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Final Report

No. RD-822-1

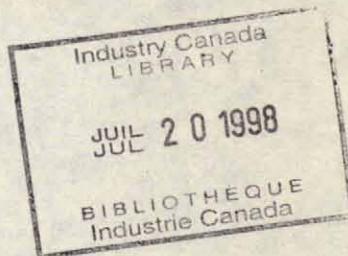
(1) Passive Intermodulation Test Facility

for

UHF Multi-Purpose Satellite

For  
The Department of Communications  
under DSS Contract 2PL 36100-5-2069

Serial OPL5-0150



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SINCLAIR

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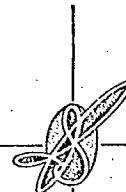
## Appendix

- I Qualification Test Plan
- II Test Facility Schematic Circuits

## Acknowledgement

The co-operation provided by the Department of Communications, the Communications Research Centre of the Department of Communications, and the Department of Supply and Services, in the establishing, monitoring, and financing of the project is gratefully acknowledged.

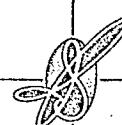
Most valuable assistance was provided by Canadian Astronautics Limited, who along with Sinclair Radio Laboratories, carried out the project on a joint basis.



## 1.0 Introduction

The report presents the results of Final Acceptance Tests and Unit Level Tests carried out on the Passive Intermodulation Test Facility developed in accordance with the Department of Communications Statement of Work Appendix 'A' of DSS Contract Serial OPL5-0150. The final acceptance tests were carried out partially at Sinclair Radio Laboratories and partially at Canadian Astronautics Limited as noted. Tests covering two items of hardware, Part 350198 Output Cable Assembly and Part 350230 Non-Linear Load Diode Assembly were performed following the final acceptance tests due to incompleteness of these particular assemblies at the time, and are reported on under the Unit Level Tests.

The test facility provides a means for applying two-tone and high - power band - limited noise test signals, and for measurement of the magnitude of intermodulation products generated by components and sub-systems for the Multi-Purpose UHF Satellite. Measurement of third and higher-order two-tone products in a 10 Hz bandwidth and of noise-generated intermodulation in a 30 KHz bandwidth, with detection sensitivities of approximately -155 dBm and 5° K equivalent noise respectively are catered for.



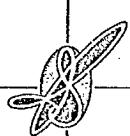
## 2.0 Summary

The Test Facility performance meets the requirements of the Statement of Work in all respects as established for the best-effort basis, and will meet the initial requirement for -130 dBm third-order product measurement under careful maintenance and test conditions.

The Source Sub-system provides amplifier power output levels of +49.3 to +53.4 dBm over the frequency range 275-330 MHz, with approximately +47 to +51 dBm power into the test facility load terminal. The power amplifier drive levels are adjustable to -99 dB from maximum, and output levels are monitorable to approximately 1 watt minimum by means of the power meters. The maximum noise power at the load as measured with a peak-responding meter was +51.8 dBm.

The frequency stability of the synthesizers was shown to be compatible with the requirement for a fifteenth-order product spectral linewidth of 10 Hz 3dB BW.

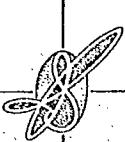
The Filter Sub-system provides the necessary selectivity enabling the facility to meet residual two-tone intermod requirements of less than -160 dBm at fifteenth order products, -120 to -130 dBm at third-order, and noise-generated intermods of less than a 5°K equivalent signal in both high and low noise bands.



The detector sub-system noise level was approximately -160 dBm for the two-tone test mode, and less than a 5°K Gaussian noise signal in the noise test mode.

Intermod two-tone reference signals of approximately -60 dBm at third-order to -110 dBm at seventeenth-order can be generated by means of the diode-device coupled into the standard linear load.

Both one and two-port devices under test employing Type N connectors can be measured, with receive filter connections providing for both two-port reflected-mode and two-port transmitted-mode measurements.



3.0

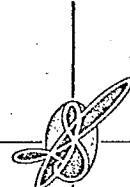
Acceptance Test Results

Passive Intermodulation Test Facility

System and Subsystem Level Tests

According to Qualification Test

Plan Issue 3, Para. 2.0.



### Test 2.1. Power Output

Test Performed at SRL: Nov. 8. 1976.

#### 2.1.1 CW Mode, Single Tone.

Output Load power was measured using a Bird Wattmeter at the standard load terminal.

Test Freq. (mhz)	Output Power (Watts)			
	Channel 1		Channel 2	
Load	Source	Load	Source	
275	110	220	125	190
300	110	185	115	160
310	75	120	95	140
330	50	85	109	165

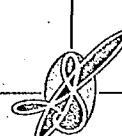
Note 1: Tunable Filter F2 can be tuned to within 3 Mhz of F1 with minimal change of channel 1 output power, and vice versa. i.e., 52 W. with F2 tuned to large separation; 50 W with F2 at 3 Mhz. separation.

Note 2: Synthesizer 2 occasionally failed to lock in frequency on the first attempt at switch tuning. Repeat switching accomplished the lock-on.

#### 2.1.2 Continuous Mode

The following power readings were measured with a Bird Model 43 wattmeter (Peak reading), and must be treated with caution due to the non-average reading.

- (1) High Band; Continuous noise power into load: 150 W. max.
- (2) Low Band; Continuous noise power into load: 175 W. max.



### 2.1.3 Noise Mode, Noise diode off

Noise output power at load not detectable on 10 watt full scale power meter (less than 0.1W).

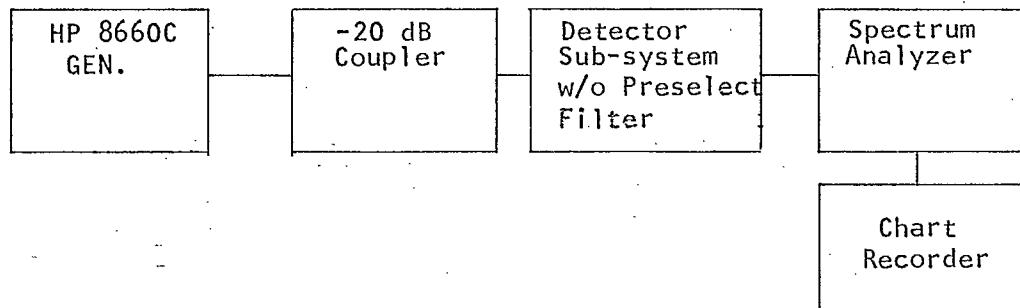
### Test 2.2 Load VSWR.

Test Performed at SRL; Test not witnessed by Proj. Officer.

VSWR into 9dB Pad and Load: 1.25 1 referenced to 50 ohms.  
(Fig. 3-1).

### Test 2.3 Detector CW Sensitivity

Test Performed at CAL; The test equipment configuration was as follows:



Freq: 400.000 Mhz. HP 8660 output: -135 dBm. Detector Sub-system input: -155 dBm. Spectrum analyzer Settings; 10 HzBW, 10 sec/cm.  
Result: A - 155 dBm CW signal at the Detector Sub-system (Low-noise pre-amp) input is clearly detectable. (Fig. 3-2).

### Test 2.4 Detector Noise Sensitivity.

Test Performed at CAL; Sept. 28. 1976.

Test Equipment Configuration: Same as for Test 2.3 with the exception that Signal Gen. HP 8640 replaced HP 8660C.

Test Conditions:

- (1) Detector Sub-system input: -147 dBm (approx 5° K) Spectrum  
Analyzer BW: 30 Khz.

Note

The HP 8640 Signal Gen. was square-wave amplitude modulated by means of the synchronous detector chopping signal within the detector control unit. The modulated output signal was assumed to be 6 dB above CW values.

Result: A -147 dBm signal is detectable with respect to  $\leq$  -147 dBm.  
(Fig. 3-3).

- (2) The internal noise source was attenuated by 53 dB (atten = 33 dB) to buck the - 147 dBm Signal.

Noise diode power = + 35.5 dB above KTB

- 53

= - 18.5 dB w.r.t. 290° K  $\cong$  5° K

Test 2.5 Passive Intermodulation.

Test Performed at SRL: Nov. 8. 1976.

a) Reflected Mode Measurement

Results.

	Test Freqs. (Mhz)	Power at Amp. Output (watts)	IM Order	IM (dBm)
1)	f = 275	90	3	-130
	f = 330	75		
2)	f = 275	180	3	-120
	f = 330	175		
3)	f = 310	90	7	< -160
	f = 330	90		
4)	f = 322.5	75	15	< -160
	f = 330	75		

Note: Detector Noise Level  $\approx$  - 160 dBm.

5) Reflected Mode Measurement of Type N 'T' Connector:

Test Freqs. (Mhz)	Power at Amp. Output (watts)	IM Order	Approx IM (dBm)
f = 275	85		
f = 330	90	3	-103
f = 310	90		
f = 330	90	7	-150
f = 322.5	75		
f = 330	75	15	< -160

Note: Detector noise level  $\approx$  -160 dBm.

b) Transmitted Mode Measurement.

Results: Refer to Unit Level Test Results (P).

c) Noise Mode Measurement.

Test Conditions: Noise - generated intermod levels were recorded by the strip-chart recorder for the following conditions:

- 1) The output circuit and standard load was connected for a Reflected mode measurement.
- 2) The source noise power was turned 'off' to chart the detector sub-system reference level.
- 3) Full source noise power into the load was applied to chart the test facility noise-generated intermods.
- 4) A 5° K calibration noise signal was injected from the detector sub-system standard noise source.

Result: The chart deflection (not calibrated) for noise-generated intermods at full output power was much less than the 5° K deflection.

d) Output Circuit Connection Repeatability.

The Type N connection at the input to the 9 dB pad was disconnected and re-engaged approximately five times.

Result: At two-tone input power levels of 180 and 175 watts, third-order intermod levels were repeatable between -120 and -130 dBm levels.

Test 2.6. Measurement Time.

The Test facility was operated for a prolonged period (approx four hours). No significant change in amplifier output power or system gain was noted. The operating temperatures of all units remained within safe limits during the test.

Test 2.7. Intermod Spectral Linewidth.

Result: A fifteenth-order product generated by means of a small signal diode coupled into the load circuit was observed on the Spectrum Analyzer at a 10 Hz. IF BW setting. The - 3 DB BW. of the product was 10 Hz. The signal sources were concluded to be sufficiently stable.

Test 2.9. Line Voltage Tolerance.

a) Source Sub-system Output Power:

Result A 5% change in line voltage produced no discernable change in amplifier output power.

b) Detector Sub-system Gain:

Result A 5% change in line voltage produced no detectable change in a - 135 dBm readout on the spectrum Analyzer linear scope, with a constant input signal of approximately -110 dBm into the 20 dB coupler.

VSWR. Into Pad and Load Combination

-10-

1.5

2

1.25

1

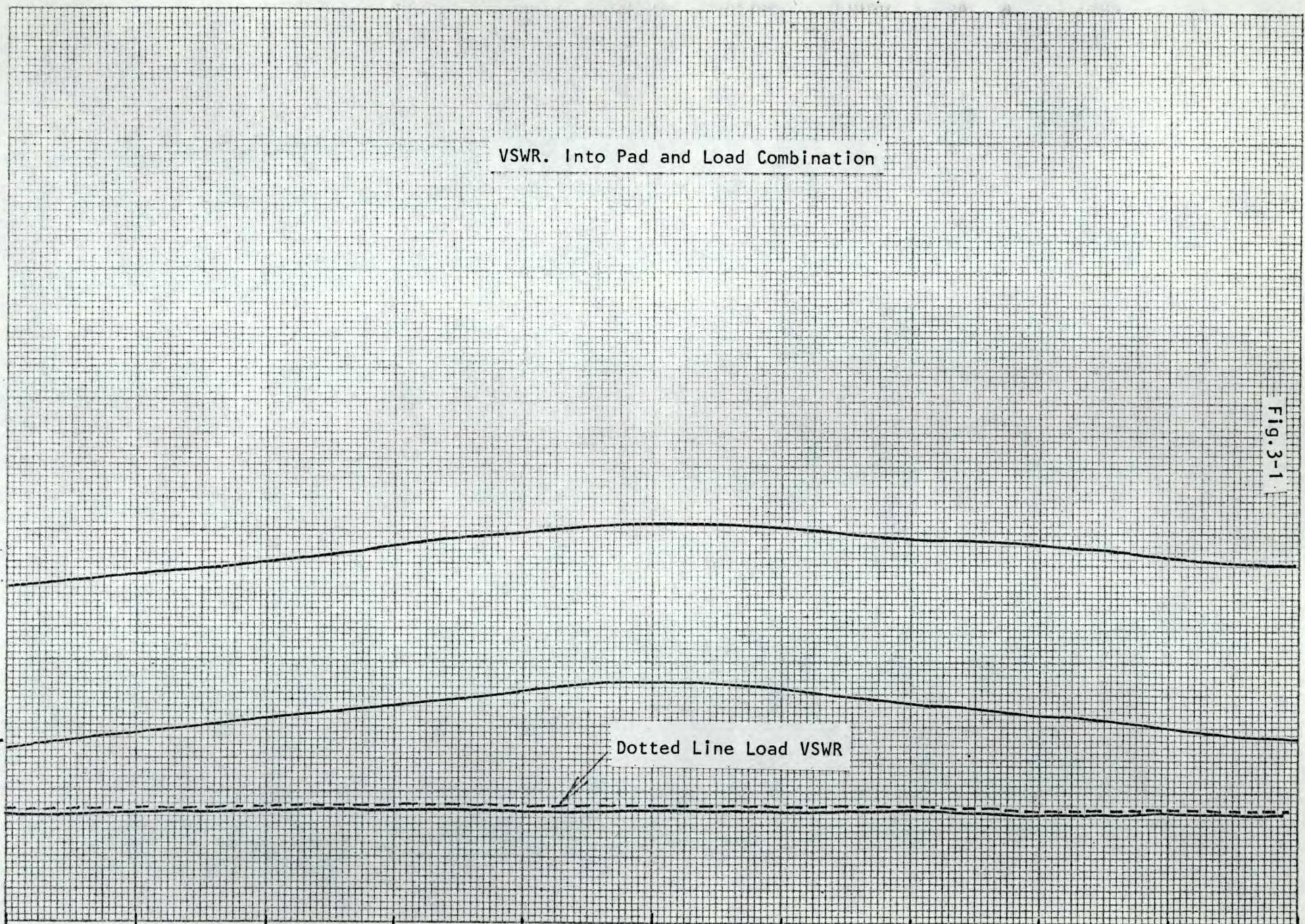
200

300  
MHz

Fig. 3-1

Dotted Line Load VSWR

400



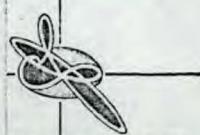
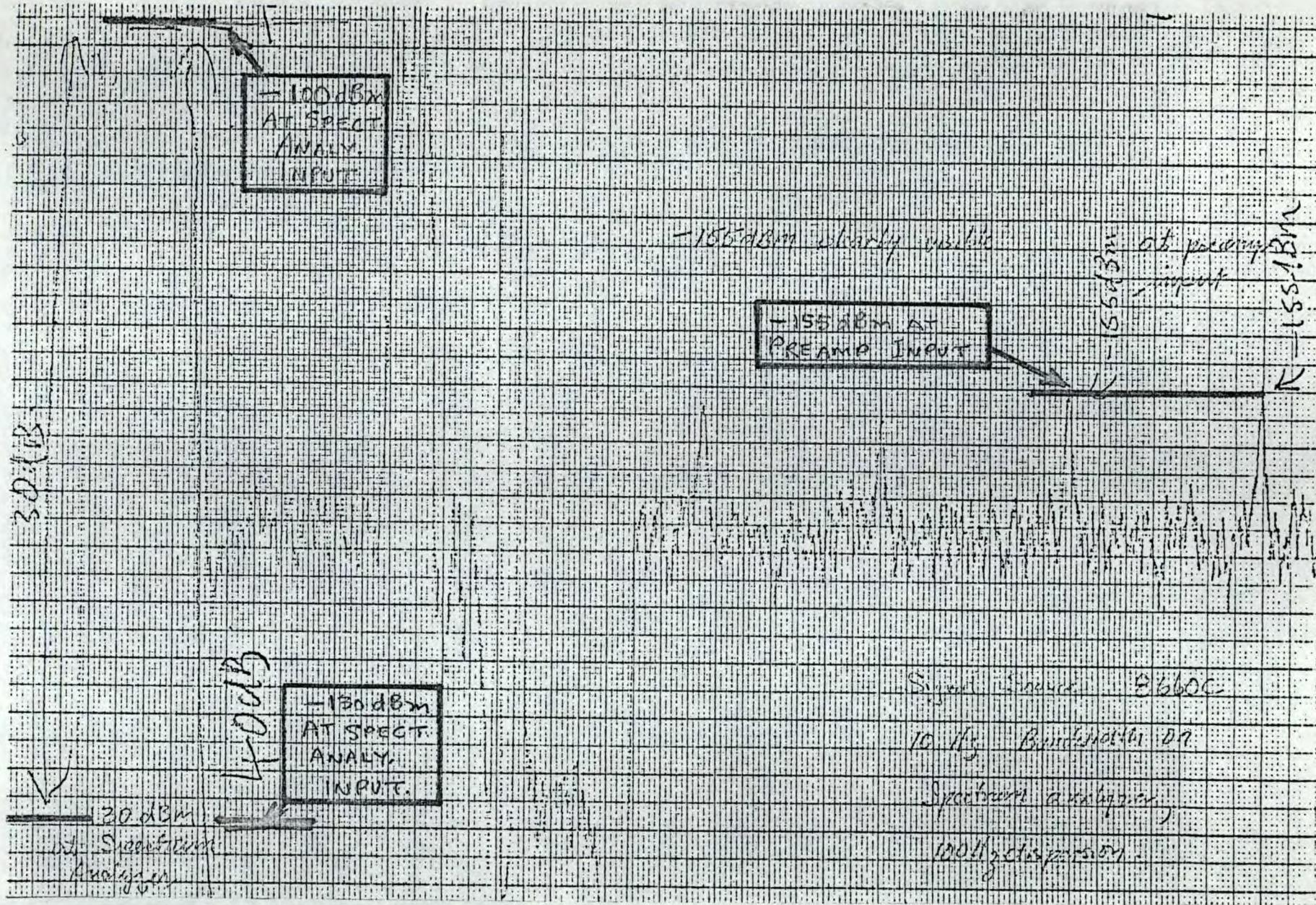
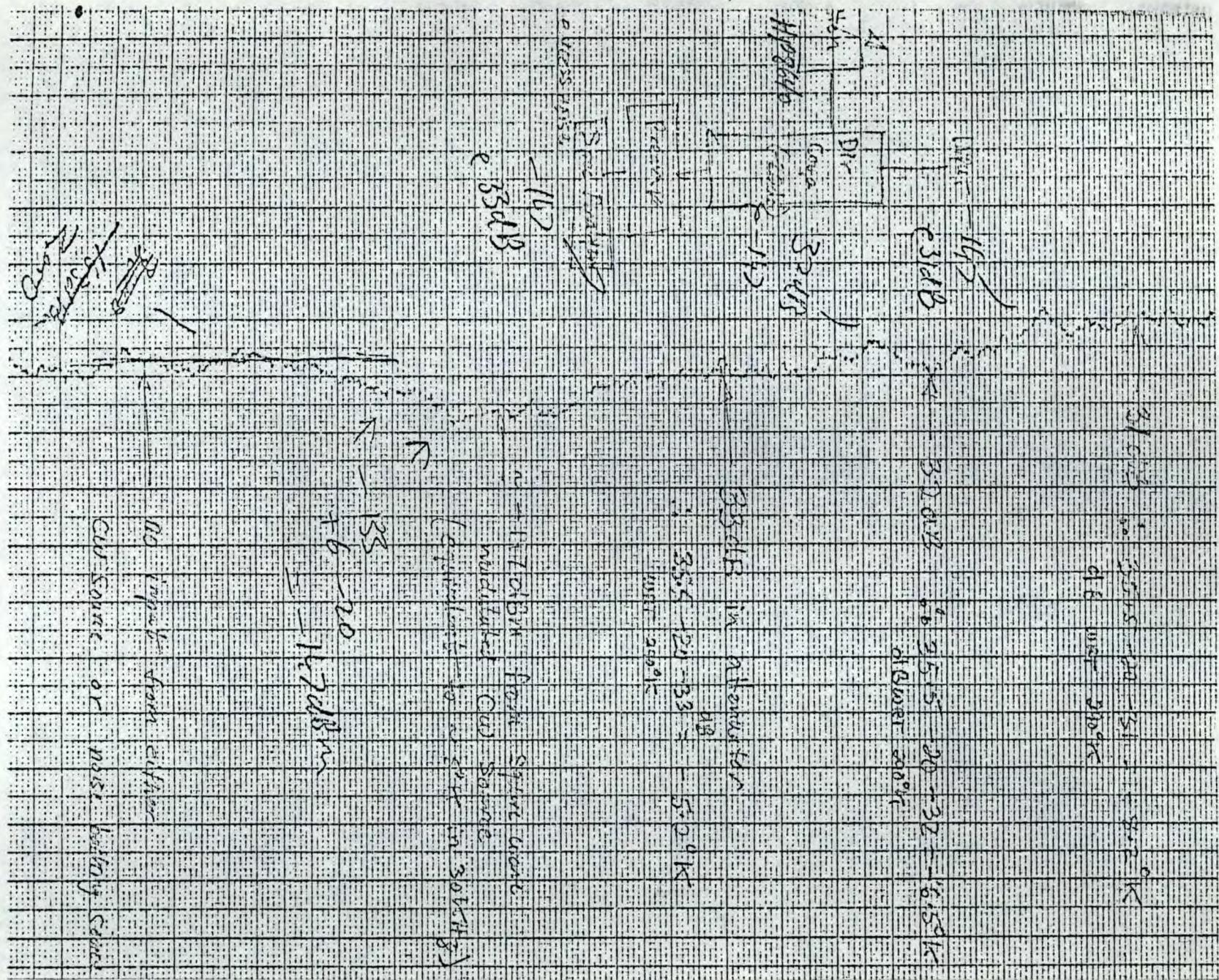
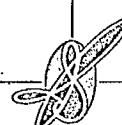


Fig. 3-3



#### 4.0 Unit Level Test Results

- (A) HPA 1 and 2
- (B) LNA and Mixer
- (C) 450 Mhz Oscillator
- (D) Frequency Synthesizer 1 & 2.
- (E) Channelizing Filters F1, F2 with Combiner.
- (F) Noise Post-Filter F3
- (G) Noise Post-Filter F4.
- (H) Noise Pre - Filter F5.
- (J) Noise Pre - Filter F6.
- (K) Transmit Duplex Filter F7; Refl. mode.
- (L) Receive Duplex Filter F8; Refl. mode.
- (M) Duplex Filters F7 & F8, Transmitted mode connection.
- (N) Duplexed Filters & Load; Third-order intermod.
- (O) Test Facility in Reflected mode; Third-order intermod.
- (P) Test Facility in Transmitted mode; Third-order intermod.
- (Q) Standard Non-linear Load; Intermod at Filter F8 output.
- (R) HP 8553B Spectrum Analyzer.



PASSIVE INTERMODULATION TEST FACILITY

UNIT TESTS

(A) Unit under test: 1 and 2

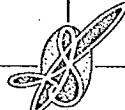
Test performed : Input power for 50 watts and 175 watts  
output versus frequency range 275-330  
MHz in 5 MHz steps

Equipment used : HP8660 Signal Generator and dual power  
meters

Results:

Freq. (MHz)  $P_{IN}$  (dBm) for 50 Watts out  $P_{IN}$  (dBm) for 175 Watts out

	HPA 1	HPA2	HPA 1	HPA 2
275	-10.5	-7.5	-3.0	-3.0
280	-10.0	-7.0	-3.5	-3.0
285	-10.0	-7.0	-3.5	-2.5
290	-9.5	-6.5	-3.0	-2.0
295	-9.0	-6.5	-2.5	-2.0
300	-8.5	-6.0	-1.5	-2.0
305	-8.5	-6.0	-1.5	-2.0
310	-8.0	-6.0	-1.5	-2.0
315	-8.0	-6.5	-1.5	-2.0
320	-8.0	-7.0	-1.5	-3.0
325	-8.0	-7.0	-1.5	-3.5
330	-7.5	-7.0	-2.0	-3.0



(B) Unit under test: LNA and Mixer

Test performed : Output power ( $P_{out}$ ) versus frequency  
range 370-406 MHz in 2 MHz steps, with  
input level set at -120 dBm

Equipment used : HP8660 signal generator and HP Spectrum  
Analyzer

Results:

Freq. (MHz)	$P_{OUT}$ (dBm)
370	-77
372	-77
374	-77
376	-77
378	-77
380	-77
382	-77
384	-77
386	-77
388	-77
390	-77
392	-76
394	-76
396	-76
398	-77
400	-77
402	-77
404	-77
406	-77

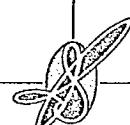
Spectrum Analyzer Settings: Bandwidth: 1 KHz/div

Scan Width: 1 KHz/div

Log Ref.: -60 dBm

Video Filter: 10 Hz

Manual Scan used



(C) Unit under test: 450 MHz Local Oscillator

Test performed: Output power at 450 MHz

Equipment used: HP Spectrum Analyzer with HF plug-in

Results: Output power is +13 dBm

Spectrum Analyzer Settings: Bandwidth 100 KHz/div

Scan Width: 1 MHz/div

Log Ref.: 10 dBm with HP355C

VHF Attenuator at 10 dB

(D) Unit under test: Frequency Synthesizer 1 and 2

Test performed: Output power ( $P_{OUT}$ ) versus frequency range  
137-165 MHz in 2 MHz steps

Equipment used: HP Spectrum Analyzer with HF plug-in

Results:

Freq. (MHz)	Synthesizer 1 $P_{OUT}$ (dBm)	Synthesizer 2 $P_{OUT}$ (dBm)
137	11	15
139	11	15
141	11	15
143	11	15
145	10	15
147	10	15
149	10	15
151	10	15
153	10	15
155	9	15
157	9	15
159	9	15
161	9	16
163	8	16
165	8	16

Spectrum Analyzer Settings: Bandwidth: 100 KHz/div

Scan Width: 1 MHz/div

Log Reg.: 10 dBm with HP355C

VHF Attenuator at 10 dB

PASSIVE INTERMODULATION TEST FACILITY

UNIT TESTS

(E) Unit Under Test: Channelizing Filters F1, F2 with Combiner.

Test Performed:

(1) Filter F1; Insertion loss and freq. response

$f_0 = 275 \text{ mhz}$  (Fig. 4-1)

$f_0 = 300 \text{ mhz}$  (Fig. 4-2)

$f_0 = 330 \text{ mhz}$  (Fig. 4-3)

(2) Filter F2; Insertion loss and freq. response.

$f_0 = 275 \text{ mhz}$  (Fig. 4-4)

$f_0 = 300 \text{ mhz}$  (Fig. 4-5)

$f_0 = 330 \text{ mhz}$  (Fig. 4-6)

(3) Isolation between input terminals at 3 mhz freq. separation  
(Fig. 4-7).

(4) Filter F1; Input and output terminal VSWR at 300 mhz, with  
 $50\Omega$  termination (Fig. 4-8).

(5) Filter F2; Input and output terminal VSWR at 300 mhz, with  
 $50\Omega$  termination (Fig. 4-9).

(6) Third order Intermodulation, referenced to Combiner output  
terminal '0'. (Fig. 4-10).

Test Equipment: HP 774D Directional Complex

HP 8554B, 8552B Spectrum Analyzer

HP 8444A Tracking Gen., HP735B Plotter,  
SRL Intermod. Test Bed.

(F) Unit Under Test: Noise Post - Filter F3.

Test Performed:

- (1) Pass and Stop Bands insertion loss. (Fig. 4-11).
- (2) Input and output terminals VSWR, with  $50\Omega$  termination (Fig. 4-12).
- (3) Third-order Intermodulation at Terminals A & B. (Fig. 4-13).

Test Equipment: as in (E)

(G) Unit Under Test: Noise Post - Filter F4.

Test Performed:

- (1) Pass and Stop Bands Insertion Loss (Fig. 4-14).
- (2) Input and output terminal VSWR with  $50\Omega$  termination (Fig. 4-15).
- (3) Third- order intermodulation (Fig. 4-16).

Test Equipment: as in (E).

(H) Unit Under Test: Noise Pre-Filter F5.

Test Performed:

- (1) Insertion loss characteristic (Fig. 4-17).
- (2) Pass band insertion loss (Fig. 4-18).
- (3) Third-order intermodulation referenced to input and output terminals (Fig. 4-19).

Test Equipment: as in (E).

(J) Unit Under Test: Noise Pre-Filter F6.

Test Performed:

- (1) Insertion Loss characteristic. (Fig. 4-20).
- (2) Pass-band insertion loss. (Fig. 4-21).
- (3) Input and output terminal VSWR, with  $50\Omega$  termination. (Fig. 4-22).

- (4) Third-order intermodulation referenced to F6 input and output terminals. (Fig. 4-23).

Test Equipment: as in (E)

(K) Unit Under Test: Transmit Duplexer Filter F7.

The following tests were performed with the 'Reflected mode' duplex connection (Part No. 350196) to Filter F8.

Test Performed:

- (1) Pass-band insertion loss. (Fig. 4-24).
- (2) Insertion loss characteristic. (Fig. 4-25).
- (3) Input VSWR, with  $50\Omega$  termination (Fig. 4-26).
- (4) Output VSWR (Fig. 4-27).

Test Equipment: as in (E).

(L) Unit Under Test: Receive Duplexer Filter F8.

The following tests were performed with filters F7 and F8 interconnected with the 'Reflected' Mode duplex connection. (Part No. 350196).

Test Performed:

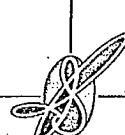
- (1) Pass-band insertion loss (Fig. 4-28).
- (2) Insertion loss characteristic (Fig. 4-29).
- (3) Input VSWR (Fig. 4-30).

Test Equipment: as in (E).

(M) Unit Under Test: Duplex Filters F7 and F8.

The following filter frequency response tests were performed with filters F7 and F8 duplexed by means of the 'Transmitted' Mode duplex connection (Part Nos. 350197 and 350198). Variation of Filter F8 pass band loss with effective length of Part No. 350198 is demonstrated.

Test Performed:



- (1) Filter F8 insertion loss characteristic for Part Nos. 350197 and 350198 interconnected. (Fig. 4-31).
- (2) Filter F8 pass band loss for Part Nos. 350197 and 350198 interconnected. (Fig. 4-32).
- (3) Filter F8 pass band loss variation with incremental length change of stub path length containing Part No. 350198. (Figs. 4-33, 4-34).
- (4) Filter F7 insertion loss characteristic for Part Nos. 350197 and 350198 interconnected. (Fig. 4-35).
- (5) Filter F7 pass band loss for Part Nos. 350197 and 350198 interconnected. (Fig. 4-36).

Note The stub electrical length (i.e., total length of Part 350198 and including the 50 ohm transmission line device-under-test) from the junction of Part 350197 through to the coupling loop ground of Filter F7 is required to be  $(2n-1) \frac{\lambda}{4}$  where

$\lambda$  = wavelength in dielectric at the receive frequency,

$n = 1, 2, 3, \dots$

The admittance at the T-junction looking toward F7 should be small at the receive frequency to minimize the mismatch loss measurement error.

(N) Unit Under Test: Duplexing Filters & Load.

Test Performed: Third-order intermodulation measurement using SRL IM test bed, for two 100 watt CW signals into device under test.

Note: Measurements were limited to approximately -120 dBm minimum due to use of temporary test cables and connections into the device under test.

- (1) Dummy load (excluding Cable Pad) ~ 114 dBm. IM levels produced by alternate resistor elements ranged to ~ 93 dBm.
- (2) Dummy load and 9 dB Cable Pad: -117 dBm maximum. -130 dBm

minimum with improved test connections.

- (3) Filters F7 and F8 connected via reflected mode duplex connections; Third-order intermod measured at Filter F8 output terminal; Test signals applied to Filter F7. input via SRL IM Test Bed:

$f_1 = 275 \text{ mhz}$ ,  $f_2 = 330 \text{ mhz}$ . Third-order IM at 385 mhz  
= - 120 dBm max, -130 dBm min.

- (0) Unit Under Test: Passive Intermod. Test facility, complete with source, Filter, and Load Sub-systems.

Test Performed: Third-order intermod at 100 watt CW test signals into load; Output circuit connections per reflected mode test.

Result

Third-order IM at 385 mhz = 125 dBm max.

$f_1 = 275 \text{ mhz}$ .

$f_2 = 330 \text{ mhz}$ .

S/N  $\sim 10 \text{ dB}$ , for detector comprising HP8554B spectrum

Analyzer & Avantek UT0511 + 501 Low noise amplifier.

- (P) Unit Under Test: Passive Intermod. Test Facility complete with Source, Filter, and Load Sub-systems.

Test Performed: Third-order intermod; output circuit connections per transmitted mode test; 100 watt CW test signals into load.

Result: - 120 dBm max. with test cable flexure. (Fig. 4-37).

Detector: HP 8554B Analyzer and Avantek UT0 511 + 501 LNA.

- (Q) Unit Under Test: Standard Non-linear Load; comprised of Part 350230 Connected in series with Dummy Load and 9 dB Cable Pad.

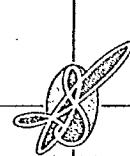
Test Performed: Third to seventeenth-orders intermod levels at  
Filter F8 output terminal.

Results: Figs. 4-38, 4-39, 4-40. with Source sub-system output  
power levels as noted.

(R) Unit Under Test: HP 8553B Spectrum Analyzer.

Test Performed: as follows:

- (1) Peak noise level vs. Bandwidth setting (Fig. 4-41).
- (2) Third-order Intermod vs. frequency separation, for Out-of-Band  
signals. (Fig. 4-42).
- (3) Third to seventh-order intermod versus two equal input signal  
amplitude. (Fig. 4-43).



## FILTER F1

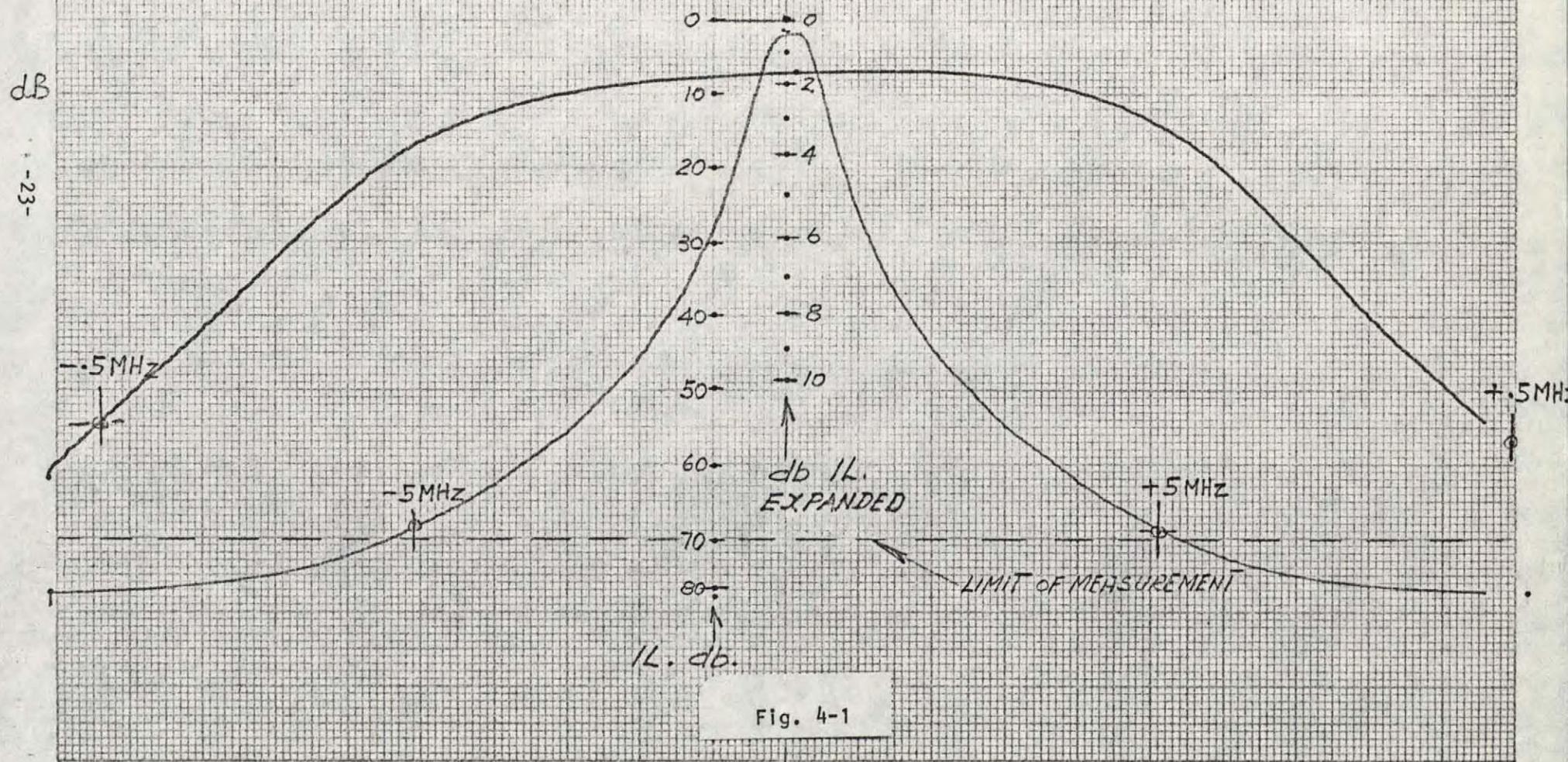
 $f_0 = 275 \text{ MHz}$ 

Fig. 4-1

FREQ.

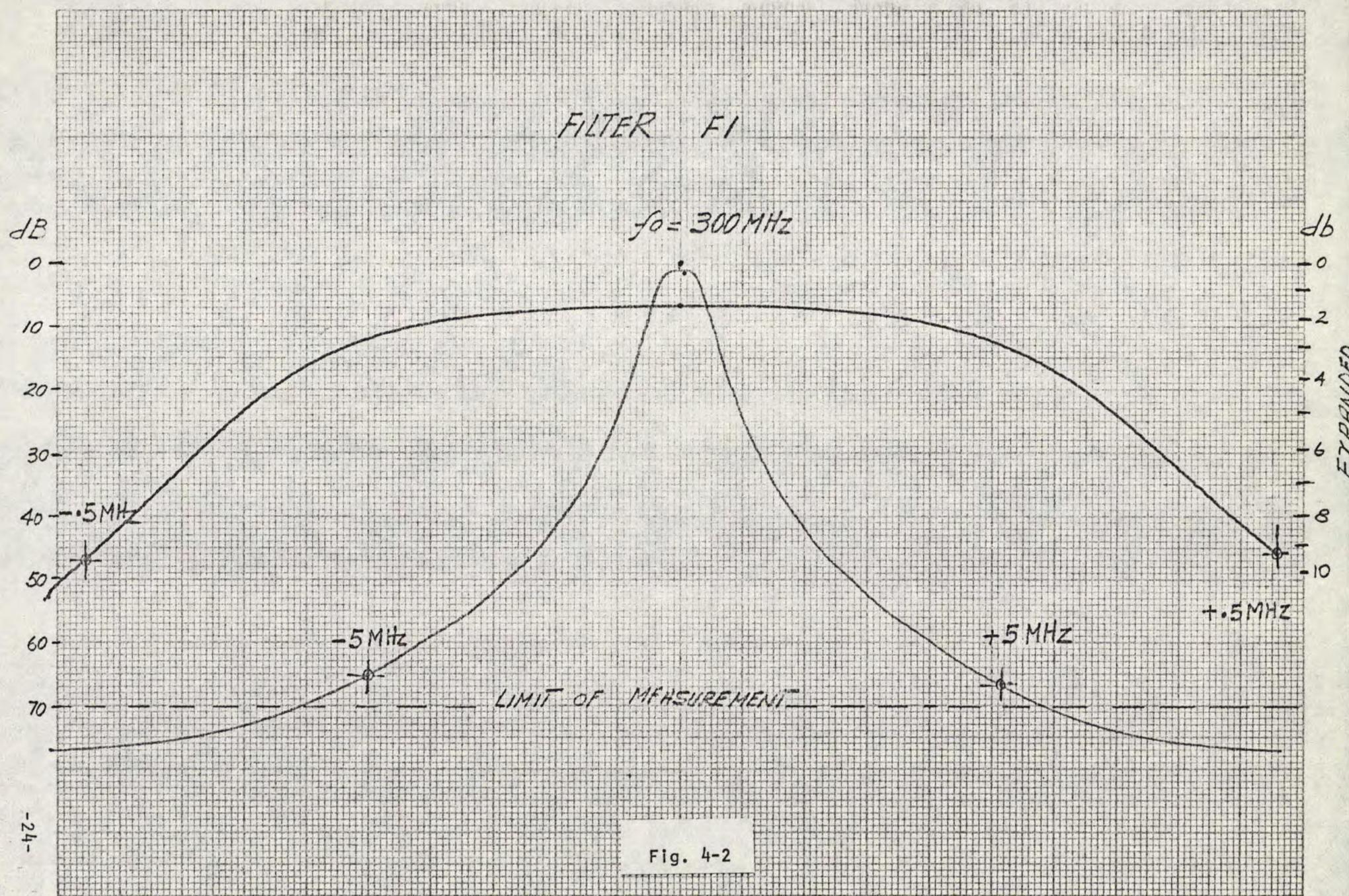


Fig. 4-2

*FREQ.*

## FILTER F1

IL.

db.

0

10

20

30

40

50

60

70

-25-

IL.

db.

0

2

4

6

8

10

 $f_0 = 330 \text{ MHz}$ 

-.5 MHz

-5 MHz

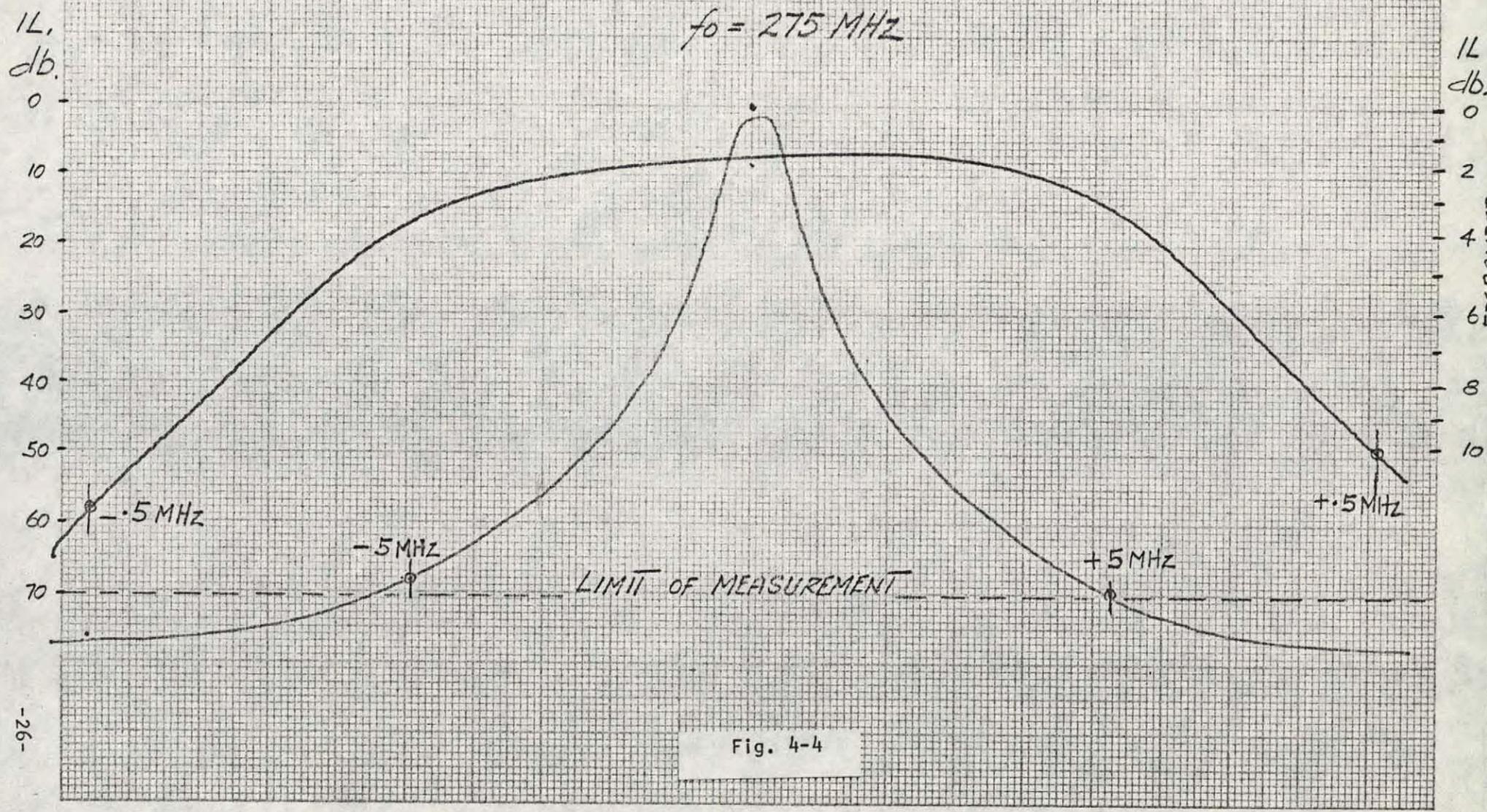
+.5 MHz

LIMIT OF MEASUREMENT

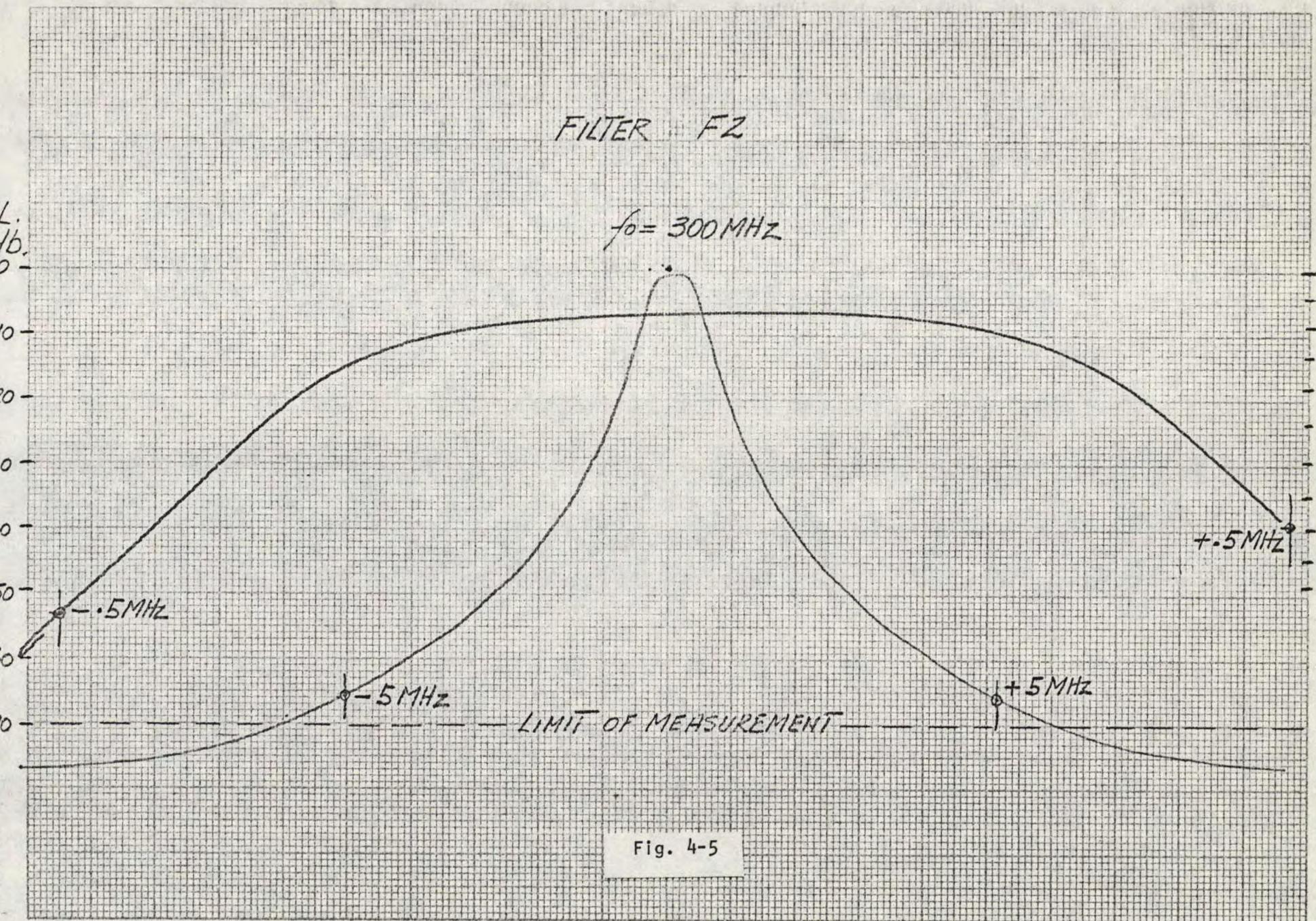
Fig. 4-3

FREQ.

## FILTER F2



FREQ.



FREQ.

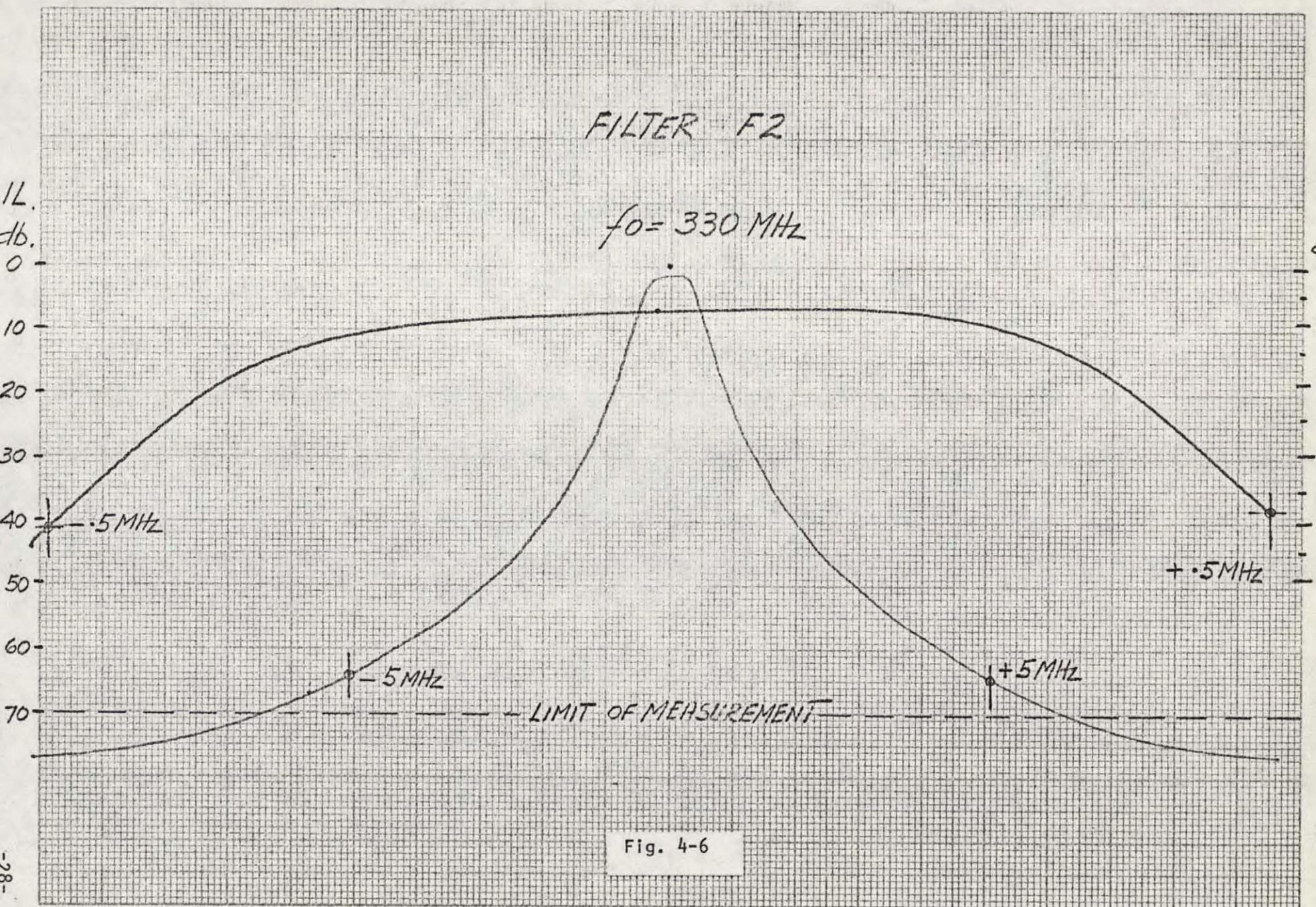
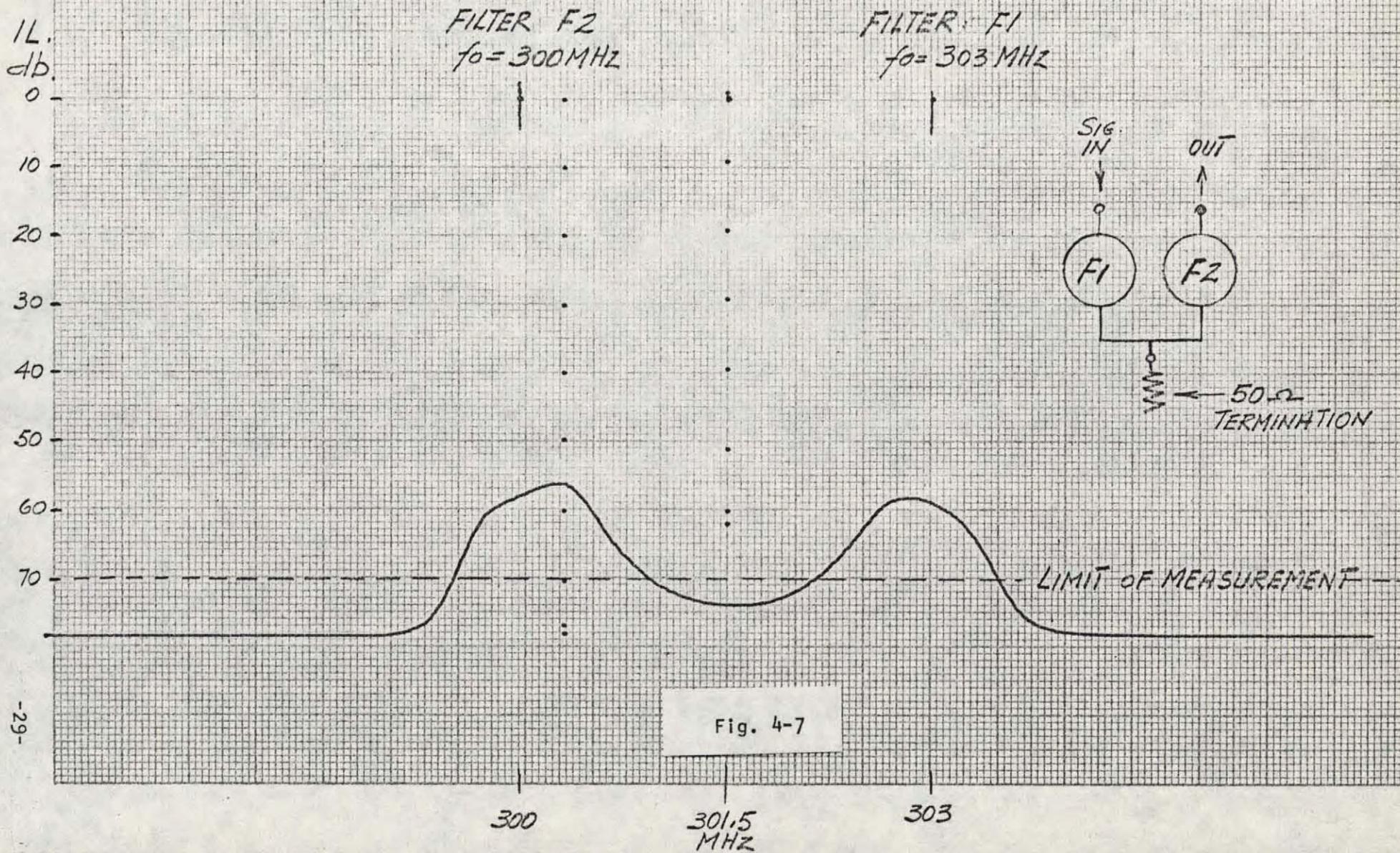
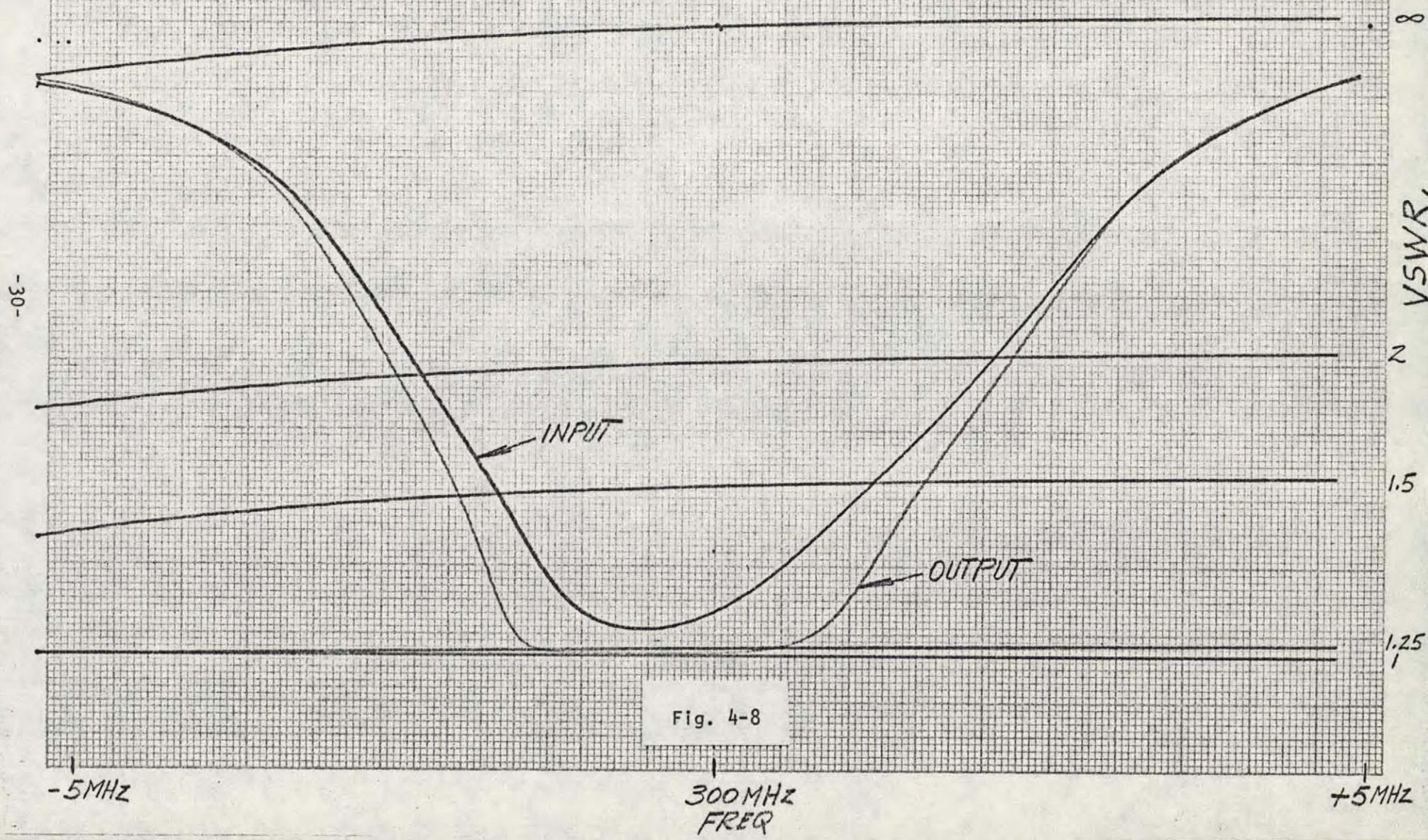
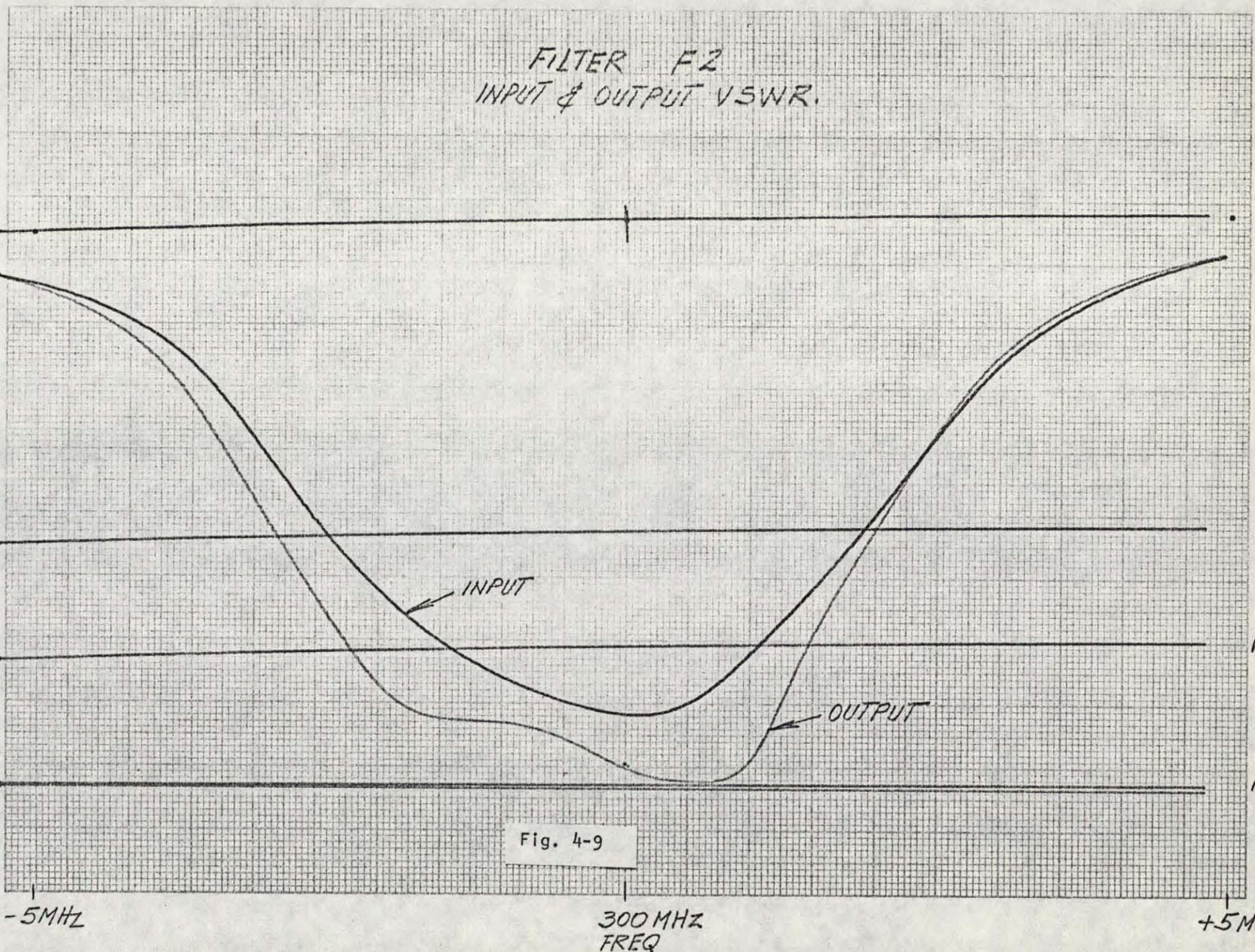


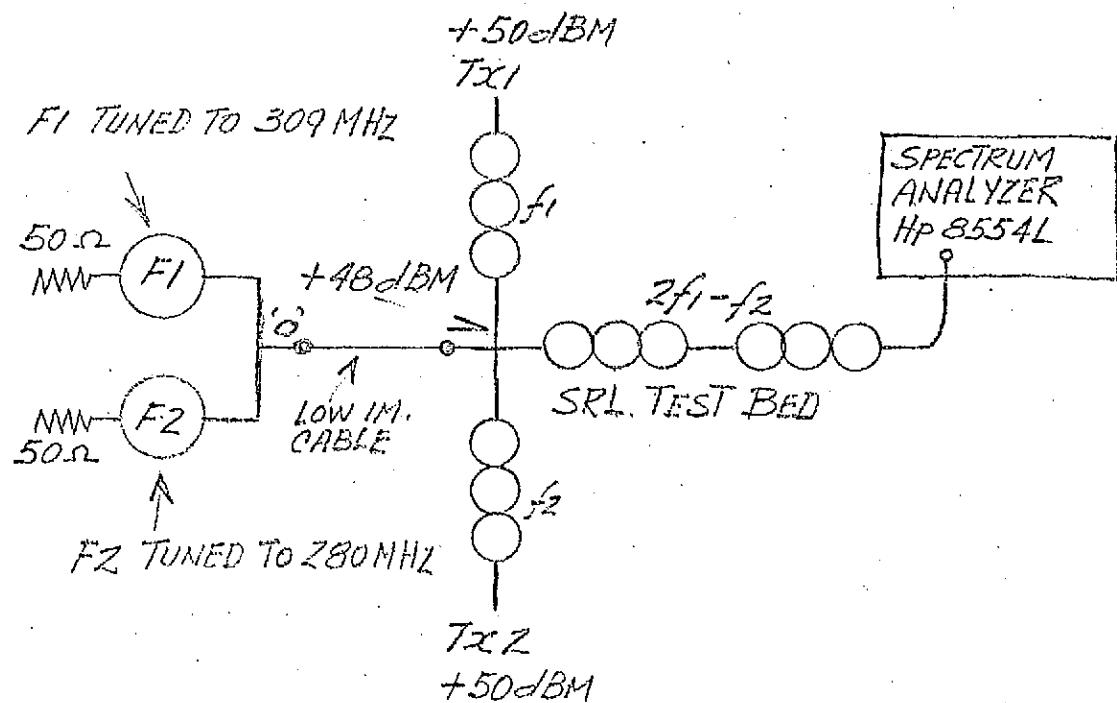
Fig. 4-6

FREQ.

TWO TONE FILTER  
ISOLATION TEST

FILTER F1  
INPUT & OUTPUT VSWR.





$$\begin{aligned}
 f_1 &= 309 \text{ MHz} \\
 f_2 &= 280 \text{ MHz} \\
 2f_1 - f_2 &= 338 \text{ MHz}
 \end{aligned}$$

IM. LEVEL = 100 dB

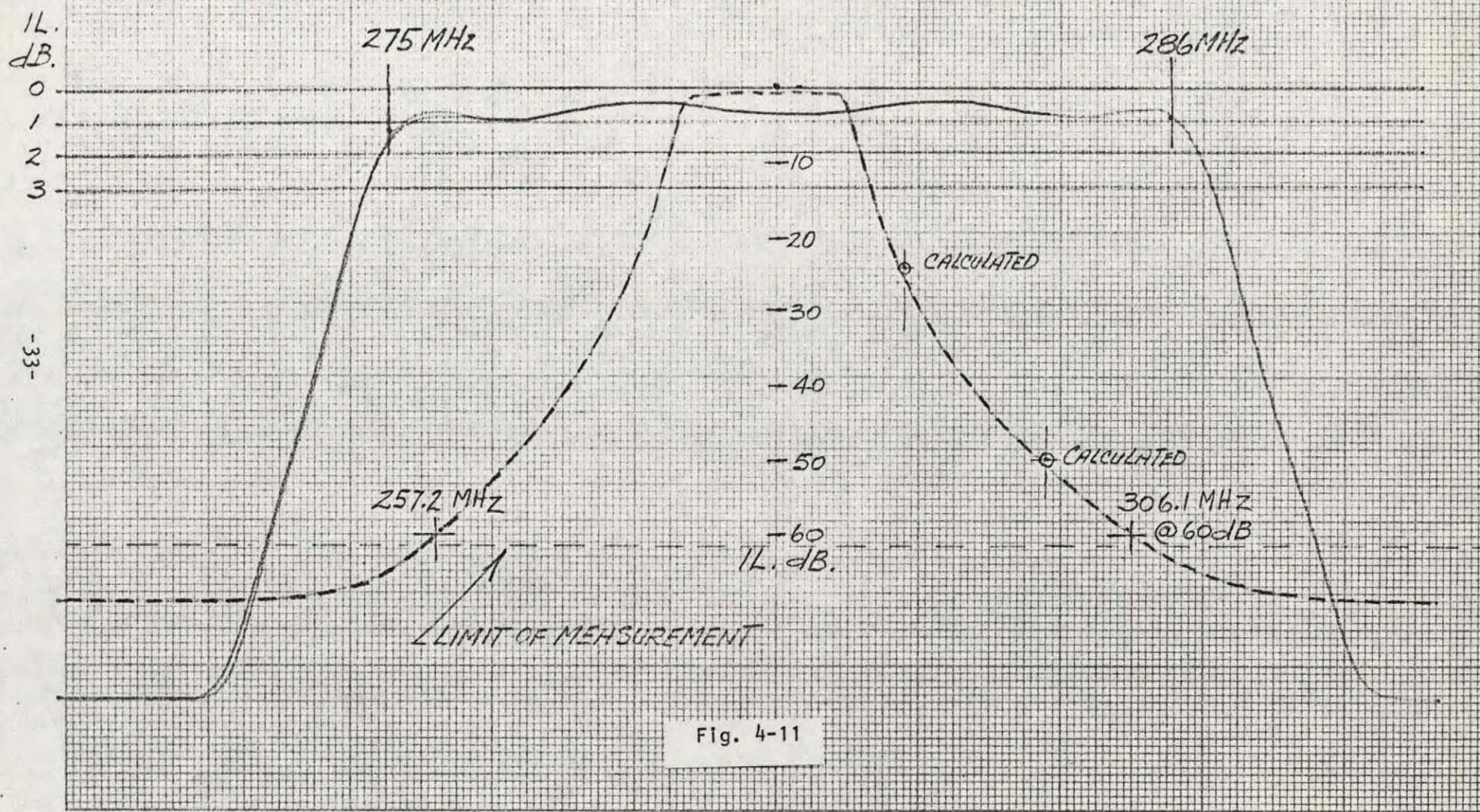
REFERENCED TO TERMINAL 0  
WITH +48 dBm EQUAL AMPL.  
TEST SIGNALS.

Fig. 4-10

OCT 7.76

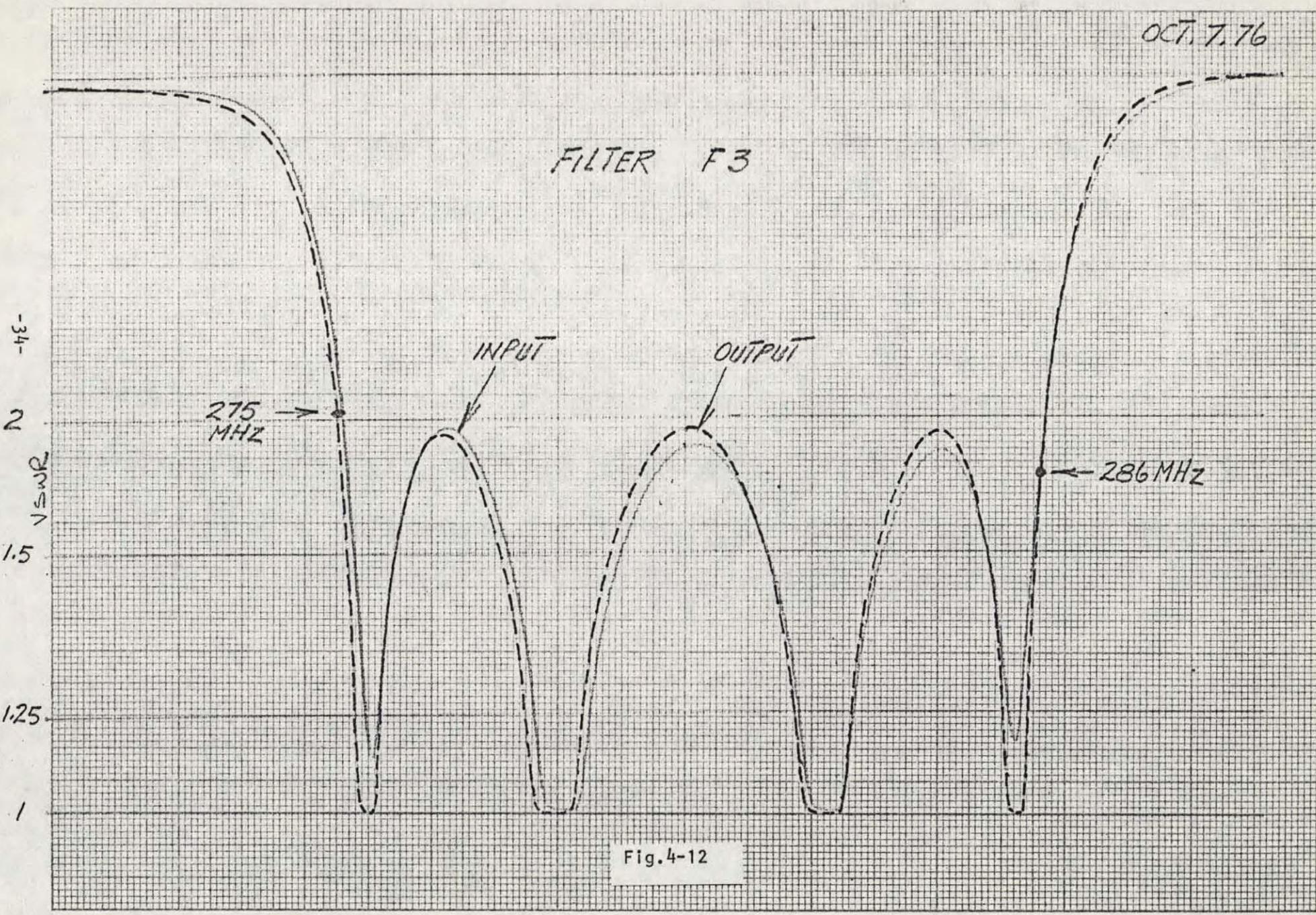
EXPANDED

## FILTER F3



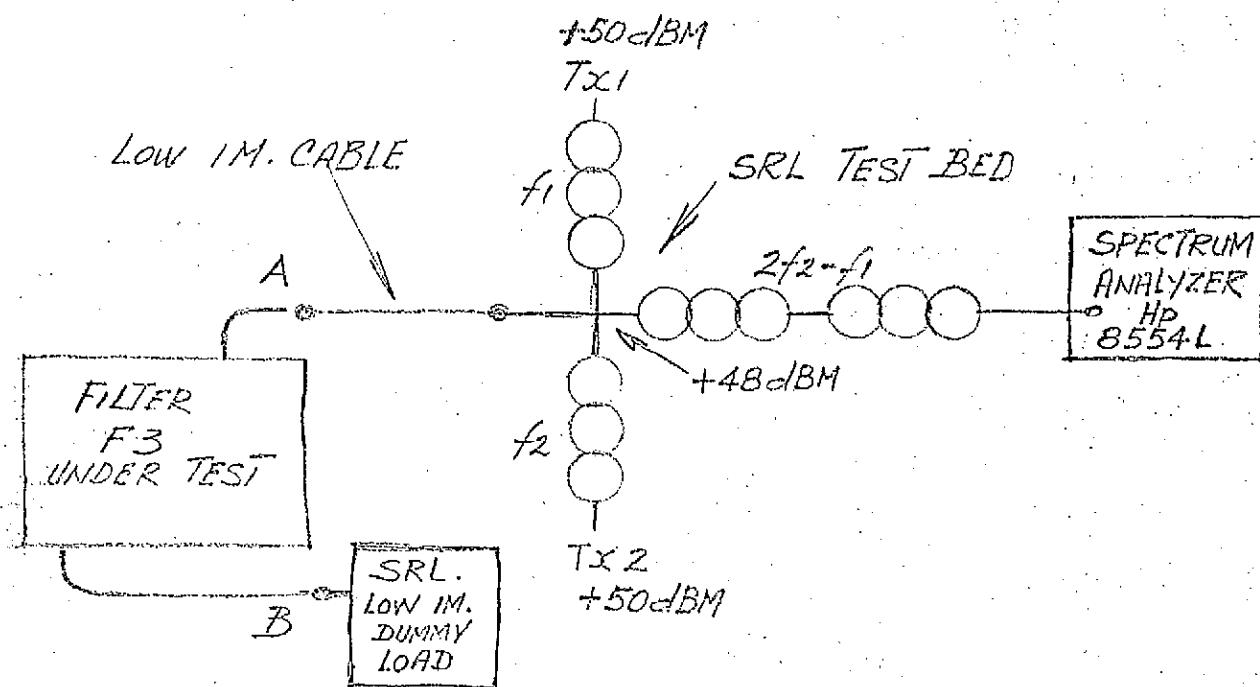
FREQ.

OCT. 7, 76



FREQ.

# FILTER F3 IM. TEST



$$Tx 1 = 276 \text{ MHz} \quad f_1 \quad 2f_2 - f_1 = 284 \text{ MHz}$$

$$Tx 2 = 280 \text{ MHz} \quad f_2$$

IM. LEVEL - 100 dBm - FILTER CONNECTED TO TEST BED AS SHOWN IN SKETCH ABOVE

IM. LEVEL - 100 dBm - FILTER TERMINALS A & B REVERSED.

Fig. 4-13

OCT 7-76

Z30MHz 2.  
dB

## FILTER F4

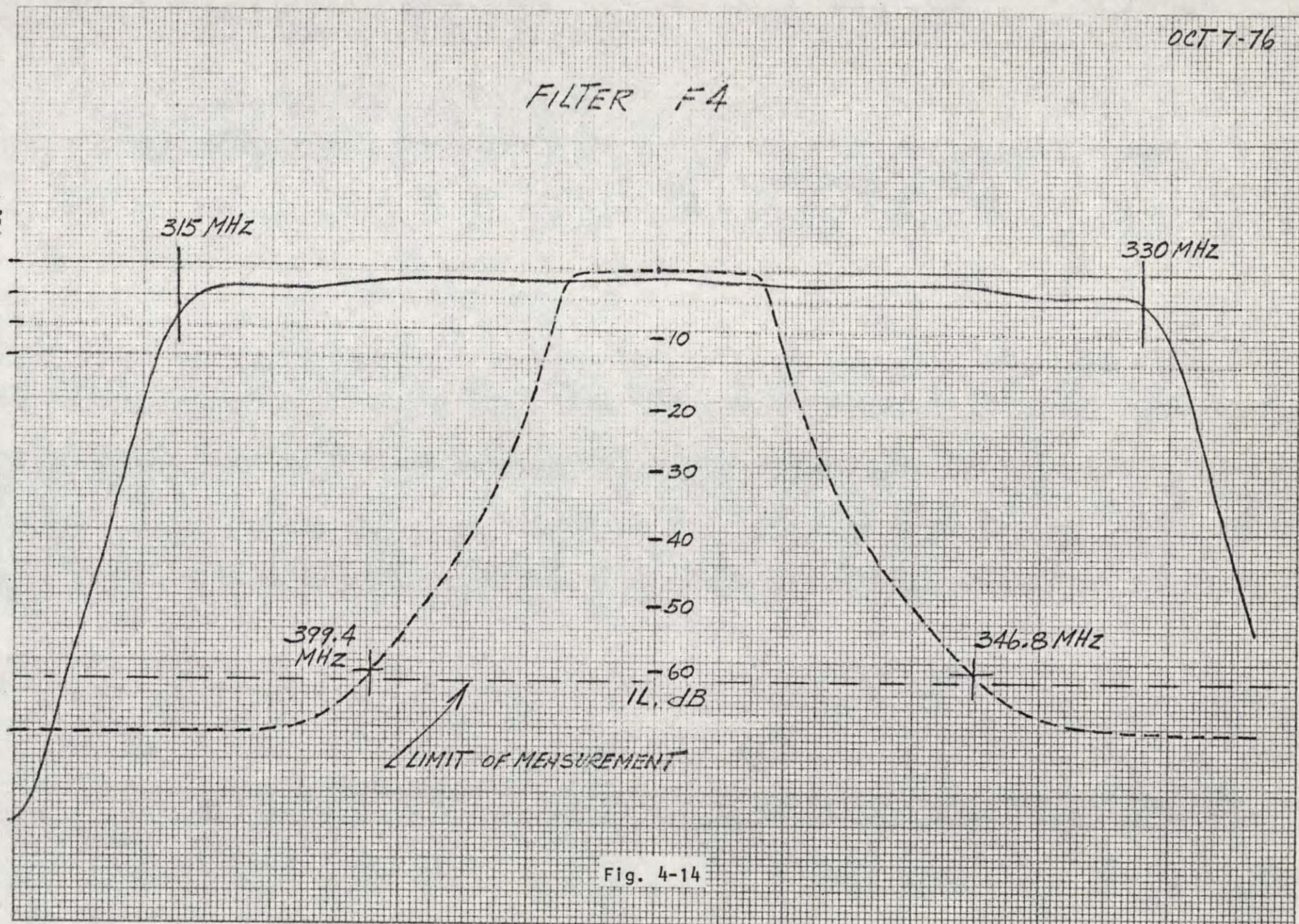


Fig. 4-14

FREQ.

© Calculated.

OCT 7-76

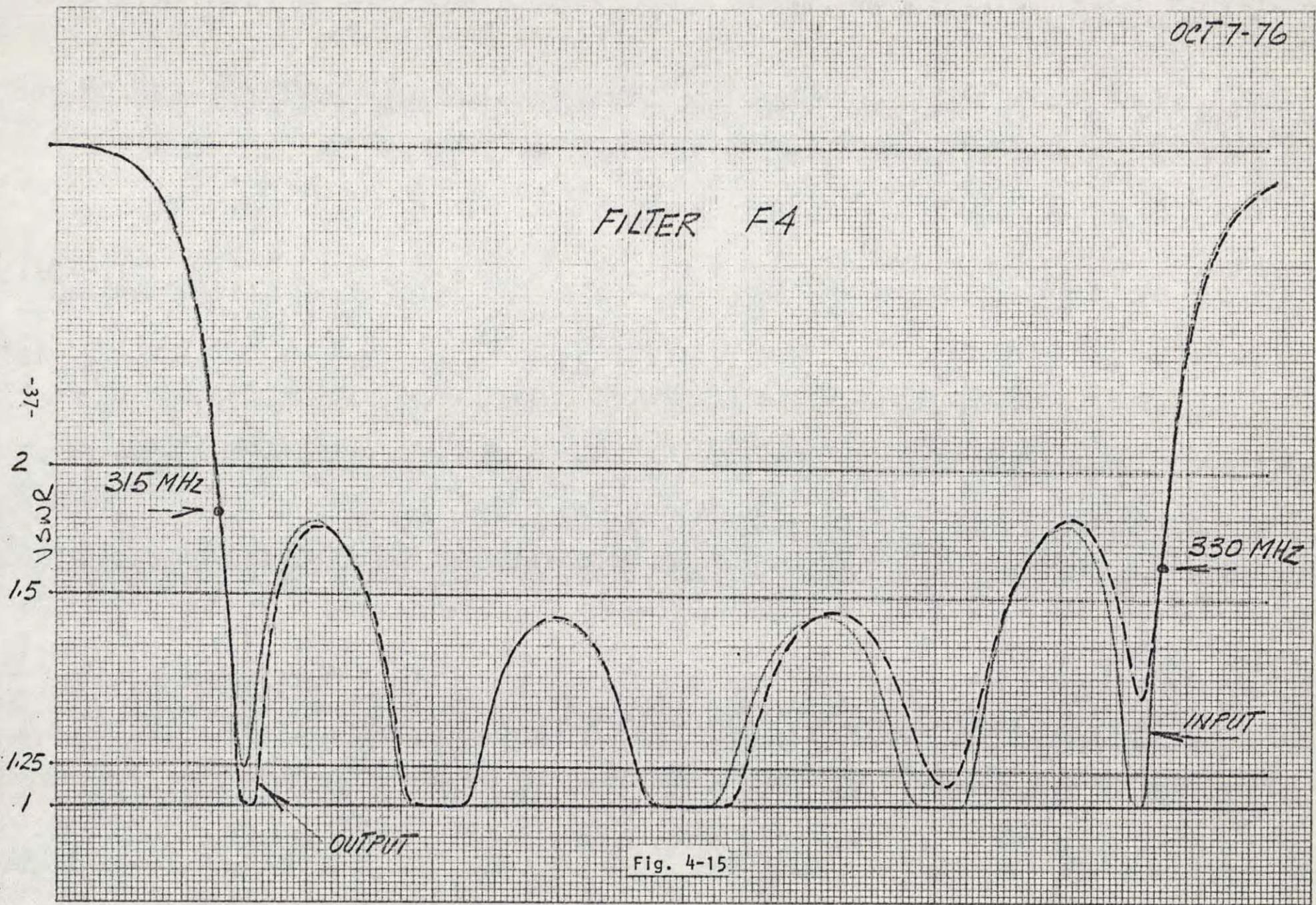
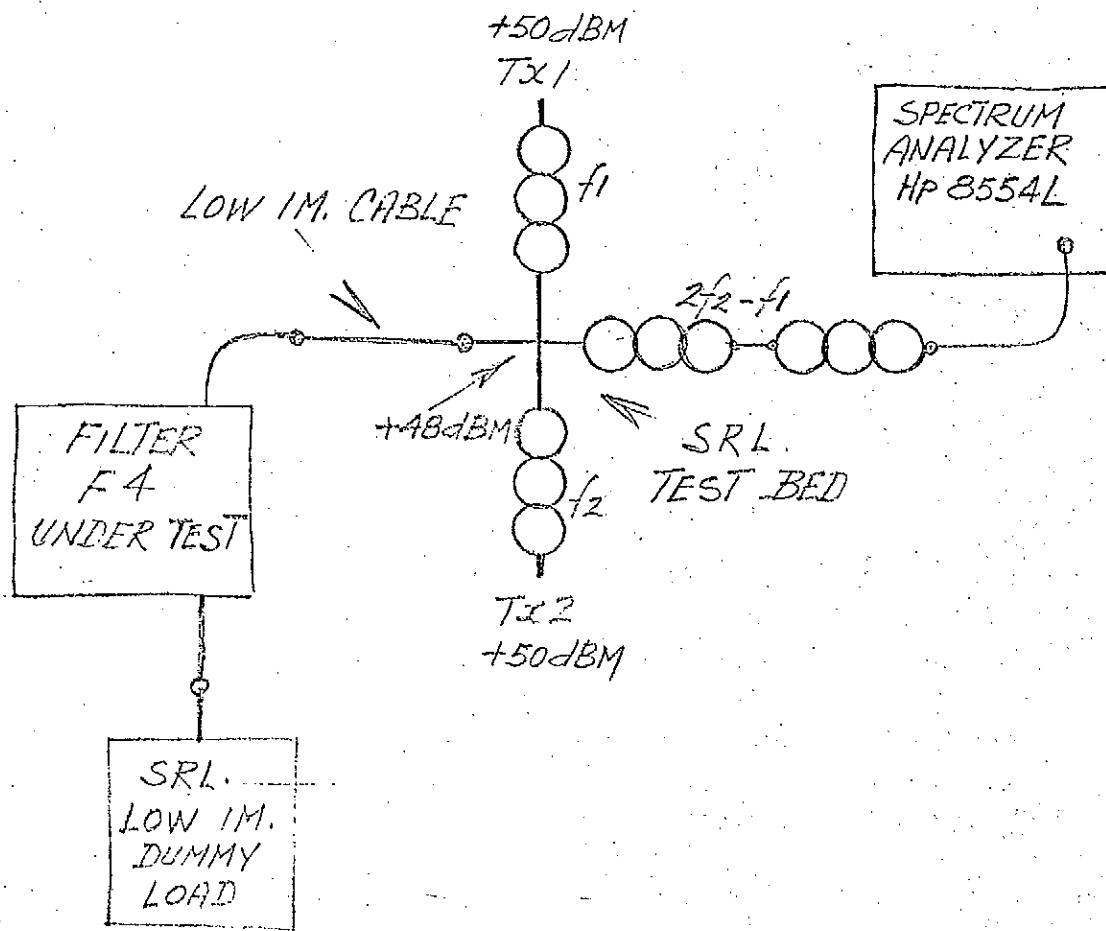


Fig. 4-15

FREQ.

# FILTER F4 IM. TEST

4-16



$$Tx1 = 315.4 \text{ MHz} \quad f_1$$

$$Tx2 = 313.6 \text{ MHz} \quad f_2$$

$$2f_2 - f_1 = 3.2 \text{ MHz}$$

IM. LEVEL - 95 dBm TO -100 dBm

Fig. 4-16

FILTER F5

11.

db

0 -

10 -

20 -

30 -

40 -

50 -

60 -

70 -

-39-

 $f_0 = 280.44 \text{ MHz}$ 

LIMIT OF MEASUREMENT

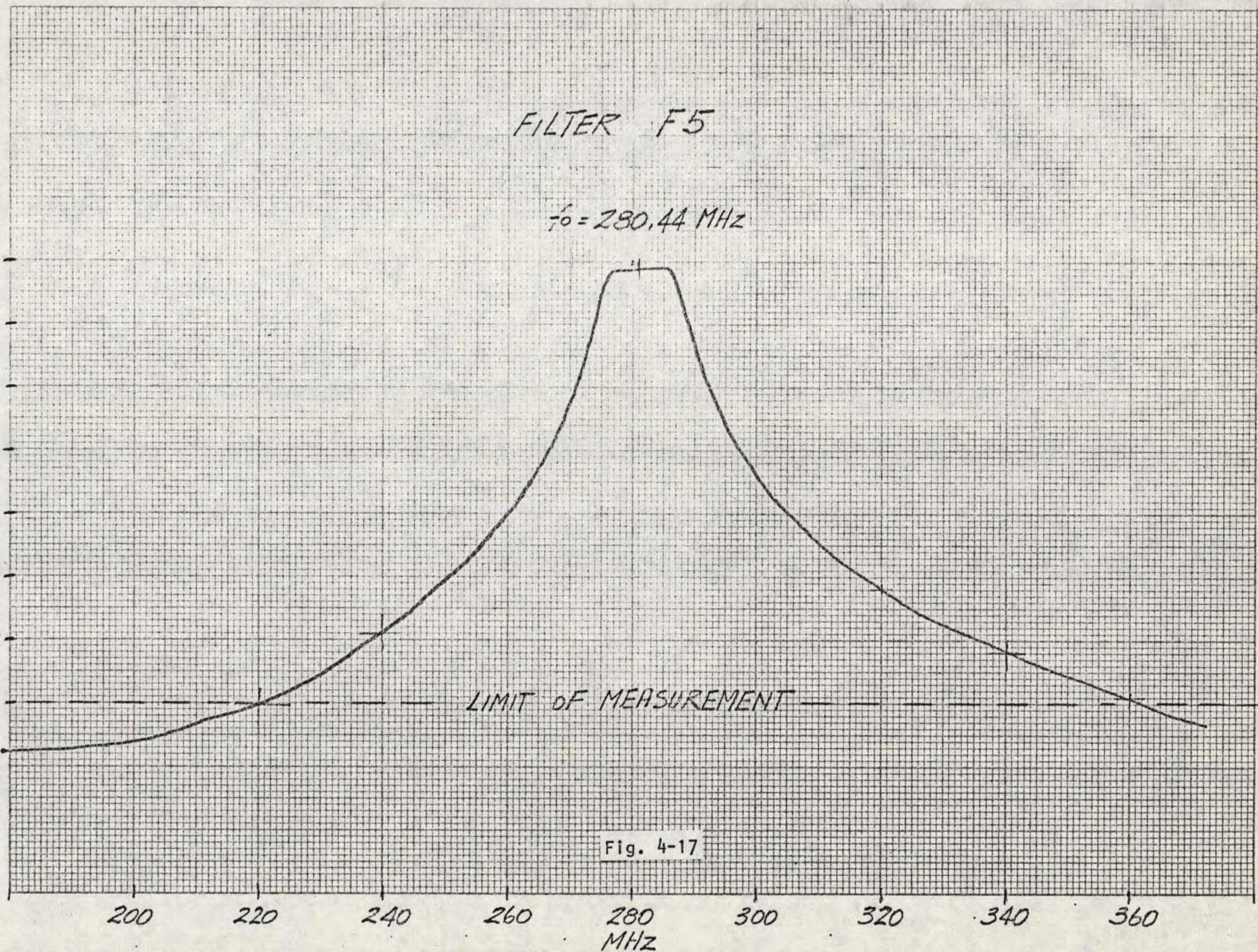


Fig. 4-17

FILTER F5

1L  
db.

$f_0 = 280.44 \text{ MHz}$

0

-2.75

-40

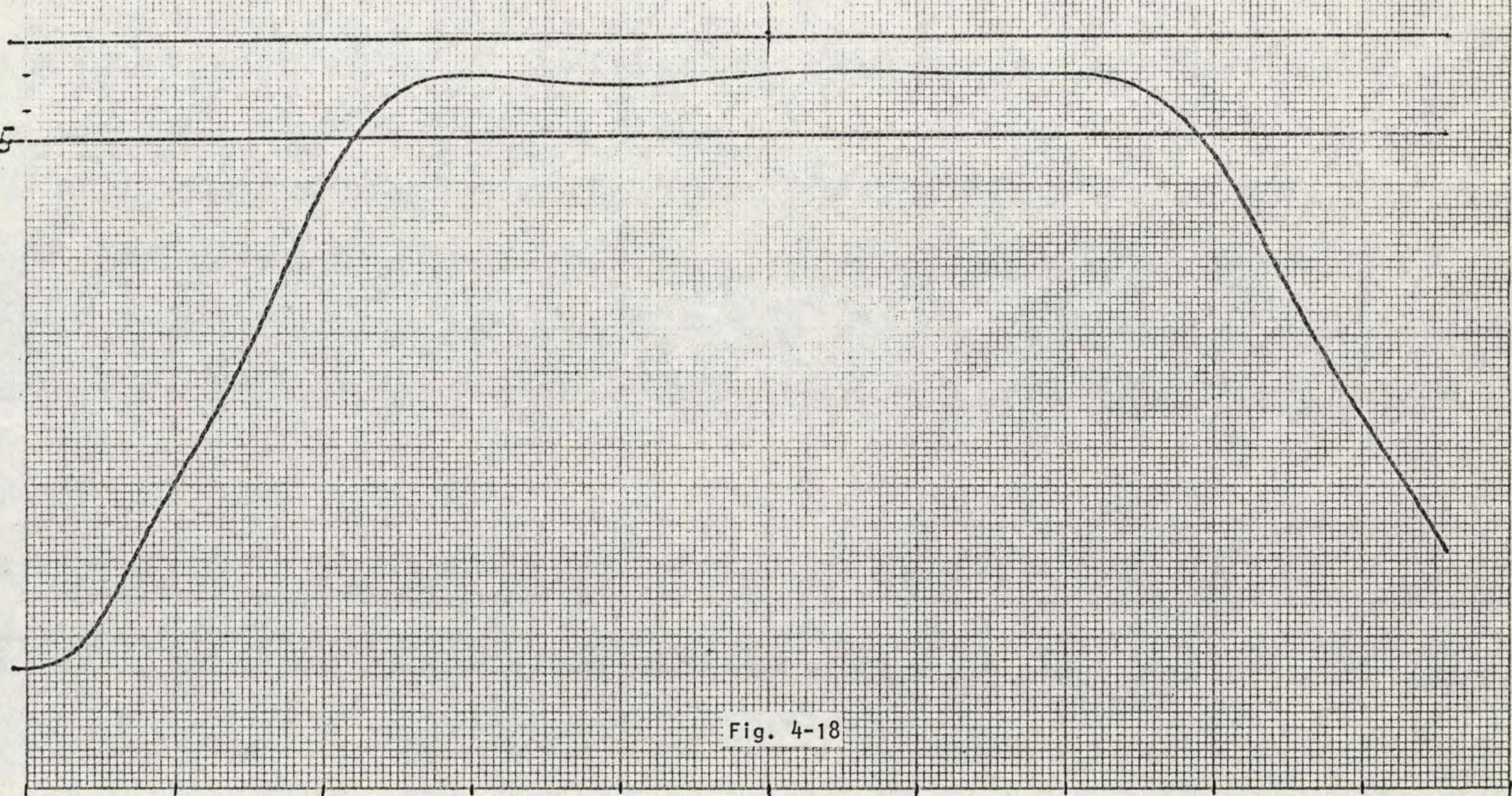


Fig. 4-18

2.0 MHZ / INCH

SEPT 9-76

## FILTER F5

$$f_1 = \sim 276.0 \text{ MHz}$$

$$f_2 = 280.0 \text{ MHz}$$

$$2f_2 - f_1 = 284.0 \text{ MHz}$$

dBm

-50

-60

-70

-80

-90

-100

PEAKS TO -70 dBm

SPECTRUM  
ANALYZER

HP

8554B

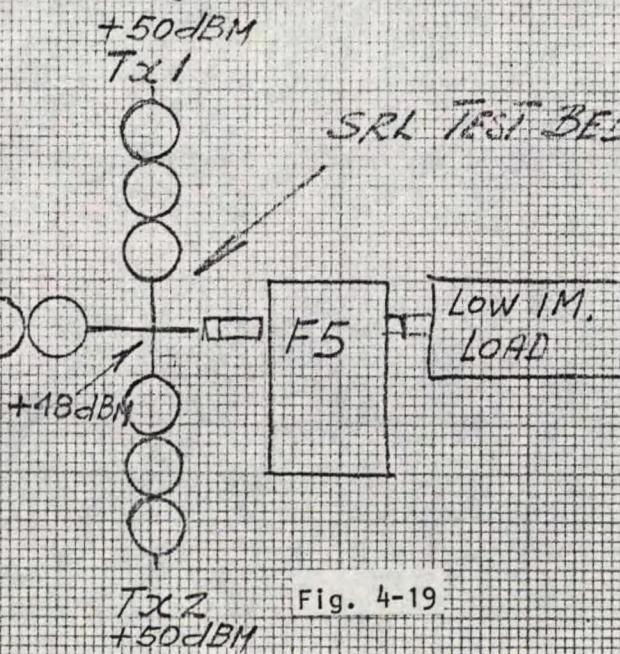
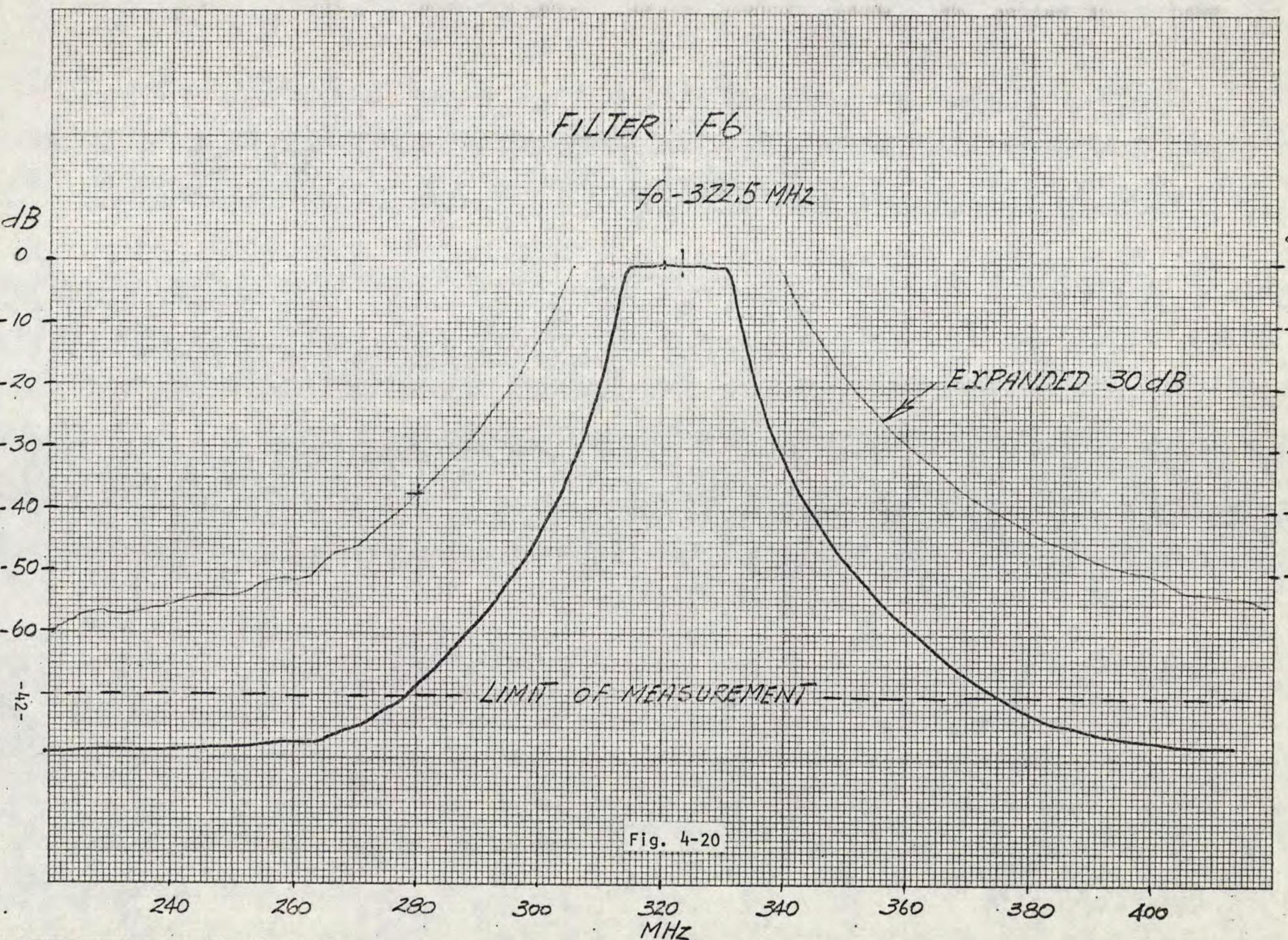
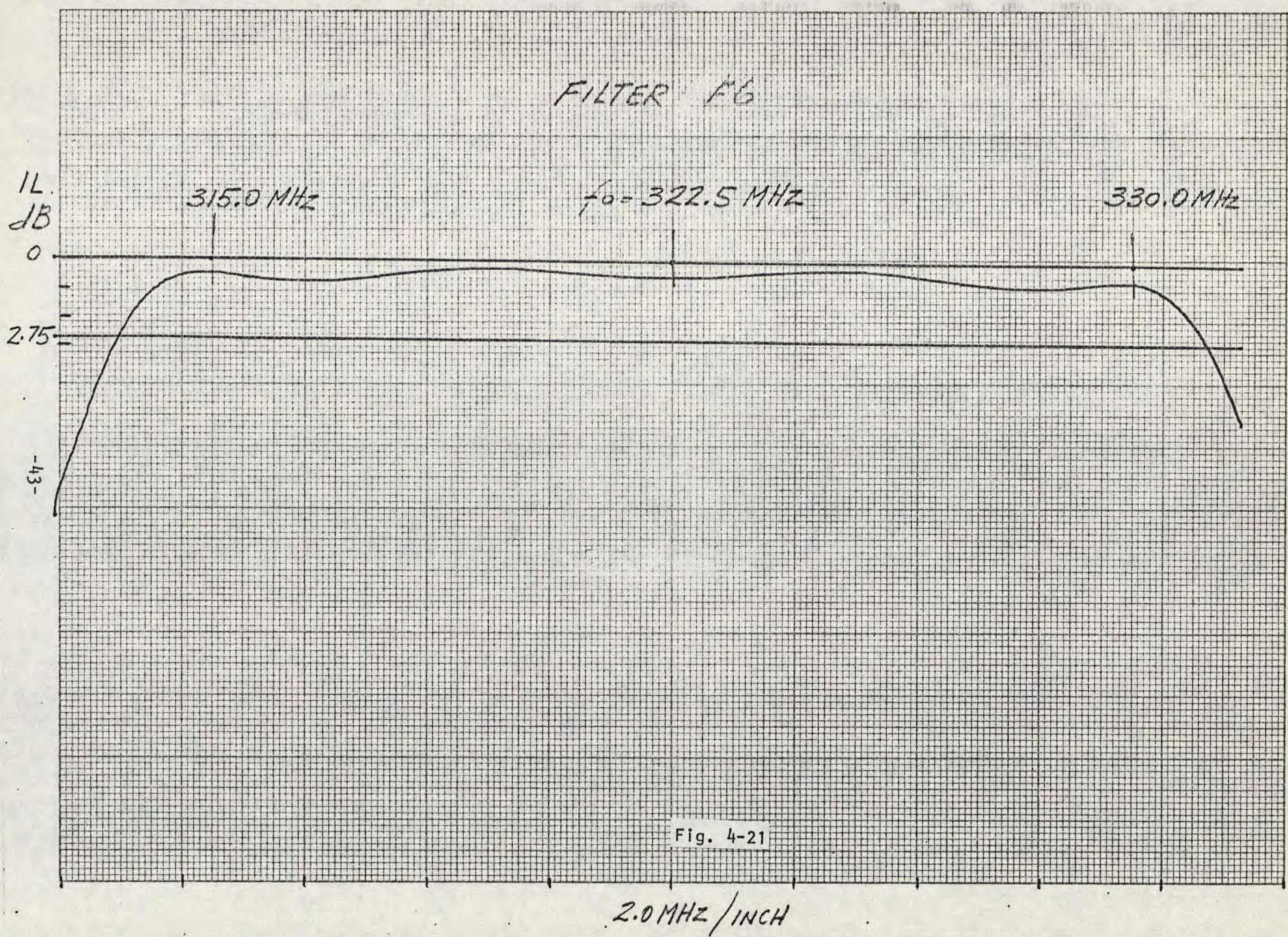


Fig. 4-19

100 SEC.





V.S.W.R. INPUT &amp; OUTPUT

2.0

-47-

1.0

FILTER F6

V.S.W.R. —&gt;

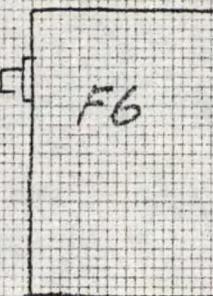
50- $\Omega$   
TERMINATION $f_0 = 322.5 \text{ MHz}$ 

Fig. 4-22

2.0 MHz / INCH

SEPT. 9-76

3RD ORDER IM. MEASUREMENT  
FILTER F6

dbM

-50

-60

-70

-80

-90

-100

$$\begin{aligned}
 f_1 &= 315.4 \text{ MHz} \\
 f_2 &= 318.6 \text{ MHz} \\
 2f_2 - f_1 &= 321.8 \text{ MHz}
 \end{aligned}$$

$$P_1 = P_2 = 100 \text{ W}$$

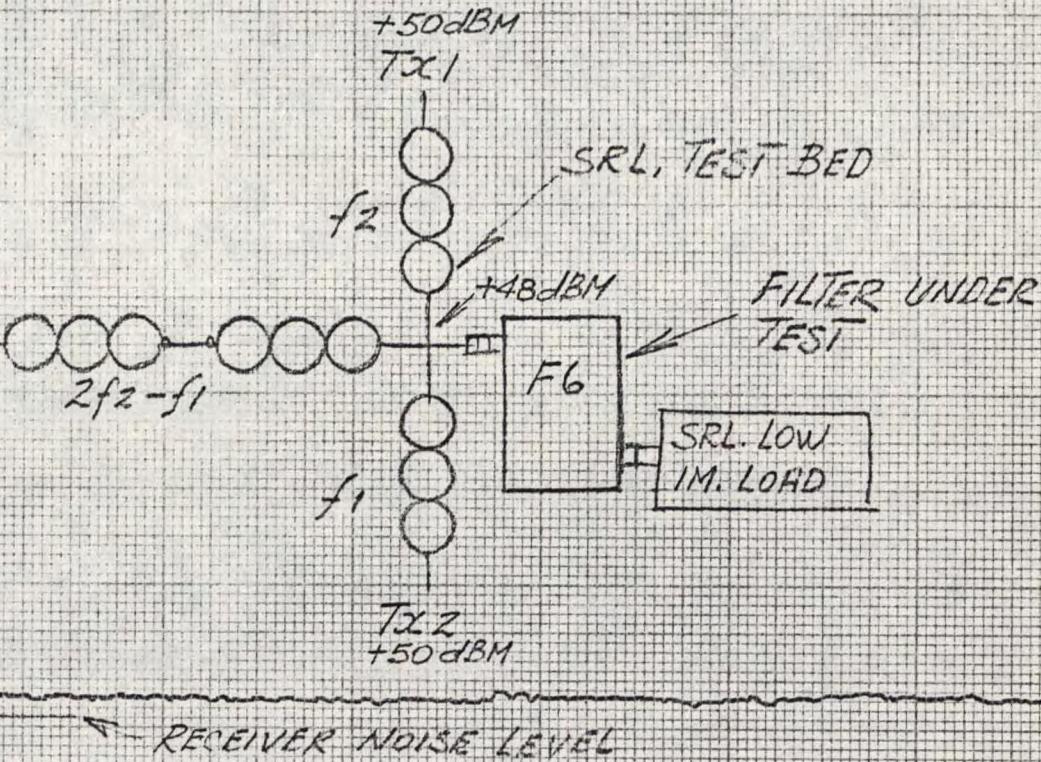
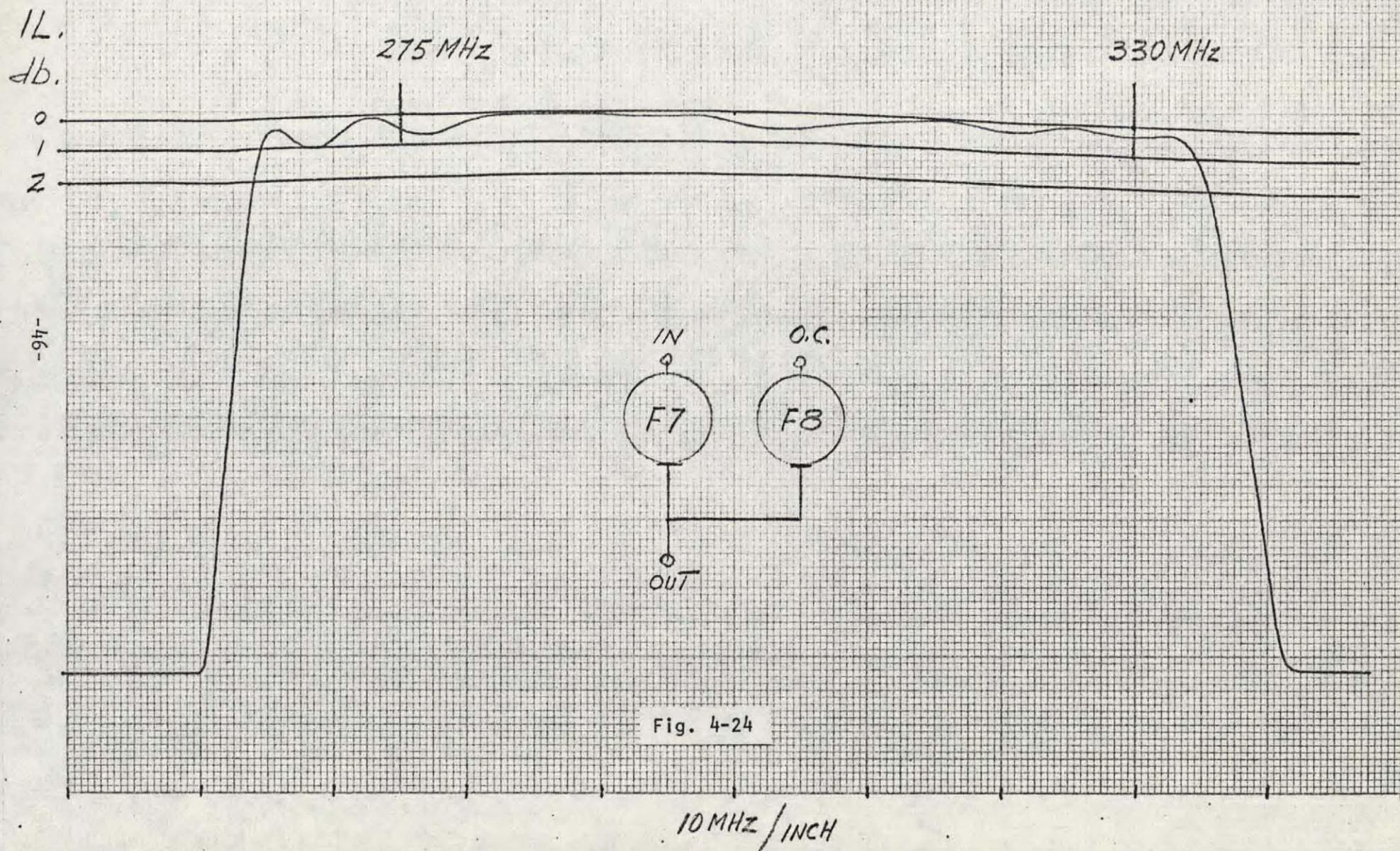
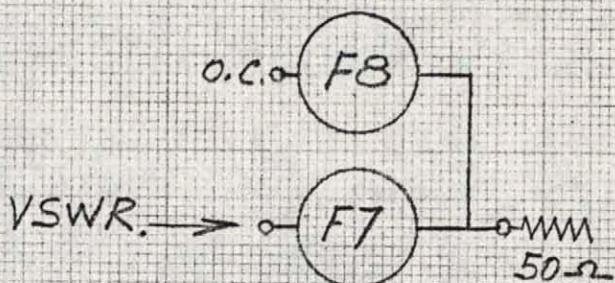
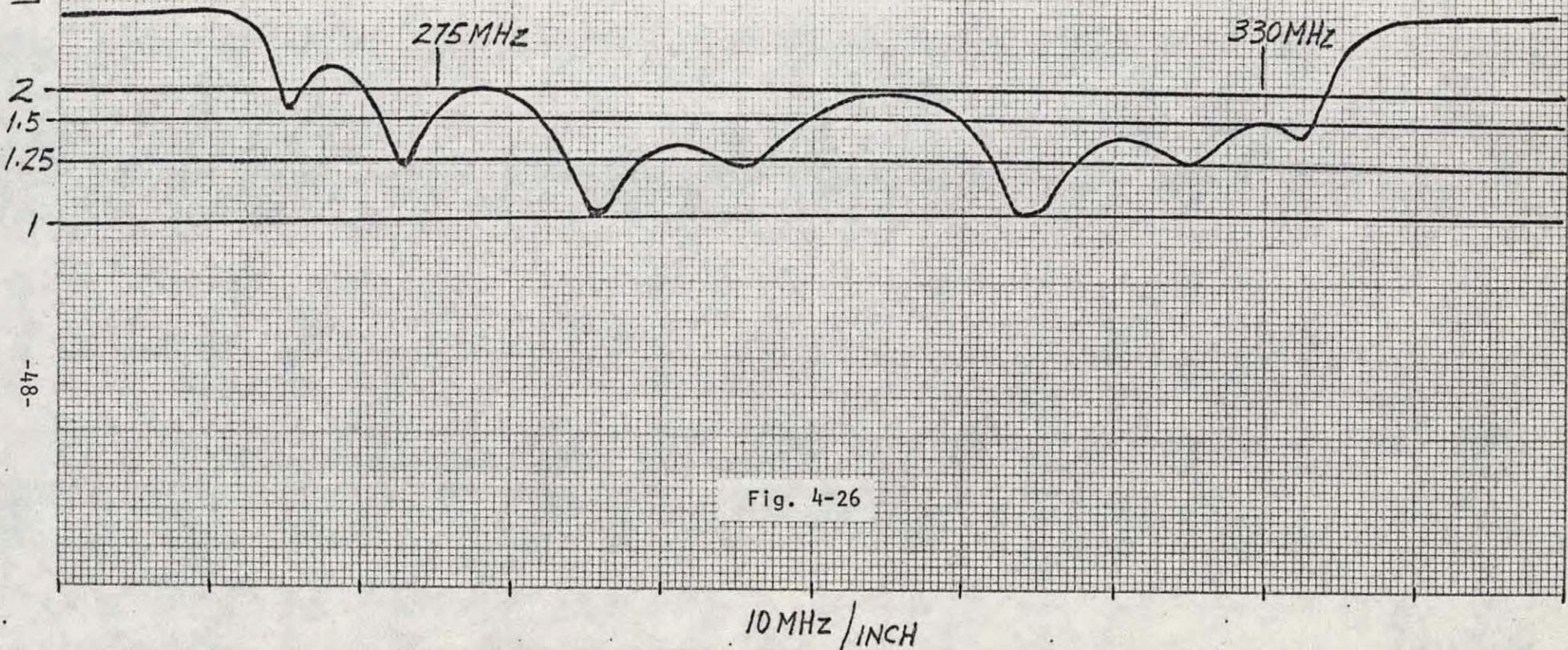
SPECTRUM  
ANALYZERHP  
8554B

Fig. 4-23

TIME 100 SEC.

FILTER F7  
PASS BAND RESPONSE

FILTER F7  
VSWR, INTO INPUT PORTV.SWR.  
-48-

## FILTER F7

IL.

dB

0

10

20

30

40

50

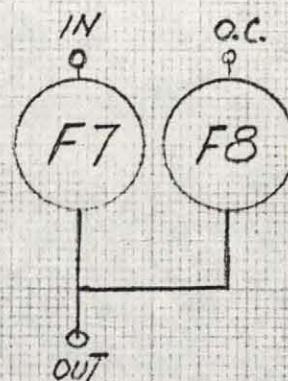
60

70

-10

275 MHz

330 MHz



## MEASURED POINTS

390 MHz - 71 dB

410 MHz - 83 dB

LIMIT OF MEASUREMENT

Fig. 4-25

20 MHz / INCH

FILTER F7  
VSWR. INTO OUTPUT PORT

VSWR.

2

1.5

1.25

1

-

275 MHz

330 MHz

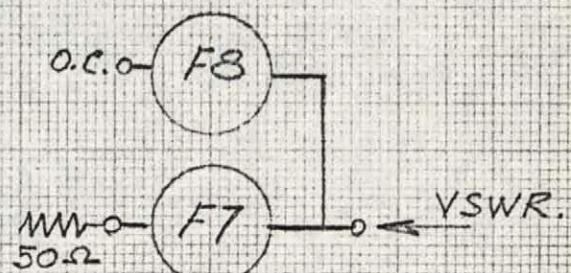


Fig. 4-27

10MHz / INCH

FILTER F8  
BAND PASS RESPONSE

IL.

db.

0

1

2

-50

370 MHz

406 MHz

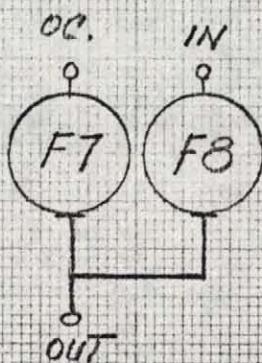


Fig. 4-28

5 MHz / INCH

## FILTER F8

IL.

db.

0

10.

20.

30.

40.

50.

60.

70.

-51-

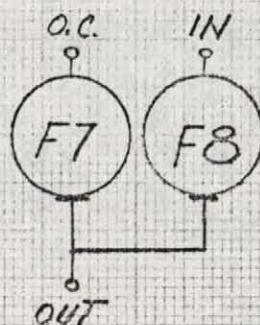
370MHz

406MHz

## MEASURED POINTS

350 MHz: 83 db

340 MHz: 122 db



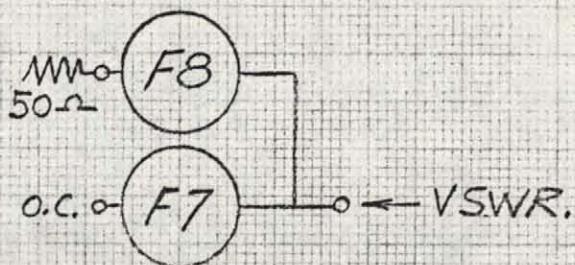
— LIMIT OF MEASUREMENT —

Fig. 4-29

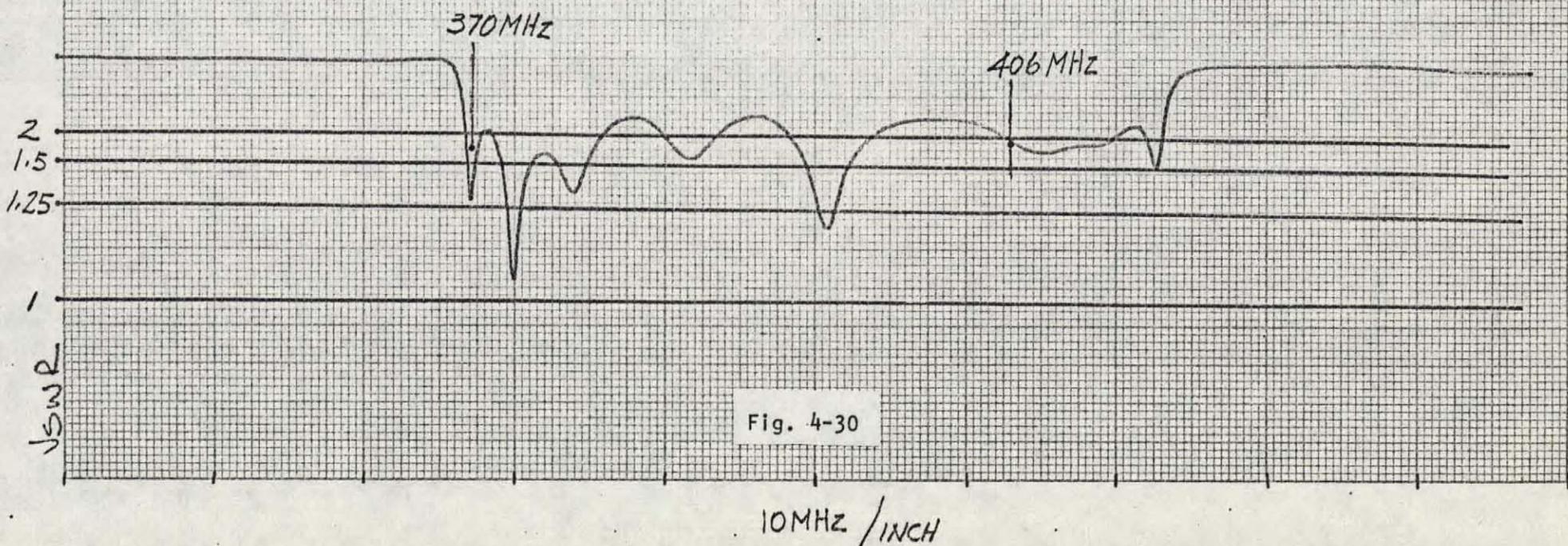
10MHz / INCH.

FILTER FB

VSWR.



-52-



NOV. 11, 76

## FILTER F8

IL.

db

0

10

20

30

40

50

60

70

-53-

370 MHz

406 MHz

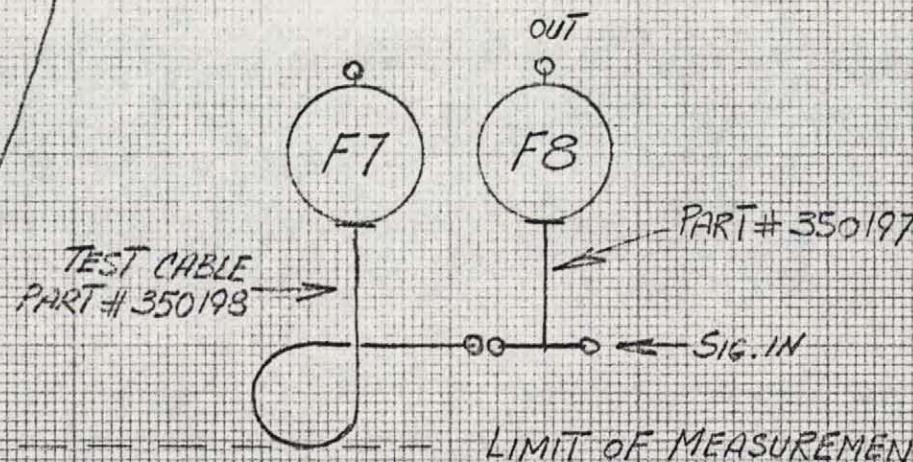


Fig. 4-31

10 MHz / INCH

## FILTER F8

IL.

db

0

1

2

3

-5

370 MHz

406 MHz

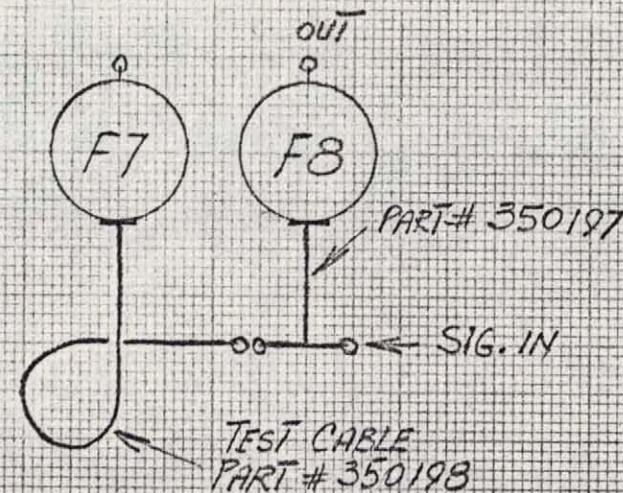


Fig. 4-32

10MHz / INCH

## FILTER F8

IL,

db

0

1

2

3

4

5

6

7

8

9

10

-55

370 MHz

406 MHz

TEST CABLE  
PART # 350198  
ONLYUG 29B/u & UG 57B/u  
ADDEDTEST CABLE  
PART # 350198

OUT

F8

PART # 350197

SIG. IN

UG 29B/u &amp; UG 57B/u

Fig. 4-33

10 MHz / INCH.

FILTER F8



16

o

1

2

三

-56-

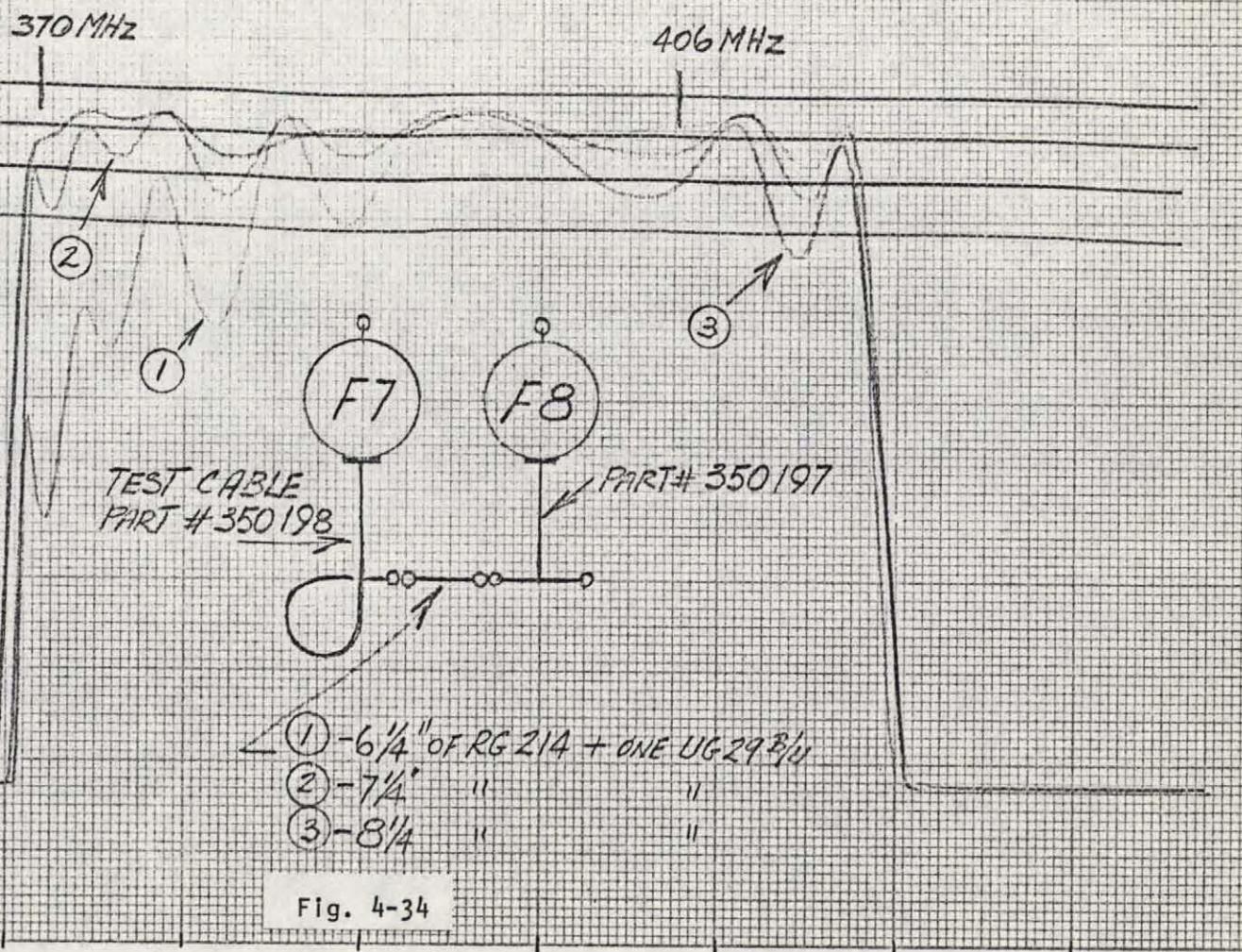


Fig. 4-34

10 MHz / INCH.

## FILTER F7

IL.

db.

0

10

20

30

40

50

60

70

-57-

275 MHz

330 MHz

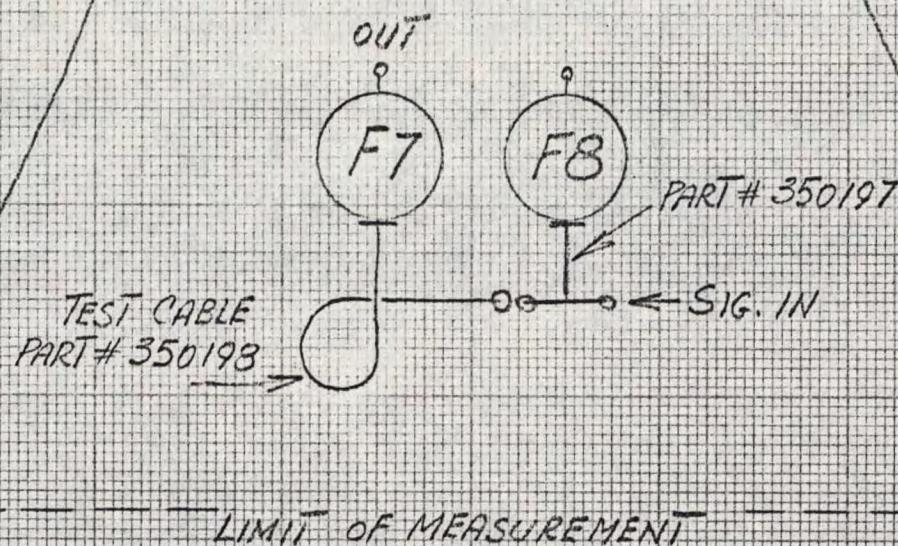


Fig. 4.35

20MHz / INCH

## FILTER F7

1L.

d0

0

1

2

-58-

275 MHz

330 MHz

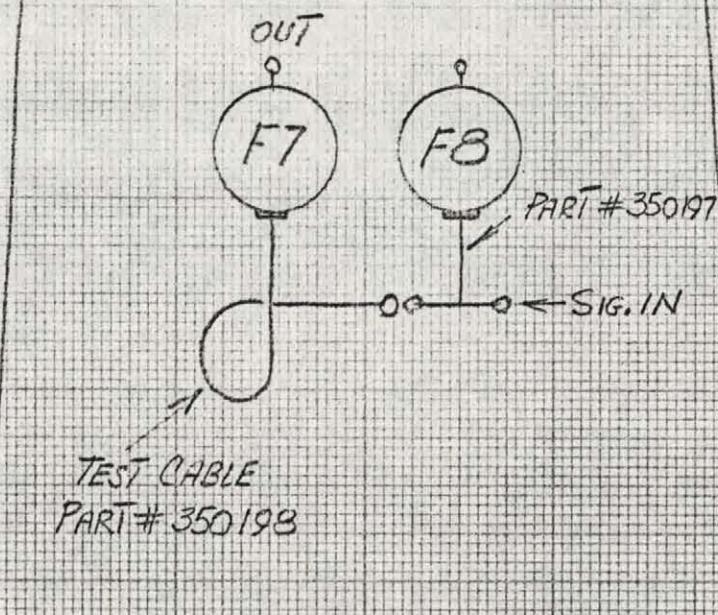


Fig. 4-36

20 MHZ / INCH,

Nov 10-76

TRANSMIT MODE 1M. TEST.

$$\begin{aligned}f_1 &= 275 \text{ MHz} \\f_2 &= 330 \text{ MHz}\end{aligned}$$

-13M

-90 -

-100 -

-110 -

-120 -

-130 -

-13M

-59 -

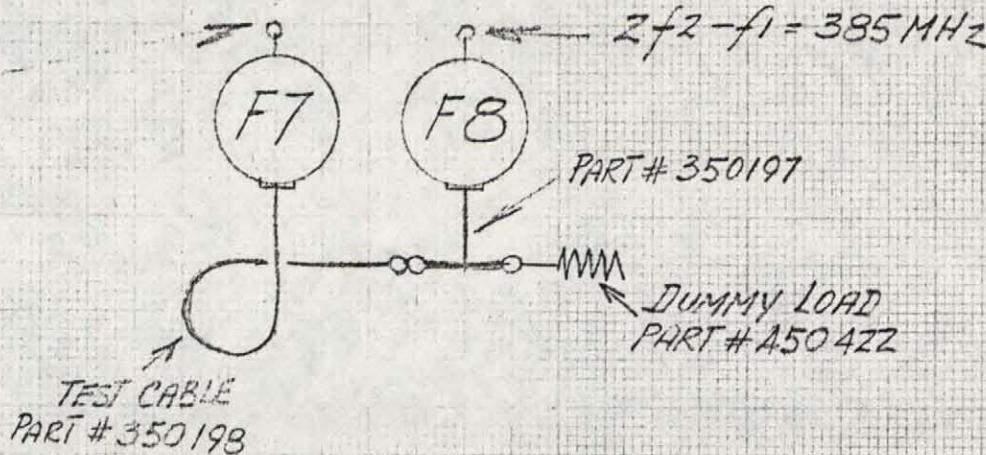


Fig. 4-37

100 SEC.

$f_1 = 290 \text{ MHz} @ 160 \text{ W}$   
 $f_2 = 330 \text{ MHz} @ 170 \text{ W}$

TO SPECTRUM ANALYZER

dBm

-50

-60

-70

-80

-90

$$2f_2 - f_1 \\ = 370 \text{ MHz}$$

$$3f_2 - 2f_1 \\ = 410 \text{ MHz}$$

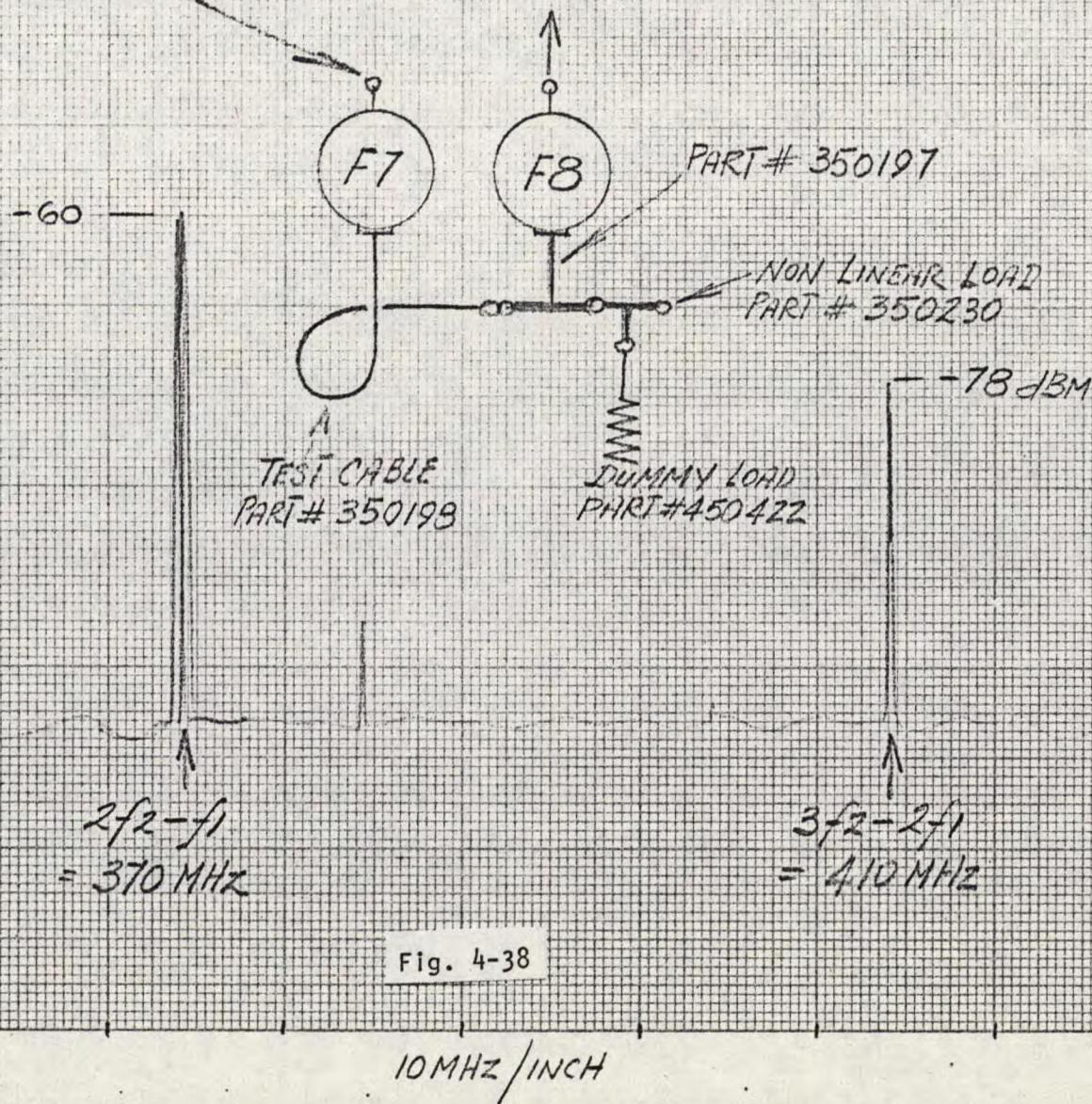


Fig. 4-38

$$f_1 = 310 \text{ MHz} @ 140 \text{ W}$$
$$f_2 = 330 \text{ MHz} @ 165 \text{ W}$$

dBm

-70 -

-80 -

-90 -

-100 -

-110 -

-120 -

-78 —

-83 —

-93

$$3f_2 - 2f_1 \\ = 370 \text{ MHz}$$

$$4f_2 - 3f_1 \\ = 390 \text{ MHz}$$

$$5f_2 - 4f_1 \\ = 410 \text{ MHz}$$

Fig. 4-39

20 MHz/inch

$f_1 = 320 \text{ MHz} @ 115 \text{ W}$   
 $f_2 = 330 \text{ MHz} @ 165 \text{ W}$

dBm

-70

-80

-90

-100

-110

-62

-93

-96

-103

-108

-110

$5f_2 - 4f_1$   
 $= 370 \text{ MHz}$

$6f_2 - 5f_1$   
 $= 380 \text{ MHz}$

$7f_2 - 6f_1$   
 $= 390 \text{ MHz}$

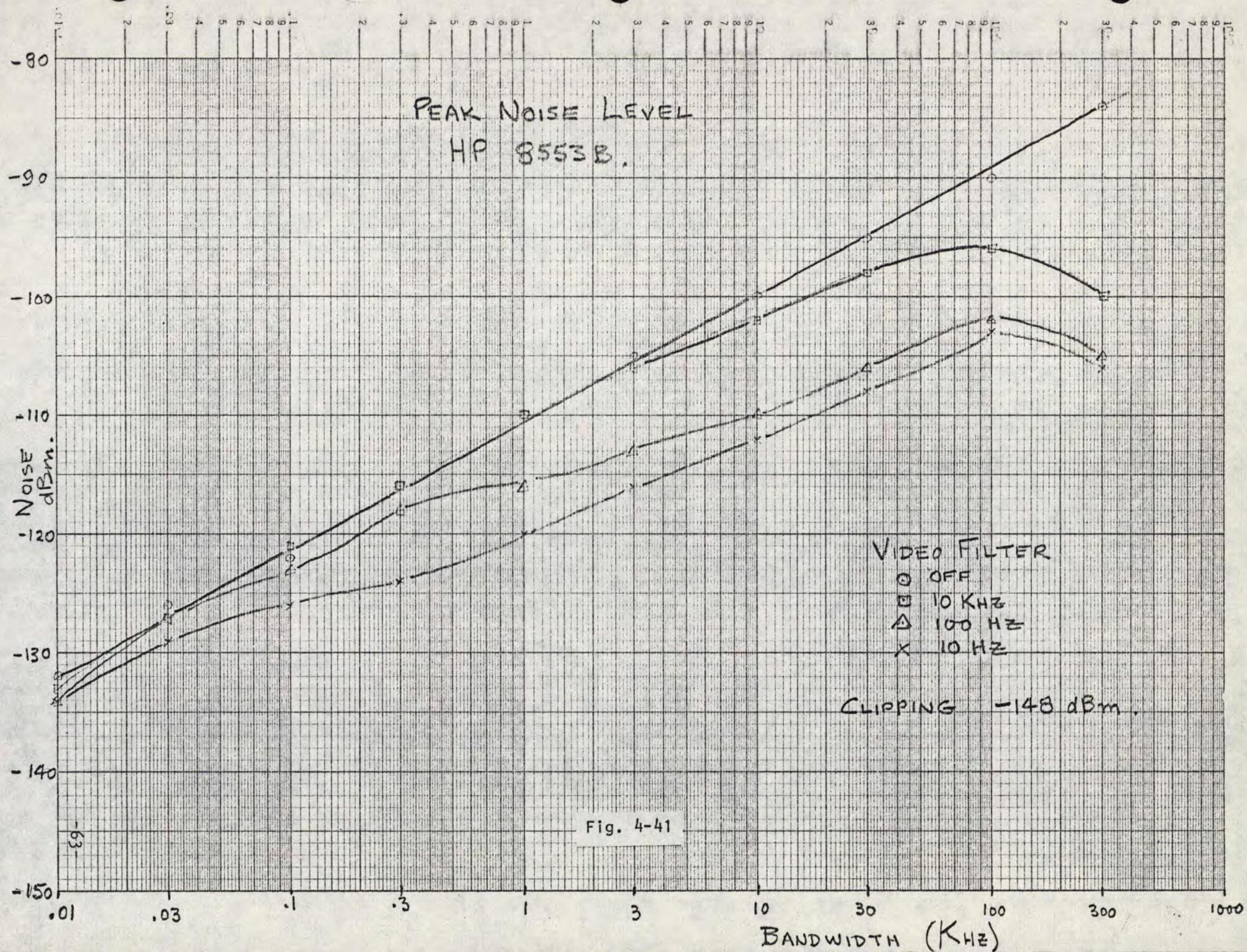
$8f_2 - 7f_1$   
 $= 400 \text{ MHz}$

$9f_2 - 8f_1$   
 $= 410 \text{ MHz}$

Fig. 4-40

10 MHz / INCH

MICRO TAPE

G 9-91G  
Semi-Logarithmic, 5 Cycles X 10 to the inch.  
MADE IN CANADA

Apr. 21/76.

HP 8553B. THIRD ORDER IM  
FOR OUT-OF-BAND SIGNALS.

NOTE: DATA APPROX FOR

ASSUMPTION THAT

$$f_1 = 120 \text{ MHz}$$

$$f_2 = 120 + 4f_1$$

CURVE APPLIES FOR  
315-330 & 275-330  
BANDS.

MEASURED

ESTIMATED

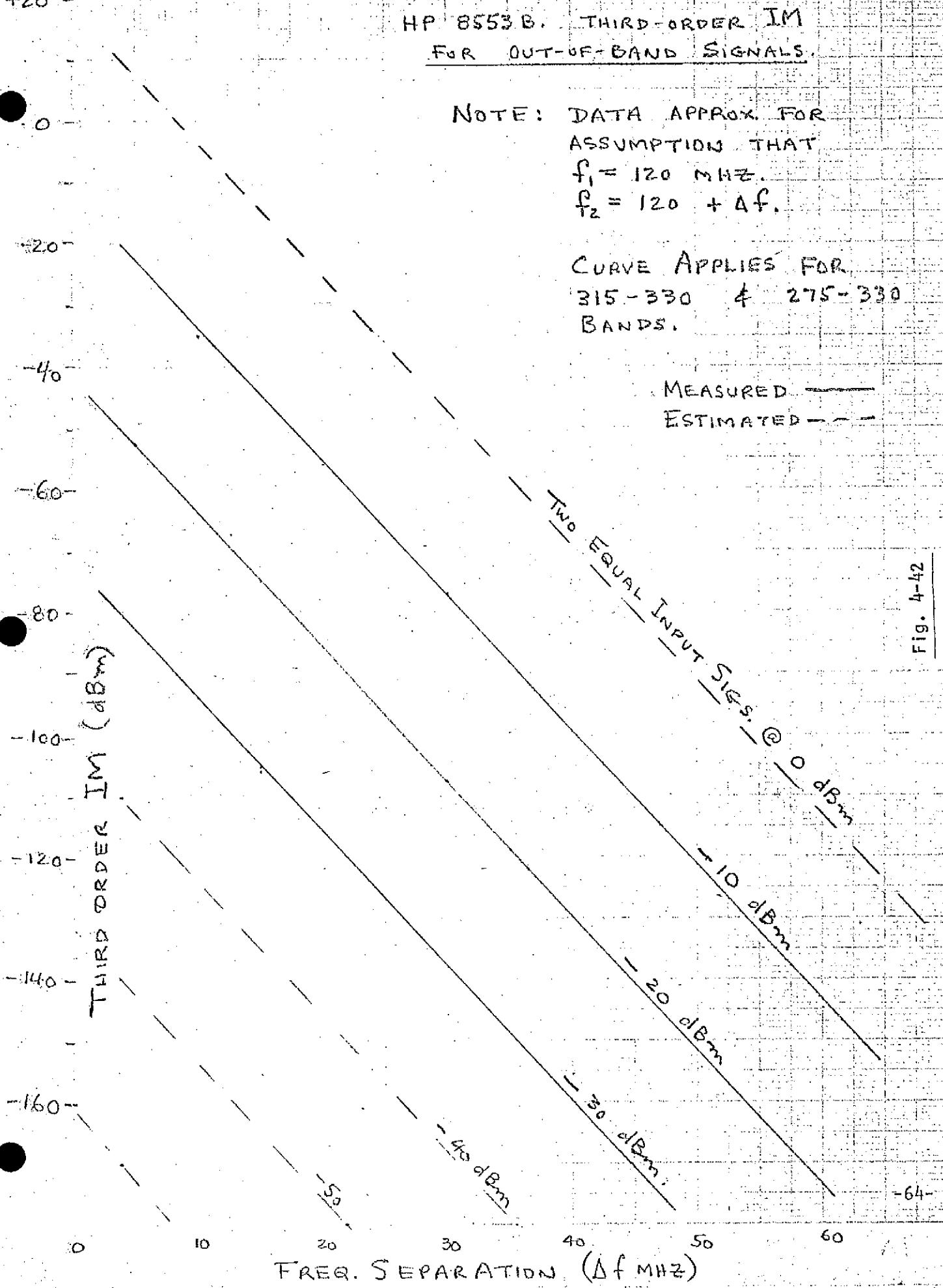


Fig. 4-42

HP 8555 B : SPECTRUM ANALY.

MEASURED IM DATA

$$f_1 = 107 \text{ MHZ.}$$

$$f_2 = 110 \text{ MHZ.}$$

• 3 RD. ORDER

X 5 TH.

○ 7 TH.

NOTE: IM SPECTRUM IS  
UNSYMMETRICAL,  
LARGEST PRODUCT  
IS PLOTTED.

IM (dBm)

-30

-20

-10

-65-

Fig. 4-43

TWO-TONE EQUAL INPUT SIGS. (dBm).

SLOPE = 3.25

SLOPE = 5.2

SLOPE = 7

SLOPE = 6

QUALIFICATION TEST PLAN

Passive Intermodulation Test Facility

Under

Contract DSS File 2PL 36100-5-2069

Serial OPL5-0150

SRL RD-822

9 September 1976

Issue 3

Approved by W.D. Hineson 20/9/76  
Project Officer

SINCLAIR

## 1.0 INTRODUCTION

In order to reduce costs, testing will, in most cases, be performed at the system or subsystem level.

Tests performed at the unit level are primarily to verify operation or to verify the manufacturer's specification. Some unit and subsystem tests are also intended to reduce the amount of de-bugging necessary after system integration.

Section 2 outlines system and subsystem tests according to Paragraph 6, Appendix 'A' of the contract.

Section 3 summarizes unit level tests to be performed during the development and pre-qualification test phases of the contract work plan, and for which data is to be available at the onset of formal qualification tests.

## 2.0 SYSTEM AND SUBSYSTEM LEVEL TESTS

### 2.1 Power Output (System Level)

Measure the output power with a Bird Wattmeter and the standard load, or with a high-power 50 ohm tapped-load as in Figure 2.1, under the following conditions:

1. CW Mode at maximum output; 1 tone and 2 tones
2. Noise mode at maximum output.
3. Noise mode, <sup>noise diode</sup> with noise density turned off.



2.2 Load VSWR (Unit Level Test)

Measure the input VSWR over the frequency range 275-406 MHz using a Rhotector and Chart Recorder or similar technique, as in Figure 2.2.

2.3 Detector CW Sensitivity

Either:

Input a calibrated signal from a standard signal generator via a calibrated coupler installed between the standard load and duplexer filter, for example as in Figure 2.3(a). Measure the displayed power and signal/noise ratio at the detector subsystem. Verify that a -155 dBm signal at the test port can be measured.

Or:

Generate a variable level signal at about 400 MHz from the source control unit by setting one synthesizer to about 100 MHz and using the low level 4th harmonic output from the frequency doublers. Connect the source control unit output to the Receive Filter input and adjust the source control unit attenuator to provide a -155 dBm signal (or use extra attenuators if necessary). Calibrate the



receiver level by means of a HP 8640 signal generator with the detector subsystem at about 100 Hz bandwidth.

A typical configuration is shown in Figure 2.3(b). Measure the displayed power and signal/noise ratio on the detector subsystem. Verify that a -155 dBm signal at the receive filter input can be measured.

#### 2.4 Detector Noise Sensitivity

Either:

With the facility in the noise-test configuration and with the source subsystem 'off', plot strip-chart recorder reading vs. calibration noise attenuator setting. Estimate the variance of the recorder trace, and verify that 5°K excess noise can be detected and measured with a 30 KHz measurement bandwidth.

Equipment configuration as in Figure 2.4(a).

Or:

Using a HP 8640 signal generator (or equivalent) inject a CW signal with an energy level equivalent to 5°K in a 30 KHz bandwidth and chopped by the synchronous detector within the detector control unit. Verify that a signal of this level can be detected and measured. Equipment configuration as in Figure 2.4(b).

## 2.5 Facility Passive Intermodulation

- a) Set up the test facility in two-tone CW mode for reflected IM measurement using the facility standard load. Measure the self-generated PIM products and verify the third, seventh, and fifteenth-order levels.
- b) Repeat a) in the two tone CW mode for transmitted IM measurement.
- c) Set up the facility in the noise-test mode using the test facility standard load. Measure the self-generated intermodulation noise and the effective noise temperature increase over the detector subsystem noise.
- d) Demonstrate output circuit connector maintenance in the two-tone test mode for 3rd order measurement. Measure the self PIM of the connectors and load. Break and re-make the connections five times and re-measure the PIM after each re-make. Demonstrate that PIM stability is within + 3 db of the average value, with maintenance if necessary.

The equipment set-up is as shown in Figure 2.5.



2.6 Measurement Time

Either:

Place the facility in standby mode for a long period (all oscillators running\*). Set up the facility as in 2.5 and measure the CW PIM levels using a standard non-linear load (to be provided) after 30 minutes and 1 hour. Show that no significant change ( $\pm 3$  db) in levels occurs between the two measurements.

After the above test, change the frequency and power levels systematically over the ranges. Measure the CW intermods after 15 minutes and 30 minutes. Show that no significant change occurs between the two measurements.

Verify that the operating temperatures of all units is within safe limits after a prolonged period of operation.

Or:

Place the facility in standby mode for a long period (all oscillators running\*). Set-up the facility as in 2.5 and measure the power output and receive system gain after 30 minutes and 1 hour. Show that no significant ( $\pm 3$  db) in values occurs between the two measurements.

\* Standby mode is not defined in the system specification. It is assumed here to include all low power units and units containing oscillators are fully energised and operating.



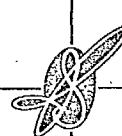
After the above test, change the frequency and power levels systematically over the ranges. Measure the power output and gain after 15 minutes, and 30 minutes. Show that no significant change occurs between the two measurements. Verify that the operating tempertures of all units is within safe limits after a prolonged period of operation.

2.7 Intermod Product Spectral Linewidth

Set up the test facility in the two-tone CW mode. Generate a high-order (seventeenth) IM by coupling into the non-linear load. Demonstrate that the product spectral linewidth is measureable with a 10 Hz (12 Hz effective) detector bandwidth.

2.8 Source-Detector Subsystem Coupling (Qualitative only)

During preliminary integration of the source detector subsystems, set up the two subsystems adjacent to each other and verify that no significant coupling problems exist.



2.9 Line Voltage Tolerance

Either:

Set up the test facility as in 2.5 with the non-linear load connected. Verify the following under line voltage variations of  $\pm 5\%$  from the nominal line voltage of 117 V AC.

- a) Less than  $\pm 3$  db change in the measured level of a third order IM product, in the CW mode.
- b) Less than  $5^{\circ}\text{K}$  change in indicated excess noise temperature in the noise test mode at low excess noise temperature.

Or:

Measure the power output of the source subsystem and the gain of the detector subsystem (in the CW mode) and verify that neither parameter changes by more than  $\pm 3$  db under line voltage variations of  $\pm 5\%$  from the nominal voltage of 117 V.

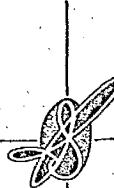
3.0 UNIT LEVEL TEST SUMMARY (Test data to be provided for information only)

3.1 Synthesizers

Power output - 13 dBm

Frequency range to 165 MHz

Phase noise verification



3.2 HPA's

Gain and stability  
Power output  
Output VSWR tolerance

3.3 Source Control Unit

CW output power  
Noise output power

3.4 Filters

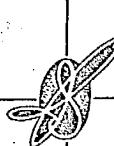
Frequency response  
Insertion Loss, including reflection loss  
Intermodulation performance

3.5 LNA

Gain  
Intermod Intercept point  
Noise Figure

3.6 Local Oscillator

Frequency  
Output power



3.7 Detector Control Unit

Noise Source drive voltages

Chopper frequency and mark/space ratio

Synchronous detector D.C. zero and balance

Integrator time constant

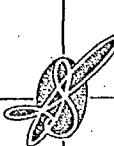
3.8 Spectrum Analyzer

Noise Figure

Intercept Point

4.0 DOCUMENTATION

Test results from Section 2 will be provided in  
the final report.



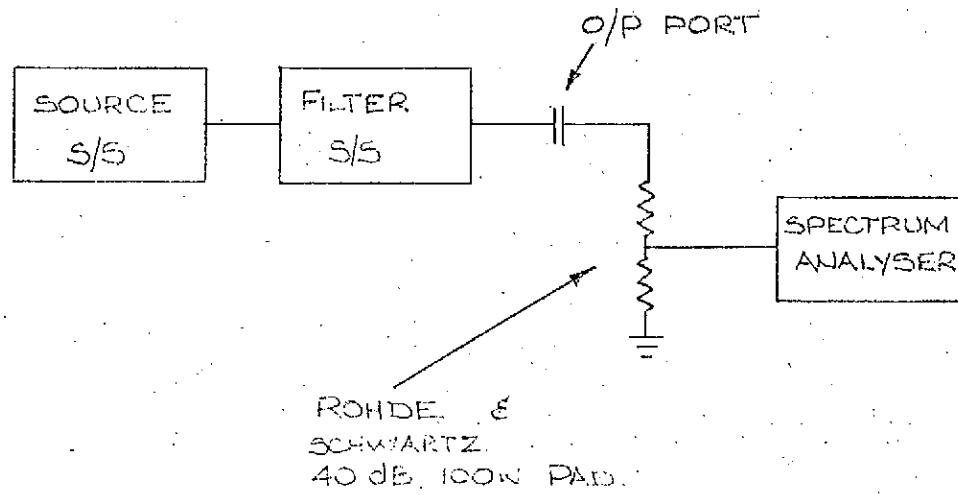
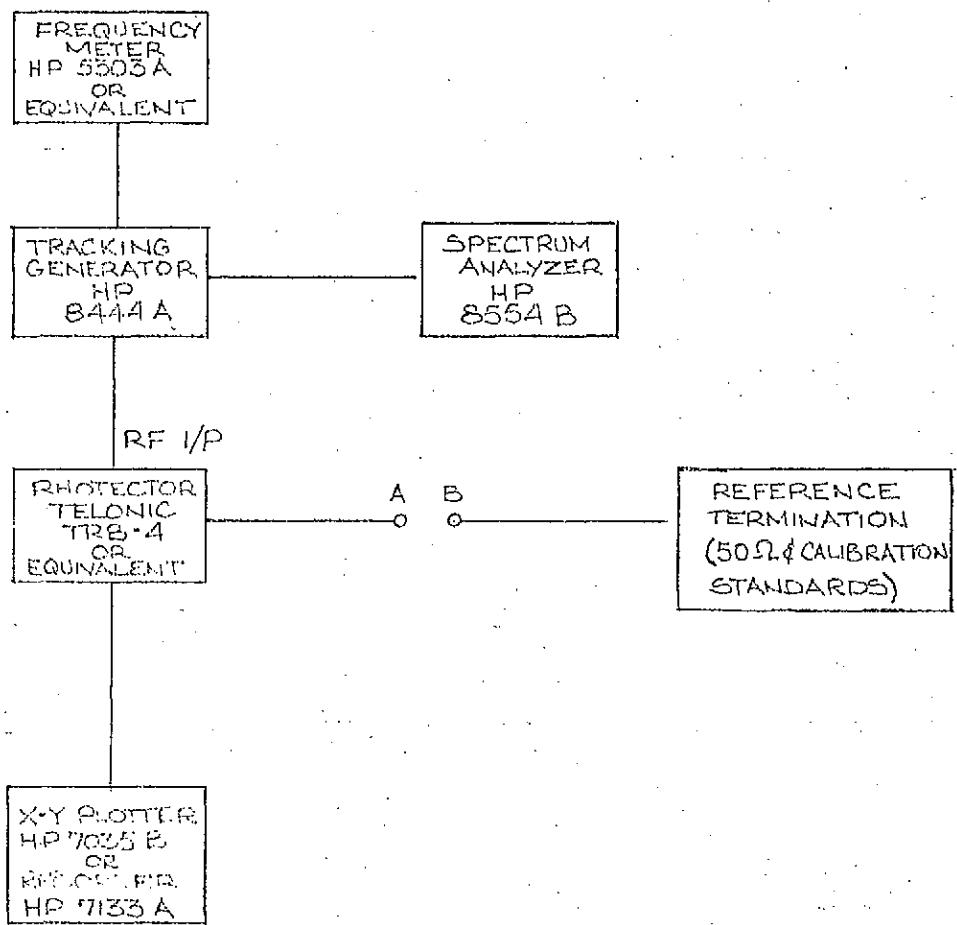
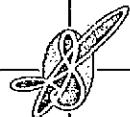


FIGURE 2-1



VSWR TEST CIRCUIT

FIGURE 2-2



EITHER A

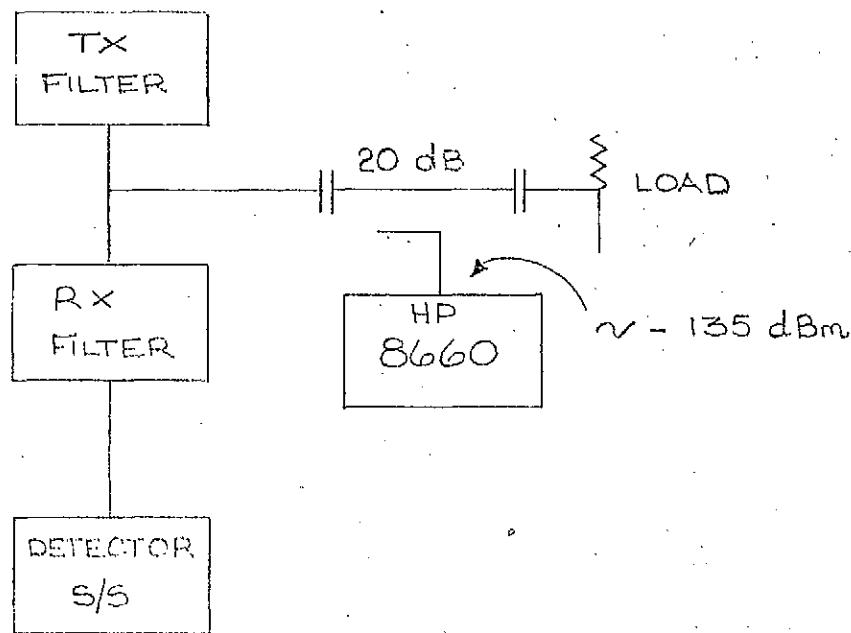


FIGURE 2-3 (a)

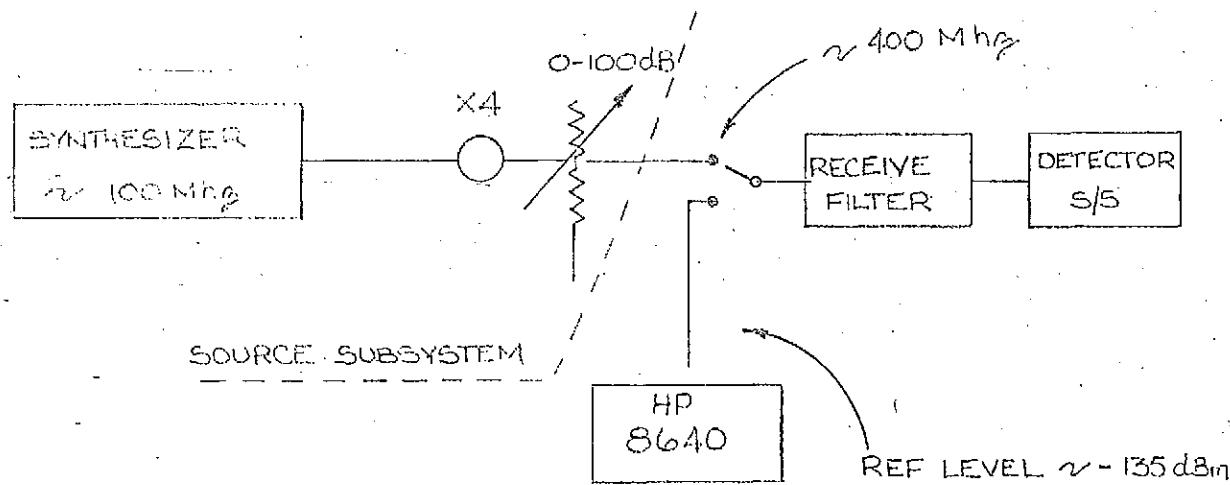


FIGURE 2-3 (b)

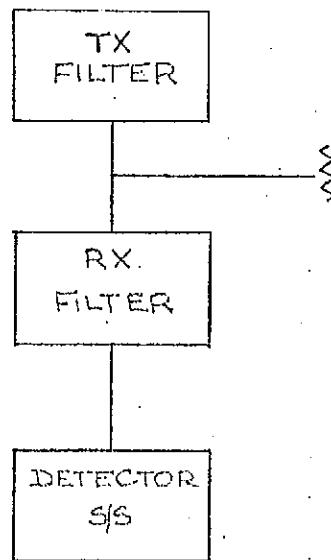


FIGURE 2-4 (a)

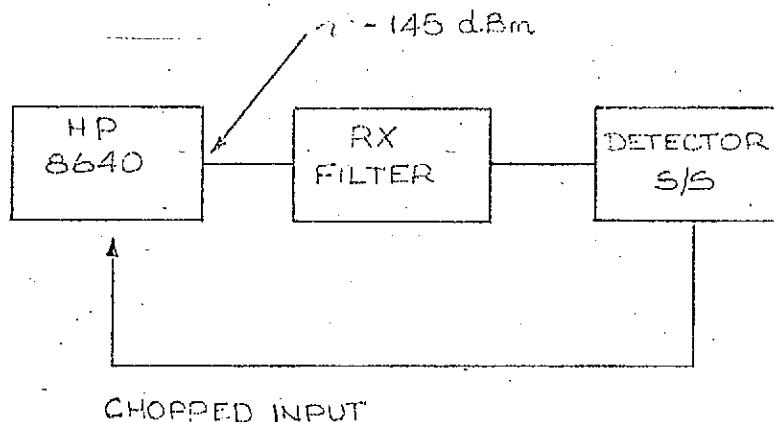
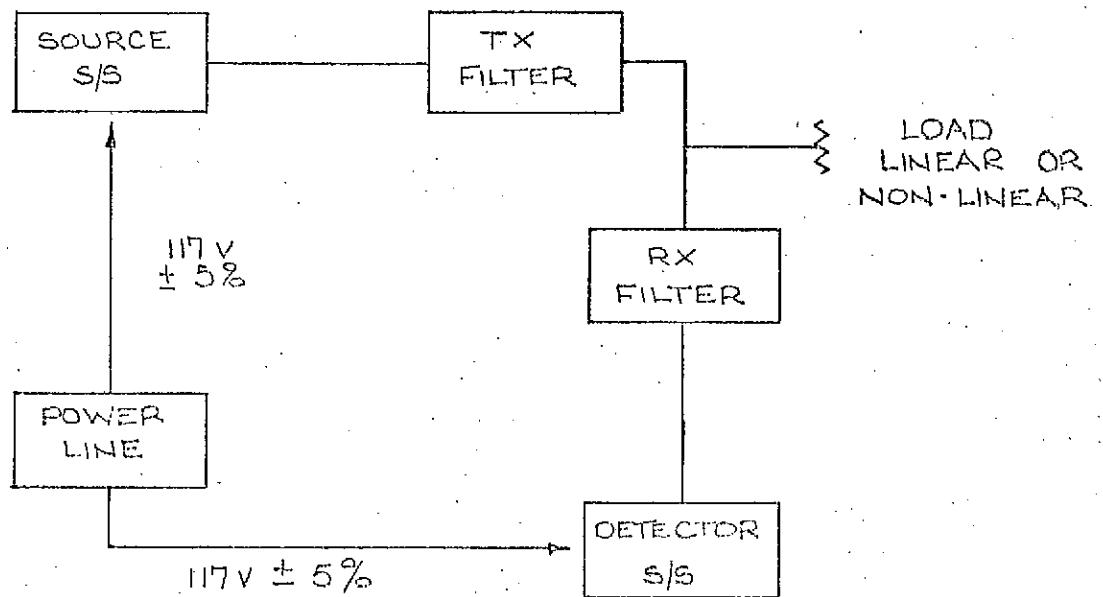


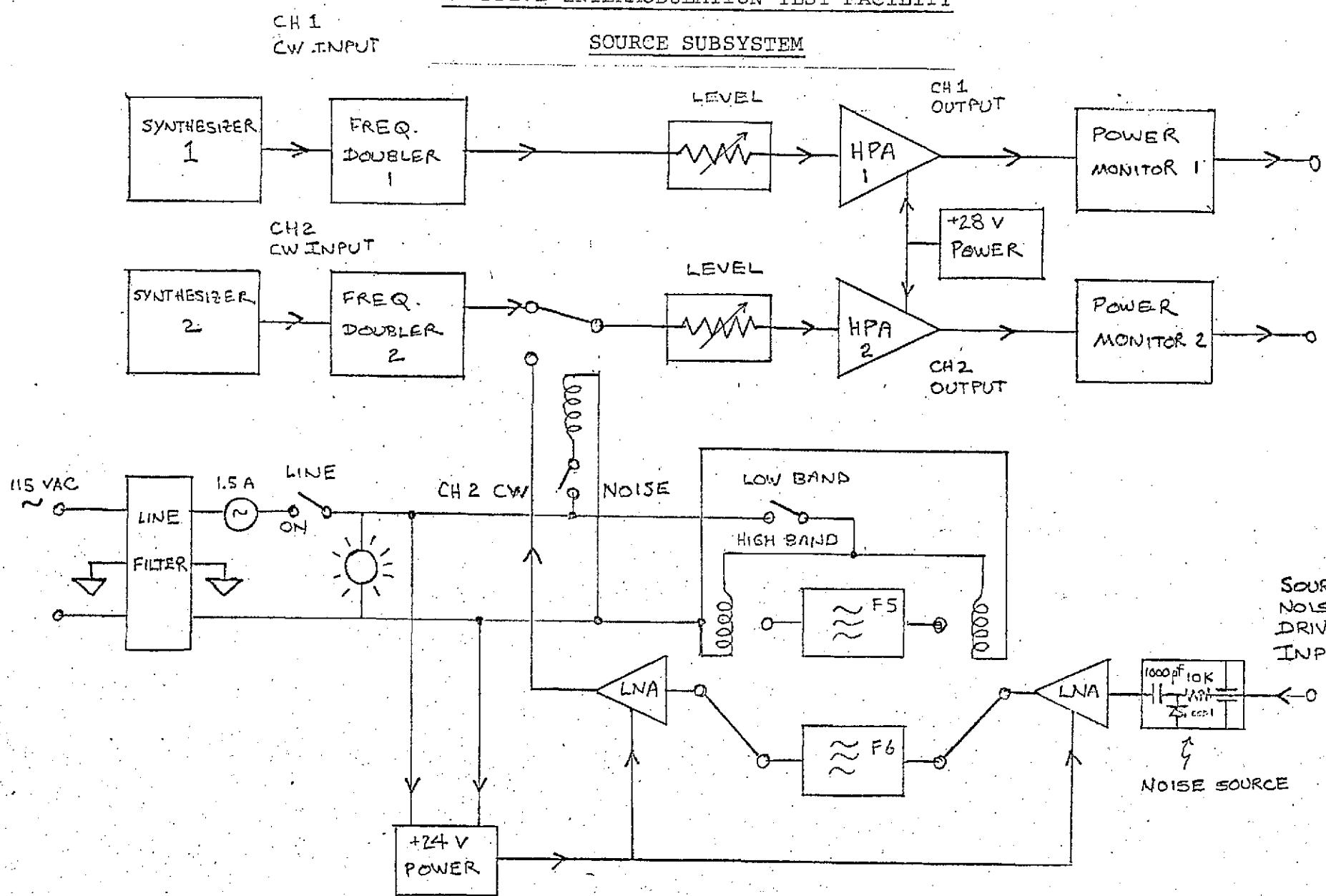
FIGURE 2-4 (b)

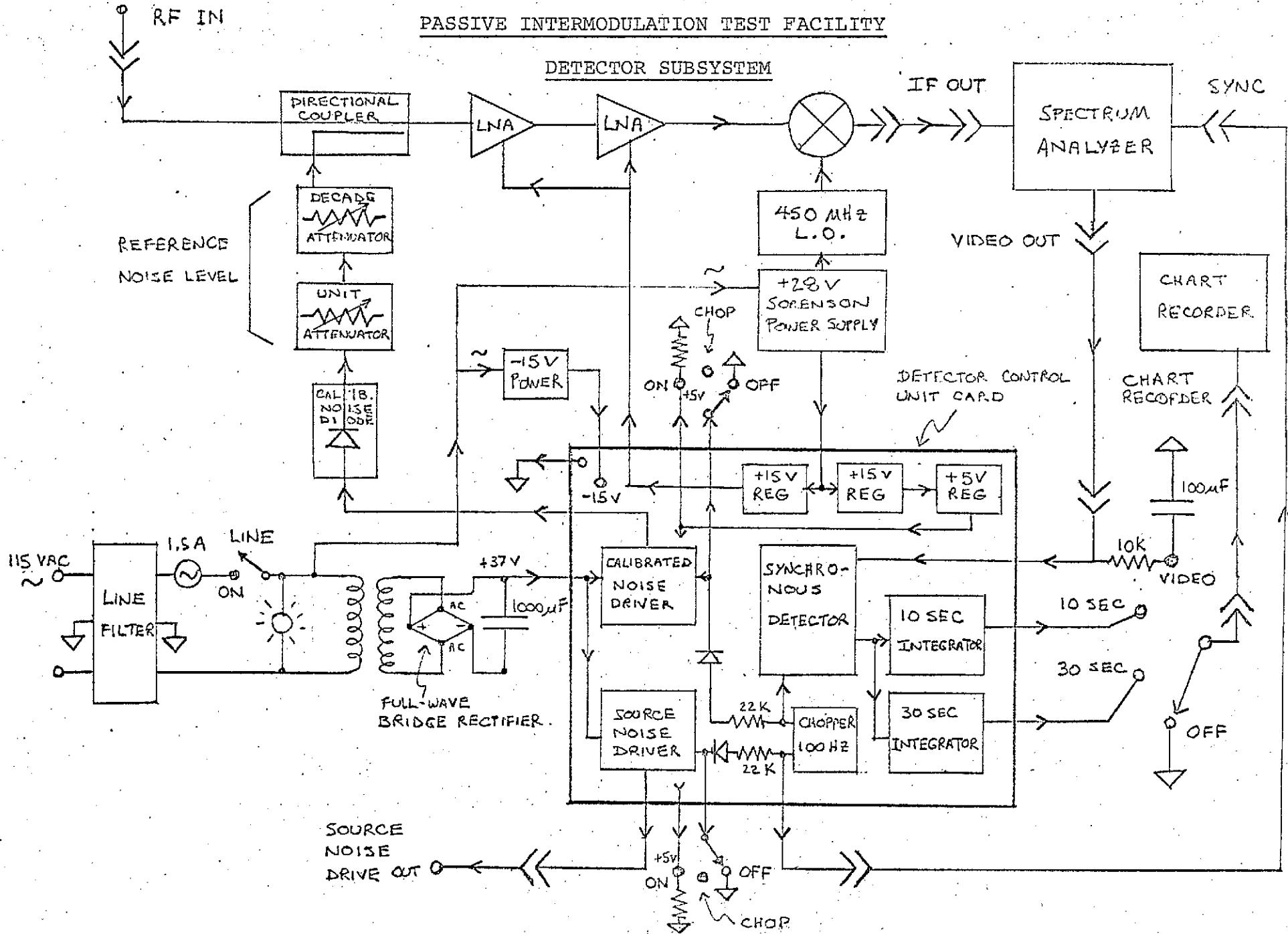


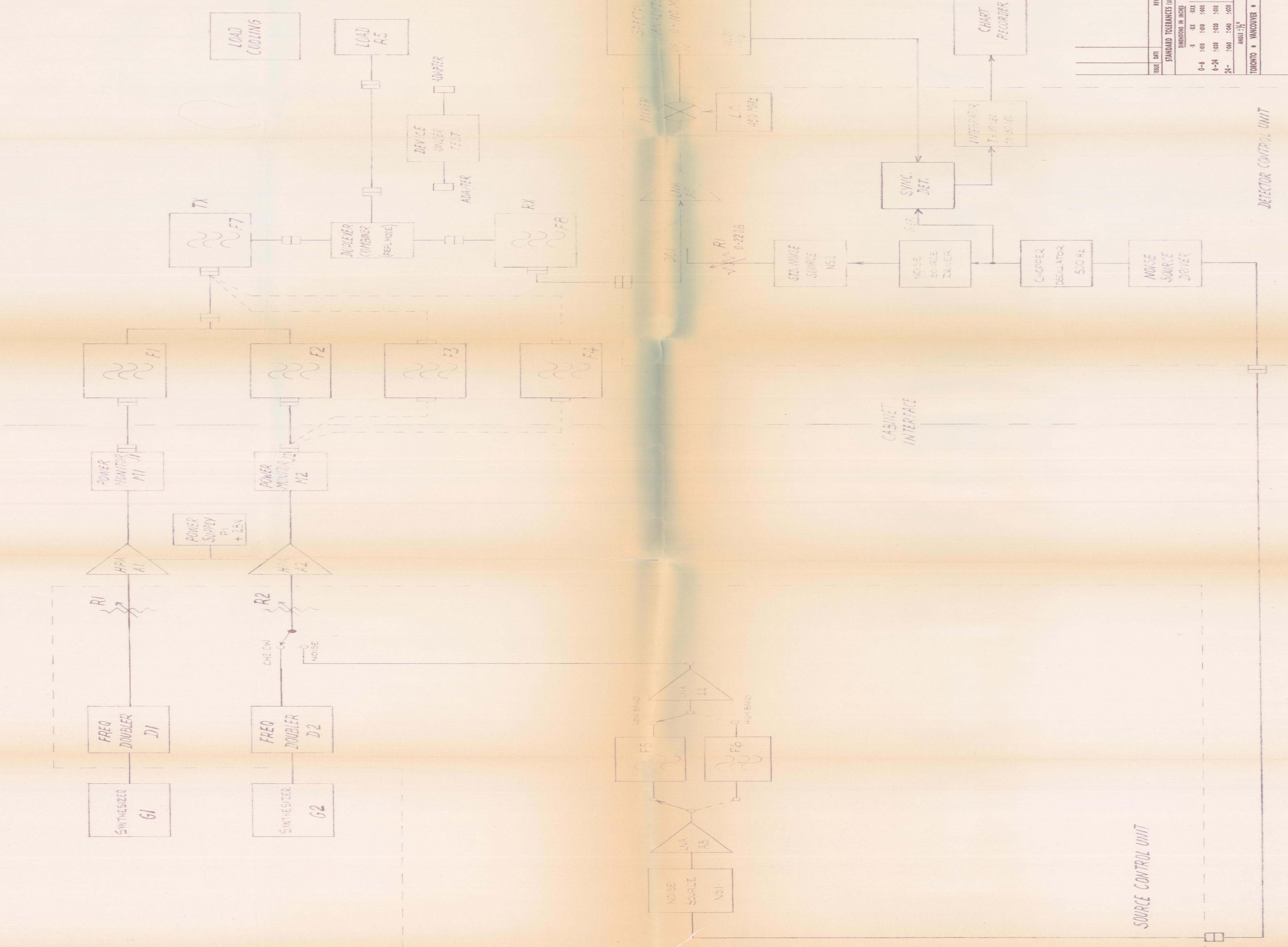
ADDITIONAL EQUIPMENT REQUIRED: 1) CONTACT THERMOMETER  
2) VARIAC 117V ± 5% @ 40A.

FIGURE 2-5

PASSIVE INTERMODULATION TEST FACILITY







BLOCK • SCHEMATIC

UHF SATELLITE INTERNAL TEST FACILITY 452400  
DRAWN BY: DATE: 11-5-76  
CHECKED BY: DATE:  
APPROVED BY: DATE:  
DRAFT: 1 OF 1 SERIAL: 1  
DRAWING NO.: 230061 B  
ISSUE DATE: REVISION: APR.  
STANDARD TOLERANCES (UNLESS OTHERWISE SPECIFIED)  
DIMENSIONS IN INCHES

0-6	.000-.030	1/16
6-24	.000-.040	5/32
24-	.000-.040	5/32

SINCLAR