X-75041 TELEGRAPH TRANSMISSION MEASURING SET
DESCRIPTION

1. GENERAL

1.01 This Section is reissued to change the← rating from Provisional to Standard. It← describes and gives the operating principles of the X-75041 Telegraph Transmission Measuring Set.

1.02 The X-75041 Telegraph Transmission Measuring Set, the front panel of which is shown in Fig. 1 is a portable testing device which may be patched into a telegraph loop to measure the distortion of teletypewriter signals.

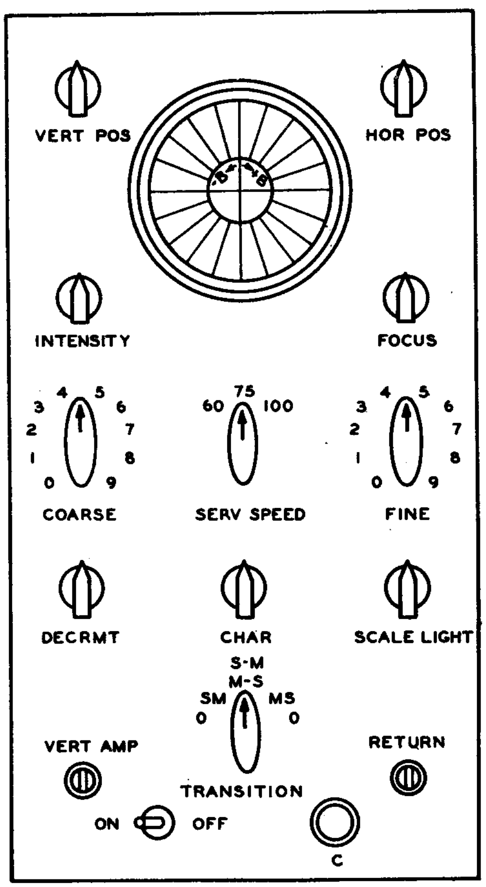

Fig. 1 - Front Panel

1.03 The method of measuring the distortion of the pulses, which make up teletypewriter characters is based on the establishment of a circular or spiral reference timing trace on the screen of a cathode-ray tube, each 360° of trace representing the length of a perfect pulse at the proper speed of operation. The reference trace is normally made invisible by adjustment except momentarily at the occurrence of transitions in the signals, thus causing spots of light on the screen of the tube. Fig. 2 shows a spiral reference trace and the position of the spots of light for undistorted pulses. The appearance of these spots to the right or left of the zero line is indicative of marking or spacing distortion, respectively, and the percentage may be read directly from the scale.

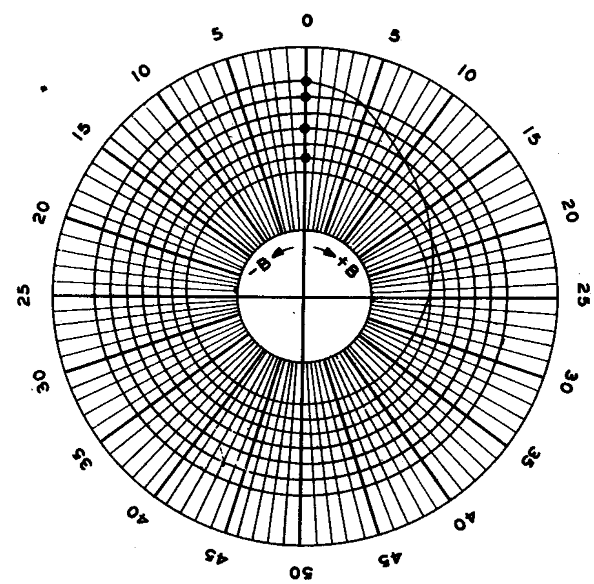

Fig. 2 - Oscilloscope Sweep

1.04 In start-stop operation bias affects space-to-mark transitions only, whereas characteristic and fortuitous distortion affect both mark-to-space and space-to-mark transitions. End distortion affects mark-to-space transitions only. In the case of end distortion the location of the spots on the screen is to the left of the zero line for marking and to the right for spacing distortion.

2. GENERAL DESCRIPTION

2.01 The set is arranged to receive polar, inverse neutral or 20 or 60 milliampere neutral telegraph signals. Any of these types of signals may be used by selecting the proper jack for making the patch to the telegraph circuit. These jacks are located in the rear of the set and are shown on Fig. 3.

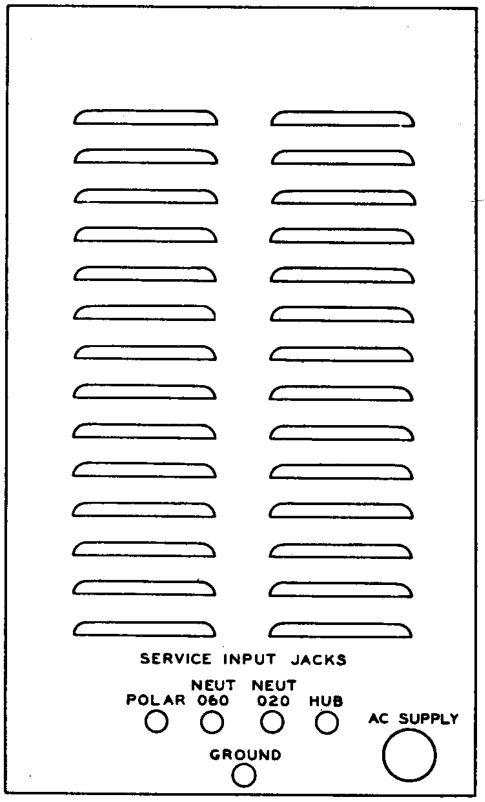

Fig. 3 - Rear View

2.02 The set is arranged to measure the pulses received on teletypewriter circuits operating at speeds of 60, 75, or 100 words per minute. The measuring circuit is set for these operating speeds by turning the SERV SPEED (service speed) knob on the face of the set to the desired speed.

Circuit Features

2.03 The telegraph transmission measuring set is equipped with circuit arrangements to provide the following:

(a) To measure an interval of time equal to the time length of a character when the teletypewriter is operating at a speed of 60, 75, or 100 words per minute.

(b) To provide either a spiral time axis or a circular time axis upon the screen of the cathode-ray tube during the measured time interval. A spiral time axis is shown on Fig. 2.

(c) To control the time axis, so that one complete revolution of the spiral or circle corresponds to the length of a unit pulse of the teletypewriter character when operated at 60, 75, or 100 words per minute.

(d) To indicate on the time axis the distortion of all mark-to-space or space-to-mark transitions or both which may occur in the teletypewriter character. These transitions are indicated by the heavy spots on Fig. 2.

(e) To provide, through an internal power pack, the necessary voltages which are required for the operation of the transmission measuring circuit with the exception of the -48 volts which is required when the set is used in connection with telegraph circuits operated on an inverse neutral basis.

Equipment Arrangement

2.04

(a) The set weighs about 47 pounds, and is approximately 8-3/4 inches wide, 14-3/4 inches high and 16 inches long.

(b) A handle is provided on top for carrying and another handle is provided at the bottom of the face panel to facilitate removal of the chassis from the casing.

(c) The chassis may readily be withdrawn from the casing by removal of eight screws. For ordinary maintenance, however, sufficient access is afforded by a hinged door on the right side.

(d) All controls, excepting the power voltage adjusting switch which is seldom used, are located on the face panel. The screen end of the cathode-ray tube with its cylindrical light shield is located at the top of the face panel. Designations for the face panel are carried on a separate masking panel which is screwed to the front of the face panel and which may be removed by the removal of the screws, control knobs and handle.

(e) At the rear of the set are provided louvers for ventilation and jacks for connections to the a-c power supply, the telegraph circuit and ground.

(f) The cathode-ray tube is fitted into a cone-shaped envelope of magnetic iron to shield it from electromagnetic disturbances. This cone is further used as a means of mounting the cathode-ray tube and for this purpose is provided with four feet which slide under clamps located on the floor of the top shelf. The conical cathode-ray tube chamber is also fitted with rubber grommets to serve as protective bumpers between the iron chamber and the glass cathode-ray tube.

(g) The fuses and all vacuum tubes except the cathode-ray tube are accessible by opening the door on the right side. Access to the cathode-ray tube is made by sliding the chassis out of the casing. The tube may be removed by loosening four clamps with a screw driver and sliding back the cathode-ray tube chamber so that its feet are free of the clamps and its front edge is free of the light shield. Grasp the tube chamber in one hand and the cable connector in the other and separate the cable connector from the base of the cathode-ray tube. The cathode-ray tube may then be pushed out of the tube chamber.

(h) To replace the cathode-ray tube and associated tube chamber, place the tube in the chamber so that the arrow on the base is diverted upward with respect to the chamber feet. Then holding the cable connector so that the orientating dot is at the top, engage it with the tube base. After making sure that the tube is properly seated in the tube chamber, put the chamber in position on the top shelf, slide the feet under the clamps, and push the front edge within the light shield. Tighten the clamp screws.

(i) A transparent scale is provided in front of the screen of the cathode-ray tube to facilitate evaluation of bias and other distortions, and is glued within the light shield. The mounting flange of the light shield is slotted to facilitate minor adjustments; and by loosening three screws, the shield may be rotated ± 20 degrees. The scale is illuminated indirectly by small lamps placed around its outer edge, the intensity of illumination being controlled by the rheostat designated SCALE LIGHT.

(j) Space within the casing is economically utilized by mounting the apparatus on vertical as well as horizontal panels.

The complete chassis consists of a top shelf, a bottom shelf, a vertical panel and a face panel.

Power Requirements

2.05 The operation of the set requires a 100 to 125-volt, 60 cycle, a-c power supply. A two position voltage adjusting switch is provided in the power pack to permit operation on a normal power voltage range of either 100-115 volts or 110-125 volts. This switch is located in the rear right-hand corner of the bottom shelf. The a-c power consumption is approximately 100 watts.

Approximately 30 milliamperes of -48 volt battery is required when measuring pulses from inverse neutral circuits.

3. THEORY OF OPERATION

General

3.01 The telegraph transmission measuring set contains electronic circuits for producing a series of six sweeps in circular or spiral form on the screen of an oscilloscope. An illustration of a spiral sweep is shown in Fig. 2. The complete spiral sweep corresponds to the six possible transitions which may be used in forming 5 unit teletypewriter characters. The speed of the sweep is adjusted so that each 360 degrees of the spiral is completed in a unit of time corresponding to that of a correct pulse when the teletypewriter is operated at a speed of 60, 75, or 100 words per minute. The electron beam which describes this spiral or circular sweep is intensity-modulated by the transitions occurring in the received teletypewriter signal. At the instant of each transition occurrence, therefore, a spot appears on the screen. Since each revolution of the spiral or circular sweep corresponds to the exact time interval of a perfect unit-length pulse, all spots should fall on a radius of the screen for a distortionless signal. The oscilloscope screen is equipped with a radial scale of 100 divisions which permits reading the per cent. displacement of each transition within the teletypewriter character.

3.02 The block diagram shown in Fig. 4 illustrates the various circuit elements which make up the complete circuit of transmission measuring set and also indicates how these circuit elements are interconnected. In the following use has been made of some simplified diagrams which correspond generally to the actual circuits.

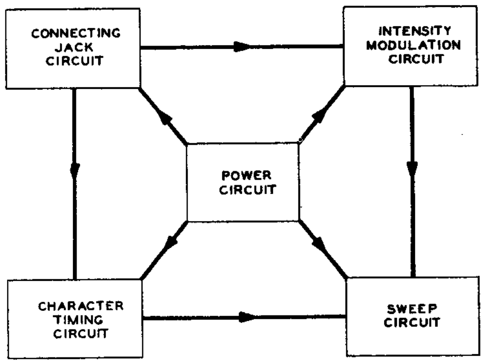

Fig. 4 - Block Diagram of Circuit Connections

Connecting Jack Circuit

3.03 All connections to the telegraph transmission measuring set are made through the SERVICE INPUT JACKS located in the rear of the set (Fig. 3). The GROUND and the A-C SUPPLY jacks are for plugging ground and 115-volt 60-cycle power respectively, to the set. The POLAR, NEUT 060, NEUT 020, and HUB jacks are for making plug connections to ± 30 to 35-mil polar, to 60 and 20-mil neutral, and to inverse neutral (hub) circuits, respectively. The connecting jack circuit (Fig. 5) is arranged to produce a constant drain on the power pack regardless of the jack used for the connection. This feature is provided to simplify the problem of maintaining close voltage regulation.

3.04 The connecting jack circuit is so arranged that the necessary 30 and 10-mil bias currents are supplied to the bias winding P2 of the line relay K1 when connection is made through the NEUT 060 jack or the NEUT 020 jack, respectively. For inverse neutral service, -48-volt battery is provided over the tip of the patching cord and ground over the sleeve. The ring spring of the HUB jack should be connected to the inverse neutral (hub) circuit over the ring conductor of the patching cord.

3.05 By using the proper jack for the particular type of service to be measured, the circuit conditions are such that the line relay K1 should faithfully follow the received signals.

3.06 Connections with the telegraph circuit may be made through any loop or line jack of a polar or neutral telegraph circuit or through a jack in the inverse neutral hub circuit.

Character Timing Circuit

3.07 As already indicated, a spiral or circular sweep is used as a time axis. In order to limit the length of this time axis to the time length of a teletypewriter character at a particular speed of 60, 75, or 100 words per minute, a character timing circuit is incorporated in the transmission measuring set. This character timing circuit is shown in Fig. 6.

3.08 Prior to connecting the set to the telegraph service to be measured, capacitor C49-C54 is charged to about 90 volts with respect to ground from the power lead marked +210 volts. The charging circuit is made up of resistor R49, resistors R76, R50 and R51A controlled by CHAR rheostat and SERVICE SPEED switch, and resistor R48 to ground. The voltage is maintained at approximately 90 volts by the action of section 3-4 of the diode tube V5 which has approximately 90 volts connected to its cathode terminal through the potentiometer formed by resistors R64 and R67. Under these conditions any tendency for the voltage on capacitor C49-C54 to rise above 90 volts is immediately accompanied by a flow of current from terminal 3 to terminal 4 in tube V5. This maintains the charge on capacitor C49-C54 at 90 volts.

3.09 When the set is connected to a closed telegraph circuit, the armature of line relay K1 moves to its No. 4 or marking contact thus connecting +210 volts to resistor R57, resistor R53A, and the two parallel potentiometers made up of resistors R31, R55 and R78 and resistors R53B and R53C, respectively. Through the latter potentiometer(R53B and R53C) a potential of approximately +200 volts is connected to the main anode (terminal 5) of tube V9. Tube V9 immediately fires and current flows through the main gap of this tube and resistor R48 to ground. This current sets up a voltage of approximately 125 volts across resistor R48 which discharges capacitor C49-C54 and charges it in the reverse direction. This discharge and recharge occurs through diode V5, since its plate potential is increased with respect to ground by the voltage across resistor R48 through capacitor C49-C54. This same 125-volt potential at one end of the potentiometer composed of resistors R46, R45, and R44, drives the grid (terminal 4) of tube V8 slightly positive and causes plate current to flow in its cathode circuit.

3.10 Upon the receipt of a spacing signal, which might be the start signal of a teletypewriter character, the armature of relay K1 moves to its No. 5 or spacing contact and removes voltage from terminal 5 of tube V9, capacitor C56, and the plate terminal of

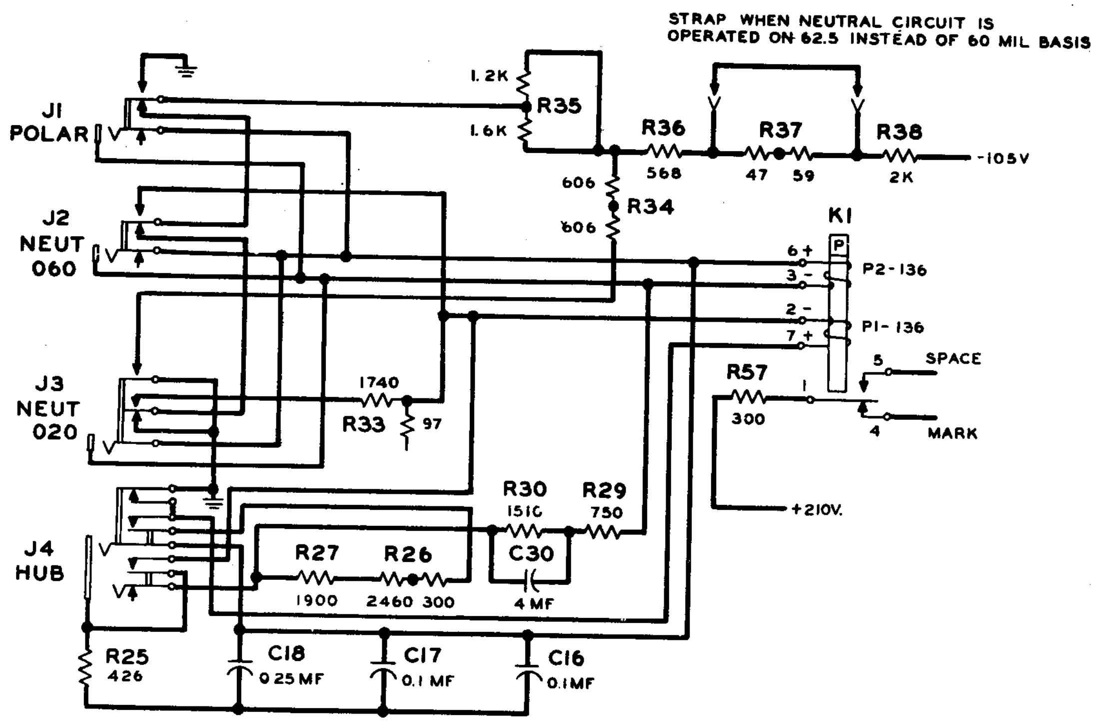

Fig. 5 - Jack Connecting Circuit

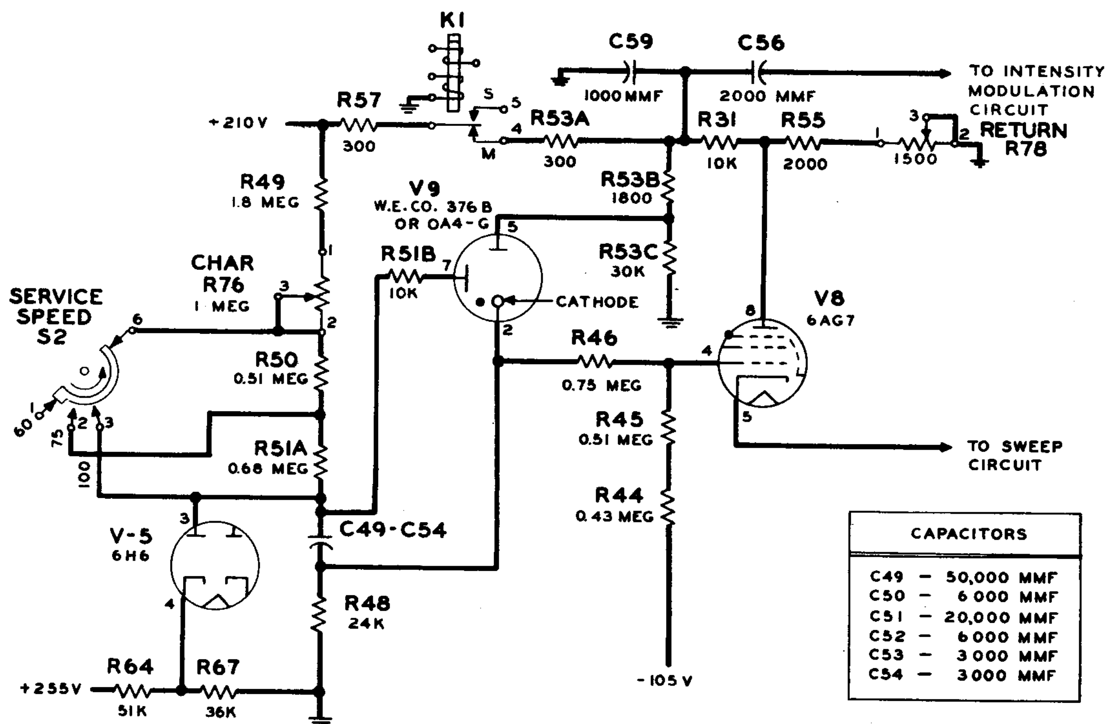

Fig. 6 - Characte:

tube V8. Cathode current in tube V8 and current in the main gap of tube V9 cease to flow. The cathode potential of tube V9 returns to zero with respect to ground. The loss of the voltage drop across resistor R48 also causes the grid bias of tube V8 to swing negative beyond the cutoff point and leaves capaciter C49-C54 with an effective negative charge of 35 volts. Capacitor C49-C54 then begins to charge from +210 volts. The charging resistors, however, are so regulated that capacitor C49-C54 does not obtain sufficient potential to fire tube V9 until approximately six unit pulses later. At that time, provided the armature of relay K1 is on its marking contact, tube V9 again fires and again permits the grid of tube V8 to swing positive and allow current to flow in its cathode circuit. The plate voltage of tube V8 and hence its maximum cathode current are controlled by means of the RETURN rheostat (resistor R78).

Sweep Circuit

3.11 The sweep circuit, which is also referred to as the spiral or circular time axis circuit, is shown in Fig. 7. This circuit controls the path of the electron beam of the cathode-ray tube between the start and stop signals of a teletypewriter character and causes it to trace a spiral or circular sweep over the face of the tube as illustrated in Fig. 2.

3.12 As mentioned in Paragraph 3.09 current ceases to flow in the cathode of tube V8 upon the receipt of the first space signal. This may be assumed to be the "start" pulse of a teletypewriter character. Current again begins to flow in the cathode circuit of tube V8 six unit pulses later, at which time the "stop" mark signal should be received. The firing of tube V9 and the flow of current in the cathode of tube V8 require sufficient time for capacitor C49-C54 to be charged to the breakdown potential of the control gap (terminals 7 and 2) of tube V9. The cathode circuit of tube V8 may be traced from the cathode terminal of tube V8 through resistors R23 and R24, as determined by SERV SPEED switch S2, through four parallel paths to ground. These four paths are made up of a capacitor path, an inductor and resistor path, and two potentiometer resistor paths. The capacitor path is composed of a group of capacitors as determined by the position of the SERV SPEED switch in parallel with such capacitors as may be inserted in this path by the position of the COARSE and FINE switches. The inductor and resistor path is composed of winding 1-2 of retardation coil L1, VERT AMP potentiometer R79, and resistors R10, R9, and R1 as determined by the position of the SERV SPEED switch. The two potentiometer resistor paths are composed of resistors R3 and R2 of one path and R43 and R42 of the other path.

3.13 Depending on the position of the SERV SPEED switch and the position of the RETURN rheostat (see the plate circuit of tube V8, Fig. 6), the total steady state cathode current for a mark signal varies between three and six mils. As a result a small amount of energy is stored in the capacitor path, and many times more energy is stored in the coil L1. Also depending upon the adjustment of the VERT AMP potentiometer, a definite positive potential-to-ground exists at terminal 3 of this potentiometer. Similarly a small positive potential-to-ground exists between resistors R43 and R42 which is applied to grid 4 of tube V7 and causes plate current to flow through winding 3-4 of coil L1 to add to the stored energy in this coil. This plate current is regulated by the adjustment of the DECRMT rheostat in the cathode circuit (terminal 6) of tube 7. Finally a very small potential-to-ground appears between resistors R3 and R2. The effect of positive potentials to ground at terminal 3 of the VERT AMP potentiometer and between resistors R3 and R2 may best be explained by describing a portion of the calibration of the set which is made with the relay K1 on its spacing contact, and therefore without the benefit of these two positive potentials.

3.14 In the preliminary calibration, the electron beam of the cathode-ray tube V1 is controlled so that the spot of light is located in the exact center of the distortion scale. For this purpose two potentiometers are provided to permit the control of the grid bias of the two half sections of tube V6. Section 3-4 of tube V6 which controls the vertical displacement of the spot is associated with the potentiometer arrangement composed of the VERT POS potentiometer R72, resistor R11, and resistors R7 and R6 to terminal 3 of VERT AMP potentiometer which is practically at ground potential. Similarly section 5-6 of tube V6, which controls the horizontal displacement of the spot, is associated with the potentiometer arrangement composed of the HOR POS potentiometer R71, resistor R12, and resistors R5 and R4 to ground through approximately 120,000 ohms. Both potentiometer systems are connected to negative 105 volts through resistor R8, and both potentiometer systems are practically alike. Therefore, by correct adjustment of the VERT POS and HOR POS potentiometers, the proper negative bias can be established on both grids of tube V6 causing plate currents to flow through resistors R14 and R13 to produce the desired positive potentials at the two plate terminals 3 and 6 of tube V6.

3.15 With a proper potential connected to the lower vertical deflecting plate (terminal 5) of cathode-ray tube V1 and simultaneously a

CAPACITORS		
C 2 20,000 MMF	C 12 20000 MMF	C 25 20000 MMF
C 3 20000 MMF	C 13 0.1 MF	C 26 20000 "
C 4 50000 "	C 14 50000 MMF	C 27 20000 "
C 5 10000 "	C 15 20000 "	C 28 20000 "
C 6 50000 "	C 19 0.25 MF	C 43 10000 "
C 7 20000 "	C 20 0.25 MF	C 44 8200 "
C 8 10000 "	C 21 0.1 "	C 45 6200 "
C 9 0.1 MF	C 22 20000 MMF	C 46 2000 "
C 10 0.25 MF	C 23 50000 "	C 47 2000 "
C 11 0.1 "	C 24 20000 "	C 48 2000 "

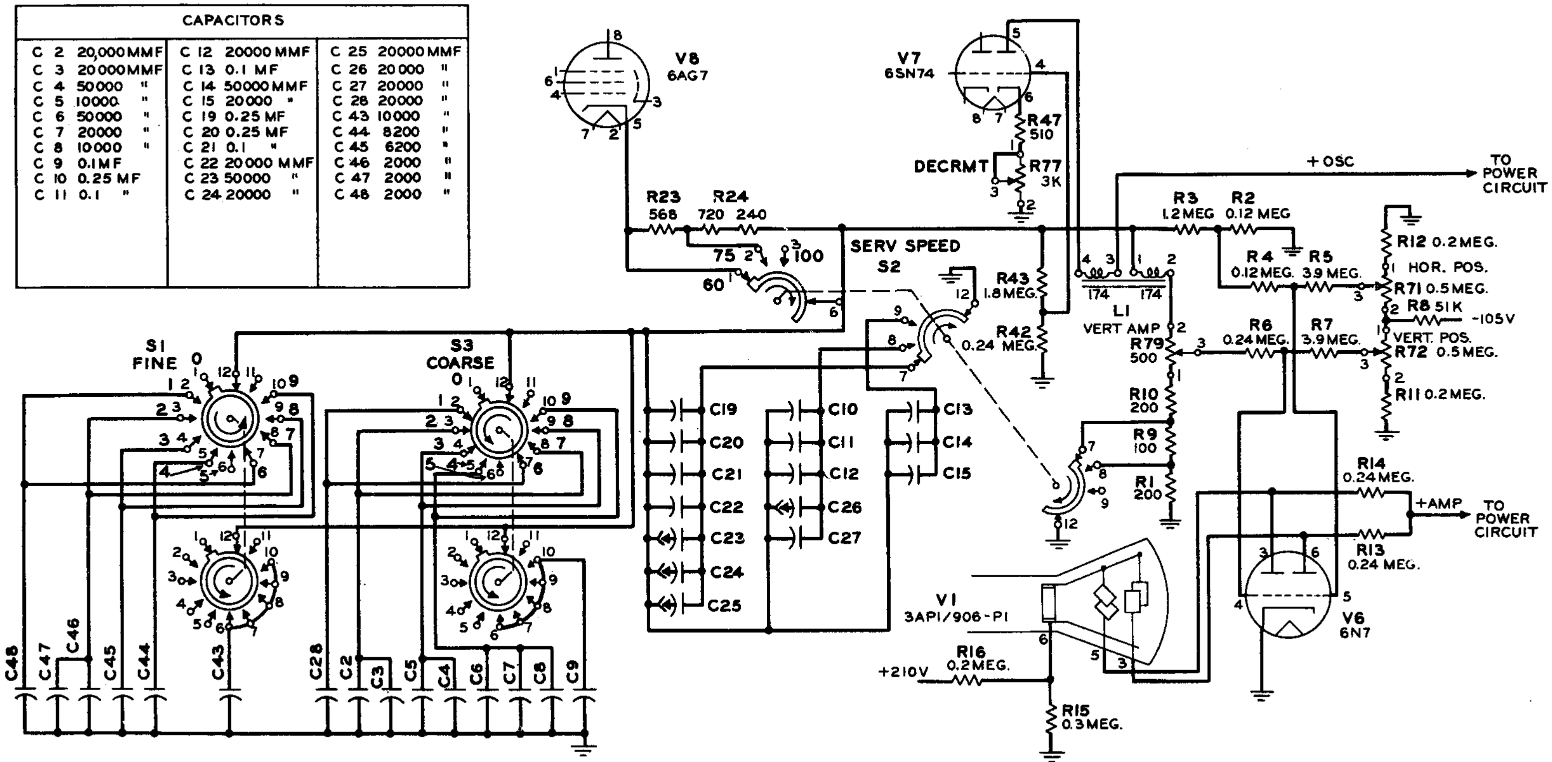

Fig. 7 - Sweep Circuit Schematic Diagram

proper potential connected to the left horizontal deflecting plate (terminal 3) of the cathode-ray tube V1 and with a potential of approximately 126 volts, obtained from potentiometer resistors R15 and R16, connected to terminals 6 of the cathode-ray tube V1, the electron beam is centered on the distortion scale. A more positive bias on the grid (terminal 4) of tube V6 lowers the potential at terminals 3 and 5 of tubes V6 and V1, respectively, and causes the electron beam to move vertically upward. Similarly, a more negative bias on the grid terminal 4 of tube V6 raises the potential at terminals 3 and 5 of tubes V6 and V1, respectively, and causes the electron beam to move vertically downward. Correspondingly a more negative grid bias on terminal 5 of tube V6 causes the electron beam to be moved horizontally to the left, and a more positive grid potential causes the electron beam to be moved horizontally to the right.

3.16 When the armature of relay K1 is on its mark contact and current is flowing in the cathode of tube V8, the positive potential-to-ground at terminal 3 of the VERT AMP potentiometer makes grid terminal 4 of tube V6 more positive and causes the electron beam to move vertically upwards; the very small positive potential-to-ground from the potentiometer resistors R3 and R2 causes a very small movement of the electron beam to the right.

3.17 When a space signal corresponding to the start signal is received, cathode current ceases to flow in tube V8; but oscillating currents begin to flow in the sweep circuit as a result of the capacitor, inductor, and resistor branches. This may be described as follows: The instant the cathode current of tube 8 is cut off, the stored electrostatic energy in the capacitors and the electromagnetic energy in coil L1 cause the current to flow in the same direction through the winding of the coil and in a reverse or discharge direction through the capacitors. Since the energy in the capacitors is small, the potential drops quickly to zero; and since current continues to flow due to the energy in the coil L1, the capacitors become charged negatively, reaching a maximum when the current in the coil L1 drops to zero. This occurs in the first quarter cycle of the oscillation frequency. The capacitors now discharge in the opposite direction reversing the current through the inductor branch coil L1, and the potential of the capacitors reaches zero when the current in coil L1 is at a maximum. This is the second quarter of the oscillation frequency. The oscillation continues provided energy is available. Because of resistor losses, each succeeding voltage and current maximum will show a decrement in value. The very high resistance of the potentiometers R43 to R42 and R3 to R2 contributes very little to this loss. To compensate for

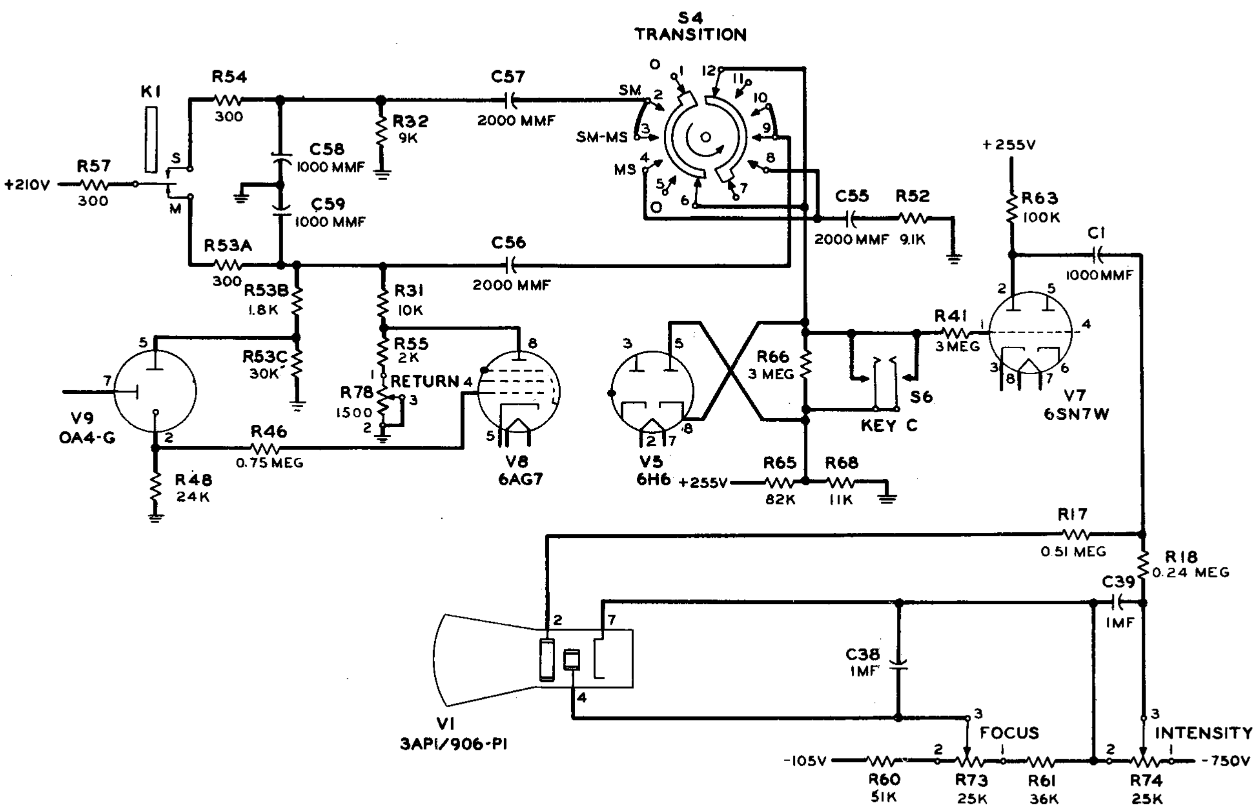

Fig. 8 - Intensity Modulation Circuit Schematic Diagram

this loss, a small portion of the voltage across the capacitors is connected to grid 4 of tube V7 and the varying plate current flows through winding 3-4 of coil L1 thus adding to the stored electromagnetic energy.

3.18 A comparison of the current in coil L with the voltage across the capacitors reveals that the former varies as a cosine function of time as measured in degrees of an oscillation cycle while the latter varies as a sine function. Therefore, from the instant that the current in the cathode of tube V8 ceases, the electron beam in the first quarter cycle sweeps in a circular trace in a counterclockwise direction. If the energy returned to the system by means of winding 3-4 of coil L equals the internal losses, the trace is a continuous circle of constant diameter. Less restored energy causes the trace to travel in a constantly decreasing diameter circle or a spiral until the energy is dissipated. The amount of this decrement is controlled by the DECRMT rheostat R77.

3.19 By adjusting the capacitors accurately, the cycle of the oscillation may be made equal to the time length of a perfect unit signal. This is accomplished by adjusting the COARSE and FINE capacitor switches. As a result the trace may be considered as a time axis with each revolution beginning exactly one-unit pulse length later than the preceding one.

3.20 When the cathode current of tube V8 again begins to flow, the above oscillation will stop. The trace will then return to the starting point as the cathode current of tube V8 restores the energy in coil L1. The position of the RETURN rheostat controls the initial current in the oscillating circuit and thereby controls the energy supplied to the sweep circuit and the outer diameter of the sweep on the screen of the oscilloscope.

Intensity Modulation Circuit

3.21 Distortion is indicated by the time of occurrence of mark-to-space and space-to-mark transitions along the time axis. If the received signal is composed of perfect unit or multiple unit length signals, these transitions always occur along a radial axis of the scale as illustrated in Fig. 2. Since vertical and horizontal displacement of the electron beam has already been used in the formation of the time axis, the exact time of transition is indicated by momentarily increasing the intensity of the beam. This is accomplished by the circuit shown in Fig. 8.

3.22 The intensity of the beam is primarily controlled by the INTENSITY potentiometer which regulates the amount of negative grid bias of the cathode-ray tube V1. Assume the armature of relay K1 is on its marking contact and the TRANSITION switch is thrown to SM-MS. On one side of capacitor C56 a positive potential of approximately 200 volts exists while on the other side there is a positive potential of approximately 30 volts obtained through the potentiometer arrangement consisting of resistors R68 and R65. Capacitor C56 is charged accordingly. When the armature of relay K1 moves toward its spacing contact, the 200-volt potential is removed, and capacitor C56 discharges quickly through resistors R31, and R55 and R78 and resistors R53B and R53C, and the potentiometer arrangement R65 and R68. Resistor R66 is effectively removed from the circuit because the plate terminal 5 of the diode tube V5 is positive with respect to the cathode terminal 8 and this diode passes current. As a result a large transient of short duration occurs in the circuit resulting in a heavy negative bias swing of the grid (terminal 1) of tube V7. The plate (terminal 2) of tube V7 which is condenser coupled to the grid (terminal 2) of the cathode-ray tube V1 thus momentarily increases the grid 2 potential in a positive direction and increases the intensity of the electron beam. When the armature of relay K1 returns to its mark contact, capacitor C56, charged in the reverse direction to a potential of approximately 30 volts, begins to recharge through potentiometers R65 to R68; but the cathode terminal 8 of tube V5 is positive with respect to the plate terminal 5, this diode does not draw current, and resistor R66 remains in the circuit. Because of resistor R66 the capacitor C56 charges slowly, and chatter of the armature of relay K1 on making contact does not find capacitor C56 sufficiently charged to affect the intensity of the electron beam. Thus only upon the break of the mark contact is the intensity of the electron beam affected. A similar circuit arrangement using capacitor C57 is available for the space contact. Hence if the normal intensity of the electron beam, as controlled by the INTENSITY potentiometer, is such that the trace is not visible, spots of light will appear on the screen of the tube in accordance with the occurrence of the transitions in the teletypewriter signals. The displacement of these spots of light or dots from the "zero" axis indicates the distortion of each and every transition.

Power-Supply Circuit

3.23 The telegraph, transmission measuring set is arranged to provide all necessary direct current and alternating current required for its operation from the 115-volt, 60-cycle

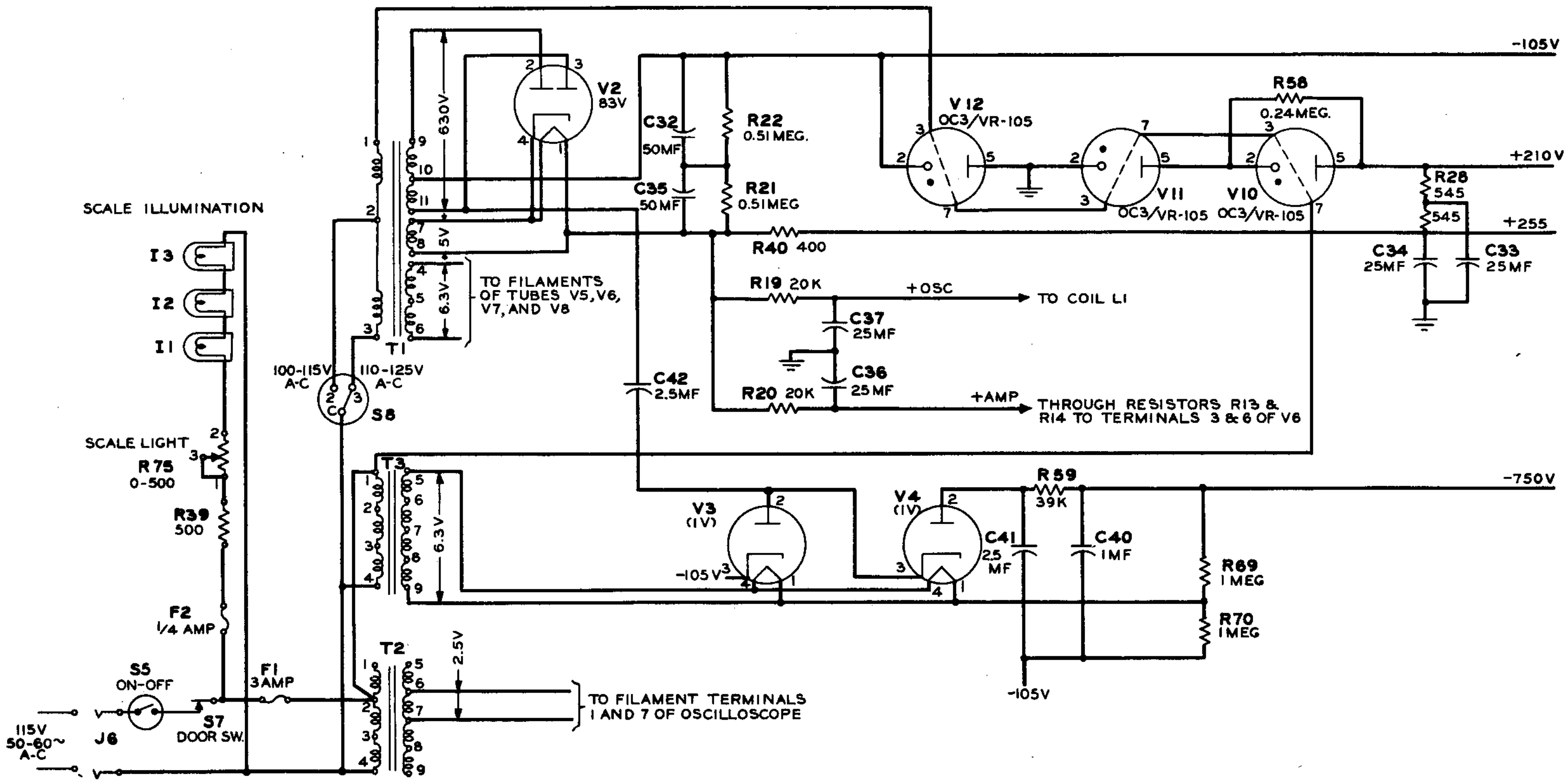

Fig. 9 - Power Circuit Schematic Diagram

service supply. The only exception is the -48-volt battery required for inverse neutral telegraph operation which is, as already indicated, supplied over the tip lead of the 3-conductor patching cord connected to the HUB jack of the set.

3.24 As illustrated in Fig. 9, the a-c power delivered to the transmission measuring set is controlled by a door switch S7, a power switch S5, and in addition the circuit is open if any of the regulator tubes V10, V11, or V12 are not in their sockets. The main power supply is fused with a 3-ampere fuse while the scale illumination circuit, composed of resistor R39, SCALE LIGHT rheostat R75, and three lamps 11, 12, and 13, is fused with a quarter-ampere fuse.

3.25 The main power supply is obtained from power transformer T1 through the full-wave rectifier tube V2 and the capacitor input filter C32 and C35. The plate power for tube V6 (Fig. 7) has an additional filter section composed of resistor R20 and capacitor C36. The plate power furnished over lead OSC for section 2 of tube V7 (Fig. 7) also has an additional filter section composed of resistor R19 and capacitor C37. The major portion of the d-c supply, after passing through additional stages of filtering, is regulated by three 105-volt voltage regulator tubes V10, V11, and V12 connected in series and grounded in such a manner to produce potentials of -105 volts and +210 volts to ground. To assist these regulator tubes in accomplishing satisfactory regulation of these potentials, a switch S8 is provided to permit use of different taps on the primary winding of transformer T1 when the a-c supply mains have wide range of potentials.

3.26 The high-voltage power supply for the cathode-ray tube is obtained from transformer T1 through capacitor C42 and is rectified by tubes V4 and V3 acting as half-wave voltage doublers followed by a two-stage capacitor input filter. A bleeder circuit for this supply furnishes the potentials required for regulating the intensity and focus of the electron beam. Transformers T2 and T furnish filament current for the cathode-ray tube and for tube V4 and tube V3, respectively.

4. INITIAL ADJUSTMENTS AND CALIBRATION

Initial Adjustments

4.01 When a set is used on 62.5-mil loop circuits, strap resistor R37. When a set is used on 60-mil loop circuits, resistor R37 should not be strapped.

4.02 Connect 115-volt, 60-cycle power to the A-C SUPPLY jack and ground to the GROUND JACK.

4.03 Operate the voltage variation switch located in the right rear corner of the lower shelf to 100-115 volts or to 110-125 volts depending on which range covers the normal voltage of the a-c power supply.

4.04 Operate the power switch on the front panel to ON and allow the set to warm up for at least two minutes.

4.05 Adjust the scale illumination to the desired value by means of the SCALE LIGHT potentiometer.

4.06 Insert a dummy plug in the NEUT 060 jack, turn DECRMT potentiometer fully counterclockwise, and adjust INTENSITY potentiometer to obtain a spot of the desired intensity on the oscilloscope screen.

4.07 By means of VERT POS and HOR POS potentiometers adjust the spot to the center of the scale. Do not increase the intensity of the beam by a large amount after the spot is centered as an excessive increase will tend to throw the spot off center.

> Caution: Under no circumstances should an intensely brilliant spot be allowed to stand at the same place on the screen for more than a few seconds.

Calibration for 60 Words Per Minute

4.08 Operate the TRANSITION switch to zero and the SERV SPEED switch to 60.

4.09 Operate the set locally with undistorted miscellaneous test signals at 60 words per minute. To do this, patch from the proper jack of the set (POLAR, NEUT 060, NEUT 020, or HUB) to the local test circuit containing the source of test signals. The set should preferably be calibrated using the type of test circuit with which it will be used during measurement. For an initial calibration, for calibration, after replacement of tubes V1, V6, V7, or V8, or for calibration after the set has not been adjusted for a long time, proceed with Paragraph 4.10 below; otherwise omit Paragraph 4.10 and proceed with Paragraph 4.11.

4.10 Slowly turn the DECRMT potentiometer counterclockwise until a conventional spiral is obtained outside of the inner circle. Adjust CHAR potentiometer until the trace is approximately 6.5 revolutions for a five-unit selecting code and 7.5 revolutions for a six-unit selecting code. Adjust RETURN potentiometer until the pattern is of a convenient size.

Slowly turn DECRMT potentiometer until a circular trace is formed. Adjust VERT AMP potentiometer until the trace is as near circular as possible. Following this the setting for VERT AMP and RETURN potentiometers does not need correcting.

4.11 Adjust the DECRMT potentiometer to obtain a spiral of convenient spacing. Rotate INTENSITY potentiometer counterclockwise until the trace is no longer visible. Operate the TRANSITION switch to MS and adjust INTENSITY and FOCUS potentiometers to obtain clear spots on the face of the tube.

4.12 Adjust COARSE and FINE capacitor switches until spots line up on a radius of the scale. In doing this disregard the dot formed by the initial start transition since a small starting transient may slightly delay this dot. Since speed and decrement adjustments are not independent, it may be necessary to readjust both until the desired result is obtained.

4.13 If necessary, orient the scale so that the spots referred to in Paragraph 4.12 above fall on the scale radius marked "zero." This may be done by loosening the set screw. Tighten the set screw after alignment.

4.14 Operate the TRANSITION switch to zero and turn INTENSITY potentiometer clockwise until the trace is visible. Refocus by adjusting the FOCUS potentiometer if necessary. Adjust CHAR potentiometer until the shortest spiral trace is about 6.5 revolutions in length.

4.15 Operate TRANSITION switch to SM and turn INTENSITY potentiometer counterclockwise sufficiently to obtain clear spots. Refocus by adjusting the FOCUS potentiometer. The average displacement of the spots from the "zero" radius is the combined bias of the calibrating signals and the receiving relay. If this exceeds one per cent. steps should be taken to correct it. See Part 5. covering maintenance.

4.16 Operate the TRANSITION switch to SM-MS. If the source of calibrating signals is of good quality, no spot should depart more than one and one-half per cent. from the zero radius.

4.17 The set may be calibrated with circular sweep by proceeding as for the spiral sweep except DECRMT potentiometer should be turned clockwise until a circular sweep is obtained.

Calibration for Other Speeds

4.18 When calibrating for 75 words per minute, use a source of undistorted miscellaneous test signals (75 words per minute). Operate the SERV SPEED switch to 75. With these exceptions, proceed as outlined in Paragraphs 4.08 to 4.17.

4.19 When calibrating for 100 words per minute, use a source of undistorted miscellaneous test signals (100 words per minute). Operate the SERV SPEED switch to 100. With these exceptions, proceed as outlined in Paragraphs 4.08 to 4.17.

Measurement

4.20 After the set has been calibrated for signals of the speed and type desired, it is ready for measuring telegraph transmission and may be patched to any circuit in which measurements are desired and which is operated with the same type of signal and at the same speed for which it was calibrated.

4.21 Since the sweep circuit causes counterclockwise rotation of the electron beam, any displacement of the spots to the left of the zero axis is caused by the transition occurring late; and any displacement to the right, by the transition occurring early. In a teletypewriter circuit, signals having pure bias will have only their space-to-mark transitions displaced. When observing space-to-mark transitions only, spots occurring consistently to the left indicate spacing bias and to the right marking bias. The scale is marked to show the sign of the bias for these displacements.

4.22 When measuring miscellaneous signals in a working system, characteristic and fortuitous distortion may be present as well as bias. In this case space-to-mark and mark-to-space transitions are likely to be displaced, and hence both types of spots depart from the zero axis. The bias in this case can be estimated by observing the average departure of the space-to-mark transitions from the zero axis. Characteristic and fortuitous distortion add to the bias to produce the maximum displacement of space-to-mark transitions, or what is called the total distortion.

4.23 Total distortion is the maximum shift of any transition from the zero axis. This can be observed on a spiral trace. However, it may be more easily observed on a circular trace as adjusted per Paragraph 4.17. In this case the maximum departure of the spots either side of the zero axis is the total distortion.

4.24 An indication of the contact chatter which exists when relay K1 makes contact may be observed by pressing key C, located at the bottom of the face panel. Under this condition a spot is produced on the screen of the oscilloscope for every break regardless of the speed at which they may occur. With no relay chatter, the number of spots on the oscilloscope screen is the same when key C is operated as when key C is not operated. The increase in the number of spots when key C is operated is an indication of the amount of chatter of the armature of the receiving relay K1.

5. MAINTENANCE

General

5.01 Few repairs should be required to keep the set in good condition; in general it will not be practicable to repair much of the apparatus in the field. Care should be taken not to disturb the cable forms or damage the insulation. Should serious defects develop, it will probably be advisable to replace the defective parts with new apparatus.

5.02 It is essential that parts and contacts be clean since failure of a circuit to function properly is often traced to dirty contacts or dirty or gummy parts. It is important that the inside of the K1 relay cover should be kept clean and should not be left off the relay longer than is absolutely necessary.

5.03 If necessary to check for a reliable contact, bridge a receiver in series with an 0.1-mf capacitor across the made contact through which current is flowing. Absence of fluttering in the receiver is evidence of a reliable contact.

Operating Voltages

5.04 The satisfactory operation of the transmission measuring set depends on the proper voltages being applied to the terminals of various tubes and condensers. These voltages may be checked by observing the rectified output voltages of the power equipment.

> Caution: Dangerous voltages are employed in this equipment and precautions should be taken against accidental shock.

5.05 When the a-c power supply is 100 to 115 volts, the voltage variation switch should be thrown to 100-115V; where the a-c power supply is 100 to 125 volts, the voltage variation switch should be thrown to 110-125V.

5.06 After power has been connected for at least two minutes, measure the voltage-to-ground at the following points:

Point 1. End of resistance R38 nearest to the door.

Point 2. End of resistance R28 farthest from the door.

Point 3. End of resistance R28 nearest to the door.

• The readings should be as follows:

Point 1, -109 ± 4.5 volts d-c

Point 2, +215 ± 9 volts d-c

Point 3, +258 ± 20 volts d-c

Vacuum Tubes

5.07 Check that the proper tube, tested in accordance with instructions provided with an available tube tester, is securely in place in each tube socket.

Receiving Relay K1

5.08 The receiving relay K1 (255A or D-163119-A) of the transmission measuring set should be checked and be adjusted in the 111A2 Relay Test Panel.

Multicontact Switches

5.09 The multicontact switches which are used in the transmission measuring set are difficult to repair. They should be replaced if any contact trouble develops.

Illumination Lamps

5.10 All three lamps 11, 12, and 13 for illuminating the scale of the oscilloscope should light. Check that the operation of the rheostat SCALE LIGHT controls the amount of illumination on the scale.

6. DRAWINGS

General

6.01 Circuit and equipment drawings covering the X-75041 Transmission Measuring Set are provided with the equipment. The following drawings are listed for reference purposes, and may be ordered from the Western Electric Co.

Wiring Diagrams

BR-462185, Circuit Label.

BR-462184, Sheets 1-6, Wiring Diagrams.

Circuit Drawings

BR-403598-1, Schematic Circuit.

Equipment Drawings

X-442668, Chassis Assembly.

BR-442486, Front Panel Assembly.

BR-442488, Lower Shelf Assembly.

BR-442660, Vertical Panel Assembly.

BR-442189, Top Shelf Assembly.

BL-442493, Tube Chamber Assembly.

BR-462183, Casing Assembly.