RMA release # 399,
Feb. 21, 1945

902

CATHODE-RAY TUBE

Electrostatic Deflection
Electrostatic Focus

2-Inch Diameter

Medium-Persistence Screen
7-1/2" Overall Length

RCA-902 is a high-vacuum cathode-ray tube having a fluorescent viewing screen two inches in diameter. This tube is provided with two sets of electrostatic electrodes for deflection of the electron beam. The 902 will operate with anode voltages as low as 400 volts, and it can replace electrically the RCA-913 provided the anode No.2 voltage is not less than 400 volts. The 902 produces a brilliant luminous spot having a greenish hue and is suitable for use in compact, portable oscillographic equipment for the observation and photography of transient and recurrent phenomena.

General

HEATER VOLTAGE (A.C. or D.C.)	6.3 ±10% Volts
HEATER CURRENT	0.6 Ampere
FOCUSING METHOD	Electrostatic
DEFLECTION METHOD	Electrostatic
Electrodes DJ_1 and DJ_2: nearest to screen	
DJ_1 is on same side of tube as base pin 3	
Electrodes DJ_3 and DJ_4: nearest to base	
DJ_3 is on same side of tube as base pin 1	
PHOSPHOR	No.1
FLUORESCENCE	Green
PERSISTENCE	Medium
DIRECT INTERELECTRODE CAPACITANCES (Approx.):	
Grid No.1 to All Other Electrodes	7 μμf
DJ_1 to All Other Electrodes	9.5 μμf
DJ_4 to All Other Electrodes	5.5 μμf
OVERALL LENGTH	7-7/16" ±3/16"
GREATEST DIAMETER of BULB	2" ±1/16"
MINIMUM USEFUL SCREEN DIAMETER	1-3/4"
BASE	Medium Shell Octal 8-pin

Maximum Ratings Are Absolute Values

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

ANODE No.2 (High-Voltage Electrode) VOLTAGE		660 max.	Volts
ANODE No.1 (Focusing Electrode) VOLTAGE		330 max.	Volts
GRID No.1 (control Electrode) VOLTAGE RANGE	0 (never +)	to −125 max.	Volts
PEAK VOLTAGE BETWEEN ANODE No.2 and ANY DEFLECTING ELECTRODE		385 max.	Volts
IMPEDANCE of ANY DEFLECTING-ELECTRODE CIRCUIT at HEATER-SUPPLY FREQUENCY		1 max.	Megohm
GRID-CIRCUIT RESISTANCE		5 max.	Megohms
TYPICAL OPERATION:			
Anode No.2 Voltage*	400	600	Volts
Anode No.1 Voltage for Focus at 75% of Grid Voltage for Cut-Off (Approx.)**	100	150	Volts
Grid Voltage for Cut-Off‡	−40	−60	Volts
Deflection Sensitivity:			
DJ_1 and DJ_2	0.273	0.182 mm/volt	D.C.
DJ_3 and DJ_4	0.321	0.214 mm/volt	D.C.
Deflection Factor:‡‡			
DJ_1 and DJ_2	93	139 volts	D.C./in.
DJ_3 and DJ_4	78	117 volts	D.C./in.

* Brilliance and definition decrease with decreasing anode No.2 voltages. In general, anode No.2 voltage should not be less than 400 volts.

** Individual tubes may require between +20% and −35% of values shown for focus when grid No.1 voltage is varied between zero and cut-off.

‡ Visual extinction of a stationary focused spot. Supply should be adjustable to ±50% of the values shown.

‡‡ Individual tubes may vary ±20% of the values shown.

SPOT POSITION

The undeflected focused spot will fall within a 10-mm square centered at the geometric center of the tube face and having one side parallel to the trace produced by DJ_3 and DJ_4. Suitable test conditions are: anode No.2 volts, 600; anode No.1 volts, adjusted for focus; deflecting-electrode resistors, 1 megohm each, connected to anode No.2; the tube shielded from extraneous fields. To avoid damage to the tube, grid No.1 voltage should be near cut-off before anode voltage is applied.

BASING and DEFLECTING-ELECTRODE ARRANGEMENT

The angle between the trace produced by DJ_3 and DJ_4 and its intersection with the plane through the tube axis and pin 1 will not exceed 10°.

The angle between the trace produced by DJ_1 and DJ_2 and the trace produced by DJ_3 and DJ_4 will be 90° ±4°.

When DJ_1 (pin 4) is positive with respect to DJ_2 (pin 1), the spot will be deflected toward pin 3; likewise, when DJ_3 (pin 1) is positive with respect to DJ_4 (pin 6), the spot will be deflected toward pin 1.

INSTALLATION

The *base* pins of the 902 fit the standard octal socket which may be installed to hold the tube in any position. The socket should preferably be mounted so that it may be rotated through a small angle. It should be made of good insulating material; a type of socket 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 effects of extraneous fields on tube operation, care should be taken in its construction to insure that the case is completely demagnetized.

The *heater* is designed to operate at 6.3 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 to appear 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. The terminal for this common connection is base pin No.2.

The *fluorescent screen* of the 902 employs phosphor No.1 which fluoresces to produce a green spot. It has good visual and photographic qualities as well as high luminous efficiency.

The *d-c supply voltages* for the electrodes may be obtained conveniently from a vacuum-tube rectifier. Since a cathode-ray tube requires very little current, the rectifier system can be

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of either the half-wave or the voltage-doubler type. For the same reason, the filter requirements are simple. A 0.5 to 2 μf condenser will ordinarily provide sufficient filtering. If this is inadequate, a two-section filter is recommended.

Two pairs of *electrostatic electrodes*, at right angles to each other, are located within the bulb neck to provide for deflection of the beam. The electrostatic field of each pair of electrodes causes deflection of the beam parallel to the lines of the field; therefore, the deflections caused by each pair are at right angles. The d-c potential of each electrode must be maintained essentially equivalent to that of anode No.2 in order to avoid building up a charge on the deflecting electrode. A charge on the deflecting electrodes causes a permanent deflection of the beam. The d-c potential of the deflecting electrodes may be kept essentially the same as that of anode No.2 by connecting resistors having values not greater than 10 megohms between each deflecting electrode and anode No.2. This arrangement by suitable choice of resistor values minimizes pattern distortion and pattern drift resulting from unbalanced potentials on the deflecting electrodes. The smaller the resistor values, the less the distortion for a given beam current. The beam current should ordinarily be kept low. At times when it is necessary to use a high value of beam current, as when photographs are taken, the value of the resistor should be reduced so that the zero-axis shift will be minimized. The resistor of one or both free deflecting electrodes may be connected to a d-c bias voltage to obtain centering of the beam.

The *deflection sensitivity* and the *deflection factors* of the deflecting electrodes for typical anode No.2 voltages are given under TYPICAL OPERATING CONDITIONS.

The high voltages at which the 902 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 must include safeguards which definitely eliminate all hazards to personnel. All circuit parts which may be at high potentials should always be enclosed and "interlock" switches should be used to break the primary circuit of the high-voltage power supply when access to the equipment is required.

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 because of condenser breakdown or incorrect circuit connections. Before any part of the 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 the comparison of frequencies, measurements of modulation and peak voltages, location and adjustment of faults in radio receivers and a-f amplifiers, and the indication of balance in bridge circuits. The low cost of the 902 and its associated apparatus, the low voltages at which it can be operated, and the small size and portability of equipment using the tube are factors contributing to the utility of the 902 by engineers, radio servicemen, radio amateurs, and school laboratories.

An oscillograph, in its simplest form, can be designed to use only the cathode-ray tube and a bleeder circuit with provision for connection to external anode and heater supplies. Means of coupling to the deflecting electrodes usually consist of condensers in the lead to the common connection to anode No.2 and two of the deflecting electrodes, and in each of the leads to the "free" deflecting electrodes. When the cathode or the negative end of the cathode-ray high-voltage supply is grounded, these coupling condensers should have a high voltage rating since the deflecting electrodes and anode No.2 are then at high potential with respect to ground. When anode No.2 is grounded, the condenser in the lead to the anode may be omitted and the condensers in the leads to the "free" deflecting electrodes may be low-voltage condensers. For d-c amplifier service, the deflecting electrodes should be coupled direct to the output of the amplifier by omitting the condensers. In addition, it will usually be preferable to remove the associated deflecting-electrode resistors in order to minimize the loading effect of the resistors on the d-c amplifier. With the resistor removed, it is essential, in order to minimize spot defocusing, that anode No.2 be returned to some point in the d-c amplifier circuit such that the potential difference between anode No.2 and the average voltage across the deflecting electrodes will be as low as possible.

The simple basic circuit arrangement can be improved greatly by the inclusion of a sweep oscillator and amplifier, and an amplifier for the phenomena under observation. Such a circuit is shown in the accompanying diagram. The electrode voltages are obtained from a bleeder circuit connected across a separate high-voltage supply. A bleeder current of one or two milliamperes is satisfactory usually; considerably higher values may require the use of more filtering than that provided by a single condenser shunted across the high-voltage supply. With small bleeder currents, a single filter condenser usually is adequate. A variable d-c voltage for the control electrode and one for anode No.1 are obtained from potentiometers in the bleeder circuit. One set of deflecting electrodes is used for the phenomenon under observation; the other set for the time sweep which spreads the trace across the fluorescent screen. Two a-f voltage amplifiers are shown— one for the vertical and one for the horizontal deflecting electrodes. Many applications, however, do not require the signal-volt-

age amplifier, and others can dispense with the linear time-sweep oscillator and amplifier.

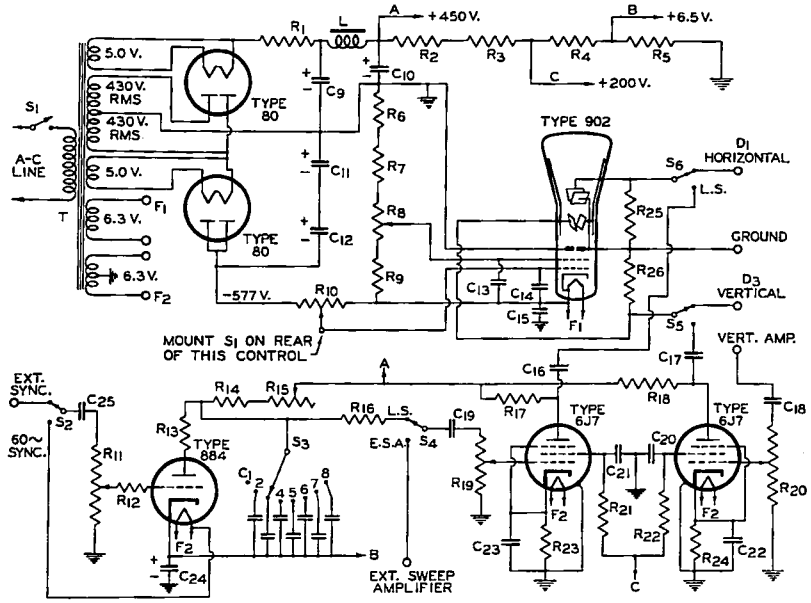
Focusing of the fluorescent spot produced by the beam is controlled by adjustment of the ratio of anode No. 1 voltage to anode No. 2 voltage. Ordinarily, the ratio is varied by adjustment of anode No. 1 voltage.

Spot intensity, for a given anode No. 2 voltage, can be varied by changing the control-electrode (grid) voltage.

Anode No. 2 voltage may be chosen from a range of values. As anode No. 2 voltage is increased, the spot intensity increases and the spot size decreases. The 902 will operate satisfactorily at lower anode voltages than the highest typical values shown but brilliance and definition decrease with decreasing anode No. 2 voltage. In general, anode No. 2 voltage should not be less than 400 volts. The maximum value shown under MAXIMUM RATINGS is an absolute value beyond which the usefulness of the tube may be impaired.

The anode No. 2 current should be reduced to the minimum consistent with the desired brilliance of the pattern. Where high brightness is an important consideration, the voltage applied to anode No. 2 may be increased to the maximum value. This procedure, however, is not always desirable since the greater speed of the electrons causes reduced deflection sensitivity while

OSCILLOGRAPH CIRCUIT WITH LINEAR SWEEP AND AMPLIFIERS



C_1 – STRAY CIRCUIT CAPACITANCE*
C_2 – 0.0008 μf, 500 V.
C_3 – 0.002 μf, 500 V.
C_4 – 0.005 μf, 500 V.
C_5 – 0.015 μf, 500 V.
C_6 – 0.05 μf, 500 V.
C_7 – 0.15 μf, 500 V.
C_8 – 0.25 μf, 500 V.
C_9 C_{10} C_{11} C_{12} – 8 μf, 475 V. (Working)
C_{13} C_{14} – 0.1 μf, 250 V.
C_{15} – 0.1 μf, 600 V.
C_{16} C_{17} – 0.25 μf, 500 V.
C_{18} C_{19} – 0.5 μf, 500 V.
$C_{20}C_{21}C_{25}$ – 0.25 μf, 250 V.
C_{22} C_{23} – 0.003 μf
C_{24} – 25 μf, 15 V.
R_1 – SEE NOTE 1
R_2 – 10000 OHMS, 2 WATTS
R_3 – 15000 OHMS, 2 WATTS
R_4 – 20000 OHMS, 5 WATTS
R_5 – 650 OHMS, 0.5 WATT
R6 R7 – 50000 OHMS, 1 WATT
R8 – 25000-OHM POTENTIOMETER
R9 – 15000 OHMS, 0.5 WATT
R10 – 25000-OHM POTENTIOMETER
R11 – 250000-OHM POTENTIOMETER
R12 – 25000 OHMS, 0.5 WATT
R13 – 500 OHMS, 0.5 WATT
R14 – 300000 OHMS, 0.5 WATT
R15 – 2-MEGOHM POTENTIOMETER
R16 – 1 MEGOHM, 0.5 WATT
R17 – 70000 OHMS, 1 WATT
R18 – 100000 OHMS, 1 WATT
R19 R20 – 0.5-MEGOHM POTENTIOMETER
R21 R22 – 200000 OHMS, 0.5 WATT
R23 R24 – 1000 OHMS, 0.5 WATT
R25 R26 – 2 MEGOHMS, 0.5 WATT
L – 30 HENRYS, 15 MA.
T – POWER TRANSFORMER
S_1 – A-C LINE SWITCH
S_2 S_4 – S.P.D.T. SWITCH
S_3 – S.P. 8-POINT SWITCH
S5 S6 – S.P.D.T. LOW-CAPACITY SWITCH

NOTE 1: Choose values of R_1 to give 450 volts at point A. Start with 10000 ohms and decrease value until desired voltage is obtained. This method protects condensers C_9 and C_{10} from excessive voltage.

* The 884 will not oscillate when S_3 is set at C_1. This point may be used to stop the saw-tooth oscillator when the linear sweep is not being used.

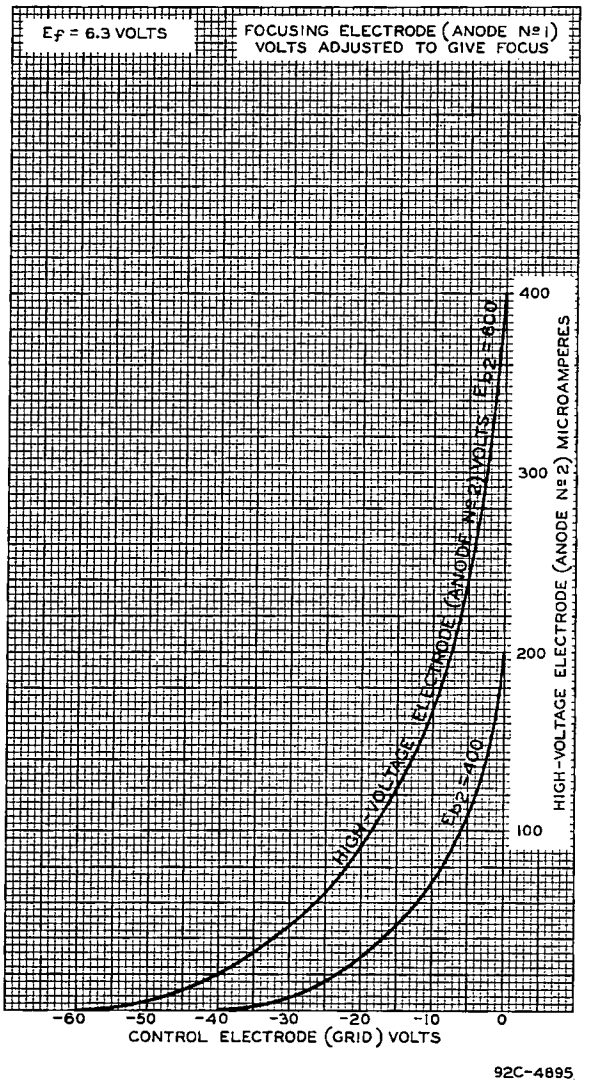
reduced electron speed results in improved spot size and prevents burning of the screen.

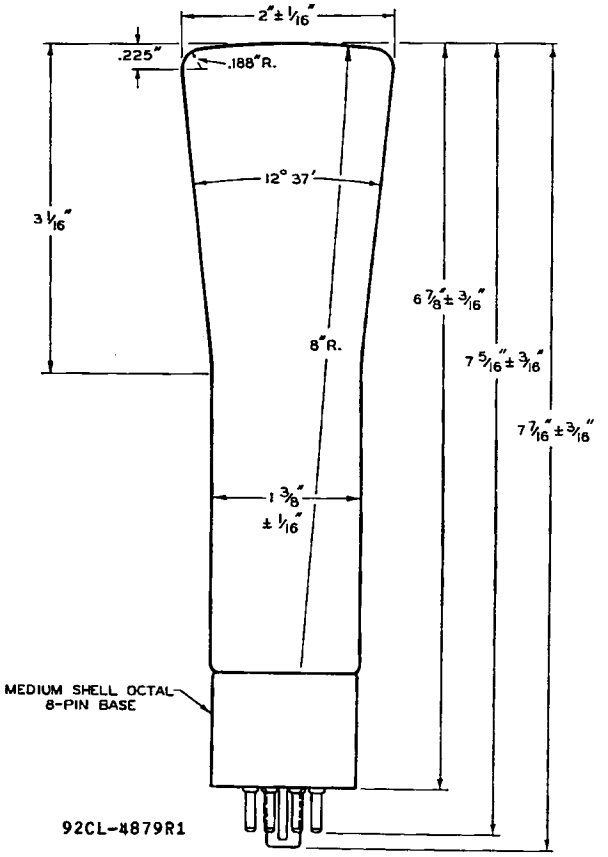
It is important to note that a high-intensity spot will burn the fluorescent screen if the spot is allowed to remain stationary. To prevent this possibility, it is recommended that the beam be kept in motion over a reasonably large area by the application of voltage to the deflecting electrodes or that the brilliance be reduced to a low value by adjustment of the grid voltage.

Photographs of the phenomena under observation can be made with an ordinary camera. The photographing is done preferably in a subdued light in order to obtain as much contrast as possible between the fluorescent pattern and the screen. 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 be compensated for by longer exposure. The use of film having high green sensitivity is recommended; orthochromatic types of emulsion have been found to give excellent results.

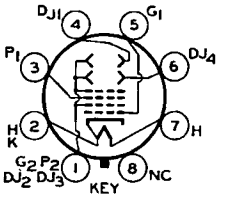
For high-speed photographic work involving non-recurrent phenomena, it is permissible to increase the trace brightness for the short interval required to make the exposure, above that required for visual observation. The extent to which the anode No.2 current may be increased without harming the screen is proportional to the velocity of beam travel and pattern size, and an inverse function of the duration of the phenomenon. Short-interval operation at increased current 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 less-negative value.

AVERAGE CHARACTERISTICS





BOTTOM VIEW of SOCKET CONNECTIONS



DJ_1 to DJ_4 – Deflecting Electrodes
P_2 – Anode No.2
P_1 – Anode No.1
G_2 – Grid No.2
G_1 – Grid No.1
H – Heater
K – Cathode
NC – No connection