164C1 TELEGRAPH TRANSMISSION MEASURING SET DESCRIPTION

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1. GENERAL

1.01 This section describes the circuits and operating principles of the 164C1 telegraph transmission measuring set per J70119A, List 4, or modified per ES-945471 and ES-947086.

1.02 This section is reissued to include information previously covered in the Addendum. (New Fig. 13)

1.03 The principal changes and additions included in this issue are as follows:

(a) Revision of the circuit description and associated simplified schematics to agree with the modified set.

(b) Revision of the component location tables and figures to agree with the modified set.

(c) Clarification and amplification of the calibration and use procedures.

(d) Addition of oscilloscope and voltmeter tests in the maintenance instructions.

(e) Addition of information describing features and procedures for measuring in the send side of a 43A1 channel.

1.04 The 164C1 telegraph transmission measuring set is portable and, when patched into telegraph loops, provides direct indication of the distortion present in start-stop teletypewriter signals without interruption of service. The distortion indications have an accuracy of about ±3 per cent. This compares favorably with older designs of telegraph transmission measuring equipment.

1.05 The modified set also provides a separate input circuit which permits the measurement of distortion in the signals applied to the send-control tube of a 43A1 channel terminal. Measurements made at this point include the combined distortion effect of the sending station and the loop. This input circuit should not be used to measure signals sent into the loop toward the station. This latter type of measurement is made with the regular input circuit.

1.06 Displacements of the teletypewriter signal transitions from their proper positions are indicated on the screen of a cathode-ray tube in the form of vertical excursions on a horizontal trace or by the appearance of a bright spot. The value of such displacements in per cent of a signal element may be observed directly on a scale mounted in front of the face of the cathode-ray tube.

1.07 The displacement expressed as a percentage of a signal element of a teletypewriter character is established by referring impulses generated from the input signal transitions to a locally-generated timing wave.

1.08 The horizontal displacement of the beam of the cathode-ray tube is controlled by either of two different voltages to produce two different types of display. With the DISPLAY switch in the PIP position, a triangular sweep voltage is applied to the deflection plates so that a "pip" is produced on the screen for every signal transition. With the switch in the PK position, a voltage is accumulated which is proportional to the maximum, or peak, distortion of the received pulses. (See Figs. 1A to 1E.)

1.09 The timing wave is produced by a multivibrator circuit which generates a series of square-wave cycles equal in number to the elements of the teletypewriter signal under test. Each square-wave cycle has a time duration of one element of the teletypewriter signal under test. The square-wave multivibrator output signals are applied to a wave-shaping circuit to produce an isosceles-triangle-shaped wave having essentially linear amplitude vs time relations as shown at (E) in Figs. 1A to 1D.

1.10 The multivibrator operation is started by the first mark-to-space transition (beginning of start pulse in a teletypewriter character. It is stopped by a circuit that operates during the stop pulse of the teletypewriter character.

1.11 Impulses produced from the transitions in the input signal are directed to the vertical deflection plates of the cathode-ray tube. The polarity of these impulses is established by the nature of the particular transition. It determines whether the vertical-plate deflection circuit will move the beam above or below the horizontal axis. This effect is shown at (D) in Figs. 1A to 1D.

1.12 For the PIP display, the triangular timing voltage causes the beam to sweep from left to right to left. Each cycle (or pulse) of the timing voltage is equal to the length of a unit pulse for the signal speed to be measured. The beam therefore reaches the right extremity of its travel, and then reverses, at a time corresponding to the 50 per cent point of an undistorted signal pulse. The left extremity occurs at times corresponding to both the beginning and end of such pulses. The persistence of the phosphor in the cathode-ray tube makes the trace visible on the screen.

1.13 Distortion is present in a start-stop teletypewriter signal when any mark-to-space or space-to-mark transition occurs early or late with respect to its correct position. The manner of combining the horizontal sweep and vertical deflection effects in the 164C1 circuit (as arranged for PIP presentation) results in a display pattern which shows the magnitude and direction of the displacement as well as the type of transition affected.

1.14 When signals having uniform displacement of all mark-to-space or of all space-to-mark transitions are generated by a special signal source and applied to the 164C1 circuit, the circuit operations and distortion displays are as shown in Figs. 1A to 1D. The four types of pips which appear under these special conditions are shown on the distortion scale. It should be noted, however, that display patterns which appear during measurements on actual transmission circuits will in general have a combination of effects. In addition, the displayed pattern may vary as a result of random effects (fortuitous distortion), and of the varying nature of the text material being transmitted if characteristic distortion is present. For this reason it will usually be desirable to record pip indications of bias and end distortion effects as average values with plus and minus variations, as well as the peak indication of maximum total distortion. Bias may be determined from the pips above the axis. Characteristic distortion may be determined from the pips below the axis. Fortuitous effects may best be observed from peak indications over a period of time. The peak indications will, of course, include the bias and characteristic distortion also.

1.15 It will be noted in Figs. 1A to 1D that the vertical-deflection impulses resulting from transitions in the input signal have steep wave fronts with tapering returns. The combination of horizontal sweep and vertical deflections causes this impulse shape to be reproduced on the cathode-ray tube screen. It will also be noted that the percentage distortion is established by observing the position on the scale at which the vertical portion of the impulse departs from the horizontal trace. The position of the tapering return with respect to the vertical portion of the impulse will indicate whether the distortion is marking or spacing.

1.16 When only maximum distortion (PEAK condition) is of interest, the triangular-shaped timing wave is not used to produce a horizontal trace but is gated into a capacitor-charging circuit as each signal transition occurs, as shown in Fig. 1E. The capacitor assumes the maximum voltage occurring during the series of gated intervals. This voltage is applied to the horizontal deflection circuit. In this way the cathode-ray beam is deflected horizontally to a point which indicates the maximum distortion which was present during the series of teletypewriter pulses. Operation of the RESET button will discharge the capacitor. When the RESET button is released the capacitor will assume the voltage corresponding to the distortion of the pulses then being received. The reading will be zero while the button is actually depressed.

1.17 ***Important:*** Relay armature bounce sometimes causes "ghost" pips to appear up scale from the normal indications. When such "ghosts" appear, use the PIP display only. The armature bounce will cause erroneous PK readings. The "ghost" pips are somewhat square in shape and appear both above and below the reference line. If two "ghosts" are present, one will be narrower than the other.

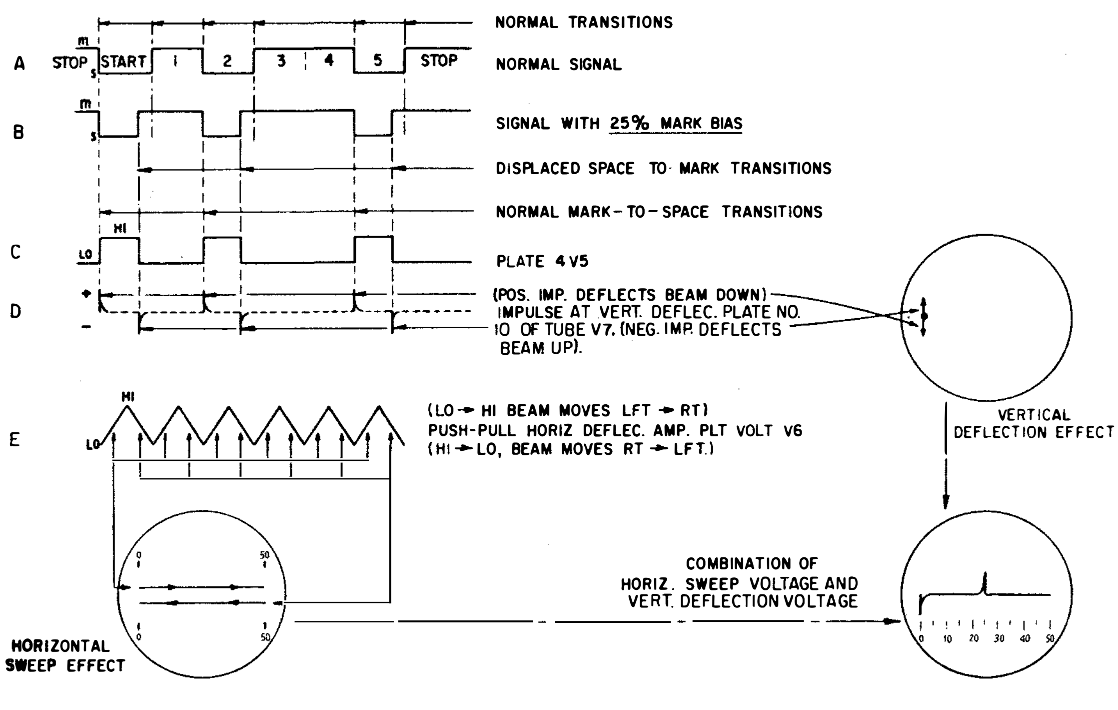


Fig. 1A – Impulse and Sweep Relations for PIP Display 25% Marking Bias

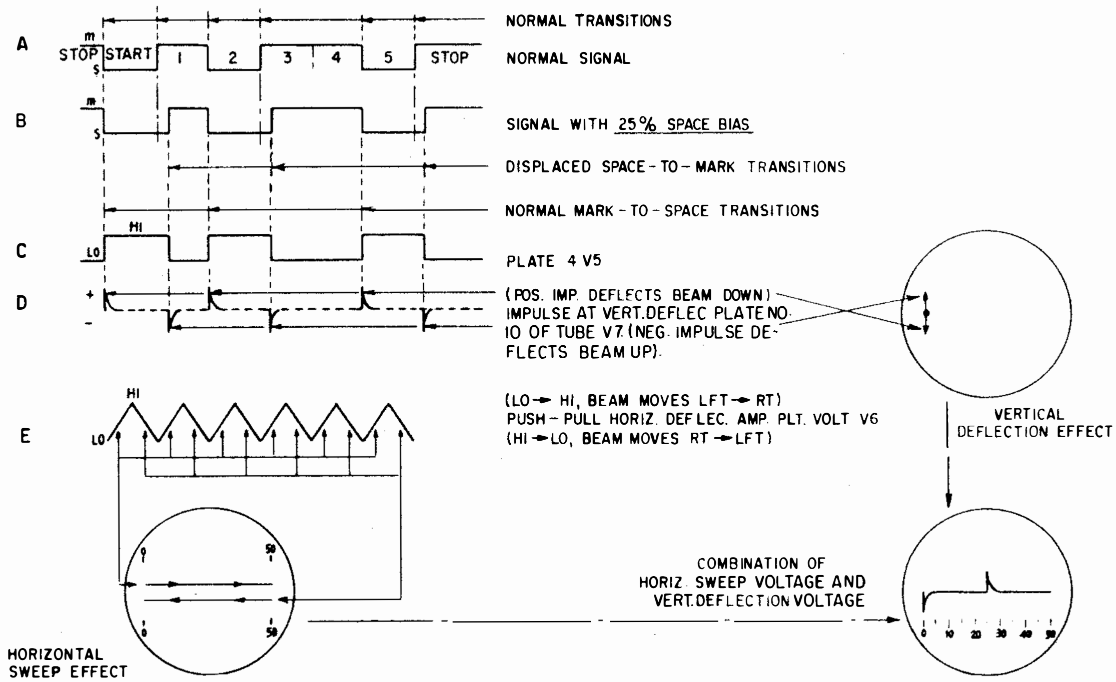


Fig. 1B – Impulse and Sweep Relations for PIP Display 25% Spacing Bias

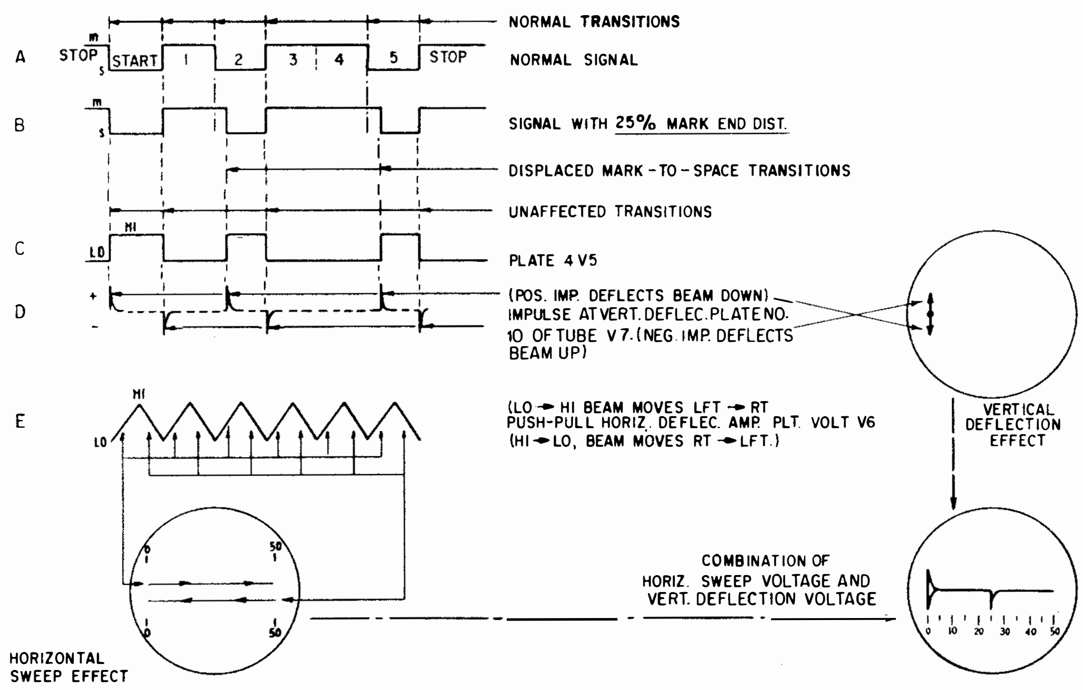


Fig. 1C – Impulse and Sweep Relations for PIP Display 25% Marking End Distortion

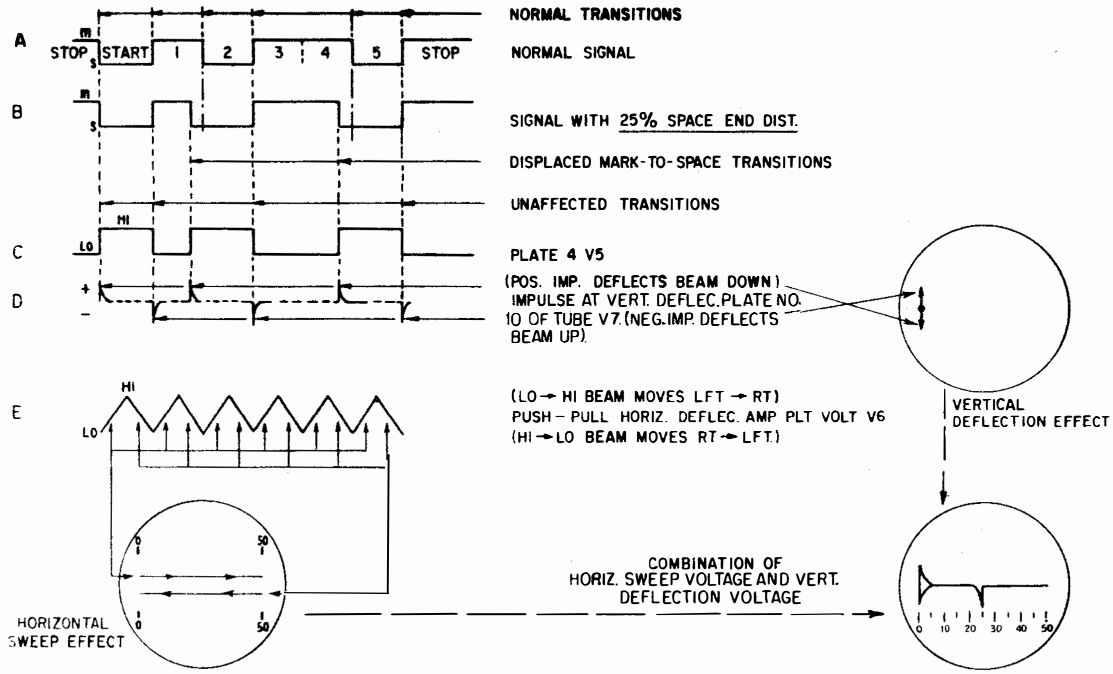


Fig. 1D – Impulse and Sweep Relations for PIP Display 25% Spacing End Distortion

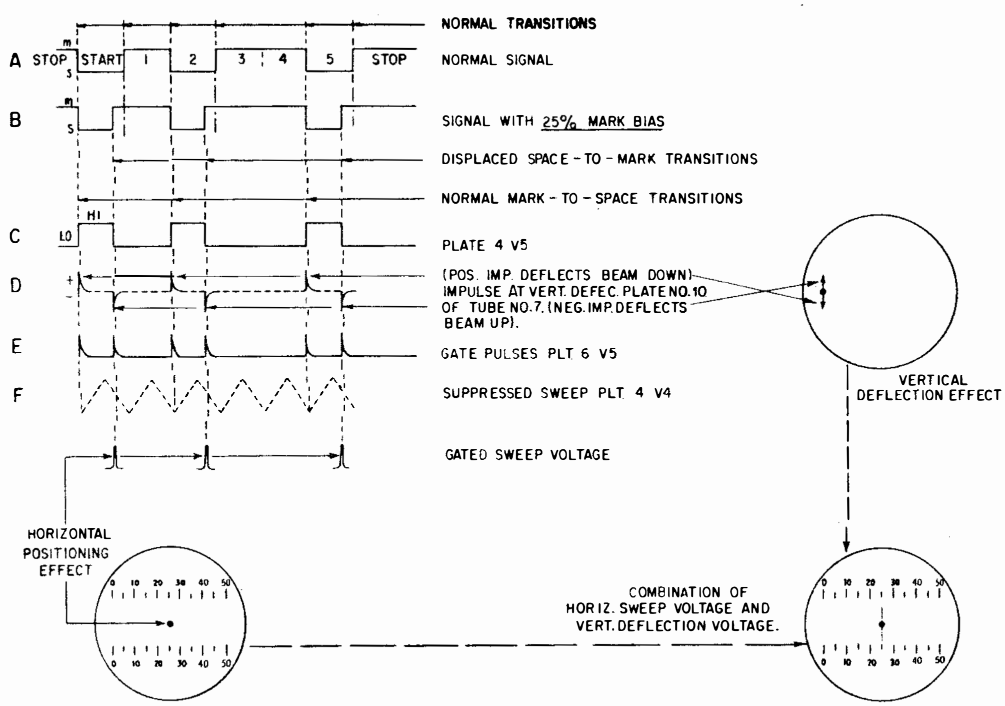


Fig. 1E – Impulse and Gating Relations for Peak Display 25% Distortion

2. GENERAL FEATURES

(A) Circuit Features

2.01 Reference should be made to Fig. 2 showing front view of the transmission measuring set.

2.02 Control switches LOOP, SPEED and CODE provide for measurement in transmission circuits having any of the following conditions:

(a) Polar, 20 ma neutral, or 60 ma neutral transmission.

(b) 60, 75, or 100 words per minute transmission speeds.

(c) 5- or 6-unit teletypewriter code.

2.03 Control switch DISPLAY provides for either of two types of distortion display:

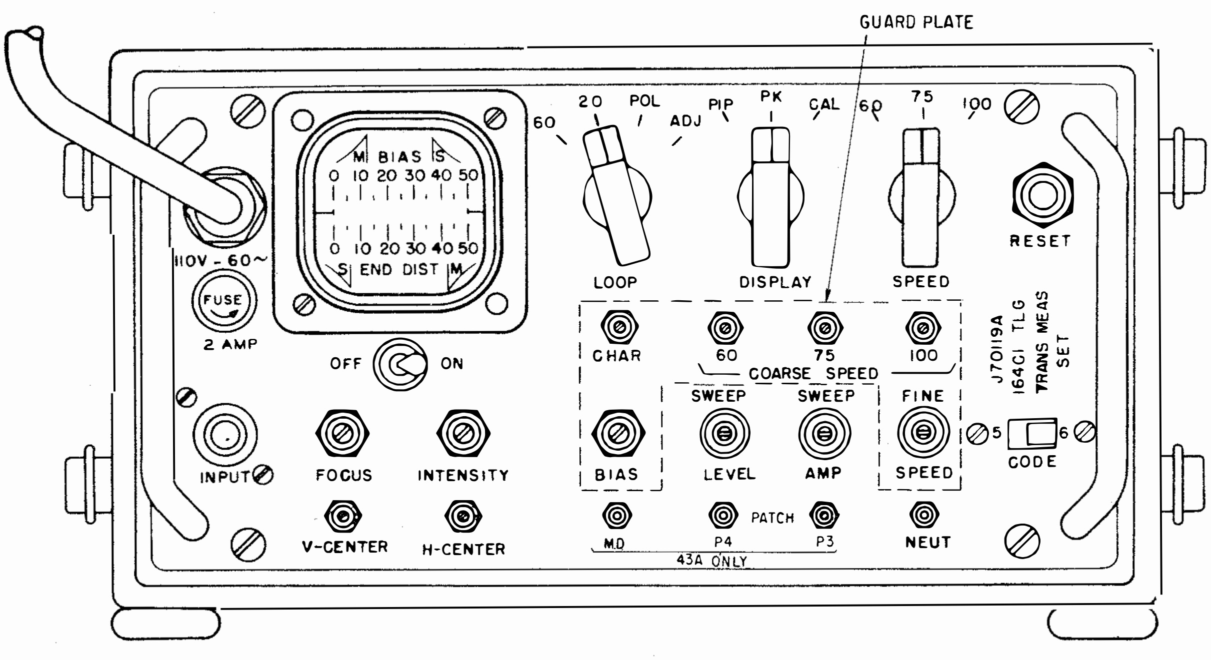
(a) Maximum distortion occurring during a series of pulses (PK position of switch).

(b) Bias and/or end distortion of individual pulses (PIP position of switch).

2.04 In addition to the control switches, the continuously-variable controls listed in Table I are provided for calibration and for close adjustment of circuit constants. The test points listed in Table I are provided for observation of circuit performance during calibration.

2.05 The seven electron tubes required and the general functions which they perform in the circuit are listed in Table II.

2.06 All voltages required for operation of the set are provided by an internal power rectifier. Input power requirements are 30 watts from a commercial source of 105 to 125 volts, 60-cycle ac.



NOTE: ON EARLY MODELS OF THE SET, THE 43A PIN JACKS WERE DESIGNATED 43A, P3 AND P4, INSTEAD OF MD AND PATCH AS NOW SHOWN.

Fig. 2 – 164C1 Telegraph Transmission Measuring Set — Front View — Cover Removed

TABLE I

CONTROL SWITCHES, CONTROL POTENTIOMETERS AND TEST POINTS

NAME OF CONTROL	CIRCUIT DESIG.	POSITIONS	FUNCTION
LOOP	SW1	60-20-POL.-ADJ.	a. Adjustment of input circuit biasing voltages to agree with the type of transmission used in the circuit under observation. The LOOP switch must be in position 60 for measurements in the send side of 43A1 channels. The set will read correctly regardless of the type of loop since it is reading the voltage swing across the send-control tube. b. Removal of input circuit biasing voltages other than calibration bias voltage to facilitate input circuit calibration.
CODE	SW2	5-6	Adjustment of capacitance in gating circuit associated with timing multivibrator to control number of code pulses between successive start pulses.
SPEED	SW3	60-75-100	Adjustment of character-timing, element-timing and timing-wave-shaping circuits to correlate reference timing with the signals under observation. Adjusts capacity in wave-shaping circuit, adjusts grid-return voltage in element-timing and character timing circuits.
DISPLAY	SW4	PIP-PEAK-CAL.	a. Arrangement of horizontal deflection circuit for continuous or peak display of input signal distortion. b. Elimination of start pulse from gating circuit so that element-timing multivibrator is allowed to run free during calibration.
RESET	SW5	(Nonlocking)	Quick discharge of capacitor which gives peak-distortion indication.
BIAS	R8	(Continuous)	Adjustment of calibration component of input circuit biasing voltage.

TABLE I (Cont'd)

NAME OF CONTROL	CIRCUIT DESIG.	POSITIONS	FUNCTION
MV BAL	R47	(Continuous)	Differential adjustment of plate-circuit impedance in element-timing multivibrator to effect unbiased square-wave output.
CHAR	R39	(Continuous)	Fine adjustment of grid voltage in character-timing circuit.
60 COARSE SPEED 75 COARSE SPEED 100 COARSE SPEED	R60 R63 R66	(Continuous) (Continuous) (Continuous)	Coarse adjustment of grid voltage of element-timing multivibrator to produce pulse intervals of the proper length.
FOCUS INTENSITY	R109 R113	(Continuous) (Continuous)	Adjustment of potentials at cathode-ray tube control elements to effect sharp definition of cathode-ray beam at fluorescent tube face.
V CENTER	R116	(Continuous)	Adjustment of relative potentials of vertical deflection plates of cathode-ray tube to provide control of vertical rest position of cathode-ray beam.
H CENTER	R100	(Continuous)	Adjustment of cathode potential of input triode of horizontal deflection amplifier to control the rest position of cathode-ray beam in the horizontal plane.
SWEEP LEVEL	R81	(Continuous)	Adjustment of grid bias voltage at timing-wave amplifier input triode to control the relation between the triangular timing wave and the grid-plate characteristic of the timing-wave amplifier.
SWEEP AMP	R70	(Continuous)	Adjustment of attenuation at input to timing-wave-shaping circuit to control length of horizontal sweep.
FINE SPEED	R69	(Continuous)	Adjustment of grid voltage for element-timing multivibrator to provide fine control of reference element length. Adjustment is common to 60, 75 and 100 COARSE SPEED control circuits.

TABLE I (Cont'd)

TEST POINTS	CIRCUIT DESIGNATION	PURPOSE
MV BAL	P2 Test Pin Jack	To provide a high impedance test connection to plate of multivibrator for oscilloscope observation of square-wave reference timing signal.
Patch (P3 and P4 on old sets)	P3 Test Pin Jack P4 Test Pin Jack	Special patch is required between these two jacks when measuring distortion in send side of 43A1 channel.
NEUT	P5 Test Pin Jack	To provide, on the front panel, a test connection to circuit neutral potential.
MD (43A on old sets)	P6 Test Pin Jack	To provide a connection to 43A1 carrier terminals.
NEUT	P7 Test Pin Jack	To provide, on the chassis, a test connection to circuit neutral potential.

TABLE II

ELECTRON TUBES REQUIRED

DESIG.	TYPE*	CIRCUIT FUNCTION
V1	RCA 12AX7	Two-Stage Input Amplifier
V2	WE 396A	One-Shot Multivibrator Character Timer
V3	12AU7 or 5963**	Multivibrator Element Timer
V4	WE 396A	Timing-Wave Amplifier and Gate
V5	WE 396A	a) Inverter-Amplifier b) Impulse Amplifier or Clamp
V6	WE 396A	Horizontal Deflection Amplifier
V7	RCA 2BP1	Distortion Display (Cathode-Ray Tube)

* All tubes twin-triode type except cathode-ray tube V7.

** The 5963 is essentially like the 12AU7, but may give better performance when used in the socket. (See Paragraph 4.31.)

(B) Equipment Arrangement

2.07 The measuring set without the cover is about 11 inches long, 6 inches high and 8 inches deep. The weight is approximately 13 pounds including the cover.

2.08 A handle is provided with the cover for carrying purposes when the cover is attached to the unit. Two handles are mounted on the face panel to aid in positioning the unit when the cover is removed.

2.09 The power cord of the set is terminated in a 3-conductor (one grounding pin) plug. A power plug adapter is required when the ac power supply is available only through a 2-conductor, parallel-slot receptacle. A 2P1D patch cord is required for connecting the set to standard loops. A P2CR patch cord is required for connecting the set to 43A1 terminals. A compartment in the cover provides for storage of the power cord, power plug adapter, patch cords and spare fuses.

2.10 A shelf assembly is available for mounting the measuring set, complete except for the cover, in 19-inch or 23-inch relay rack framework. The set may readily be mounted in or removed from the shelf assembly so that it is available for either central office or portable use. A bench stand for inclining the set with respect to a bench top is also available.

2.11 The chassis and face panel form an integral unit upon which all circuit components are mounted. The release of four screws which secure the face panel to the case permits the chassis to be withdrawn from the case for maintenance purposes.

> ***Caution: Potentials as high as 800 volts may be encountered within the set. When working with the chassis removed from the case, extreme care should be exercised to contact only those points intended for measurement.***

2.12 All controls and test pin jacks except those associated with the multivibrator are located on the face panel. The multivibrator controls, which require only occasional adjustment, are mounted on the chassis.

2.13 The cathode-ray tube, whose screen appears in the upper left corner of the face panel is surrounded and supported by a cone-shaped magnetic iron shield. The shield reduces electrostatic and electromagnetic disturbances which might otherwise impair the cathode-ray tube performance.

2.14 A transparent scale and rectangular frame are placed in front of the cathode-ray tube screen. The frame which holds the scale is secured to the face panel by two diagonally-positioned mounting screws. The removal of the scale and frame from the face panel makes possible the positioning or extraction of the cathode-ray tube. The scale is calibrated to read in terms of per cent distortion. Symbols distinguishing the various types of distortion which may be displayed on the screen are shown on the four corners of the scale.

2.15 The face and side panels of the set are insulated from the main chassis and are grounded through the power cord. This arrangement allows the main chassis to be connected to the circuit neutral potential while the other members of the structure, particularly the outer case and front panel, are maintained at building ground. The circuit neutral is the potential which appears on the tip of the input jack from the connecting circuit. This potential may lie anywhere between +130 and −130 volts depending upon the particular connected circuit.

2.16 An aluminum guard plate has been designed which can be attached to the 164C1 set. This plate covers certain controls which are not required for making transmission measurements and which should not be disturbed after the set has been calibrated. The plate covers the following controls as indicated by the broken lines in Fig. 2: BIAS, CHAR, 60, 75, 100 (coarse speed controls) and FINE SPEED. However, an opening in the plate over the FINE SPEED control permits the use of this control if required when the plate is attached. The plate is attached to the measuring set by two hollow screws which can be inserted in the shaft holes of the CHAR and 100 controls.

3. CIRCUIT DESCRIPTION

(A) General

3.01 The relation of major functions within the measuring circuit is shown in Fig. 3. Simplified schematic drawings showing the portions of the circuit included in each of the blocks of Fig. 3 are given in Figs. 9, 10, 11, 12 and 13 (fold-out pages).

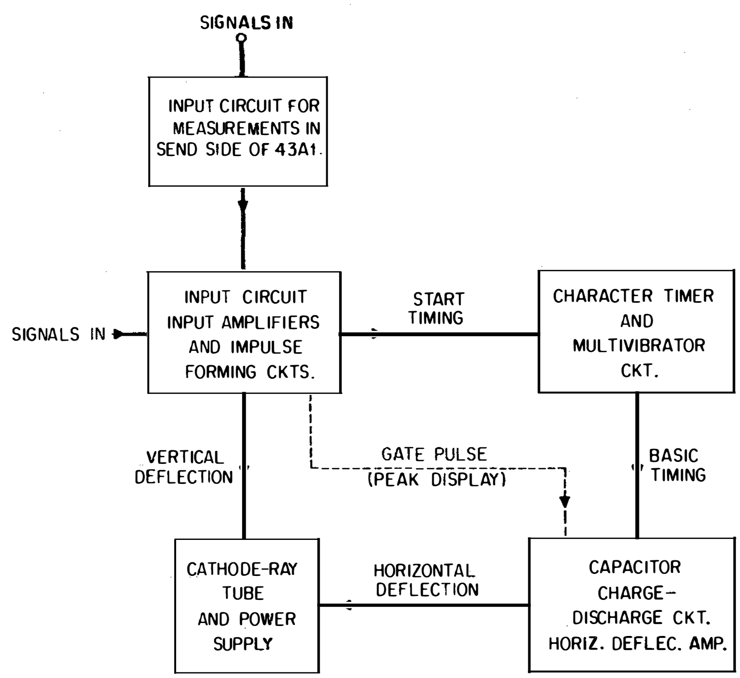


Fig. 3 – Functional Relations

3.02 The simplified schematics are used as the basis of explanations of circuit operation; these explanations are given only in sufficient detail to provide an understanding of the principles of operation and the method of using the set. Reference should be made to the circuit schematic and circuit description when more detailed information on circuit operation and components is required.

3.03 In the explanations of circuit operation the terms positive and negative are, in general, used in a relative sense and are not necessarily the potentials with respect to the circuit neutral.

3.04 In the following descriptions of circuit operation the phase of signals is, unless otherwise stated, referred to that of the signal voltage developed across resistor R1.

(B) Input Control (Fig. 9)

3.05 The input signal to the measuring set is the voltage developed by the flow of loop current through the 150-ohm input resistor R1. The R-C filtering circuit in the input path attenuates high-frequency transients which have no significant relation to telegraph signal distortion.

3.06 The input control circuit provides for properly relating the input signal to the grid-voltage, plate-current characteristic of input tube V1. Three types of BIAS control are required to establish this relation: calibration, centering and "stick-stick" or "hysteresis" response.

3.07 The calibration BIAS control provides a component of bias on the control grid of tube V1 to compensate for manufacturing and aging variations in the components of the input circuit. The BIAS control is also used to simulate an input signal during calibration and adjustment of other portions of the circuit.

3.08 A second component of bias on the control grid of tube V1 is provided which is called "centering" bias. The input signal to the control grid is applied to a 150-ohm resistor. This would swing the grid from 0 to about +9.4 volts for a 62.5 ma signal, from 0 to 3 volts for a 20 ma signal, and from −4.5 volts to +4.5 volts for a polar signal. The centering bias circuit provides a negative component on the grid equal to half the voltage of the signal: −4.7 volts, −1.5 volts, and 0 volts, for the three cases cited above, respectively. The centering bias circuit is controlled by one wafer of the LOOP switch.

3.09 The purpose of the "stick-stick" bias function is to bring the distortion indications of the measuring set into agreement with the observed performance of telegraph signal receivers which have input relays. This is accomplished by simulating, in the electronic circuit, a "stick-stick" or "hysteresis" response characteristic similar to the operate and release characteristics of a polar relay as adjusted for telegraph service. The transmission indication with rounded input signals is made to agree more closely with the performance to be expected from the actual transmission circuit termination. As shown in Fig. 9, the amplified and squared signal at plate 1 of tube V1 is in phase with the input signal at pin 7 of tube V1. A portion of the amplified-signal, properly centered by a potentiometer, is fed back to pin 7 by way of the LOOP switch to provide the stick-stick effect illustrated in the upper left portion of Fig. 9. The magnitude of stick-stick effect required to simulate 62.5 ma neutral, 20 ma neutral and polar types of receiving devices is established at the similarly-designated positions of the LOOP switch. The input circuit for signals from a 43A1 channel (see Fig. 10) contains an amplifier which squares up the signal pulses. The "stick-stick" bias is still applied when this input circuit is being used, but has no effect on the square signals.

3.10 When calibrating the set, the LOOP switch (in the ADJ position) removes the "stick-stick" bias from the grid of tube V1 so that the calibration component of the bias may be adjusted by itself.

(C) Input Amplifiers (Fig. 9)

3.11 It will be noted from the wave shape diagrams in Fig. 9 that the two stages of amplification provided by tube V1 result in a square-wave in-phase version of the input signal at plate 1 of this tube. A portion of this in-phase square-wave signal is applied to pin 3 of tube V5 and results in an inverted square-wave signal at pin 4 of tube V5. The inversion results from the fact that a change towards negative in control grid voltage produces a decrease in plate current and hence an increase in voltage at the plate of the tube.

(D) Impulse Formation (Fig. 9)

3.12 The in-phase and inverted square-wave signals developed by the input amplifier stages are applied to the two branches of the inpulse-forming network as indicated near the center of Fig. 9. It will be noted that the varistors in both branches of this network are so poled that their impedance is low when the connected plate circuit becomes negative and is high when the connected plate circuit becomes positive. Thus for a mark-to-space input transition, varistor CR6 presents a low impedance to the impulse voltage developed across resistor R22 while varistor CR7 presents a very high impedance to the impulse developed across resistor R23. This effect is reversed for a space-to-mark input transition. That is, varistor CR7 presents a low impedance and varistor CR6 presents a high impedance to the impulses produced from the associated plate circuits. For either type of transition, however, a negative-going impulse is applied to pin 7 of tube V5 and results in a positive-going impulse at the plate of this tube. This positive-going impulse is routed by the DISPLAY switch either to the beam-intensifying control of the cathode-ray tube (PIP display) or to a gate circuit in the horizontal-position control circuit for the cathode-ray tube (PEAK display). The functions performed by pulses in these circuits are covered more fully in following paragraphs.

3.13 A second impulse-forming circuit connected to pin 4 of the tube V5 supplies both positive-going and negative-going impulses to the vertical-deflection circuit of the cathode-ray tube. These impulses, in combination with the horizontal deflecting voltages, result in the bias and end distortion display patterns shown in Figs. 1A to 1D.

(E) Input Circuit for Distortion Measurements in Send Side of 43A1 Terminal (Fig. 10)

3.14 This special input circuit provides for the measurement of dc teletypewriter signals sent from the loop into a 43A1 channel terminal. It should not be used to measure signals sent into the loop from the channel terminal. This latter type of measurement is made using the regular input circuit of the 164C1 set. The input circuit for 43A1 is operated from the voltage swing on the control grid of the send control tube in the 43A1 channel terminal, and can be used satisfactorily for measurements on 43A1 terminals arranged for either half or full duplex loop terminations. The circuit allows the measurement of the combined distortion effect of the sending station and loop, plus the response of the carrier terminal modulator tube.

3.15 To measure signals sent toward the carrier terminal the following pin-plug patches are made as shown in Fig. 10:

164C1 JACK DESIGNATION		43A1 JACK DESIGNATION
MD or 43A	to	MD
NEUT	to	C
PATCH or P3 and P4	together	—

3.16 The carrier input circuit uses a P-N-P transistor as a grounded-emitter dc amplifier. Current from a negative voltage source, when applied to the base, causes the transistor to conduct as a virtual short circuit from collector to emitter. This effectively grounds the grid of the input amplifier V1, (Fig. 9) causing a marking signal. Positive voltage applied to the base cuts off the transistor so that the collector appears as an open circuit, and leaves the regular spacing bias applied to the input amplifier.

3.17 Square-wave signals from the carrier modulator are about 12 volts peak-to-peak, and are relatively positive for spacing. The dc off-ground component is removed by capacitors C32 and C31 so that the signal at R144 becomes based on the 164 set NEUTRAL or chassis voltage. The new dc component is reinserted by varistor CR12. This varistor is poled so that marking signals do not go further negative than ground, so that the full value of the positive spacing signals will be applied to the base, for the spacing condition. During idle, or marking conditions, a small marking current is applied to the base via R146.

3.18 When the carrier channel terminates a long loop, there is a tendency for the tails of the signal pips to display small loops caused by the carrier frequency. These loops do not affect the accuracy of the set, and should be ignored if they occur.

(F) Character and Element Timing (Fig. 11)

3.19 The character-timing circuit provides an interval that is equal in time to the length of the start pulse plus five signal pulses for the signal speed being observed. This interval begins with the mark-to-space transition of the start element and ends shortly after the space-to-mark transition of the stop pulse. The first mark-to-space transition in each character is amplified by 4-3-2 section of tube V5 and is used to initiate the character-tuning circuit operation.

3.20 Tube V2 (Fig. 11) and associated circuitry form a circuit called a one-shot multivibrator. This circuit activated over a path from pin 4 of tube V5 (Fig. 9). The circuit returns to the rest condition after a capacitor-charging interval. The length of the interval depends upon the position of the CHAR potentiometer and of the SPEED and CODE switches.

3.21 There is a delay network in the activating path to tube V2. It is comprised of resistors R29 and R30 and capacitor C6. It provides a proper phase relation between the locally-generated timing wave and the impulses associated with the signal transitions. It does this by assuring the simultaneous operation of the horizontal and vertical deflection circuits.

3.22 As shown near the center of Fig. 11, activation of the character-timing circuit results in a change toward positive at pin 4 and a change toward negative at pin 6 of the character timer V2. The change toward positive at pin 4 releases a clamping condition on the multivibrator circuit associated with tube V3 and the change toward negative at pin 6 produces an impulse which starts multivibrator action rapidly in a precise phase relation to the incoming signal.

3.23 The multivibrator circuit, tube V3 and associated components, operates at a frequency of one cycle per signal element of the teletypewriter characters being observed. The grid voltage is set by the SPEED switch and the COARSE and FINE potentiometers to establish the proper frequency for 60-, 75- or 100-word-per-minute operation. Precise adjustment for unbiased multivibrator output signals is made with the MV BAL potentiometer.

(G) Horizontal Deflection Control (Fig. 12)

3.24 The square-wave signals generated by the element-timing multivibrator are converted to isosceles-triangle form by the R-C circuit shown in the left portion of Fig. 12. The amplitude of the triangular wave, which determines the length of the horizontal trace, is controlled by the SWEEP AMP potentiometer. The SWEEP LEVEL potentiometer regulates the negative bias on grid 3 of tube V4 so that it will not drift as the charge on capacitor C14 varies.

3.25 Tube V4 amplifies the timing wave and, by way of the DISPLAY switch, drives the push-pull horizontal deflection amplifier, tube V6. With the DISPLAY switch in the PIP position as shown in Fig. 12, the complete amplified timing wave is applied to the horizontal deflection amplifier circuit and results in a horizontal trace on the cathode-ray tube screen as previously described.

3.26 Operation of the DISPLAY switch to PK position connects one triode of tube V5 (Fig. 9) as a gating circuit between the two triodes of the timing-wave amplifier (Fig. 12). The timing-wave signals can pass to the horizontal deflection amplifier only when the gating voltage is removed. As shown in Fig. 9, the gating triode of tube V5 is conducting (and therefore has a strong clamping action) except for short intervals during which the signal transitions occur. Thus, for peak readings, the timing wave is allowed to pass through the amplifier at only the instants of the teletypewriter signal transitions.

3.27 Operation of the DISPLAY switch to PK position, in addition to connecting the gating circuit referred to in the preceding paragraph, shunts the path between the timing-wave amplifier and the horizontal-deflection amplifier with a rectifier and capacitor. This shunt path serves to retain the most positive voltage which the gating circuit has allowed to pass through the timing-wave amplifier. The value of the capacitor charge is proportional to the per cent distortion present in the signals under test. The deflection amplifier, controlled by this voltage, will cause the cathode-ray beam to be positioned accordingly. The storage capacitor is discharged by operation of the RESET key.

3.28 The horizontal deflection amplifier circuit containing tube V6 produces output voltages for deflecting the cathode-ray beam. The H CENTER potentiometer controls the horizontal rest position of the beam.

(H) Display Tube Controls (Fig. 13)

3.29 Controls FOCUS and INTENSITY provide for adjusting the size and brightness of the cathode-ray beam so that the distortion display is a bright, sharply-defined trace. The position of control V CENTER establishes the rest potential of the vertical deflection plates and thus controls the vertical position of the distortion display.

(I) Power Supply (Fig. 13)

3.30 The following power supply circuits are shown in Fig. 13.

(a) A full-wave rectifier for +265 volts

(b) A half-wave rectifier for −275 volts

(c) A voltage multiplier (voltage doubler plus rectifier (b) above) for −800 volts

(d) A regulated voltage supply circuit (+VR and −VR)

Primary and secondary taps on the power transformer provide for adjustment of the dc supply voltages. This adjustment is made during manufacturing testing and should not ordinarily have to be changed.

4. CALIBRATION AND OPERATION

(A) Primary Calibration

4.01 It is intended that the primary calibration procedures be performed only at test rooms or maintenance centers, or where a source of signals is available. Certain routine calibration adjustments covered in section (B) below may be made in the field if required.

4.02 Primary calibration is required only after tubes have been changed, when major repairs have been made, or after the set has not been in use for a long period. If certain tubes only have been changed, only specific adjustments, rather than a complete calibration, need be made. These cases are as follows:

TUBES	ADJUSTMENT REQUIRED	REFERENCE
V1	BIAS Control	Par. 4.16
V2	CHAR Control	Par. 4.24
V4	H CENTER	Par. 4.15
V6	" "	" "

Complete calibration should be made after changing any other tubes. Only routine calibration as covered in (B) below is generally required on a new set since complete calibration is made by the Western Electric Company before a set is shipped. The calibration must be made at a location where a source of undistorted signals, a dummy loop, and preferably a cathode-ray oscilloscope (DuMont 208- or 304-type) are available. (See Paragraph 4.12.)

In descending order of preference, usable SIGNAL SOURCES are:

4.03 1A TTY test set, sending the test message. For highest precision the set should have a clean face and sharply cut wire brushes.

4.04 POLAR CAL signals from a 110C1 multiple sender if feasible. These signals are provided for the calibration of 118-type telegraph transmission measuring sets and are accessible only at a jack in the 118-type set equipment bay.

4.05 100A TTY test set, first sending repeated LETTERS for coarse adjustments and then sending repeated character R to refine adjustments. The wire brushes of the test set should be new and sharply cut to insure the precision of the calibration.

4.06 110-type multiple sender, using a non-clutch-type distributor. If a No. 2 electronic hub arrangement, 110C1 multiple sender and spare 144B1 coupling unit are available, it is preferable to use the loop output of the coupling unit to provide the calibrating signals.

4.07 14-type transmitter-distributor. These signals are reliable only if the clutch has correct pressure. Otherwise clutch slipping cause a serious frequency error.

4.08 Signals obtained from a distant office, transmitted over a carrier facility. The distant office must use one of the approved sources.

4.09 Effective polar signals obtained from an approved source transmitted over a dc facility of not over 10 miles of 19-gauge cable. The use of a poorer facility (such as a longer dc loop) might introduce fortuitous distortion, and the downward pips will jitter affecting the accuracy of the set. In this case at least 10 seconds would be required for every observation while tuning to obtain the smallest amount of scattering of the downward pips.

4.10 A keyboard sending repeated SPACE signals may be used as a last resort. In this case the distortion indications may be in error by as much as 5 per cent.

4.11 If difficulty is experienced in meeting the requirements for primary calibration, the maintenance test procedures of Part 5 should be applied.

4.12 Set the switches and controls as follows:

LOOP on ADJ
DISPLAY on PIP
SPEED on 75 (for adjustment of MV BAL control)
CODE on 5 or 6 depending on the type of signals to be used for calibration.

Set all screwdriver controls and the SWEEP LEVEL and SWEEP AMP controls in the center of their range of rotation. The following procedure covered in Paragraphs 4.13 through 4.18, describes the setting of the MV BAL control, which is mounted internally. It requires the use of an oscilloscope. A major readjustment of the control is required only after tube V3 has been changed. If an oscilloscope is not available and tube V3 has not been changed, do not touch the control. If an oscilloscope is not available and tube V3 has been changed, set the MV BAL control at the center of its range. This will result in only small inaccuracies in the distortion readings. If the MV BAL control procedure is not to be used, skip to Paragraphs 4.14, 4.15, 4.16 and then to Paragraph 4.19.

4.13 Release the four large screws which are located near the ends of the handles.

***Caution:** Potentials as high as 800 volts may be encountered within the set. When working with the chassis removed from the case, extreme care should be exercised to contact only those points intended for measurement.*

Remove the set chassis from the case and place it on an ungrounded framework with the electron tubes uppermost. Connect the vertical input

(Y axis) of a cathode-ray oscilloscope to the MV BAL and NEUT test pin jacks (located near tube V3 on the right rear of the chassis (refer to top view, Fig. 14) with the NEUT pin jack connected to the return side of the oscilloscope input circuit.

Caution: For this test the oscilloscope input and chassis must be isolated from building ground.

4.14 Connect the power cord of the 164C1 set to a source of 115V 60-cycle ac. If a 3-wire receptacle is not available, use the adapter located in the cover and connect the ground wire of the adapter to the nearest reliable building ground.

4.15 Operate the power switch to ON and allow the set to warm up for one minute. Adjust FOCUS, INTENSITY, V CENTER and H CENTER controls to give a small fluorescent spot on the face of the cathode-ray tube at about the vertical center and at approximately 10 on the horizontal scale.

Note: If the set has not been in use for a long period of time, it is desirable to check the +265 and −275 dc operating voltages. These may be checked in accordance with Items 1 and 2 of Table III in Part 5.

4.16 Slowly rotate the BIAS control until the spot moves intermittently back and forth across the face of the tube to form a horizontal line. Each time the BIAS control is moved back and forth, one or more sweeps should appear. This point is the final setting, but an error of one-tenth turn would not be important.

Note: A vertical display may be superimposed on the horizontal line.

4.17 Operate the DISPLAY switch to CAL. Arrange the test oscilloscope for internal horizontal sweep with ***synchronizing control on zero*** and carefully adjust the speed of the sweep so that the pattern is stationary with each downward transition of the trace crossed by an upward transition as shown in Fig. 4A. The speed of the sweep should be slow enough so that only one transition region appears in the pattern. With an insulated screwdriver, carefully adjust the MV BAL control (located near tube V3) until the region of intersection appears as a figure "X", with the point of intersection of the two branches of the "X" halfway between the upper and lower horizontal lines of the oscilloscope pattern. This adjustment balances the output of the multivibrator element timing tube V3.

4.18 Operate the power switch on the 164 set to OFF. Remove the test connections to the oscilloscope. Restore the chassis to the case, fastening the four mounting screws securely. Operate the power switch to ON and allow one minute for warmup.

4.19 Patch the source of calibrating signals to a dummy circuit arranged for proper termination (neutral, polar or effective polar). Patch from the dummy circuit to the INPUT jack of the set with negative polarity on the tip. This polarity is referred to as "normal." Set the LOOP switch to correspond to the type of signal used, the DISPLAY switch on PIP, and the SPEED on the speed of signal used. Set need be calibrated only at speed(s) to be used in testing.

4.20 Proceed with rough adjustment as follows:

4.21 Impress test signals on the dummy circuit.

Note: If repeated characters such as from a 100A TTY test set, are used as a signal source, it is important that the set be arranged to send the LETTERS code (all pulses marking. Toggle switches 1, 2, 3, 4, 5 and STOP of the 100A set in the ON position).

4.22 Disregarding the "pips" adjust SWEEP LEVEL so that the horizontal trace almost touches the bright spot on the left.

4.23 With the COARSE SPEED control, bring all pips somewhere near the zero end of the scale. If this cannot be done, try a different setting of the CHAR control and repeat COARSE SPEED adjustment.

Note: If it is not possible to bring all pips near scale zero, repeat Paragraphs 4.12 through 4.22 using a different tube V3 which has been tested and which meets requirements. (Refer to Paragraph 4.31.) A type 5963 tube is essentially the same as the type 12AU7 tube, but may give better performance when used in this socket.

4.24 When the pips are stable, and near scale zero, the CHAR control should be rotated clockwise until pips being to appear at higher scale readings (30 to 40 per cent). Back off one-third of a full counterclockwise turn from this point. If pips do not appear at the higher readings set the control one-third turn from the clockwise stop.

> ***Note:*** It is important that the CHAR control can be backed off the one-third turn as described above in Paragraph 4.24. If it is not possible to back off the control more than one-quarter turn, refer to maintenance testing instructions Paragraph 5.18.

4.25 The set is now ready for a more careful final adjustment.

4.26 If repeated characters such as from a 100A TTY test set are being used as a source of signals, repeated character R (pulses 2 and 4 and STOP marking) should be substituted for repeated LETTERS. (Toggle switches 2, 4, and STOP at the ON positions.)

4.27 Rotate the SWEEP LEVEL control until the left end of the horizontal sweep line appears to separate from the bright spot at the left, as shown in Fig. 4C. Reverse the direction of rotation until the left end of the horizontal line reaches a point just above the spot as shown in Fig. 4B. The bright spot appears slightly downward from the rest of the sweeps, and because of this offset a faint second trace will be observed.

4.28 Adjust the SWEEP AMP and H CENTER controls to make the horizontal trace extend from 0 to 50 on the scale.

4.29 Verify that the FINE SPEED control is at the middle of its range. (This will minimize the amount of readjustment required when changing speeds.) Adjust the 60-, 75-, or 100-COARSE SPEED control (depending on the speed of signal being used for calibration) until the downward vertical deflections (PIPS) of the trace all occur as near as possible to scale 0. For greatest accuracy the downward pips should barely turn around near scale zero, forming a small loop at their tips, as shown in Fig. 4(D). After the COARSE SPEED control has been adjusted, use the FINE SPEED control to refine the display to match that of Fig. 4(D). Since the signals from some sources may contain small amounts of bias, it may not be possible to calibrate the set so that the upward pips as well as the downward pips are near scale 0. 1A or 100A sets are normally free from bias. When these sets are used as signal sources it should be possible to calibrate so that both upward and downward pips are near scale 0.

4.30 Without touching the FINE SPEED control (which should be left in its center), repeat 4.29 for every speed of signals to be measured using appropriate signals and settings of the COARSE SPEED control.

4.31 In some cases it may be difficult to calibrate the 164C1 set at one or more of the required speeds. When this occurs tube V3 should be replaced. Either a type 12AU7 or a type 5963 tube may be used in this socket. If only 12AU7-type tubes are available, some selection of the tube will be required. In a small percentage of 12AU7 tubes there is a residual portion of plate current which cannot be controlled by the grid. A type 5963 tube is manufactured to meet more exacting specifications. For this reason it will probably give better performance in the V3 socket. If the difficulty in calibration is caused by a 12AU7 tube which will not cut off completely as mentioned above, it may be recognized as described below in Paragraph 4.32. If tube V3 is replaced, repeat the calibration in Paragraphs 4.12 through 4.30. Type 12AU7 tubes which are rejected for use in socket V3 should not be discarded since they may perform satisfactorily in other test room applications.

4.32 Care should be taken so that the SWEEP LEVEL adjustment is correct at all three TTY speeds. Ordinarily the adjustment will be correct at the other two speeds after having been set at any given speed. However, if the V3 tube does not cut off completely, this will not be true. The presence of such a tube may be detected in the following manner:

(a) After the set has been calibrated preferably at all three speeds, impress 60-speed signals on the loop and adjust the SWEEP LEVEL as in Paragraph 4.27.

(b) Impress higher speed signals on the loop and operate the speed switch to correspond to the signal. Ideally no gap should develop at the left end of the sweep (refer to Fig. 4C). However, a gap length of 2 per cent distortion may occur and should be corrected using the SWEEP LEVEL control. This effect is most noticeable when switching from 60 speed to 100 speed.

(c) If a gap of more than 2 per cent distortion develops, tube V3 should be replaced and Paragraphs 4.12 through 4.30 repeated.

4.33 It is not necessary to readjust the SWEEP AMP when changing speeds.

4.34 It is preferable to make character-timer adjustments at 75 speed if signals of this speed are available.

(a) ***5-Unit Code:*** With a source of 5-unit code calibrating signals connected to the INPUT jack, operate the CODE switch to 5 and, starting from the fully counterclockwise position, rotate the CHAR control clockwise until some of the vertical deflections begin to appear to the right on the scale. Set the CHAR control one-third turn counterclockwise from this position. If deflections do not appear at the right of the scale, set the CHAR control one-third turn counterclockwise from the clockwise stop.

(b) ***6-Unit Code:*** With a source of 6-unit code calibrating signals connected to the INPUT jack, operate the CODE switch to 6. Starting from the fully counterclockwise position, rotate the CHAR control clockwise until vertical deflections begin to appear to the right on the scale. Set the CHAR control one-third turn counterclockwise from this position.

Note: It is important that the CHAR control can be backed off the one-third turn as described above in Paragraph 4.34 (a) and (b). If it is not possible to back off more than one-quarter turn before deflections appear at the right of the scale, refer to maintenance testing instructions in Paragraph 5.18.

(c) ***Final Check Test:*** (optional) If the character timing and other adjustments have been made properly, the set should accept any of the following distorted test signals and remain in synchronism. Pips appearing on the horizontal scale at points over 39 per cent indicate that the set is not staying synchronized. This final check test of the set adjustment should be made whenever possible.

35 per cent steady bias, either marking or spacing
35 per cent switched bias
35 per cent switched end distortion
35 per cent combination distortion

(B) Routine Calibration

4.35 Routine calibration should be performed when new sets are first put in service and approximately once per week thereafter (or at longer intervals if experience indicates).

4.36 Routine calibration should be performed if the downward pips indicate more than 2 or 3 per cent distortion (but not over 20 per cent) with input signals known to be of better quality. If more than 20 per cent distortion is indicated, the set requires complete calibration, or maintenance.

4.37 Routine calibration should be done with one of the signal sources listed in Part 4(A). Calibration is as follows:

4.38 If necessary adjust INTENSITY, FOCUS, and V CENTER as covered in Paragraph 4.15.

4.39 Adjust H CENTER so that the trace starts at zero position.

4.40 Adjust SWEEP AMP so that the trace ends at 50.

4.41 Adjust SWEEP LEVEL in accordance with Paragraph 4.27.

4.42 Adjust FINE SPEED so that the downward pips are all as near zero as possible. The pips should barely begin to turn around forming a small loop at their tips as shown in Fig. 4(D).

4.43 In routine calibration, the MV BAL, CHAR, BIAS and COARSE SPEED controls should not be disturbed.

4.44 If the correct setting of FINE SPEED is more than one-quarter turn off center, it is possible that all 3 COARSE SPEEDS require readjustment. This should be done at an early opportunity (see Paragraphs 4.29 and 4.30).

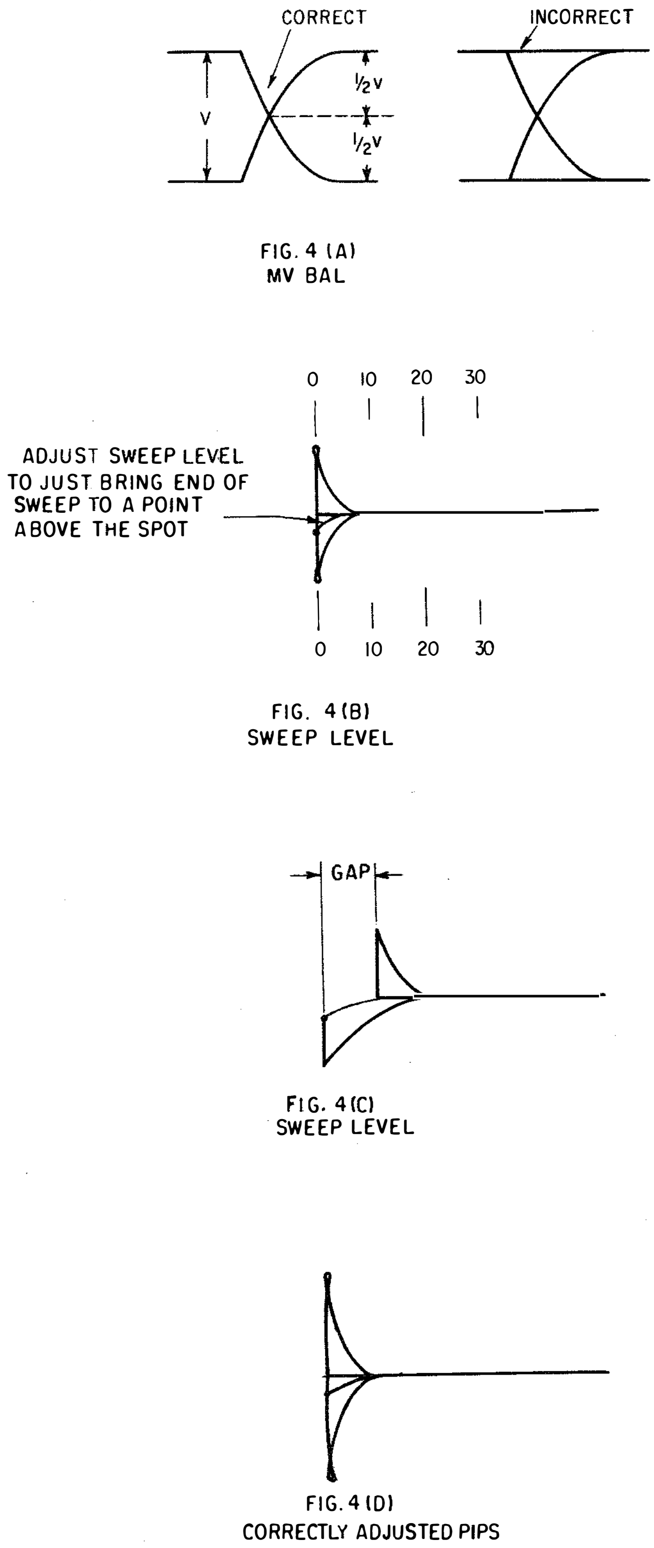


Fig. 4 – Calibration Displays

(C) Use in Test Rooms

4.45 Connect set to power (using adapter if necessary) and allow to warm up for one minute.

4.46 Make input connections and adjustments as follows:

(a) ***For Dc Loop Measurements:*** Connect INPUT jack to loop in which measurements are to be made by first inserting plug in INPUT jack and then in jack in the loop. Use a 2P1D cord. Remove any plugs in the four 43A1 input jacks in set. Set LOOP, SPEED, and CODE switches to agree with loop current and signaling conditions. While signals are being received, adjust H CENTER and SWEEP AMP until the trace extends from 0 to 50 on the scale. Adjust the SWEEP LEVEL control as in Paragraph 4.27. Do not adjust FINE SPEED control since this might mask distortion resulting from inaccurate speed at the sending end (see Paragraph 4.47). For greatest accuracy, the SWEEP LEVEL control should be rechecked each time the SPEED switch is changed. The amount of readjustment should be very small.

(b) ***For measurements at Send Control Tube in 43A1 Channels, Half- or Full-Duplex Loop Terminations:*** Remove any plug from the regular INPUT jack, set the LOOP switch at 60, and make the following pin-plug patches using a P2CR patch cord. Be sure to insert plugs in 164C1 set jacks and then in 43A1 terminal jacks.

164C1 JACK DESIGNATION		43A1 CARRIER JACK DESIGNATION
MD or 43A	to	MD
NEUT	to	C

PATCH or P3 and P4 together.

Set the SPEED and CODE switches to agree with the signaling conditions. While signals are being sent from the station loop toward the 43A1 carrier channel terminal, make adjustments as in (a) above.

4.47 One source of distortion in telegraph signals is a speed error in the signal source (see Paragraph 4.53). Speed errors may be detected with the 164C1 set. The set will indicate a difference between the speed of the signals being tested and the speed of the signals used for the last previous calibration. ***In order to detect such an error, however, it is important that both the COARSE and FINE SPEED controls be left in the position at which they were set at the last calibration.*** Speed errors will appear as follows:

(1) Miscellaneous Signals

(a) Speed faster than calibrating signals: Scattered values of both ***marking bias*** and of ***spacing end distortion*** will show on the tube. The maximum displacement will occur on a space-to-mark transition with the fifth pulse spacing. The maximum value will be approximately 6 times the per cent error in speed. The minimum value will always be greater than zero. A typical display for miscellaneous signals where the speed of the signal source is approximately 4 per cent faster than the speed of the calibrating signals is shown in Fig. 5A.

(b) Speed slower than calibrating signals: Scattered values of ***spacing bias*** and ***marking end distortion*** will show on the tube. Values will be as described in (1) above. A typical display for this condition where the signal speed is approximately 4 per cent slow is shown in Fig. 5B.

(2) Repeated Character

(a) Speed faster than calibrating signals: There will be fewer pips visible on the tube than there would be with miscellaneous signals. The number of pips which appears depends on the number of transitions in the character being sent. Figs. 5C and 5D illustrate the case for characters containing three and five transitions which can be measured by the 164 set. The mark-to-space transition representing the beginning of the start pulse is not measured. The pulses will show ***marking bias*** and ***spacing end distortion,*** with the maximum value being that of the last space-to-mark transition.

(b) Speed slower than calibrating signals: Effects will be the reverse of those in (2) (a) above. Number of visible pips depends on character selected. Pulses will show ***spacing bias*** and ***marking end distortion,*** with the maximum value being that of the last space-to-mark transition. Figs. 5E and 5F illustrate these conditions.

(D) Use at Customers' Premises

4.48 Since it is assumed that primary and routine calibration procedures for the 164C1 set are to be performed as required at test rooms or maintenance centers, the CHAR, COARSE SPEED, BIAS and FINE SPEED controls should not be adjusted at the customers' premises, with the following possible exception:

In some cases it may be desired to verify that the BIAS control is properly set in order to be reassured that there will be no inaccuracies in the measurements. This may be done with the set connected to a power source but with no signal input. Operate the LOOP switch to ADJ and slowly rotate the BIAS control until the spot moves intermittently back and forth across the face of the tube to form a horizontal trace. Each time the control is moved back and forth, one or more sweeps should appear. The point where this occurs is the final setting of the control, but an error of one-tenth turn would not be important.

4.49 Make connections and adjustments in accordance with preceding Paragraphs 4.45 and 4.46.

4.50 Paragraph 4.46(b) will apply to 130-type subscriber sets.

4.51 For all stations except those using a 130-type set, the 164C1 set should be connected in series with the teletypewriter in the loop to measure keyboard or transmitter-distributor signals. In order to measure the signals sent by the station teletypewriter, where the station employs a 128-type set, the 164C1 set must be inserted in the loop between the station teletypewriter and the 128-type set. For 130-type sets, use the 43A1 input circuit and make measurements at the MD and C jacks as covered in Paragraph 4.46(b). For the measurement of signals received from the central office, the 164C1 set should be connected in series with the teletypewriter station loop circuit in all cases, using the regular input circuit of the measuring set. For full-duplex arrangements, the measurements will be made in the receive loop.

4.52 Test signals sent from a test center should have distortion within ± 2 per cent of the desired value. The test center should verify this accuracy before signals are transmitted to the

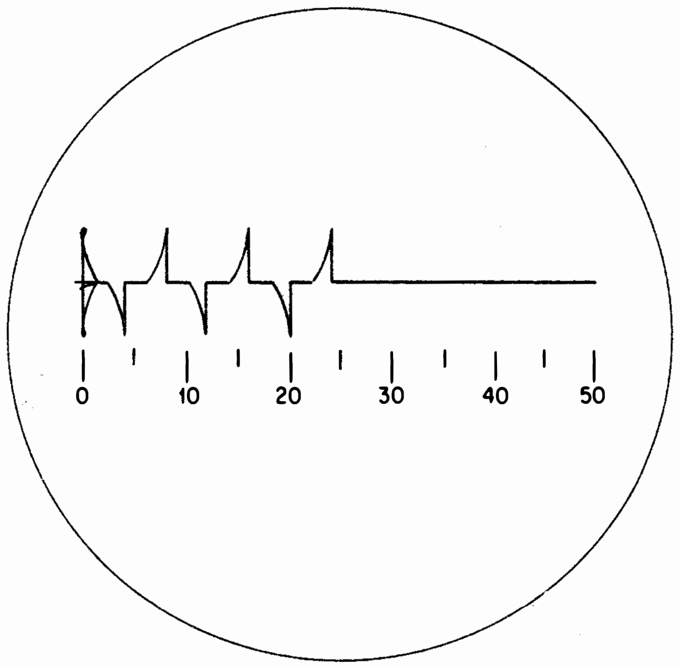


FIG. 5A - CATHODE-RAY TUBE DISPLAY - MISCELLANEOUS SIGNALS-
TRANSMITTER SPEED 4 PERCENT FAST.

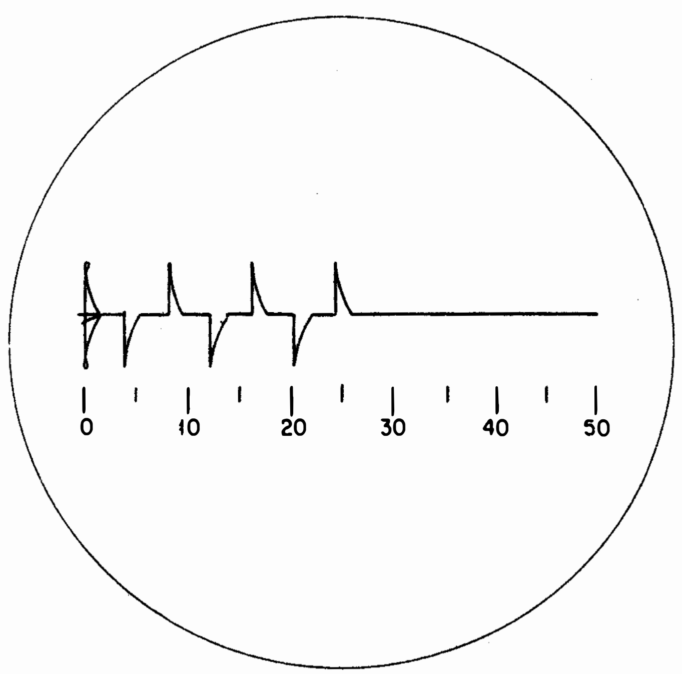


FIG. 5B - CATHODE-RAY TUBE DISPLAY - MISCELLANEOUS SIGNALS-
TRANSMITTER SPEED 4 PER CENT SLOW.

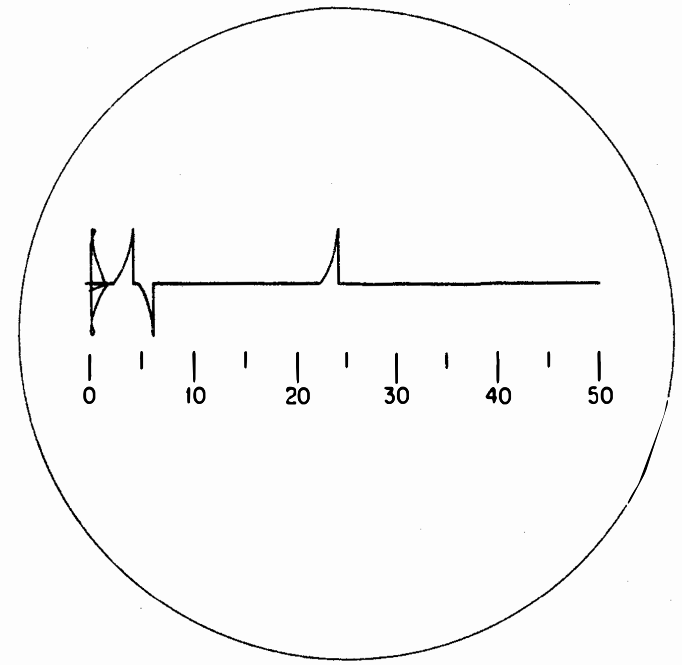


FIG. 5C - CATHODE-RAY TUBE DISPLAY - REPEATED CHARACTER E-
TRANSMITTER SPEED 4 PER CENT FAST.

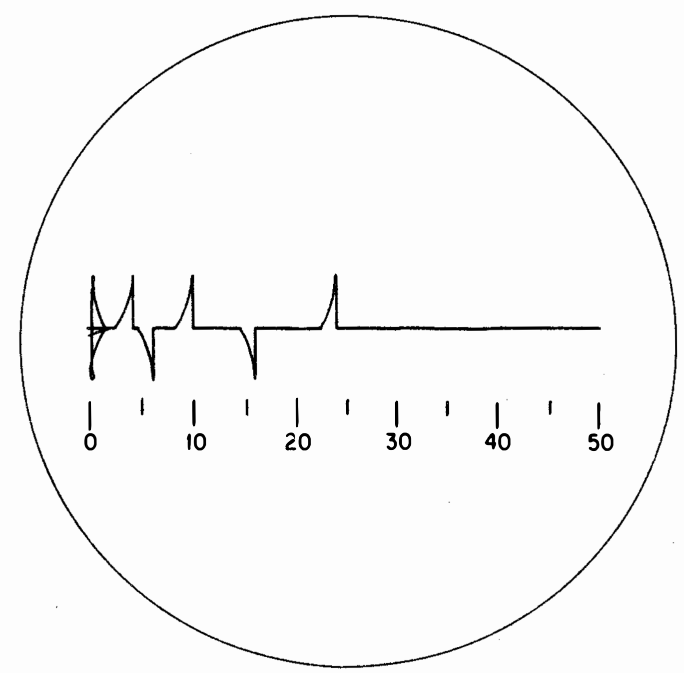


FIG. 5D - CATHODE-RAY TUBE DISPLAY - REPEATED CHARACTER S
TRANSMITTER SPEED 4 PER CENT FAST.

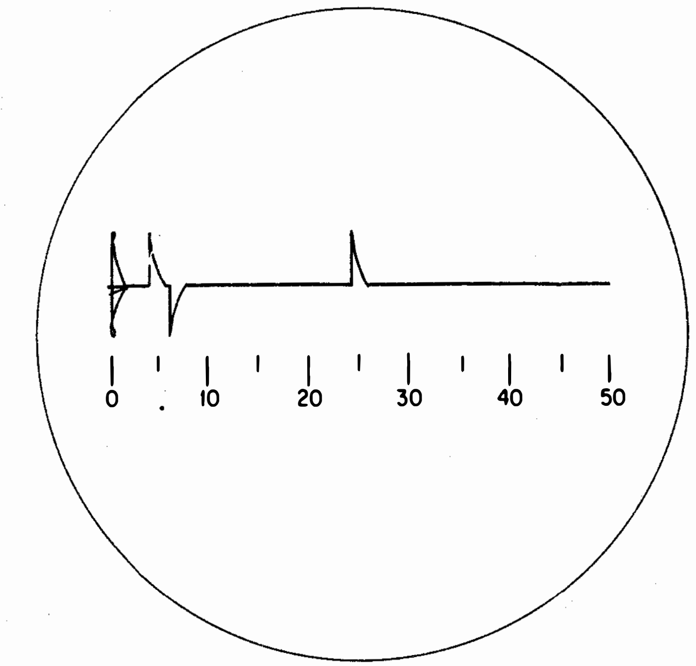


FIG. 5E - CATHODE-RAY TUBE DISPLAY - REPEATED CHARACTER E-
TRANSMITTER SPEED 4 PER CENT SLOW.

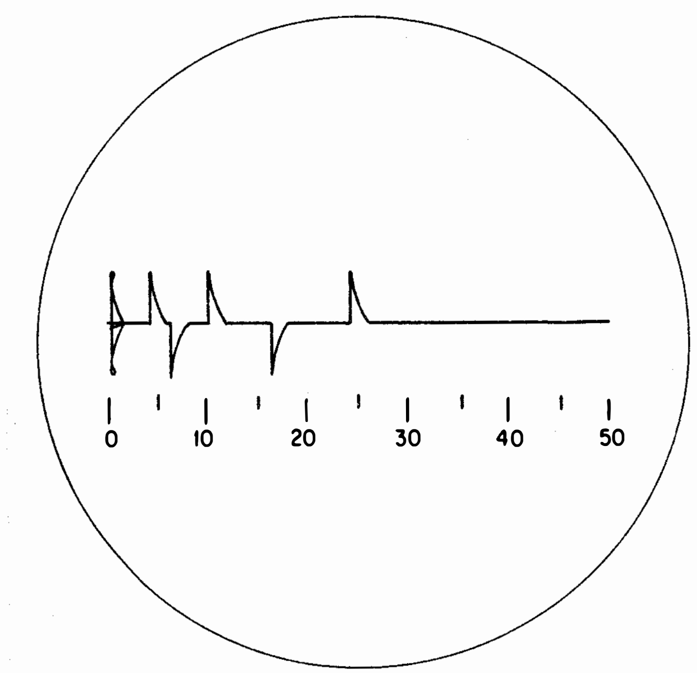


FIG. 5F - CATHODE-RAY TUBE DISPLAY - REPEATED CHARACTER S
TRANSMITTER SPEED 4 PER CENT SLOW.

Fig. 5 – Cathode-Ray Tubes Displays Illustrating Speed Errors

station. If these requirements cannot be met, the proper allowances for the inaccuracy of the signal source must be made in the distortion measurements taken at the station.

4.53 Various conditions at a station location can be responsible for speed errors in the transmission of signals from the station: (1) use of governed series type ac motor, (2) use of dc motor, (3) operation of emergency engine alternator as a power source, and (4) power supplied by a noninterconnected power system, such as a municipal plant or a customer-owned plant. In connection with (3) and (4) a one-half-cycle error in the nominal 60-cycle line frequency will cause 1 per cent distortion in the start pulse, assuming that the first code pulse is a mark. Successive transitions in the character will be displaced by greater amounts, since the distortion is cumulative within a character. (Refer to Paragraph 4.47.)

(E) Special Operating Considerations

4.54 In older 164C1 sets which do not incorporate the circuit improvements shown on Issue 6AR of SD-70698-01, an effect known as "jitter" may sometimes be evident. Electrically the "jitter" results from noise pickup between the circuit and the building ground. The "jitter" can be prevented simply by insuring that at least one-third of the loop resistance is connected between the 164 set and positive battery. The 164 set should ***not*** be connected directly to positive battery. Issue 6AR of the SD drawing provides a circuit modification which eliminates the "jitter" regardless of the method of connection to the circuit.

4.55 Do not operate the set on top of warm cabinets or apparatus since the set is sensitive to temperature rise.

5. MAINTENANCE TESTING

(A) General

5.01 The maintenance testing procedures consist of voltage measurements and oscilloscope observations. Both may be applied to the individual circuits as described in this part. It is assumed that the usual practices of testing tubes, measuring resistances and the like will be followed to isolate defective components.

(B) Test Instruments and Apparatus

5.02 The following equipment is used for maintenance testing:

(a) Cathode-ray Oscilloscope, such as DuMont type 208 or 304, which has provision for a sweep frequency rate of six cycles per second or less and which has a capacity-coupled input circuit of two megohms impedance or more. The framework and case of the instrument must ***not*** be connected to building ground. This requirement is necessary to avoid shunt paths to ground which would distort the signals under observation.

Caution: Contact with the case of the oscilloscope should be avoided. One input terminal of the oscilloscope may be connected to the case of the oscilloscope and hence the case may be at potentials considerably higher than ground during certain test observations.

(b) KS-14510 Volt-Ohm-Milliammeter. Voltage readings must be taken on the scales specified in Table III to avoid misleading indications.

(c) A source of undistorted open-and-close teletypewriter signals. (See Paragraphs 4.03 through 4.10.)

(d) Dummy loop circuit similar to Fig. 6. (62.5 ma)

(e) Milliammeter with 0-75 scale, ±2 per cent accuracy.

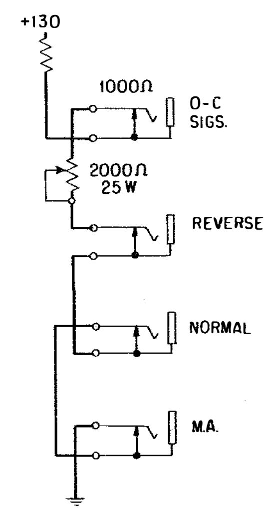


Fig. 6 – Dummy Loop for Maintenance Testing

(C) Voltmeter Test of Power Supply and Input Circuits

Caution: Potentials as high as 800 volts may be encountered within the set. When working with the chassis removed from the case, extreme care should be exercised to contact only those points intended for measurement.

5.03 Release the four large screws located near the end of the handles. Remove chassis from the case and place it on an ***un***-grounded framework.

5.04 Make a visual inspection for broken wires, rosin joints, insulation breakdown and evidence of overheated resistors or defective components.

5.05 Connect the power cord to a source of 115-volt, 60-cycle ac. If only a 2-wire receptacle is available make connection by means of the adapter furnished with the set and connect the grounding wire to a reliable ground. Operate the power switch to ON.

5.06 Check visually that tube heaters (including that of the cathode-ray tube) are glowing.

5.07 Follow the test procedures of Table III for localizing power supply and input circuit irregularities. The voltage indications shown in the table should be considered typical rather than absolute. Meter indications somewhat outside of these limits may result from unfavorable combinations of primary supply voltage, voltmeter error and component variation. A few measurements somewhat outside of the indicated limits do not necessarily indicate an inoperative condition.

5.08 Reference should be made to Figs. 9 to 13 for the circuit locations of test points and terminals referred to in Table III, and to Figs. 14 and 15 and Tables V and VI for the physical locations of apparatus components.

TABLE III

164C1 SET VOLTMETER TEST DATA

ITEM	INPUT FROM FIG. 6	Dc VOLTMETER SCALE	CONNECT + VOLTMETER PROBE	CONNECT − VOLTMETER PROBE	METER INDICATION	LOOP SWITCH POSITION	SPECIAL PREPARATION
1	None	300	Test Point E5 (See Fig. 13)	Neut Test Jack	270 ± 10 at 115V ac Input	60	Bias Pot at Center of Range
2	None	300	Neut Test Jack	Test Point E6 (See Fig. 13)	10 ± 5 volts Greater Than Above	60	
3	None	300	Test Point E17 (See Fig. 13)	Neut Test Jack	180 ± 24	60	
4	None	300	Neut Test Jack	Test Point E20 (See Fig. 13)	180 ± 24 and Within 7 volts of Item 3	60	
5	None	600	Test Point E6 (See Fig. 13)	Terminal of C23 Nearest Side of Chassis	530 ± 15 at 115V ac Input	60	
6	Normal	12	Sleeve of Input Jack	Neut Test Jack	9.2 ± 0.4	ADJ	Adjust Fig. 6 62.5 MA Steady Marking Signal
7	Normal	12	Test Point E1 (See Fig. 9)	Neut Test Jack	8.0 ± 0.4	ADJ	

TABLE III (Cont'd)

ITEM	INPUT FROM FIG. 6	Dc VOLTMETER SCALE	CONNECT + VOLTMETER PROBE	CONNECT − VOLTMETER PROBE	METER INDICATION	LOOP SWITCH POSITION	SPECIAL PREPARATION
8	Normal	12	Test Point G2	Neut Test Jack	5.8 ± 0.4	ADJ	
9	None	300	Neut Test Jack	Loop Switch Terminal 3 (See Fig. 9)	27.5 ± 5.0	ADJ	
10	None	300	Neut Test Jack	Loop Switch Terminal 3	27.5 ± 5.0	POL	
11	None	300	Neut Test Jack	Loop Switch Terminal 3	62.5 ± 5.0	20	
12	None	300	Neut Test Jack	Loop Switch Terminal 3	130 ± 7.5	60	
13	None	300	Neut Test Jack	Pin 7, Tube V1	30 ± 5.0	ADJ	Remove Fuse F2
14	Normal	300	Loop Switch Terminal 10 or 12 (See Fig. 9)	Neut Test Jack	42.5 ± 5.0	ADJ	Restore Fuse F2
15	Normal	300	Loop Switch Terminal 11	Neut Test Jack	30 ± 5.0	ADJ	
16	Reverse	300	Neut Test Jack	Loop Switch Terminal 10 or 12	32.5 ± 5.0	ADJ	
17	None	300	Pin 6, Tube V1	Neut Test Jack	120 ± 7.5	ADJ	Rotate Bias Control Fully Clockwise
18	None	300	Pin 6, Tube V1	Neut Test Jack	Less Than 80	ADJ	Rotate Bias Control Fully Counterclockwise
19	None	300	Pin 6, Tube V1	Neut Test Jack	100	ADJ	Rotate Bias Control As Required
20	Normal	300	Pin 6, Tube V1	Neut Test Jack	30 ± 10	60	
21	Normal	300	Pin 1, Tube V1	Neut Test Jack	205 ± 10	60	
22	Normal	300	Pin 4, Tube V5	Neut Test Jack	25 ± 10	60	
23	Reverse	300	Pin 1, Tube V1	Neut Test Jack	65 ± 15	60	
24	Reverse	300	Pin 6, Tube V1	Neut Test Jack	125 ± 10	60	
25	Reverse	300	Pin 4, Tube V5	Neut Test Jack	225 ± 10	60	
26	Reverse	60	Neut Test Jack	Pin 3, Tube V5	45 ± 10	60	
27	Normal	60	Neut Test Jack	Pin 2, Tube V1	40 ± 10	60	
28	Normal	3	Pin 3, Tube V5	Neut Test Jack	0 + 0.5	60	
29	Reverse	3	Pin 2, Tube V1	Neut Test Jack	0 + 0.5	60	

5.09 Arrange the volt-ohm-milliammeter for indication on the 300-volt dc scale. Connect the voltmeter negative test lead to the NEUT test point and connect the voltmeter positive test lead to pin 4 of tube V6. The voltmeter indication should be less than 75 volts with the H CENTER control fully counterclockwise, and should increase at least 135 volts as the H CENTER control is rotated fully clockwise.

5.10 Move the voltmeter positive test lead to pin 6 of tube V6. The indication should be 270 ± 20 volts with the H CENTER control fully counterclockwise, and should decrease at least 75 volts as the H CENTER control is rotated fully clockwise.

(D) Tests with Oscilloscope

5.11 Observations of oscilloscope patterns at various points in the circuit provide a check on the dynamic performance of the circuit which cannot readily be tested by means of voltmeter indications.

5.12 The following general rules apply to the use of the cathode-ray oscilloscope:

(a) The common return side of the oscilloscope should be connected to the NEUT test point. Neither the case nor the common return side of the oscilloscope should be connected to building ground. Precautions should be observed to avoid bodily connection between actual ground and the case of the test instrument.

(b) The input circuit of the oscilloscope should be arranged for the lowest sensitivity which will permit satisfactory observation of the signals. On oscilloscopes having very high sensitivity, it is advisable to provide an additional L pad having a 10 megohm series resistor and a 0.2 megohm shunt resistor adjacent to the scope input terminals. The DuMont-type 304 has built-in attenuator to accomplish this. However, the external L pad will be found advantageous with the DuMont-type 208.

(c) The synchronizing control on the oscilloscope should be adjusted for a minimum injection of signal into the sweep circuit.

(d) When the amplitude of a pattern having high peaks is to be observed, the vertical-position control on the oscilloscope should be used to place the pattern in the central portion of the tube face. This minimizes nonlinear distortion effects which may be large near the circumference of the cathode-ray tube.

5.13 Following tests in accordance with Table III patch the NORMAL jack of dummy loop (Fig. 6) to the INPUT jack of the measuring set and adjust the current to 62.5 ma. Set the LOOP switch of the set at the 60 position. Patch a source of undistorted open-and-close test signals to the O-C SIGS jack of dummy loop (Fig. 6.) Connect the common-return side of the oscilloscope to the neutral test jack of the measuring set.

5.14 Connect the "Y axis" input terminal of the oscilloscope to pin 6 of tube V1. Adjust the vertical amplitude of the display to one inch. Carefully adjust the sweep frequency for a rate of one sweep per teletypewriter character. This adjustment will be facilitated by temporarily changing the teletypewriter test signal to a repeated character such as "blank" or "letters" and adjusting the oscilloscope sweep frequency for a stationary pattern as indicated in Fig. 8A. If a repetitive single-character test signal is not available, the stop pulses in miscellaneous test signals should be observed while making the sweep-frequency adjustment.

5.15 Use the voltmeter test data of Items 24 and 20, Table III, to calculate the voltage swing at pin 6 of tube V1. Subtract the reading of Item 20 from that of Item 24 to find the voltage swing. Adjust the oscilloscope vertical deflection to give a peak-to-peak amplitude, in inches, of 1/100 of this voltage swing; that is, for a sensitivity of 100 volts per inch. Note the setting of the vertical gain.

5.16 Move the "Y axis" input connection in turn to pin 2 of tube V1, pin 1 of tube V1, pin 3 of tube V5 and pin 4 of tube V5 noting in each case the peak-to-peak amplitude of the oscilloscope trace. These amplitudes in inches times 100 should in each case agree with the voltage swing at the same point as calculated from the data obtained in tests 20 through 27 of Table III. In each case the oscilloscope pattern should contain only the normal signal transitions; that is, there should be no evidence of interruptions or chatter-like effects between signal element transition points. (These effects often may be traced to the source of test signals.)

5.17 Operate the DISPLAY switch to PIP and connect the oscilloscope input lead, in turn, to pin 7 of tube V5 and to terminal 9 of the DISPLAY switch. (Fig. 9) The patterns observed at these points should be as shown in Figs. 8B and 8C.

5.18 Set the CODE switch at 5, set the SPEED switch to correspond with the speed of the available test signals and connect the oscilloscope input lead to pin 6 of tube V2. Observe that a pattern similar to Fig. 8D is obtained. Change the CODE switch to 6 and observe that the pattern changes as indicated in Fig. 8D. Vary the CHAR potentiometer setting and observe that the length of the short positive interval varies over a range of about one element length (about 1/7 of the total length of trace 8D). When the CHAR control is adjusted during primary calibration (Paragraph 4.24 and Paragraph 4.34), the control is turned counterclockwise one third of a turn from the point where distortion readings are indicated. If it is not possible to obtain this one third of a turn, another V2 tube should be tried. If the one third of a turn cannot be obtained after the tube replacement, remove power from set. Measure resistor R38 with a carefully adjusted ohmmeter. Replace resistor if necessary with one which measures between 5.1 and 5.7 megohms. Before replacing any soldered-in components, remove the ac power from the set.

5.19 Disconnect the test signals from the dummy loop (Fig. 6). Operate the DISPLAY switch to CAL and connect the oscilloscope input lead to the MV BAL pin jack. With the SPEED switch at 60, set the sweep frequency of the oscilloscope and the MV BAL potentiometer to obtain the pattern illustrated in Fig. 4A.

> ***Note:*** In some instances the multivibrator action of tube V3 may not occur when the DISPLAY switch is at the CAL position. This happens when the switch is operated to the CAL position while the power is removed from the set. When power is restored tube V3 "locks up" with one section "on" and the other section "off". This condition can be corrected by operating momentarily either the DISPLAY or the SPEED switch to another position. This produces a transient which starts the multivibrator running. This case of "lock up" of tube V3 is not indicative of a defective element timer.

Some readjustment of the input level to the oscilloscope may be necessary for this observation. Rotate the SPEED switch through positions 60, 75 and 100 and observe that the sweep frequency of the oscilloscope must be increased after each change to obtain the pattern of Fig. 4A. Observe also that at each position the speed of the multivibrator may be varied a small amount by the FINE SPEED control and a relatively larger amount by the COARSE SPEED control corresponding to the position of the SPEED switch. Restore the oscilloscope vertical gain to the setting which gives a deflection sensitivity of 100 volts per inch.

5.20 Using a tube extractor, remove tube V5 and connect the oscilloscope input lead to pin 4 of tube V4. If a tube extractor is not available, operate the power switch of the 164 set to OFF during extraction or insertion of tube V5. Set the SWEEP AMP control at about the center of its range of rotation and adjust the sweep frequency of the oscilloscope to obtain a pattern similar to Fig. 8E. Observe that with the SWEEP AMP control fully counterclockwise a very low amplitude pattern similar to Fig. 8E is obtained, and that the peak-to-peak amplitude of the pattern increases smoothly as the SWEEP AMP control is rotated clockwise.

5.21 At some point in the clockwise rotation of the SWEEP AMP control, the top or bottom peaks of the oscilloscope pattern may begin to be flattened. Adjust the SWEEP LEVEL control until this flattening is approximately the same on top and bottom peaks or until, with the SWEEP AMP control fully clockwise, neither the top nor the bottom peaks are flattened. Readjust the SWEEP AMP control until any flattening just disappears. The oscilloscope pattern should have the amplitude indicated in Fig. 8E.

5.22 Rotate the SPEED switch through positions 100, 75, and 60 and observe that in each case the pattern of Fig. 8E may be obtained by suitable adjustment of the oscilloscope sweep frequency.

5.23 Move the oscilloscope input lead to pin 8 of tube V4. The pattern of Fig. 8E should be obtained.

5.24 With the oscilloscope input lead connected to pin 4 of tube V4, replace tube V5. The oscilloscope pattern 8E should decrease to a low amplitude as the cathode of tube V5 becomes heated.

5.25 Connect teletypewriter test signals to the dummy loop (Fig. 6) and connect the oscilloscope input lead to pin 4 of the tube V2. Operate the DISPLAY switch to PIP and adjust the sweep frequency of the oscilloscope for one sweep per teletypewriter character. Observe that the pattern of Fig. 8F is obtained. Move input lead of oscilloscope to the junction of resistors R36, R138 and varistor CR11. Observe that the pattern of Fig. 8I is obtained.

5.26 Move the oscilloscope input lead to the MV BAL test point. Check the position of the CODE switch for agreement with the type of test signals being used and observe that the pattern of Fig. 8G is obtained. Rotate the CHAR control and observe that the length of one element of the pattern changes as the control is rotated.

5.27 If the tests of Part 5 have been performed successfully up to this point and the circuits associated directly with cathode-ray tube V7 are correct, adjustment of the FOCUS, INTENSITY, V CENTER and H CENTER controls should result in a fluorescent glow pattern on the face of cathode-ray tube V7 which can be refined to a correct distortion indication by the adjustment procedures of Part 4. If the fluorescent trace pattern does not appear on the face of tube V7, the circuits associated directly with the cathode-ray tube should be checked in accordance with the following paragraphs.

(E) Voltmeter Tests of Cathode-Ray Tube Circuits

5.28 Remove the test signal input from dummy loop (Fig. 6), and remove the oscilloscope test leads. Arrange the voltmeter for indication on the 300-volt dc scale and connect the negative test lead to the NEUT test point. Connect the positive test lead to the junction of resistor R114 and capacitor C7. An indication of 200 volts or less should be obtained with the V CENTER control fully counterclockwise. The indication should increase smoothly by 40 volts or more as the control is rotated to the full clockwise position.

5.29 Connect the positive test lead of the voltmeter to the junction of resistors R106 and R107. The voltmeter indication should be 180 ± 15 volts.

5.30 Arrange the voltmeter for indication on the 600-volt dc scale and using an insulated "clip-clip" cord, connect the positive test lead to test point E6. Connect the negative test lead to the junction of resistors R105 and R111. The meter should indicate 450 ± 20 volts with the INTENSITY potentiometer at the center of its range of rotation.

5.31 Connect the negative test lead of the voltmeter to the junction of resistors R110 and R112. The voltmeter should indicate 500 ± 15 volts with the INTENSITY control fully counterclockwise. The indication should decrease smoothly by 30 volts or more as the INTENSITY control is rotated to the fully clockwise position.

5.32 If all of the preceding tests are performed successfully with teletypewriter signals connected to dummy loop (Fig. 6), adjust in accordance with Part 4. If this does not result in a satisfactory pattern on the face of the cathode-ray tube V7, proceed as follows: ***Remove the power cord from the outlet receptacle and connect a "clip-clip" lead first to a circuit neutral connection point*** (such as lug N7 near capacitor C28) and then to the terminal of capacitor C23 nearest the side of the chassis. Similarly, connect a "clip-clip" lead first to circuit neutral and then to test point E5. Remove the protective cover on the cathode-ray tube socket to expose the wired connections. After visual inspection for broken wires, rosin joints and poor contact at tube pins, make ohmmeter measurements as indicated in Table IV.

(F) Test of Input Circuit for 43A1 Measurements

5.33 A simple test circuit similar to the one shown in Fig. 7 may be assembled locally to provide a means of checking the operation of the input circuit for 43A1 measurements.

5.34 Connect a source of open-and-close test signals to the jack of the test circuit (Fig. 7). Connect the input of the oscilloscope to the 12-volt heater circuit of tubes V1 to V6. Calibrate the vertical gain to present a two-inch display. Now connect the input of the oscilloscope between terminal G2 (Fig. 10) and a cir-

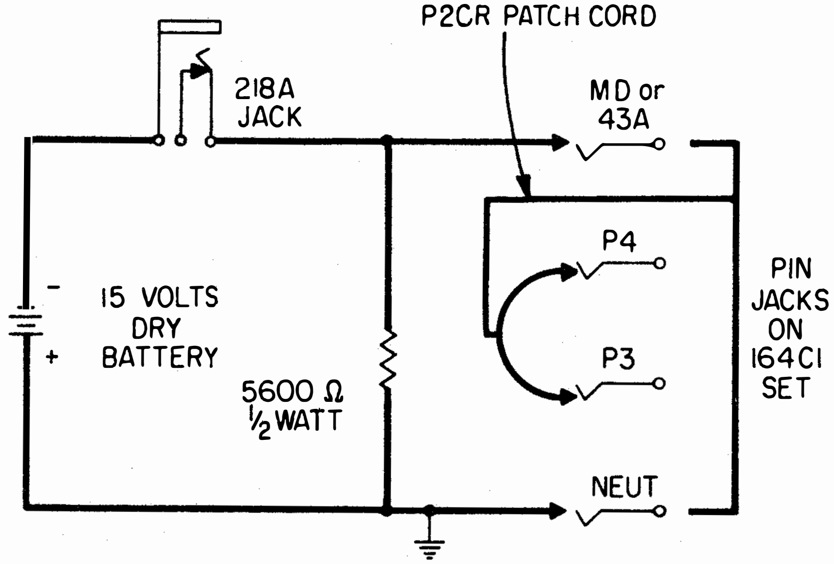


Fig. 7 — Test Circuit for Input Measurements of 43A1

cuit neutral point (terminals N7 through N12). A minimum peak-to-peak voltage of 6 volts (1 inch) should be obtained, (see Fig. 8H). Be sure to connect the grounded side of the oscilloscope to a circuit neutral point.

TABLE IV

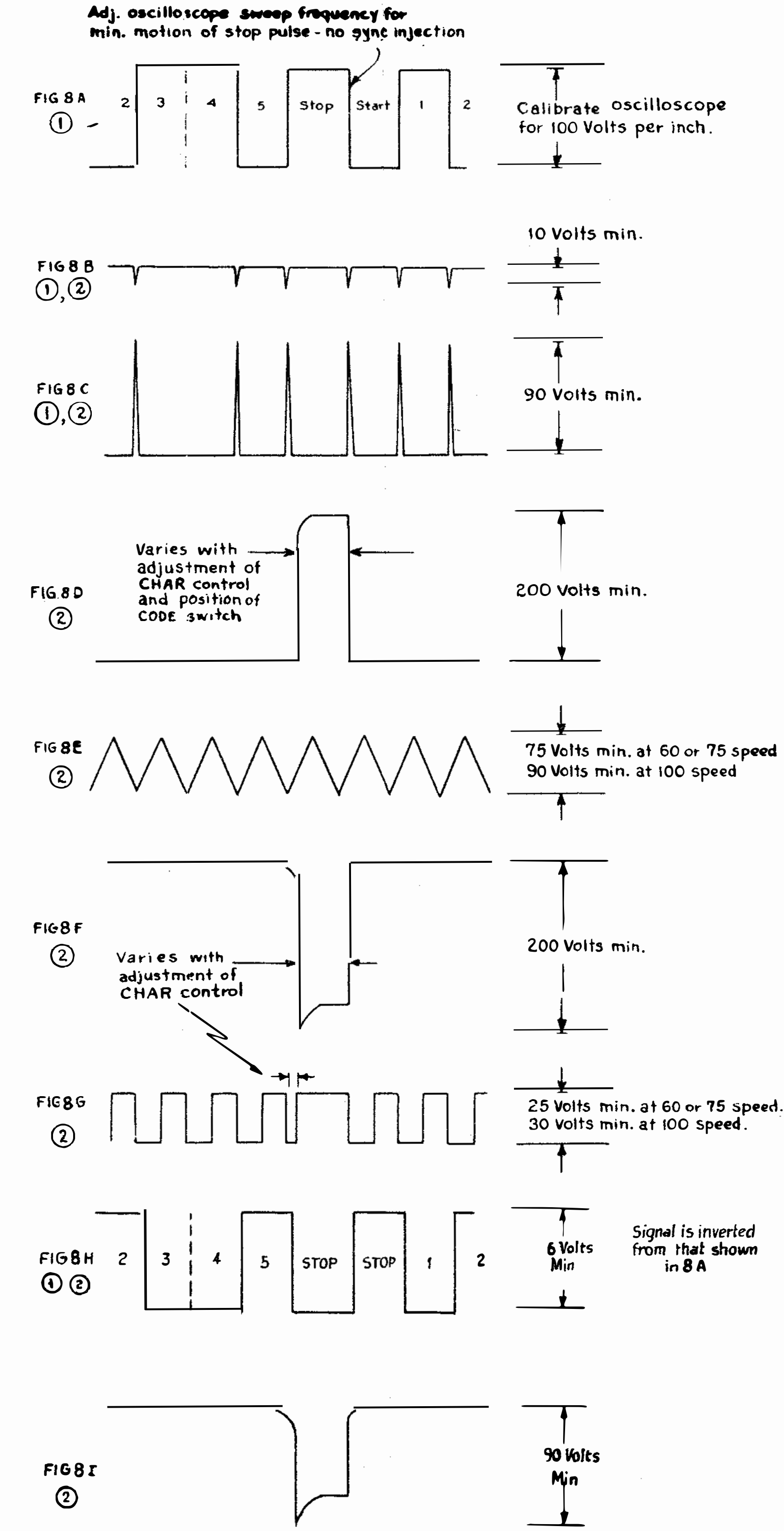
RESISTANCE MEASUREMENTS IN CATHODE-RAY TUBE CIRCUITS

MEASURE TO CIRCUIT NEUTRAL FROM PINS	OHMMETER INDICATION (OHMS) * (x 10,000 RANGE)
1,3,12	92,000 ± 10%
2	890,000 ± 10%
4	420,000 ± 10%
6	119,000 ± 10%
7	125,000 ± 10%
8,9	150,000 ± 10%
10	1,600,000 ± 10%

* FOCUS, INTENSITY and V CENTER control in center of range of rotation.

6. REFERENCES

Circuit Drawings	SD-70698-011
	SD-70698-012
Equipment Drawing	J70119A



① Pattern shown for "F" character.

② Amplitudes not drawn to scale.

Fig. 8 – Oscilloscope Patterns for Maintenance Testing

TABLE V

RESISTOR LOCATION TABLE
(No Ac Power Connected to Set)

DESIG.		TYPE	VALUE	LOCATION
R1	—	147A	150Ω	INPUT Jack
R2	—	KS-13490,L1	10,000Ω	INPUT Jack and E1 Term.
R3	—	145A	22,900Ω	G2 and E1 Terms.
R4	—	KS-13490,L1	0.15 meg	V1 Socket, No. 7 Pchg
R5	—	KS-13490,L1	10 meg	Ladder A
R6	—	KS-13490,L1	0.33 meg	Ladder A
R7	—	KS-13490,L1	0.33 meg	Ladder A
R8	—	KS-13790	1 meg	Face Panel (BIAS)
R9	—	145A	0.75	Ladder A
R10	—	145A	0.348 meg	Ladder D
R11	—	145A	0.562 meg	Ladder G
R12	—	KS-13490,L1	24,000Ω	Ladder D
R13	—	KS-13490,L1	0.10 meg	Ladder D
R14	—	145A	0.301 meg	V1 Socket No. 2 Pchg
R15	—	145A	0.91 meg	V1 Socket No. 2 Pchg
R16	—	KS-13490,L1	0.91 meg	V5 Socket No. 3 Pchg and Ladder A
R17	—	145A	0.825 meg	LOOP Switch
R18	—	145A	0.562 meg	LOOP Switch
R19	—	145A	0.33 meg	LOOP Switch and Term. N2
R20	—	KS-13490,L1	0.27 meg	V1 Socket, No. 1 Pchg and E16 Term.
R21	—	KS-13490,L1	0.24 meg	V5 Socket, No. 3 Pchg and E16 Term.
R22	—	KS-13490,L1	0.1 meg	Ladder D
R23	—	KS-13490,L1	0.1 meg	Ladder D
R24	—	KS-13490,L1	33,000Ω	Ladder A
R25	—	KS-13490,L1	24,000Ω	Ladder A
R26	—	KS-13490,L1	0.13 meg	V5 Socket, No. 4 Pchg and Ladder A
R27	—	KS-13490,L1	3.3 meg	Ladder A
R28	—	KS-13490,L1	1.2 meg	Ladder A
R29	—	KS-13490,L1	0.51 meg	Ladder A
R30	—	KS-13490,L1	0.51 meg	V5 Socket, No. 4 Pchg and Ladder A
R31	—	KS-13490,L1	0.1 meg	Ladder A
R32	—	KS-13490,L1	0.1 meg	Ladder A
R33	—	KS-13490,L1	1.0 meg	Ladder A
R34	—	KS-13490,L1	56,000Ω	Ladder A
R35	—	KS-13490,L1	4.7 meg	Ladder A
R36	—	145A	0.422 meg	Ladder E
R37	—	KS-13490,L1	24,000Ω	Ladder A
R38	—	KS-13490,L1	5.6 meg	Ladder A
R39	—	KS-14786	0.1 meg	Face Panel (CHAR)
R40	—	KS-13490,L1	0.39 meg	CHAR Potentiometer and N2 Term.
R41	—	KS-13490,L1	3.6 meg	SPEED Switch and E7 Term.
R42	—	KS-13490,L1	2 meg	SPEED Switch and E7 Term.
R43	—	KS-13490,L1	0.33 meg	SPEED Switch and E7 Term.
R47	—	KS-14786	50,000	Chassis (MV BAL)
R48	—	145A	36,100Ω	Ladder B
R49	—	145A	36,100Ω	Ladder B
R50	—	145A	68,100Ω	Ladder B
R51	—	KS-13490,L1	10 meg	Ladder B

TABLE V (Cont'd)

DESIG.		TYPE	VALUE	LOCATION
R52	—	145A	68,100Ω	Ladder B
R53	—	KS-13490,L1	0.27 meg	Ladder B
R54	—	KS-13490,L1	0.75 meg	Ladder B
R55	—	145A	4.53 meg	Ladder B
R56	—	145A	0.681 meg	Ladder E
R57	—	145A	0.681 meg	Ladder E
R58	—	KS-13490,L1	0.75 meg	Ladder B
R59	—	145A	4.53 meg	Ladder B
R60	—	KS-14786	0.1 meg	Face Panel (60 COARSE SPEED)
R61	—	KS-13490,L1	0.1 meg	SPEED Switch and 60 COARSE SPEED Potentiometer
R62	—	KS-13490,L1	51,000Ω	75 COARSE SPEED Potentiometer and SPEED Switch
R63	—	KS-14786	0.1 meg	Face Panel (75 COARSE SPEED)
R64	—	KS-13490,L1	51,000Ω	SPEED Switch and 75 COARSE SPEED Potentiometer
R65	—	KS-13490,L1	0.1 meg	SPEED Switch and 100 COARSE SPEED Potentiometer
R66	—	KS-14786	0.1 meg	Face Panel (100 COARSE SPEED)
R68	—	145A	4.53 meg	Ladder B
R69	—	KS-14786	25,000Ω	Face Panel (FINE SPEED)
R70	—	KS-14786	1.0 meg	Face Panel (SWEEP AMP)
R71	—	KS-13490,L1	0.68 meg	Ladder A
R72	—	KS-13490,L1	1.0 meg	Ladder A
R73	—	145A	4.64 meg	Ladder F
R74	—	KS-13490,L1	15 meg	Ladder F
R75	—	145A	4.64 meg	Ladder F
R76	—	KS-13490,L1	0.47 meg	Ladder A
R77	—	KS-13490,L1	2,000Ω	Ladder A
R78	—	145A	4.64 meg	Ladders A & F
R79	—	145A	4.64 meg	Ladder A
R80	—	145A	4.64 meg	Ladder A
R81	—	KS-14786	0.25 meg	Face Panel (SWEEP LEVEL)
R82	—	KS-13490,L1	0.82 meg	SWEEP LEVEL Potentiometer and N4 Term.
R83	—	KS-13490,L1	0.56 meg	V4 Socket
R84	—	KS-13490,L1	0.47 meg	Ladder G
R85	—	KS-13490,L1	0.47 meg	Ladder G
R86	—	KS-13490,L1	0.39 meg	Ladder F
R87	—	KS-13490,L1	2.4 meg	V4 Socket, No. 7 Pchg and E8 Term.
R88	—	KS-13490,L1	0.82 meg	V4 Socket
R89	—	145A	2.15 meg	V4 Socket No. 7 Pchg and Ladder A
R90	—	KS-13490,L1	3.3 meg	E8 Term. and Ladder A
R91	—	KS-13490,L1	1.1 meg	DISPLAY and RESET Switches
R92	—	KS-13490,L1	0.33 meg	Terms. E8 and N5
R93	—	Victoreen-Type 249	1,000 meg	DISPLAY and RESET Switches
R94	—	KS-13490,L1	0.33 meg	V6 Socket
R95	—	145A	3.32 meg	V6 Socket
R96	—	145A	3.65 meg	V6 Socket, No. 7 Pchg and Term. E6
R97	—	KS-13490,L1	0.15 meg	V6 Socket, No. 6 Pchg and Term. E5

TABLE V (Cont'd)

DESIG.	TYPE	VALUE	LOCATION
R98 —	KS-13490,L1	0.15 meg	V6 Socket, No. 4 Pchg and Term. E5
R99 —	KS-13490,L1	0.13 meg	Terms. E4 and N4
R100 —	KS-13490,L1	0.18 meg	H-CENTER Potentiometer and Term. E4
R101 —	KS-14786	0.5 meg	Face Panel (H CENTER)
R102 —	KS-13490,L1	0.22 meg	H-CENTER Potentiometer and Term. N3
R105 —	KS-13490,L1	6.8 meg	Ladder C
R106 —	KS-13490,L1	0.27 meg	Ladder C
R107 —	KS-13490,L1	0.56 meg	Ladder C
R108 —	KS-13491,L1	1.2 meg	FOCUS Potentiometer and Term. N3
R109 —	KS-13790	0.5 meg	Face Panel (FOCUS)
R110 —	KS-13490,L1	0.47 meg	Ladder C
R111 —	KS-13490,L1	1.0 meg	Ladder C
R112 —	KS-13490,L1	33,000Ω	Ladder C
R113 —	KS-13790	0.1 meg	Face Panel (INTENSITY)
R114 —	KS-13490,L1	1.0 meg	Ladder A
R115 —	KS-13490,L1	0.68 meg	Ladder A
R116 —	KS-14786	1.0 meg	Face Panel (V CENTER)
R117 —	KS-13490,L1	2.2 meg	V-CENTER Potentiometer and Term. N3
R118 —	KS-13491,L1	47,000Ω	Capacitor C23 and Term. E10
R119 —	KS-13490,L1	3.3 meg	Capacitor C23
R120 —	KS-13490,L1	3.3 meg	Capacitor C24
R121 —	KS-13490,L1	1,000Ω	Terms. 2 & 3, Capacitor C25
R122 —	KS-13490,L1	1,000Ω	Terms. 1 & 2, Capacitor C25
R123 —	KS-13490,L1	1,500Ω	Capacitor C26 and Term. E14
R124 —	KS-13490,L1	1,500Ω	Capacitor C27 and C28
R125 —	KS-13492,L1	4,700Ω	Capacitor C26 and Term. E13
R126 —	145A	4.53 meg	Ladder B
R127 —	KS-13490,L1	6.8 meg	60 COARSE SPEED and SWEEP LEVEL Potentiometer
R128 —	KS-13490,L1	0.24 meg	Ladder A
R130 —	KS-13490,L1	1.0 meg	DISPLAY and SPEED Switches
R132 —	145A	4.99 meg	Ladder G
R133 —	KS-13490,L1	8.2 meg	Ladder G
R134 —	145A	3.8 meg	Ladder G
R135 —	145A	2.37 meg	Ladder G
R136 —	KS-13490,L1	0.82 meg	Ladder A
R137 —	KS-13490,L1	5.6 meg	Ladder C
R138 —	145A	0.909 meg	Ladder E
R139 —	145A	0.196 meg	Thermistor RT1 and Term. E26
R140 —	145A	0.348 meg	Terms. E25 and N9
R141 —	KS-13492,L1	27,000Ω	Terms. E20 and E24
R142 —	KS-13492,L1	0.18 meg *	Terms. E20 and N10
R143 —	KS-13492,L1	See Note	Terms. E17 and E21
R144 —	KS-13490,L1	20,000Ω	Terms. E27 and E28
R145 —	145A	82,500Ω	Terms. E27 and E30
R146 —	145A	4.64 meg	Resistor R132 and Term. E30

Note: R143 is one of four ohmic values (15,000, 18,000, 22,000, 27,000) selected by test during manufacture for proper −VR and +VR voltages.

* 0.12 meg on Issue 7B of the SD drawing

TABLE VI

CAPACITOR, VARISTOR, THERMISTOR AND TRANSISTOR

LOCATION TABLE

DESIG.		TYPE	VALUE	LOCATION
C1	—	KS-14289,L4	0.02 mf	G1 and E1 Terms.
C2	—	KS-14289,L3	0.01 mf	G2 Terms. and F2 Fuse Mtg.
C3	—	KS-13365,L2	100 mmf	E16 Terms. and V5 Socket, Pchg 8
C4	—	Sprague 96-P15203S2	1500 mmf	Ladder D
C5	—	Sprague 96-P15203S2	1500 mmf	Ladder A
C6	—	Sprague 96-P15203S2	1500 mmf	Ladder A
C7	—	KS-13365,L3	270 mmf	Ladder A
C8	—	KS-13368,L5	4700 mmf	Ladder A
C9	—	402C	0.025 mf	V2 Socket, Pchg 6 and Ladder A
C10	—	KS-13365,L2	100 mmf	CODE Switch and Term. E9
C11	—	KS-13367,L4	0.001 mf	Ladder B
C12	—	KS-13367,L4	0.001 mf	Ladder B
C13	—	KS-13365,L3	47 mmf	Term. N5 and Ladder F
C14	—	402C	0.02 mf	FINE Potentiometer and SPEED Switch
C15	—	KS-13368,L11	0.006 mf	Ladder F
C16	—	KS-13368,L11	0.007 mf	Ladder F
C18	—	Sprague 96-P47394S2	0.047 mf	DISPLAY Switch and Ground Lug on SWEEP AMP Potentiometer
C19	—	KS-13406,L6	0.01 mf	Terms. E2 and E3
C20	—	Sprague 96-P47394S2	0.047 mf	Ladder C
C21	—	Sprague 96-P56294S2	5600 mmf	***INTENSITY*** Potentiometer
C22	—	Sprague 96-P27496S2	0.27 mf	Terms. E11 and E15
C23	—	KS-14780	10 mf	Chassis
C24	—	KS-14780	10 mf	Chassis
C25	—	KS-13685	10-10-10 mf	Chassis
C26	—	KS-14780	10 mf	Chassis
C27	—	KS-14780	10 mf	Chassis
C28	—	KS-14780	10 mf	Chassis
C29	—	KS-14144,L1	0.047 mf	Pin Jacks F2 and P5
C30	—	KS-14144,L1	0.047 mf	***V CENTER*** Potentiometer and Chassis
C31	—	Sprague 64P32	1.0 mf	Pin Jack P6 and Term. E27
C32	—	Sprague 64P32	1.0 mf	Pin Jack P6 and Term. E27

TABLE VI (Cont'd)

DESIG.	TYPE	VALUE	LOCATION
CR1	Int. Rect. Y20HP Corp.		Capacitor C25 and Term. E15
CR2	Int. Rect. Y20HP Corp.		Capacitor C25 and Term. E12
CR3	Int. Rect. Y20HP Corp.		Capacitor C26 and Term. E12
CR4	Int. Rect. Y20HP Corp.		Terms. E11 and E13
CR5	Int. Rect. Y20HP Corp.		Terms. E10 and E11
CR6	Hughes Type IN 97		Ladder D
CR7	Hughes Type IN 97		Ladder D
CR8	420H		Ladder A
CR9	417B		Ladders A and F
CR10	417B		DISPLAY Switch
CR11	420G		Resistors R57 and R138
CR12	420H		Resistor R144 and Term. N11
CR13	420H		Terms. E22 and N10 (Diode Card)
CR14	420H		Terms. E23 and N10 " "
CR15	420H		Terms. E19 and E22 " "
CR16	420H		Terms. E18 and E23 " "
CR17	420H		Terms. E19 and E20 " "
CR18	420H		Terms. E17 and E18 " "
Q1	G.E. Co. 2N44 Transistor		Resistors R145, R146, Term. N12 and Pin Jack P4 (Transistor Card)
RT1	8A Thermistor		Resistor R140 and ***FINE SPEED*** Potentiometer

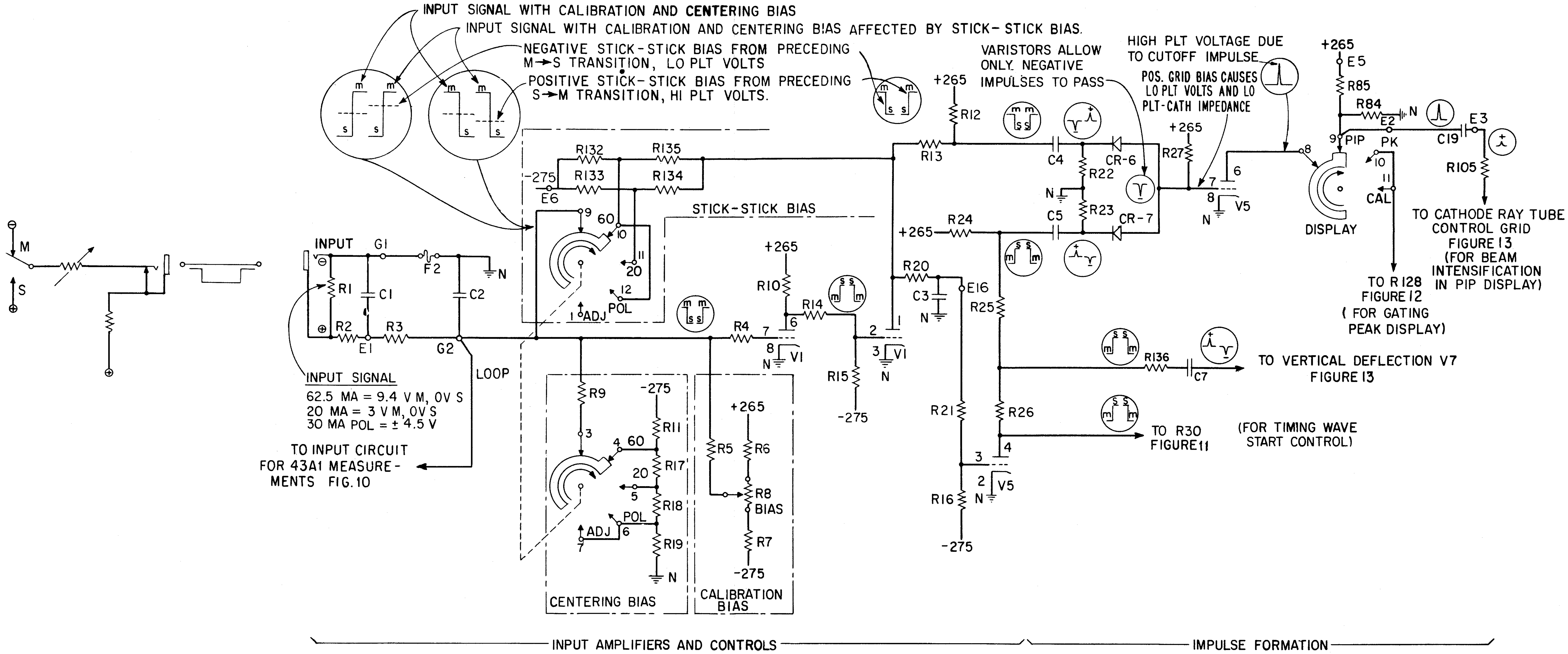


Fig. 9 – Input Circuit, Input Amplifiers and Impulse Forming Circuits

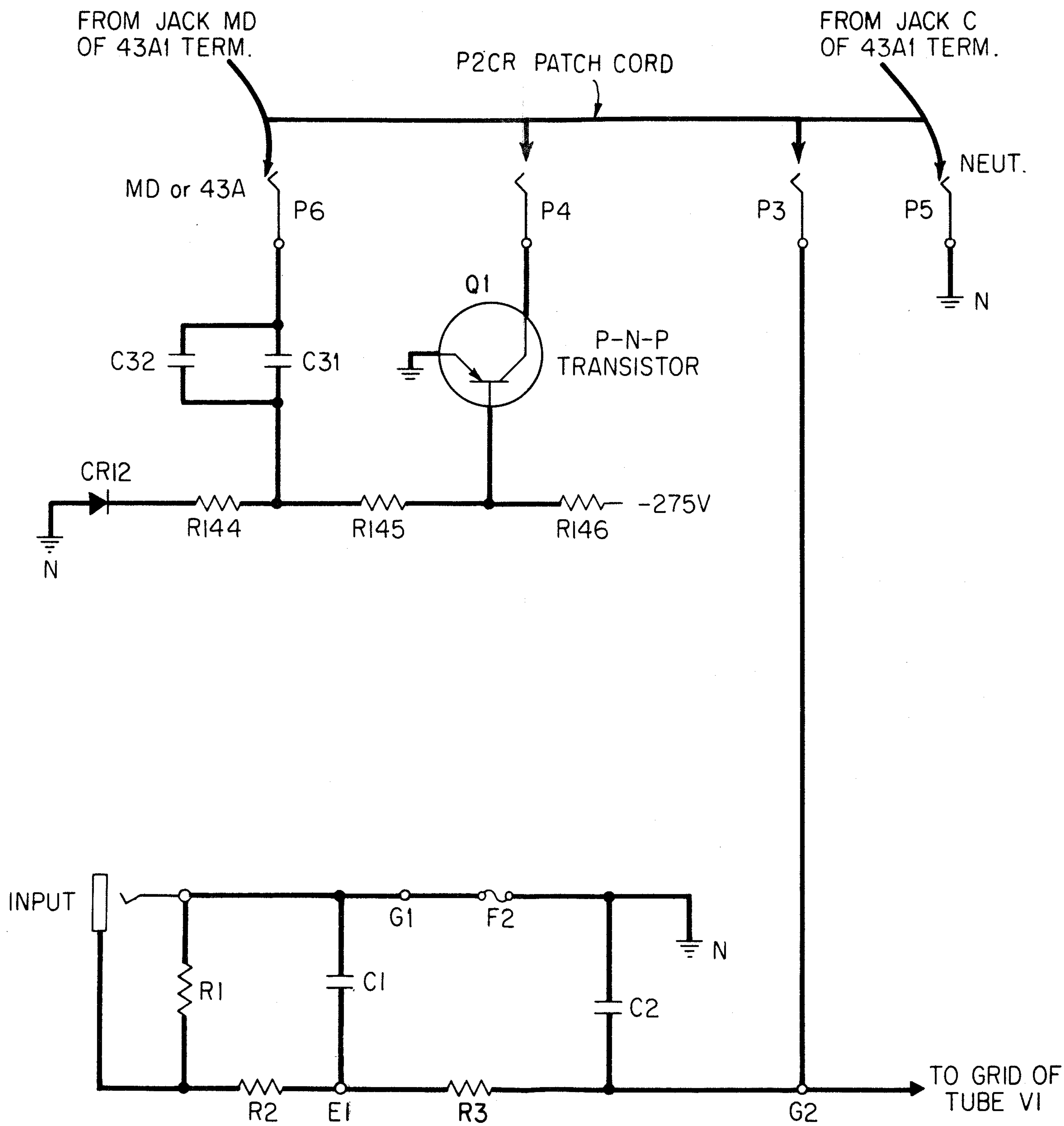


Fig. 10 – Input Circuit for 43A1 Carrier Measurements

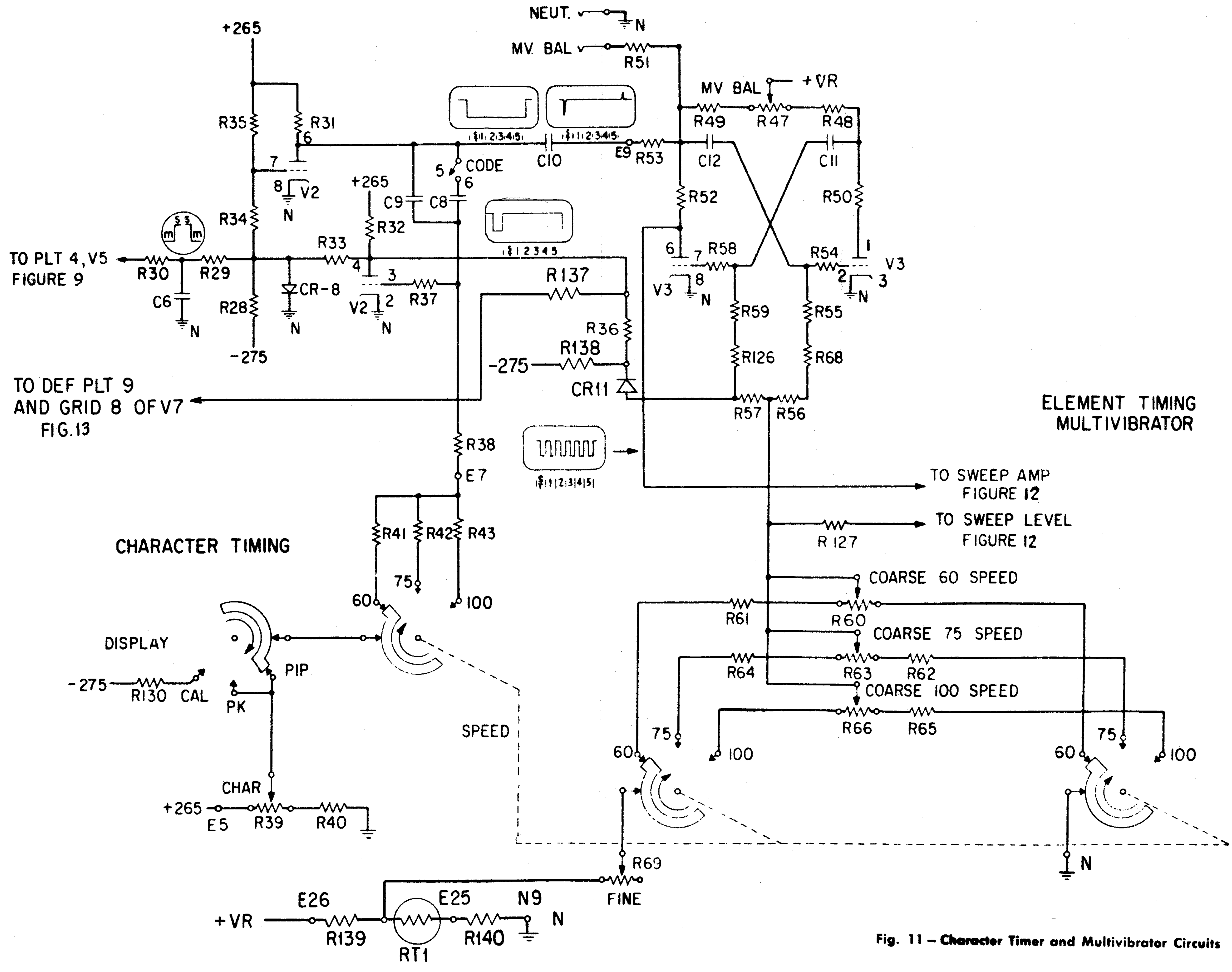


Fig. 11 – Character Timer and Multivibrator Circuits

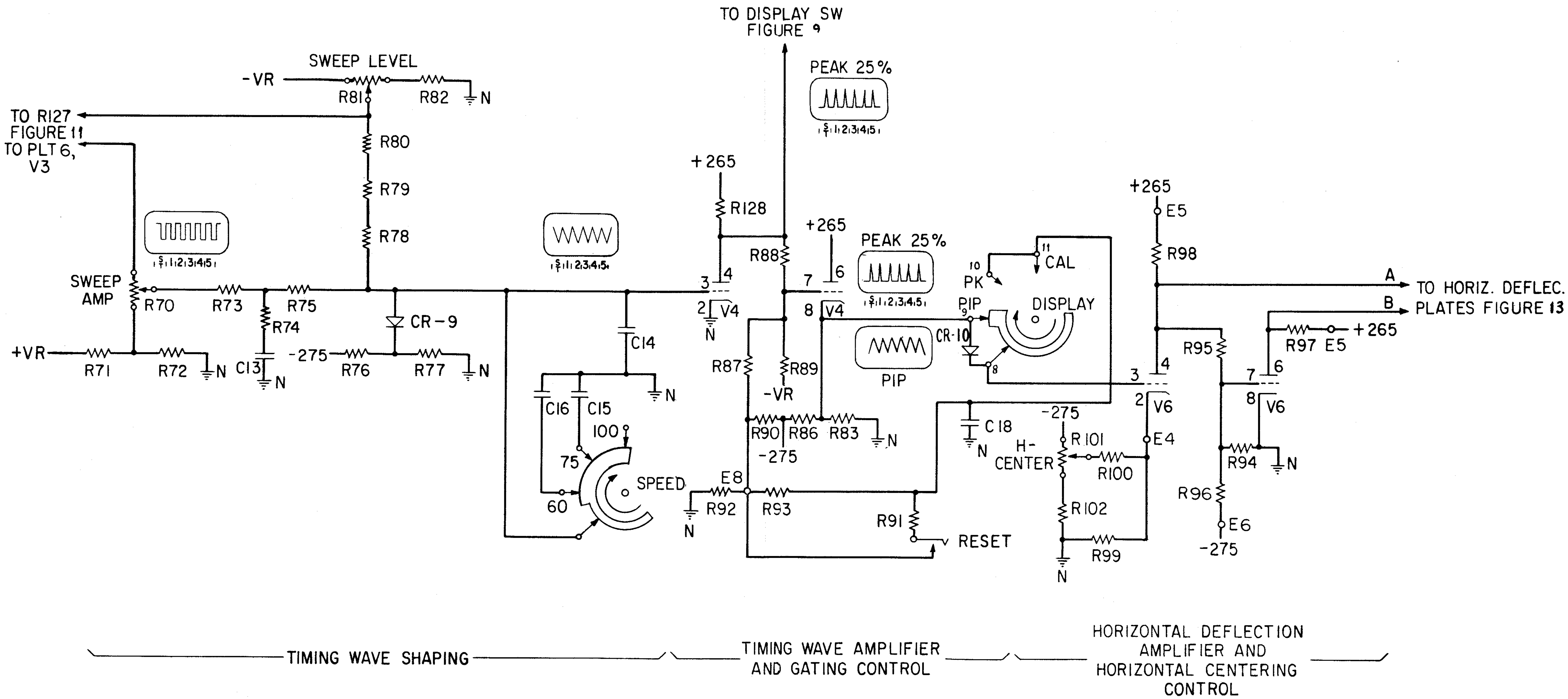


Fig. 12 – Horizontal Deflection Control Circuits

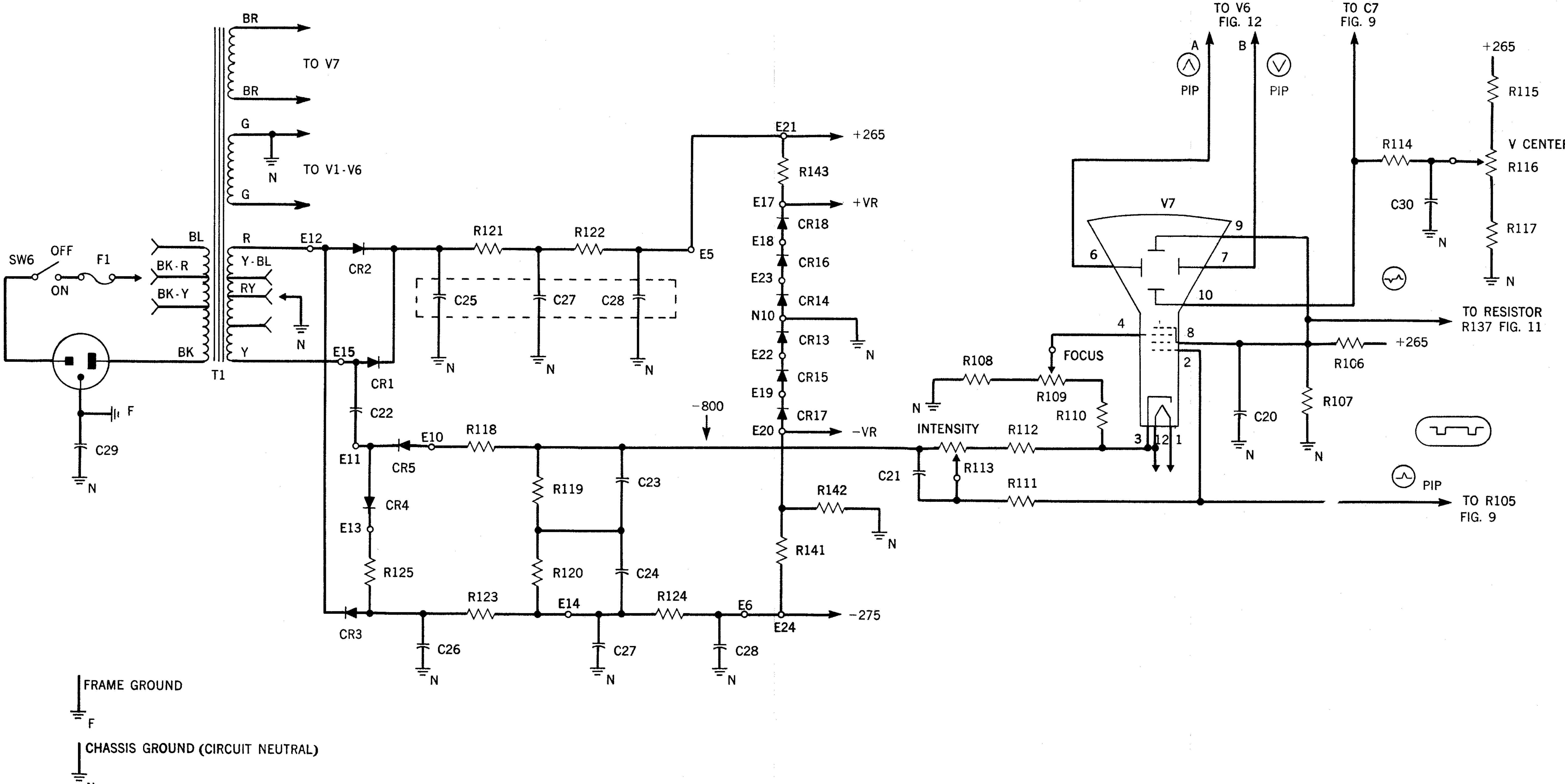
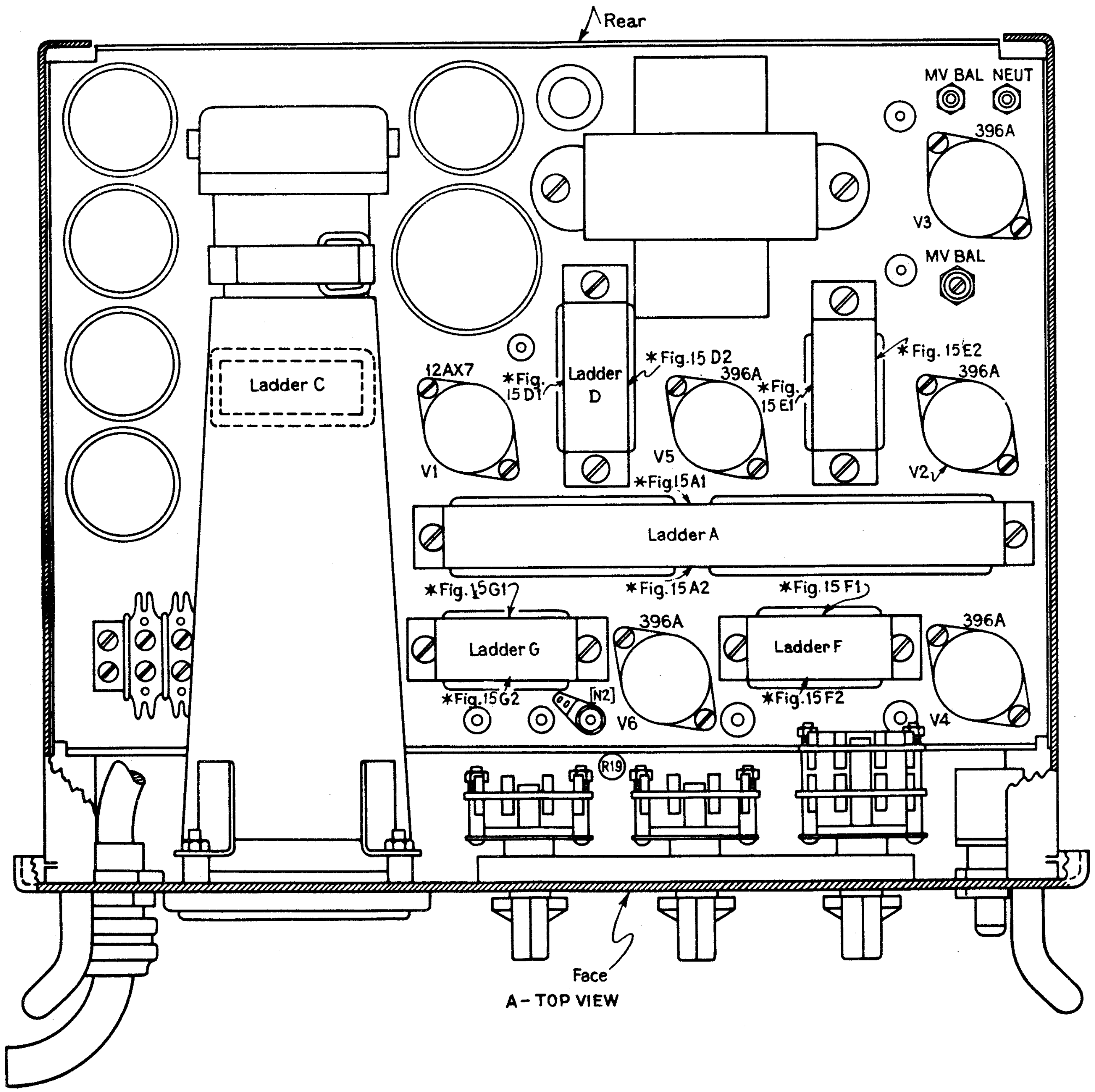
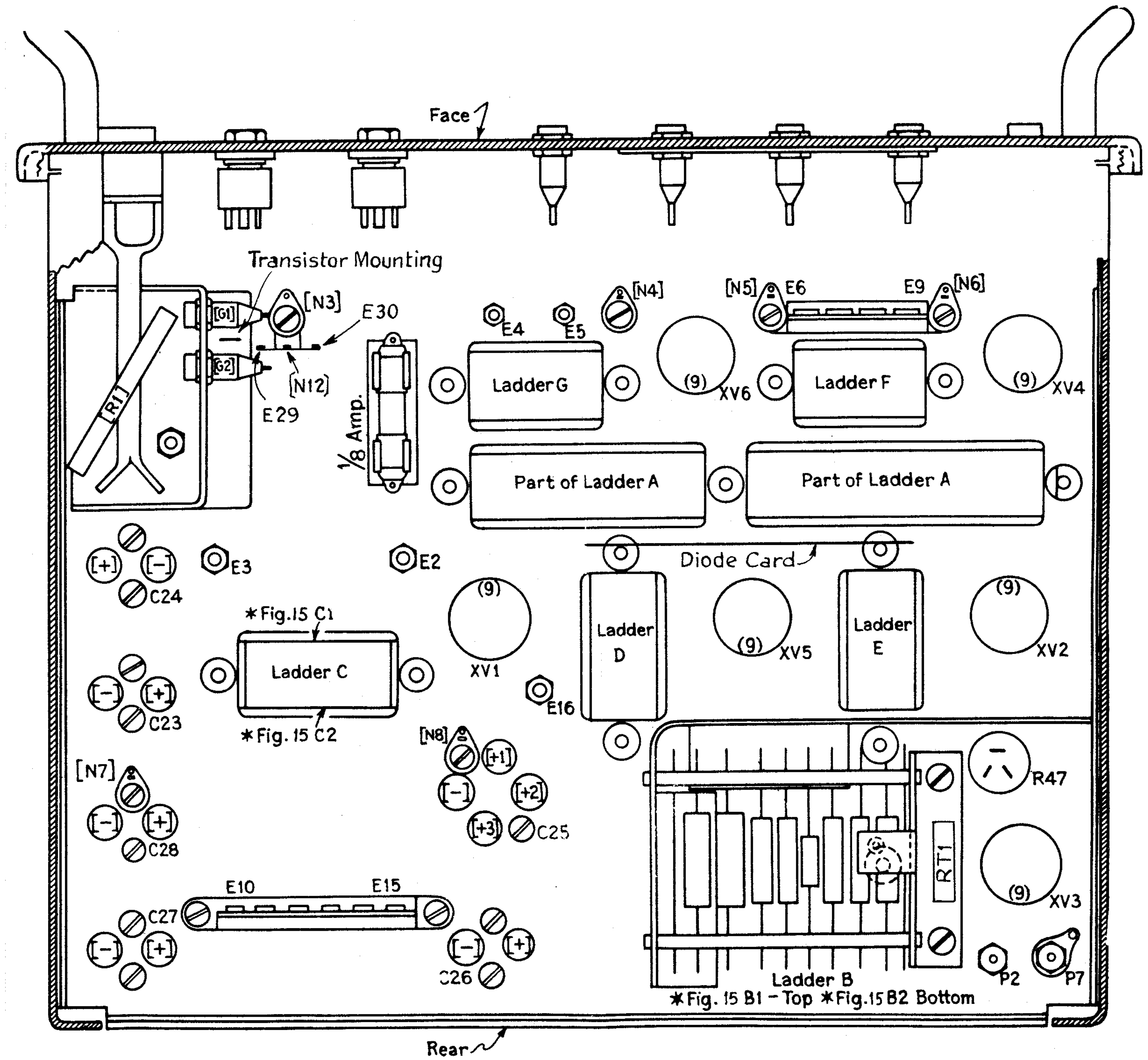


Fig. 13 – Display Tube Adjustment and Power Supply Circuits



A – TOP VIEW



B – BOTTOM VIEW

* See indicated figure for mounting of components.

Fig. 14 – Locations of Equipment Ladders and Circuit Doubling-up Points

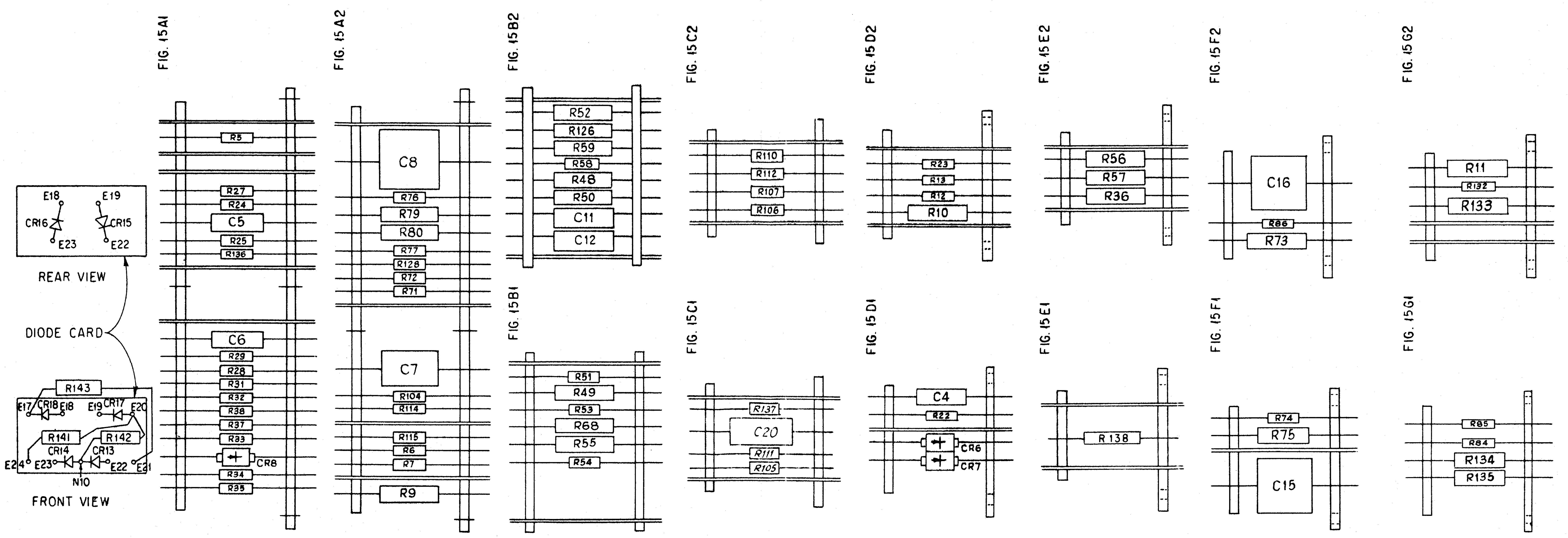


Fig. 15 – Location of Components on Equipment Ladders and Diode Card