

For serials 3088 and above

OPERATING NOTE 16 MAY 67

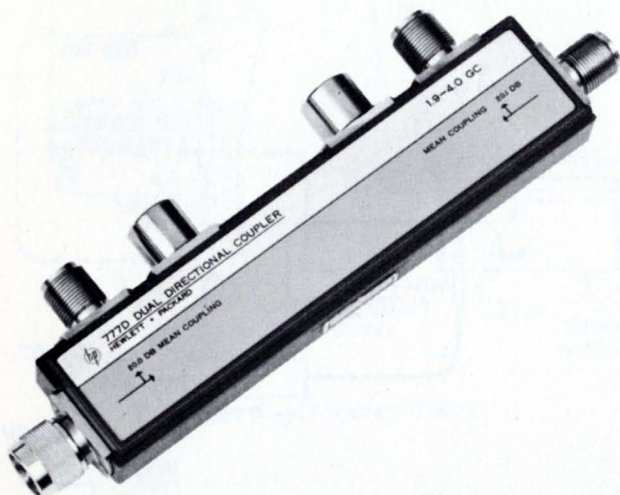



Figure 1. Model 777D Directional Coupler

1. INTRODUCTION.

2. The Model 777D is a dual directional coupler. It is designed for use in 50-ohm coaxial systems. In this coupler, coupling attenuation (ratio of output

power from secondary arm to main line input is specified as mean coupling. The mean coupling of each auxiliary arm is stamped on its nameplate opposite the appropriate auxiliary arm. The variation in coupling is within ± 0.4 db of the mean, and the mean coupling is within ± 0.5 db of -20 db. In addition, the variation in ratio of the two auxiliary arm coupling factors is within 0.5 db. Complete specifications are given in Table 1. The Model 777D is shown in Figure 1. Performance check procedures are given in Paragraphs 14 through 19.

3. Uses of the coupler include reflectometer measurements, simultaneous forward and reverse power monitoring, and closed loop leveling applications.

4. Each coupler is supported by four plastic feet ( Stock No. 0361-0207) on the bottom of the coupler. The feet are inserts in 8-32 tapped holes and may be removed to mount the coupler. Lateral dimensions between mounting holes are given in Figure 2.

5. CONNECTORS.







6. An  Compatible type N connector is used on the coupler. When this connector is mated with a standard type N connector, only slight discontinuity should exist.

Table 1. Specifications

FREQUENCY RANGE: 1900 to 4000 Mc	PRIMARY LINE INSERTION LOSS: Approximately 0.6 db
MINIMUM DIRECTIVITY ¹ : 30 db	PRIMARY LINE CONNECTORS ³ :  Compatible type N connectors, one male and one female
NOMINAL COUPLING ATTENUATION (each secondary arm): 20 db	SECONDARY LINE CONNECTORS ³ :  Compatible type N connectors, female
ACCURACY OF COUPLING (each secondary arm): ± 0.5 db	ACCESSORIES AVAILABLE:  11511A Type N Female Shorting Jack  11512A Type N Male Shorting Plug
MAX COUPLING VARIATION (each secondary arm): ± 0.4 db	SIZE: 8-7/8 in x 2-1/2 in x 1-1/8 in (225 x 64 x 29 mm)
AUXILIARY ARM TRACKING ² : Equal to or less than 0.5 db.	NET WEIGHT: 1-1/2 lb (700 g)
MAX PRIMARY LINE SWR ¹ : 1.2	
MAX SECONDARY LINE SWR: 1.25	
MAX POWER HANDLING CAPACITY: 50 watts CW or 10 kw peak	

¹ Measured with  Model 906A Sliding Load.

² 0.5 db maximum change in coupling curve of one secondary arm relative to the other.

³ HP compatible connectors mate with all connectors whose dimensions conform to MIL-C-71B or MIL-C-39012

CAUTION: Do not mate HP Precision male connectors with these connectors.

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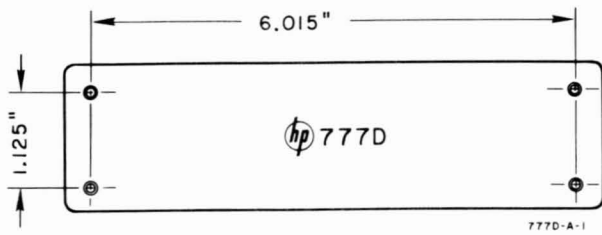


Figure 2. Lateral Dimensions of Tapped Mounting Holes

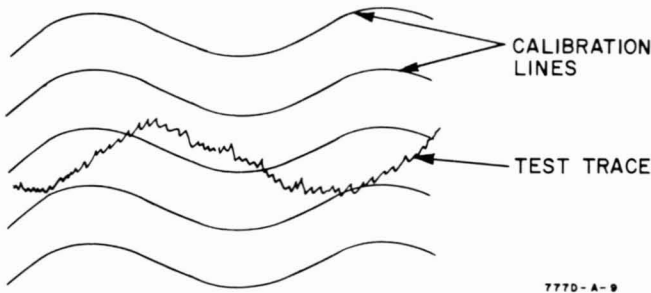


Figure 3. Typical Recorder Plot

8. REFLECTOMETER APPLICATION.

9. Figure 5 illustrates a typical setup for making reflectometer measurements. The forward output of the coupler is used for leveling the sweep oscillator. Any variations in the detected forward-wave output are proportional to the swept frequency output level variations and when applied to a sweep oscillator, such as the hp Model 692A, these variations are amplified to produce a negative control voltage which is used to maintain a leveled RF output.

10. The output of the reverse arm which is proportional to the reflections from the device under test is

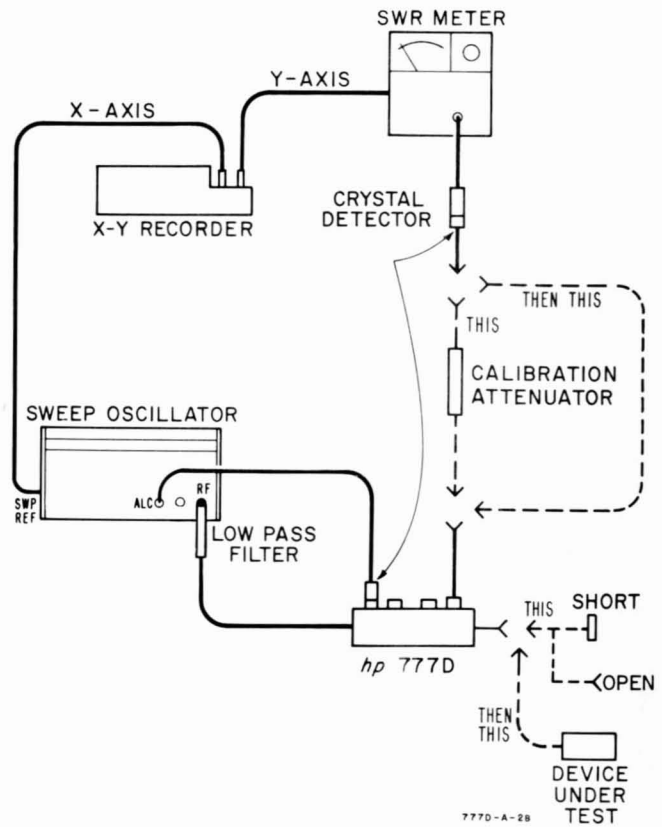
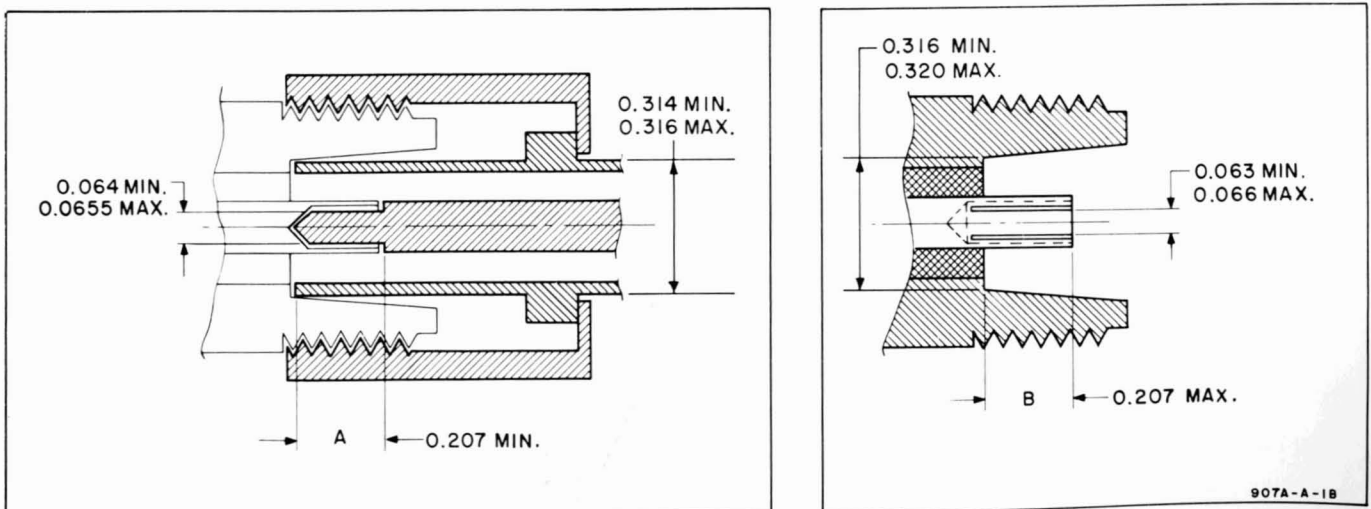


Figure 5. Typical Reflectometer Setup

displayed on an SWR Meter. The unknown load on which the reflection measurements are being made is used as a termination on the main line output of the coupler opposite the end fed by the leveled sweep oscillator.

11. EQUIPMENT CONSIDERATIONS. The hp Model 423A Crystal Detectors are suitable for use as the



ALL DIMENSIONS IN INCHES

Figure 4. Dimensions of hp Compatible Type N Connectors

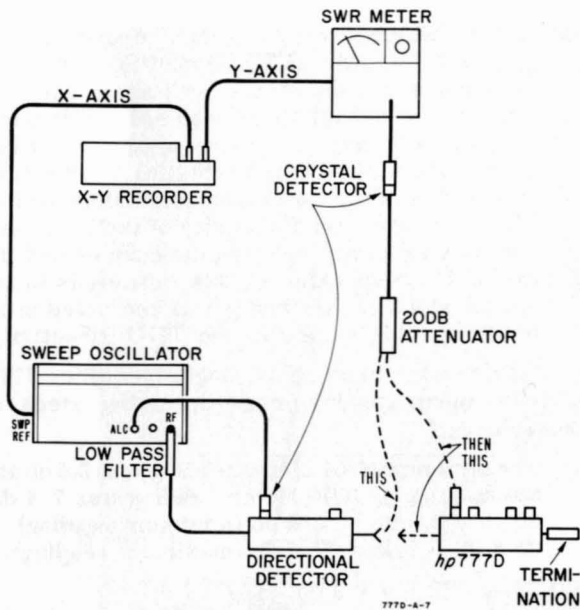


Figure 6. Coupling Check

detectors. An hp Model 415E SWR Meter, hp Model 140A Oscilloscope, or hp Model 130B/C Oscilloscope is suitable for use as the calibrated display instrument. If a permanent record of the measurements is required, the Moseley Model 7035 X-Y Recorder is suitable for use with the SWR Meter.

12. For more information on reflectometer systems, refer to Hewlett-Packard Application Note 65, copies of which may be obtained from your local field office upon request.

13. PERFORMANCE CHECKS.

14. Test equipment recommended for use in checking specifications of the coupler is listed in Table 2. Equipment whose characteristics are equal to or better than the critical specifications listed may be substituted for the equipment listed.

15. MECHANICAL INSPECTION. Mechanical inspection should include periodic mechanical dimension checks on the connector (refer to Figure 4 for important dimensions). Also, any accumulated dust and dirt should be removed from the coupler connectors.

16. ELECTRICAL INSPECTION. Electrical inspection of the coupler should include directivity and coupling checks and optionally the SWR check. (The directivity and SWR characteristics of the coupler are to a degree, interdependent characteristics and a satisfactory directivity check should indicate satisfactory coupler SWR.)

17. COUPLING CHECK.

COUPLING ATTENUATION: 20 ± 0.5 db
 MAXIMUM COUPLING VARIATION: ± 0.4 db

a. Set up test equipment as shown in Figure 6.

Note

SWR Meter and Sweep Oscillator should not be connected to common grounds.

b. Set Sweep Oscillator for a square-wave modulated 2.0-Gc single frequency RF output.

c. With Crystal Detector Attenuator connected to Directional Detector output, set RF output level for a reference setting of 0 on the 30 dB-NORMAL scale of the SWR Meter. Check 423 output to assure ≤ 5 mV peak-to-peak output.

d. Disconnect Crystal Detector attenuator and attach to secondary arm of 777D. Connect 777D main line connector to Directional Detector output.

e. Switch SWR Meter range switch down 20 dB and record a trace. (See Figure 3)

COUPLING ATTENUATION: Max 20.5 db
 Min 19.5 db
 Actual Reading _____ (2.0 Gc)

f. Disconnect 777D from attenuator. Go back to e and record calibrating lines in 0.2 dB increments, setting SWR Meter to 2 GHz and then sweeping 2-4 GHz: Note 777 mean coupling and coupling variation.

COUPLING ATTENUATION: Max 20.5 db
 Min 19.5 db
 Actual Readings: _____ (2.2 Gc), _____ (2.4 Gc),
 _____ (2.6 Gc), _____ (2.8 Gc), _____ (3.0 Gc),
 _____ (3.2 Gc), _____ (3.4 Gc), _____ (3.6 Gc),
 _____ (3.8 Gc), _____ (4.0 Gc), _____ (Gc),
 MAX COUPLING VARIATION: Maximum variation between any of the actual coupling attenuation measurements may not vary by more than 0.8 db.

18. DIRECTIVITY CHECK.

MINIMUM DIRECTIVITY: 30 db

a. Set up equipment as shown in Figure 6 with 10 dB Attenuator connected between 423A and 777D, and 777D terminated in an open-circuit.

Note

The signal source and the SWR Meter should not be connected to common ground. Connect signal source to power line ground and isolate SWR Meter.

b. Set Sweep Oscillator for leveled, square-wave modulated RF output. Check 423A output and set to ≤ 5 mV peak-to-peak.

c. Set 0-dB reference on SWR Meter as average indication between open- and short-circuit at any frequency in the band.

Note

The 0-dB reference setting assumes total attenuator attenuation to be 10 dB; if the total attenuation is more or less than 10 dB, the SWR Meter reference setting should be offset so that the 0-dB reference represents 0 dB when pad is removed.

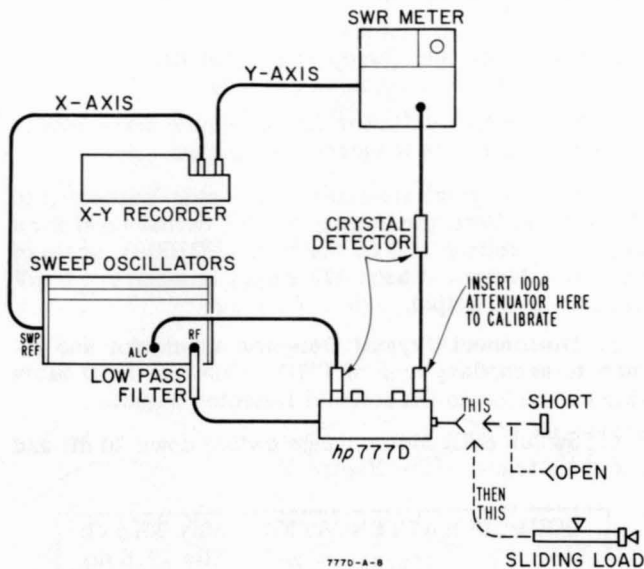


Figure 7. Directivity Check

- d. Remove 10dB Attenuator from setup and connect sliding load to coupler. Increase 415 gain by 20 dB.
- e. Set Sweep Oscillator for 100-second sweep rate.
- f. Continuously phase Sliding Load and note SWR Meter minimum and maximum indications. If both the minimum and maximum indications are greater than the 0-db reference the coupler meets the directivity specification (30 db).

DIRECTIVITY: At least 30 db. SWR Meter indication should not exceed 0 DB on high end of scale. If any points are questionable proceed to next step.

g. To determine actual directivity make single frequency measurements using the above procedure and the following procedure:

- (1) Add 30 db to the minimum and maximum SWR Meter readings; $30\text{-db} + \underline{\hspace{1cm}} = \underline{\hspace{1cm}}\text{ db}$
 $30\text{-db} + \underline{\hspace{1cm}} = \underline{\hspace{1cm}}\text{ db}$
- (2) Subtract minimum reading from maximum reading; $\underline{\hspace{1cm}} = \underline{\hspace{1cm}} = \underline{\hspace{1cm}}\text{ db}$
- (3) Refer to Figure 7 and determine two correction factors; correction factors = $\underline{\hspace{1cm}}$ and $\underline{\hspace{1cm}}$.
- (4) Add minimum reading to each correction factor separately; $\underline{\hspace{1cm}}\text{ db} + \underline{\hspace{1cm}} = \underline{\hspace{1cm}}\text{ db}$
 $\underline{\hspace{1cm}}\text{ db} + \underline{\hspace{1cm}} = \underline{\hspace{1cm}}\text{ db}.$
- (5) Loosen Sliding Load center conductor lock and, being careful not to rotate center conductor, slightly loosen connection to 777D.

- (6) Repeat minimum and maximum measurements and the above five steps. One of the corrected minimum readings (step 4) will agree with one of the corrected minimum readings within a few tenths of a db when the above procedure is repeated. This reading is the Sliding Load return loss. The other corrected minimum reading will represent the directivity of the 777D plus a mismatch error between the coupler and the load. The only value of this reading is to indicate which of the first set of corrected minimum reading values is the 777D directivity.

h. The following is an actual single frequency 777D directivity measurement made following steps of Paragraph 18g:

- (1) The minimum SWR Meter reading was 2.5 db and the maximum SWR Meter reading was 7.4 db; $30\text{ db} + 2.5\text{ db} = 32.5\text{ db}$ (minimum reading)
 $30\text{ db} + 7.4\text{ db} = 37.4\text{ db}$ (maximum reading).
- (2) $37.4 - 32.5 = 4.9\text{ db}.$
- (3) Referring to Figure 7, the two correction factors are 2.1 and 13.3 db.
- (4) Adding minimum reading to each correction resulted in the following corrected minimum readings:
 $32.5\text{ db} + 2.1\text{ db} = 34.6\text{ db}$ and
 $32.5\text{ db} + 13.3\text{ db} = 45.8\text{ db}.$
- (5) Sliding Load loosened slightly and drawn away from 777D.
- (6) The above procedure when repeated resulted in the following:
 - (a) SWR Meter readings: +7.5 db and 0.0 db (or 27.5 and 30.0 db).
 - (b) Subtracted readings: $30.0 - 27.5 = 2.5\text{ db}.$
 - (c) Correction factors from Figure 7: 1.2 db and 18.0 db.
 - (d) Correction factors added to minimum:
 $27.5 + 1.2 = 28.7\text{ db}$ and $27.5 + 18.0 = 45.5\text{ db}$
 - (e) The previous corrected minimum readings were 34.6 and 45.8 db. The 45.5 and 45.8 db readings were known to represent the Sliding Load return loss since the mismatch connection introduced between the coupler and the load had no appreciable effect. However, the 28.7 and 34.6 db readings indicated the mismatch effect of the mismatch connection. Therefore, the 34.6 db reading is known to represent the directivity of the 777D under measurement.

19. SWR CHECK.

MAXIMUM MAIN LINE SWR: 1.2:1

- a. Set up equipment as shown in Figure 9.

Note

The Sweep Oscillator and the SWR Meter should not be connected to common ground.

- b. Set Sweep Oscillator for a 1000-cps square-wave modulated single frequency RF output.

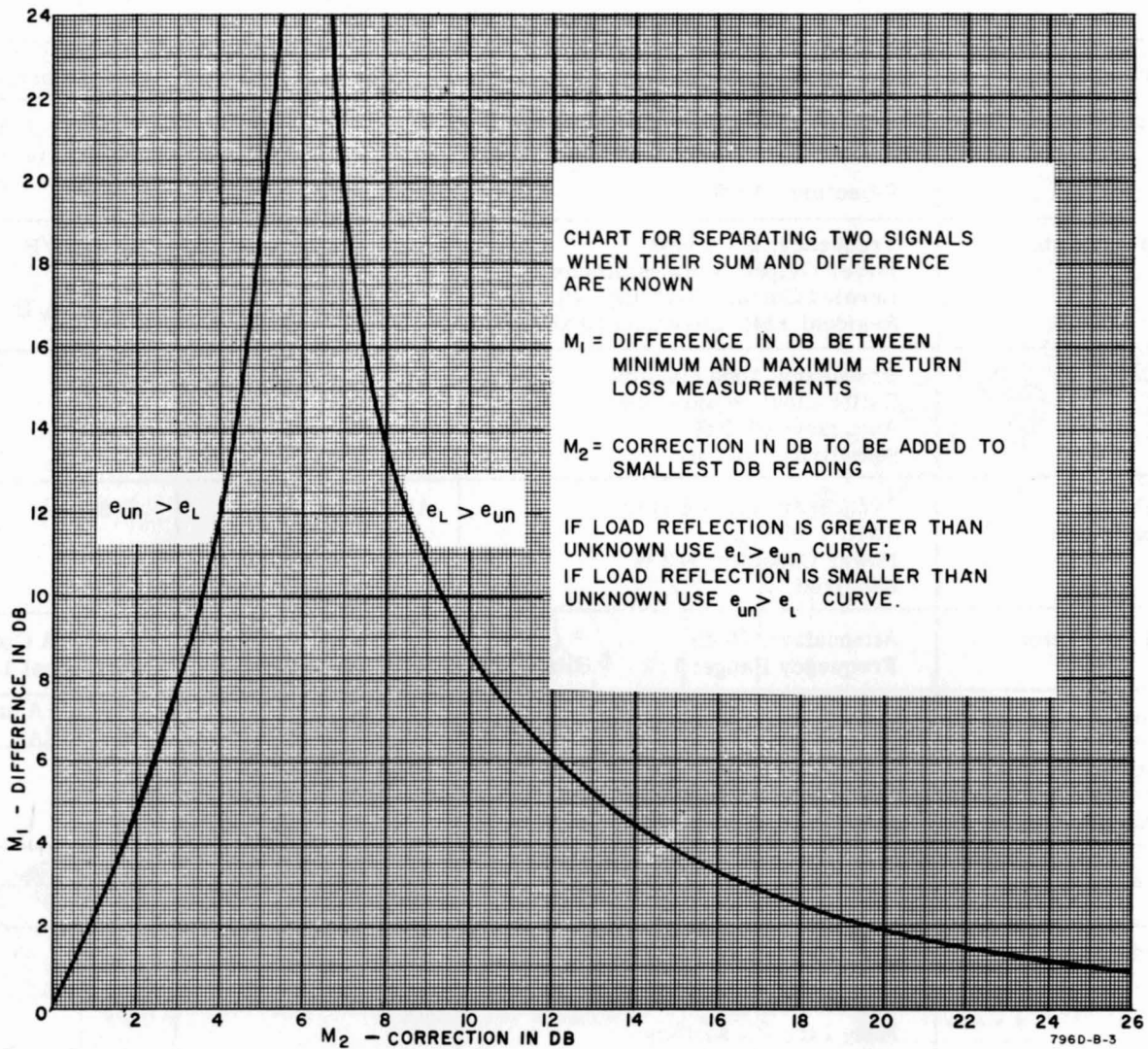


Figure 8. Signal Separation Chart

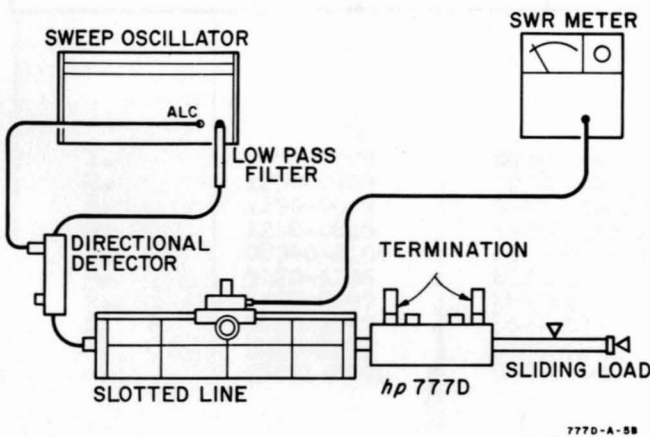


Figure 9. SWR Check

c. Set any convenient reference on SWR Meter 40-db NORMAL scale.

d. Slide Slotted Line carriage to a minimum SWR-scale indication as near the center of the slotted section as possible.

e. Phase the Sliding Load to obtain a maximum SWR-scale indication.

f. Switch SWR Meter to EXPAND scale and set a 1.0 indication on SWR scale.

g. Slide Slotted Line to a maximum SWR-scale indication and phase Sliding Load for a minimum reading. Record reading.

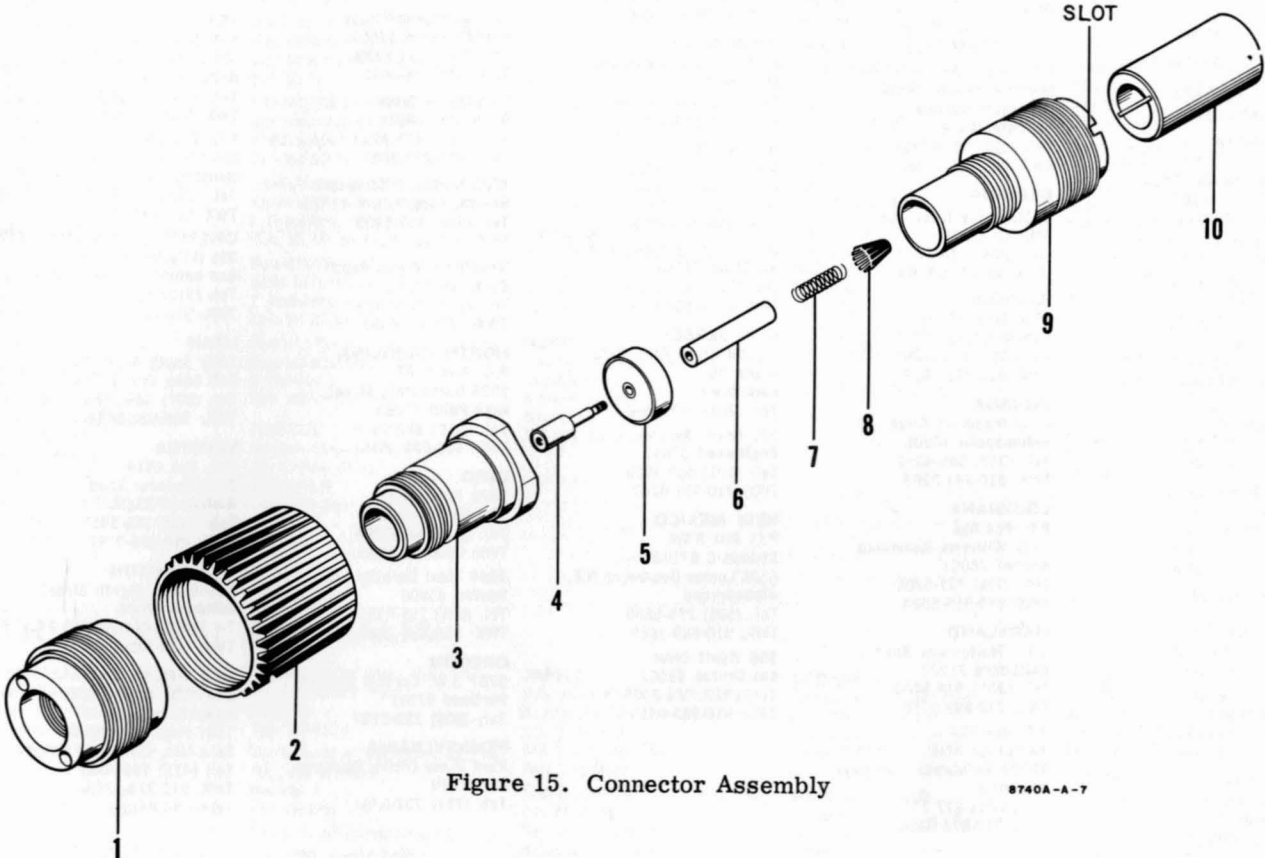
h. Remove 777D from setup and connect Sliding Load to Slotted Line using appropriate connector on Sliding Load. Measure and record SWR of Slotted Line.

i. Divide reading obtained in step h by 1.2 (the coupler SWR specification). The reading of step g must not exceed this quotient which accounts for measurement ambiguity due to Slotted Line residual SWR.

Table 2. Recommended Test Equipment

Instrument Type	Critical Specifications	Check	Model
Low-Pass Filter	Frequency Cutoff: 2.2 GHz 4.1 GHz Rejection: 40 db	All	Ⓜ 360C (2.2 GHz) Ⓜ 360D (4.1)
Sweep Oscillator	Frequency: 2 - 4 GHz Power Output: 3 mw minimum Leveled Output Capability: ± 0.3 db Residual FM: Less than 30 kc peak	All	Ⓜ 692A/B or Ⓜ 8692A/B
SWR Meter	Frequency: 1000 cps $\pm 2\%$ Calibration: Square law Accuracy: ± 0.2 db Sensitivity: $0.1 \mu v$	All	Ⓜ 415E or Ⓜ 415B
Low Power Termination	Frequency: 1.9 - 4 GHz SWR: 1.05 Power Capacity: 1/2 W Required: 2	All	Ⓜ 908A
Fixed Attenuator	Attenuation: 10 db Frequency Range: 1.9 - 4 GHz	All (10-db)	Ⓜ 8491A Opt 10 Weinschel 1-10
Shorting Plug & Jack	Type N male plug & N Female Jack	Directivity	Ⓜ 11511A and Ⓜ 11512A
Directional Coupler and Crystal Detector	Frequency Range: 1.9 - 4 GHz Frequency Response: ± 0.2 db Sensitivity: $4 \mu v / \mu w$ CW	Directivity	Ⓜ 787D
Sliding Load	Frequency: 1.9 - 4 GHz	Directivity SWR	Ⓜ 906A or Ⓜ 907A
Slotted Line	Frequency: 1.9 - 4 GHz SWR: 1.04 Output: Detected Main Line Connectors: Standard Type N	SWR	805C
Crystal Detector	Frequency: 1.9 - 4 GHz Frequency Response: ± 0.5 Square Law Tracking: ± 0.5 db for power levels up to 50 mv	Coupling (1) Directivity (2)	Ⓜ 423A

Table 3. Reference Designation Index

Reference Designation	Stock No.	Description #	Note
			
<ol style="list-style-type: none"> 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 	<p>1250-0909 1250-0909 1250-0909 1250-0816 08740-2100 5020-3296 1460-0297 5020-3297 5020-3298 08491-6000</p>	<p>COUPLING SLEEVE } COUPLING NUT } CONNECTOR ASSY APC-7 OUTER CONDUCTOR INNER CONDUCTOR; CONTACT MECHANISM SUPPORT BEAD CENTER CONDUCTOR SPRING CONTACT CARTRIDGE ADAPTER CARTRIDGE ASSEMBLY 100B</p>	
<p>FIGURE 15 CONNECTOR & CARTRIDGE ASSEMBLY</p>			

See list of abbreviations in introduction to this section



MANUAL CHANGES

MODEL 777D

DUAL DIRECTIONAL COUPLER

Operating Note Serials 3088 and above

Printed May 16, 1967

MAKE ALL CORRECTIONS IN THIS MANUAL ACCORDING TO ERRATA BELOW, THEN CHECK THE FOLLOWING TABLE FOR YOUR INSTRUMENT SERIAL PREFIX (3 DIGITS) OR SERIAL NUMBER (8 DIGITS) AND MAKE ANY LISTED CHANGE(S) IN THE MANUAL.

► NEW ITEM.

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES	SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES
3088 and above	ERRATA		
►04875 and above	► Change 1 & Change 2		

ERRATA: Page 1, Table 1. Change Specifications to read:
FREQUENCY RANGE: 1.9 to 4.0 GHz

►CHANGE 1: Page 1, Table 1.
Change Specifications to read:
MAX SECONDARY LINE SWR: 1.3

►CHANGE 2: Page 7, Table 3.
Disregard this information.

ADDENDUM SHEET

CONNECTORS

Hewlett-Packard is in the process of changing over the "precision" Type N connectors used on previous instruments of this model to a type compatible with the new MIL-C-39012 specification. One or more of the connectors on this instrument are of this new type. These connectors can be identified as follows:

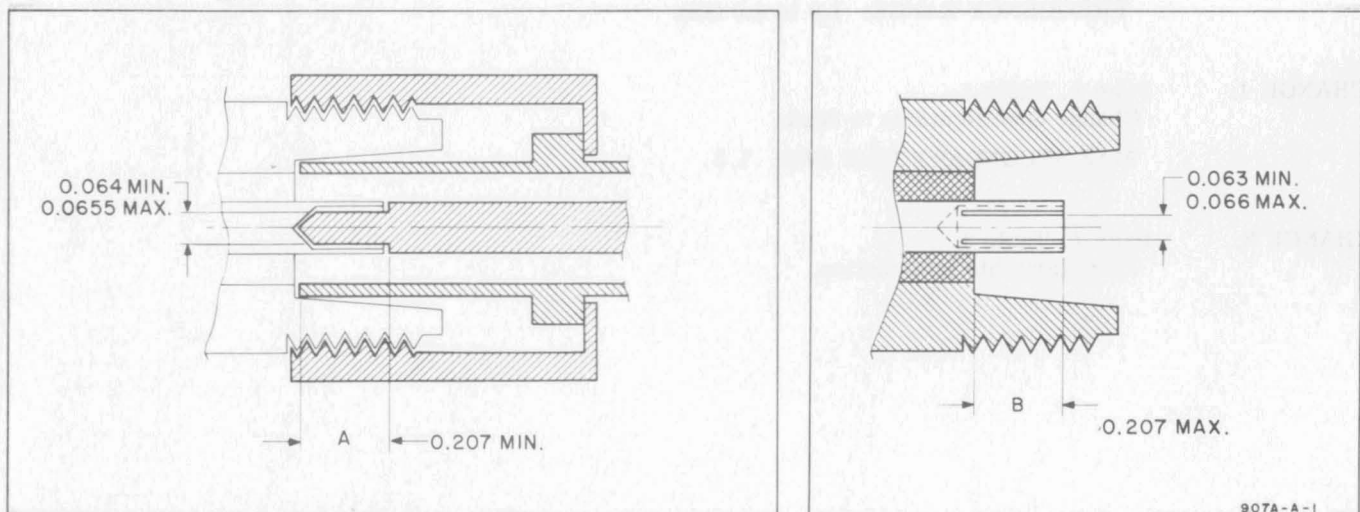
- MALE - No slots in the male outer conductor.
- FEMALE - Gold-plated inner conductor (except 788/789)
- LABEL - "Mates with MIL-C-39012 Connectors"

These new connectors are compatible with MIL-C-71B connectors, also. However they are NOT compatible with the Hewlett-Packard "precision" male Type N connectors.

CAUTION

Do NOT attempt to mate these new connectors with the Hewlett-Packard "precision" male Type N connectors as the center conductor will be damaged due to the forced fit. Use an adapter made of standard Type N connectors with this "precision" connector.

Because of the close coupling of inner conductors all connectors should be checked for contact separation to prevent damage to the equipment. A gauge set for this measurement is available from Hewlett-Packard under part number 00805-602.



Service Note 774D-1, obtainable from your nearest Hewlett-Packard field office, details what connectors are on what instruments, how to recognize and/or measure the connectors, which connectors mate with which, measuring tools, etc.

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