118C3 AND 118C4 TELEGRAPH TRANSMISSION MEASURING SETS DESCRIPTION

CONTENTS PAGE

1. GENERAL

1.01 This section gives the description and the operating principles for the 118C3 and 118C4 telegraph transmission measuring sets (TMS).

1.02 This section is reissued to bring the descriptive information of the 118C3 TMS up to date and to include coverage of the 118C4 TMS. Since this reissue covers a general revision, arrows ordinarily used to indicate changes have been omitted.

1.03 The 118C3 and 118C4 sets employ the same features and basic principles of design as the 118C1 and 118C2 sets with a number of improvements, which are listed in Section 103-811-100. The 118C3 TMS and 118C4 TMS differ only in the panel arrangements of their equipment, therefore; they will be discussed generally as one set.

1.04 The set is arranged to indicate directly on meters the distortion of start-stop teletypewriter signals and may be used to indicate the distortion of telegraph reversals. One meter indicates the average bias or end distortion; another meter indicates the peak value of the total distortion, that is, the maximum effect of all types of distortion present.

1.05 The set is arranged to measure at 60-, 75-, and 100-word speeds, i.e., 45.5, 56.9, and 74.2 bauds. The set may be used at any one of these speeds by operating a key at the set, the telegraph board extension, or serviceboard position.

1.06 By the proper settings of its controls, the set may be used to measure teletypewriter signals in either the 5-unit or the 6-unit selecting codes. The 5- 6 CODE key may be provided at the extensions, if desired.

1.07 The set is arranged for use in the following types of circuits:

(a) 0.0625-ampere, 260-volt neutral.

(b) 0.020-ampere, 130-volt neutral.

(c) 0.020-ampere, 96-volt neutral.

(d) Type 1 hub (1 serviceboard).

(e) Polar circuits (0.020-ampere or 0.035-ampere).

Operation with a 2 or 9B serviceboard is with a circuit of type (a) above, working into the coupling unit associated with the serviceboard. A given set may have extensions arranged for use in circuits of type (a), (c), (d), or (e), as desired. Type (b) may be used in place of type (c) on an optional basis.

1.08 The general appearance of the modified 118C3 set is shown in Fig. 1.

1.09 The cabinet is approximately 7 feet high, 21 inches wide, and 12 inches deep. The apparatus panel and mounting plates form the front of the cabinet. When the rear door is opened, the power supply is disabled and the wiring of the set is accessible.

1.10 Extension circuits are provided to permit locating indicating meters and controls at telegraph or toll testboard positions, at serviceboards, or at line concentrating units for the convenience of the attendants. The limiting number of extensions which may be associated with one measuring set is nominally 10 or 11. As many as 15 may sometimes be used where local conditions permit. One or more extensions may be located at No. 15 telegraph testboards, in this case, arranged for 0.020-ampere, 96-volt operation only.

1.11 One form of the extension unit for use with testboards and line concentrating units is shown in Fig. 2. A patch cord connection is made between this unit and the circuit to be tested. In the case of serviceboards, the meters are located on the keyshelf, and the set is connected to test cords for measurement purposes by means of keys.

2. OPERATING PRINCIPLES

A. Simplified Description

2.01 The 118C3 measuring set measures the displacement of signal transitions from their proper positions, using as a reference the initial mark-to-space transition of the start element.

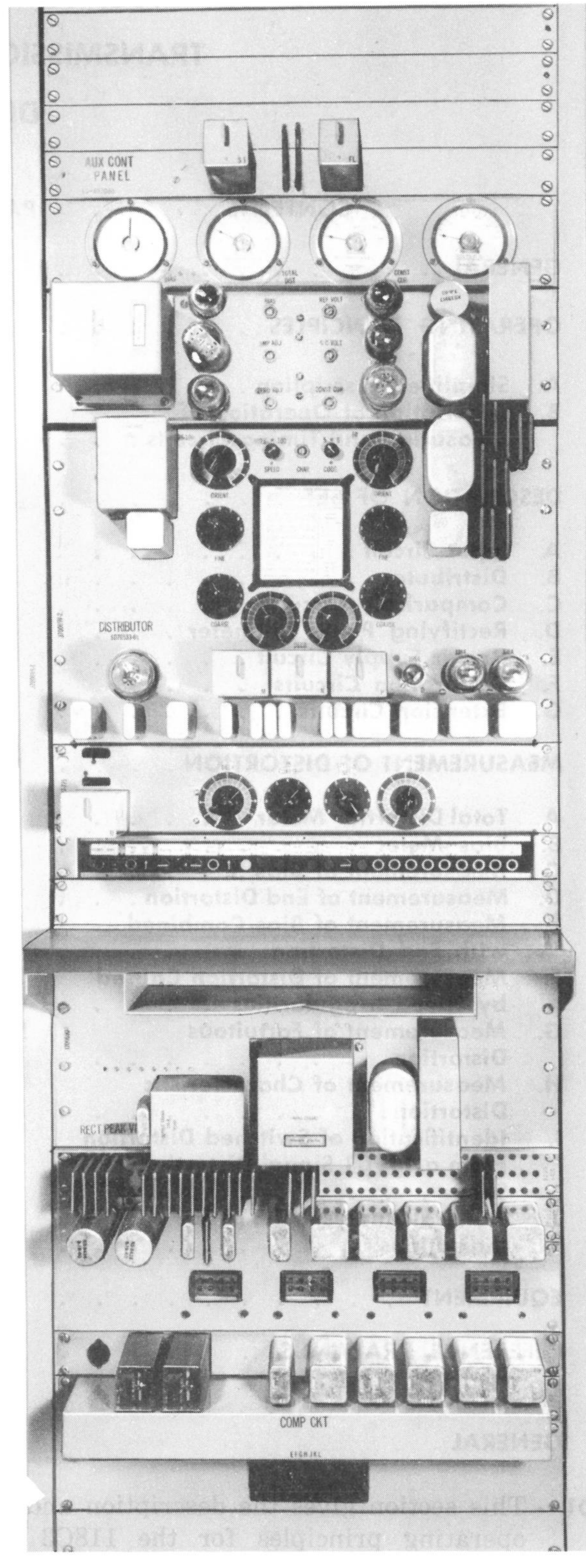


Fig. 1 — 118-Type Set — Front View

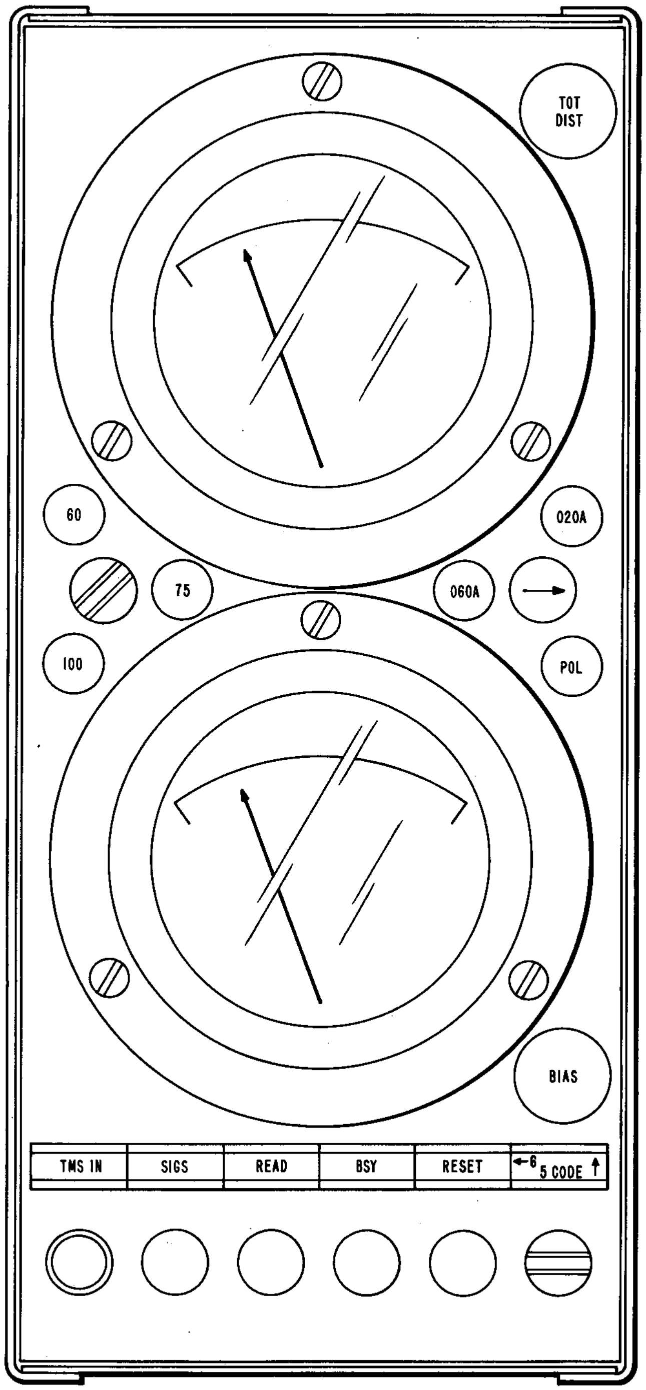


Fig. 2 — Testboard Extension — Jack and Meter Circuit

These displacements are measured as the difference between voltages on capacitors, which are charged at a constant rate during the time intervals to be measured, and a reference voltage. The charging intervals are started at the correct times with respect to the start element by means of an electronic distributor. The occurrence of transitions in the signals determines the endings of the charging intervals and the instants of comparison with the reference voltages. If the capacitor voltages and the reference voltage agree, indicating that the transitions are correctly placed and hence that there is no distortion, the meters will indicate zero distortion.

2.02 To assist in understanding the general principles of the set, a brief explanation is given, first using the simplified circuit of Fig. 3. In the upper part of this figure at 1, is shown a capacitor charging circuit associated with a receiving relay and an electronic distributor. This particular part of the circuit is arranged for the measurement of the displacement of space-to-mark transitions only. (Another part, discussed later, measures the displacement of mark-to-space transitions.) The incoming signals, for instance those comprising the teletypewriter character F shown at 2, actuate the receiving relay. During the spacing interval, capacitor G starts to charge at a constant rate from the constant current supply so that its voltage increases directly with time.

2.03 The electronic distributor contains a character timer which is started by the mark-to-space transition at the beginning of the start element and is stopped approximately six elements later (for the 5-unit selecting code) at the beginning of the stop element, as indicated at 3 in Fig. 3. During these six elements the pulse timer furnishes six capacitor discharging pulses, one at the middle of each signal element, as indicated in 4 of Fig. 3. The effect of these pulses on the circuit causes capacitor G to be discharged in the middle of each spacing signal element and its voltage to be reduced to zero. However, capacitor G immediately begins to charge again and continues charging until the next space-to-mark transition, when the receiving relay armature moves to its marking position. The voltage stored on capacitor G is then compared with the reference voltage and any difference between the two produces an indication on the meter, M. The reference voltage is so adjusted that if the space-to-mark transition occurs at the correct time, the capacitor voltage and the reference voltage are alike; and no current flows in the meter, indicating no distortion in the signal

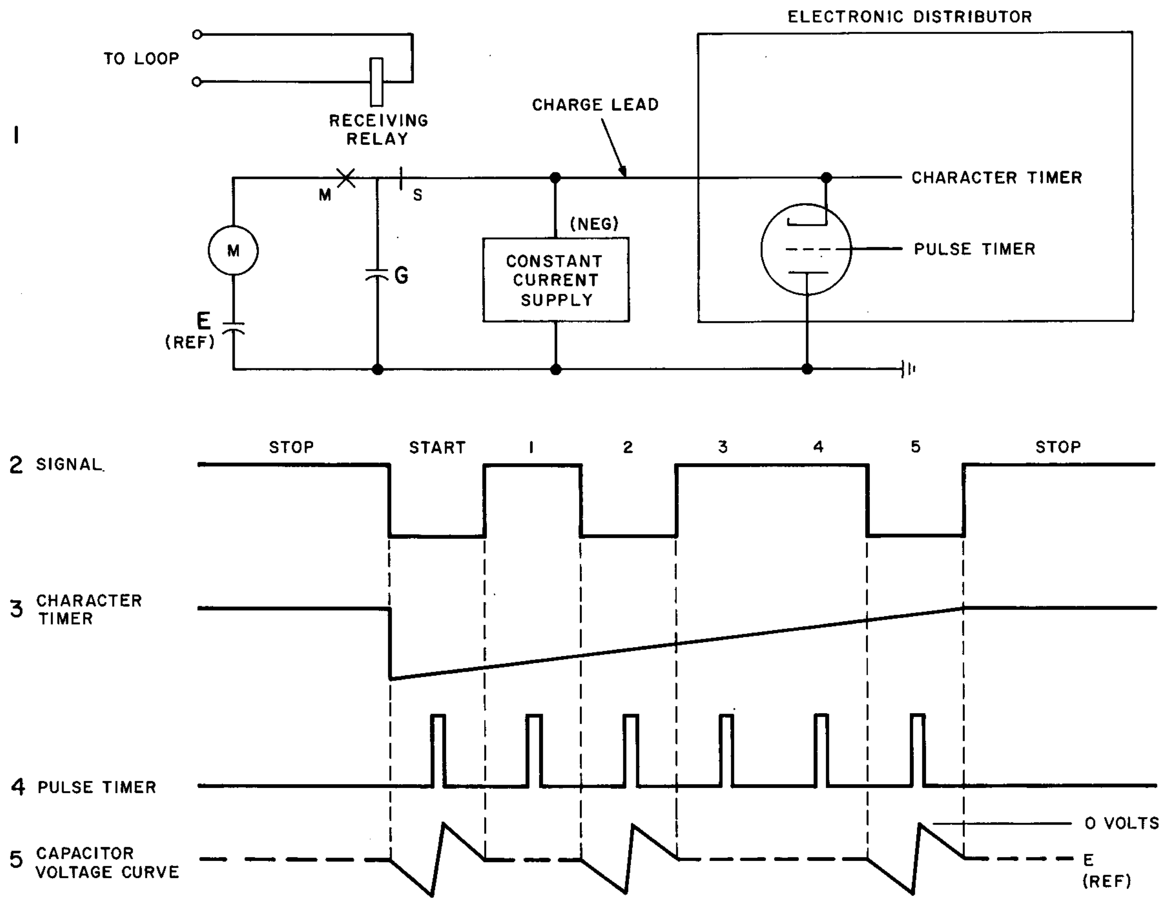


Fig. 3 — Elementary Circuit and Pulse Shapes

at that transition. If enough distortion exists in the signal to cause the transitions to occur early, the voltage built up on capacitor G will be less than the reference voltage and the meter will indicate in one direction (to the right in this case). If the transitions occur late, the voltage built up on capacitor G will be greater than the reference voltage and the meter will indicate in the other direction (to the left). Therefore, both the amount and the sign of the distortion are indicated. The capacitor voltage curve in Part 5 of Fig. 3 illustrates the action.

B. Description of Operation of Measuring and Timing Circuits

2.04 The elementary circuit of Fig. 3, discussed in the preceding paragraphs, illustrates the basic principles upon which the 118C3 set operates. The actual circuit is more complicated, because it is required to measure displacements of both space-to-mark and mark-to-space transitions. Furthermore, the various functions which were shown as performed by the receiving relay in Fig. 3 are actually performed by several relays.

2.05 Referring to Fig. 4, polar relays C and D in the measuring circuit switch the main measuring capacitors F and G from the charging to the measuring position, one being charged as the other is discharging through the meter circuit. Relays C and D follow receiving relay A, their armatures being on the marking contacts when the receiving relay armature is on marking and on spacing contacts when the receiving relay armature is on spacing.

2.06 Both relay B, which starts and stops the character timer and the pulse timer, and relay SC, which connects the constant current charging circuit to the capacitor discharger, operate to spacing when the receiving relay goes from

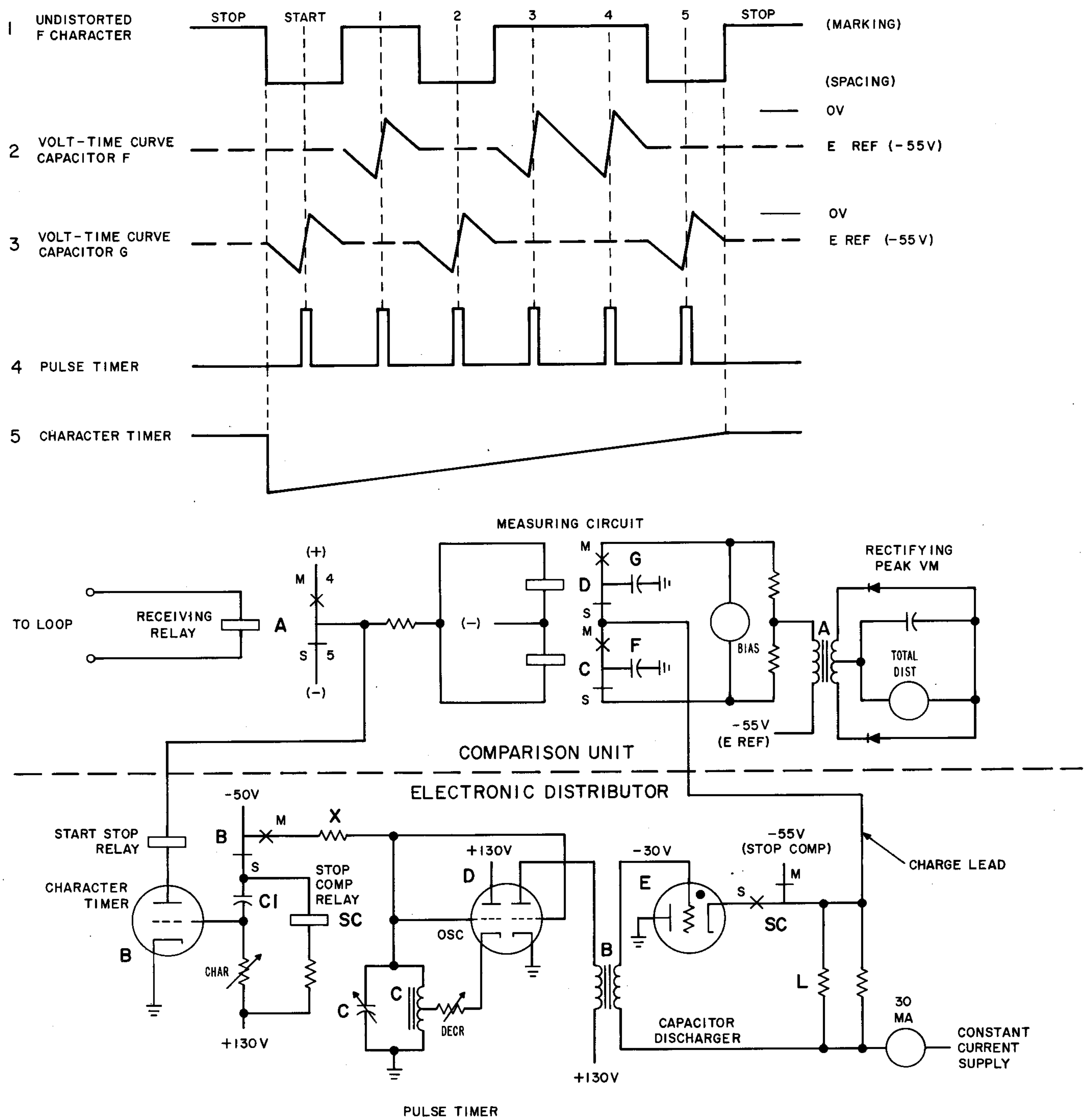


Fig. 4—Simplified Schematic Circuit and Pulse Shapes

mark-to-space on the start transition. They remain so operated until shortly after the space-to-mark transition at the beginning of the stop element.

2.07 The various waveshapes and the simplified schematic circuit of Fig. 4 are the basis for the following discussion concerning the details of operation of the charging and timing circuits. Waveshape 1 shows the undistorted teletypewriter character F; waveshape 2, the voltage on capacitor F; waveshape 3, the voltage on capacitor G; waveshape 4, the capacitor discharging pulses furnished by the pulse timer; and waveshape 5, the voltage-time relationship in the character timer.

2.08 During the stop element and whenever a steady marking condition exists, all five relays shown in Fig. 4 are operated to marking. Relay A is held on marking by the loop current from the circuit under test. It in turn holds relays C and D on marking. Relay B is held on marking by the current flowing through its winding which is dependent upon two conditions: (1) the positive voltage from relay A, and (2) the conducting condition of tube B. Relay SC is held on marking by mechanical internal bias.

(a) Relay C, on marking, connects capacitor F to the constant current charge lead. Capacitor F is limited to a charge of —55 volts at this time as explained in (d).

(b) Relay D, on marking, connects capacitor G to the measuring circuit, where it acquires a charge of —55 volts from the reference voltage.

(c) Relay B, on marking, applies —50 volts to both halves of tube D, thereby cutting off the pulse timer.

(d) Relay SC, on marking, connects the stop compensating voltage (—55 volts) to the charge lead. This limits the charge on capacitor F to —55 volts during the stop element or steady marking condition of the set.

2.09 The mark-to-space transition at the beginning of the start element causes all five relays to operate to spacing, with the following results:

(a) Relay B removes the negative grid voltage (—50 volts) from the two halves of tube D, causing the pulse timer to oscillate.

(b) Relay B also connects the —50 volts to the character timer circuit.

(c) Relay SC disconnects the charge lead from the stop compensating voltage and connects it to the capacitor discharger tube.

(d) Relay C disconnects capacitor F from the charge lead and connects it to the measuring circuit where its voltage is compared with the reference voltage.

Note: For the subsequent operations during a single character, relays C and D follow the operations (mark and space) of receiving relay A. Relays B and SC, however, remain on spacing throughout the character until the character timer times out at, or slightly after, the beginning of the stop element.

2.10 At the middle of the start element the pulse timer (waveshape 4 of Fig. 4) delivers a short positive pulse to the capacitor discharger tube E which momentarily makes tube E conducting. This momentarily grounds capacitor G and completely discharges it (voltage curve 3, Fig. 4). As soon as the discharging interval is ended, tube E again becomes nonconducting and the charging of capacitor G from the constant current source is resumed and continues until the next space-to-mark transition at the beginning of the No. 1 selecting element. At this point, relays A, C, and D operate to marking.

(a) Operation of relay D to marking connects capacitor G to the measuring circuit. The voltage of capacitor G is compared with the reference voltage. For the undistorted signal shown in Fig. 4, the voltage stored on capacitor G is equal to the reference voltage and no current flows through the BIAS and TOTAL DIST meters. If the signal were distorted, however, enough that the transition occurred earlier (advanced) or later (delayed) with respect to the proper time, the voltage acquired by capacitor G would be smaller or larger, respectively, than the reference voltage. This difference causes a flow of current through the measuring circuit as indicated by the meters. The indication on the TOTAL DIST meter is directly proportional to the magnitude of the voltage difference. The magnitude of the BIAS meter indication is determined partially by the magnitude of the voltage difference, but other factors are involved, as explained later. The sign of the BIAS meter indication is determined by the magnitude of the capacitor voltage. If the voltage on capacitor G is smaller than the reference voltage, the BIAS meter is influenced in the marking (positive) direction; and if the voltage on capacitor G is larger than the reference voltage, the BIAS meter is influenced in the spacing (negative) direction.

(b) Operation of relay C to marking connects capacitor F to the constant current supply circuit. Upon the occurrence of the second capacitor discharging pulse (waveshape 4, Fig. 4), capacitor F is completely discharged and resumes charging from the constant current supply. It continues charging until the next mark-to-space transition at the beginning of the No. 2 selecting element. At this point, relays A, C, and D operate to spacing.

(c) Operation of relay C to spacing connects capacitor F to the measuring circuit. The voltage of capacitor F is compared with the reference voltage. For the undistorted signal shown in Fig. 4, the voltage stored on capacitor F is equal to the reference voltage, and no current flows through the BIAS and TOTAL DIST meters. If the mark-to-space transitions were advanced or delayed as a result of distortion, the voltage acquired by capacitor F would be smaller or larger, respectively, than the reference voltage. This voltage difference, causes a flow of current through the measuring circuit as indicated by the meters. The meters respond as in (a), except for the sign of the BIAS meter indication with respect to voltage magnitude. If the voltage on capacitor F is smaller than the reference voltage, the BIAS meter is influenced in the spacing (negative) direction; and if the voltage on capacitor F is larger than the reference voltage, the BIAS meter is influenced in the marking (positive) direction.

2.11 From the foregoing it may be seen that space-to-mark transition displacements are measured as a result of the voltage charges on capacitor G, and mark-to-space transition displacements are measured as a result of the voltage charges on capacitor F. The action of the measuring circuit may be summarized further as follows:

(a) Delayed or advanced space-to-mark or mark-to-space transitions result in TOTAL DIST meter indications proportional to the magnitude of voltage difference between the measuring capacitor and the reference voltage.

(b) Delayed space-to-mark transitions, such as spacing bias, cause the BIAS meter to indicate in the spacing (negative) direction. Advanced space-to-mark transitions, such as marking bias, cause the BIAS meter to indicate in the marking (positive) direction.

(c) Delayed mark-to-space transitions, such as marking end distortion, cause the BIAS meter to indicate in the marking (positive) direction. Advanced mark-to-space transitions, such as spacing end distortion, cause the BIAS meter to indicate in the spacing (negative) direction.

2.12 For the subsequent transition points in Fig. 4, the space-to-mark transitions are measured as described in 2.10(a) and the mark-to-space transitions are measured as described in 2.10(c).

2.13 At the beginning of the stop element, relays A, C, and D operate to marking. Shortly thereafter tube B becomes conducting, as described later, and all five relays restore to the condition described in 2.08.

2.14 At the start of a character, relay B operates to spacing and connects —50 volts to capacitor C1, dropping the potential on C1 180 volts (from +130 volts to —50 volts). The CHAR potentiometer resistance prevents C1 from changing instantaneously. The grid of tube B becomes negative. Tube B is thereby cut off, and no current flows in its plate circuit when the armature of the receiving relay A goes to marking and applies positive voltage to this plate circuit. This condition continues for the duration of one character, holding relay B on spacing. At this time, however, capacitor C1 begins to charge through the CHAR potentiometer, and the grid of tube B becomes less negative through the time of one character. Shortly after the plate of tube B becomes positive (about half of one signal element), the grid reaches the conducting potential and plate current starts flowing. This plate current operates relay B to marking which, in turn, (1) releases the SC relay and allows it to operate to marking by self-bias, (2) stops the pulse timer, and (3) removes the negative voltage from C1. The timing and measuring circuit is thus restored to its original condition. By delaying the conducting point of tube B so that relay B operates slightly later than relay A, the oscillator (tube D) is kept running for a portion of a cycle after the beginning of a normal stop element.

3. DESCRIPTION OF SET

A. Input Circuit

3.01 The connections of the input circuit to receiving relay A for measurements in various types of circuits are shown in schematic form in Fig. 5.

3.02 Receiving relay A provides ±130 volt signals to the measuring circuit corresponding to received marking or spacing signals at the TMS IN jack. Relay A has two windings, an operating winding 3-6 and a biasing winding 2-7. The currents in these two windings determine the operational state of the relay. In the idle condition (no connections at the TMS IN jack), the 31-ma biasing current in the 2-7 winding is offset by a 62-ma marking current in the 3-6 winding developed between —24 volts and ground through contacts of unoperated relays K and N, operating relay A to marking. This marking condition will be maintained until connection to a signaling circuit is made at the TMS IN jack.

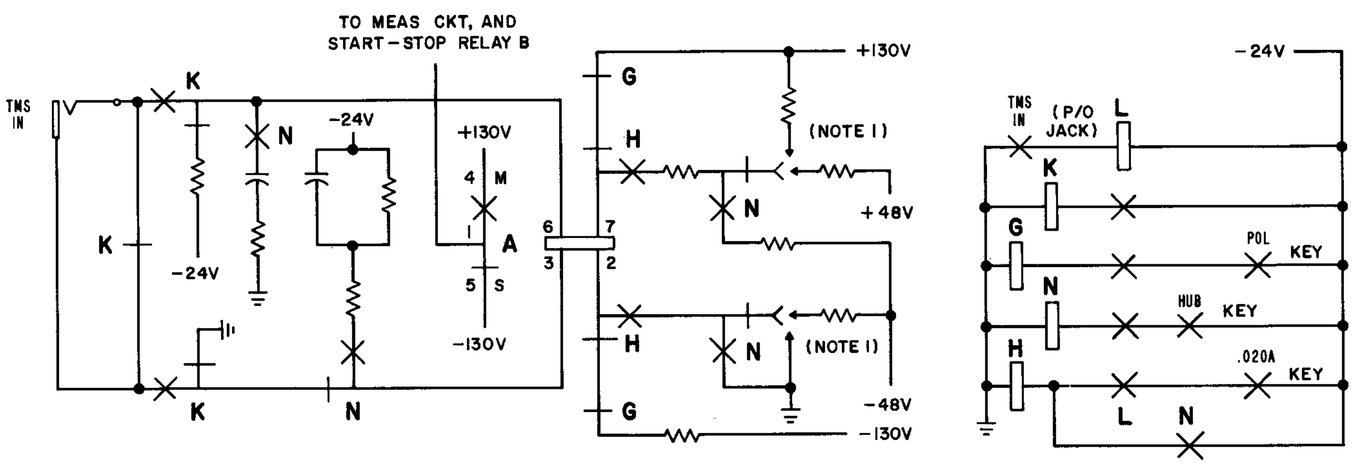
3.03 Various types of signaling circuits which have different marking and spacing signals may be connected at the TMS IN jack. These circuits are listed in Table A.

B. Distributor

3.04 The distributor circuit, shown in simplified form in Fig. 6, performs the functions of starting and stopping the character timing period and of supplying timed pulses to the measuring circuit for use as time reference points. This circuit includes a character timer, a pulse timer, and a capacitor discharger.

Character Timer

3.05 The character timer starts and stops the measuring period of the measuring circuit and controls stop-compensating relay SC. At the mark-to-space transition of the start element, relay B operates to spacing and applies a negative potential to the winding of relay SC, operating that relay to the spacing condition where it will



NOTES:

1. OPTIONAL CONNECTIONS ARE TO ±48V FOR 96V, NEUTRAL CIRCUITS; TO +130 AND GROUND FOR 130V NEUTRAL CIRCUITS.
2. CONTACTS ASSOCIATED WITH THE TMS IN JACK ARE CLOSED WHENEVER THE JACK IS PLUGGED, THEREBY CAUSING RELAYS L AND K TO OPERATE.

Fig. 5 — Input Circuit — 118C3 TMS and 118C4 TMS

TABLE A

INPUT CONNECTION	OPERATED KEYS AND RELAYS	INPUT SIGNALS	APPROXIMATE WINDING CURRENTS (MA) IN INPUT RELAY A		OPERATED CONDITION OF INPUT RELAY A
			OPERATING WINDING 3-6	BIASING WINDING 2-7	
SET IDLE	—	—	62(M)	31(S)	MARKING
.0625 AMP, 260V NEUTRAL CIRCUITS	—	MARK	62(M)	31(S)	MARKING
		SPACE	0	31(S)	SPACING
.020 AMP 96V or 130V NEUTRAL CIRCUITS	.020A, H	MARK	20(M)	10(S)	MARKING
		SPACE	0	10(S)	SPACING
POLAR CIRCUITS	POL, G	MARK	30(M)	OPEN	MARKING
		SPACE	30(S)	OPEN	SPACING
HUB (48V INVERSE NEUTRAL) CIRCUITS	HUB, N, H	MARK	0	11(M)	MARKING
		SPACE	22(S)	11(M)	SPACING

remain until relay B returns to marking. While on spacing, relay SC disconnects —55 volts from the charge lead to permit free charging of the connected capacitor F or G in the measuring circuit and also connects the charge lead directly to the cathode of tube E. During the stop element at the end of the character, relay B restores to marking, de-energizing relay SC to marking. Relay SC then reconnects —55 volts to capacitor F again limiting its charge.

3.06 The character timing may be varied by changing either the value of the capacitance (capacitor C1) or the value of the resistance (CHAR potentiometer). The set is arranged so that the character timing is made correct for different speeds by switching in the proper fixed value of capacitor C1, the timing having been initially adjusted by means of the CHAR potentiometer. To change the character timing from the 5-unit to the 6-unit code, a fixed resistance is added to the CHAR potentiometer resistance by the operation of the 5-6 CODE key. Approximate values of the CHAR potentiometer resistance when properly set are:

5-unit code	335,000 ohms
6-unit code	395,000 ohms

Pulse Timer

3.07 The pulse timer circuit in Fig. 6 contains inductor C, capacitor C, resistor DECR, and double triode D. The circuit containing the left-hand triode is arranged to oscillate during a character spacing element at twice the signal element or dot frequency (one complete cycle per signal element) by adjustment of capacitor C. The right-hand triode of tube D is a detector with a grid-cathode bias varied by the ORIENT potentiometer. By shifting the detector bias with the ORIENT potentiometer, the orientation adjustment with a start-stop distributor may be made.

Capacitor Discharger

3.08 The voltage surges from the secondary of transformer B of Fig. 6 are impressed on the capacitor discharger, which contains gas-filled tubes E and F that function to discharge the measuring capacitors. Since these surges have presumably been properly oriented with respect to the start element by the adjustment of the ORIENT potentiometer of the pulse timer, the capacitor discharging intervals are correctly placed with respect to the start element.

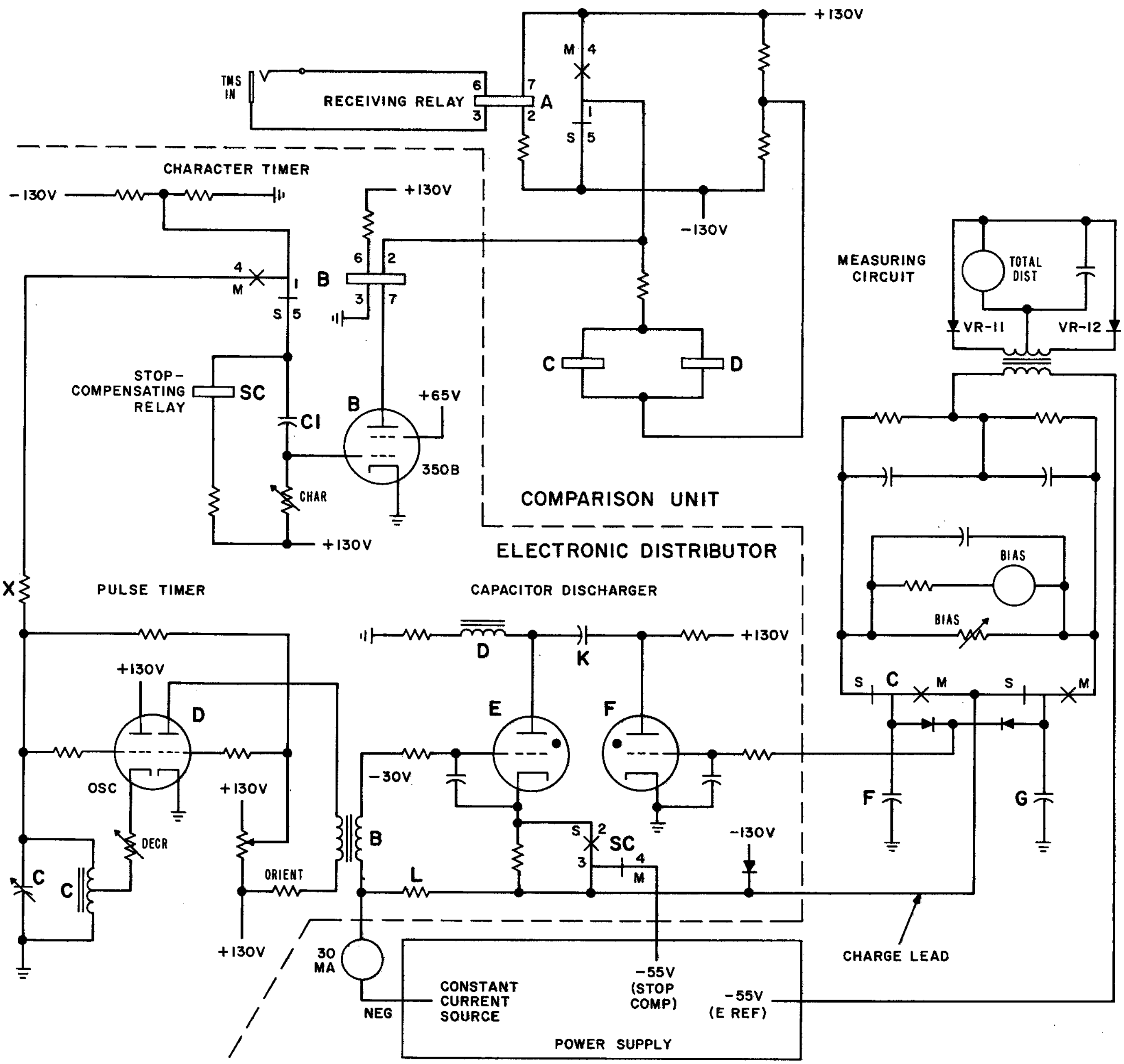


Fig. 6 — Simplified Schematic — 118C3 TMS and 118C4 TMS

C. Comparison Circuit

3.09 The comparison circuit (Fig. 6) comprises two capacitor charging circuits, one using capacitor F and relay C for measuring mark-to-space transitions and the other, using capacitor G and relay D for measuring space-to-mark transitions. The capacitors have different values for different speeds; 5.4, 4.3, and 3.2 uf for 60-, 75-, and 100-speed 5-unit code signals and 53-, 66-, and 86-speed 6-unit code signals, respectively.

3.10 These two measuring capacitors are charged alternately to a negative potential by a constant current of 30 milliamperes from the power supply. They are then, in turn, connected to opposite sides of the BIAS meter by the operation of the relays. When one capacitor is being charged, the other is connected to the measuring circuits. The circuit through the BIAS meter is completed through the rectifying peak voltmeter, containing the TOTAL DIST meter, then to the reference voltage source, and ground. The reference voltage is obtained from the power supply circuit, as described later.

3.11 If the signals are not distorted, the transitions in the signals occur when the measuring capacitors are charged to the reference voltage. There is, accordingly, no current flow at the time of comparison.

3.12 If there is distortion in the signals, the capacitor voltage will differ from the reference voltage and current will flow at the time of comparison causing an indication on the BIAS and TOTAL DIST meters.

3.13 The BIAS meter at the extensions is a zero center meter, with 70 scale divisions covering the range of ±35 per cent bias. The BIAS meter at the set is a zero center meter, with 50 scale divisions covering the range of ±25 per cent bias. The meter is shunted by the adjustable 300-ohm BIAS potentiometer, which is bridged across the two 300-ohm arms of the comparison circuit. A capacitor is also shunted across the BIAS meter to reduce the variation in the meter indication when distorted signals are received, thus improving the accuracy and ease of reading.

D. Rectifying Peak Voltmeter

3.14 The TOTAL DIST meter is designed to give an indication approximately proportional to the maximum difference in voltage between the measuring capacitors and the reference voltage at the times of transitions from mark-to-space or from space-to-mark. Current caused by the differences between capacitor and reference voltages is applied to the rectifying and peak voltmeter through the input transformer A. (Fig. 7.) The indication of the TOTAL DIST meter is substantially proportional to the input voltage and hence to distortion over the working range. The meter has 50 scale divisions, 10 to the left of zero and 40 to the right. The portion to the left is used for the initial setting of the meter needle before the power is turned on, a reading of −5 representing no current in the meter. The portion of the scale to the right of zero indicates up to 40 per cent distortion.

3.15 The ZERO ADJ potentiometer is provided for balancing the bridge during the calibration of the set. The RESET key is used to restore the meter needle to zero before making a measurement. The AMP ADJ potentiometer is used to obtain correct indication of per cent distortion on the TOTAL DIST meter.

3.16 The power supply circuit for the rectifying peak voltmeter is shown in Fig. 7. This circuit employs a 274A rectifier tube and a simple filter arrangement.

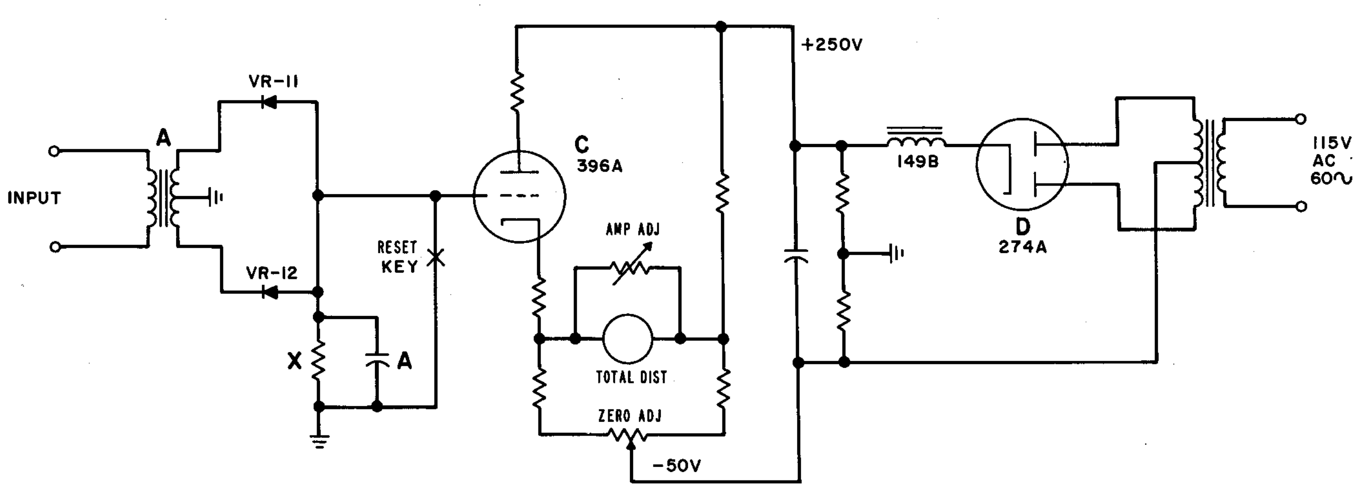


Fig. 7 — Simplified Rectifying and Peak Voltmeter Circuit

E. Power Supply Circuit

3.17 The power supply circuit (Fig. 8) provides a source of constant current for charging the measuring capacitors and sources of constant voltage for the stop-compensating and reference voltages. The total battery drains for the set are as follows:

DC Signal Battery (−24 ± 4 Volts)	DC Telegraph Battery −130 ± 5	+130 ± 5 Volts
0.6 Ampere	0.3 Ampere	0.4 Ampere

60-Cycle AC 115-Volt Supply
2.5 Amperes

3.18 The magnitude of the measuring capacitor charging current (constant current) is indicated by the CONST CUR meter which is in series in the plate circuit of tube E.

3.19 The power supply circuit is used to supply the desired constant reference voltage. To avoid overloading the rectifier, the power for the reference voltage supply is obtained from a negative 130-volt telegraph battery which is regulated by tube F so that the reference voltage varies in the same manner as the stop-compensating voltage.

3.20 The SC VOLT potentiometer is connected directly across voltage regulating tube D so as to obtain the desired constant stop-compensating voltage. This voltage is connected to measuring capacitor F in the measuring circuit during the stop element and any following steady marking condition. The stop-compensating voltage is made equal to the reference voltage by adjustment, so that the occurrence of the start transition in the signals has no effect upon the distortion indicating circuit.

F. Calibration Circuits

3.21 The procedure for calibrating the set as given in Section 103-811-503 specifies that the constant current be 30 milliamperes and that the stop-compensating and reference voltages be 55 volts each. The CONST CUR meter located at the right of the TOTAL DIST meter is permanently connected in series with the constant current supply to indicate directly the value of the current. The voltmeter located to the right

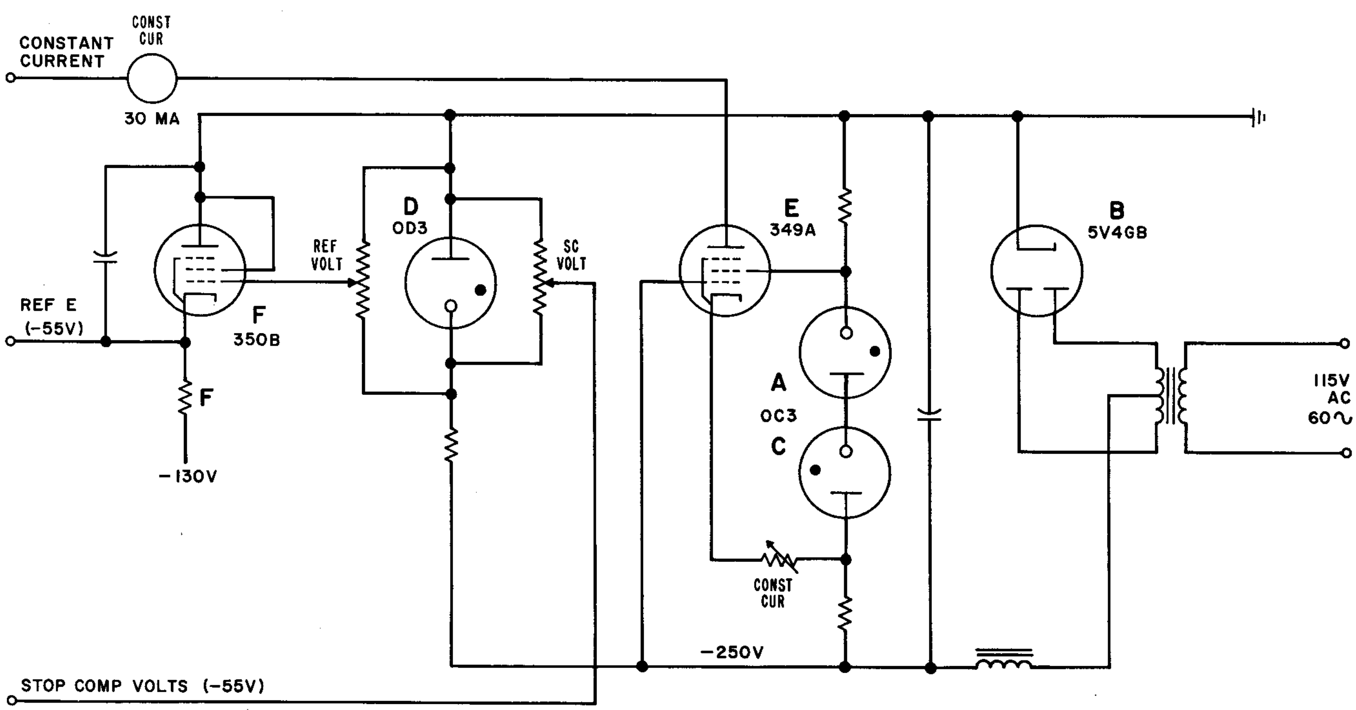


Fig. 8 — Simplified Power Supply Circuit

of the CONST CUR meter and designated SC-REF VOLTS normally indicates the stop-compensating voltage. It may be connected to read the reference voltage by depressing the REF VOLT key located in the miscellaneous jack strip.

3.22 The local check procedure also specifies that the distributor be adjusted to have the correct character timing, decrement, speed, and orientation. The character timing adjustment is required so that the oscillator will stop oscillating at the end of the character. The CHAR potentiometer (located at the distributor panel) adjusts the character timing by changing the value of resistance in series with a capacitor which is charged during the character. The adjustment is such that the character timer operates approximately six element lengths from the initial transition of the character when the 5-6 CODE key is set for 5-unit code. When this key is set for 6-unit code, sufficient resistance is added in series with the CHAR potentiometer to cause the character timer to operate approximately seven element lengths from the initial transition.

3.23 In making the decrement adjustment, the ADJ DECR key is operated and the set is operated to steady spacing by operating the SIGS key to S. This allows the pulse timer to oscillate continuously. The DECR control (located in the lower part of the distributor panel) is adjusted to make the decrement of the oscillation nearly zero, that is, to give constant amplitude. The TOTAL DIST meter circuit is used as a voltmeter to observe the voltage of the oscillator when making the decrement adjustment. Two DECR controls are provided, one for each of the two speeds at which measurements are usually made.

3.24 The frequency of oscillation is checked against test signals having the desired speed. The source of these signals will usually be a multiple sender. The ADJ SPD key (in the miscellaneous jack strip) is operated for the measurement of space-to-mark transitions using the BIAS meter, which has readings independent of both orientation setting and signal bias. The procedure is to adjust the speed of the oscillator using the COARSE and FINE dials for the speed in question (60, 75, or 100) to cause a minimum indication on the BIAS meter. Three sets of capacitors designated C are provided, one for each of the three speeds at which measurements are usually made. The capacitor C values are also correct for 53-, 66-, and 86-speed 6-unit code signals.

3.25 The distributor is oriented while receiving the test sentence by depressing the M-S ONLY key and adjusting the ORIENT potentiometer so that the BIAS meter indicates zero. Three ORIENT dials are provided, one for each speed.

3.26 The peak voltmeter may be checked for response to currents flowing in both directions through its input transformer by use of the CAL and REV CAL keys (Fig. 9). The CAL and REV CAL keys provide a means for checking varistors VR11 and VR12 for balanced characteristics. This is an important feature, because in the measuring condition of the set VR11 rectifies voltages resulting from delayed transitions and VR12 rectifies voltages resulting from advanced transitions.

3.27 The CAL key provides a means of adjusting the indications of the BIAS and TOTAL DIST meters to correspond with a known amount of distortion applied to the input of the set. By the operation of the CAL key, a fixed calibrating voltage is applied to the space-to-mark measuring capacitor G which fixes the voltages to which it is charged at a value corresponding to 15 percent distortion of 60-speed 5-unit code signals. The indications on the BIAS and TOTAL DIST meters are then adjusted to 15 per cent by the BIAS and AMP ADJ potentiometers, respectively.

3.28 In checking the set locally it is desirable to hold it in steady marking or spacing condition while performing certain operations. A key marked SIGS is provided for this purpose in the miscellaneous jack strip. This key holds the circuit on steady marking or steady spacing, as desired.

3.29 Polar signals from multiple senders may appear at the POL CAL jacks which are provided in the miscellaneous jack strip. If the set is to be used at all three speeds, 60-, 75-, and 100-speed polar signals are desirable. If polar signals are not available, open and close signals

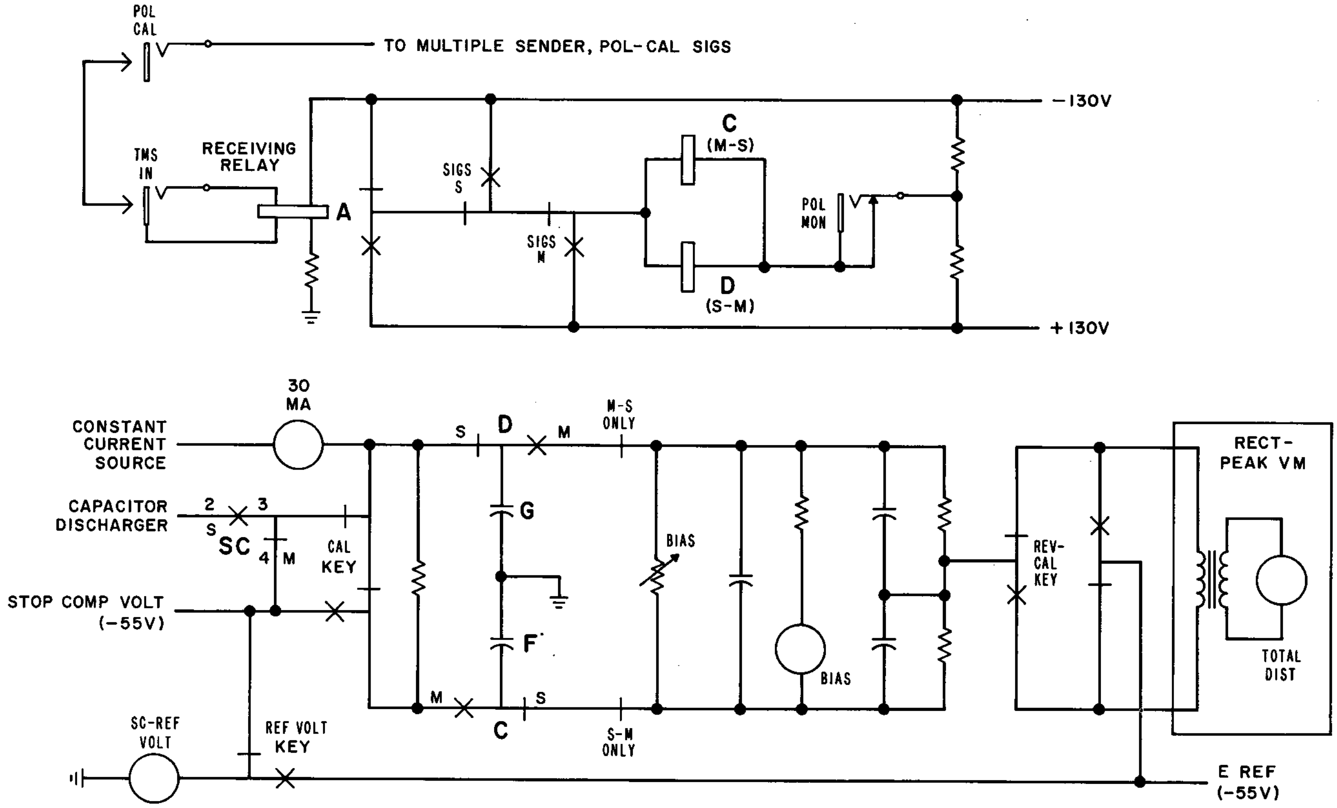


Fig. 9 — Calibration Circuits

may be used with good results, if these signals are of good quality. In this case, the local check instructions of Section 103-811-503 apply except that the POL key should not be operated and a patch from the TMS IN jack should be made to a 60-milliampere dummy (resistance) circuit and the source of signals should also be connected into that circuit.

G. Extension Circuits

3.30 At telegraph boards a TMS IN jack, a BSY lamp, a RESET key, a 60-, 75-, 100-speed changing key, and a 0.020 to 0.060 POL key are provided. Serviceboard positions are provided with similar facilities as described in the Bell System Practices on these boards. A READ key is provided as follows:

Board	READ Key
Telegraph Testboard	Optional
No. 1 Serviceboard	Not generally provided
2& 9B Serviceboards	Provided

3.31 All extension circuits are connected through a lockout circuit, so that it is impossible to cause interference between working telegraph circuits if an attempt is made to measure several circuits at the same time using one set.

3.32 When a plug is inserted in a TMS IN jack at a telegraph board extension not provided with a READ key, the BSY lamp is dark at the extension in use and lighted at all other extensions. Insertion of a plug into the TMS IN jack at an extension where the lamp is lighted permits the attendant at that position to obtain the set as soon as the user has withdrawn the plug from his TMS IN jack. In case a READ key is provided, the BSY lamp is lighted at the other positions only during the time the READ key is depressed at a given position. The user is advised by the flashing of his BSY lamp at 60 ipm that another attendant is waiting for the set. This is provided to reduce the holding time of sets.

3.33 When the CODE key of the set is turned to 6 for measuring 6-unit code signals, the set cannot be used for measuring 5-unit code signals. Accordingly, provision is made for flashing the BSY lamp at the rate of 120 ipm at the position where the set is in use to warn the attendant. The lamp also flashes at 120 ipm to warn the attendant that the speed setting of the set is not one of the two normal settings indicated at the extension.

3.34 The flashing of the BSY lamp at 60 ipm to advise the attendant that the set is desired at another position is disabled when the lamp is flashed at 120 ipm as described above.

3.35 Operating requirements for the switching relays in the set limit the resistance of the wiring to the extensions, as follows:

Relay	Lead Designation	Limiting Resistance
G	V	640 ohms
H	T	225 ohms
J	W	420 ohms
N	C	25 ohms

4. MEASUREMENT OF DISTORTION

4.01 The BIAS and TOTAL DIST meters are calibrated in their respective circuits to indicate in percent, the bias and the total distortion of a unit signal element.

A. Total Distortion Meter

4.02 The TOTAL DIST meter indicates in accordance with the voltages applied to the measuring circuit; that is, the magnitude of difference between the reference voltage and the voltage on the measuring capacitor at a transition point where comparison is made. The TOTAL DIST meter indication is substantially proportional to this voltage difference regardless of which voltage is greater or which measuring capacitor is involved. Furthermore, the relationship of this voltage difference to per cent distortion is the same at all measuring speeds and is independent of the number of transitions per second, so long as several transitions occur within a few seconds. It retains for a reasonable length of time the highest indication obtained and may be reset to zero by depressing the RESET key. Since the measuring circuit is calibrated at 60 speed only, the voltage to distortion relationship must be maintained at the higher speeds. This is accomplished by the selection of measuring capacitor values for the higher speeds which develop the proper voltages on the shorter signal elements involved. This relationship is demonstrated by comparing 15 per cent distortion (the calibrated value) at the three measuring speeds in Table B.

B. Bias Meter

4.03 The BIAS meter indicates in accordance with the average number of surges applied to the measuring circuit per second, the capacitance of the measuring capacitor, the magnitude

TABLE B

MEASURING SPEED		NORMAL SIGNAL ELEMENT LENGTH SECONDS (TN)	CONST CUR AMPS	TIME BIAS 15% (0.15 TN)	MEAS CAP. FARADS	VOLTAGE DIFFERENCE IN MEASURING CIRCUIT IT/C
5-Unit	6-Unit		I	T	C	
60	53	0.022	0.030	0.0033	$\frac{5.4}{10^6}$	18.3 ± 0.3 Volts
75	66	0.0175	0.030	0.0026	$\frac{4.32}{10^6}$	18.3 ± 0.3 Volts
100	—	0.0134	0.030	0.0020	$\frac{3.24}{10^6}$	18.3 ± 0.3 Volts

TABLE C

SPEED	AVG NO. OF S-M TRANS	OPS	FREQ OF SURGES	VOLTAGE DIFF 15% BIAS	MEAS CAP. (MF)	MAGNITUDE OF BIAS METER INDICATION
			** (F)	(E)	(C)	(CEF/80)*
60 (5-Unit)	2	6.1	12.2	18.3V	5.40	15%
53 (6-Unit)	2.25	5.3	12.0	18.3V	5.40	15%
75 (5-Unit)	2	7.6	15.3	18.3V	4.32	15%
66 (6-Unit)	2.25	6.6	15.0	18.3V	4.32	15%
100 (5-Unit)	2	10	20.0	18.3V	3.24	15%

*Correction factor of 80 derived from calibration circuit

$$\frac{5.4 \times 18.3 \times 12.2}{15} = 80.4$$

**Represents the average condition for measurement of bias.

of the voltage surges, and the direction of current flow. The set is so designed that when miscellaneous signals are transmitted at the full rate, such as the standard test sentence, the average conditions are met for the measurement of bias at all of the normal speeds. The relationship of the various components and conditions affecting the magnitude of the BIAS meter indications are demonstrated in Table C.

C. Measurement of Bias

4.04 The set is calibrated for bias because this is the most common type of distortion encountered on working circuits. When the average conditions do not prevail, the BIAS meter may not accurately indicate the bias present in the circuit. Ordinarily this characteristic of the BIAS meter is of little concern. If the measurement indicates that the total distortion is within the prescribed requirements, small erroneous BIAS meter indications may not be worthy of any special consideration. On the other hand, if the TOTAL DIST meter indicates considerably more than the BIAS meter and corrective action is indicated, special analysis procedures may prove helpful in determining the cause. Since bias affects only the space-to-mark transitions, there is no current applied to the measuring circuit from capacitor F, if bias is the only type of distortion present.

4.05 If bias is the only type of distortion present and the signals contain the average number of transitions per second, the BIAS and TOTAL DIST meters should indicate the same magnitude. BIAS meter indications are not reliable for signals sent from a keyboard because of the variation in stop time affecting the average number of transitions per second.

D. Measurement of End Distortion

4.06 End distortion is produced in predetermined amounts for performing certain tests on teletypewriter circuits and apparatus. The 118 type set, like other start-stop apparatus, is started by the first mark-to-space transition of each character. As discussed before, the starting transition is prevented from indicating distortion by charging capacitor F (the mark-to-space measuring capacitor) to the stop-compensating voltage during the stop element. The net result of this arrangement is to reduce (by one) the number of measurable mark-to-space transitions in each character. Since end distortion shifts the mark-to-space transitions only, a given amount of end distortion would cause only half the average number of surges through the measuring circuit. The result of this reduction in the frequency of surges through the measuring circuit is a BIAS meter indication of only half the actual per cent end distortion present. In other respects the BIAS meter responds to end distortion as though it were bias. It should be remembered, however, that end distortion cannot be indicated on 2-transition characters, because the only mark-to-space transition contained in such characters is the starting transition.

E. Measurement of Bias Combined with End Distortion

4.07 If bias and end distortion are both present in the received signals, the measuring circuit will receive surges from both measuring capacitors F and G. The surges from capacitor F may combine with those from capacitor G in an aiding or opposing direction. In either case the accuracy of the BIAS meter indication is altered. When such situations arise, it may be helpful to measure the two types of distortion separately. This may be done by depressing the S-M ONLY key at the set to measure bias and by depressing the M-S ONLY key at the set to measure end distortion. If the TOTAL DIST and BIAS meter indications with the S-M ONLY key depressed correspond to the indications under normal measurement, bias only is indicated. When the M-S ONLY key is depressed, the TOTAL DIST meter indicates the magnitude of the largest mark-to-space transition displacement in the characters being measured, but the BIAS meter indicates only half the average effect of mark-to-space transition displacements on average full speed signals. On 6-unit code signals the average mark-to-space transitions per character is 1.25; therefore, the BIAS meter indicates slightly more than half of the end distortion present. Ordinarily this correction factor should be of no concern.

4.08 For convenience, Table D lists the test conditions under which BIAS meter corrections should usually be applied.

F. Measurement of Distortion Caused by Speed Irregularities

4.09 If the signal source being measured is not at the correct speed, this fact can be determined in one of two ways. The simplest test is to operate the ADJ SPD key at the set and observe the BIAS meter indication. Any difference in the BIAS meter indication with respect to the indication with polar calibrating signals indicates speed irregularity in the signal source. This, of course, assumes that the 118-type set is calibrated

TABLE D

TYPE OF SIGNALS (FULL SPEED) (NOTE 1)	NUMBER OF SURGES THROUGH BIAS METER WITH RESPECT TO AVERAGE (NOTE 2)	MULTIPLY BIAS METER INDICATION BY:
(A) Reversals	Twice Average	0.5
(B) Misc Signals 5- and 6-Unit Code	Average	1.0
(C) Repeated Blank, T, O, M, V, Letters (5-Unit Code)	Half Average	2.0
(D) Repeated D, F, J, R, S, Y (5-Unit Code)	1-1/2 Average	0.66
(E) Repeated Characters Other than those in (C) and (D) (5-Unit Code)	Average	1.0

Note 1: On keyboard transmission of miscellaneous signals only, the TOTAL DIST indication is reliable. Accurate BIAS meter indications may be obtained by locking up the keyboard to transmit a repeated character, with the sending shaft running free, and applying the appropriate corrections.

Note 2: Average refers to the average number of space-to-mark transitions in the standard test sentence. This is the condition under which the BIAS meter is calibrated. Refer to Frequency of Surges column (F), in Table C.

and the polar calibrating signals are of the correct speed. When the 118-type set is used in the normal manner to measure signals from a transmitter with an incorrect speed, an ambiguous BIAS meter indication is obtained. The TOTAL DIST meter will, as in the usual case, indicate the maximum transition displacement. If the signal source is ***slow***, all transitions will be delayed with respect to the starting transition. The maximum TOTAL DIST indication will, therefore, be from space-to-mark transition displacements at the beginning of the stop element which is the sixth multiple of the speed irregularity on 5-unit code signals or the seventh multiple on 6-unit code signals. The magnitude of the speed irregularity in per cent may, therefore, be calculated by dividing the TOTAL DIST meter indication by six for 5-unit code signals or by seven for 6-unit code signals. The BIAS meter attempts to average the space-to-mark delayed transitions (sending source slow) which causes the meter to indicate in the spacing direction. At the same time the mark-to-space delayed transitions are acting in the BIAS meter circuit in the opposite direction. Because of the characteristics already explained, the mark-to-space transitions have only half the effect of the space-to-mark transitions and cancel only about half of the space-to-mark indications. The result, therefore, is a spacing bias indication representing a ***slow*** distributor. A ***fast*** transmitter distributor may be identified in the same manner except that the BIAS meter would indicate marking bias. The cancelling action may be demonstrated by depressing the S-M ONLY and M-S ONLY keys, one at a time, and measuring the effects separately. See Table E.

G. Measurement of Fortuitous Distortion

4.10 If fortuitous distortion only is present, it is reasonable to assume that on the average it will affect the mark-to-space and space-to-mark transitions equally and that the transitions will occur early as frequently as they occur late. The effect of this is to cause the currents flowing through the BIAS meter in the marking direction to be substantially equal to those flowing in the spacing direction on the average. Thus fortuitous distortion causes the BIAS meter to indicate at zero on the average. The TOTAL DIST meter, however, operates on rectified peak voltages and, therefore, indicates in the same direction regardless of the direction of the current. This meter is, therefore, responsive to the largest displacement of mark-to-space and space-to-mark transitions and, accordingly, to the maximum distortion of a unit signal element. The indicated value of an infrequently occurring large hit is about 70 per cent of the actual value of distortion, since the 0.05-microfarad capacitor in the peak voltmeter does not attain full charge on a single voltage surge.

H. Measurement of Characteristic Distortion

4.11 When characteristic distortion is present, it may produce apparent bias effects which produce indications on the BIAS meter. With miscellaneous signals, however, the effects of

TABLE E

	TOTAL DIST INDICATION		BIAS INDICATION (NOTE 1)	SIGNAL SOURCE (NOTE 2)
	5-UNIT	6-UNIT		
(1) Normal TMS Measurement	6 x % Speed Irregularity	7 x % Speed Irregularity	Marking Spacing	Fast Slow
(2) S-M Only TMS Measurement	(Same as 1)	(Same as 1)	Marking Spacing	Fast Slow
(3) M-S Only TMS Measurement	5 x % Speed Irregularity	6 x % Speed Irregularity	Marking Spacing	Slow Fast

Note 1: The magnitude of BIAS in (2) is approximately twice that in (1) and (3) for a particular irregularity. The sign in (3) is opposite to the sign in (1) and (2) for a particular irregularity.

Note 2: By reversing all BIAS meter signs the table may be used to represent speed irregularity in the 118-type set pulse timer. As an example, in (1) spacing bias may indicate the pulse timer is fast, etc.

characteristic distortion tend to average out so that the average indication of the BIAS meter will usually be near zero for moderate amounts of characteristic distortion. With large values of characteristic distortion, there might occur systematic end distortion effects which would contribute to the indication of the BIAS meter. The peak distortion effects of characteristic distortion will show on the TOTAL DIST meter.

4.12 For the measurement of characteristic distortion in connection with circuit equalization, the repeated characters, BLANK, T, O, M, V, and LTRS are sent by a distributor. When characteristic distortion is present; the apparent bias, and hence the indication on the BIAS meter; will be different for each of these characters. (Note from Table D that each BIAS meter indication should be multiplied by two.) Furthermore, it should be remembered that the 118-type set does not indicate the effects of end distortion on these 2-transition characters.

I. Identification of Switched Distortion from a 119C1 Signal Distorting Set

4.13 Special test procedures are provided in Section 103-812-102 to identify switched distortion from a 119C1 set. Since a 118-type set office not having a 119C1 set may be required to assist an adjacent 119C1 set office in making this test, the procedure is included herein for convenience.

4.14 The 119C1 set is capable of generating three types of switched distortion; namely, switched bias, switched end distortion, and switched combination bias and end distortion. The three types look so much alike when measured on a 118-type set in the normal manner that a special procedure is necessary in order to identify them. The procedure is as follows:

(a) Make a normal measurement and note the TOTAL DIST indication.

(b) Depress the S-M ONLY key at the 118-type set momentarily and note the TOTAL DIST indication.

(c) Depress the M-S ONLY key at the 118-type set momentarily and note the TOTAL DIST indication.

Analysis of Results

Switched bias: (a) = (b), and (c) = near zero.

Switched end distortion: (a) = (c), and (b) = near zero.

Switched combination distortion: (a) = (b) = (c).

J. General Analysis of 118-Type Set Indications

4.15 As indicated in the preceding paragraphs, the indication of the TOTAL DIST meter is proportional to the maximum displacement of a transition during the period of observation, whatever type of distortion may be the cause of the displacement. The maximum reduction of either orientation limit of a teletypewriter is also dependent upon this maximum displacement. Hence, the indication of the TOTAL DIST meter usually indicates the maximum reduction in teletypewriter orientation range at the end of the orientation range where the greater reduction occurs. See Table F.

4.16 It should be realized, however, that the 118C3 and 118C4 measuring sets, since they do not have a receiving magnet and are different from the teletypewriter mechanism in other respects, will not give indications which always agree with the effect on the teletypewriter. For instance, the teletypewriter may not be affected by short hits which cause set indications. Another point of difference is that the set measures displacements of the space-to-mark transition at the beginning of the first selecting element which tend to shorten the start element and displacements of the space-to-mark transition at the beginning of the stop element which tend to lengthen the No. 5 selecting element, whereas the teletypewriter is not affected by these displacements unless they are very large. Furthermore, as stated before, in the case of a comparatively large distortion which occurs infrequently, displacing a single transition but not breaking up the marks or spaces, the measuring set TOTAL DIST meter indication will be in the order of 70 per cent of the actual distortion. Except in special cases these differences are seldom important. Generally, the distortion indicated by the measuring set in a testing period of a minute or so is a good measure of the effect of the distortion in the signals on the teletypewriter.

TABLE F

CIRCUIT CONDITION	TMS INDICATION	TTY RANGE* COMPUTED FROM TMS INDICATIONS	TTY RANGE* MEASURED
Trans-Dist 3% Slow Trans-Dist 3% Fast	18S5 18M5	28 to 77 23 to 72	25 to 96 7 to 72
10% Marking Bias and 20% Spacing End Dist	20NB	30 to 70	0 to 70
20% Marking Bias and 20% Spacing End Dist	20M10	20 to 70	** -10 to 70
20% Marking End Dist 20% Spacing End Dist	20M10 20S10	20 to 70 30 to 80	30 to 90 10 to 70

*Assumes a monitoring teletypewriter in good adjustment with a local range of 10 to 90.

**Off scale.

4.17 Other situations may develop in which 118-type set meter indications are not indicative of teletypewriter orientation range reductions. Some examples are summarized in Table F.

4.18 In the process of measuring distortion on working circuits, certain conditions may arise which require some analysis. The measurements recorded in the preceding table fall into this category. In order to illustrate this point more clearly, however, three hypothetical cases are listed in Table G which produce the same 118-type set indications.

4.19 Referring to example (A) of Table G, it first appears that it would be difficult to distinguish between fortuitous and characteristic distortion; however, there are generally definite distinguishing factors present. Characteristic distortion is systematic in its effect upon the signal elements. It, therefore, will produce approximatly the same results during one moment of observation as in another. A few comparisons will generally identify it by this systematic pattern. Fortuitous distortion on the other hand, as its name implies, is nonsystematic and frequent rechecks will usually indicate considerable variations in the meter indications. Furthermore, characteristic distortion usually reduces teletypewriter upper and lower range limits unequally, while fortuitous distortion usually reduces both upper and lower range limits equally. If the two conditions cannot be distinguished from observation, a special test using repeated characters as outlined in 4.12 may be used to definitely classify the type of distortion present. In making this special test if the circuit contains characteristic distortion, it will change the sign of the long marking elements with respect to the long spacing elements. If the distortion is fortuitous, it will have no systematic effect upon the signs of the repeated characters. Examples (B) and (C) demonstrate the cancelling effect of transition displacements driving the BIAS meter in opposing directions. In such situations it is usually advisable to clear up one of the irregularities and make a new measurement. In the case of example (B) the ratio of the TOTAL DIST indication to the BIAS indication is not correct for end distortion and, therefore, suggests speed irregularity. The speed irregularity could also be identified by operating the ADJ SPD key on the 118-type set and observing the BIAS meter indication, as explained earlier. A BIAS meter indication of more than about 2 per cent in this case would suggest speed irregularity. In example (C) the ADJ SPD test would indicate immediately that the cause was not speed irregularity.

5. EQUIPMENT

5.01 The arrangement of the equipment for the 118C3 and 118C4 sets are shown in Fig. 1. All of the equipment which must be adjusted by

TABLE G

CIRCUIT CONDITION (ASSUMED)	NORMAL TMS INDICATION	M-S ONLY TMS INDICATION	S-M ONLY TMS INDICATION	TTY* RANGE
(A) 18% Fortuitous Distortion	18NB	18NB	18NB	28 to 72
(B) Trans-Dist 3% Slow and 5% Marking Bias	18NB	15M5	18S5	25 to 91
(C) 18% Marking End Dist and 9% Spacing Bias	18NB	18M9	9S9	28 to 123**

*Assumes a monitoring teletypewriter in good adjustment with a local range of 10 to 90.

**Off scale.

the attendant is located above the keyshelf. A sketch showing the designations of the jack strip for a typical set is shown in Fig. 10.

5.02 The set power supply panel is located above the distributor, and it has six controls, the ZERO ADJ and AMP ADJ controls in addition to the CONST CUR, REF VOLT, SC VOLT, and BIAS potentiometers. These are all provided with screwdriver adjustments.

5.03 The meter panel is located immediately above the power supply panel. This panel contains the four meters required with the set, namely, the BIAS, TOTAL DIST, CONST CUR, and SC-REF VOLT meters reading from left to right on the panel.

5.04 Immediately above the keyshelf is a jack strip containing 26 jack, key, and lamp spaces. The first jack, at left, is marked RCRD and is used for connection to a recording meter. The next sixteen spaces mount keys, jacks, and a lamp required in the operation of the set. Next, three jacks are provided for supplying the polar calibrating signals for 60, 75, and 100 speeds. Six jacks are also provided for use with miscellaneous trunks.

5.05 The panel immediately below the keyshelf contains the rectifying peak voltmeter circuit. Below that are the relays and other equipment which are associated with the comparison unit. The power switch which controls both the ac commercial power supply and the telegraph battery power is located immediately below the comparison unit at the bottom of the rack.

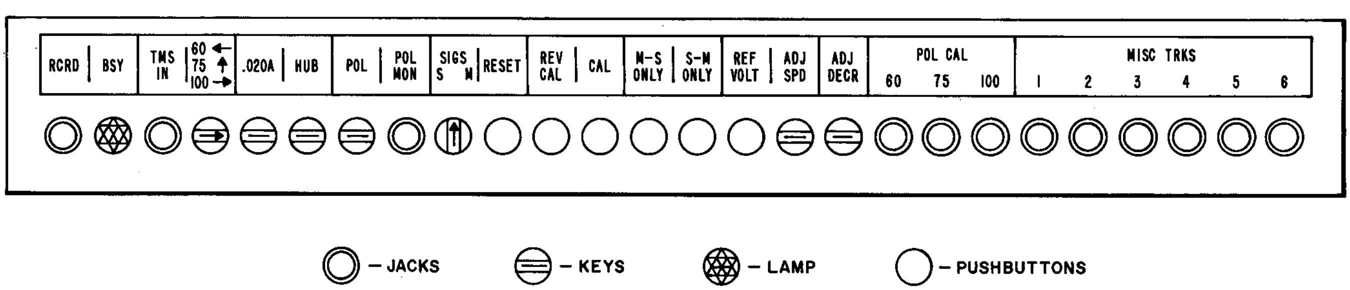


Fig. 10—Jack Strip Designations

6. REFERENCE DRAWINGS

6.01 *Circuits*

118C3 Telegraph Transmission Measuring Set	SD-70533-01
118C3 Extension Circuit	SD-70364-01

6.02 *Equipment Drawings*

Extension Circuit Jack and Meter Box	ED-70964-01
Rectifying Peak Voltmeter Panel	ED-71055-01
Power Supply Panel	ED-71056-01
Comparison and Extension Circuit Equipment	ED-71057-01
Distributor Panel	ED-71058-01
Bay Equipment	ED-71059-01