

1600- OR 2000-CYCLE SINGLE FREQUENCY SIGNALING CIRCUITS

SD-55954-01 AND SD-55954-02

ANALYSIS AND CLEARANCE OF TROUBLE

1. GENERAL

1.01 This section describes methods and procedures that may be followed in the analysis and clearance of troubles encountered in 1600- or 2000-cycle single frequency signaling circuits.

1.02 This section is reissued to add to the voltage readings, amplify varistor test information and to change the rating of the section from AT&TCo Provisional to AT&TCo Standard. Since this reissue covers a general revision, arrows ordinarily used to indicate changes have been omitted.

1.03 This procedure is based on the failure of the signaling circuit to meet the test requirements described in Section 179-215-501 and, where so indicated, could not be adjusted in accordance with Section 179-215-701. The headings are as follows:

A. Sensitivity of Receiver

B. Pulsing Performance of Receiver

C. Guard Sensitivity

D. Transmitter Performance

E. Relay Timing

F. Voice Amplifier

G. Blocking Amplifier

H. Blocking Network

I. Varistor Data

In the trouble-locating procedures unless otherwise specified, the same switch and attenuator settings on the signaling testing circuit SD-56137-01, used for tests in Section 179-215-501 or adjustments in Section 179-215-701, are required.

2. APPARATUS

2.01 In addition to the apparatus mentioned in Sections 179-215-501 and 179-215-701, the apparatus listed below may be required.

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

2.03 Volt-ohm-milliammeter, M9B or KS-14510.

2.04 Varistor test set, KS-12054.

2.05 Cold cathode tube test set.

3. TROUBLE CONDITIONS

A. Sensitivity of Receiver

3.01 If unable to adjust P2 and P4 potentiometers as specified in Section 179-215-701, test for:

(a) Faulty V2 or V3 electron tubes.

Note: It is essential that both the V2 and V3 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) Component failure in the electron portion of the receiver.

3.02 Check that the tubes have proper plate, screen, cathode, and grid voltages in accordance with Table 1A or 1B with no signal input.

TABLE 1A

Typical DC Voltage Readings Using M9B Meter
No Signal Input

| METER SCALE USED | VOLTMETER CONNECTIONS | | VOLTMETER READING |
|------------------------|-----------------------|-----------------|-------------------|
| | +V TERM. TO | -V TERM. TO | |
| 3V DC | 7(V2) | (See Note 1) | 2.4 — 3 |
| 150V DC | 6(V2) | Grd | 118 — 123 |
| 150V DC | 5(V2) | Grd | 123 — 128 |
| 15V DC | Grd | 11 (See Note 2) | 7.6 — 8.2 |
| 150V DC | 5(V3) | Grd | 128 — 132 |

TABLE 1B

Typical DC Voltage Readings Using KS-14510 Meter
No Signal Input

| METER SCALE USED | VOLTMETER CONNECTIONS | | VOLTMETER READING |
|------------------------|-----------------------|-----------------|-------------------|
| | +V TERM. TO | -V TERM. TO | |
| 3V DC | 7(V2) | (See Note 1) | 2.4 — 3 |
| 300V DC | 6(V2) | Grd | 124 — 126 |
| 300V DC | 5(V2) | Grd | 126 — 129 |
| 12V DC | Grd | 11 (See Note 2) | 7.6 — 8.2 |
| 300V DC | 5(V3) | Grd | 129 — 134 |

Notes

1. Adjusting band on P3 potentiometer.
2. Terminal on apparatus assembly card.

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

3.03 If the typical voltages of Table 1A or 1B are approximately obtained, proceed in accordance with Tables 2A or 2B and 3A or

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.

For Table 2A or 2B

| | +4 UNIT | +7 UNIT |
|--------------|---------|---------|
| Low level | -24 db | -21 db |
| Medium level | -16 db | -13 db |
| High level | - 4 db | - 1 db |

For Table 3A or 3B

| | +4 UNIT | +7 UNIT |
|--------------|---------|---------|
| Low level | -16 db | -13 db |
| Medium level | - 4 db | - 1 db |
| High level | + 4 db | + 7 db |

Note: For signal units associated with 2-wire blocking network, use 1.5 db less tone in each case.

TABLE 2A

Typical AC and DC Voltages Using M9B Meter
With Signal Input, S Relay Normal, and
Dummy Plug in R Jack

| METER SCALE USED | VOLTMETER CONNECTIONS | | VOLTMETER READINGS WITH VARIOUS INPUTS | | |
|------------------------|-----------------------|-----------------|--|-------------|-------------|
| | +V TERM. TO | -V TERM. TO | LOW | MEDIUM | HIGH |
| 3V AC | 2(T2) | 1(T2) | — | — | 0.82 — 0.87 |
| 3V AC | 7(T2) | 1(P2) | — | — | 1.0 — 1.03 |
| 150V AC | 4(T3) | 3(T3) | 37 — 47 | 75 — 84 | 113 — 125 |
| 15V AC | 7(V2) | (See Note 1) | 2.7 — 3.2 | 2.7 — 3.3 | 3.1 — 3.9 |
| 150V AC | 2(T3) | 1(T3) | 10 — 14 | 20 — 25 | 29 — 37 |
| 150V AC | 10 (See Note 2) | 1 (See Note 2) | 20 — 24 | 34 — 40 | 43 — 51 |
| 150V AC | 10 (See Note 2) | 11 (See Note 2) | 20 — 23 | 33 — 39 | 43 — 51 |
| 3V AC | 1 (See Note 2) | 11 (See Note 2) | 0.3 — 0.45 | 0.8 — 0.85 | 1 — 1.3 |
| 150V DC | 12 (See Note 2) | 11 (See Note 2) | 23 — 26 | 37 — 43 | 48 — 55 |
| 3V DC | 11 (See Note 2) | 8 (See Note 2) | 0 — 0.1 | 0.17 — 0.25 | 0.5 — 0.75 |
| 150V DC | 13 (See Note 2) | 11 (See Note 2) | 5 — 6 | 8 — 10 | 10 — 12 |

TABLE 2B

Same as Table 2A, Except Using KS-14510 Meter

| METER SCALE USED | VOLTMETER CONNECTIONS | | VOLTMETER READINGS WITH VARIOUS INPUTS | | |
|------------------------|-----------------------|-----------------|--|------------|-------------|
| | +V TERM. TO | -V TERM. TO | LOW | MEDIUM | HIGH |
| 3V AC | 2(T2) | 1(T2) | — | — | 0.9 — 0.92 |
| 3V AC | 7(T2) | 1(P2) | — | — | 1.46 — 1.50 |
| 300V AC | 4(T3) | 3(T3) | 35 — 47 | 77 — 82 | 112 — 121 |
| 12V AC | 7(V2) | (See Note 1) | 2.5 — 3.1 | 2.6 — 3.1 | 2.9 — 3.7 |
| 60V AC | 2(T3) | 1(T3) | 11.5 — 15 | 22 — 25 | 31 — 37 |
| 60V AC | 10 (See Note 2) | 1 (See Note 2) | 22 — 24 | 35 — 39 | 44 — 50 |
| 60V AC | 10 (See Note 2) | 11 (See Note 2) | 21 — 24 | 35 — 38 | 43 — 48 |
| 3V AC | 1 (See Note 2) | 11 (See Note 2) | 0.4 — 0.6 | 0.8 — 0.95 | 1.2 — 1.4 |
| 60V DC | 12 (See Note 2) | 11 (See Note 2) | 28 — 31 | 44 — 50 | 55 — 68 |
| 3V DC | 11 (See Note 2) | 8 (See Note 2) | 0 — 0.2 | 0.3 — 0.5 | 0.9 — 1.3 |
| 300V DC | 13 (See Note 2) | 11 (See Note 2) | 9 — 10 | 14 — 15 | 16 — 18 |

TABLE 3A
Typical AC and DC Voltages Using M9B Meter
With Signal Input, S Relay Operated, and
Dummy Plug in R Jack

| METER SCALE USED | VOLTMETER CONNECTIONS | | VOLTMETER READINGS WITH VARIOUS INPUTS | | |
|------------------------|-----------------------|-----------------|--|-------------|------------|
| | +V TERM. TO | -V TERM. TO | LOW | MEDIUM | HIGH |
| 3V AC | 2(T2) | 1(T2) | — | 0.75 — 0.85 | 1.5 — 1.75 |
| 3V AC | 7(T2) | 1(P2) | 0.35 — 0.4 | 1.7 — 1.8 | 5 — 6 |
| 150V AC | 4(T3) | 3(T3) | 25 — 32 | 85 — 92 | 105 — 115 |
| 15V AC | 7(V2) | (See Note 1) | 2.7 — 3.3 | 2.8 — 3.3 | 3.0 — 3.6 |
| 150V AC | 2(T3) | 1(T3) | 8 — 10 | 22 — 27 | 28 — 33 |
| 150V AC | 10 (See Note 2) | 1 (See Note 2) | 14 — 16 | 38 — 43 | 43 — 50 |
| 150V AC | 10 (See Note 2) | 11 (See Note 2) | 14 — 16 | 37 — 43 | 42 — 49 |
| 3V AC | 1 (See Note 2) | 11 (See Note 2) | 0.2 — 0.3 | 0.9 — 1 | 1.1 — 1.3 |
| 150V DC | 12 (See Note 2) | 11 (See Note 2) | 16.5 — 17.5 | 41 — 47 | 46 — 54 |
| 3V DC | 11 (See Note 2) | 8 (See Note 2) | 0 — 0.04 | 0.25 — 0.35 | 0.45 — 0.6 |
| 150V DC | 13 (See Note 2) | 11 (See Note 2) | 3.5 — 4 | 9 — 10 | 10 — 12 |

TABLE 3B
Same as Table 3A, Except Using KS-14510 Meter

| METER SCALE USED | VOLTMETER CONNECTIONS | | VOLTMETER READINGS WITH VARIOUS INPUTS | | |
|------------------------|-----------------------|-----------------|--|-------------|-------------|
| | +V TERM. TO | -V TERM. TO | LOW | MEDIUM | HIGH |
| 3V AC | 2(T2) | 1(T2) | — | 0.85 — 0.95 | 1.82 — 1.85 |
| 3V AC | 7(T2) | 1(P2) | 0.45 — 0.5 | 2.1 — 2.3 | 6 — 6.1 |
| 300V AC | 4(T3) | 3(T3) | 23 — 30 | 84 — 90 | 105 — 113 |
| 12V AC | 7(V2) | (See Note 1) | 2.5 — 3.1 | 2.6 — 3.1 | 2.8 — 3.3 |
| 60V AC | 2(T3) | 1(T3) | 7 — 9 | 25 — 28 | 29 — 34 |
| 60V AC | 10 (See Note 2) | 1 (See Note 2) | 14.5 — 16 | 38 — 42 | 43 — 48 |
| 60V AC | 10 (See Note 2) | 11 (See Note 2) | 13 — 15 | 37.5 — 41 | 42 — 47 |
| 3V AC | 1 (See Note 2) | 11 (See Note 2) | 0.3 — 0.4 | 1 — 1.2 | 1.25 — 1.4 |
| 60V DC | 12 (See Note 2) | 11 (See Note 2) | 19 — 21 | 48 — 54 | 54 — 65 |
| 3V DC | 11 (See Note 2) | 8 (See Note 2) | -0.05 — +0.05 | 0.5 — 0.65 | 0.8 — 1.2 |
| 300V DC | 13 (See Note 2) | 11 (See Note 2) | 6 — 7 | 14 — 16 | 15 — 18 |

Notes for Tables 2A, 2B, 3A, and 3B

1. Left-hand terminal of P3 potentiometer.
2. Terminal on apparatus assembly card.

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

3.04 If the voltage measurements do not approximate the typical readings given in Tables 2A or 2B and 3A or 3B, check tone circuit continuity through testing circuit and T2 transformer. If this appears to be satisfactory check circuit connections to components and the component parts.

3.05 If varistors VR2, VR3, VR4, and VR5 are suspected due to low voltage readings, check in accordance with heading I Varistor Data.

B. Pulsing Performance of Receiver

3.06 Inability to meet per cent limits of R jack as outlined in Adjustment G of Section 179-215-701 may be due to:

- (a) Faulty VR6 varistor. Test in accordance with heading I Varistor Data.
- (b) Lack of guard voltage indicated by failure to meet the higher limits.
 - (1) Test varistors VR4 and VR5 in accordance with heading I Varistor Data.
 - (2) If satisfactory, test varistors VR13 and VR14 using the same data.
- (c) Excessive guard voltage or low signal channel voltage indicated by failure to meet the lower limits.
 - (1) Check voltages using Table 2A or 2B.
 - (2) Test varistors VR2 and VR3 in accordance with heading I Varistor Data.

3.07 If the R jack requirements are met and the E lead per cent break cannot be adjusted, proceed as follows:

- (a) Test VR12 varistor in accordance with heading I Varistor Data.
- (b) Test components R32, P5, C19, C23, and C24 for operation and wiring.
- (c) Test VR19 and VR20 varistors in accordance with heading I Varistor Data.

C. Guard Sensitivity

3.08 Talk Condition Failure

- (a) If the limits under this high guard condition cannot be met, check the guard and signal channel voltages using Table 3A or 3B.

- (b) If there is a lack of guard voltage (test attenuator control reads too low), check that the guard channel is not short-circuited and the R11 resistor is not connected across terminals 3 and 4 of the N1 network through the contacts of the S and GR relays.

- (c) Test VR4 and VR5 varistors in accordance with heading I Varistor Data.

- (d) If there is excessive guard voltage (test attenuator control reads too high), check that the S relay has operated and reduced the receiver to low sensitivity.

- (e) If unable to adjust S relay with P7 potentiometer, test VR15 and VR16 varistors in accordance with heading I Varistor Data.

3.09 Awaiting Subscriber Answer Failure — Receiver at Originating End

Check that the R10 resistor is connected between terminals 2 and 3 of the N1 network and terminals 3 and 4 are short-circuited through the contacts of the S and GR relays.

3.10 Awaiting Subscriber Answer Failure — Receiver at Terminating End

Check voltages using Table 2A or 2B.

D. Transmitter Performance

3.11 Low-level signal tone failure may be due to:

- (a) Faulty VR7 or VR8 varistor. Test in accordance with heading I Varistor Data.
- (b) False ground on the T or R leads.
- (c) CO relay has not properly cut and terminated the voice pair in 600 ohms.
- (d) Defective capacitors or resistors in the transmit tone path.

3.12 Low-level signal tone too high.

Check that HL relay is released, putting R27 and R28 resistors in the circuit.

3.13 If the limits of suppressed tone are not met, the trouble is probably due to faulty VR7 and VR8 varistors. Test in accordance with heading I Varistor Data.

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3.14 Momentary high-level signal tone failure may be due to:

- (a) HL relay releasing too fast.
 - (1) Send pulses of 72% break at 9 PPS on M lead and HL relay should remain operated while M relay pulses. If HL relay releases, check its mechanical and electrical requirements.
- (b) Defective VR9 and VR10 varistors. Test in accordance with heading I Varistor Data.

E. Relay Timing

3.15 Timing of CO Relay

- (a) Failure of the CO relay to meet its hold requirement is due, in most cases, to a faulty VR11 varistor. Check in accordance with heading I Varistor Data.
- (b) If VR11 is satisfactory, check adjustment of CO relay.

3.16 Timing of T Relay

- (a) If the T relay follows 60 IPM, its locking path is not functioning.
 - (1) To check, remove T electron tube and the relay should hold.
 - (2) If the relay holds, check the tube.
 - (3) If the tube is satisfactory, check for +130 volts at terminal 2 of the T tube socket with the T relay held operated.
 - (4) If the voltage is satisfactory, check R44, R45, and R46 resistors, C17 and C18 capacitors.

3.17 Timing of RR Relay

- (a) If unable to adjust P6 potentiometer to meet the RR relay requirements, check for:
 - (1) Defective VR17 and VR18 varistors. Test in accordance with heading I Varistor Data.
 - (2) RR relay out of adjustment.
 - (3) S relay out of adjustment.

F. Voice Amplifier

3.18 Inability to meet the receiver voice amplifier gain requirements by adjustment of the P1 potentiometer may be due to:

- (a) A faulty V1 electron tube.
- (b) Incorrect voltages. Check using Table 4A or 4B.
- (c) Defective P1 potentiometer.

3.19 If the 1000-cycle gain requirements have been met and the filter-out condition cannot be met, check the following:

- (a) The S relay is operated and R relay is released.
- (b) There is a short across terminals 9 and 10 of the N1 network.
- (c) Possible trouble condition on the lead connected to terminal 11 of the N1 network.

3.20 If the filter-in requirement cannot be met, check the following:

- (a) The RF relay is operated.
- (b) Short is removed from terminals 9 and 10 of the N1 network.

G. Blocking Amplifier

3.21 Inability to meet the blocking amplifier gain requirements by adjustment of the P potentiometer may be due to:

- (a) A faulty V electron tube.
- (b) Incorrect voltages. Check using Table 4A or 4B.
- (c) Defective P potentiometer.

3.22 If the 1000-cycle gain requirements have been met and the filter-out condition cannot be met, check the following:

- (a) The F relay is operated.
- (b) There is a short across terminals 9 and 10 (1 and 2) of the N network.
- (c) The lead on terminal 11 (3) of the N network is open.

Note: Terminals in parentheses are used by odd-numbered amplifiers.

TABLE 4A
Typical DC Voltage Readings Using M9B Meter
No Signal Input

| METER SCALE USED | VOLTMETER CONNECTIONS | | VOLTMETER READINGS |
|------------------|-----------------------|-------------|--------------------|
| | +V TERM. TO | -V TERM. TO | |
| 150V DC | 5(V1) or (V) | Grd | 120 — 123 |
| 150V DC | 6(V1) or (V) | Grd | 121 — 125 |
| 3V DC | 7(V1) or (V) | Grd | 1.8 — 2.4 |

TABLE 4B
Same as Table 4A, Except Using KS-14510 Meter

| METER SCALE USED | VOLTMETER CONNECTIONS | | VOLTMETER READINGS |
|------------------|-----------------------|-------------|--------------------|
| | +V TERM. TO | -V TERM. TO | |
| 300V DC | 5(V1) or (V) | Grd | 123 — 126 |
| 300V DC | 6(V1) or (V) | Grd | 125 — 129 |
| 3V DC | 7(V1) or (V) | Grd | 1.9 — 2.5 |

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

H. Blocking Network

3.23 The insertion loss will usually be satisfactory if the 1000-cycle loss requirement has been met. If not, proceed as follows:

Check F relay for electrical and mechanical requirements.

I. Varistor Data

3.24 When operation difficulties are believed to be due to defective varistors, their forward and reverse resistance may be tested in the circuit by means of the M9B or KS-14510 meter in accordance with Table 5A or 5B. Certain paired varistors may also be tested in the circuit by means of the KS-12054 varistor test set in accordance with the procedure of 3.25. A rigorous out-of-circuit test may also be made with the KS-12054 varistor test set.

3.25 To make an in-circuit test of paired varistors VR2 and VR3, VR4 and VR5, VR13 and VR14, remove tone input to signaling unit and block the GR relay released. Connect the

KS-12054 varistor test set to the varistor in accordance with Section 032-160-701 and test to determine if they meet the following requirements.

(a) VR2-3-4-5

Forward indication for each varistor

| SCALE | READING |
|-------|----------------------------|
| F2V | Not greater than 1.5 volts |

Reverse indication for each varistor

| SCALE | READING |
|-------|------------------------------------|
| 2 MA | Not greater than 0.8 milliamperere |

Note: The reverse indication of any one of these varistors can be as high as 1.15 milliamperes provided it and its associated pair measured in series does not have an indication greater than 0.43 milliamperere.

(b) VR13-14

Forward indication for each varistor

| SCALE | READING |
|-------|----------------------------|
| F2V | Not greater than 1.5 volts |

Reverse indication for each varistor

| SCALE | READING |
|-------|------------------------------------|
| 2 MA | Not greater than 0.7 milliamperere |

Note: The reverse indication of either of these varistors can be as high as 1.05 milliamperes provided VR13 and VR14 measured in series do not have an indication greater than 0.4 milliamperere.

3.26 The values shown in Tables 5A and 5B are intended as a guide for locating defective varistors. These values cannot be used as rigorous tests for 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. Make these tests without power on the receiver and with same conditions as the Test Notes of Tables 5A and 5B.

Note: Once a 400-type varistor is removed from the circuit, it is not advisable to re-use the varistor, as excessive heat will damage it. (See Sections 032-173-301 and 069-140-811.)

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3.27 In order to measure *reverse* resistance (that is, resistance during negative voltage application to terminal 1), connect the + jack of the KS-14510 meter or the RX pin jack of the M9B meter to terminal 1 (positive end) of the varistor. Connect the - jack of the KS-14510 meter or the X pin jack of the M9B meter to the other terminal of the varistor.

3.28 In order to measure *forward* resistance (that is, resistance during positive voltage application to terminal 1), connect the - jack of the KS-14510 meter or the X pin jack of the M9B meter to terminal 1 (positive end) of the varistor. Connect the + jack of the KS-14510 meter or the RX pin jack of the M9B meter to the other terminal of the varistor.

TABLE 5A

Varistor Ohmmeter Test Readings Using KS-14510 Volt-Ohm-Milliammeter

| VARISTOR DESIGNATION | TYPE | APPROXIMATE FORWARD RESISTANCE | | APPROXIMATE REVERSE RESISTANCE | | TEST NOTES |
|----------------------|--------------|--------------------------------|----------|--------------------------------|----------|--|
| | | SCALE | MAX OHMS | SCALE | MIN OHMS | |
| VR1 | 310A | Rx100 | 650 | Rx100 | 450 | Block GR relay operated. |
| VR2-3-4-5 | 400C | Rx10 | 350 | Rx10,000 | 100,000 | Block S relay operated. " GR " released. |
| VR6 | 400A | Rx10 | 150 | Rx10 | 350 | With "X" wiring. |
| VR7-8 | 400C | Rx10 | 350 | Rx10,000 | 122,000 | Disconnect one side of varistor. |
| VR9-10 | 400B or E | Rx10 | 135 | Rx10 | 450 | Block CO and HL relays released. Varistors and HL relay in parallel. |
| VR11 | 400B or E | Rx10 | 150 | Rx10 | 460 | Insulate 4-5 top of HL relay. Varistor in parallel with CO relay. |
| VR12 | 27A | Rx10,000 | 15,000 | Rx1000 | 60,000 | Remove RG relay. |
| VR13-14 | 400C | Rx10 | 350 | Rx1000 | 100,000 | |
| VR15-16 | 400B or E | Rx10 | 190 | Rx1000 | 50,000 | Varistors in parallel. Block GR relay operated. " M " released. |
| VR17-18 | 400B or E | Rx10 | 135 | Rx10 | 475 | Varistors and RR relay in parallel. Potentiometer P6 turned fully counter-clockwise. |
| VR19 | 400C | Rx10 | 330 | Rx1000 | 120,000 | Remove RG relay. |
| VR20 | 400B | Rx10 | 330 | Rx1000 | 50,000 | Remove RG relay. Insulate 1-2 top of S relay. |

TABLE 5B

Varistor Ohmmeter Test Readings Using M9B Volt-Ohm-Milliammeter

| VARISTOR DESIGNATION | TYPE | APPROXIMATE FORWARD RESISTANCE | | APPROXIMATE REVERSE RESISTANCE | | TEST NOTES |
|----------------------|--------------|--------------------------------|----------|--------------------------------|-----------|--|
| | | SCALE | MAX OHMS | SCALE | MIN. OHMS | |
| VR1 | 310A | Rx10 | 590 | Rx10 | 450 | Block GR relay operated. |
| VR2-3-4-5 | 400C | Rx10 | 310 | Rx1000 | 100,000 | Block S relay operated. " GR " released. |
| VR6 | 400A | Rx10 | 130 | Rx10 | 350 | With "X" wiring. |
| VR7-8 | 400C | Rx10 | 320 | Rx1000 | 122,000 | Disconnect one side of varistor. |
| VR9-10 | 400B or E | Rx10 | 125 | Rx10 | 450 | Block CO and HL relays released. Varistors and HL relay in parallel. |
| VR11 | 400B or E | Rx10 | 130 | Rx10 | 460 | Insulate 4-5 top of HL relay. Varistor in parallel with CO relay. |
| VR12 | 27A | R | 2,000 | Rx1000 | 66,000 | Remove RG relay. |
| VR13-14 | 400C | Rx10 | 310 | Rx1000 | 100,000 | |
| VR15-16 | 400B or E | Rx10 | 170 | Rx1000 | 50,000 | Varistors in parallel. Block GR relay operated. " M " released. |
| VR17-18 | 400B or E | Rx10 | 125 | Rx10 | 475 | Varistors and RR relay in parallel. Potentiometer P6 turned fully counter-clockwise. |
| VR19 | 400C | Rx10 | 300 | Rx1000 | 120,000 | Remove RG relay. |
| VR20 | 400B | Rx10 | 300 | Rx1000 | 50,000 | Remove RG relay. Insulate 1-2 top of S relay. |