RMA release # 399,
Feb. 21, 1945

905

CATHODE-RAY TUBE

Five-Inch Electrostatic-Deflection Type

RCA-905 is a high-vacuum cathode-ray tube with a fluorescent viewing screen five inches in diameter. This tube, designed for oscillographic applications, is provided with two sets of electrostatic electrodes for deflection of the electron beam. The 905 produces a brilliant luminous spot having a greenish hue, and is suitable for the observation and photography of recurrent and transient phenomena.

The electron source of the 905 is a substantial cathode, indirectly heated. The cathode, grid, and two anodes constitute an electron gun which projects an electron beam upon the fluorescent screen. The resulting luminous spot, easily visible in a normally lighted room, can be regulated as to size and intensity by a suitable choice of electrode voltages.

The two sets of electrostatic electrodes in the bulb neck produce fields at right angles to each other and, consequently, deflections at right angles. By their use, the luminous spot can be deflected to any part of the screen.

The 905 is recommended for use in oscillographic applications where the inertialess character of the electron beam, electrostatic deflection, and a brilliant image of the phenomena under observation are of importance.

GENERAL

HEATER VOLTAGE (A.C or D.C.)	2.5 Volts
HEATER CURRENT	2.1 Amperes
FOCUSING METHOD	Electrostatic
DEFLECTION METHOD	Electrostatic
Electrodes DJ_1 and DJ_2 (upper): nearest to screen	
Electrodes DJ_3 and DJ_4 (lower): nearest to base	
DJ_1 is on same side of tube as pin 3	
DJ_3 is on same side of tube as pin 2	
PHOSPHOR	No.1
FLUORESCENCE	Green
PERSISTENCE	Medium
DIRECT INTERELECTRODE CAPACITANCES (Approx.):	
Control Electrode to All Other Electrodes	9.0 μμf
Deflecting Electrode DJ_1 to Deflecting Electrode DJ_2	2.0 μμf
Deflecting Electrode DJ_3 to Deflecting Electrode DJ_4	1.0 μμf
OVERALL LENGTH	16-1/2" ± 3/8"
BULB DIAMETER AT SCREEN END	5-1/4" + 1/16" - 3/32"
MINIMUM USEFUL SCREEN DIAMETER	4-1/2"
CAPS (four)	Small
BASE	Long Shell Medium 5-Pin MICANOL

Maximum Ratings Are Absolute Values

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

ANODE NO.2 (High-Voltage Electrode) VOLTAGE	2200 max. Volts
ANODE NO.1 (Focusing Electrode) VOLTAGE	660 max. Volts
GRID (Control Electrode) VOLTAGE RANGE	0 (never positive) to -125 max. Volts
PEAK VOLTAGE BETWEEN ANODE NO.2 and ANY DEFLECTING ELECTRODE	1100 max. Volts
GRID-CIRCUIT RESISTANCE	1.5 max. Megohms

TYPICAL OPERATION:			
Anode No.2 Voltage *	1500	2000	Volts
Anode No.1 Voltage for Focus at 75% of Grid Voltage for Cut-Off #	338	450	Volts
Grid Voltage for Visual Cut-Off ##	-26	-35	Volts
Deflection Sensitivity:			
DJ_1 and DJ_2	0.295	0.221	mm/volt d.c.
DJ_3 and DJ_4	0.349	0.262	mm/volt d.c.
Deflection Factor:			
DJ_1 and DJ_2	86.2	115	volts d.c./in.
DJ_3 and DJ_4	72.7	97	volts d.c./in.
Subject to variation of	±20	±20	per cent

* Brilliance and definition decrease with decreasing anode voltage. In general, anode voltage should not be less than 1500 volts.

\# Individual tubes may require between +25% and -30% of these values with grid voltage between zero and cut-off.

\## Visual extinction of stationary focused spot. Supply should be adjustable to ±50% of these values.

INSTALLATION

The *base* pins of the 905 fit a standard, five-contact socket which may be mounted to hold the tube in any position. The socket alone, however, should not be used to support the tube. Other support, such as a yoke or saddle arrangement should be used near the screen end of the tube. The socket should be made of good insulating material; a type having insulating baffles between contacts provides an additional factor of safety.

The *bulb* of this type, except for the screen surface, should be enclosed in a grounded metal case. If an iron or steel case is employed to minimize the effect of extraneous fields on tube operation, care should be taken to insure that the case is completely demagnetized.

The *heater* is designed to operate at 2.5 volts. The transformer winding supplying the heater power should be designed to operate the heater at the rated voltage under average line-voltage conditions. If the circuit design is such as to cause a high voltage between the heater winding and ground, the heater transformer should be adequately insulated to withstand the high voltage.

The *cathode* is connected within the tube to one side of the heater and to base pin 5 to which grid and anode returns should be made.

The *fluorescent screen* employed in the 905 is of the phosphor No.1 (medium persistence) type. It has good visual and photographic qualities as well as high luminous efficiency.

The *d-c supply voltages* for the electrodes may be conveniently obtained from a high-voltage, vacuum-tube rectifier. Since a cathode-ray tube requires very little current, the rectifier system can be of either the half-wave or the voltage doubler type. Likewise, the filter requirements are simple. A 0.5 to 2 μf condenser will ordinarily provide sufficient filtering. If this

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905-12-43
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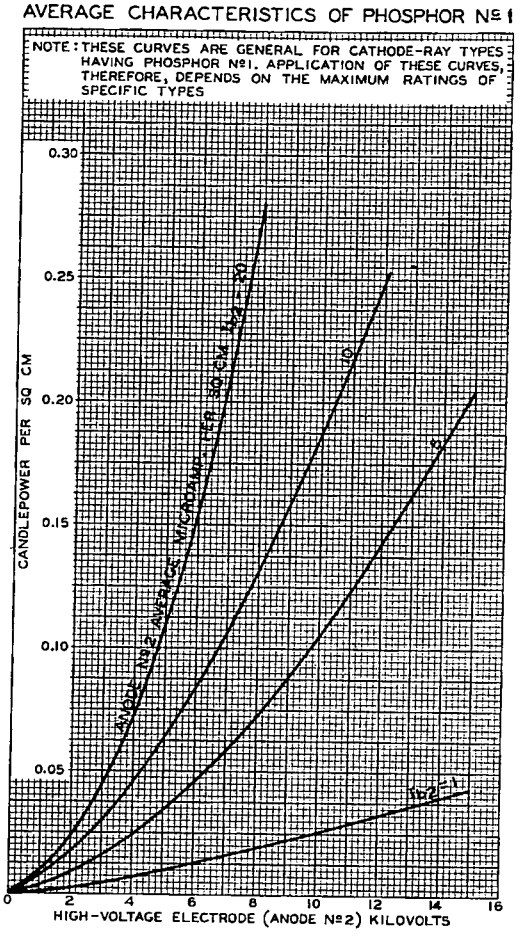
is inadequate for a particular application, a two-section filter is recommended.

AVERAGE CHARACTERISTICS OF PHOSPHOR Nº 1

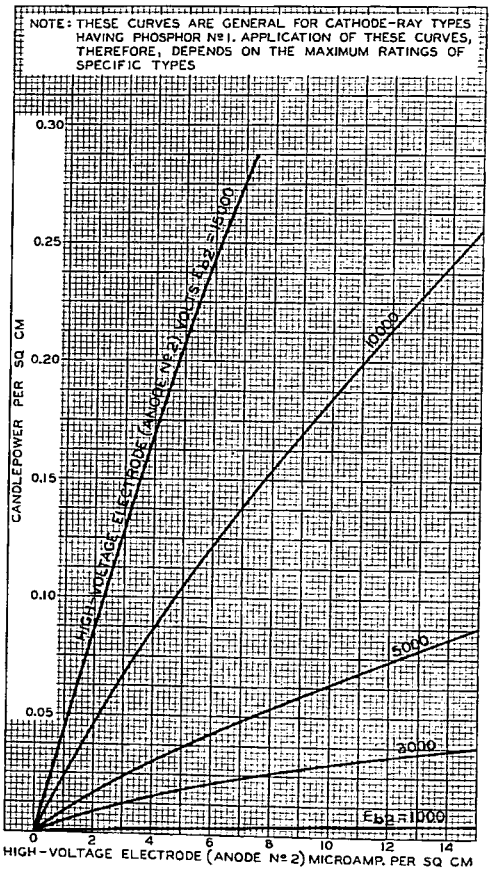


Two sets of *electrostatic electrodes*, producing fields at right angles, are located within the bulb neck to provide for deflection of the electron beam. The electrostatic field of each pair of deflecting electrodes deflects the beam parallel to the lines of the field; therefore, the deflections produced by the two fields are at right angles. In order to maintain each set of electrodes at essentially the d-c potential of anode No.2, each electrode of each set should be connected through a resistor of up to ten megohms to the anode No.2 socket terminal (ordinarily grounded). This arrangement permits a choice of resistor value such that the electron beam is not distorted by d-c potentials built up on the deflecting electrodes. If, during operation, the zero axis should be permanently deflected, it is usually because the beam current is too high for the resistors used. The beam current should ordinarily be kept low. At times when it is necessary to use a high value, such as when photographs are taken, the value of the deflecting-electrode resistors should be reduced so that the zero-axis shift will not carry the spot off the viewing screen. Where only a small shift in the spot is required, one resistor of each pair of the deflecting-electrode resistors can be connected to a d-c bias voltage to compensate for the shift.

The deflection sensitivity of each set of electrodes for typical anode No.2 voltages is given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.

The high voltages at which the 905 is operated are very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions include the enclosing of high-potential terminals and the use of "interlock" switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required. In most installations it is recommended that the positive high-voltage terminal be grounded, rather than the cathode terminal. With this method, which places the cathode and heater at a high negative potential with respect to ground, the dangerous voltages can more easily be made inaccessible.

AVERAGE CHARACTERISTICS OF PHOSPHOR Nº 1



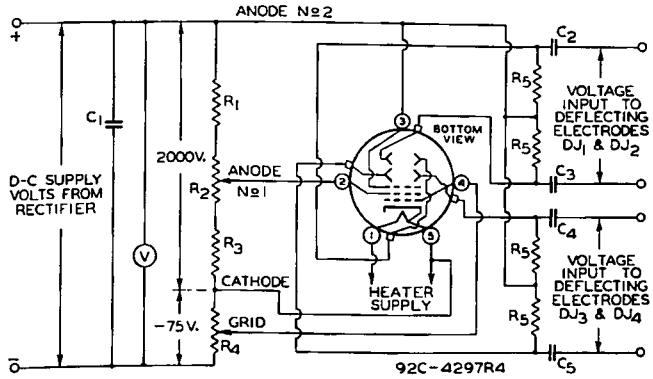
In the use of cathode-ray tubes, it should always be remembered that high voltages may appear at normally low-potential points in the circuit, due to condenser breakdown or to incorrect circuit connections. Therefore, before any part of a cathode-ray tube circuit or its associated circuit is touched, the power-supply switch should be turned off and both terminals of any charged condensers grounded.

APPLICATION

The cathode-ray oscillograph is an instrument adaptable to a wide variety of applications. A few of the more important are: the study of wave shapes and transients, measurement of modulation and peak voltages, adjustment of radio receivers, comparison of frequencies, and the indication of balance in bridge circuits.

A diagram illustrating the *essential circuit* for the use of the 905 in an oscillograph is shown below. The electrode voltages are obtained from a bleeder circuit connected across the high-voltage supply. A bleeder current of one or two milliamperes is usually satisfactory; considerably larger values may require the use of

TYPICAL OSCILLOGRAPH CIRCUIT



C_1 – FILTER CONDENSER 0.5 TO 2 μf
C_2 C_3 C_4 C_5 – SEE NOTE BELOW
R_1 – 0.45 MEGOHM
R_2 – 0.10 MEGOHM
R_3 – 0.125 MEGOHM
R_4 – 0.025 MEGOHM
R_5 – SEE TEXT, PAGE 2
V – VOLTMETER

NOTE: When the cathode or the negative end of the cathode-ray high-voltage supply is grounded, blocking condensers $C_2C_3C_4C_5$ should have a high voltage rating. When anode No.2 is grounded, condensers $C_2C_3C_4C_5$ may be low-voltage condensers.

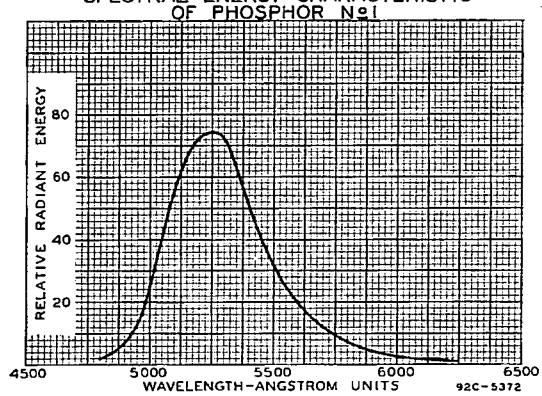
more filtering than that provided by a single condenser shunted across the d-c supply. With small bleeder currents, a single condenser filter is usually adequate. A variable d-c voltage for the control electrode and for anode No.1 can be obtained from potentiometers in the bleeder circuit. One set of electrostatic deflecting electrodes is used for the phenomena under observation; the other set, for the sweep, which serves to spread the tracing across the fluorescent screen.

Focusing of the fluorescent spot produced by the beam is controlled by adjustment of the ratio of anode No.2 voltage to anode No.1 voltage. Ordinarily, the ratio is varied by adjustment of anode No.1 voltage.

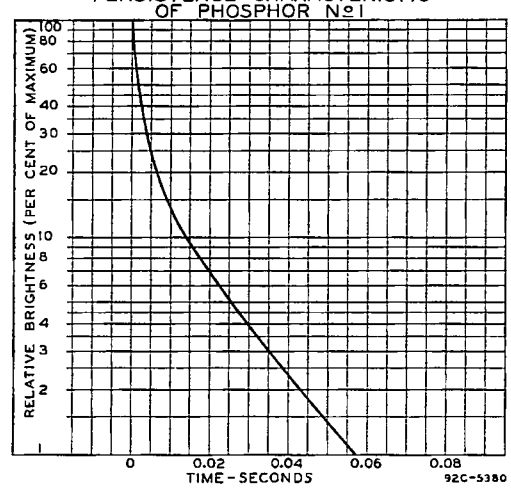
Regulation of *spot size* and *intensity* can be accomplished by varying anode No.2 current and/or voltage. The current to anode No.2 may be increased by decreasing the bias voltage applied to the control electrode (grid). An increase in anode No.2 current increases the size and intensity of the spot. An increase in the voltage applied to anode No.2 increases the beam current and the sharpness of focus and, therefore, the spot intensity. When any of these adjustments are made, consideration should be given to the absolute maximum voltage ratings shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.

In applications involving *extremely accurate measurements*, the anode No.2 current should be reduced to the minimum value consistent with the desired brilliance of pattern. Where high brightness is an important consideration, the voltage applied to anode No.2 may be increased to the maximum rated value. This procedure, however, is not always desirable since the greater speed of the electrons in the beam causes reduced deflection sensitivity.

SPECTRAL ENERGY CHARACTERISTIC OF PHOSPHOR N°1



PERSISTENCE CHARACTERISTIC OF PHOSPHOR N°1



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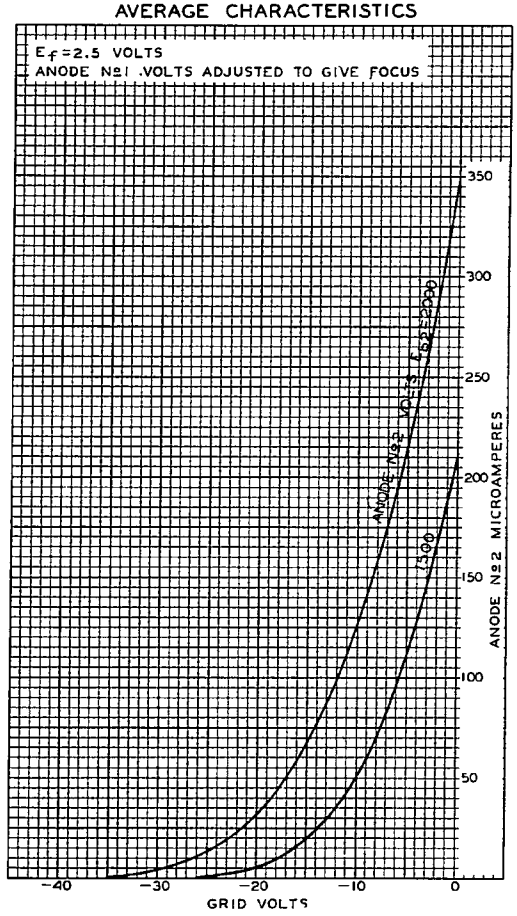
It is important to note that a beam producing a high-intensity spot will burn the fluorescent screen if the spot is allowed to remain stationary. To prevent this possibility, it is recommended that the *beam be kept in motion* by the application of voltage to the deflecting plates or that the brilliancy be reduced to a low value by adjustment of the control-electrode voltage. The spot may also be prevented from burning the screen by removal of the voltage from anode No.2.

Photographs of the phenomena appearing on the

viewing screen of the 905 can be made with an ordinary camera. The photographing is done preferably in subdued light in order to obtain as much contrast as possible between the fluorescent pattern and the background. The time of exposure will depend on the speed of the camera lens, the kind of film or plate emulsion used, the magnification of the pattern, and the brightness of the pattern. Where transients are to be photographed, maximum brightness and a short exposure are required; where recurrent wave forms are to be photographed, patterns having low brightness can easily be compensated for by longer exposure. The use of panchromatic film may be preferable due to its greater sensitivity at the longer wavelengths of the light spectrum, although verichrome film gives excellent results.

AVERAGE CHARACTERISTICS



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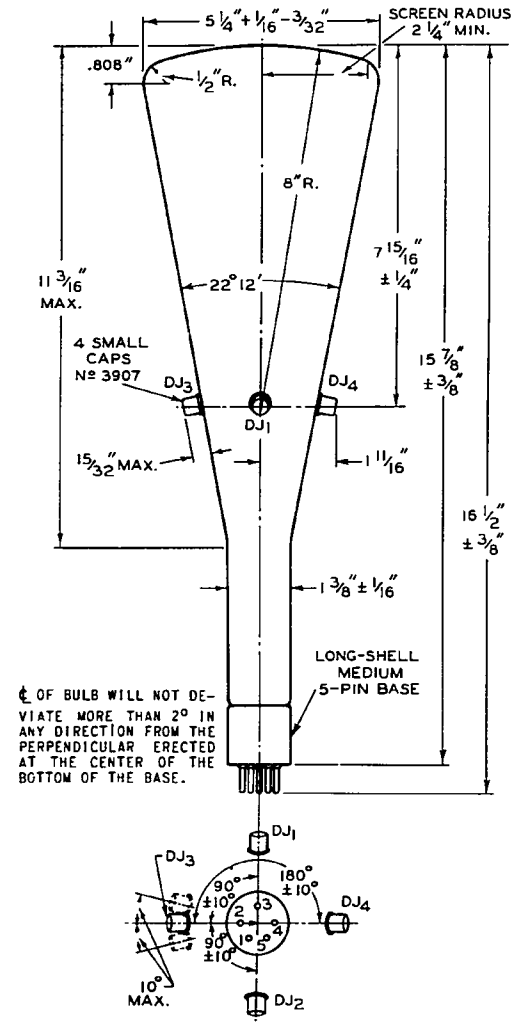
For *high-speed photographic work* involving non-recurring phenomena, it is permissible to increase the screen input power per sq cm, for the short interval required to make the exposure, above that required for visual observation. The extent to which the anode No.2 current may be increased without harming the screen is a direct function of the rate of beam travel and pattern size, and an inverse function of duration. Short-interval operation at increased input can be obtained by means of a temporary decrease in the control-electrode voltage. A switching arrangement should be provided to switch the control-electrode voltage rapidly between a negative and a less negative value. The exposure is made while the control-electrode voltage is at the decreased (less negative) value.



BOTTOM VIEW OF TUBE

THE PLANE THROUGH THE TUBE AXIS AND PIN 3 MAY VARY FROM THE TRACE PRODUCED BY DJ_1 AND DJ_2 BY AN ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF 10°; ANGLE BETWEEN DJ_1-DJ_2 TRACE AND DJ_3-DJ_4 TRACE IS 90° ± 6°.

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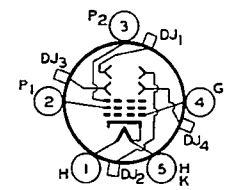
Bottom View of Socket Connections



DJ_1 to DJ_4 – DEFLECTING ELECTRODES
P_2 – ANODE No.2
P_1 – ANODE No.1
G – GRID
K – CATHODE
H – HEATER