plate.

Deflection-Plate Resistance

Each pair of deflection plates in a cathode-ray tube loads the circuit connected to the plates. This loading is due to capacitance between the plates and to a flow of current to the plates. The deflecting plates collect secondary electrons from the screen. In the type 906, one plate of each pair connects to the second anode inside the tube. The number of electrons collected by the free plates is less in the coated-type 906 than in the uncoated type, because the graphite coating collects many of the electrons which otherwise would go to the free plates in an uncoated tube.

The pair of plates nearest the fluorescent screen are called the upper plates and are labelled D_1 and D_2 in Fig. 1; the pair of plates nearest the gun are called the lower plates and are labelled D_3 and D_4 in Fig. 1.

The deflection-plate current is not constant but depends on the position of the beam. This variable current constitutes a non-linear load on the circuit connected to the plates. The effect of a non-linear load is to distort the trace of an applied voltage. To reduce this effect, the minimum resistance presented by a pair of deflection plates to an external impedance should be much higher than the value of the external impedance.

Approximate values of minimum deflection-plate resistance for different values of second-anode current are given in Table II. These data obtain for the coated- and uncoated-type 906 at the 400- and 1200-volt operating conditions and for the position of the spot corresponding to maximum loading. These data show that the upper deflection-plate resistance of the coated tube is several times that of the uncoated tube. The lower deflection-plate resistances are about the same for both tube types. The high ratio of lower to upper deflection-plate resistance is due to the relative location of these pairs of plates; the upper plates are so disposed as to shield the lower plates.

Spot Displacement

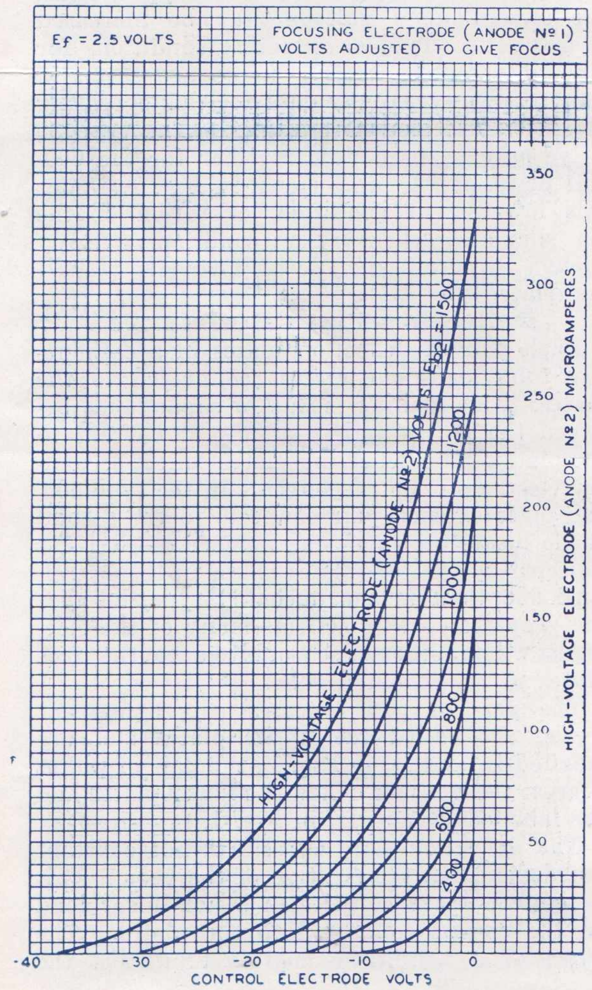
The electron current to the free plates causes another undesirable effect known as spot displacement. The position of the spot on the screen varies with the value of resistance connected between plates. This variation in position is due to the voltage drop across the resistor; the voltage drop, in turn, depends on the current flowing to the free plates.

The relations between spot displacement and external resistance for the 400- and 1200-volt operating conditions are shown in Figs. 2A and 2B. The data in Fig. 2A obtain for the coated tube and the data in Fig. 2B obtain for the uncoated tube. The values of displacement shown by the curves obtain when the spot is near the edge of the screen, where maximum displacement is observed. The displacement is less for other positions of the spot. These curves indicate clearly the superior performance of the coated-type 906. The external voltage necessary to position the spot properly can be determined from the given values of deflection sensitivity and spot displacement.

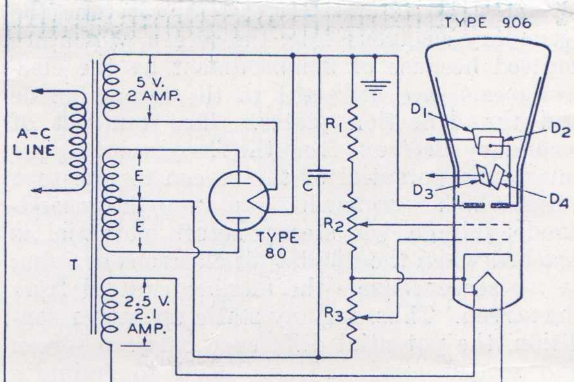
Conclusion

A graphite coating on the envelope of the type 906 cathode-ray tube permits the use of this tube at low voltages. In addition, the coating increases the upper deflection-plate resistance and reduces the spot displacement. The spot definition of the improved 906 with only 400 volts on the second anode is adequate for most applications.

906
AVERAGE CHARACTERISTICS



POWER-SUPPLY UNIT
FOR TYPE-906 CATHODE-RAY TUBE



ITEM	400-VOLT OPERATION	600-VOLT OPERATION
RECTIFIER	TYPE 80	TYPE 80
T	240 V./650 V. WITH CENTER TAP (E = 325 V.); FILAMENT WINDINGS AS SPECIFIED.	240 V./900 V. WITH CENTER TAP (E = 450 V.); FILAMENT WINDINGS AS SPECIFIED.
C	1 µf, 450 V.	0.5 µf, 600 V.
R_1	0.25 MEG., 0.5 WATT	0.4 MEG., 0.5 WATT
R_2	0.15 MEG., 1.0 MA.	0.5 MEG., 1.0 MA.
R_3	0.015 MEG., 1.0 MA.	0.03 MEG., 1.0 MA.

FIG. 1

TABLE I
Operating Conditions for Type 906

HEATER VOLTAGE	2.5	2.5	2.5	2.5	Volts
ANODE NO. 2 VOLTAGE	400*	600	1200	1500	Volts
ANODE NO. 1 VOLTAGE (Approx.)	128	170	345	475	Volts
NEGATIVE GRID VOLTAGE	Adjusted to give suitable luminous spot.				
GRID VOLTAGE FOR CURRENT CUT-OFF (Approx.)	−30	−45	−60	−70	Volts
DEFLECTION SENSITIVITY:					
Plates D_1 and D_2 (Upper Plates)	0.81	0.55	0.27	0.22	Mm/volt d.c.
Plates D_3 and D_4 (Lower Plates)	0.87	0.58	0.29	0.23	Mm/volt d.c.

* This operating condition is recommended only for coated type 906.

TABLE II
Minimum Deflection-Plate Resistance of the Type 906

MINIMUM DEFLECTION-PLATE RESISTANCE* Megohms

ANODE No. 2 CURRENT μamp.	400-VOLT OPERATION COATED BULB Plates Upper[1]	400-VOLT COATED BULB Plates Lower[2]	400-VOLT UN-COATED BULB Plates Upper[1]	400-VOLT UN-COATED BULB Plates Lower[2]	1200-VOLT OPERATION COATED BULB Plates Upper[1]	1200-VOLT COATED BULB Plates Lower[2]	1200-VOLT UN-COATED BULB Plates Upper[1]	1200-VOLT UN-COATED BULB Plates Lower[2]
1	110	150	55	150	100	225	50	225
5	55	60	19	55	40	100	20	80
10	35	55	16	35	35	95	14	95
50	16	20	5	15	15	35	4.5	30
100	10	9	2.8	8	8	25	2.5	15

* Approximate [1]Plates D_1 and D_2 [2]Plates D_3 and D_4

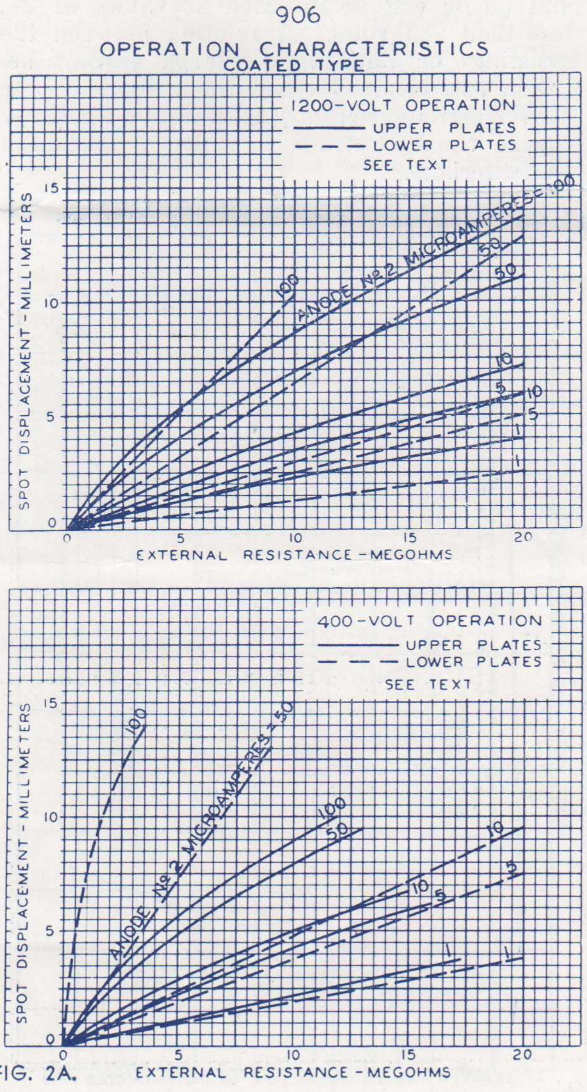


FIG. 2A.

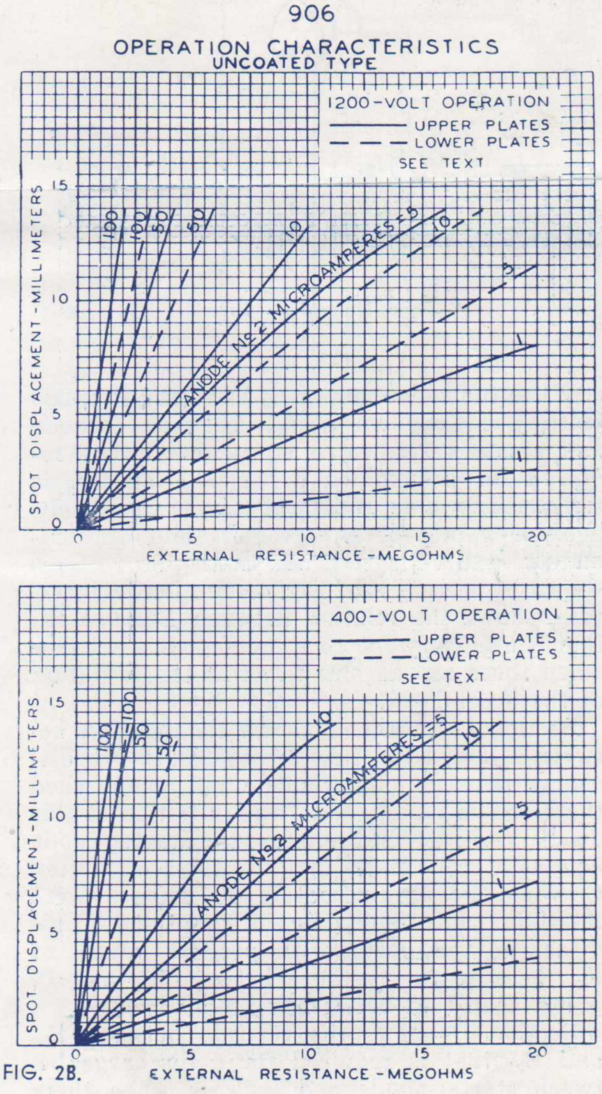


FIG. 2B.

RCA APPLICATION NOTE

OPERATION OF THE GAS TRIODE 0A4-G

Breakdown Characteristics

Any one of six different discharges may occur in a gas-triode, depending on the relative potential differences and relative distances between electrodes. The closed curve which describes the voltage conditions necessary for breakdown between any two electrodes in a tube of given geometry is called the breakdown characteristics of the tube.

Consider the test circuit of Fig. 3. A voltage E_{bb1} is applied to P_1 through a high resistance R_{b1}; a voltage E_{bb2} is applied to P_2 through a load impedance R_{b2}. From the curve of a typical tube shown in Fig. 4, it will be noted that for values of E_{b2} less than approximately +285 volts, no discharge is initiated until E_{b1} is approximately +85 volts. When this value is reached, a discharge between K and P_1 is initiated. This condition is depicted by section A (above zero ordinate) of the breakdown characteristics shown in Fig. 4.

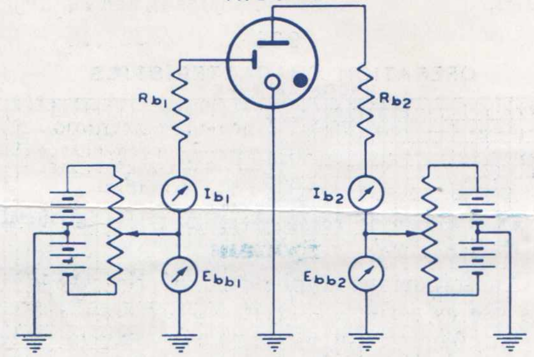


FIG. 3.

When the anode voltage is increased to +285 volts, a breakdown occurs between cathode and anode. The value of anode voltage required for breakdown between K and P_2 is substantially independent of starter-anode voltage for values of E_{b1} greater than approximately +18 volts, and less than +85 volts as shown by section B of Fig. 4. Section B, therefore, shows the relation between E_{b2} and E_{b1} that is necessary for a cathode-anode discharge when there are no ions to assist the initiation of the breakdown.

Section C of Fig. 4 shows the relation between E_{b2} and E_{b1} that is required for a discharge between starter-anode and anode when there are no ions to assist the initiation of this discharge. In this discharge, the starter-anode acts as a cathode, so that the slope of section C would be approximately 45 degrees were there no third electrode in the tube. This discharge can occur with positive values of E_{b1}, because the distance between P_2 and P_1 is less than that between P_2 and K.

Section D shows the relation between E_{b2} and E_{b1} that is required for a discharge between starter-anode and cathode when there are no ions to assist the initiation of this discharge. It should be noted that this discharge takes place between the same two electrodes as in section A. However, under the conditions of Section D, P_1 acts as cathode, because it is negative with respect to K.

Sections E and F show the relations between E_{b2} and E_{b1} that are required to initiate a discharge between anode and cathode and between anode and starter-anode, respectively, when there are no ions to assist the initiation of these discharges. In these cases, as in the previous ones, the first word of the term describing the discharge denotes the electrode acting as cathode.

The breakdown characteristics of Fig 4 indicate the voltage conditions necessary for breakdown between any two electrodes when there is no assisting discharge current. For example, a discharge between anode and cathode is initiated when E_{b2} = +285 volts and I_{b1} = 0. When the voltage applied to P_1 is increased so that starter-anode current flows, the discharge between cathode and anode can be initiated at values of E_{b2} less than 285 volts. A relation between the assisting- or initiating-discharge current between two electrodes and the voltage on the third electrode necessary to initiate a discharge to the third electrode is called a transition characteristic.

TYPICAL BREAKDOWN CHARACTERISTICS FOR DIFFERENT ELECTRODE POLARITIES

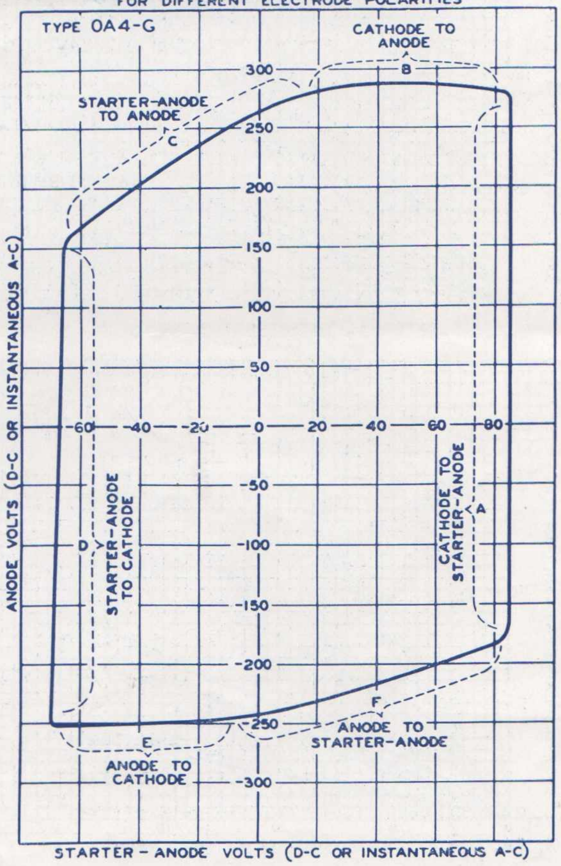


FIG. 4.

Transmission and Anode Characteristics

The OA4-G is designed for operation only in that part of the breakdown characteristics designated by section A (positive anode) of Fig. 4. Although the tube functions in other regions, as previously described, its operation in these regions is unstable because of design characteristics. In normal operation, a discharge between cathode and starter-anode assists in initiating a main discharge between cathode and anode.

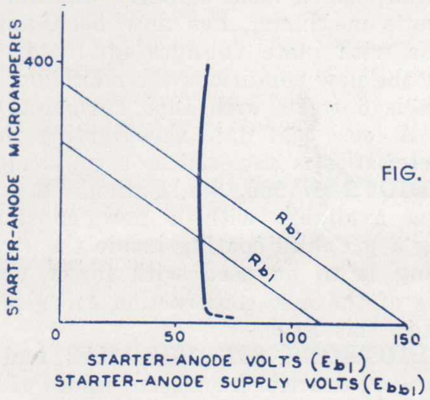


FIG. 5.

The relation between starter-anode current and starter-anode voltage is shown in Fig. 5. This curve is obtained by applying various values of E_{bb1} to P_1 through a high resistance (R_{b1} in Fig. 3) and recording I_{b1}; the starter-anode voltage is then $E_{bb1}-I_{b1}R_{b1}$. The load line R_{b1} intersects the abscissa at values of E_{bb1} of interest. As E_{bb1} is increased above the value at which the K–P_1 discharge occurs I_{b1} increases proportionately and the starter-anode voltage (E_{b1}) remains substantially constant at approximately 60 volts.

Now, for each value of I_{b1}, there is a corresponding value of E_{b2} necessary to initiate the main discharge between cathode and anode. This relation between I_{b1} and E_{b2}, the transition characteristic, is shown in Fig. 6. It shows the anode voltage necessary to initiate a discharge between cathode and anode when there is an assisting discharge current (I_{b1}) flowing.

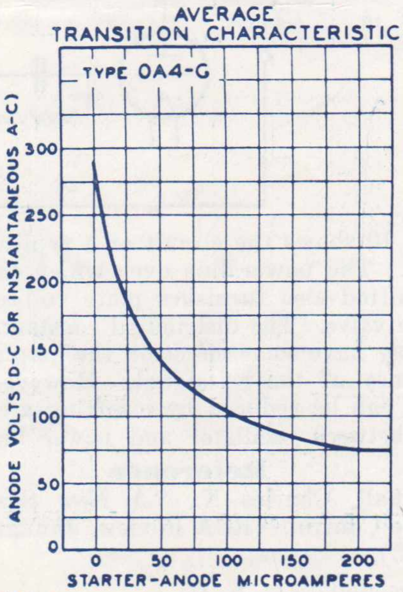


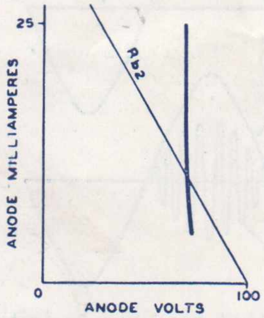
FIG. 6.

For practical purposes, it is convenient to think of the discharge to starter-anode as transferred to the anode when sufficient anode voltage is applied; hence, the name transition characteristic is used to define the relation shown in Fig. 6.

The transition characteristic approaches the line $E_{b2} = 70$ volts, the voltage drop across the tube. When the value of E_{b2} is less than the voltage drop across the tube, the transfer of the main discharge cannot take place.

The anode characteristic of the tube (Fig. 7) shows the relation between anode current and anode voltage. This relation is obtained by varying E_{bb2} and recording I_{b2}. The anode voltage is then $E_{bb2} - I_{b2}R_{b2}$. Fig. 7 shows that over the useful operating range the anode-

FIG. 7.

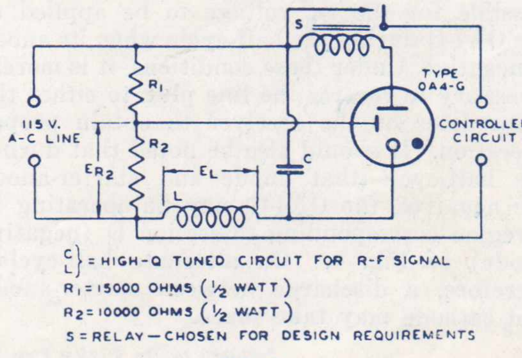


cathode voltage drop remains substantially constant at 70 volts. Operation at anode currents less than 5 milliamperes or greater than 25 milliamperes is not recommended.

The OA4-G in a Carrier-Actuated System

An important application of the OA4-G is its use as a relay tube in carrier-actuated systems. The circuit of a typical receiver system is shown in Fig. 8. Low-frequency voltage is applied between anode and cathode through relay S and r-f coil L. A portion of this voltage is also applied between starter-anode and cathode through coil L by means of the voltage divider R_1 and R_2. Under the conditions shown in Fig. 8, 65 volts peak is applied to P_1 and is in phase with the anode voltage. In addition to this low-frequency voltage, the line carries radio-frequency voltage that is furnished by a remote transmitter. When the resonant frequency of L and C is the same as the frequency of the r-f voltage on the line, a comparatively high r-f voltage is generated

SCHEMATIC RELAY CIRCUIT USING TYPE OA4-G
A-C OPERATION



C, L = HIGH-Q TUNED CIRCUIT FOR R-F SIGNAL
R_1 = 15000 OHMS (½ WATT)
R_2 = 10000 OHMS (½ WATT)
S = RELAY—CHOSEN FOR DESIGN REQUIREMENTS

FIG. 8.

across L. The r-f voltage across L is applied to P_1 and P_2 in series with their respective low-frequency voltages.

The radio-frequency voltage is modulated 100 per cent. at 60 cycles when the transmitter is a-c operated. Under these conditions, the wave form of the voltage impressed on P_1 is shown in Fig. 9. With the proper adjustments, the value of starter-anode voltage is greater

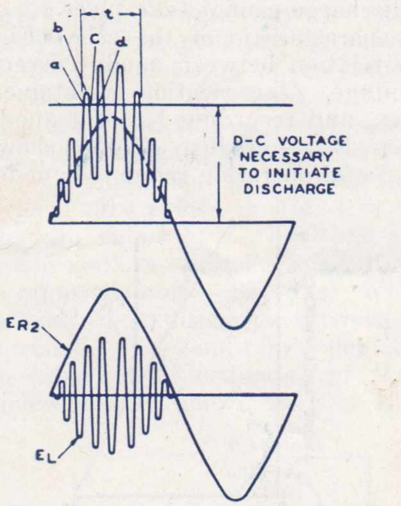


FIG. 9.

than that required to initiate a discharge between K and P_1 for only a part of the interval t. During the small interval ab, the gas (argon) ionizes at an increasing rate; during the interval bc, the rate of ionization decreases; and during the interval cd, the gas de-ionizes at a comparatively slow rate. The process is repeated during successive r-f cycles and the discharge to starter-anode is completed only when the number and amplitude of the peaks are sufficiently great. Thus, to initiate a discharge under a-c conditions, it is not sufficient that the peaks exceed the value required for d-c excitation; the rates of ionization and de-ionization, the amplitude of each r-f cycle above the value required with d.c. applied, and the frequency should be considered. For power-line frequencies of the order of 60 cycles and radio frequencies of the order of 100 kilocycles, it is suggested that $E_{R_2} + E_L$ be greater than 110 volts peak.

It should be noted that the low-frequency starter-anode and anode voltages are in phase and that the r-f voltage may be applied during one-half or throughout the entire low-frequency cycle. When the r-f is generated during one-half of the low-frequency cycle, it is possible for the r-f voltage to be applied to the OA4-G during the half-cycle when its anode is negative. Under these conditions, it is merely necessary to reverse the line plug to either the transmitter or the receiver to obtain proper operation. It should also be noted that during the half-cycle that anode and starter-anode are negative, the OA4-G may be operating in a region corresponding to section D (negative anode) of Fig. 4. On alternate half-cycles, therefore, a discharge between starter-anode and cathode may take place.

RADIOTRON NEWS

RADIOTRON 1613 is a type 6F6 specially selected for operation at 350 volts and about 40 megacycles, and is intended for use in transmitting circuits.

RADIOTRON 1614 is a type 6L6 specially selected for operation at 375 volts and approximately 42 megacycles in radio transmitters.

Further information on **types 1613 and 1614** will be given at a later date.

RADIOTRON 6Y6G, Beam Tetrode Power Amplifier, which until recently was limited to 135 volts maximum, has now been approved for use with plate voltages up to 200 volts. Under the new conditions the maximum power output is 6 watts with 13% harmonic distortion. A loose leaf data sheet giving the new characteristics is enclosed as a supplement.

RADIOTRON 906, 3in. Cathode Ray Tube, is now available with a new construction, having a graphite coating inside the envelope, enabling it to be used with lower voltages. Details of the new construction are given elsewhere in this issue.

RADIOTRONS 832, 1619, 1852 and 1853, which were described in recent issues of Radiotronics, are now available from stock.

From this description, it is seen that the r-f signal need not supply all the power required to initiate the K-P_1 discharge. In actual practice, R_2 is adjusted for a value of E_{R_2} that is somewhat less than the breakdown value. Then, the r-f voltage need only be enough to supply the difference between the breakdown voltage and the applied low-frequency voltage. In addition, the r-f signal should have sufficient amplitude to compensate for low line voltage. It is recommended, therefore, that provision be made to supply an r-f starter-anode voltage (E_L) of at least 55 volts peak.

FIG. 10.

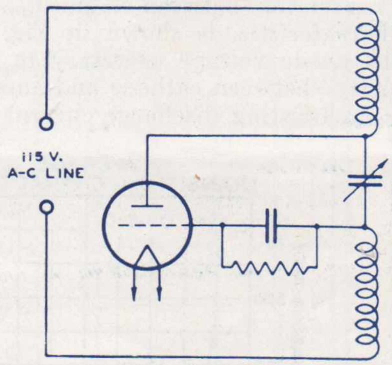


Fig. 10 shows the circuit of a typical transmitter. The power line over which the r-f is transmitted also furnishes plate voltage (a-c) for the valve. The distributed constants of the line may have some effect on the amplitude or frequency of the r-f signal. However, these effects can be reduced by inserting a coupling valve between oscillator and power line.

Reference

Kimball, Charles N., "A New System of Remote Control," RCA Review, January, 1938 (p. 303).

Published by The Wireless Press for Amalgamated Wireless Valve Co. Pty. Ltd.