MICROWAVE ANTENNAS

RETURN LOSS MEASUREMENTS

TD-2 SYSTEM—USING 45A TEST SET

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1. GENERAL

1.01 This section describes the equipment and detailed procedures for making the return loss measurements, using the J68345A test set. The general procedure, together with a brief outline of the necessary theory, is given in Section 402-400-100.

1.02 This section is reissued to make corrections in the Step-by-Step Procedure and in Fig. 7 and 9. This reissue does not affect the Equipment Test List.

1.03 The increased channel capacity of the TD-2 microwave radio has required the use of an 8A isolator or a 2A circulator in the common waveguide run to reduce echo-type cross-modulation noise. When antenna system return loss tests are to be made on a run containing an 8A isolator, the isolator must be physically removed from the waveguide run by sliding it in a direction that is perpendicular to the wide side of the waveguide. A section of waveguide must then be inserted in the same manner for the measurements.

> ***Warning: Possible radiation hazard! Do not look into a transmitting waveguide or expose any part of the head or torso to the end of, or area adjacent to, an opened waveguide flange while the RF equipment is energized. The power density near the end of or adjacent to an opened flange of an energized transmitting waveguide can cause damage to living tissues. The eyes, internal, and reproductive organs are especially susceptible to this damage.***

If the 8A isolator is not removed, any reflection from a point beyond the isolator is attenuated by more than 30 dB; hence, the reflection will not be visible. When a 2A circulator is used, the circulator may be electrically removed by removing the 520B termination and replacing it with a shorting plate. The shorting plate converts the 2A circulator to a low loss in both directions and tests may then be made through it.

1.04 This test employs a 1A hybrid junction and a movable short circuit, in conjunction with the J68345A test set. The waveguide and antenna system are swept through a 20-MHz range at RF and any impedance mismatch produces amplitude ripples, which are displayed on an oscilloscope. These ripples are then evaluated to give return loss in dB. Maximum return loss represents the best impedance match, as well as less possibility of intermodulation noise caused by echoes in the waveguide.

1.05 Because of the high level test signal required to make return loss measurements on receiving antenna systems, it is possible to cause interference to any receiving channel separated by only 20 MHz from the channel being used. Therefore, when interstitial channels are being employed, the receiving channels that are only 20 MHz away must be removed from service before these tests can be made.

1.06 Single-antenna systems may be measured in the same way as normal 2-antenna systems as long as the requirement in 1.05 is met.

1.07 Tests made on channel separation networks have indicated that each network may not have a good return loss across the entire 3700- to 4200-MHz band. For example, the channel 1 separation network may have a much lower return loss at the channel 6 frequencies. Should channel 6 be selected to make antenna return loss measurements, an indication of poor return loss may be seen due to the lower return loss of the channel 1 network. When possible, the channel closest to the waveguide system should be used to prevent the return loss of the networks from giving false indications of poor antenna return loss.

2. RETURN LOSS MEASUREMENT OF ANTENNA SYSTEM

A. Required Equipment

2.01 The following equipment is needed:

1—1A Hybrid Junction

2—Variable RF Attenuators, 0- to 20-dB, ED-63927-70, G2

1—Movable Short Circuit, ED-64021-01, G1

1—128S Precision Termination

1—J68345A, (45A) Test Set

1—Oscilloscope (optional), DuMont Type 304-A or 304-AR

B. Method of Operation

2.02 Set up the equipment as shown in Fig. 1 and 8.

Caution: Before being connected to the antenna system, the test set must be set to the proper channel frequency and adjusted to the proper level as in 2.06.

If the common waveguide run has an 8A isolator or a 2A circulator installed, the 8A isolator must be physically removed or the 2A circulator must be electrically removed as described in 1.03. Connect AT3 directly or through a short cable transducer assembly to the waveguide of the antenna system to be checked. If the system has been fully turned down, this can be done simply by disconnecting the appropriate waveguide from the TD-2 equipment bay. (Use a sling to hold the attenuators and other test gear in place.) Under these conditions, any frequency in the TD-2 band may be used for the test except receiving channel frequencies of other routes at the same station. De-energize the TD-2 transmitter by removing the IF drive to the transmitter or by pulling the plate fuse in the microwave generator.

2.03 It is not always possible to obtain a full system turndown; in such cases, a turndown on any one channel will do except as noted in 1.05. If the antenna system under test is connected to the receiver bays, AT3 can be connected directly to the receiver beat frequency rejection filter. This is done by removing the receiver-converter and IF preamplifier. (See Fig. 2.) The test frequency must be that of the receiver removed.

2.04 To measure a transmitting antenna and waveguide system, the transmitter amplifier first must be removed. Attenuator AT3 is then connected to the output monitor directional coupler. This cannot be done directly, so transducers must be used. Figure 3 shows a cable transducer assembly, but a 90-degree E-plane waveguide bend can be used instead. (Use a sling to prevent any damage to the equipment.) The test frequency must be the same as that of the transmitter removed.

2.05 Note that the cable length of the transducer assembly in Fig. 3 should not exceed 12 inches. A cable made up especially for this measurement is helpful.

C. Step-by-Step Procedure

2.06 Proceed in steps, as follows:

(1) Set up the equipment as in Fig. 8, and

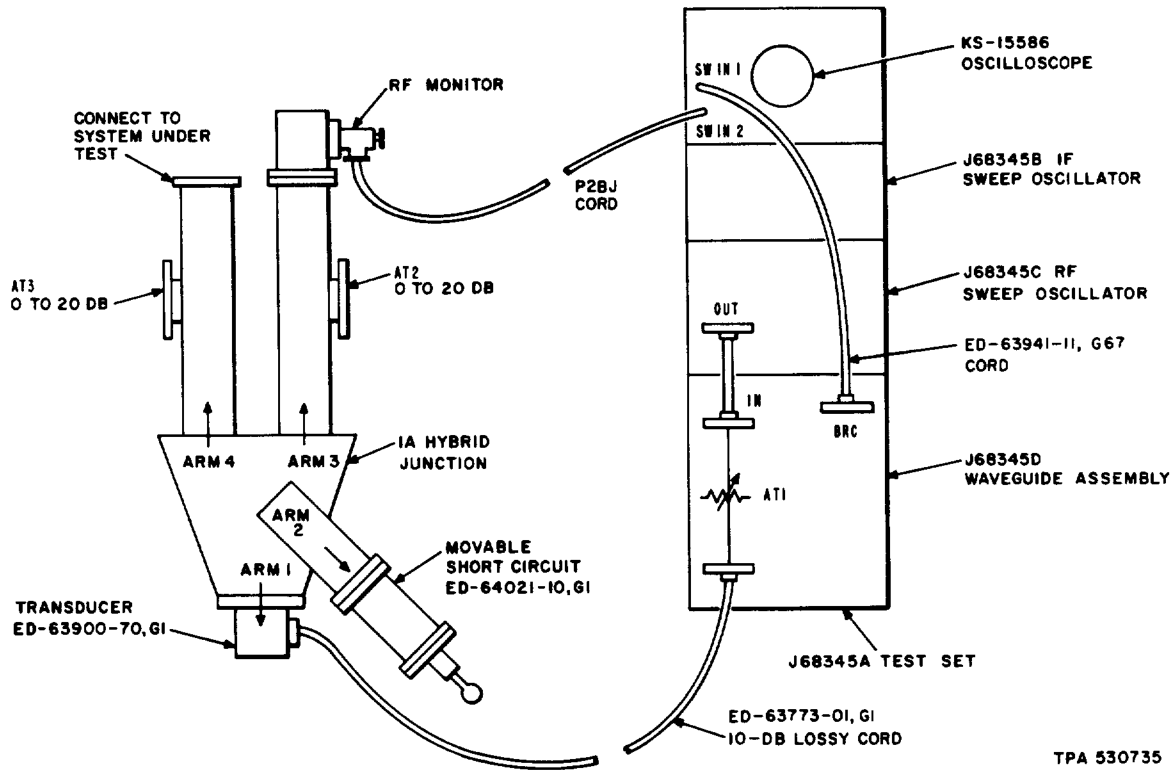


Fig. 1—Return Loss Measurement Test Setup Using the J68345A Test Set

(a) Connect the output of the calibrated RF monitor to the SW IN 1 jack on the test set.

(b) Set AT1 to 3 dB, AT2 to 5 dB, and AT3 to 20 dB.

(2) Adjust the RF frequency meter to the desired frequency. Adjust the RF sweep oscillator to sweep ±10 MHz, with the pip of the frequency meter at approximately midband on the oscilloscope. (This is easier to do if two frequency meters are available to provide two pips, one at −10 MHz and one at +10 MHz, on the sweep.) It is especially important to limit the oscillator sweep width to ±10 MHz to prevent interference into adjacent channels which are in service.

(3) Note the position of the SWEEP switch; then turn it to the OFF position, and adjust the frequency by observing the dip of the trace caused by the frequency meter, using the FEEDBACK tuning control. Adjust the RF oscillator to the midband frequency of the channel under test.

(4) Remove the output of the calibrated RF monitor from the SW IN 1 jack and connect it to the MTR RF jack. Turn the MTR switch on the RF sweep oscillator to the RF DBM position and adjust the output level. The desired output, as indicated on the meter, is equal to 21 dBm minus the marked loss of the BR C output of the waveguide assembly. This establishes the output of the oscillator at +21 dBm.

(5) Return the output of the calibrated RF monitor to the SW IN 1 jack and return the SWEEP switch to its previously noted operating position. Use the pip of the frequency meter, with the X controls on the oscilloscope, to adjust the horizontal gain on the oscilloscope to fit the 20-MHz sweep between the heavy vertical lines on the screen. This sets the frequency scale so that one small division on the oscilloscope equals 2 MHz. This is easier to do when using two pips from two frequency meters, as mentioned in Step 2.

(6) Connect the test set to the antenna system.

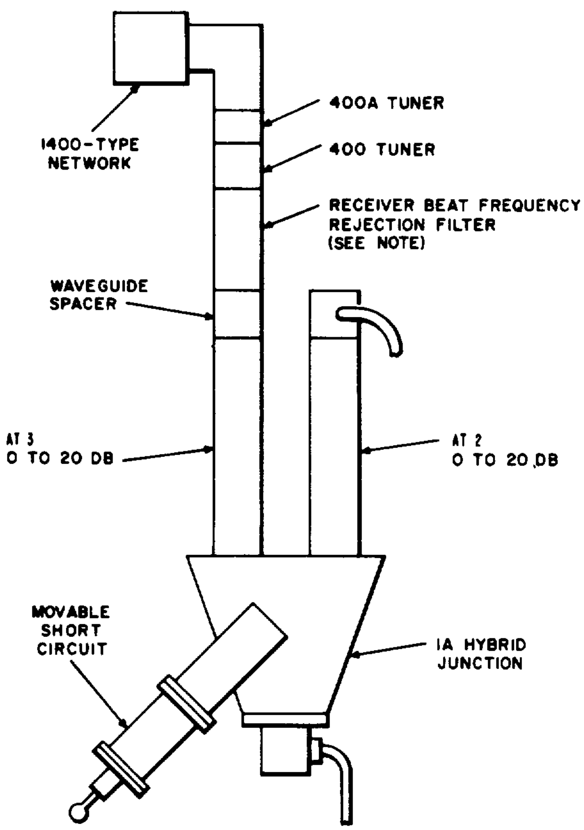


Fig. 2—Test Setup and Receiver Waveguide

(7) Adjust the movable short circuit until the test trace is horizontal and at its highest point on the screen. This adjustment balances the hybrid and is important. ***It must not be disturbed*** until the test is finished.

(8) Operate the ADJUST INPUT 1 control to make the two traces coincide. If the traces cannot be made to coincide, interchange the SW IN 1 and SW IN 2 connections.

(9) Decrease AT1 by 1 dB and adjust the vertical gain of the oscilloscope to separate the two traces by 1 inch. This establishes a vertical scale calibration of 1 dB equals 1 inch.

(10) Restore AT1 to 3 dB. The traces should again coincide within one-twentieth (0.05) of an inch. If they do not, repeat Steps 7, 8, and 9. The test trace may be slightly elliptical at this point. This is normal and is no cause for concern.

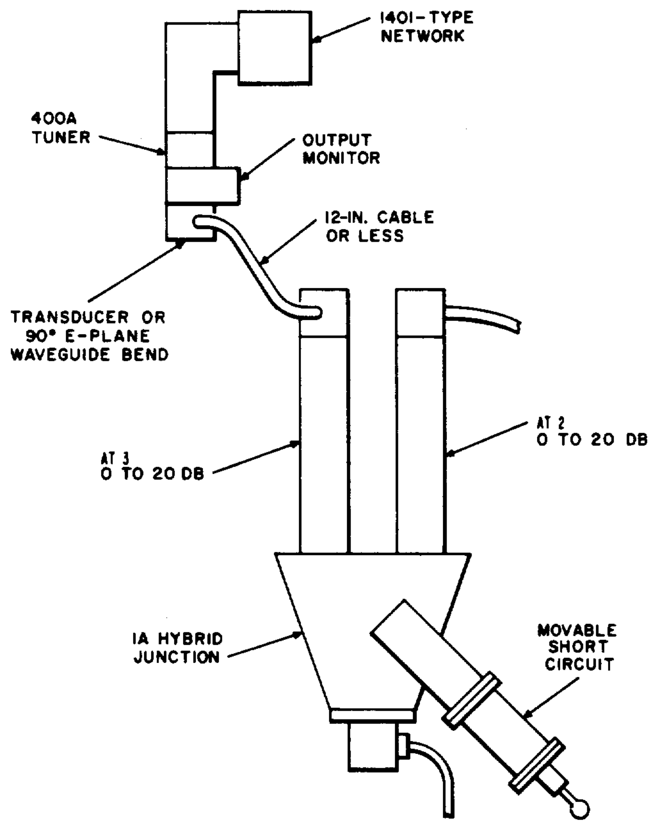


Fig. 3—Test Setup at Transmitter Waveguide

(11) Set AT3 to 0 dB. The ripple that now shows on the screen is an indication of the return loss of the antenna system under test.

> ***Note:*** It is desirable to take photographs of the ripples obtained on the oscilloscope display. The DuMont type 304-A or 304-AR oscilloscope has an illuminated scale, which shows clearly on photographs. This oscilloscope also has a shield which can be used to mount a Polaroid camera for taking pictures. Part 4 describes a very simple modification which may be made to the DuMont oscilloscope to adapt it for this use.

D. Comparison of Observed Ripple Amplitude with Objectives

2.07 In order to determine if an antenna system will meet the objectives for return loss, it is necessary to make a Fourier analysis (separation into individual frequency components) of the waveform on the oscilloscope. Frequently, impedance irregularities at different locations in the antenna system result in several waveguide echoes. Echoes from different sources will have different amplitude and phase relationships on the transmission line. The ripple pattern must be analyzed by observing the peak-to-peak amplitude and the frequency spacing between peaks of the individual ripples which compose the ripple pattern within the 20-MHz bandwidth. Once determined, the amplitude and frequency spacing of the ripple cycle can be compared with the objectives shown in Fig. 4.

Note: Under certain conditions, a modification of the Fig. 4 requirements will be necessary. The peak-to-peak amplitude of ripple components with a frequency spacing corresponding to the distance between the measuring point and the systems combining network (1407A) shall not exceed 0.5 dB. For example, if the measuring distance is 50 feet with a corresponding ripple frequency spacing of 7.7 MHz, the normal peak-to-peak ripple amplitude requirement as shown in Fig. 4 is not to exceed 0.35 dB. In this case, the 0.5-dB requirement applies instead. For all other ripple components, the Fig. 4 requirements apply.

E. Locating the Reflection Sources

2.08 A rule of "one ripple cycle per 20 feet" can be used to find the approximate location of an impedance irregularity causing reflections in the antenna system. Once the ripple pattern is analyzed to determine the number of ripple cycles within the 20-MHz sweep, the distance to the irregularity can be more accurately determined using Fig. 5. For example, if ripple cycles were observed that had a frequency spacing of 2 MHz between peaks (or there were 10 Hz per 20-MHz sweep), the distance to the irregularity causing the reflection would be 192 feet.

F. Return Loss Measurements for Individual Parts of the Antenna System

2.09 The ripple amplitude is affected by waveguide loss. If it is desirable to calculate the return loss of an individual part of the antenna system, such as the antenna, it is necessary to account for the waveguide loss. For example, the ripple pattern is first analyzed to determine the amplitude of the ripple due to the antenna mismatch. This ripple amplitude is converted to return loss by means of Fig. 6, line B. The loss of the waveguide is then subtracted from the return loss obtained above. The result will be the actual return loss of the antenna.

2.10 In practice, it is sufficiently accurate to assume a loss for rectangular copper waveguide of 0.009 dB per foot and a loss for circular waveguide of 0.004 dB per foot. Since the ripple is caused by a wave traveling out to the mismatch and back again, the total length of waveguide to be accounted for is twice the distance to the mismatch. For instance, if a discontinuity with a ripple amplitude of 0.1 dB (peak-to-peak) has been located at a point 250 feet away (including 50 feet of rectangular and 200 feet of circular waveguide), the indicated return loss corresponding to 0.1 dB ripple measured with this test setup is 38 dB.

The waveguide loss is:

$(50 \times 2) \times 0.009 = 0.9$ dB, in the rectangular waveguide

$(200 \times 2) \times 0.004 = 1.6$ dB, in the circular waveguide

$0.9 + 1.6 = 2.5$ dB

Therefore the actual return loss is 38 - 2.5 = 35.5 dB.

3. CHECKING SLOPE AND TUNING OF FILTERS AND TUNERS

3.01 Excessive slope may be encountered when the test equipment is connected to the receiver beat frequency rejection filter or the transmitter output monitor. If this happens, proceed as follows.

(1) Remove the tuners (with the exception of the 400A tuner associated with the 1400- and 1401-type networks), filters, etc from the 1400- or 1401-type network and check again directly into the 1400- or 1401-type network.

(2) If the slope now disappears, check the filter and tuner assemblies, as in Step 4 below. If the slope is still evident, disconnect the common waveguide run from the repeater bay. Then, starting with Step 7 in 2.06, repeat the return

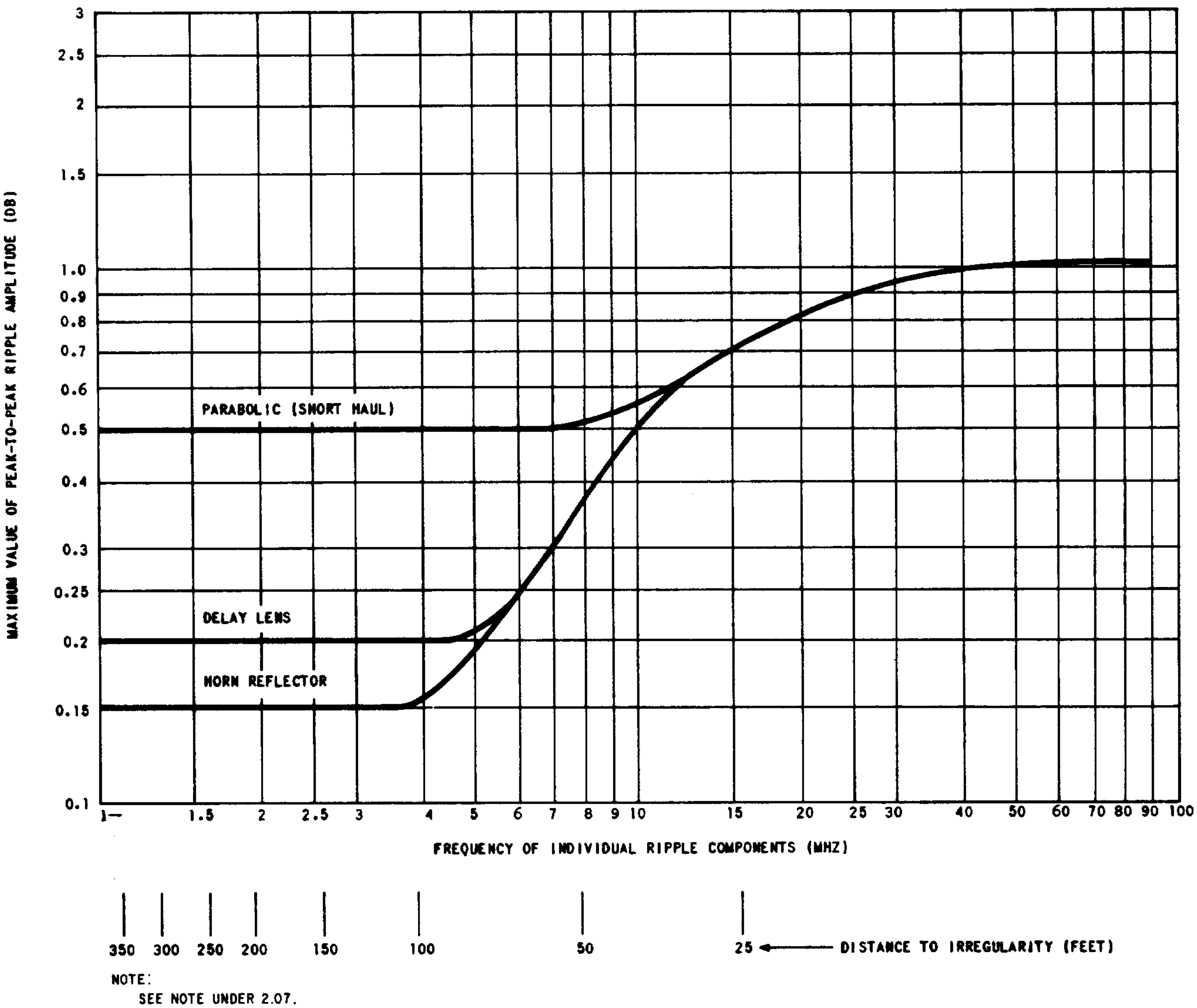


Fig. 4—TD-2 Radio Relay Systems—Permissible Amplitude Ripple Caused by Impedance Irregularities in the Antenna System

loss test with AT3 set to 20 dB and connected to the common waveguide run. If the slope is still excessive, a defect probably exists within the first 25 feet of waveguide.

(3) If the slope disappears after the common waveguide is disconnected in Step 2 above, the defect is probably in the 1400- or 1401-type network. Arrangements must be made to replace the defective part as soon as possible.

(4) To check the receiver beat frequency rejection filter assemblies or transmitter output monitor and tuner, set up the test equipment as in 2.06, but with a 128S termination on AT3. Attenuator AT3 should be set to 20 dB.

(5) Repeat Steps 7 through 11 of 2.06. When AT3 is set to 0 dB, the test trace will be slightly elliptical.

(6) Connect the suspect beat frequency rejection filter (or transmitter output monitor and tuner) between AT3 and the 128S termination. If the assembly is properly tuned, the test trace will not change from what it was in Step 5. If

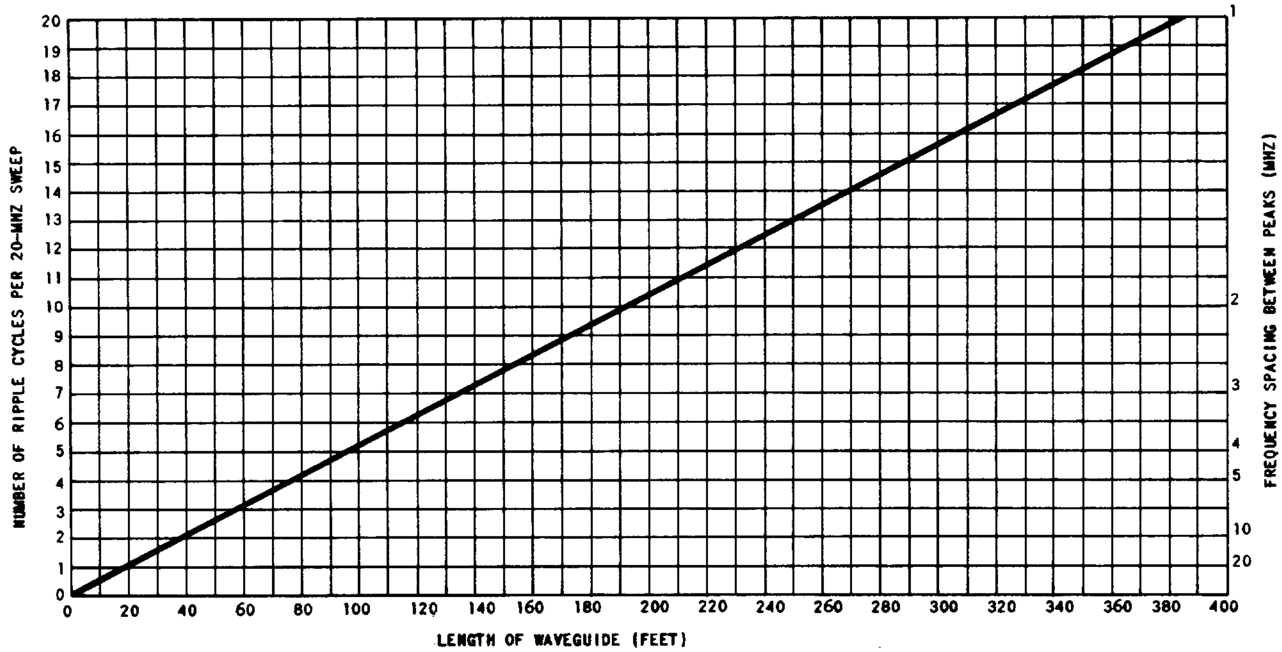


Fig. 5—Number of Ripples Versus Distance to Mismatch

the test trace opens up (in comparison with the test trace in Step 5) or the slope exceeds 0.1 dB, this indicates that one or more pieces of the assembly are misaligned. It will then be necessary to check each piece individually or to arrange for replacement of the assembly.

(7) Under no circumstances should receiver beat frequency filters, transmitter output monitors, or tuners be adjusted or tuned in the field.

4. USING THE DUMONT TYPE 304-A OR 304-AR OSCILLOSCOPE

4.01 As mentioned in 2.06 of this section, the DuMont oscilloscope is more convenient for taking photographs than the KS-15586 oscilloscope on the J68345A test set because it has an illuminated scale, which is easier to read and shows well on the photographs. Its use requires only a very simple modification to blank out the retrace, as shown by the heavy lines in Fig. 7. The change can be made very quickly, on a temporary basis, and the oscilloscope returned to its normal condition after use. The only material required is one Western Electric 404A varistor, plus a length of hookup wire.

4.02 The DuMont oscilloscope can be connected in parallel with the oscilloscope on the 45A test set by making up a multiple patchboard with coaxial connectors, as shown in Fig. 9. Interconnections can then be made quickly and simply with patch cords made up from the RG-59B/U coaxial cable.

5. PROCEDURE FOR PHOTOGRAPHING THE OSCILLOSCOPE PATTERN

5.01 It is desirable to have a permanent record of the ripple pattern, and this can be obtained by using a Polaroid camera. The following suggestions will aid in using the camera for this purpose.

(1) Adjust the oscilloscope trace brightness and the illuminated scale to normal viewing levels.

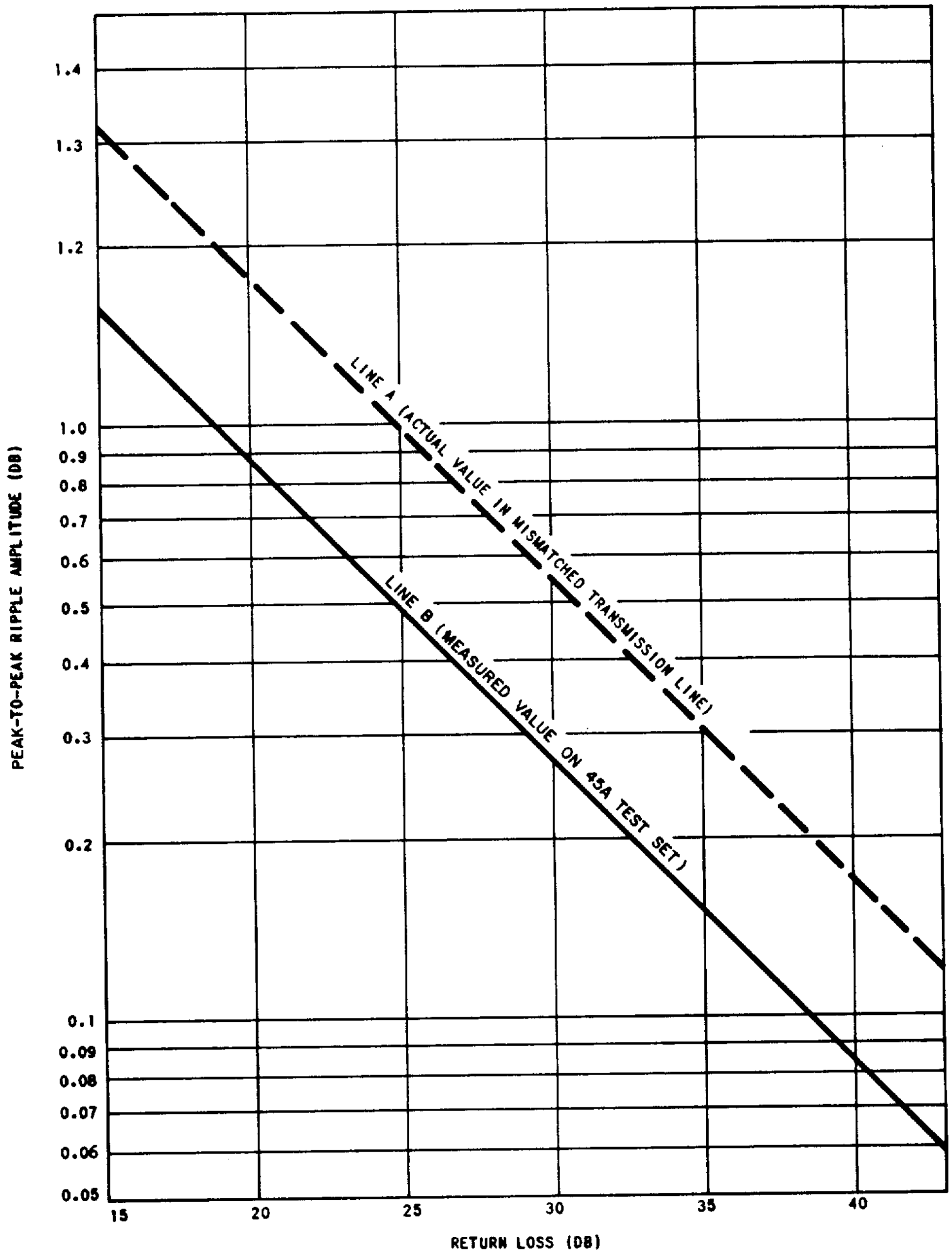
(2) Drape a piece of paper over the test set to shield the oscilloscope face from overhead lights.

(3) Use 3000 speed film.

(4) Use a #3 close-up lens with the camera shutter on 10 (wide open).

(5) Set the camera focus to 3-1/2 feet.

(6) Place or hold the camera 10-1/4 inches from the oscilloscope face.



NOTE:
USE LINE B FOR THIS BSP PROCEDURE ONLY. LINE B IS 6 DB HIGHER THAN LINE A BECAUSE THE IA HYBRID JUNCTION PRODUCES A 6 DB GREATER LOSS IN THE REFLECTED SIGNAL COMPARED TO THE ORIGINAL SIGNAL.

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Fig. 6—Load Return Loss Versus Peak-to-Peak Ripple Amplitude

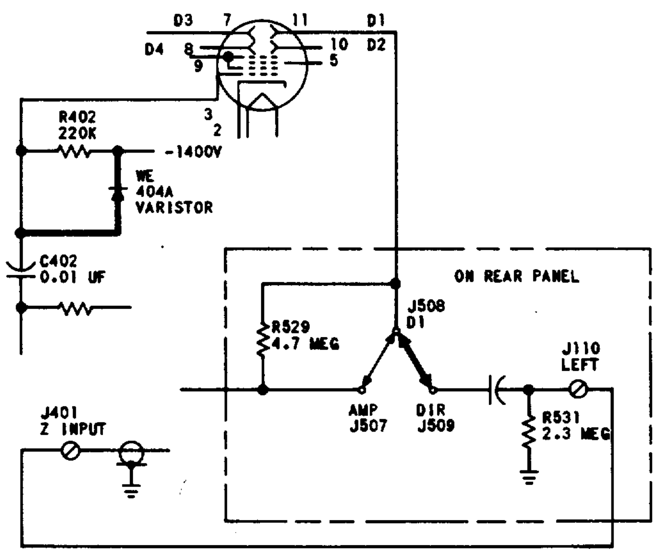

Fig. 7—◆Modifications for the DuMont Type 304-A or 304-AR Oscilloscope for Use in Antenna Return Loss Test◆

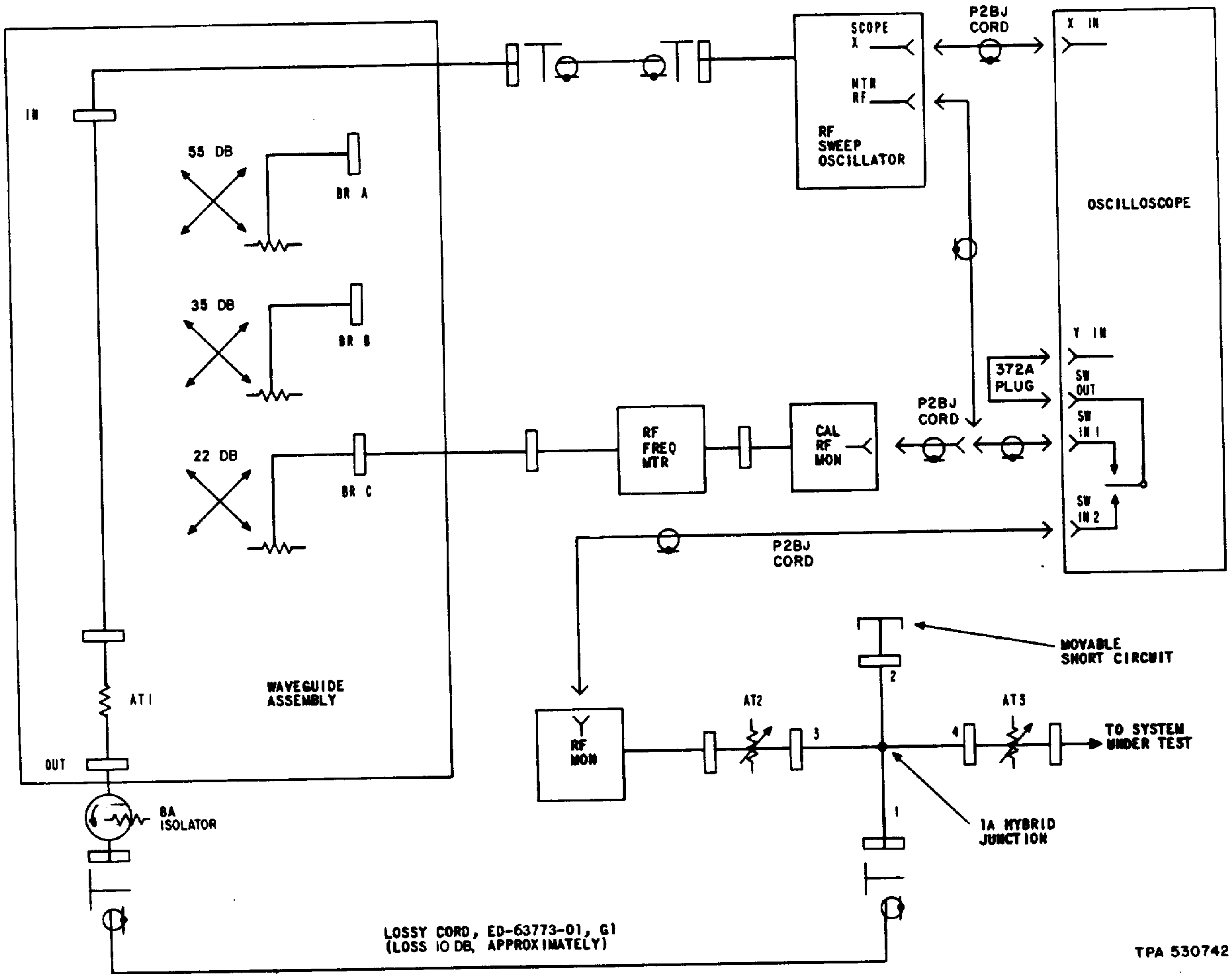

Fig. 8—Block Diagram of Test Setup Showing Interconnections for the J68345A Test Set

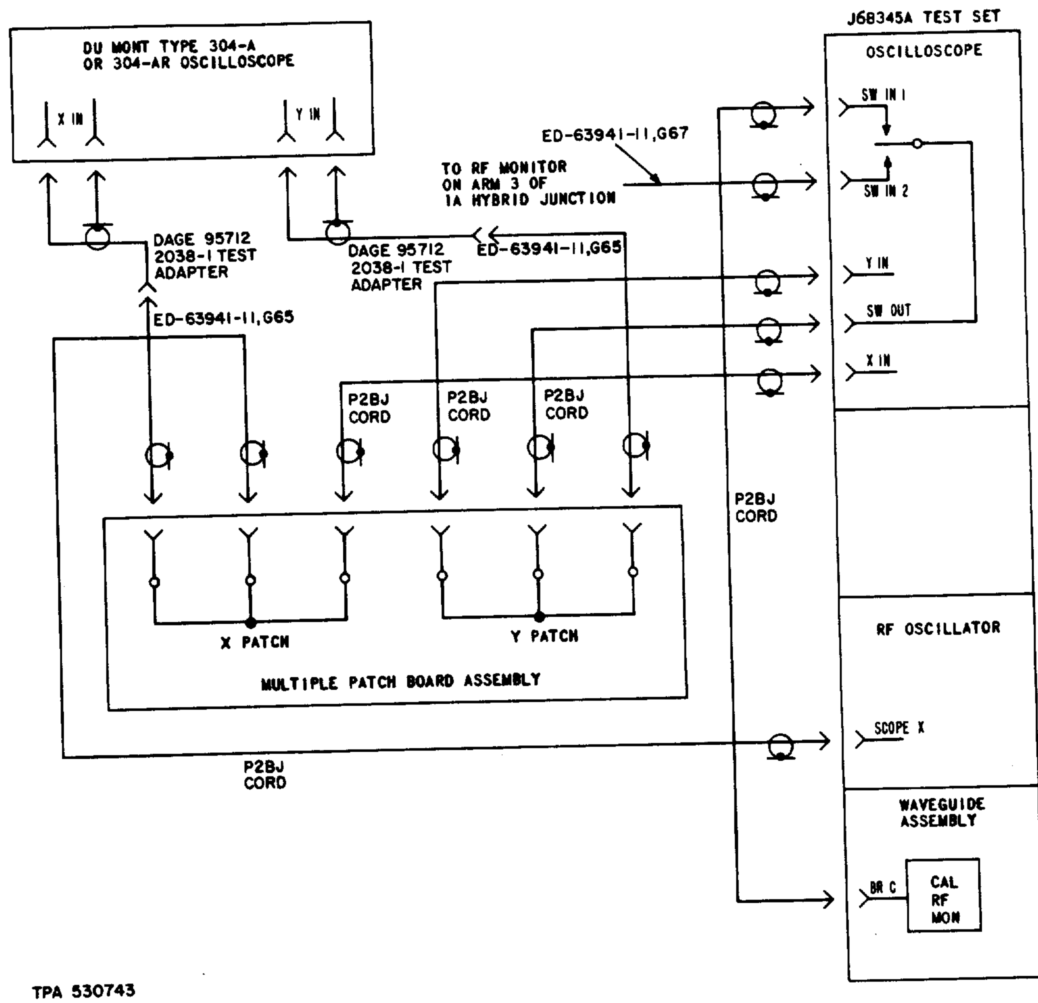

Fig. 9—Test Arrangement for Using the DuMont Type 304-A Oscilloscope and Multiple Patchboard