TJ/TM-1 MICROWAVE RADIO
SYSTEM TESTS — TELEPHONE WITH DIVERSITY
NET LOSS MEASUREMENTS

The initial overall system level adjustments must be performed as the final adjustment in conjunction with (1) deviation (Section 409-241-503), and (2) linearity (Section 409-241-504). On a multihop system, the cumulative effect of errors introduced by the accuracy limitations of the test equipment is minimized by making system level adjustments on a tandem basis. On systems with dropping points, it is desirable to make the tests and adjustments over the longest through-paths in order to minimize these cumulative errors. The procedures outlined for in-service tests are applicable to systems employing ON2 and L multiplex. In the case of L carrier, the 64 kc pilot is used as a test signal; with ON2, the test signal will be one of the transmitted carriers.

Tests to be performed are as follows:

(a) Initial or Out-of-Service Alignment (Steps 1 to 19)

(b) In-Service Tests (Steps 20 to 36)

(c) Gain-Frequency Characteristic Tests

(1) Individual Link Tests (Steps 37 to 40)

(2) Overall System Tests (Steps 41 to 49)

APPARATUS: — (For All Tests)

2 — J99262AA TL Test Sets
1 — J68376B IF Test Set
2 — ED-59517-10, Group 9 Test Cords
1 — ED-59517-10, Group 13 Test Cord
1 — ED-59517-10, Group 24 Test Cord
1 — ED-59517-10, Group 25 Test Cord
1 — ED-59517-10, Group 26 Test Cord
1 — ED-59517-10, Group 27 Test Cord
1 — J68376A, List 1 and List 2 Transmitter Disconnect Unit
2 — J68376C Impedance Matching Test Sets
1 — KS-15538 Frequency Selective Voltmeter
4 — P2AW Test Cords
2 — P3AH Test Cords
1 — Hewlett-Packard 130-Type Oscilloscope
2 — Hewlett-Packard 400D Vacuum Tube Voltmeters (VTVM)
1 — Pomona Electronics 2BA-PT063-48 (WE) Test Cord

INITIAL OR OUT-OF-SERVICE ALIGNMENT

Alignment is performed using 100 kc and 4.5 mc tones.

On systems with dropping points, alignment is performed over the longest through-path. Intermediate dropping points must, therefore, be patched through by inserting a 6 db 25C pad between HP FL OUT and HP FL IN.

These pads are inserted progressively as one proceeds down the line and must be left in place while the system alignment procedures are being carried out.

Note: All channels transmitting in the same direction at each station along the route should be tested and adjusted before proceeding to the next station.

APPARATUS:

2 — J99262AA TL Test Sets

1 — J68376B IF Test Set

2 — J68376C Impedance Matching Test Sets

4 — P2AW Test Cords

2 — P3AH Test Cords

1 — Hewlett-Packard 130-Type Oscilloscope

1 — Pomona Electronics 2BA-PT063-48 (WE) Test Cord

STEP	PROCEDURE
1	At the transmitting terminal, energize the equipment, allow a suitable warmup period, and make test connections shown in Fig. 1.
2	Ensure that the 372A patching plugs between Y PAD OUT and TRS PAD and the correct attenuation pad, as determined in Section 409-240-503 plus 4 db, between SIG OUT and TRS IN is patched on the TJ side of the diversity pair. The TM-1 side should have 372A plugs in both positions. *Note:* An additional 4 db attenuation is required to reduce the transmitter level to the correct value when using the TJ/TM-1 diversity switch and transmission unit.
3	Adjust the frequency of the OSCILLATOR to 100 kc and the OSC LEV and ATTEN controls for an indication of −16 dbm on the VOLTMETER. *Note:* The signal input level at the transmitting terminal must be held constant in all measurements of level at the various repeaters.
4	At the next and subsequent repeaters, in order, make test connections as shown in Fig. 2 and perform Steps 5 through 14.
5	At the transmitting terminal, have the 100 kc tone removed. At the repeater under test, check that the reading of the VOLTMETER is less than −38 dbm.
6	Have the 100 kc test signal restored at the transmitting terminal with the level given in Step 3 (−16 dbm). *Note:* At repeater diversity switch units, a 6 db 25C pad should be connected between the HP FL OUT and HP FL IN jacks. The correct pads between SIG OUT and TRS IN are connected in place (see Step 2). Also check that REC OUT is patched to SW IN on both sides of the diversity pair. The correct value of attenuation pad was determined in Section 409-240-504 for the TJ receiver; install a 3 db 25F pad in REC OUT — SW IN of the TM-1 receiver.

STEP	PROCEDURE
7	Operate switch S1 on the diversity switch and transmission unit to REC Y and adjust its LOSS DB attenuator for an indication of −22 dbm on the VOLTMETER.
8	Operate switch S1 on the diversity switch and transmission unit to REC X and adjust its LOSS DB attenuator to obtain a VOLTMETER indication as close as possible to that obtained in Step 7. The optimum setting of the attenuator can best be determined by observing the indication on the VOLTMETER while rapidly switching S1 from REC X to REC Y. This optimum is reached when rapid switching causes the least observable variation of the voltmeter indication.
9	Replace the 100 kc test signal with a 4.5 mc signal at the same level (−16 dbm).
10	Operate switch S1 on the diversity switch and transmission unit to REC Y, and adjust C15 on its receiver baseband amplifier for a reading as close as possible to −22 dbm on the VOLTMETER. (C15 should be adjusted with a nonconducting tool.)
11	Operate switch S1 to REC X, and adjust the 217G cable equalizer on the TM-1 B/B balancing panel to obtain a VOLTMETER reading as close as possible to that obtained in Step 10. The optimum setting can best be determined by observing the indication of the VOLTMETER while rapidly switching S1 from REC X to REC Y. ***Note:*** Recheck that the cable equalizer adjustment did not change the 100 kc setting of Step 8.
12	Check that the same indications are obtained with the VOLTMETER connected to the other Y PAD OUT jacks.
13	Make the test connections as in Fig. 3A. With the test cord connected to the MON jacks of the second voice-frequency amplifier in the passive pilot monitor (PMI-V3B MON jacks), adjust the oscilloscope Y-axis sensitivity for a display of 5 cm. Adjust the X-axis sweep rate to approximately 5 milliseconds per centimeter. ***Note:*** The 3700-cycle radio pilot tone generated at each TJ/TM-1 diversity switch and transmission unit is used to check receiver polarity and signal degradation during the baseband switch.
14	Check that the receiver polarities on both sides of the diversity pair are the same. If the polarities are the same, the oscilloscope presentation should remain essentially unchanged when switch S1 is rapidly operated to cause several baseband switches between REC X and REC Y. If the polarity of one receiver is reversed with respect to the other, a momentary blank will appear on the oscilloscope presentation as shown in Fig. 3C. The polarity of the TM-1 baseband signal can be reversed by installing the phase inverter option in the TM-1 transmitter control unit. This option is required when the receiver beat oscillators of both radio systems are not both above or below the incoming carrier. ***Requirement:*** During the switching interval, the oscilloscope presentation should not degrade by more than 15 per cent.
15	Repeat Steps 5 through 14 at each successive repeater.
16	At the receiving terminal following the last repeater under test (Step 15), make test connections as in Fig. 4. Ensure that the proper attenuation pads are inserted between REC OUT — SW IN as was determined in Section 409-240-504 for TJ. TM-1 should have a 3 db 25F pad in REC OUT — SW IN.

STEP	PROCEDURE
17	At the transmitting terminal, have the 100 kc (or 4.5 mc) tone removed. At the receiving terminal, check that the reading of the VOLTMETER is less than −40 dbm.
18	Perform Steps 6 through 14 with the VOLTMETER reading of −22 dbm at the receiver replaced by −10 dbm in all cases.
19	This completes the line-up in one direction of transmission. To line up the system in the opposite direction, proceed as outlined in Steps 1 through 18, but with the sending oscillator at the other end of the line. Upon completion, remove all test equipment and restore the circuits to normal.

IN-SERVICE TESTS

In-service tests should be performed periodically to check the overall system levels. The suggested test intervals are outlined in Section 409-200-330. In the case of L carrier, the 64 kc pilot is utilized as a test signal; whereas with ON2 carrier, one of the channel carriers, preferably in the center of the transmitted band, is used as a test signal. Tests to be performed should be in the following sequence:

(a) Measurement of the test signal at the transmitting terminal.

(b) Measurement of the test signal at each succeeding repeater in sequence and then at the distant terminal, adjusting the receiver levels as required. At each station along the route, all the channels transmitting in one direction should be tested and adjusted before proceeding to the next station.

Caution: All in-service tests should be performed with extreme care to preclude the possibility of service interruption or impairment.

APPARATUS:

J68376C Impedance Matching Test Set

KS-15538 Frequency Selective Voltmeter

Hewlett-Packard 200CD or 650A Oscillator*

Hewlett-Packard 400D Vacuum Tube Voltmeter

P3AH Test Cord — Supplied with J68376C Impedance Matching Test Set

P2AW Test Cord — Supplied with J68376C Impedance Matching Test Set

ED-59517-10, Group 9 Test Cord — Supplied with J68376C Impedance Matching Test Set

ED-59517-10, Group 13 Test Cord — Supplied with J68376C Impedance Matching Test Set

ED-59517-10, Group 24 Test Cord

ED-59517-10, Group 25 Test Cord

ED-59517-10, Group 26 Test Cord

ED-59517-10, Group 27 Test Cord

* For systems whose baseband frequency requirements do not exceed 600 kc, use the 200CD oscillator. System transmitting more than 600 kc require the use of a 650A oscillator.

STEP	PROCEDURE
20	Apply power to the KS-15538 frequency selective voltmeter for at least 30 minutes before making measurements. ***Note:*** A J64037 transmission measuring set may be used in place of the KS-15538 voltmeter as outlined after Step 36.
21	Calibrate the frequency selective voltmeter against the Hewlett-Packard 400D VTVM as follows: (a) Set up the circuit as in Fig. 5. (b) Calibrate the KS-15538 voltmeter according to the instructions supplied with the voltmeter, using the injection oscillator. (c) Set the SELECTOR switch on VM-BAL 135Ω BRG. (d) Set the oscillator to the frequency of the test tone being measured. (e) Adjust the oscillator output to obtain a reading of 3.5 mv on the VTVM and carefully tune the frequency selective voltmeter for maximum meter indication with the ATTENUATOR DB switch on −40. (f) Adjust CAL 2 (IF GAIN) control to obtain a meter reading of 0 DECIBELS. This completes the calibration.
22	At the transmitting terminal, connect the frequency selective voltmeter, with the SELECTOR switch on VM-BAL 135Ω BRG, to one of the TRS MON jacks on the appropriate diversity switch and transmission unit by means of an ED-59517-10, Group 25 cord.
23	Observe and record the level of the test signal. At the same time, determine from personnel at the first attended office preceding the radio transmitter the level of the test signal at this point and record this level also. ***Note:*** In subsequent measurements, it is necessary to know how the level of the test tone applied to the radio system from the multiplex varies during the time required to make alignment checks at the various repeater stations. For any given system there will be a fixed relation between this level and the test tone level at the first attended office preceding the radio transmitter. The two measurements in Step 23 establish this relationship. Thereafter, by monitoring this test tone level, the variation of the multiplex input to the radio transmitter can be determined. The necessary test gear is available at an attended office, so that it is not necessary to have extra test equipment or personnel at the transmitting terminal as measurements are made at successive repeaters.
24	Transfer the frequency selective voltmeter to the other TRS MON jack and check that the level is the same as in Step 23.
25	At the following repeater, connect the calibrated frequency selective voltmeter to the REC MON jacks on one side of the diversity pair by means of an ED-59517-10, Group 24 cord. The SELECTOR switch on the voltmeter must be set on VM-BAL 135Ω BRG.
26	Determine from personnel at the attended office preceding the transmitting terminal the level of the test signal at that point from which the test tone level at the transmitting terminal can be determined.

STEP	PROCEDURE
27	Observe and record the level of the received test signal. The nominal level of the test signal at the REC MON jacks should be 12 db greater than that at the TRS MON jack of the preceding transmitter. If it is not, adjust the associated LOSS DB attenuator. ***Note:*** The absolute level of the test signal is discussed under the heading Pilot Levels, at the end of this test (Step 36).
28	Transfer the frequency selective voltmeter to the REC MON jacks in the other side of the diversity pair and adjust the LOSS DB attenuator in that path for the same indicated test signal level as observed in Step 27.
29	Transfer the voltmeter to either one of the TRS MON jacks on the diversity switch and transmission panel and operate switch S1 rapidly between REC X and REC Y.
30	Equalize the receiver output levels by adjusting the LOSS DB attenuator in the side of the diversity pair referred to in Step 28. ***Note:*** In the above adjustment, the number of switches between REC X and REC Y should be kept to a minimum.
31	Transfer the voltmeter to the other TRS MON jack and check that the test tone level is the same in both transmitting legs and equals within 1.0 db to that measured at the transmitting terminal.
32	At each succeeding repeater, repeat Steps 25 through 31.
33	At the receiving terminal, repeat Steps 25 through 28.
34	The receiver output levels are equalized in a manner similar to that described in Steps 29 and 30 except for the point at which the KS-15538 voltmeter is connected. Make this connection as follows: (a) On systems carrying up to 48 channels of ON2, connect between REC (J11) and GRD (J13) on the J98706W channel combining panel. (b) On systems carrying between 48 and 96 channels of ON2, connect between IN (J56) and GRD (J5) on the J98706U channel carrier to radio multiplex mounting. (c) On systems carrying L multiplex, connect to the appropriate HYB IN jack on the wire-line entrance link bay. ***Note:*** Where the physical arrangement of equipment at the receiving terminal makes it impractical to perform Step 34, the receiver levels should be adjusted individually as described in Steps 25 through 28. In this case, extra care must be taken to adjust these levels as near to equality as possible since the comparison test of Step 29 cannot be made.
35	This completes the line-up in one direction of transmission.
36	To line up the system in the other direction, repeat Steps 20 through 35, but in this case start at the other end of the line. Upon completion, remove all test equipment and restore the circuits to normal.

USE OF THE J64037B TRANSMISSION MEASURING SET (TMS) IN PLACE OF THE KS-15538 CARRIER FREQUENCY VOLTMETER

A J64037B TMS, in conjunction with a 124:75-ohm repeating coil and an 11B attenuator may be used to make 124-ohm bridging measurements. The test connections are shown in Fig. 6.

Due to the loss of the 11B attenuator, the level in decibels referred to 124 ohms is given by the TMS reading plus 30 db.

PILOT LEVELS

The nominal pilot levels at the MX OUT jack on the diversity switch and transmission panel are as follows:

L Carrier (64 kc Pilot)	−44 dbm
ON Carrier (Channel Carriers)	−15 dbm

The signal level applied to the radio system will depend upon the number of channels being transmitted and is determined by the value of the pad between MX OUT and HP FL IN at the transmitting terminal. On any particular system, the value of this pad will have been determined when the system was engineered. If we designate this pad as A db, the pilot levels at various points in the system will be as follows:

	L CARRIER (64 KC PILOT) DBM	ON CARRIER (CHANNEL CARRIERS) DBM
REC MON & HP FL OUT	−(34 + A)	−(5 + A)
HP FL IN	−(40 + A)	−(11 + A)
TRS MON	−(46 + A)	−(17 + A)

The above levels apply at the transmitting terminal and at all subsequent repeaters including the receiving terminal unless there are dropping points. At a dropping point (ON carrier), the levels at the MX OUT jack have been fixed at −35 dbm, so that if B db is the loss of the pad between MX OUT and HP FL IN, the system levels from this point on will be as follows:

	ON CARRIER (CHANNEL CARRIERS) DBM
REC MON & HP FL OUT	−(25 + B)
HP FL IN	−(31 + B)
TRS MON	−(37 + B)

At subsequent dropping points, the value of B may change, but the above table will still apply.

GAIN-FREQUENCY CHARACTERISTIC TESTS

Overall gain-frequency tests can be made only at initial installation or on an out-of-service basis since both sides of the diversity pair come together at each diversity switch and transmission unit. In-service gain-frequency measurements can be made, however, on an individual hop basis. Individual links are measured between TRS TST and REC OUT, while overall measurements are made between HP FL IN and HP FL OUT. Measurements will be made up to 4.5 mc.

APPARATUS:

2 — J99262AA TL Test Sets
1 — J68376A, List 1 and List 2 Transmitter Disconnect Unit
2 — J68376C Impedance Matching Test Sets
4 — P2AW Test Cords
2 — P3AH Test Cords
1 — J68376B IF Test Set

STEP	PROCEDURE
	INDIVIDUAL LINK TESTS
	Gain-frequency measurements on individual links can be made on an in-service or out-of-service basis. In the former case, the link must be removed from service in accordance with the procedures described in Section 409-240-500.
37	With a talking circuit established, make test connections as in Fig. 7 at the transmitter and Fig. 8 at the receiver. Adjust the test oscillator at the transmitter to 100 kc and its OSC LEV control for a VOLTMETER indication at the receiver of −6 dbm. This is a reference level for further measurements.
38	At the transmitter, observe and record the indication on the monitor VOLTMETER. ***Requirement:*** Between −17 and −22 dbm. This is the test signal level and must be maintained over the frequency ranges to be tested. If the requirement is not met, check hop deviation per Section 409-241-503.
39	Maintain a constant output level of the test oscillator as observed in Step 38 and vary the frequency of the oscillator as outlined in the table below. Observe and record the indications on the VOLTMETER at the receiver. The requirement limits are listed for each frequency.

FREQUENCY	REQUIREMENT LIMITS DBM
2.6 kc	−7 ±0.5
100 kc	−6
1.0 mc	−6 ±0.25
4.5 mc	−6 ±0.25

40	The high-frequency end can be adjusted by means of capacitor C15 in the input circuit of the receiving baseband amplifier for TJ and by means of the 217G cable equalizer for TM-1.
	OVERALL SYSTEM TESTS — INITIAL OR OUT OF SERVICE
41	Make the test connections shown in Fig. 1 at the transmitting end of the system.
42	At the receiving end of the system, set up the test circuit as in Fig. 4.
43	Operate switch S1 on the diversity switch and transmission unit at the receiving end to either REC of the diversity pair.

STEP	PROCEDURE
44	Adjust the test oscillator to 100 kc and its OSC LEV control for an indication at the receiver of −6 dbm as observed on the VOLTMETER. This is a reference level for further measurements.
45	At the transmitter, observe and record the indication on the VOLTMETER, which should be between −17 and −19 dbm. This is the test oscillator output level and must be maintained over the frequency ranges to be tested.
46	If the level of Step 45 cannot be obtained, check hop deviation per Section 409-241-503.
47	Maintain a constant output level of the test oscillator as observed in Step 45, and vary the frequency of the oscillator as outlined in the table below. Observe and record the indications on the VOLTMETER at the receiver. The requirement limits are listed for each frequency.

FREQUENCY	REQUIREMENT LIMITS DBM
100 kc	−6
1.0 mc	−6 ±0.5
4.5 mc	−6 ±0.5

Note: The limits shown in the above table apply to a system of maximum length (10 hops). Shorter systems should be considerably flatter than this.

48	If the requirements of Step 47 are not being met at the high-frequency end of the band, it will be necessary to isolate the troublesome link.
49	Operate switch S1 on the diversity switch and transmission unit at the receiving end of the system to the other REC and repeat Steps 44 through 48.

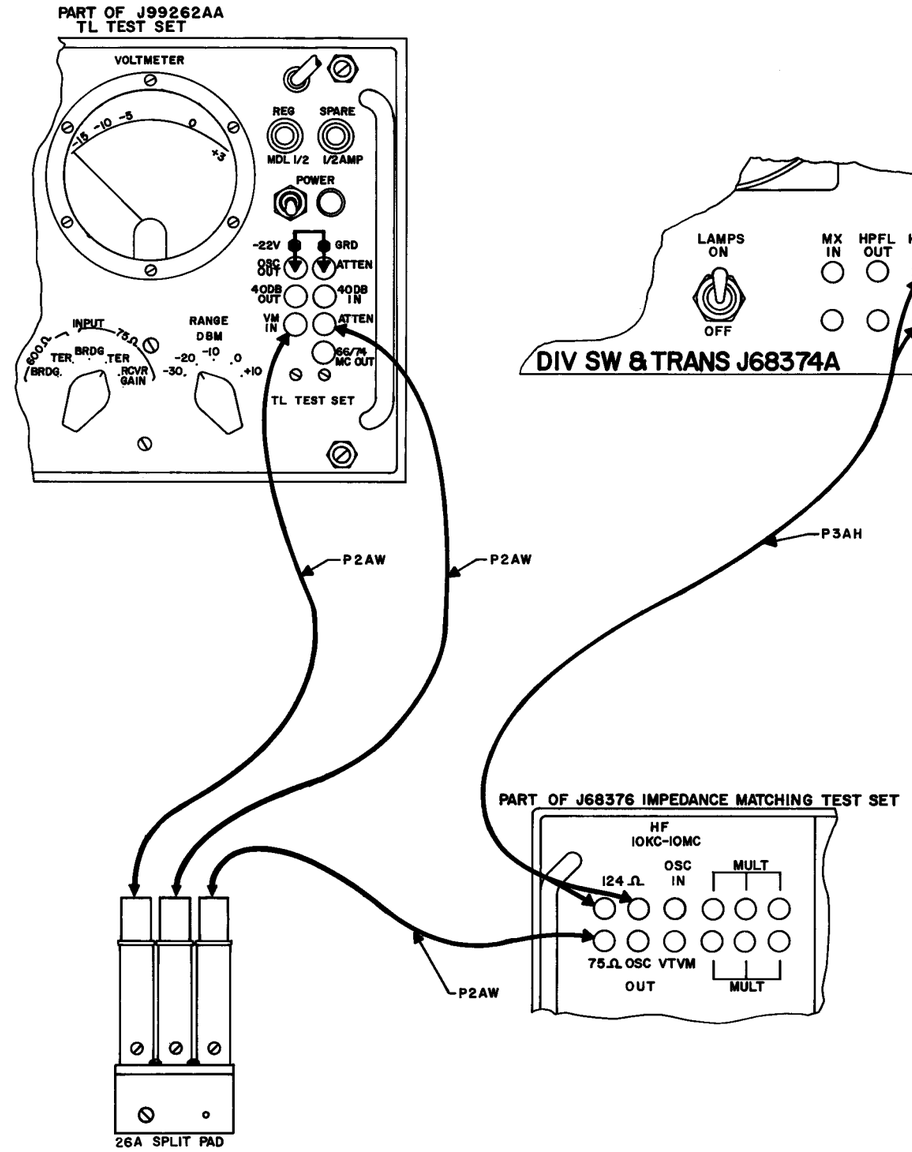


Fig. 1 – Test Connections at Transmitting Terminal

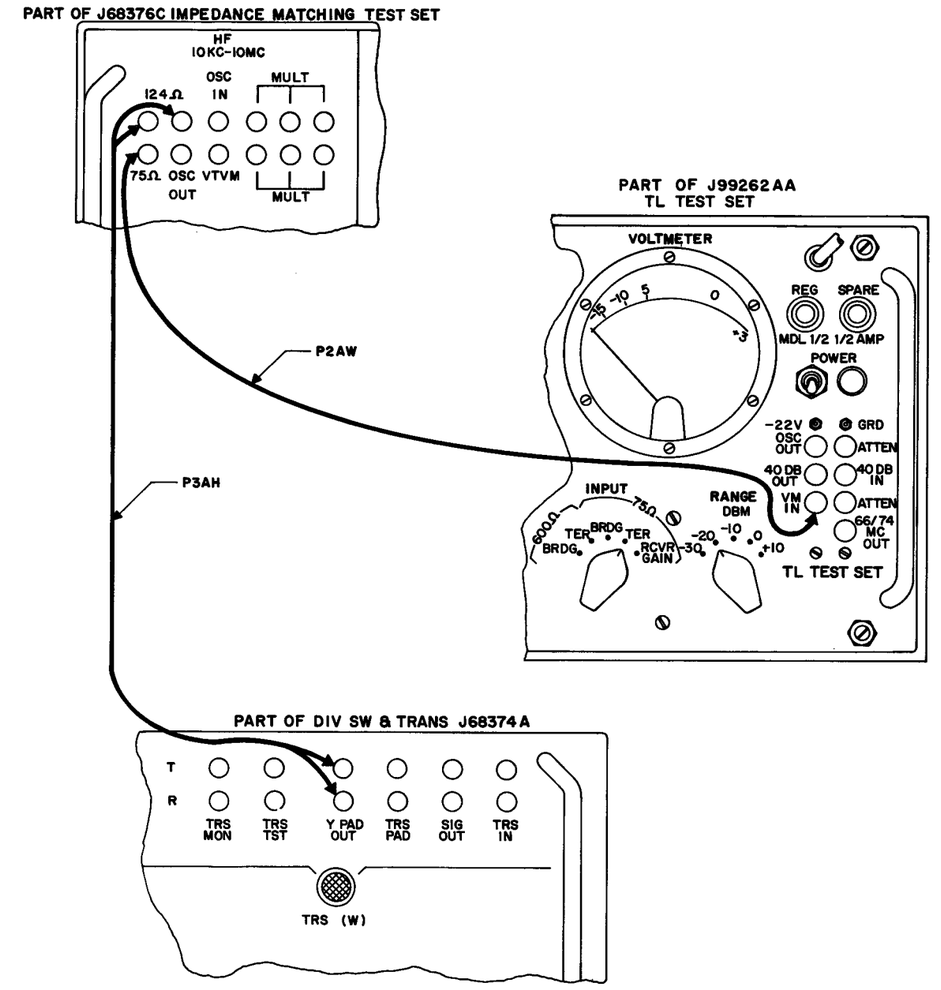
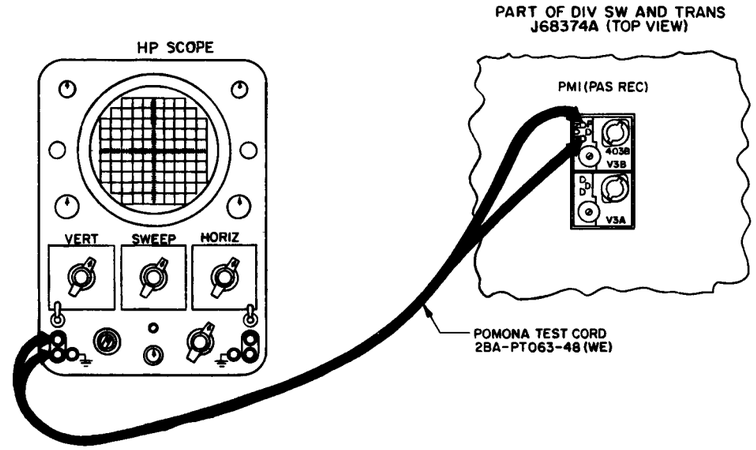
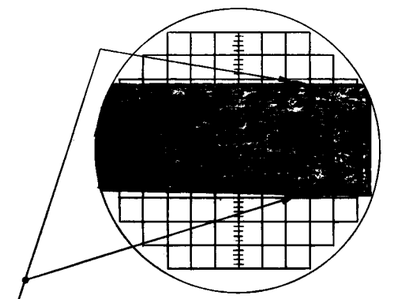


Fig. 2 – Test Connections at Repeater Stations



TEST CONNECTION FOR CHECKING RECEIVER POLARITY

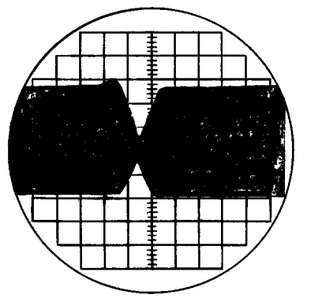
FIG. 3A



CORRECT RECEIVER POLARITY. AMPLITUDE VARIATION LESS THAN 10%. TRANSIENTS MAY APPEAR ALONG THE HORIZONTAL AXIS OF THE PRESENTATION DURING THE SWITCHING INTERVAL.

CORRECT RECEIVER POLARITY

FIG. 3B



REVERSED RECEIVER POLARITY

FIG. 3C

Figs. 3A, 3B, and 3C – Receiver Polarity

NOTE:

1. DIMENSIONS BETWEEN DIMENSIONS.

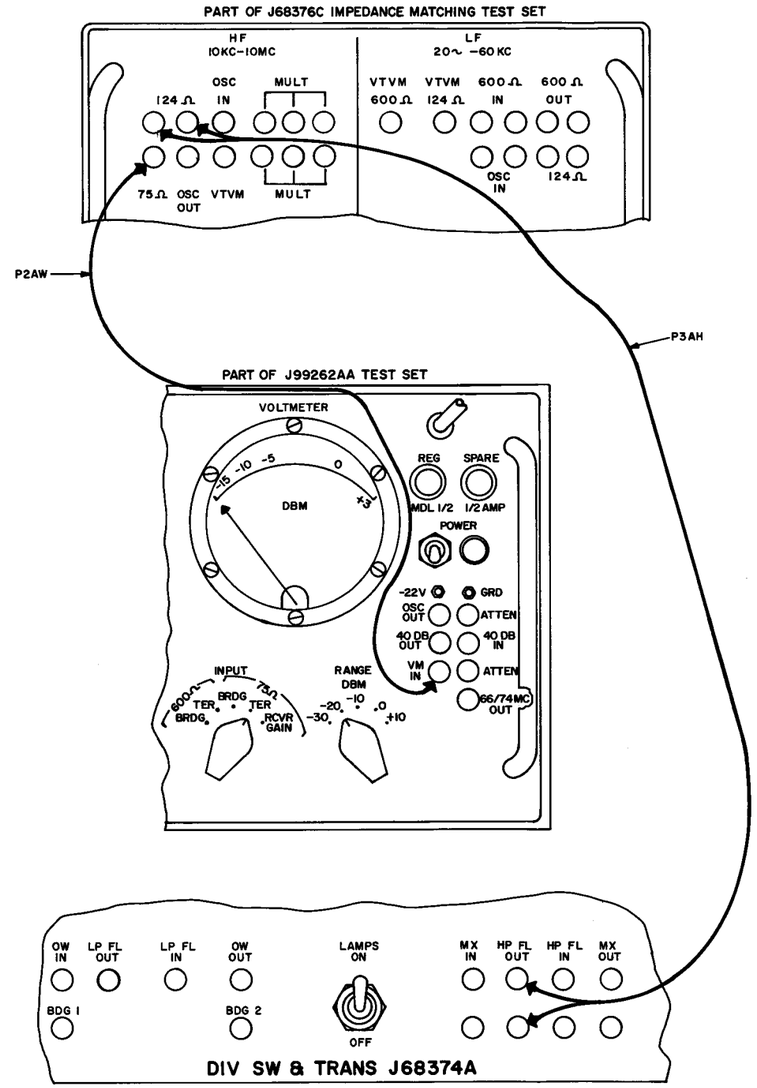


Fig. 4 – Test Connections at Receiving Terminal

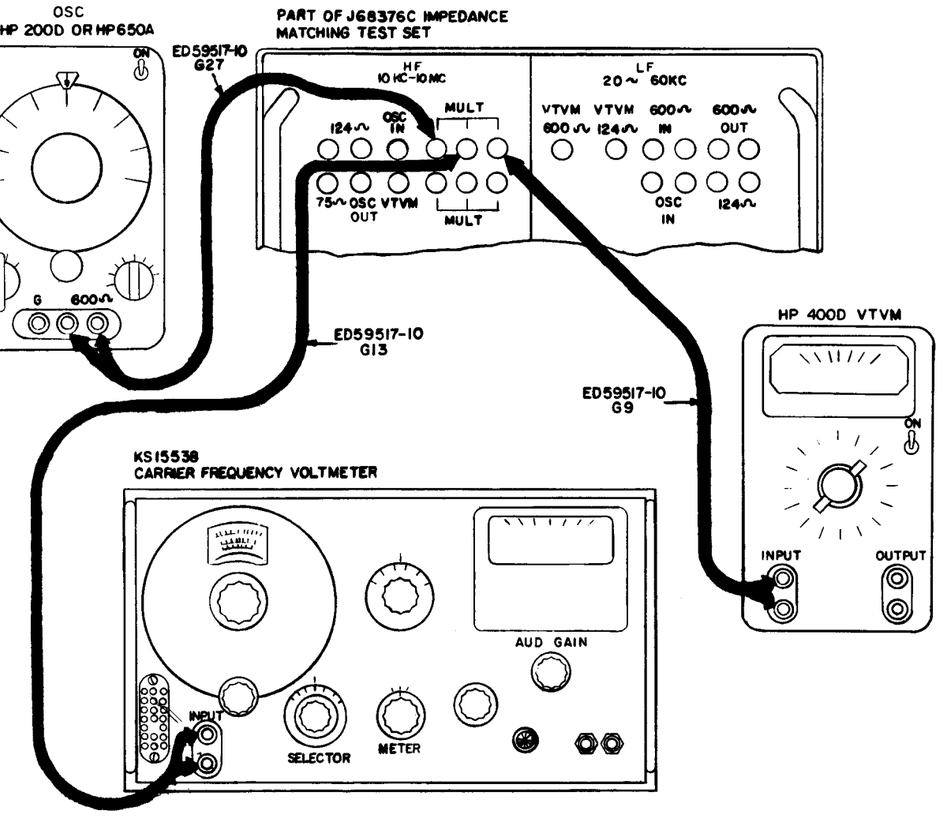
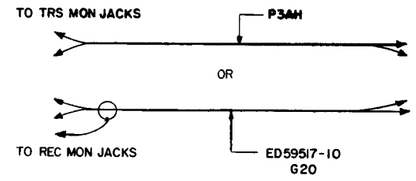


Fig. 5 – Calibration of KS-15538 Carrier Frequency Voltmeter Against Hewlett-Packard 400D Vacuum Tube Voltmeter



J64037B TMS

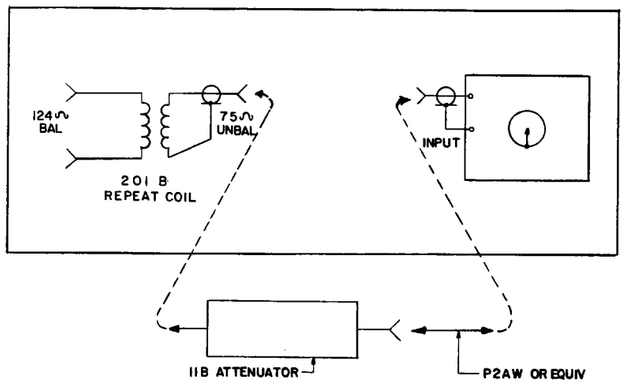


Fig. 6 – Bridging Measurements Using the J64037B Transmission Measuring Set in Place of the KS-15538 Carrier Frequency Voltmeter

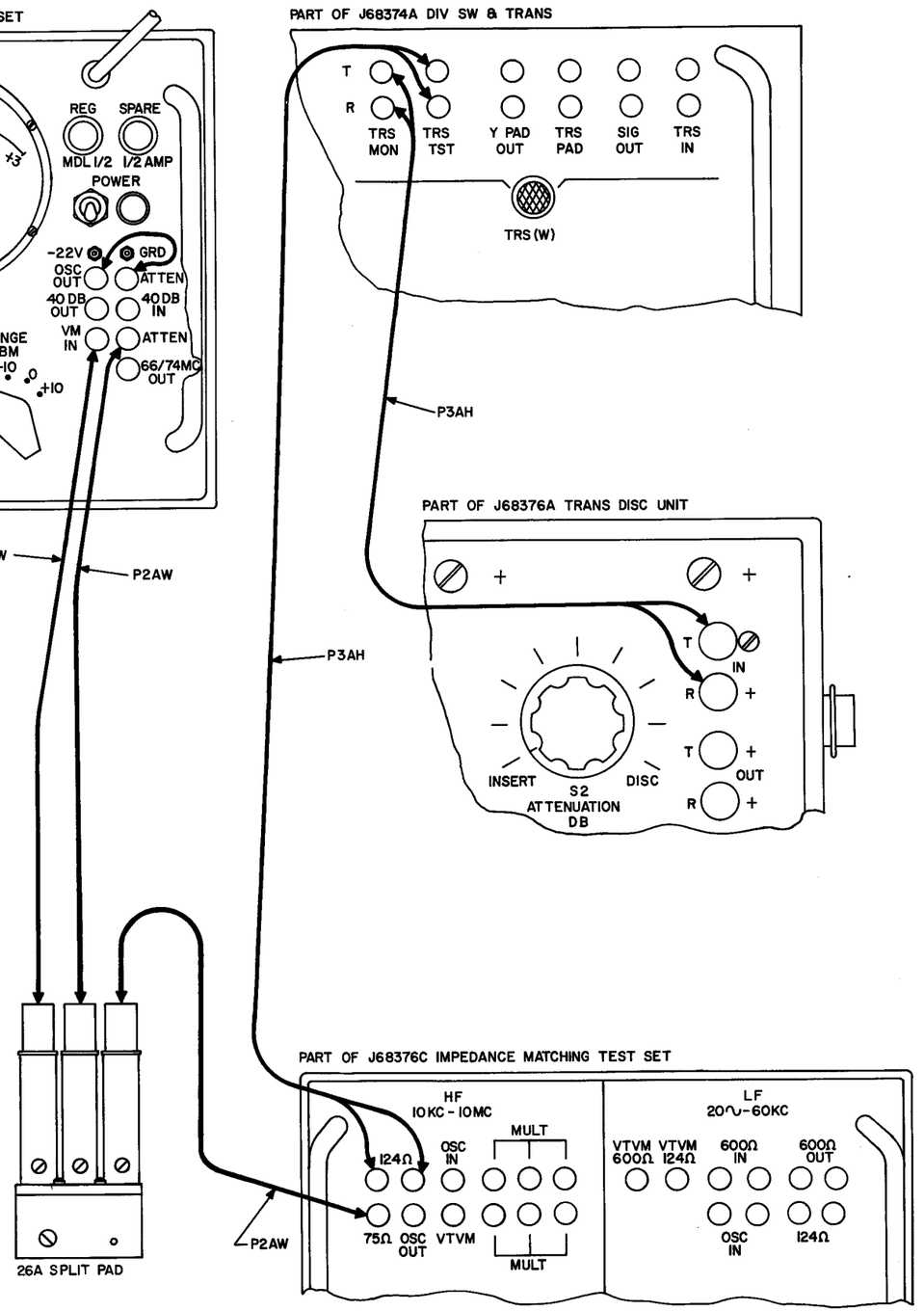


Fig. 7 – Gain-Frequency Test Connections at Transmitter

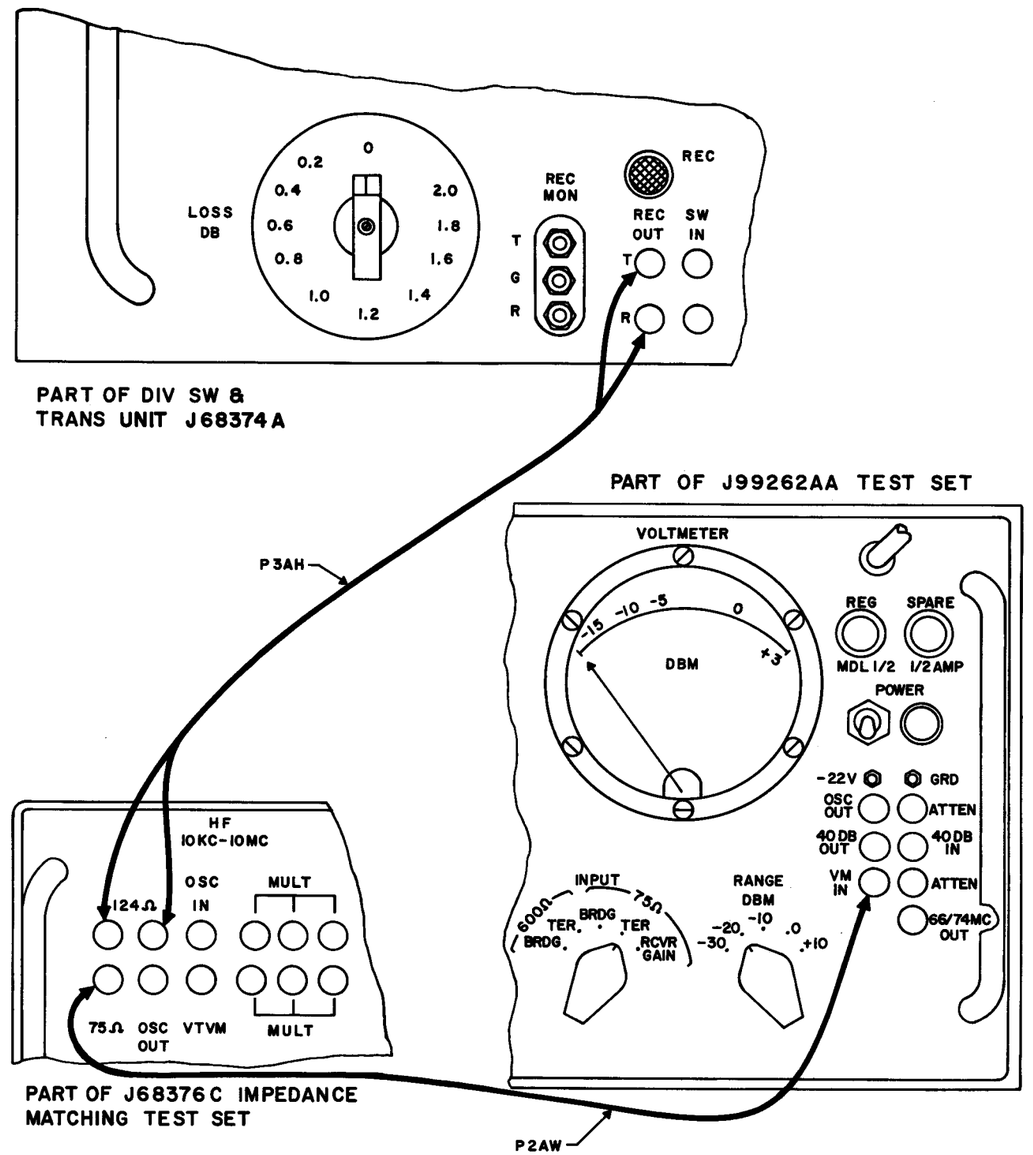


Fig. 8 – Gain-Frequency Test Connections at Receiver