RCA MANUFACTURING COMPANY, INC.
A RADIO CORPORATION OF AMERICA SUBSIDIARY
Harrison, New Jersey

RCA RADIOTRON
DIVISION

APPLICATION NOTE No. 92
May 25, 1938

# APPLICATION NOTE ON 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 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



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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 tube is used as a rectifier. A single 1 $\mu$f 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 tube 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 labeled $D_1$ and $D_2$ in Fig.1; the pair of plates nearest the gun are called the lower plates and are labeled $D_3$ 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. 2 and 3. The data in Fig.2 obtain for the coated tube and the data in Fig.3 obtain for the uncoated tube. The values of displacement shown by the curves obtain when the spot in 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.

# TABLE I

## OPERATING CONDITIONS FOR RCA-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

| ANODE NO.2 CURRENT µamp. | MINIMUM DEFLECTION-PLATE RESISTANCE* Megohms | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 400-VOLT OPERATION | | | | 1200-VOLT OPERATION | | | |
| | COATED BULB Plates | | UN-COATED BULB Plates | | COATED BULB Plates | | UN-COATED BULB Plates | |
| | Upper[1] | Lower[2] | Upper[1] | Lower[2] | Upper[1] | Lower[2] | Upper[1] | 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 $D_4$

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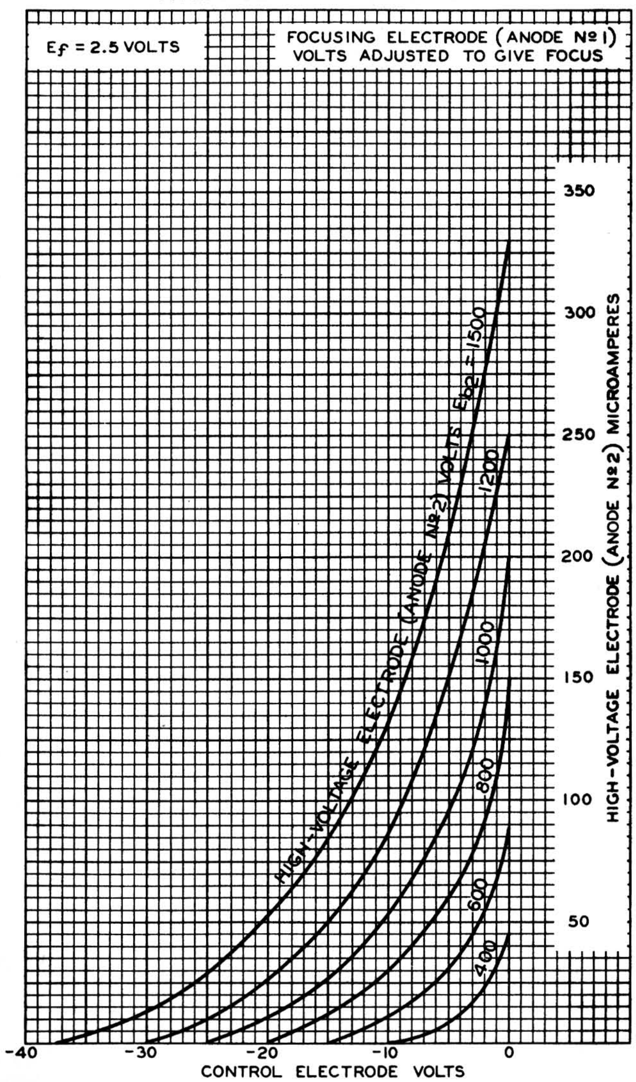
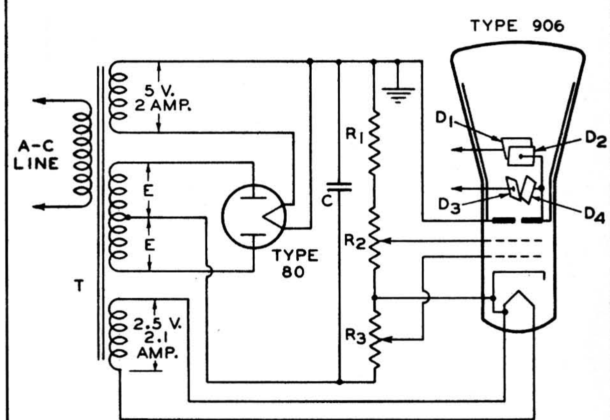
## AVERAGE CHARACTERISTICS






## POWER-SUPPLY UNIT FOR RCA-906 CATHODE-RAY TUBE




| ITEM | 400-VOLT OPERATION | 600-VOLT OPERATION |
|---|---|---|
| RECTIFIER | TYPE 80 | TYPE 80 |
| T | 110 V./650 V. WITH CENTER TAP (E = 325 V.); FILAMENT WINDINGS AS SPECIFIED. | 110 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

906

## OPERATION CHARACTERISTICS
### COATED TYPE

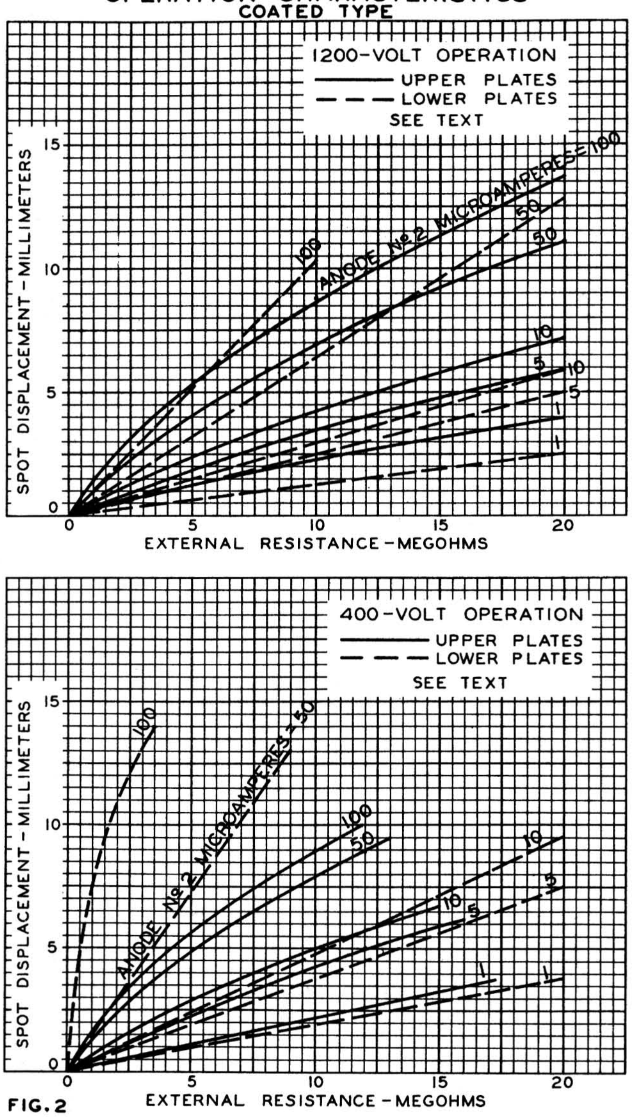



FIG. 2

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## OPERATION CHARACTERISTICS
### UNCOATED TYPE

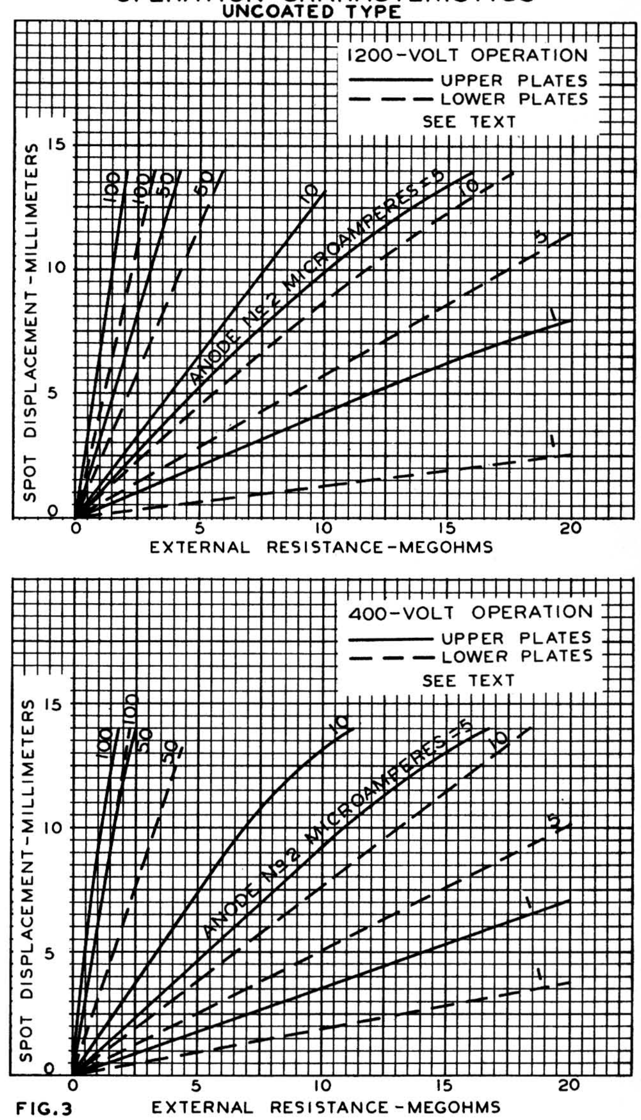


FIG. 3

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