7AP4

KINESCOPE

Seven-Inch Magnetic-Deflection Type with White Phosphor and Short Bulb

Kinescope RCA-7AP4, a high-vacuum cathode-ray tube designed for black-and-white reproduction of television pictures, employs magnetic deflection of the electron beam. Its screen accommodates a picture 4-1/2 inches by 6 inches in size, or slightly larger. A special feature of this tube is its relatively short overall length of approximately 13-1/2 inches. Because of this feature, a compact cabinet design can be used for television receivers in which the Kinescope is mounted in a horizontal position.

The electron gun in the 7AP4 provides an electron beam which impinges on the picture screen and produces a white spot of fluorescent light. The brilliance of this spot can be controlled by a modulating voltage, such as a video voltage, applied to the grid. The position of the spot on the picture screen can be controlled by means of a deflecting yoke consisting of two sets of electromagnetic deflecting coils. One set of these coils controls the horizontal motion of the spot; the other set, the vertical motion.

In the use of the RCA-7AP4 for television reception, currents of sawtooth waveform, synchronized with the transmitted signal, are supplied to the vertical-deflecting coils and to the horizontal-deflecting coils. The resultant deflections cause the spot to scan the picture area on the screen, thus forming the rectangular pattern of luminescence called the "raster". At the same time, the television picture signal is applied to the grid in order to modulate the brilliance of the spot. As a result of the modulation and motion of the spot, it traces on the screen of the Kinescope a reproduction of the scene being transmitted.

TENTATIVE CHARACTERISTICS and RATINGS

HEATER VOLTAGE (A.C. or D.C.)	2.5	Volts
HEATER CURRENT	2.1	Amperes
FLUORESCENT SCREEN:		
Material	Phosphor No.4	
Color of Fluorescence	White	
DIRECT INTERELECTRODE CAPACITANCE:		
Grid to all other electrodes	12 *max.* μμf	
OVERALL LENGTH	13-1/2" ± 3/8"	
MAXIMUM DIAMETER	7-1/8"	
BULB	J-56	
BASE	Medium 5-Pin	

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

HIGH-VOLTAGE ELECTRODE (Anode No.2) VOLTAGE	3500 *max.*△	Volts

△: See next page.

FOCUSING ELECTRODE (Anode No.1) VOLTAGE	1000 *max.*△	Volts
CONTROL ELECTRODE (Grid) VOLTAGE	Never Positive	
FLUORESCENT-SCREEN INPUT POWER PER SQ CM †	2.5 *max.*△	Milliwatts
TYPICAL OPERATION:		
Heater Voltage	2.5	Volts
Anode No.2 Voltage	3500	Volts
Anode No.1 Voltage (Approx.) *	675	Volts
Grid Voltage # ○	Adjusted to give suitable luminous spot	
Grid Signal-Swing Voltage □	15	Volts

* Adjustable to ±20%.
\# Approximately 10% of Anode No.1 voltage is required for current cut-off if the maximum permissible resistance is used in the grid circuit.
□ Peak-to-peak value for good brilliance with good resolution. For greater brilliance, up to twice this value should be available.
○ Maximum resistance in the grid circuit should be limited to 2 megohms.
† This value applies to the brightest portion of a stationary pattern. Approximately double this value is permissible with a moving pattern.
△ Design maximum for 117-volt line.

INSTALLATION

Handling of the 7AP4 requires care, because the tube may be broken or permanently damaged if subjected to sudden jars or excessive strains. When the Kinescope is placed on a hard surface, such as that of a table or work-bench, padding should be placed under the tube so as to prevent it from being scratched. Because the 7AP4 is highly evacuated and has a large surface area, its glass bulb is under considerable stress due to normal atmospheric pressure. Scratches may weaken the bulb so that it will not withstand this pressure. The 7AP4 should be inserted into its socket carefully. If the tube sticks, or fails to slip into its socket smoothly, the cause of the trouble should be investigated and removed; the tube should never be struck or forced. In order that strains will not be set up in the glass, the 7AP4 should not be subjected to rapid, extreme temperature changes.

The *base* pins of the 7AP4 fit a standard, five-contact socket, which may be installed for the operation of the tube in any position. The socket mounting should preferably be adjustable. The socket should be made of good insulating material; insulating baffles between contacts provide an additional factor of safety.

A metal *shielding case* for the Kinescope may be desirable if the tube is operated near electrical apparatus whose fields may cause distortion of the spot. If an iron or steel case is employed to minimize the effect of extraneous fields on tube operation, care should be taken in its construction to insure that the case is completely demagnetized. The shield should be grounded and the Kinescope bulb supported within the shield on insulating supports. Otherwise, leakage currents through and along the glass envelope may cause pattern distortion.

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. The terminal for this common connection is base pin No.5, to which grid and anode returns should be made. In television circuits, the cathode is usually operated near ground potential.

The *fluorescent screen* of the 7AP4 employs phosphor No.4, which fluoresces to produce a white spot and is particularly suited for the reproduction of television pictures. In equipment using the 7AP4, it is recommended that the screen of the tube be covered with a plate of clear, shatter-proof glass. This glass plate serves to protect the bulb from being struck accidentally and to protect the user in case the bulb should collapse due to some abnormal condition.

A *deflecting yoke* consisting of four electromagnetic coils is employed for deflecting the electron beam. These coils are used in pairs; the coils of each pair, located diametrically opposite each other, should produce a field of uniform flux density for deflection of the beam. The axes of the two fields ordinarily intersect at right angles in the axis of the electron beam and should be perpendicular to the beam axis. The deflection of the electron beam is at *right angles* to the direction of the magnetic fields. The yoke, placed around the bulb neck close to the bulb flare, should be properly oriented so as to produce the desired vertical and horizontal deflections.

Because of the short-bulb construction of the 7AP4, the electron beam must be deflected through a relatively wide angle (approximately 55 degrees) in order to scan the desired picture area. A deflecting yoke especially designed for wide-angle deflection should be used with this Kinescope (see Figs.3 and 4). The center of the magnetic deflecting fields should be located not more than one inch from the point where the bulb neck joins the bulb flare, measured toward the base end of the tube.

The *d-c supply voltages* for the electrodes may be obtained conveniently from a high-voltage, vacuum-tube rectifier. Because the 7AP4 requires very little current, the rectifier system can be of either the half-wave or the voltage-doubler type. For the same reason, the filter requirements are simple. A circuit of a suitable power supply is shown in Fig.1.

The high voltages at which the 7AP4 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 supply when access to the apparatus is required.

In the use of a Kinescope, it should always be remembered that high voltages may appear at points in the circuit normally at a low potential, due to condenser breakdown or to incorrect circuit connections. Therefore, before any part of a Kinescope circuit or its associated circuit is touched, the power-supply switch should be turned off and both terminals of any charged condensers grounded. Whenever any adjustments or measurements are to be made within any chassis, both leads to the primary of the high-voltage transformer should be disconnected and taped.

APPLICATION

Kinescope 7AP4 is designed for the black-and-white reproduction of television pictures. Typical circuits for the application of the tube in a television receiver are shown in Figs.1 and 2.

A typical operating circuit for the 7AP4 in a television receiver, with voltage supply, is shown in Fig.1. Electrode voltages are obtained from a bleeder circuit connected across the high-voltage supply. A bleeder current of about one milliampere is usually satisfactory. Higher values of bleeder current will require the use of additional filtering. A variable d-c voltage for anode No.1 is obtained from a potentiometer in the bleeder circuit. In a television receiver, the video signal and the background-control bias supplied by the receiver are introduced in the grid-cathode circuit of the 7AP4.

The *fluorescent-screen input power* should never exceed 2.5 milliwatts per square centimeter in the brightest portion of a stationary pattern. Approximately twice this value is permissible with a moving pattern. The use of excessive screen-input power may cause temporary loss of sensitivity or permanent destruction of the active screen material. It is recommended that the spot always be kept in motion over a large area of the screen by the application of deflecting current to both sets of deflecting coils. When it is desired to make observations of a stationary spot, or when the spot is to scan only a small area of the screen, the brightness of the spot should be reduced to a low value by adjustment of the grid bias.

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, focusing is accomplished by adjustment of anode No.1 voltage.

Spot size and *intensity* can be regulated by varying anode No.2 current or voltage. The current to anode No.2 may be increased by decreasing the bias voltage applied to the 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 speed of the electrons with the result that spot intensity is increased and spot size is decreased. When any of these adjustments are made, consideration should be given to the limiting voltage and power ratings shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.

In television circuits, the currents supplied to both pairs of deflecting coils should have a sawtooth waveform and a frequency controlled by the synchronizing components of the incoming television signal. Suitable circuits for supplying these deflecting currents are shown in Fig.2.

A typical *vertical-deflecting circuit* for television is shown in the upper section of Fig.2. This circuit generates a sawtooth deflecting voltage in the following manner: In the second 6N7 tube, triode unit "A" operates as a blocking oscillator. Oscillations are started in the circuit by the feedback action of transformer T_1. The flow of grid current which accompanies the first cycle of these oscillations causes a negative bias to build up across condenser C_4 and the grid leak, R_{10} and R_{11}. The bias voltage is sufficiently large to cause the plate current of triode "A" to cut off and thus stop the oscillations. When this occurs, the charge on C_4 leaks off gradually through R_{10} and R_{11} to a value such that the circuit will again start to oscillate. The tube blocks again, and the cycle is repeated.

Because the grid of triode unit "B" is connected to the grid of triode unit "A", the d-c plate current of "B" rises suddenly to a large value during the period of oscillation. When the oscillation stops, the d-c plate current becomes zero until a new cycle starts. With the sudden increase in d-c plate current, the plate voltage of "B" drops abruptly. During the period that the d-c plate current is zero, the plate voltage increases at a relatively slow rate, the rate being controlled chiefly by the time constant of C_{10} and R_{14}. Because the plate voltage of "B" thus goes through an abrupt decrease followed by a relatively slow increase, its variation has a sawtooth form. This voltage, applied to the grid of the 6L6, produces a sawtooth current in the plate circuit of the 6L6 and in the vertical-deflecting coils.

In television circuits, it is essential that this sawtooth wave be synchronized with that generated in the vertical scanning circuit of the Iconoscope at the studio. Synchronization of the vertical oscillator is accomplished by a synchronizing signal which is transmitted with the picture signal and which consists of a series of voltage pulses. In practice, the circuit of triode unit "A" is adjusted to function at a rate slightly slower than the rate of the incoming vertical synchronizing pulses. Hence, when the pulses are applied, the action of the blocking oscillator is speeded up to the proper rate for synchronization. The synchronizing signal should be strong enough so that it has positive control of the blocking oscillator.

Controls are provided so that the circuit can be adjusted for optimum operation. The *hold* controls, R_{10} and R_{11}, provide means for adjusting the frequency of blocking so that the oscillator can be synchronized by the incoming signal. The *picture-height* control, R_{13}, limits the voltage to which C_{10} can charge during the time that plate current is cut off in triode unit "B". The setting of R_{13}, therefore, fixes the amplitude of the sawtooth voltage generated by the 6N7, and thus controls the height of the picture. Controls R_{16} and R_{19} provide adjustments which help to improve the waveform of the vertical deflecting current. The *vertical centering control*,

R_{20}, utilizes the cathode current of both 6L6 amplifier tubes to supply a d-c deflecting current of variable polarity and magnitude to the vertical-deflecting coils. By adjustment of this control, the picture can be shifted up or down on the viewing screen.

A typical *horizontal-deflecting circuit* is shown in the lower section of Fig.2. In this circuit, a 6N7 and an output stage generate a synchronized, sawtooth current in a manner similar to that described for the vertical-deflecting circuit. However, the horizontal-deflecting circuit must operate at a much higher frequency than the vertical-deflecting circuit. Because the horizontal scanning frequency is high, the deflecting current decreases very rapidly on the return portion of the sawtooth cycle. This rapid decrease in current causes shock-excited oscillations in the plate circuit of the output stage. To damp out these oscillations, a type 83-v tube is connected across the plate circuit of the 6L6 horizontal amplifier. When oscillation starts, the effective inductance in the plate circuit of the 6L6 first swings the cathode of the 83-v to a high positive voltage, and then swings it negative. As soon as the cathode of the diode swings negative with respect to the diode plate, the diode conducts current and damps out further oscillations.

At the start of the oscillation, the upper end of the plate circuit may rise to a very large positive voltage — as high as 3000 volts. This voltage is impressed on the cathode of the 83-v. Because this voltage is much higher than the maximum value for which the 83-v is rated, some tubes may have a short life in this circuit. The high voltage is also applied to the plate of the 6L6. It is recommended that only 6L6's of recent production be used in this special application.

The heater transformer supplying the 83-v should be of special design having a secondary winding of low capacitance to ground. An air space of about 1/8 inch should be employed between the heater winding and the primary, and between the heater winding and the core. A low plate-to-ground capacitance in the output stage permits the use of a fast return time for the horizontal sweep. Adjustment of the value of capacitor C_{20} provides some control of the horizontal return time, as well as of the amplitude of the horizontal sweep.

The damping control, R_{34}, together with C_{23}, sets the point in the sawtooth cycle at which the 83-v begins to operate. Proper adjustment of this control helps to improve the waveform of the current in the horizontal-deflecting coils.

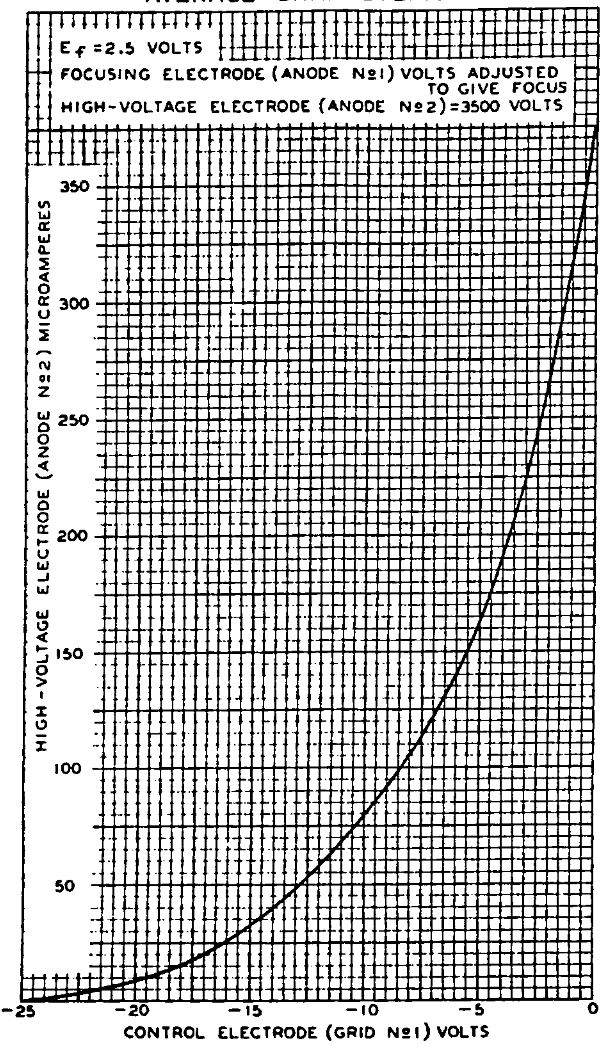
The hold control and the picture-width control in this circuit are similar to the corresponding controls in the vertical-deflecting circuit. The horizontal-centering control, R_{35}, supplies a d-c deflecting current of variable magnitude and polarity to the horizontal-deflecting coils.

In the standard RMA type of television transmission, horizontal and vertical synchronizing signals are sent at the end of each scanning line and field, respectively. These synchronizing signals are separated from the video signal in the sync-separator stage of the receiver. They can then be applied, with negative polarity, to the 6N7 frequency separator stage, shown in the upper section of Fig.2. In this stage, the horizontal and vertical synchronizing signals are separated from each other by means of suitable RC networks in the input and output circuits of the 6N7, and then applied to their respective blocking oscillators.

Many of the controls shown in Fig.2 can be adjusted once for optimum operation, and then left alone. For this reason, provision for adjusting them can be made on the chassis, rather than on the front panel of the receiver (see CIRCUIT CONTROLS, under the legend of Fig.2).

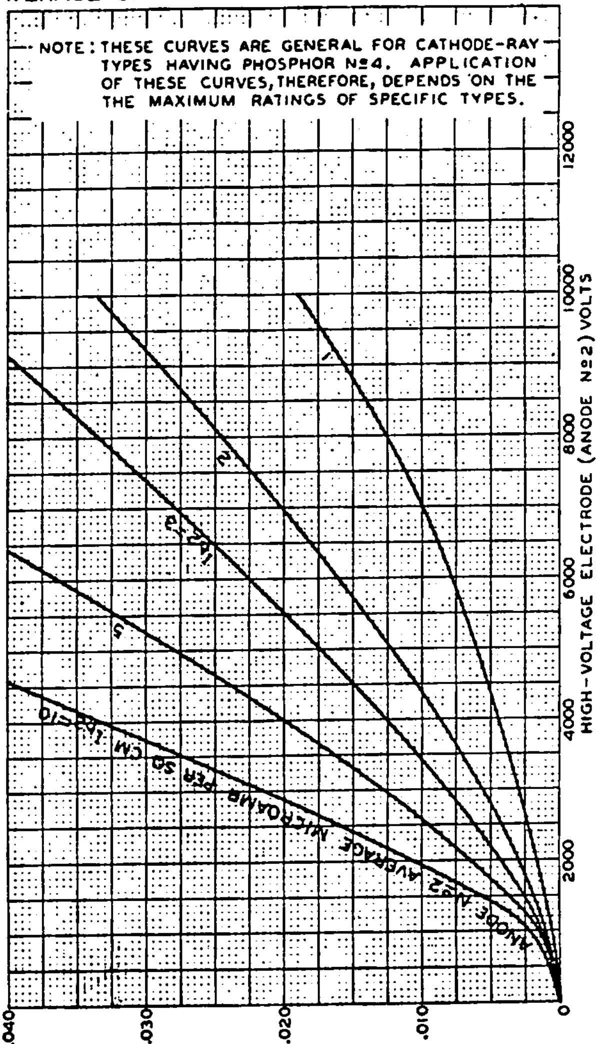
7AP4

AVERAGE CHARACTERISTIC



JULY 25, 1939 RCA RADIOTRON DIVISION 92C-6072

AVERAGE CHARACTERISTICS OF PHOSPHOR №4



OCT. 5, 1938

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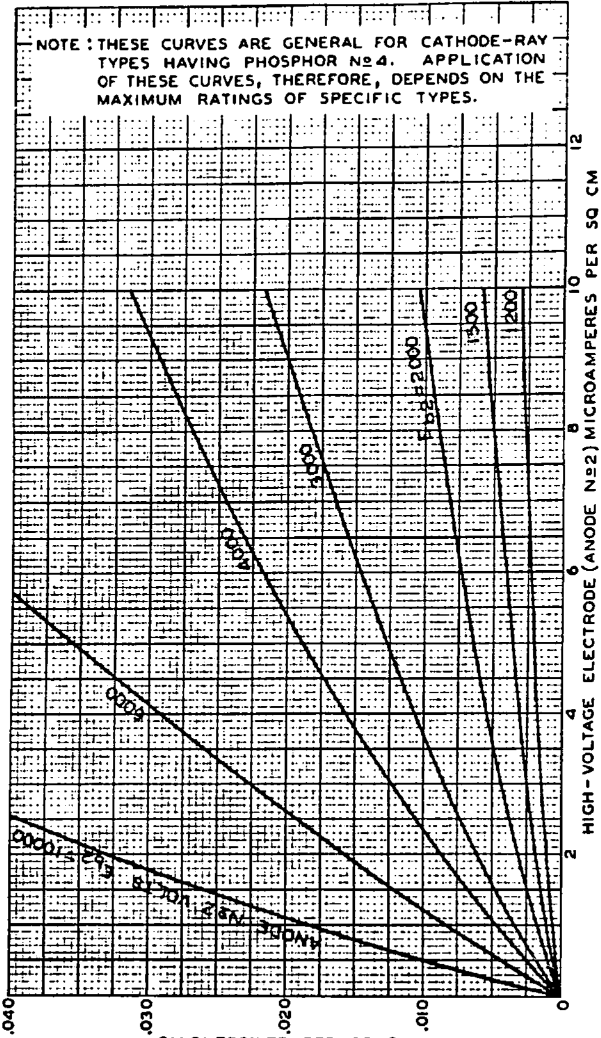
92C-4978

AVERAGE CHARACTERISTICS OF PHOSPHOR No. 4

NOTE: THESE CURVES ARE GENERAL FOR CATHODE-RAY TYPES HAVING PHOSPHOR No. 4. APPLICATION OF THESE CURVES, THEREFORE, DEPENDS ON THE MAXIMUM RATINGS OF SPECIFIC TYPES.



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VOLTAGE-SUPPLY CIRCUIT FOR RCA-7AP4

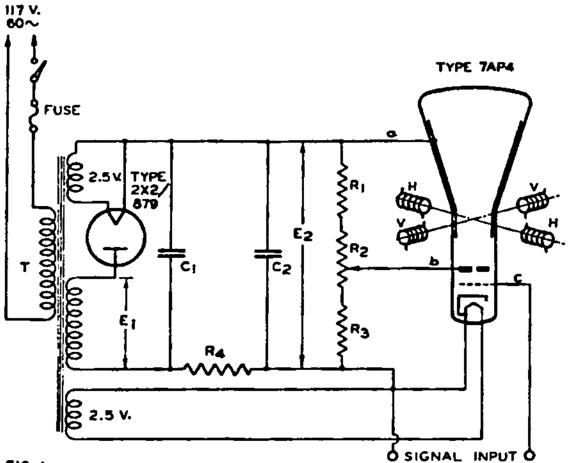


FIG. 1

CIRCUIT ELEMENT	SPECIFICATIONS
E_2	3500 VOLTS D.C.
E_1	3100 VOLTS RMS
C_1	0.05 µf, 4500 VOLTS
C_2	0.05 µf, 4000 VOLTS
R_1	2.25 MEGS., 4 WATTS #
R_2 *	0.25 MEG., 1 WATT
R_3	0.55 MEG., 1 WATT
R_4	0.5 MEG., 1 WATT

H = Horizontal Deflecting Coils
V = Vertical Deflecting Coils
T = Power Transformer

a = Anode No.2
b = Anode No.1
c = Grid

* Potentiometer R_2 should be adjusted by means of an insulated coupling shaft. If the range of voltage supplied by R_2 does not include the value for focus, the resistance of R_3 should be changed.

\# R_1 may conveniently consist of a series of four 0.5-megohm and one 0.25-megohm 1-watt resistors.

DIRECT-DRIVE MAGNETIC SCANNING CIRCUIT FOR KINESCOPE RCA-7AP4

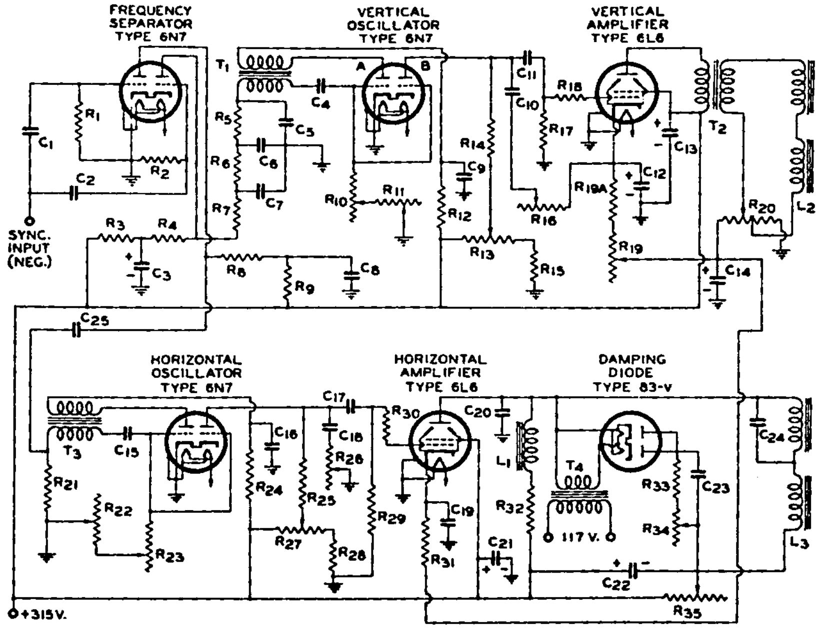


FIG.2

LEGEND FOR FIG.2

R_1 R_2 R_{12} R_{24} = 100000 ohms, 0.5 watt
R_3 R_9 = 10000 ohms, 0.5 watt
R_4 R_{15} R_{28} = 5000 ohms, 0.5 watt
R_5 R_6 R_7 = 8000 ohms, 0.5 watt
R_8 = 3000 ohms, 0.5 watt
R_{10} = 200000-ohm potentiometer
R_{11} R_{16} = 50000-ohm potentiometer
R_{13} R_{23} R_{27} = 100000-ohm potentiometer
R_{14} = 1 megohm, 0.5 watt
R_{17} R_{25} R_{29} = 500000 ohms, 0.5 watt
R_{18} R_{30} = 100 ohms, 0.5 watt
R_{19} = 2000-ohm wire-wound potentiometer, 4 watts
R_{19A} = 200 ohms, 2 watts
R_{20} = 50-ohm wire-wound potentiometer with fixed center tap
R_{21} = 500 ohms, 0.5 watt
R_{22} = 10000-ohm potentiometer
R_{26} = 5000-ohm potentiometer, 4 watts †
R_{31} = 200 ohms, 2 watts
R_{32} = See footnote □
R_{33} = 2000 ohms, 5 watts
R_{34} R_{35} = 2000-ohm wire-wound potentiometer, 4 watts
C_1 = 0.0008 µf, mica
C_2 C_4 C_{10} = 0.1 µf, 400-v. paper
C_3 = 10 µf, 150-v. electrolytic
C_5 C_6 C_7 = 0.005 µf, mica
C_8 C_9 C_{11} = 0.25 µf, 400-v. paper
C_{12} C_{14} = 40 µf, 50-v. electrolytic
C_{13} C_{21} C_{22} = 8 µf, 450-v. electrolytic
C_{15} = 0.001 µf, mica
C_{16} C_{23} = 0.05 µf, 400-v. paper
C_{17} = 0.002 µf, mica
C_{18} = 0.00025 µf, mica
C_{19} = 1 µf, paper
C_{20} = 25 to 75 µµf, mica, 3000-v. peak *
C_{24} = 50 to 125 µµf, mica
C_{25} = 150 µµf, mica
T_1 = RCA vertical oscillator transformer, No.32898
T_2 = Vertical output transformer #
T_3 = RCA horizontal oscillation transformer, No.32899
T_4 = Special 5-volt heater transformer **
L_1 = Horizontal output reactor, 5 (approx.) henries, 100 ma. ## □
L_2 = Vertical coils of deflecting yoke
L_3 = Horizontal coils of deflecting yoke

* Value determined by desired return time and amplitude of horizontal sweep.
\# Turns ratio between 8:1 and 5:1, step-down; primary inductance approximately 50 henries.
** Secondary winding must have low capacitance to primary and to core, and must be insulated for 3000 volts peak.
\## Reactor should have low capacitance to ground.
† Minimum resistance setting of R_{26} should be sufficient to maintain plate-current cut-off in 6L6 during horizontal return time. Otherwise, plate dissipation of 6L6 may be exceeded.
□ Total resistance of R_{32} and L_1 should be approximately 250 ohms.

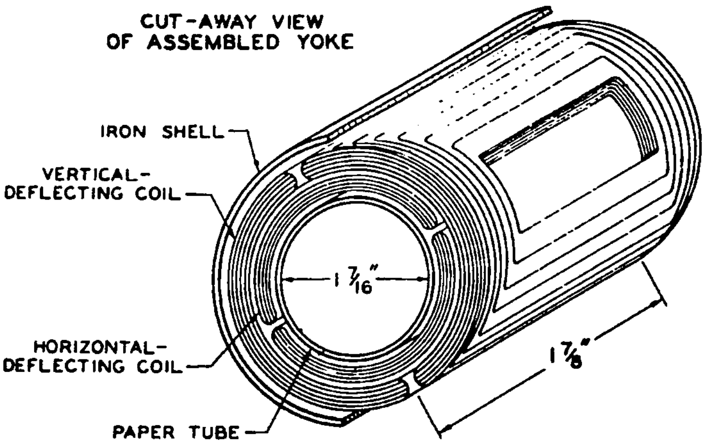
NOTE: All circuit leads associated with the 6L6 horizontal amplifier plate circuit should have low capacitance to ground. The 6L6 horizontal amplifier tube and the 83-v damping tube should have ceramic sockets.

CIRCUIT CONTROLS

R_{10} = Vertical hold (coarse)
R_{11} = Vertical hold (fine) ★
R_{13} = Picture height
R_{16} R_{19} = Vertical linearity
R_{20} = Vertical centering
R_{22} = Horizontal hold (fine) ★
R_{23} = Horizontal hold (coarse)
R_{27} = Picture width
R_{26} R_{34} C_{20} C_{24} = Horizontal linearity
R_{35} = Horizontal centering

★ These controls should be adjustable from the front panel of the receiver. The other controls require infrequent adjustments which can generally be made on the chassis.

DEFLECTING YOKE
FOR WIDE-ANGLE DEFLECTION



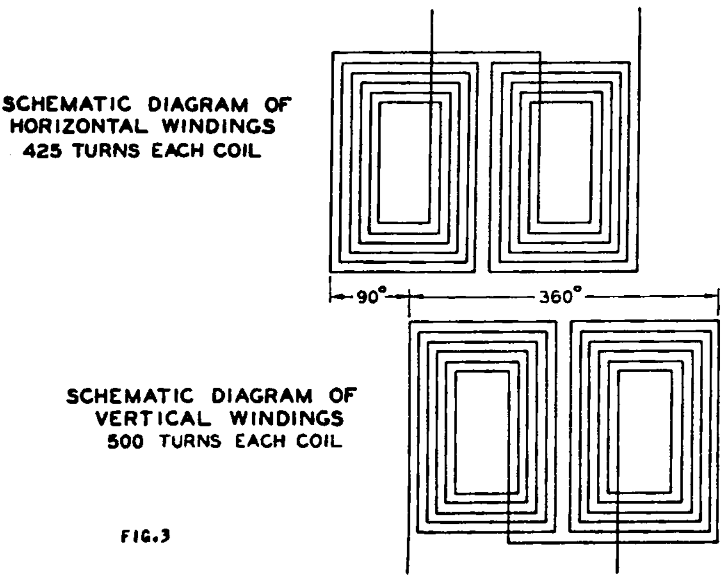
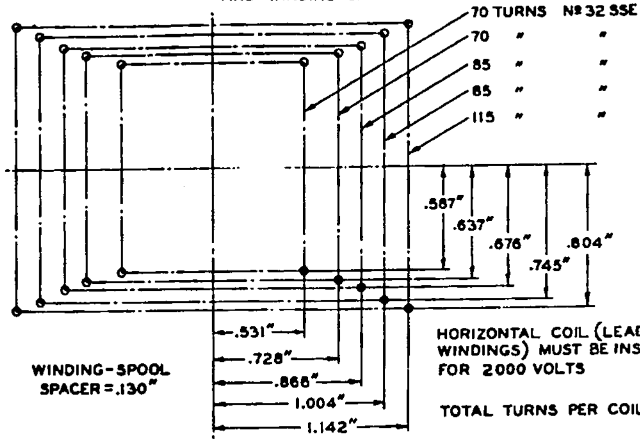


FIG. 3

WIDE-ANGLE YOKE DATA
FOR RCA-7AP4

HORIZONTAL COIL FORM AND WINDING DATA

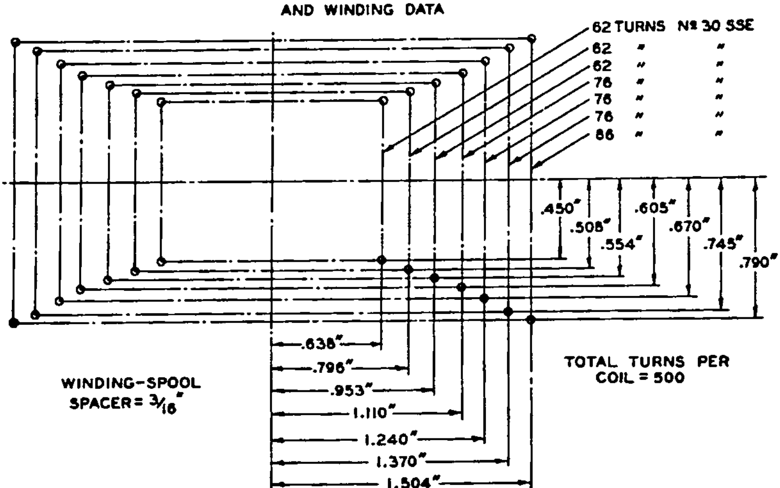


WINDING-SPOOL SPACER = .130"

HORIZONTAL COIL (LEADS AND WINDINGS) MUST BE INSULATED FOR 2000 VOLTS

TOTAL TURNS PER COIL = 425

VERTICAL COIL FORM AND WINDING DATA



WINDING-SPOOL SPACER = 3/16"

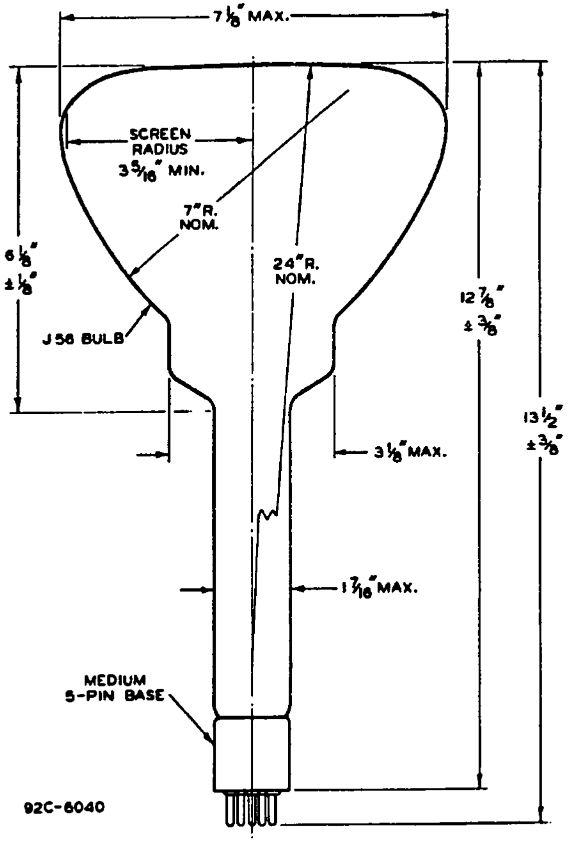
TOTAL TURNS PER COIL = 500

NOTES:
- IRON SHELL = 3 LAYERS OF .020" TO .030" SWEDISH IRON
- DRILL HOLES FOR PINS WITH Nº 55 DRILL
- INSULATION AND SHIELD = 1/32" BETWEEN HORIZONTAL AND VERTICAL COILS

FIG. 8

7AP4

KINESCOPE



Top View of Socket Connections