MICROWAVE ANTENNAS
RETURN LOSS MEASUREMENTS
TH SYSTEM

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1. GENERAL

1.01 The theory and general procedure is given in Section 402-400-100. This section describes the equipment and detailed procedures for making the return loss measurements.

1.02 The technique employs the J68405A test set as a source of swept RF signals and an oscilloscope display. A 3A hybrid junction is used to monitor the outgoing and reflected signals which combine to produce ripples on the oscilloscope trace. These ripples are evaluated for amplitude and ripple frequency to determine the return loss and to locate the point of reflection.

2. RETURN LOSS MEASUREMENT

A. Required Equipment

2.01 The following equipment is needed:

1 — J68405A Test Set
1 — 3A Hybrid Junction

B. Method of Operation

2.02 Assemble the test equipment as shown in Fig. 1.

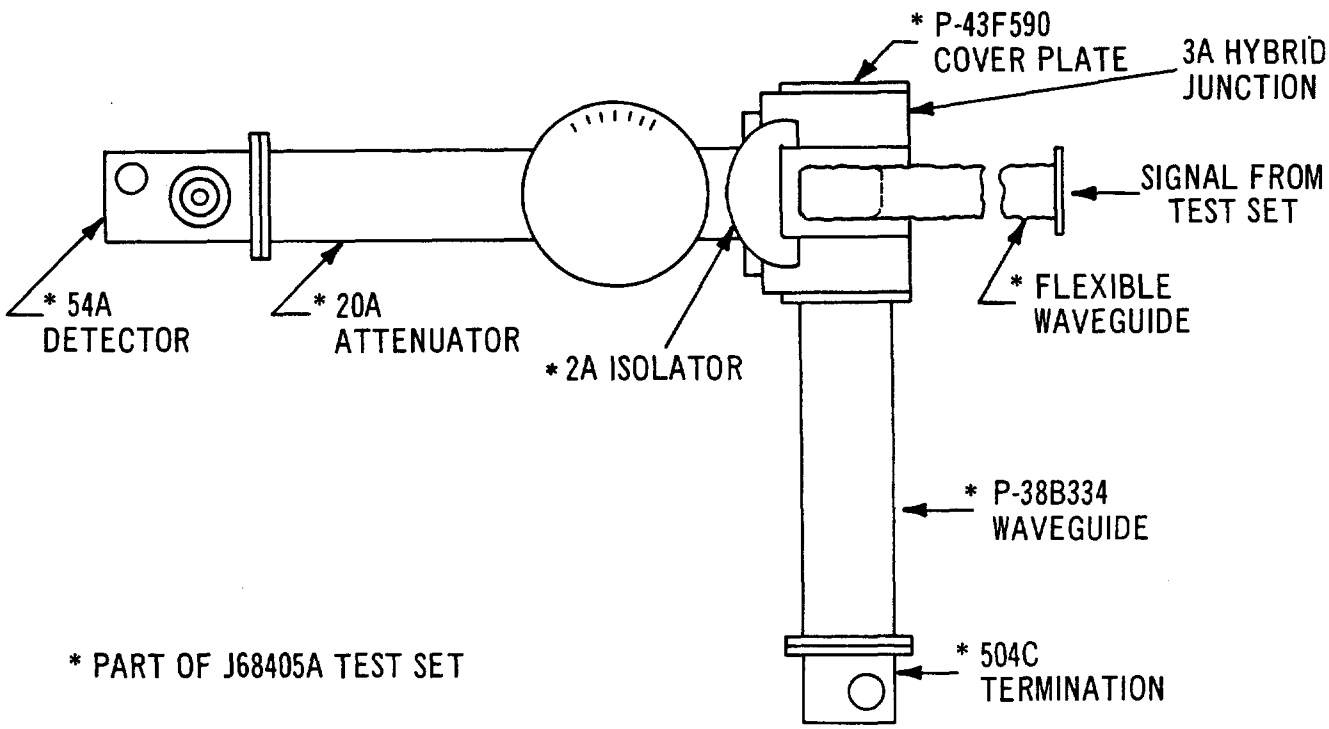

Figure 1

2.03 This test will be performed by connecting the test equipment to the drop arm of a transmitting or receiving channel dropping network. On systems which are in service it will be necessary to obtain a release of a channel to perform the test. The connection to a transmitting channel network may be made by removing the 90° bend between the MON directional coupler and the 1404 type channel network. The connection to a receiving channel network may be made by removing one of the 90° bends between the 1309 type bandpass filter and the 1404 type channel network. Connection is then made to the remaining 90° bend attached to the channel network. When attaching the test assembly of Fig. 1 it will be necessary, for mechanical clearance, to point the arm with the attenuator upward for connection to a transmitter network and downward for connection to a receiving network.

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.

2.04 Before opening the waveguide of the transmitter, remove the RF power by pulling the IF cord to the input of the transmitter modulator.

C. Step-by-Step Procedure

2.05 Proceed in steps as follows:

1. Set up the test equipment as in Fig. 2 with the 504C termination connected to the P38B334 waveguide where indicated, and adjust (AT1) to 5 db attenuation.
2. Turn on the RF test set and allow the set to warm up for 10-15 minutes.
3. Turn the SEND switch to RF and the REC switch to RF.
4. Adjust the RF generator to the channel center frequency and the sweep to ±10 megacycles. Center the trace and adjust the "X" axis gain for a spread of 20 horizontal divisions.
5. Set the frequency marker to the channel center frequency.

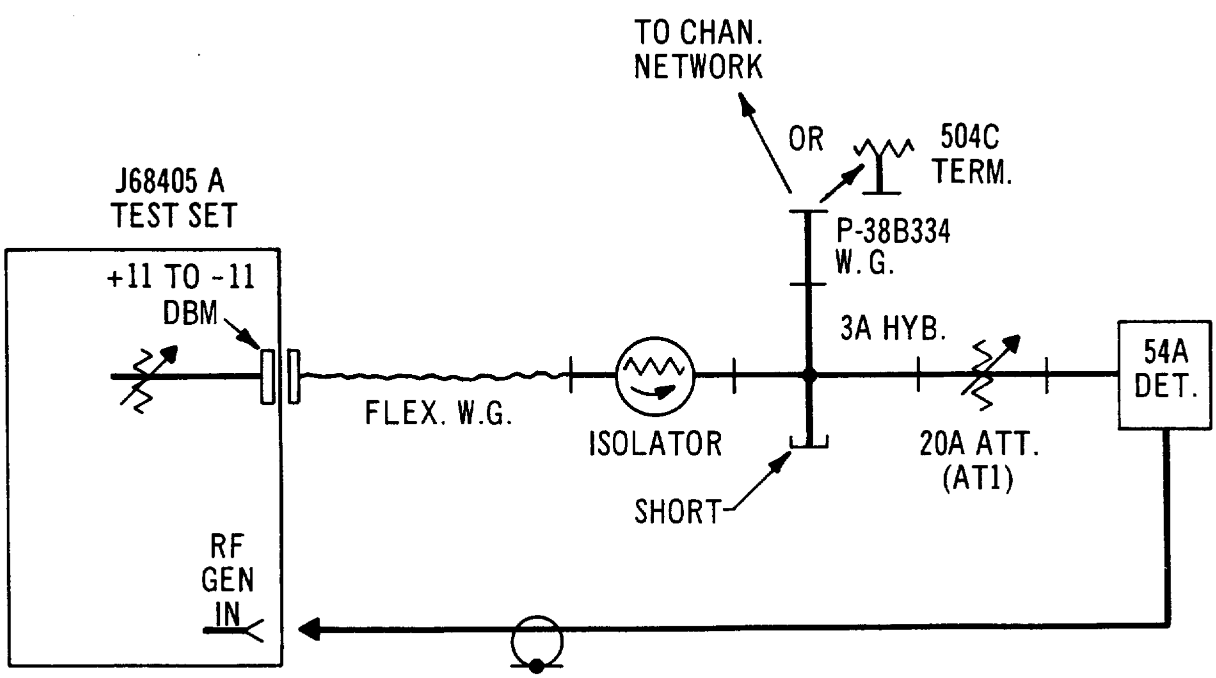

Figure 2

6. Move the marker to the center of the trace by adjusting the RF SWEEP PHASE control.

7. Adjust the RF output level for +11 dbm.

8. Adjust the REFERENCE LINE control for coincidence of traces.

9. Decrease the RF output 1 db and adjust the oscilloscope vertical gain for a separation of the traces of one major division. Restore output to +11 dbm and check for coincidence of traces.

   Note: If oscilloscope gain is insufficient to obtain the required separation, reduce the attenuation of AT1 by 1 db steps until 1 db/major division is obtainable.

10. Insert maximum attenuation in the test set RF attenuator to reduce its output to a minimum.

11. Disconnect the 504C termination and attach the test components to the channel dropping network as described in 2.03 and 2.04.

12. Remove attenuation from the test set RF attenuator to restore output level to +11 dbm.

13. The ripple that now appears on the oscilloscope screen is an indication of the antenna and waveguide system return loss.

PRECAUTION: To reduce the possibility of interference into other channels always insert maximum attenuation in the test set RF attenuator at any time the test assembly is not terminated by the 504C termination or connected to a channel network.

D. Objectives

2.06 In order to determine if an antenna system will meet the objectives for return loss it is necessary to separate the complex ripple waveform into its individual components. 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 complex pattern. The descriptive section of this Practice explains how this can be done. The RF frequency meter in the test set should be used to determine the frequency difference between peaks. The peak-to-peak amplitude may be either read from the oscilloscope screen or by adjusting the test set RF attenuator to align first the top and then the bottom of the ripple with the reference trace. The amplitude is the difference between the two attenuator readings. The latter method is more accurate because of possible nonlinearity in the oscilloscope.

2.07 When the amplitude and frequency spacing of the individual ripple components have been determined, they can be compared with the objectives shown in Fig. 3. Any antenna-waveguide system giving a result falling above the objective line should be investigated and steps taken to remove the discontinuity responsible.

E. Return Loss of Individual System Components

2.08 The following is a list of return loss values of individual parts of the antenna-waveguide system used with TH Radio and apply only in the TH frequency band. These values are included as information and should not be confused with objectives listed in Part D which take into account system application.

COMPONENT	MIN. RETURN LOSS (db)
KS-15676 H/R Antenna	40
Rectangular terminal of 1406 combining network	30
Pressure window	35
Circular flexible waveguide	42
Rectangular flexible waveguide	35

2.09 The ripple amplitude is affected by waveguide loss. If it is desired 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 peak-to-peak amplitude of the ripple due to the antenna reflection. This ripple amplitude is converted to return loss by means of Fig. 4. The round trip loss of the waveguide is then subtracted from the return loss as read from Fig. 4. The result will be the actual return loss of the antenna.

2.10 The loss for TH rectangular waveguide (1.590 x .795) is .014 db per foot and for the circular waveguide .003 db per foot at TH frequencies. Since the ripple is caused by a wave traveling out to the antenna and back again, the

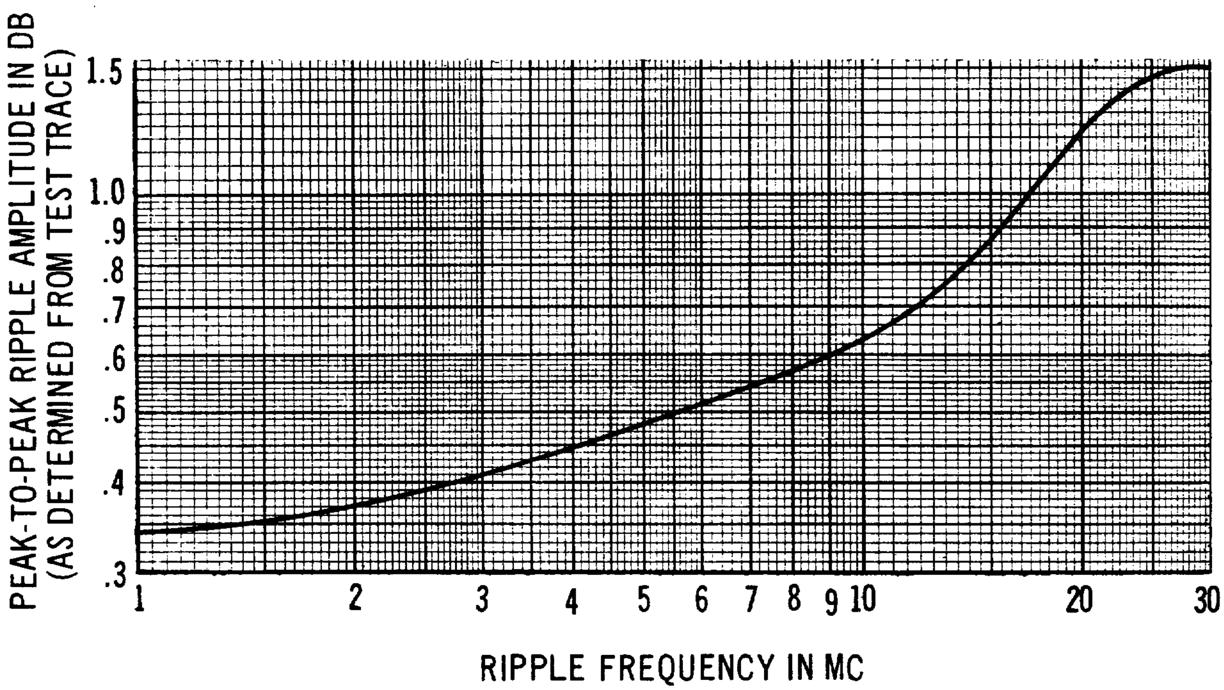

Fig. 3 – Objective for TH Radio System

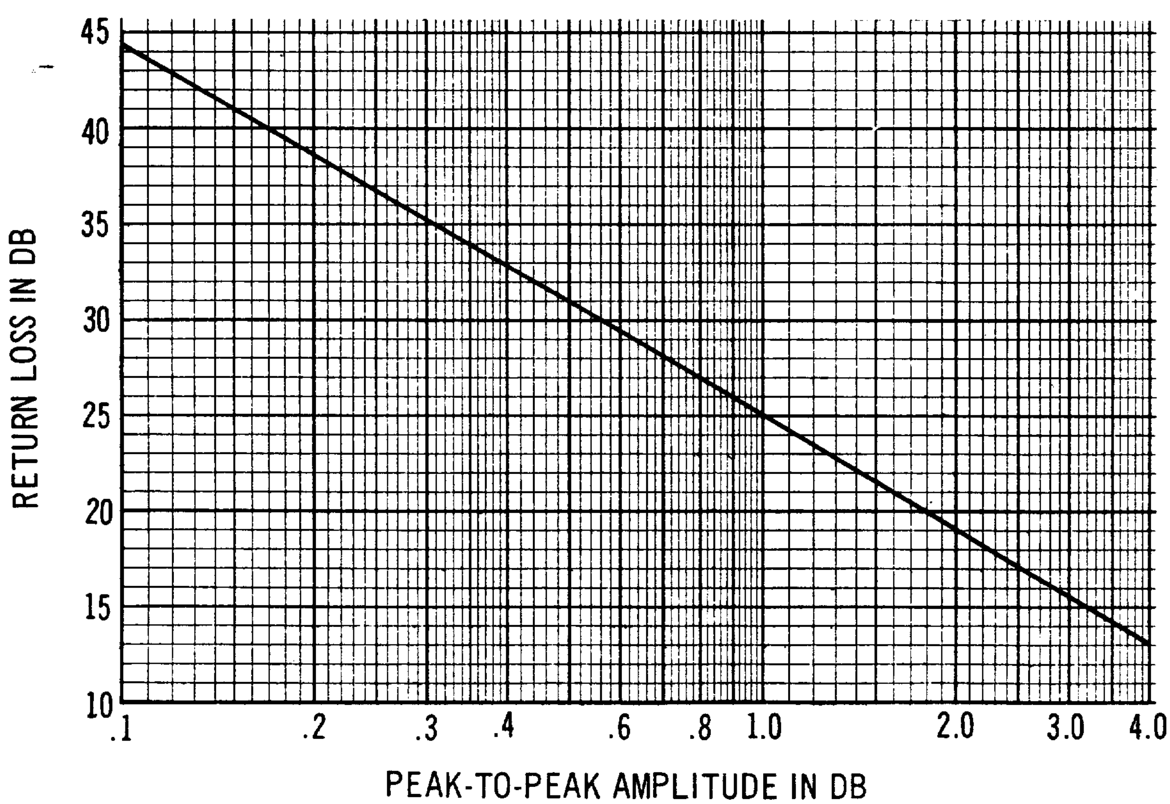

Fig. 4 – Return Loss vs. Ripple Amplitude

total length of waveguide to be accounted for is twice the distance to the antenna. For instance, if a discontinuity with a ripple amplitude of 0.5 db has been located at a point 225 feet away (75 feet of rectangular and 150 feet of circular) the total loss is:

75 x 2 x .014 = 2.1 db for the rectangular waveguide

150 x 2 x .003 = .9 db for the circular waveguide

3.0 db total

From Fig. 4 the return loss corresponding to 0.5 db ripple is 30.8 db.

The actual return loss is 30.8 − 3.0 = 27.8 db.

2.11 Fig. 5 is a graph of ripple frequency versus the waveguide distance to the discontinuity causing the reflection. At TH frequencies the speed of propagation is different in the circular waveguide than it is in the rectangular waveguide (approximately .92 vs. .8) and will also vary with the test frequency. For these reasons the relationship shown in Fig. 5 is an approximation, for the exact relationship depends upon the lengths of rectangular and circular waveguide to the point of reflection. The graph of Figure 5 was drawn for a propagation constant of .85 which is an average. The error is small for large ripple frequencies but may be up to 15 feet for a ripple frequency of 2 megacycles.

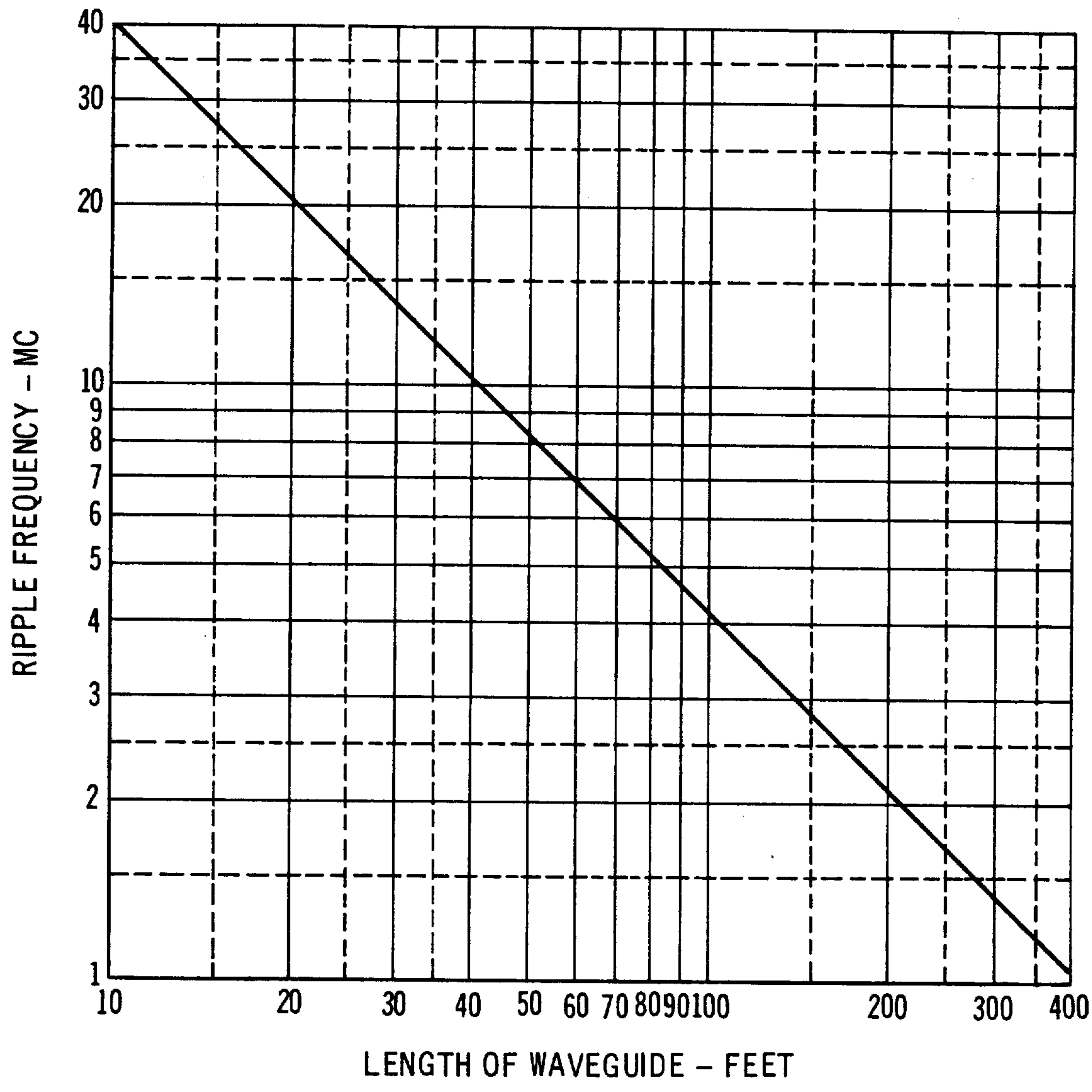

Fig. 5 – Ripple Frequency vs. Distance to Mismatch