2400- OR 2600-CYCLE SINGLE FREQUENCY SIGNALING CIRCUITS
ANALYSIS AND CLEARANCE OF TROUBLE

1. GENERAL

1.01 This section describes methods and procedures to be followed in the analysis and clearance of typical troubles which may be encountered in 2400- or 2600-cycle single frequency signaling circuits.

1.02 This section is reissued to add tests for the new band pass network for 2-wire lines (SD-56292-01, Fig. 8). Notes informing of the "Mfr. Disc." of "T" and "P" options and new varistor ohmmeter readings for "N" option are also included.

1.03 These trouble indications will generally be obtained from trouble reports resulting from inability to meet the test and adjustment requirements described in Section 179-312-501 covering out-of-service tests of the single frequency signaling circuits. The suggested procedures for location of the troubles are classified in the same order as the requirements listed in Section 179-312-501, with the same headings as follows:

A. Pulsing of Transmitter M Relay

B. Release of Transmitter CO Relay

C. Transmitted Tone Level

D. Cutoff Current of Receiver R Relay

E. Gain of Receiver Voice Amplifier and Insertion of Band Elimination Filter

F. Sensitivity of Receiver Signaling Amplifier

G. Operation of Receiver R Relay

H. Receiver Regulation

I. Receiver Guard Action and Permanent Signal and 2-wire Controls

J. Final Adjustment of Receiver Sensitivity

In the above trouble-locating procedures, the same switch and attenuator settings on the signaling testing circuit SD-56335-01, called for in the corresponding tests of Section 179-312-501, will be used unless otherwise specified. The following headings give a method for testing the networks used for 2-wire lines and the procedure for investigating possibly defective varistors: ←

K. Networks for 2-wire Lines ←
(SD-56292-01, Fig. 3 and 8) ←

L. Varistor Data

1.04 Reference to the simplified schematic attached to CD-56292-01 will, in general, be helpful in applying the procedures of this section.

1.05 Care should be used to prevent the flow of excessive direct current through the coils of this circuit to prevent core magnetization. Excessive current or direct application of the heat of a soldering iron may damage the varistors.

1.06 Whenever the analysis of the trouble leads to a change of V2 or V3 electron tubes, Tests D through J of Section 179-312-501 shall be repeated.

1.07 The transmission measuring set is referred to in this section as TMS.

2. APPARATUS

2.01 In addition to the apparatus specified in Section 179-312-501, the apparatus listed below may be required.

2.02 Electron tube test set, KS-15559, L1 or KS-15560.

2.03 Volt-ohmmeter, M9B or KS-14510.

2.04 Cathode ray oscilloscope, Dumont 208B, or equivalent.

2.05 A 35-type test set.

2.06 Varistor test set, KS-12054.

3. TROUBLE CONDITIONS

A. Pulsing of Transmitter M Relay

3.01 When the M relay cannot be adjusted by means of the M potentiometer to meet the requirements of Test A of Section 179-312-501, it is probably due to one of the following reasons.

(a) If the M relay is pulsing but the HL and CO relays are not steadily operated, trouble in the HL or CO relay circuits then should be investigated by proceeding directly to Tests B and C of Section 179-312-501 after setting the M potentiometer at approximately midposition.

(b) If the M relay is not pulsing, this condition may be due to:

(1) An open M lead or a trouble ground on the M lead (M relay released).

(2) A trouble battery on the M lead (M relay operated).

(3) A defective M potentiometer.

(4) A faulty adjustment of the M relay.

(c) If the M relay is pulsing and the HL and CO relays are steadily operated, this condition may be due to:

(1) Dirt on either pair of tone contacts on the M relay or an open in the contact wiring. (Meter reads 0 per cent break in this case.)

(2) Dirt on either pair of tone contacts on the HL relay.

(3) A defective M potentiometer.

(4) A faulty adjustment of the M relay.

3.02 If necessary, readjust the M relay to meet its mechanical and electrical requirements. (See Section 040-520-701.)

3.03 If there is still difficulty, check that battery or ground are suitably applied to the M lead by the signaling testing circuit.

B. Release of Transmitter CO Relay

3.04 When the strapping of the R6 and R7 resistors will not bring the release time of the CO relay within the requirements of Test B of Section 179-312-501, it is probably due to:

(a) Incorrect strapping.

(b) An open in the relay shunting path or associated circuits. (The no-reading requirement is not met.)

(c) A short or trouble ground in the relay shunting path or associated circuits. (The steady reading is not met.)

(d) A faulty adjustment of the CO relay.

Note: After clearing trouble, repeat Test A of Section 179-312-501.

3.05 If necessary, readjust the CO relay to meet its mechanical and electrical requirements. (See Section 040-522-701.)

3.06 If there is still difficulty, check the signaling testing circuit for the presence of tone supply and for opens.

C. Transmitted Tone Level

3.07 Inability to meet the final reading signaling tone level requirement in Test C of Section 179-312-501 is probably due to one of the following reasons.

(a) If the TMS reads higher power than required, this condition may be due to:

(1) The HL relay holding up because of a trouble ground in the operate or hold paths.

(2) A short circuit around either the R4 or R5 resistor.

(b) If the TMS reads lower power than required, this condition may be due to:

(1) A defective R4 or R5 resistor.

(2) An open in the tone path in the transmitter.

3.08 If there is still difficulty, check the signaling testing circuit for proper level of tone supply and for opens.

3.09 Inability to meet the peak-reading signaling tone level requirement is probably due to:

(a) Use of a measuring set not having the same dynamic characteristics as the No. 13A TMS.

(b) An open in the short-circuiting paths around the R4 or R5 resistor.

(c) The HL relay not operating because of an open in the operating path.

(d) A faulty adjustment of the HL relay.

Note: After clearing trouble, repeat Test A of Section 179-312-501.

3.10 If necessary, readjust the HL relay to meet its mechanical and electrical requirements. (See Section 040-522-701.)

3.11 If there is still difficulty, check the signaling testing circuit for proper level of tone supply and for opens.

3.12 Inability to obtain a reading of lower power than —45 dbm in the SIG OFF requirement is probably due to:

(a) Failure of the M relay to operate.

(b) A short circuit around either pair of tone contacts on the M relay.

Note: After clearing trouble, repeat Test A of Section 179-312-501.

3.13 If the M relay fails to operate, check the signaling testing circuit for an open M lead.

D. Cutoff Current of Receiver R Relay

3.14 If the current measured in Test D of Section 179-312-501 is above 0.25 ma, this is probably due to:

(a) A faulty V3.2 electron tube.

(b) A trouble located in the combined tube biasing and filament circuit. This may be localized by means of point-to-point voltage measurements in accordance with Table A, using the M9B or the KS-14510 volt-ohmmeter with the KEYERS switch in position 5 SIG OFF. Failure to obtain approximately the typical voltages given in the table may result from the filaments of one or more of the tubes being either open or short-circuited or from the existence of a trouble ground or open in the biasing or filament paths.

E. Gain of Receiver Voice Amplifier and Insertion of Band Elimination Filter

3.15 Inability to adjust the gain of the V3 amplifier in the signaling testing circuit to the required value for Test E of Section 179-312-501 is probably due to a faulty electron tube in the V3 test amplifier.

TABLE A — TYPICAL DC VOLTMETER READINGS WITH NO TONE INPUT

VOLTMETER CONNECTIONS		SCALE SETTING		READING
—V to	+V to	M9B METER	KS-14510 METER	IN VOLTS
3(V1)	Grd	30V-DC	60V-DC	20 ±1.5
5(V2)	Grd	30V-DC	60V-DC	20 ±1.5
9(V3)	Grd	150V-DC	60V-DC	40 ±2
8(V2)	Grd	150V-DC	60V-DC	34 ±2
2(V3)	Grd	150V-DC	60V-DC	34 ±2
Grd	4(V2)	150V-DC	300V-DC	80 ±10
Grd	6(V2)	150V-DC	300V-DC	130 ±5
Grd	4(V3)	150V-DC	300V-DC	130 ±5
Grd	5(V1)	150V-DC	300V-DC	120 ±5

3.16 Inability to meet the receiver voice amplifier gain requirement in Test E by adjustment of the TL potentiometer is probably due to:

(a) A faulty V1 electron tube.

(b) Incorrect filament, plate, or cathode dc voltages. Check by means of the procedure given previously in 3.14(b).

(c) A defective TL potentiometer.

(d) An open in the input circuit wiring or T1 transformer.

(e) The introduction of one or two sections of the N1 network into the input circuit. Verify that the RF relay is released and the M relay is operated, and then check that terminals 10 and 9 of the N1 network are short-circuited and that the path between terminals 9 and 11 is open.

3.17 Inability to extinguish the F lamp of the testing circuit by turning the SS potentiometer clockwise is probably due to:

(a) A trouble short on the A lead on SD-56292-01, if the TMS reads lower power than —29 dbm.

(b) The RF relay not being operated, if the TMS reads higher power than —29 dbm. In this case, check that the proper frequency is being used and then check the V2.1, V2.2, and V3.2 electron tubes.

3.18 If the tubes meet their requirements and the R relay also is not operated, proceed directly to Test F of Section 179-312-501. If the maximum sensitivity requirement of this test cannot be met, follow procedure F of this section.

3.19 If the tubes meet their requirements and the R relay is operated, readjust the RF relay to meet its mechanical and electrical requirements. (See Section 040-518-701.)

3.20 If there is still difficulty, check the continuity of the grid and plate circuits of the dc amplifier section of the V2.1 stage.

3.21 Inability to obtain a reading of lower power than —29 dbm, with the F lamp extinguished, is probably due to a direct short across terminals 9 and 10 of the N1 network or no direct current path existing between terminals 11 and 9 of the N1 network.

3.22 If the requirement just falls short of being met, proceed to check the next requirement by turning the SS potentiometer fully counterclockwise and setting the RECEIVER switch to position 3 M RLS.

3.23 If a reading of lower power than —29 dbm is then obtained, the failure to meet the first requirement is due to harmonics generated in the V2.2 stage that are present in the input to the receiver voice amplifier. This indicates trouble in the signal amplifier V2.2 stage which can be localized by the following actions.

(a) Check that the wires connecting terminal 4(V2) to 2(T3), terminal 2(V2) to (C5), and (T1) to terminal 18 on apparatus assembly are run in the paths specified on drawing T-56292-30 or T-56292-33.

(b) Follow the testing procedure given under procedure F of this section.

3.24 Inability to obtain a reading of lower power than —29 dbm with the RECEIVER switch on 3 M RLS and the SS potentiometer turned fully counterclockwise is probably due to:

(a) The M relay not being released, owing to the presence of trouble battery on the M lead.

(b) The M relay is released, but owing to incorrect wiring, there is a direct short across terminal 9 and 10 of the N1 network or no direct current path exists between terminals 11 and 9 of the network.

3.25 If neither the first requirement as stated in 3.21 nor the second requirement as stated in 3.24 can be met after checking wiring continuity as suggested, then the N1 network may be defective.

F. Sensitivity of Receiver Signaling Amplifier

3.26 Inability to obtain a reading of at least 8.5 ma in Test F of Section 179-312-501 is probably due to:

(a) Faulty V2.2 or V3.2 electron tubes.

Note: It is essential that both the V2.2 and V3.2 electron tubes be checked in this case, for although replacing either one might permit the requirement to be barely met, the one new tube might (due to extremely high cathode activity) temporarily hide the fact that the other remaining tube is extremely weak and will fail in a short period.

(b) Trouble ground or open circuit in the operating path of the R relay.

(c) Failure of the electronic portion of the receiver to produce sufficient current.

3.27 If the V2.2 and V3.2 tubes meet their requirements and the wiring of the R relay operate path seems to be clear of trouble grounds, the trouble is probably due to defective components or opens in the receiver signaling or dc amplifier. Localize the trouble by means of point-to-point voltmeter measurements, as follows.

3.28 First check filament, plate, and cathode dc voltages in accordance with the procedure of 3.14(b).

3.29 If the typical voltages of Table A are approximately obtained, proceed to make point-to-point voltage measurements, with the KEYERS switch of the signaling testing circuit set to 6 SIG ON and the RECEIVER switch to 3 M RLS, in accordance with Tables 1B, 2B, and 3B which give typical receiver ac and dc voltage measurements with a signal tone input to the receiver. Although limits are given, any slight deviation from those stated will not necessarily be indicative of complete component failure, but large deviations will serve to aid in localizing any trouble encountered. Three levels of applied signal tone are used. The low level

TABLE B

TABLE 1B — TYPICAL AC VOLTMETER READINGS WITH SIGNAL INPUT

	VOLTMETER CONNECTIONS		SCALE SETTING		READING IN VOLTS					
					G RELEASED			G OPERATED		
	−V to	+V to	M9B METER	METER KS-14510	LOW LEVEL	MIN HIGH LEVEL	MAX HIGH LEVEL	LOW LEVEL	MIN HIGH LEVEL	MAX HIGH LEVEL
(1)	TP6	TP5	3V-AC	3V-AC	—	—	1 ±0.3	—	—	1 ±0.3
(2)	1(SS)+	2(SS)	3V-AC	3V-AC	—	—	0.5±0.2	—	—	0.5±0.2
(3)	1(T3)	2(T3)	30V-AC	60V-AC	5.5±2	11±3	16 ±3	6.5±2	12 ±3	17 ±3
(4)	4(N1)	1(N1)	30V-AC	60V-AC	5.5±2	10±2	12 ±3	5 ±2	8 ±2	11 ±2
(5)	8*	1*	30V-AC	60V-AC	5.5±2	10±2	12 ±3	5 ±2	8 ±2	10 ±2
(6)	7(V3)	8*	3V-AC	3V-AC	0	0	0	0.2±0.1	0.6±0.2	0.9±0.3

TABLE 2B — TYPICAL DC VOLTMETER READING WITH SIGNAL INPUT FOR M9B VOLT-OHMMETER

	VOLTMETER CONNECTIONS			READING IN VOLTS					
				G RELEASED			G OPERATED		
	−V TO	+V TO	SCALE SETTING	LOW LEVEL	MIN HIGH LEVEL	MAX HIGH LEVEL	LOW LEVEL	MIN HIGH LEVEL	MAX HIGH LEVEL
(7)	8*	3*	30V-DC	5 ±2	9.5 ±2	12 ±2	5.5 ±2	9.5 ±2	11.5 ±3
(8)	8*	9*	3V-DC	0.2 ±0.2	0.2 ±0.2	0.2 ±0.2	0.25±0.2	0.4 ±0.3	0.8 ±0.4
(9)	9*+	3(OT)	3V-DC	0.03±00.2	0.05±0.02	0.06±0.02	0.03±0.02	0.06±0.02	0.07±0.02

TABLE 3B — TYPICAL DC VOLTMETER READING WITH SIGNAL INPUT FOR KS-14510 VOLT-OHMMETER

	VOLTMETER CONNECTIONS			READING IN VOLTS					
				G RELEASED			G OPERATED		
	−V TO	+V TO	SCALE SETTING	LOW LEVEL	MIN HIGH LEVEL	MAX HIGH LEVEL	LOW LEVEL	MIN HIGH LEVEL	MAX HIGH LEVEL
(7)	8*	3*	60V-DC	5.5 ±2	11 ±3	14 ±3	6 ±2	11 ±3	13 ±3
(8)	8*	9*	3V-DC	0.35±0.3	0.5 ±0.3	0.6±0.3	0.45±0.3	1 ±0.3	2 ±0.3
(9)	9*+	3(OT)	3V-DC	0.3 ±0.2	0.55±0.2	0.7±0.2	0.35±0.2	0.6±0.2	0.7±0.2

Note: The voltages given in the above tables are, in general, different from the normal operating voltages, such as could be measured with a high-impedance vacuum tube voltmeter.

*Numbered terminal on apparatus assembly.

+Block R and RF relays operated, connecting voltmeter.

signal is −25 dbm (attenuator setting 35 db). The minimum high level signal is −16 dbm (attenuator setting 26 db) and the maximum high level signal is −4 dbm (attenuator setting 14 db). Block the G relay either operated or released, as called for in Table 1B, 2B, or 3B.

3.30 If the voltage measurements do not approximate the typical readings given in Table 1B, 2B, or 3B, the following suggestions may help in localizing the trouble.

MEASUREMENT OUTSIDE OF LIMITS	SUGGESTED ACTION TO BE TAKEN
1	Check for tone circuit continuity through signaling testing circuit and through the jack and connector junction.
2	Check for continuity through T1 transformer and SS potentiometer.
3	Attempt to bring within limits given in the table by means of adjusting SS potentiometer. If this is impossible, check V2.2 tube. If tube meets requirements, check continuity in V2.2 signal amplifier stage.
4	Check T3 transformer or N1 network and C6 condenser for continuity.
5	Check signal section of N1 network for circuit continuity.
6	Check guard section of N1 network for continuity. If unable to uncover trouble by inspection, follow the procedure given in 3.56.
7	Check circuit connections to VR1 and VR2 varistors for opens. If correct, check VR1 and VR2 varistors.
8	Check for faulty V3.1 electron tube. If V3.1 electron tube meets requirements, follow the procedure in 3.56.
9	Check continuity in OT potentiometer circuit.

3.31 If all voltage measurements are typical but there is still no plate current in the V3.2 tube plate circuit, check continuity of the V3.2 DC amplifier grid circuit.

3.32 Inability to adjust the SS potentiometer to obtain a reading of 5.5 ma in Test F of Section 179-312-501 is probably due to the same causes as covered in 3.27, which can be localized by following the procedure given above in 3.28 through 3.31.

G. Operation of Receiver R Relay

3.33 Inability to obtain any kick of the PERCENT BREAK meter pointer in Test G of Section 179-312-501, despite adjustment of the OT potentiometer, is probably due to one of the following causes.

(a) If the meter reads 100 per cent break on the red scale, there is an open in the E lead or dirt on the 1-2T contact of the R relay.

(b) If the meter reads 0 per cent break on the red scale, this may be due to:

(1) A trouble ground on the E lead.

(2) A defective OT potentiometer or open circuit in associated components.

(3) Excessive guard voltage which prevents the R relay from operating on short pulses. This can be checked according to the procedure given in 3.55 through 3.57.

(4) Failure of the R relay to operate because of faulty adjustments.

3.34 If necessary, readjust the R relay to meet its mechanical and electrical requirements. (See Section 040-518-701.)

3.35 If the meter pointer kicks for the 34 per cent break condition or does not kick steadily for the 36 per cent break, despite adjustment of the OT potentiometer, this is probably due to:

(a) A VR3 varistor having an extremely low reverse impedance.

(b) The RT potentiometer turned too far clockwise.

(c) A trouble in the ac or dc guard portion of the receiver, which may be localized by means of the procedure indicated in 3.55 through 3.57.

(d) A faulty OT potentiometer.

(e) An open C12 capacitor.

(f) Failure of the R relay to operate properly because of faulty adjustment.

3.36 If necessary, readjust the R relay to meet its mechanical and electrical requirements. (See Section 040-518-701.)

3.37 Inability to adjust the RT potentiometer to meet the 51 per cent break output requirement of Test G of Section 179-312-501 is probably due to:

(a) "T" option which is "Mfr. Disc." Provide "S" option.

(b) Faulty V2.1 or V3.2 electron tubes.

Note: It is essential that both the V2.1 and V3.2 electron tubes be checked in this case, for although replacing either one might permit the requirement to be barely met, the one new tube might (due to extremely high cathode activity) temporarily hide the fact that the other remaining tube is extremely weak and will fail in a short period. A means of checking the V2.1 electron tube in the circuit is given in 3.38.

(c) A faulty RT potentiometer.

(d) An open in the coupling path between the grid of the V3.2 electron tube and the plate of the V2.1 electron tube which can be readily checked by observing with the oscilloscope (see 3.41) the voltage appearing on the plate of tube V3.2 (see 3.49). In this case, the pattern observed will be similar to Fig. 8A instead of the normal Fig. 8.

(e) A trouble in the ac or dc guard portion of the receiver which may be localized by means of the procedure given in 3.55 through 3.57 and by means of oscilloscope observations (3.41 through 3.51).

(f) A faulty VR3 varistor.

(g) A faulty adjustment of the R or RF relays.

3.38 To check the V2.1 electron tube for maximum plate current in the circuit, set the KEYERS switch to 6 SIG ON and the RECEIVER switch to 3 M RLS. With the attenuator set to 35 db, turn the SS potentiometer fully clockwise. Then connect either an M9B (150-volt scale) or KS-14510 (60-volt scale) volt-ohmmeter with its −V terminal to 7T of the RF relay and its +V terminal to 5B of the RF relay. If the voltmeter reads less than 35 volts, check the V2.1 in the electron tube test set.

Note: Following this check, readjust the SS potentiometer per Test F of Section 179-312-501.

3.39 If necessary, readjust the R and RF relays to meet their mechanical and electrical requirements. (See Section 040-518-701.)

3.40 The reason for inability to meet the maximum 70 per cent break output requirement of Test G of Section 179-312-501 can best be determined by comparing the patterns obtained on a cathode ray oscilloscope with some typical patterns, following the procedure in 3.41. However, the inability to meet the maximum 70 per cent break output is probably due to:

(a) An open circuit in the clamping path between the grid of the V3.2 electron tube and the −40-volt grid bias (cathode of the V3.1 electron tube), which can readily be investigated by oscilloscope observation (see 3.41) of the voltage appearing on the plate of tube V3.2 (see 3.49) and finding that the pattern is that of Fig. 8B instead of the normal pattern of Fig. 8.

(b) A trouble in the ac or dc guard portion of the receiver, which may be localized by following the procedure given in 3.55 through 3.57 and by means of oscilloscope observations (3.41 through 3.51).

(c) A defective VR4 varistor.

Note: Option "P" is "Mfr. Disc." Observe that correct value has been provided for R35.

(d) Faulty adjustment of the R or RF relays.

3.41 In order to obtain the oscilloscope patterns referred to above, connect the Y amplifier input of the oscilloscope between frame ground and the test points specified in Fig. 1 to 10, and check that the pulse shapes obtained for inputs of the per cent break indicated are similar to those shown in these figures. To prevent loading of the circuit by the oscilloscope, insert a 1-megohm resistor between test points and oscilloscope input. The oscilloscope pattern may be synchronized to the pulsing speed of the No. 2B test set or the No. 2A test set by means of the SYNC jack on the test set and the external synchronization features of the oscilloscope. Care should be exercised when operating the SYNC control of the oscilloscope to use a maximum setting of the control for satisfactory synchronization without distortion of the pattern.

Note: Oscilloscope patterns shown at 40 and 75 per cent breaks are from previously issued low and high limits of pulsing requirements. They are still useful in determining trouble conditions.

3.42 The Fig. 1 pattern shows the tone pulse received in the voice path of the receiver, but primarily indicates the appearance of the pulse output of the signaling testing circuit. In the event this pattern appears as shown in Fig. 1A, the M relay should be checked to determine its position. If it is operated, check the M lead of the receiver for the source of a trouble condition in the 48-volt battery. If it is nonoperated, check the 3-4T and 7-8T contacts of the M relay, which control the insertion of the N1 filter in the voice path of the receiver for continuity.

3.43 The Fig. 2 pattern shows the effect of the V2.2 amplifier-limiter stage upon the tone pulse, and when compared with Fig. 1, shows the amount of limiting and also the gain of this stage. In the event that the pattern appears as shown in Fig. 2A, the VR1 and VR2 varistors should be checked.

3.44 The Fig. 3 pattern shows the ac pulse available in the signal channel. If Fig. 1 and 2 seem satisfactory, the failure to obtain Fig. 3 may be because of trouble in the low-pass filter composed of the T3 retard coil and the C6 capacitor, or more particularly, the antiresonance portion of the network between terminals 1 and 2 of the N1 network. The slight positive dc surge, occurring approximately 20 milliseconds after the tone pulse, is due to the RF relay releasing and closing the clamping path from the grid of V3.2 through R28 and C10 to the —40-volt grid bias (cathode of V3.1). The positive voltage that is on the grid at this time (due to the coupling path between the plate of V2.1 and the grid of V3.2) causes the voltage at card punching 1 to rise momentarily with respect to ground. The negative dc surge, occurring at the beginning of the 75 per cent break input pulse, is due to the next tone pulse arriving before the R relay has released. The corollary effect of the coupling path between the plate of V2.1 and the grid of V3.2 causes a negative surge to be placed on the grid of V3.2 and (since the clamping path between V3.2 and the —40-volt grid bias is closed) causes card punching 1 to drop momentarily with respect to ground. Absence of the aforementioned positive or negative surge may be attributed to failure of the R and RF relays to operate and release on each pulse or to an open in either the coupling or clamping path. This condition is shown in Fig. 3A. In the event the R and RF relays are operating and releasing on each pulse, observing the oscilloscope patterns through Fig. 8 will further localize the open circuit trouble into either the clamping path or the coupling path.

3.45 Fig. 4 shows the ac pulse available in the guard channel. If the pattern seems greater in amplitude than normal, the steady-state signal and guard voltages should be checked by means of the procedure given in 3.55 through 3.57. It is possible that the low-pass filter, consisting of the leakage reactance of T3 retard coil and C6 capacitor, is not filtering enough of the harmonics produced in the V2.2 stage or the guard resonance network is not shunted by the R15 resistor, as required in this instance. The superimposed positive and negative dc surges are exactly the same as described in 3.44.

3.46 The Fig. 5 pattern shows the transient pulse of voltage delivered to the guard channel C9 capacitor. It is essentially Fig. 4 rectified. If the pattern of Fig. 4 was normal and the Fig. 5 pattern is not as shown, then it is probably due to an open in the V3.1 electron tube or associated circuit. Check the V3.1 electron tube.

3.47 Fig. 6 shows the transient pulse of voltage delivered to the C7 and C8 signal channel capacitors. It is essentially Fig. 3 rectified. If the ripple is as large as that indicated in Fig. 6A, the trouble is certainly in VR1 or VR2 varistors.

3.48 The Fig. 7 pattern shows the transient pulse of voltage delivered to a point 1 megohm away from the grid of V3.2 electron tube. It should be noted that on some receivers the R relay will operate slightly before the end of the 40 per cent break tone pulse, while in others the R relay will operate slightly after the end of the 40 per cent break tone pulse. In the event the pattern appears as shown in Fig. 7A or 7B, the cause of the trouble is probably a defective VR3 varistor.

TYPICAL NORMAL OSCILLOSCOPE PATTERNS

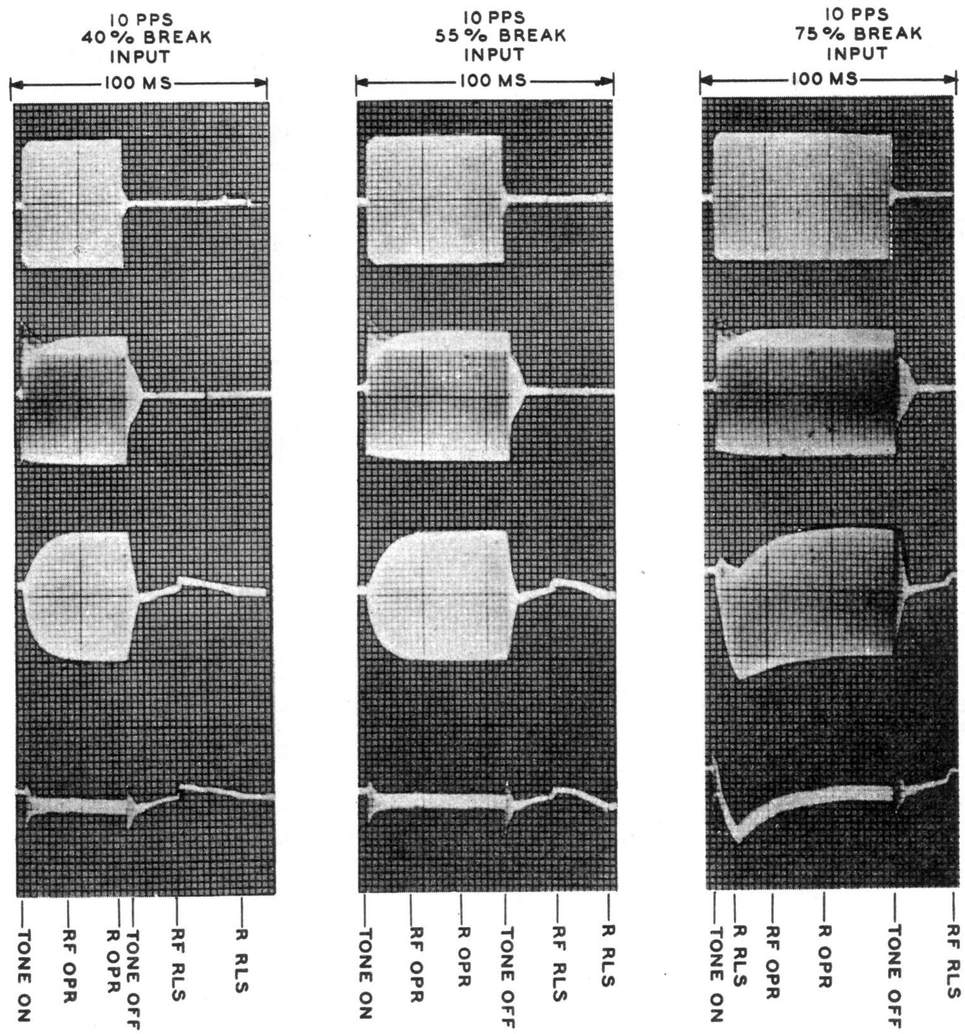


Figure 1
Terminal 10(N1)

Figure 2
Terminal 2(T3)

Figure 3
Card Punching 1

Figure 4
Terminal 4(N1)

TYPICAL NORMAL OSCILLOSCOPE PATTERNS

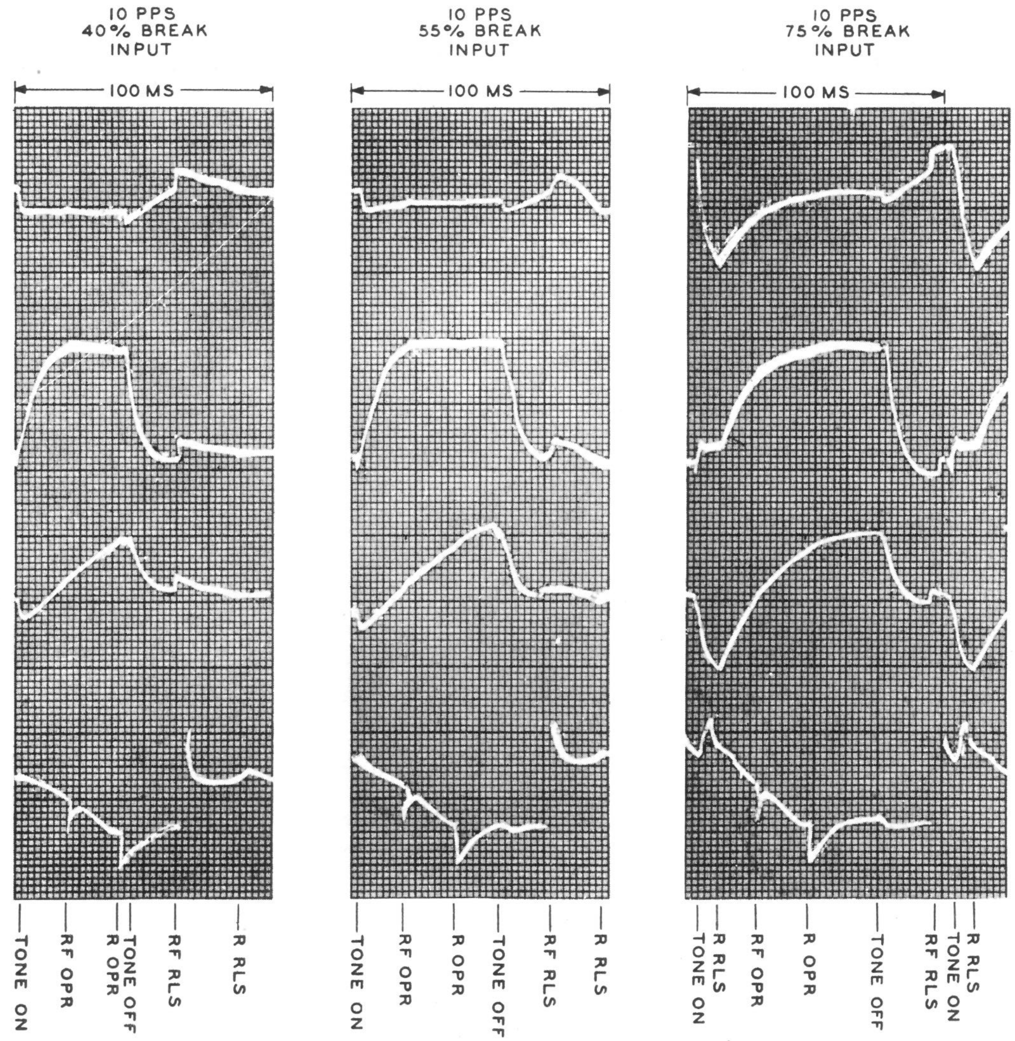


Figure 5
Card Punching 10

Figure 6
Card Punching 3

Figure 7
Card Punching 7

Figure 8
Terminal 4(V3)

TYPICAL NORMAL OSCILLOSCOPE PATTERNS

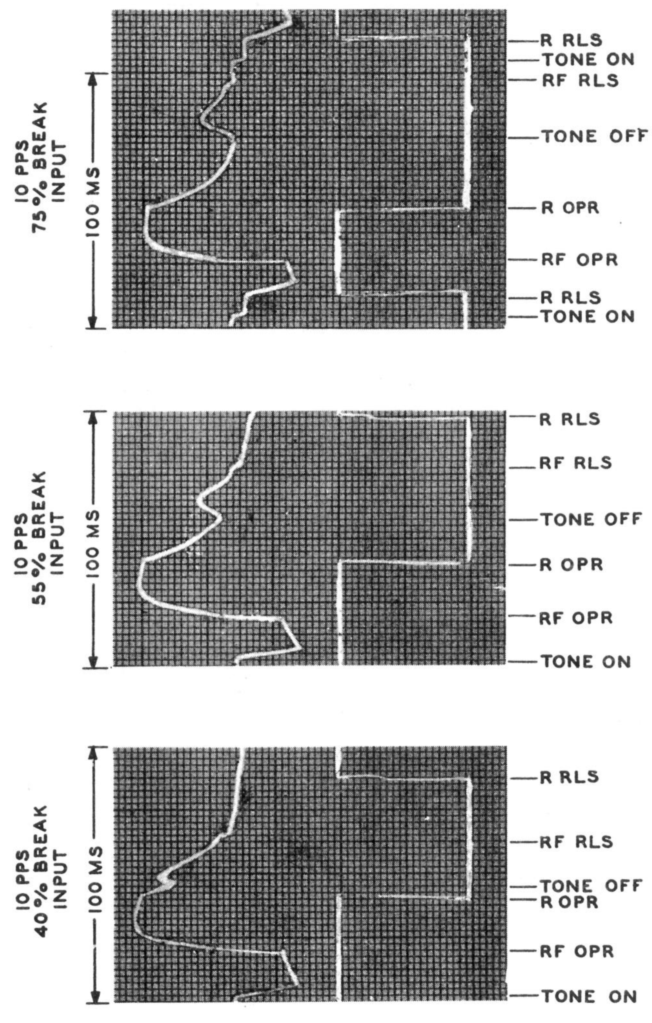


Figure 9
Terminal 1T(R)

Figure 10
E Lead

TYPICAL TROUBLE OSCILLOSCOPE PATTERNS

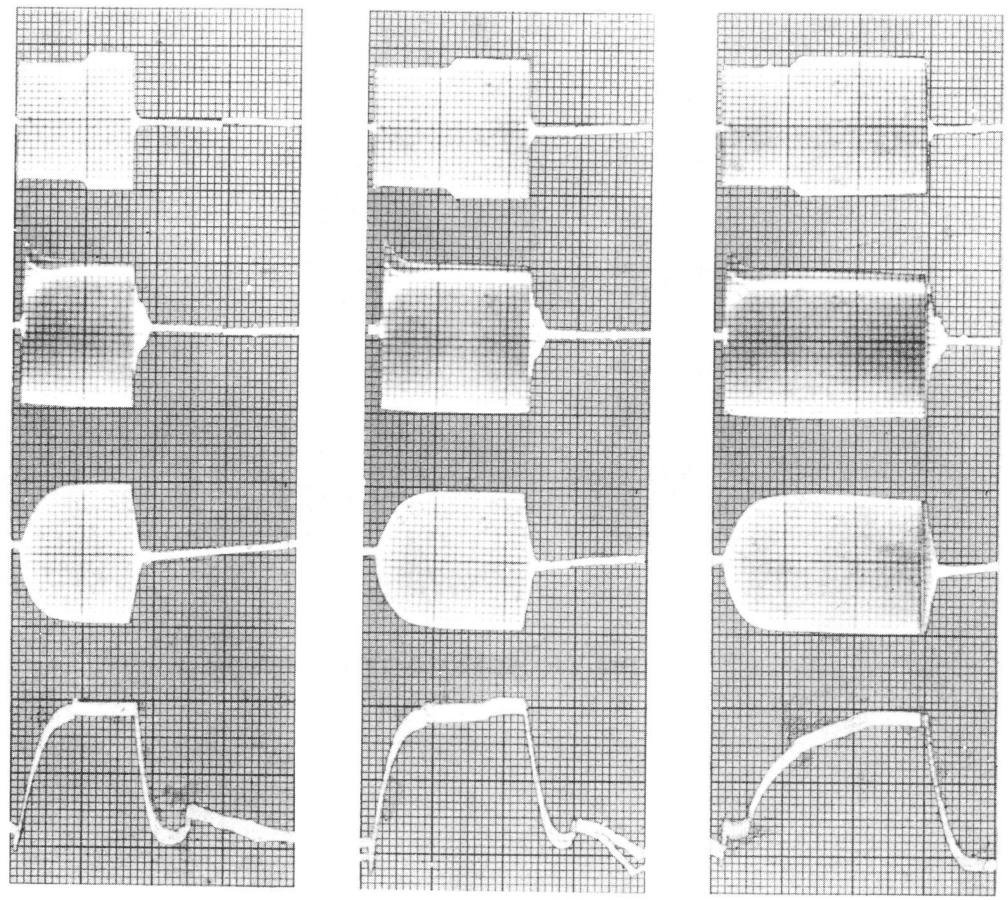
10 PPS 40% BREAK INPUT	10 PPS 55% BREAK INPUT	10 PPS 75% BREAK INPUT

Figure 1A
Terminal 10(N1)
Open Circuit In Control Circuit Of N1 In Voice Path

Figure 2A
Terminal 2(T3)
Low Reserve Impedance In VR1 or VR2 Varistor

Figure 3A
Card Punching 1
Open Circuit In Either Coupling Or Clamping Paths

Figure 6A
Card Punching 3
Low Reverse Impedance In VR1 or VR2 Varistor



TYPICAL TROUBLE OSCILLOSCOPE PATTERNS

10 PPS 40% BREAK INPUT	10 PPS 55% BREAK INPUT	10 PPS 75% BREAK INPUT

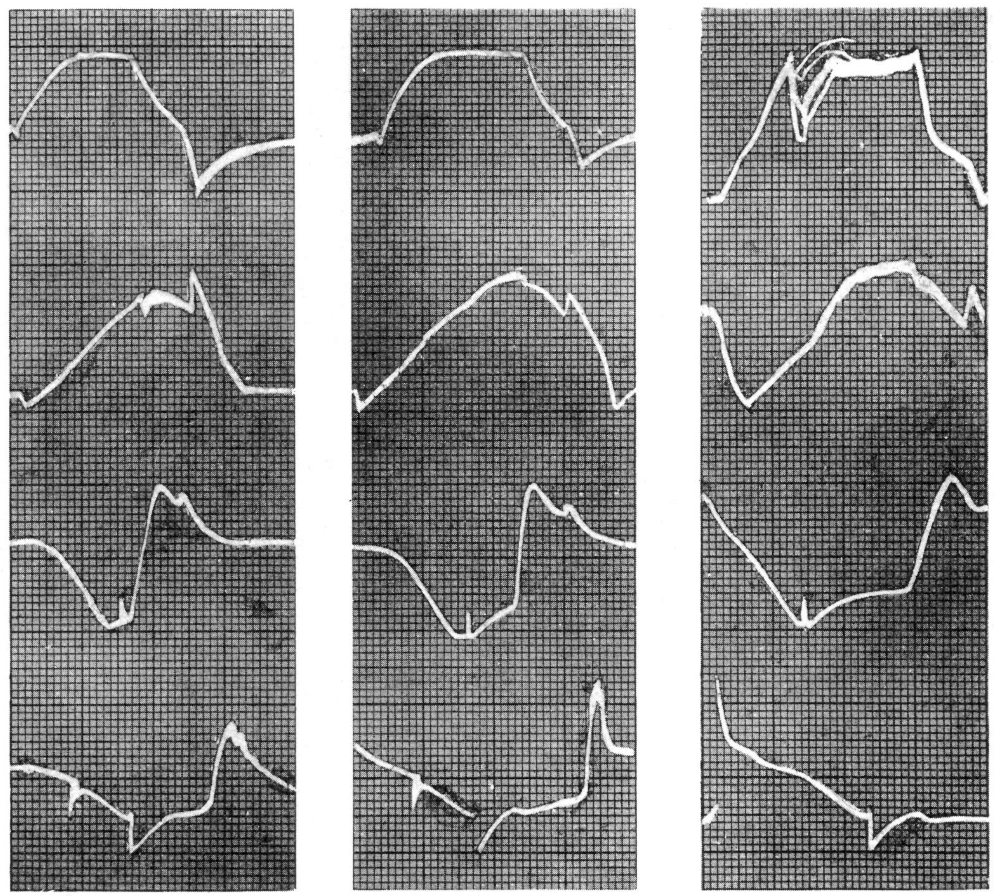


Figure 7A
Card Punching 7
Low Reverse Impedance In VR3 Varistor

Figure 7B
Card Punching 7
Open Circuit in VR3 Varistor

Figure 8A
Terminal 4(V3)
Open Circuit In Coupling Path

Figure 8B
Terminal 4(V3)
Open Circuit In Clamping Path

3.49 The Fig. 8 pattern shows the transient pulse of voltage appearing on the plate of V3.2 electron tube. It is simply the reverse polarity of the voltage actually appearing on the grid of V3.2. (Note that Fig. 7 was not exactly on the grid of V3.2, but was 1 megohm away and may have a different potential ground than the grid at any given time.) In the event the pattern appears as shown in Fig. 8A, the cause of trouble is probably an open in the coupling path between the plate of V2.1 and the grid of V3.2. In the event the pattern appears as shown in Fig. 8B, the cause of trouble is probably an open in the clamping path from the grid of V3.2 to the —40-volt bias (cathode of V3.1).

3.50 Fig. 9 shows the transient pulse of voltage delivered to the coupling path from C14 capacitor. It should be noted that although C14 capacitor appears to pass a current surge at the beginning of the tone pulse when one terminal is actually open-circuited, this is actually due to the capacitor charging through the oscilloscope high-impedance path to ground. Failure to obtain this pattern would indicate a faulty C14 capacitor.

3.51 Fig. 10 shows the E lead output which should be relatively free of R relay chatter or rebound. If chatter is apparent, the R relay should be checked to determine if it meets its mechanical and electrical requirements. (See Section 040-518-701.)

3.52 If the break requirement of 26 to 54 per cent on the red scale of Test G of Section → 179-312-501 cannot be met, it is probably due to:

(a) Failure of the M and HL relays to remain operated during the test.

(b) A short-circuit around the HL relay contacts controlling the insertion of the R35 resistor.

Note: "T" and "P" options are "Mfr. Disc." Observe that correct value of R35 is provided whenever VR4 is changed.

(c) An open R35 resistor.

(d) Failure of the G relay to remain operated during the test.

(e) Dirt on the 1-2T contacts of the RF relay or on the 5-6T contacts of the R relay.

(f) An open in the clamping path from the grid of the V3.2 tube to the —40-volt bias (cathode of V3.1).

3.53 If failure of the M, HL, or G relays to remain operated is the cause of trouble, readjust these relays to meet their mechanical and electrical requirements. Also check the operating paths for continuity.

H. Receiver Regulation

3.54 Inability to meet any of the average deflection or steady-state current requirements of Test H of Section 179-312-501 is probably due to:

(a) A faulty V2.2 or V3 electron tube.

(b) Failure of the electronic portion of the receiver to produce sufficient current because of excessive guard voltages. These excessive voltages are due to either extreme harmonics being generated in the V2.2 stage or to a trouble in the ac or dc guard circuit.

3.55 If the V2.2 and V3 tubes meet their requirements, localize the trouble by means of point-to-point voltmeter measurements, following the procedure of 3.28 through 3.31.

3.56 If all voltage measurements of Tables A, 1B, 2B, and 3B are typical, proceed as follows:

(a) At the test equipment jacks, patch the T and R MW SUP jacks to the T1 and R1 SF TONE TST jacks, using the 2P13D cord supplied with the testing circuit.

(b) Connect the No. 13A TMS to the TMS jacks. (In case the No. 2B test set or the No. 2A test set is patched to the E and M jacks, all the keys of the test set shall be normal.)

(c) Set the KEYERS switch of the testing circuit to 8 SIG PLS, with the RECEIVER switch on 6 MEAS 1KC IN.

(d) With the testing circuit attenuator set at 10 db, adjust the GAIN potentiometer of the testing circuit V3 amplifier to obtain a reading of 0 dbm on the TMS, thus adjusting the level of 1000-cycle tone to be applied to the receiver.

(e) Set the KEYERS switch to 6 SIG ON, with the RECEIVER switch on 5 M RLS or

7 M OPR, depending on the condition specified in Table 1C. This applies a 1000-cycle signal to the receiver at a level determined by the attenuator setting.

(f) Block the G relay operated.

(g) Measure the guard voltages developed in the signal amplifier and detector portions of the receiver at the points indicated in Tables 1C, 2C, and 3C which give values of typical voltages. Three levels of applied 1000 cycles are used. The low-level signal is —25 dbm (attenuator setting 35 db). The minimum high-level signal is —16 dbm (attenuator setting 26 db) and the maximum high-level signal is —4 dbm (attenuator setting 14 db).

3.57 If the voltage measurements do not approximate the typical readings given in Table 1C, 2C, or 3C, the following suggestions may help in localizing the trouble.

MEASUREMENTS OUTSIDE OF LIMITS	SUGGESTED ACTION TO BE TAKEN
1	Check for tone circuit continuity through signaling testing circuit and through the jack and connector junction.
2	Check for continuity through T1 transformer and SS potentiometer.
3	Assuming SS potentiometer was adjusted in accordance with procedure F of this section, check V2.2 tube and continuity in V2 signal amplifier stage.
4	Check T3 transformer or N1 network and C6 capacitor for continuity.
5	Check signal section of N1 network for circuit continuity.
6	Check guard section of N1 network for continuity. More specifically, determine that the M relay contacts correctly control the R15 resistor and that the G relay contacts correctly remove the short circuits across the guard network.
7	Check circuit connections to VR1 and VR2 varistors.
8	Check for faulty V3.1 electron tube.
9	Check circuit continuity in OT potentiometer.

Note: At the end of the testing procedure outlined in 3.56 and 3.57, the GAIN potentiometer of the testing circuit V3 amplifier must be restored to the setting specified in Test E of Section 179-312-501.

I. Receiver Guard Action and Permanent Signals and 2-wire Controls

3.58 The cause of inability to meet the requirements of Test I of Section 179-312-501 will most readily be found by consulting Table D and determining that the positions of the relays under the various test conditions are as shown in the table.

3.59 If the relays are in the position shown in Table D, but the L, PS, or F lamps are not in the conditions stated in the table, the cause of the trouble is probably due to one of the following reasons.

(a) If the lamp is extinguished when it should be lighted, this may be due to:

(1) An open circuit in the respective L, PS, or F lamp leads.

(2) A burned out lamp in the test circuit.

(b) If the lamp is lighted when it should be extinguished, a trouble ground or shorted contact condition in the respective L, PS, or F lamp leads.

3.60 If the M relay is operated when it should be released, check the M lead for a trouble battery condition. If the M relay is released when it should be operated, check the M lead for an open circuit condition.

3.61 If the R and RF relays are operated when they should be released, or released when they should be operated, check the steady-state guard and signal voltages by the procedure given in 3.55 through 3.57.

TABLE C

TABLE 1C — TYPICAL AC VOLTMETER READING WITH 1000-CYCLE INPUT

	VOLTMETER CONNECTIONS		SCALE SETTING		READING IN VOLTS RECEIVER SWITCH					
					5 M RLS			7 M OPR		
	−V TO	+V TO	M9B METER	KS-14510 METER	LOW LEVEL	MIN HIGH LEVEL	MAX HIGH LEVEL	LOW LEVEL	MIN HIGH LEVEL	MAX HIGH LEVEL
(1)	TP6	TP5	3V-AC	3V-AC	—	—	0.9 ±0.3	—	—	0.9 ±0.3
(2)	1(SS)	2(SS)	3V-AC	3V-AC	—	—	0.25±0.2	—	—	0.25±0.2
(3)	1(T3)	2(T3)	30V-AC	60V-AC	2 ±1	6 ±2	8 ±2	7±2	18 ±3	26 ±4
(4)	4(N1)	1(N1)	30V-AC	60V-AC	1.5±1	3.5±2	4.5 ±2	7±2	18 ±3	26 ±4
(5)	8*	1*	3V-AC	3V-AC	—	0.3±0.2	0.5 ±0.3	—	0.3±0.2	0.5 ±0.3
(6)	7(V3)	8*	30V-AC	60V-AC	1.5±1	3 ±2	4 ±2	7±2	18 ±3	26 ±4

TABLE 2C — TYPICAL DV VOLTMETER READING WITH 1000-CYCLE INPUT FOR M9B VOLT-OHMMETER

	VOLTMETER CONNECTIONS			READING IN VOLTS RECEIVER SWITCH					
				5 M RLS			7 M OPR		
	−V TO	+V TO	SCALE SETTING	LOW LEVEL	MIN HIGH LEVEL	MAX HIGH LEVEL	LOW LEVEL	MIN HIGH LEVEL	MAX HIGH LEVEL
(7)	8*	3*	3V-DC	—	0.15±0.1	0.25±0.2	—	0.15±0.1	0.35±0.2
(8)	8*	9*	30V-DC	1.5±1	3.5 ±1	4.5 ±1	7.5±2	17 ±3	23 ±4
(9)	3(OT)	9*	30V-DC	0.5±0.4	1.5 ±1	2 ±1	5 ±2	12 ±2	16.5 ±3

TABLE 3C — TYPICAL DC VOLTMETER READING WITH 1000-CYCLE INPUT FOR KS-14510 VOLT-OHMMETER

	VOLTMETER CONNECTIONS			READING IN VOLTS RECEIVER SWITCH					
				5 M RLS			7 M OPR		
	−V TO	+V TO	SCALE SETTING	LOW LEVEL	MIN HIGH LEVEL	MAX HIGH LEVEL	LOW LEVEL	MIN HIGH LEVEL	MAX HIGH LEVEL
(7)	8*	3*	3V-DC	—	0.25±0.1	0.4±0.3	—	0.25±0.1	0.5±0.3
(8)	8*	9*	60V-DC	2 ±1	4.5 ±2	5 ±2	10±2	23 ±3	31 ±4
(9)	3(OT)	9*	60V-DC	1.5±1	3 ±2	3.5±2	9±2	21 ±3	29 ±4

Note: The voltages given in the above tables are, in general, different from the normal operating voltages, such as could be measured with a high-impedance vacuum tube voltmeter.

*Numbered terminal on apparatus assembly.

3.62 If the R and RF relays are in the positions shown in Table D, but the G relay is not, check the continuity of the operating path of the G relay.

J. Final Adjustment of Receiver Sensitivity

3.63 Inability to meet requirements of Test J of Section 179-312-501 is probably due to a very low transconductance V2 or V3 electron tube, which should be checked. Changing the defective tube will usually permit this requirement to be met. Tests D through J of Section 179-312-501 shall, however, be repeated if the tube is changed. If the trouble persists, check the ac and dc steady-state signal and guard voltages by means of the procedure given in 3.55 through 3.57.

K. Networks for 2-wire Lines (SD-56292-01, Fig. 3 and 8)

3.64 To test the band elimination network for 2-wire lines, Fig. 3, proceed as follows.

(a) Disconnect from the incoming line by inserting dummy plugs at the VF patching bay or equivalent. Disconnect from the signaling equipment by removing the signaling unit from its position in the bay.

TABLE D

	KEYERS SWITCH	RECEIVER SWITCH	ATTENUATOR SETTING-DB	RELAY POSITIONS M	RF	R	G	LAMP CONDITIONS* L(2A)	L(2B)	F	PS
(1)	5 SIG OFF	5M RLS	42	Rls	Rls	Rls	Opr	L	E	E	L
(2)	6 SIG ON	5M RLS	42	Rls	Rls	Rls	Opr	L	E	E	L
(3)	6 SIG ON	5M RLS	30	Rls	Opr	Opr	Rls	E	L	E	E
(4)	5 SIG OFF	7M OPR	26	Opr	Rls	Rls	Opr	L	E	L	E
(5)	6 SIG ON	7M OPR	26	Opr	Rls	Rls	Opr	L	E	L	E
(6)	6 SIG ON	7M OPR	20	Opr	Opr	Opr	Rls	E	L	E	E

*L lamp lighted, E lamp extinguished.

(b) Check that all relays are released in associated Fig. 8, if provided.

(c) Insert a shorted pin plug in test points 5 and 6 on the network, thus grounding 5.

(d) Patch test points 1 and 2 on the network to the 2400- or 2600-cycle jack in the bay, as required for the transmitting frequency of the circuit under test.

Note: The level supplied at the 2400- or 2600-cycle jack is —12.5 ±1 dbm for a +4, —13 office (or combined +4, —13 and +7, —16 offices) and —15.5 ±1 dbm for a +7, —16 office.

(e) Connect the No. 13A TMS to test points 3 and 4. The TMS shall read —12.5 ±1 dbm for a +4, —13 office (or combined office) and —15.5 ±1 dbm for a +7, —16 office.

(f) Remove the shorted pin plug from test points 5 and 6. The output level shall drop at least 22 db below the level measured in (e) above.

(g) Reinsert the shorted pin plug in test points 5 and 6 as in (c) above.

(h) Patch test points 1 and 2 to the 2400- or 2600-cycle jack, as required for the receiving frequency of the circuit.

(i) Connect the No. 13A TMS to test points 3 and 4. The TMS shall read −12.5 ±1 dbm for a +4, −13 office (or combined office) and −15.5 ±1 dbm for a +7, −16 office.

(j) Remove the shorted pin plug from test points 5 and 6. The TMS reading shall not be more than 1.7 dbm below that obtained in (i) above.

3.65 To test the band pass network, Fig. 8, proceed as follows.

(a) Disconnect from the incoming line by inserting dummy plugs at the VF patching bay or equivalent. Disconnect from the signaling equipment by removing the signaling unit from its position in the bay.

(b) Insert a shorted pin plug in test points 5 and 6 of associated Fig. 3 thus operating the F relay which removes the band elimination network.

(c) Patch test points 1 and 2 of Fig. 8 to 1000 cycles 1 mw.

(d) Connect the 13A TMS to test points 3 and 4 of Fig. 8. The TMS shall read 0 dbm, less the loss incurred from wiring and cords.

(e) Manually operate the M1 and B relays and observe that the ouput level drops to at least —33 dbm for the 200H network and to at least −35 dbm for the 200G network.

(f) Release the M1 and B relay and remove the 1000 cycles 1 mw.

(g) Patch test points 1 and 2 to the 2400- or 2600-cycle jack, as required for the receiving frequency of the circuit. (See note, 3.64.)

(h) The TMS shall read —12.5 ±1 dbm for a +4, −13 office (or combined office), and −15.5 ±1 dbm for a +7, −16 office.

(i) Manually operate the M1 and B relays and observe that the output level drops from −1.5 to −3 db below the level measured in (h) above.

(j) After completing tests, restore to normal by removing patch cords, TMS, dummy plugs, and shorting pin plug in test points 5 and 6 of Fig. 3 and reinsert signaling unit.

L. Varistor Data

3.66 When operational difficulties are believed to be due to defective varistors, their "forward" and "reverse" resistances may be checked in the circuit by means of the M9B or KS-14510 volt-ohmmeter or the varistor test set KS-12054, in accordance with the following procedures.

Note: "P" option is "Mfr. Disc." Observe that correct value is provided for R35.

3.67 The values shown in Tables 1E and 2E are calculated values which are intended as a guide in finding definitely defective VR1 to VR4 varistors. These values cannot be used as rigorous acceptance tests for good varistors due to the wide variations in circuit shunts and the low dc voltage applied to the varistor during the test, especially with the M9B meter. A rigorous test of the VR1 and VR2 varistors may be made with the varistor test set KS-12054, per Section 100-160-101 if available. In this case, use the forward and reverse resistance values specified on SD-56292-01 for VR1 and VR2 varistors. Make tests without power on the receiver and with same conditions as the Test Notes of Table E.

Note: Once a 400-type varistor is removed from the circuit, it is not advisable to re-use the varistor, unless the most extreme care is exercised to avoid excessive heating when soldering.

3.68 In order to measure reverse resistance (that is, resistance during negative voltage application to terminal 1), connect the Rx pin jack of the M9B meter specified in Table 1E or the + jack of the KS-14510 meter to terminal 1 (positive end) of the varistor. Connect the X pin jack of the M9B meter or the −jack of the KS-14510 meter to the other end of the varistor.

3.69 In order to measure forward resistance (that is, resistance during positive voltage application to terminal 1), connect the X pin jack of the M9B meter or the −jack of the KS-14510 meter to terminal 1 (positive end) of the varistor. Connect the Rx pin jack of the M9B meter specified in Table 1E or the + jack of the KS-14510 meter on the other end of the varistor.

TABLE E

TABLE 1E — VARISTOR OHMMETER TEST READINGS USING M9B VOLT-OHMMETER

VARISTOR DESIGNATION	TYPE	FORWARD RESISTANCE SCALE	FORWARD RESISTANCE MAX OHMS	REVERSE RESISTANCE SCALE	REVERSE RESISTANCE MIN OHMS	TEST NOTES
VR1 orVR2	400C	Rx10	330	Rx1000	14,000	Block G relay released
VR3	41A	Rx10	7000	Rx1000	750,000	Block G relay operated and turn OT potentiometer fully clockwise
→	420D	Rx10	200	Rx1000	750,000	
VR4	41A	Rx10	7000	Rx1000	150,000	Block G relay operated
→	420D	Rx10	200	Rx1000	150,000	

TABLE 2E — VARISTOR OHMMETER TEST READINGS USING KS-14510 VOLT-OHMMETER

VARISTOR DESIGNATION	TYPE	FORWARD RESISTANCE SCALE	FORWARD RESISTANCE MAX OHMS	REVERSE RESISTANCE SCALE	REVERSE RESISTANCE MIN OHMS	TEST NOTES
VR1 or VR2	400C	Rx10	330	Rx10,000	14,000	Block G relay released
VR3	41A	Rx10,000	25,000	Rx1000	750,000	Block G relay operated and turn OT potentiometer fully clockwise
→	420D	Rx10	400	Rx10,000	750,000	
VR4	41A	Rx10,000	25,000	Rx1000	150,000	Block G relay operated
→	420D	Rx10	400	Rx10,000	150,000	

Note: Remove receiver from test position and make varistor tests without power on receiver.