VLA - VLBA Interference Memo No. 5

Strong Interference at the VLA, 1994

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Introduction:

Strong interference at the VLA can cause the on-line system to report various error conditions. Cued by the error messages, the VLA operator can look for signals appearing above the system temperature using a spectrum analyzer connected to the IF on one of the antenna, and file a report. This memo summarizes the VLA interference reports for 1994, and describes improvements to the monitoring techniques.

The Procedure:

Typical errors reported by the on-line system in the presence of strong interference on the IF along with the possible effect of the error on the data are as follows:

Total Power out of Range: Probable gain compression, calibration errors
High System Temperatures: Tsys errors
T5 Power out of Range: Input power to sampler out of spec

When the VLA Operator receives one of these error messages, he can visually check a spectrum analyzer screen for interference. At the VLA operator's console is an Anritsu MS610A spectrum analyzer connected to a monitor port on a T2 IF Combiner module in the CB Equipment Room. The antenna being monitored varies.

The analyzer is set for a span of 500 MHz, 1 MHz resolution bandwidth, so that the operator can look for a power level above the average Tsys noise floor on IFs A, B, C, and D. The IFs are offset in frequency from each other so that they appear from 1300 - 1700 MHz on the analyzer. If the Operator sees interference on the analyzer, he files a report which includes a hand-drawn sketch of the analyzer screen. Figure 1 is an example report.

The AOC Electronics Division Interference Protection Group (IPG) calculates the sky frequency for the interference as shown on the report, sends a copy of the annotated report to the Observer, and enters the event in a data base. The frequency measurements are accurate to about +/- 5 MHz.

1994 Results:

The reports for 1994 reveal the following:

1. Figure 2 shows the reported occurrences by frequency for the P band and Figure 3

for the L band. One can reasonably assume that interference occurs much more frequently than shown: a report is filed only if the on-line system reports a data error, if interference is visible above the noise floor of the spectrum analyzer, if the interference occurs in the band being observed, and if the antenna being monitored is in use. The spectrum analyzer sensitivity is limited to interfering signals about 2 dB or more above the system noise, or RFI > 0.6 * Tsys * RBW, where RBW is the resolution bandwidth of the spectrum analyzer.

2. Almost all the reports are a result of intermittent transmissions. Local interference exists, but is too low level to be seen above Tsys. Continuous emissions are known and typically avoided. An exception is the FAA radar at 1310 MHz and 1330 MHz which still catches a few observers who venture too close.

3. The signal causing the most reports is at 1427 - 1435 MHz. According to one reference (ref. 1), the source of the signal is the Navy White Cloud Ocean Spysat which uses 1427 - 1434 MHz for telemetry, a use which complies with the allocation tables (ref. 2). The interference is intermittent, but can be strong enough to cause gain compression. Figure 4 and 5 show typical interference at 1435 MHz, figure 4 in the average mode and figure 5 in peak mode. Notice that the interference is appearing at 3 frequencies separated by a few MHz. The reports show that the interference at 1435 MHz is likely to occur at any time. 1435 MHz is unlikely to be an image of 1765 MHz because of the filter at F3 which provides an attenuation >40 dB above 1760 MHz.

4. Following close behind 1435 MHz, signals at 1380 - 1385 MHz collected the second most reports. Military aircraft are often heard maneuvering over the VLA when the reports of a signal at 1385 MHz are made. The CATO Military Operations area overlays the VLA southwest arm, and the band 1350 - 1400 MHz is allocated for fixed, mobile, and radio location services (ref. 2). The WSMR DOD Area Frequency Coordinator has been asked for early notification of activity at 1385 MHz.

5. Radiosonde transmitters (1675 - 1700 MHz) (ref. 2) on weather balloons can ruin data. Weather balloons may be launched by the military at WSMR or one of several Air Force bases in NM, by the Weather Service, and by NMIMT's Langmuir Lab. Because of the number of launches, early notification has not been reliable.

6. The National Scientific Balloon Facility (NSBF) at Fort Sumner, NM, uses the telemetry band 1435 - 1535 MHz for balloon-mounted scientific payloads. When the balloons pass over the VLA, the telemetry signal is strong enough to cause gain compression on the L band front end; however, the NSBF has been cooperative in providing advance notification. Reports of balloon launches and other potential interference are received by the VLA operators, who have a

procedure in place to advise observers via e-mail when a report is received.

7. Much of the remaining L band interference is caused by satellites: INMARSAT (1530 - 1534 MHz), GPS (1575.42 MHz), GLONASS (1602 - 1616 MHz), and other satellite telemetry (1452 - 1492 MHz) (ref. 2).

8. The bulk of the L band interference reports occur during the period 15 May to 15 July, when WSMR summer war games are in progress (Figure 6).

9. Intermittent L band interference is least likely to occur over lunch and from 9 pm to 4 am (Figure 7).

10. Local interference in P band, though a problem (ref. 3), is too low level to appear on the IF spectrum analyzer. All the reported problems in P band are intermittent, apparently caused by FAA/military traffic in allocated bands (ref 2). The determination of sky frequency from the operators' reports is too inaccurate to determine if the interference is in the Radio Astronomy band at 322.0 - 328.6 MHz, which in the U. S. is protected only by footnote.

11. So few reports were received at bands with wavelength shorter than L band that they are listed here:

Date	Band	Frequency	Amplitude above IF	Possible Source
Jul 8	Q	43.49 - 43.59 GHz	?	?
Aug 3	C	4490 MHz	2 dB	Satellite
Oct 11	Q	43.4 GHz	5 dB	Satellite
Nov 4	C	4535 MHz	10 dB	Satellite
Nov 4	C	4560 MHz	10 dB	Satellite

Monitor Improvements:

1. A second spectrum analyzer, an HP 8559A, has been added to the VLA operator's console, this one with a connection to a PC and to Ethernet. Since December 3, 1994, the second analyzer has been collecting IF spectra from antenna 8 (W8). The PC receives each analyzer sweep to find the peak and to calculate the average of each frequency bin every 15 minutes. The data are available immediately via the Ethernet at the end of each 15 minute interval and for a few weeks back. Older data will be archived on Exabyte tape and can be accessed on request to the AOC Electronics Division IPG.

   The procedure for accessing the new monitor data is shown in Appendix A. An example report developed from the new monitor system is shown in Figure 8. Improvements planned are 1) the ability to detect automatically an interfering signal more than 3 dB over the Tsys noise floor, RFI > 2 * Tsys * RBW; and 2) to incorporate Observe File information from the on-line system for use in automatically identifying sky frequencies

and observing programs.

2. To skirt the limitations imposed by the Observe File on monitoring, there is a plan to bring the P and L band receiver outputs to a second monitoring system in the CB. This will permit continuous monitoring of the entire P and L bands.

3. The monitoring in step 2 could include lower level interference if the spectrum analyzer were replaced with a wide band digital spectrometer. By auto-correlating, the digital spectrometer would permit simultaneous measurement of each frequency bin to a power level well below the Tsys noise floor. One proposal calls for development of the spectrometer using the disqualified slower Canaris correlator chips and circuit boards copied from the GBT correlator project.

Conclusions:

1. L band frequencies to avoid or at least use with caution are shown in Figure 9, which combines the information in Figure 3 and a recent SYSLQUIK test.

2. Improved reporting by other agencies would provide advanced warning of interference in the band at 1385 MHz, in the radiosonde band, in the aero-telemetering band such as that used by NSBF and WSMR, and in P band. Software to compare the antenna positions in the Observe File with satellite positions from tracking data would permit early warning of interference from satellites.

3. The new PC-based monitoring system will permit more thorough and more accurate reporting of interference problems. Using the monitor on the receiver outputs may help develop better resolution for reports on bands available; for example, there is a quiet band available from 1720 to 1721 MHz for observing the OH line; the band is masked by the filter skirts on the SYSLQUIK plot.

4. A digital spectrometer would permit monitoring of lower level interference not currently measurable with the spectrum analyzer. As well, frequencies would be measured concurrently, rather than sequentially as they are on the spectrum analyzer.

References:

1. The Outer Space Frequency Directory, Anthony R. Curtis, Tiare Publications, 1994.

2. Known and Potential RFI in Frequency Bands Proposed for the VLA Upgrade, W. D. Brundage, in process, 1995.

3. A Proposal to Control Local Interference at the VLA, W. D. Brundage and C. Janes, VLA Test Memorandum No. 188, 1994.

Appendix A.

Accessing data from the VLA RFI Monitor

An HP 8559A spectrum analyzer at the VLA is connected to a PC via an HPIB interface so that the PC can collect the data from each sweep of the analyzer. The PC currently takes the average of each sweep and remembers the peak for each frequency bin over an interval of 15 minutes. The average and peak data are available remotely via an Ethernet connection.

The HP 8559 is not remotely programmable, nor is it possible to determine its settings via remote inquiry. The analyzer settings can be changed and the input can be changed to some other signal, so one should make inquiry when collecting data. At this writing, the analyzer is connected to antenna 8 at pad W8, with a 500 MHz span of 1250 to 1750 MHz so that all IFs A, B, C, and D are displayed. The RBW is 1 MHz, input attenuation 10 dB, sweep time 1 second, and the video filter selected. The flat areas along the peaks of the four IF pedestals represent Tsys. Interference is excursions of the plot above Tsys. The amplitude scale is logarithmic with a scale in dB shown on the left of the plot. Interference that is strong in peak mode, but weak or absent in average mode is intermittent. Interference that is nearly the same amplitude in both peak and average plots is continuous.

The current PC setup is experimental; for instance, the interval for finding the peak and averages at this writing is set for 15 minutes, but that interval can be changed. The PC clock is used for time so that measurement intervals may be off a minute or two from real time. At this writing, no information is available from the on-line system, so that it is necessary to refer to the observing schedule and observe files to determine filter, band, and sky frequency settings.

With that disclaimer, data can be accessed as follows:

1. From zia, enter the command ~vlarfi/if.monitor/bin/plotif <DATAFILE>, where DATAFILE specifies the beginning of the measurement interval in Mountain Standard Time and is in the following format: MMddhhmm.tyy.

   MM is the number for the month; i.e., 01 = January, 02 = February, etc.
   dd is the day of the month; i.e., 01, 02, 03, etc.
   hh is the hour in MST; i.e, 00, 01, ... 22, 23, etc.
   mm is the beginning of the measurement interval in minutes; at this writing only four possibilities are allowed: 00, 15, 30, and 45.
   t field has only two possibilities: a for average mode and p for peak mode.
   yy is the last 2 digits of the year; i.e., 95, etc.

   For example, a DATAFILE of 01302215.p95 will provide the peak data for the interval 2215 - 2230 MST on January 30, 1995 (also MST).

2. If the data are present, you will be asked if you want a screen plot (S) or to continue (C). Selecting S will result in a screen plot of the data in Tektronix 4012 format, after which a Postscript file of the data will be transferred to your directory. Selecting C will skip the screen plot but still transfer the Postscript file. The Postscript file can be printed at the AOC with the command psprint -Pps<your favorite printer> <filename.PS>. Be sure to remove the *.PS files from your directory when complete.

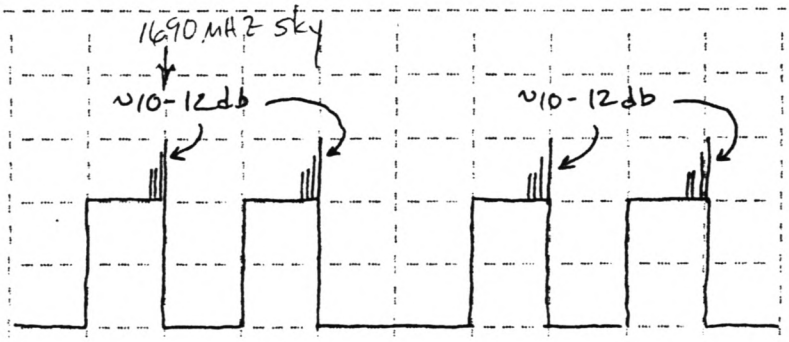
3. If the data are not present, you will receive a message informing you of such. Contact the Electronics Division IPG to see if the data have been archived. No data are available before December 3, 1994.

2NOV
3:52 am MST

```
SDT ZZZ DB DWR CAL CRYO FEX FRO LOX PA SYSTMP TST
KILL:If <CR> is struck.Clear the screen and return to menu.
*ANTENNA #: 22                                        YEAR.DAY#:  1994.306
     DCS #: 16    ***** VLA INTERFERENCE MONITOR *****       IAT:  10h52m40s
                                                            LST:   6h27m39s
ID MODE DCS PAD            T2 Received IF Spectrum

                                                           STOP:   6h29m10s
-- WEST  ARM --                                         SOURCE: 0741-06L.0
 3 use   4  C1                                            AZ:  152d17m31s
12 use   5  C2                                            EL:   45d35m26s
21 use  11  C3
 8 use   3  C4                                        PROG.ID: TESTS .321
 2 use   1  C5
10 use   7  C6                                       CORMODE:    1A
18 use   6  C7                                       OBSMODE:   C00
28 use   2  C8                                          BAND:    LL
20 use  10  C9                                       *1ST LO:  17.6 GHz

-- NORTH ARM --
13 use  26  C1                                                  COMMAND
14 use  30  C2                                                        K
15 use  27  C3     MHz                  MHz              MHz        SUB:2
27 use  25  C4                                                  ANTENNA:
15 use  24  C5          <<<<<<CHECKER MESSAGES>>>>>>>
11 use  28  C6          TOTAL POWER out of RANGE -- 1
 9 use  38  C7          HIGH SYSTEM TEMPERATURES -- 1
 1 use  32  C8          T5 POWER out of RANGE    -- 0       OPERATOR: T. PERREAULT
26 use  31  C9
                    A              B              C              D       : PARAMETERS
-- EAST  ARM --
 4 use  14  C1              L              L              L              L :*BAND SELEC
22 use  16  C2    1.6679117      1.6679117      1.6679117      1.6679117 :SKY FREQ-GH
16 use  15  C3         3840           3840           3840           3840 :LO  FREQ-MH
17 use  12  C4            1              1              1              1 :*FLUKE SET
24 use  22  C5 128.01168100 114.00584200 110.99416900 121.98833600:FLUKE #1-MH
 5 use  20  C6 100.00001000 000.00000800 125.00002000 150.00001700:FLUKE #2-MH
23 use  17  C7            6              6              6              6 :*BAND  WIDT
 7 use  13  C8                                                          :*AVG SYSTEM
 6 use  21  C9                                                          :
```



IAT: 10:50:40 → 10:54:10

1670-1690 meteorological aids – radiosondes

DIST:

reply to
CLINTON C. JANES
N.R.A.O. BOX 0
SOCORRO, NM 87801

FIG 1

VLA
P-BAND INTERFERENCE
1994

OCCURENCES VS FREQUENCY

CJ

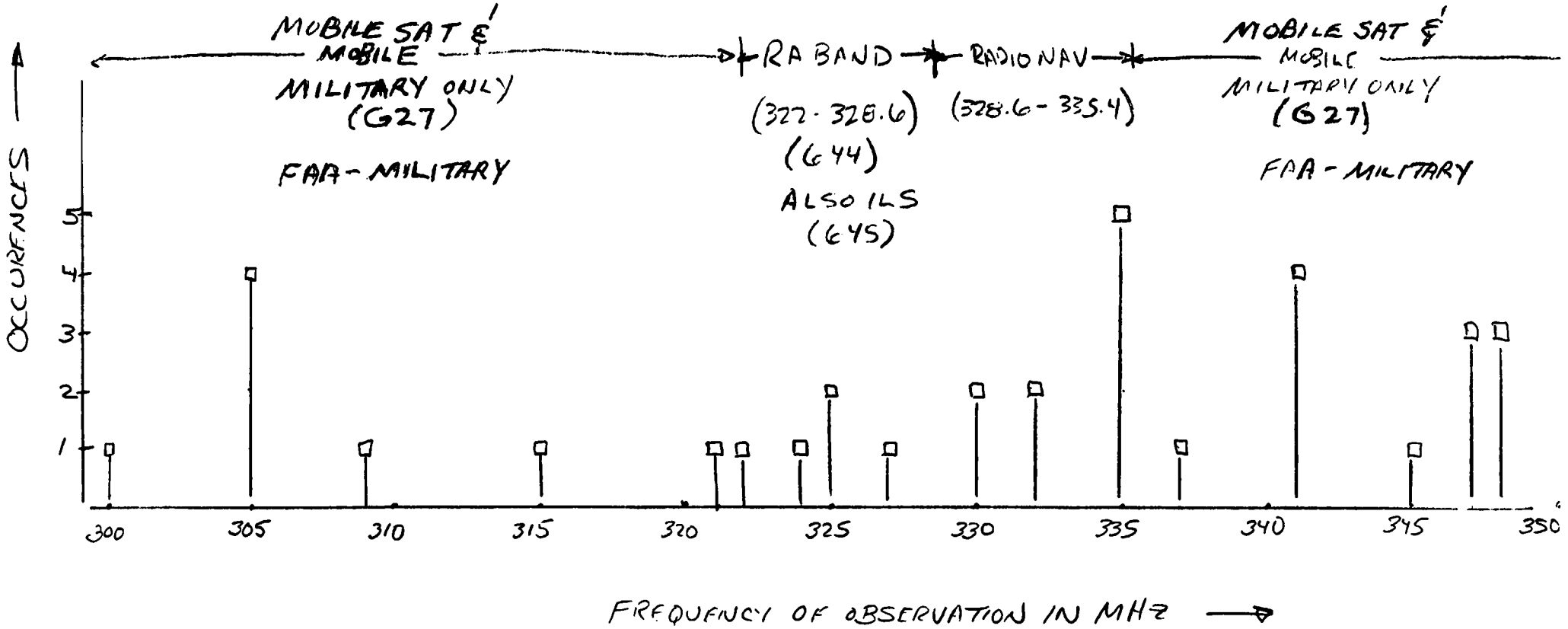


FIG 2

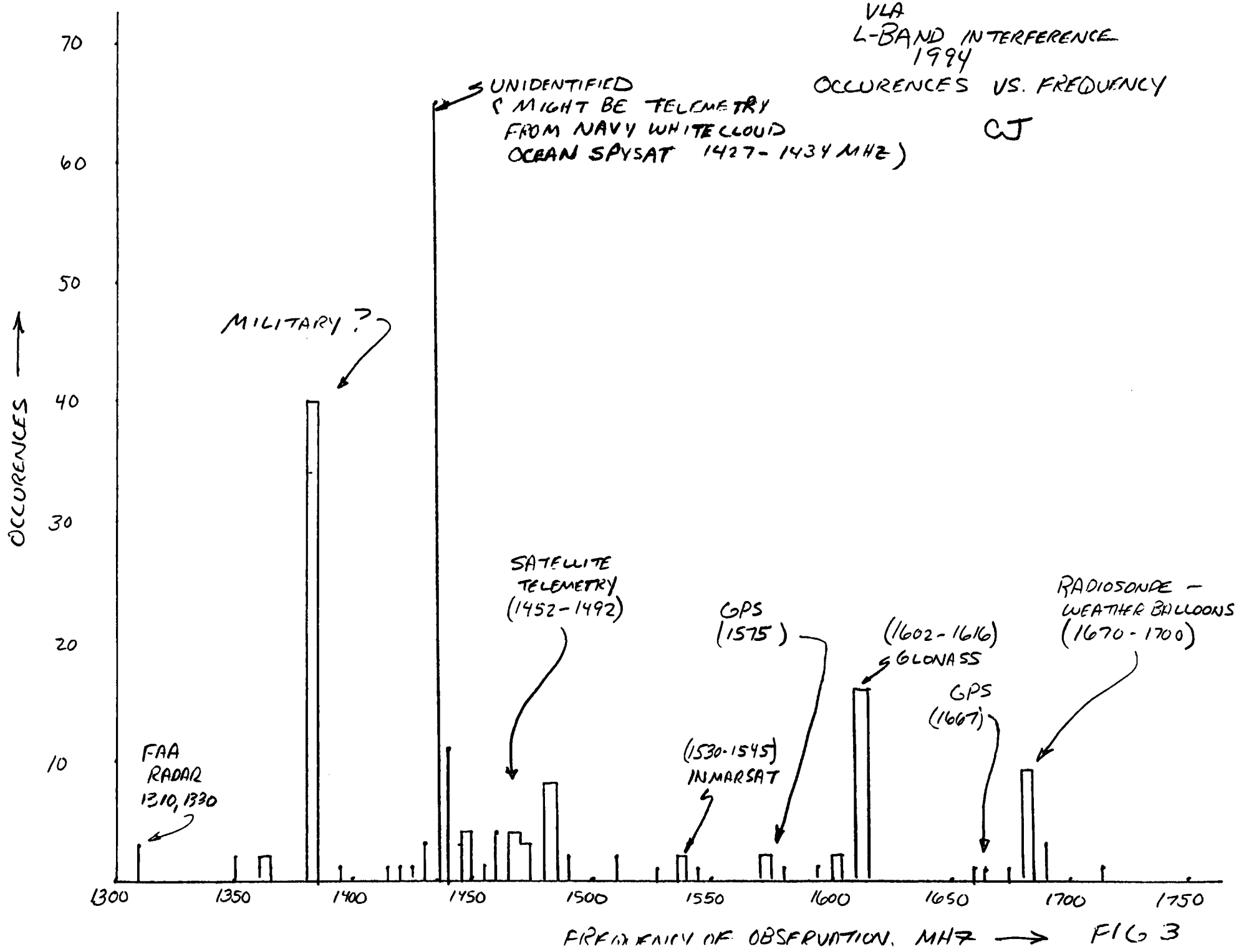

VLA
L-BAND INTERFERENCE
1994
OCCURENCES VS. FREQUENCY
CJ
UNIDENTIFIED
(MIGHT BE TELEMETRY
FROM NAVY WHITECLOUD
OCEAN SPYSAT 1427-1434 MHz)
MILITARY ?
SATELLITE
TELEMETRY
(1452-1492)
GPS
(1575)
(1602-1616)
GLONASS
GPS
(1667)
RADIOSONDE -
WEATHER BALLOONS
(1670-1700)
FAA
RADAR
1310, 1330
(1530-1545)
INMARSAT
OCCURENCES
70
60
50
40
30
20
10
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
FREQUENCY OF OBSERVATION, MHz

FIG 3

T. TONGUE, NRAO

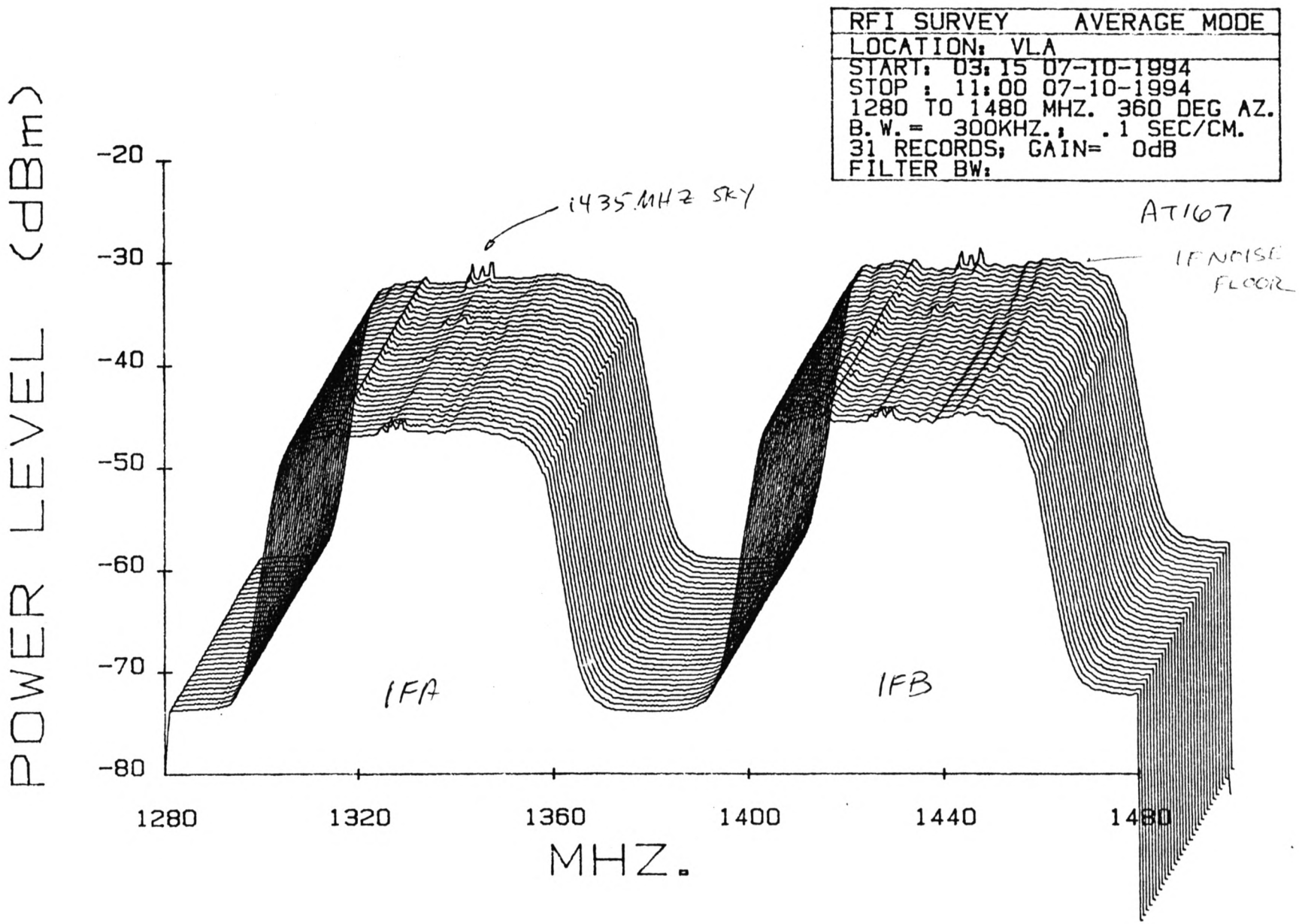


FIG 4

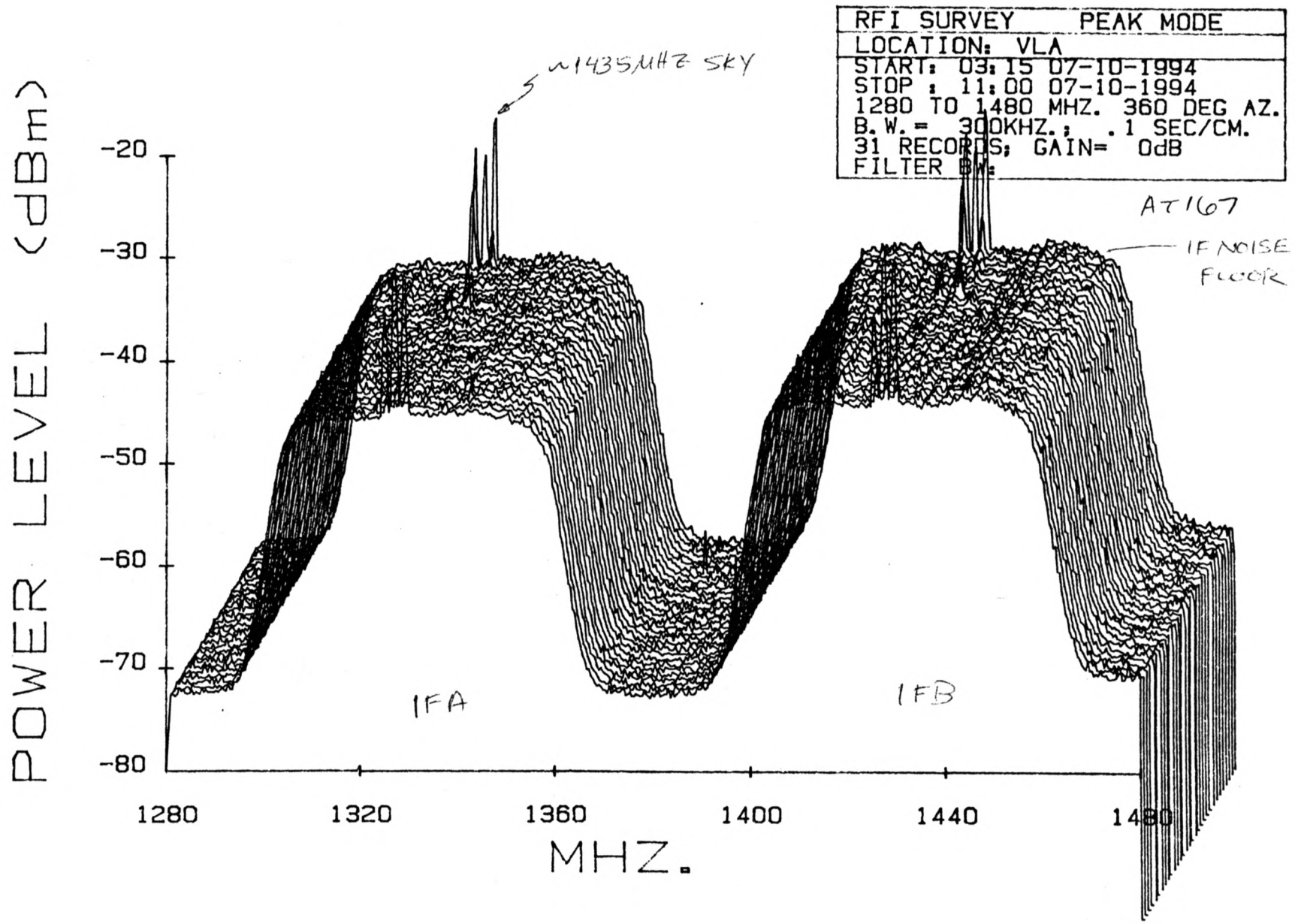

RFI SURVEY PEAK MODE
LOCATION: VLA
START: 03:15 07-10-1994
STOP : 11:00 07-10-1994
1280 TO 1480 MHZ. 360 DEG AZ.
B.W. = 300KHZ.; .1 SEC/CM.
31 RECORDS; GAIN= 0dB
FILTER BW:
~1435MHZ SKY
AT167
IF NOISE FLOOR
IFA
IFB
POWER LEVEL (dBm)
-20
-30
-40
-50
-60
-70
-80
1280
1320
1360
1400
1440
1480
MHZ.

FIG 5

VLA
L-BAND INTERFERENCE
OCCURENCES VS MONTH OF YEAR
1994

CJ

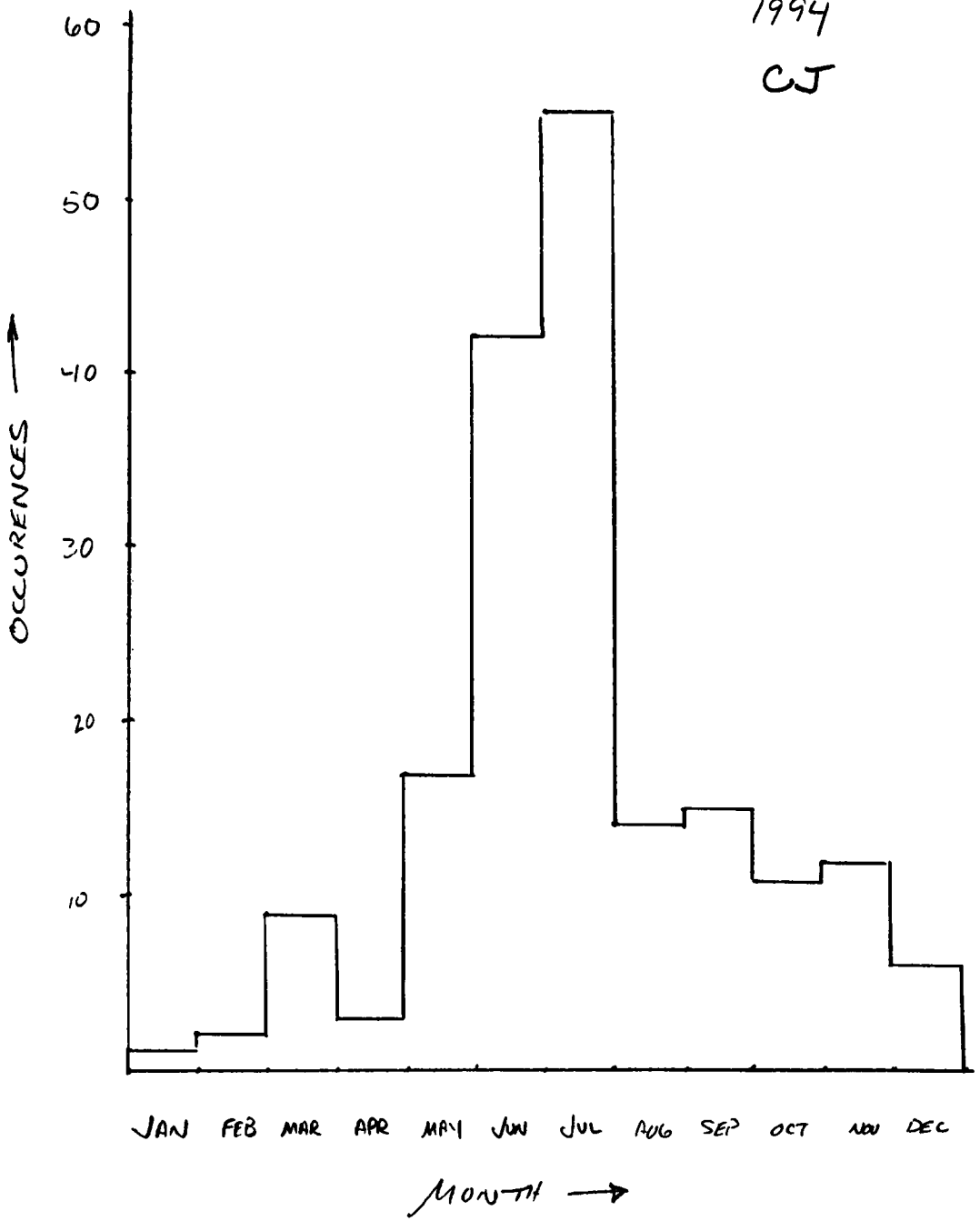


FIG 6

VLA
L-BAND
INTERFERENCE
1994

OCCURRENCES VS TIME-OF-DAY

CJ

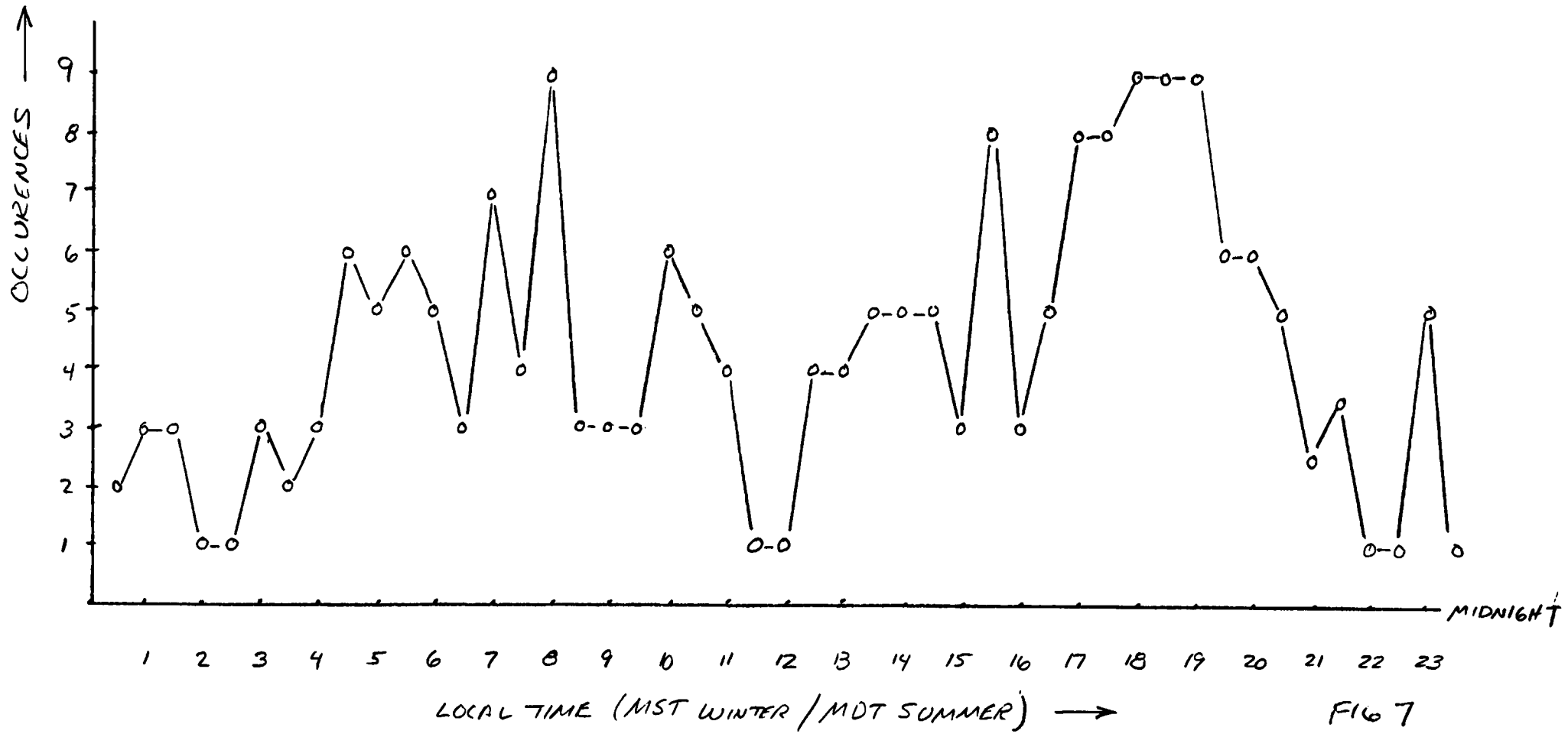


FIG 7

VLA IF - PEAK - SHOWING INTERMITTENT INTERFERENCE

DEC 15, 94
0745 - 0800 MST

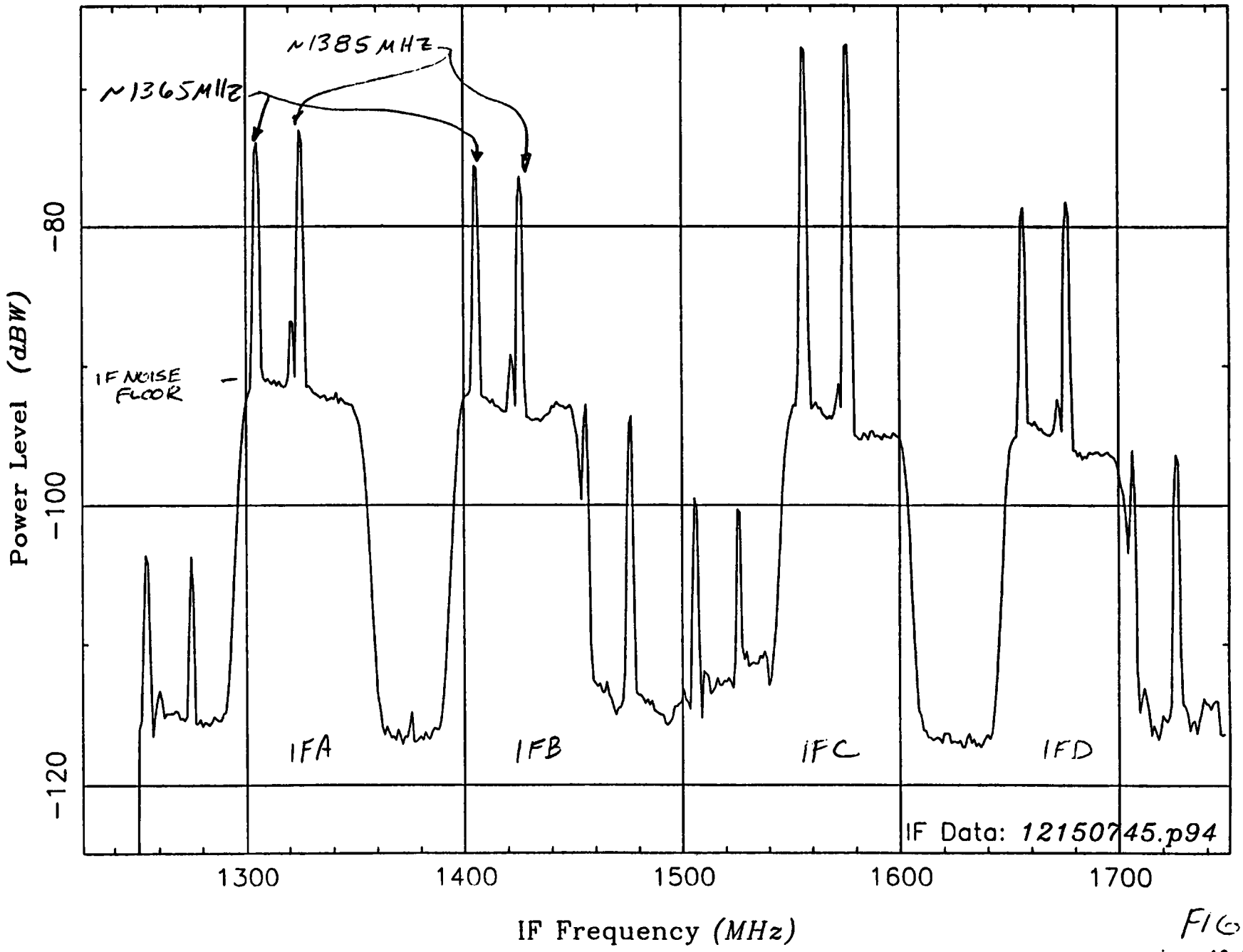


FIG 8

cianes 16-Dec-1994 07:50

LOWK

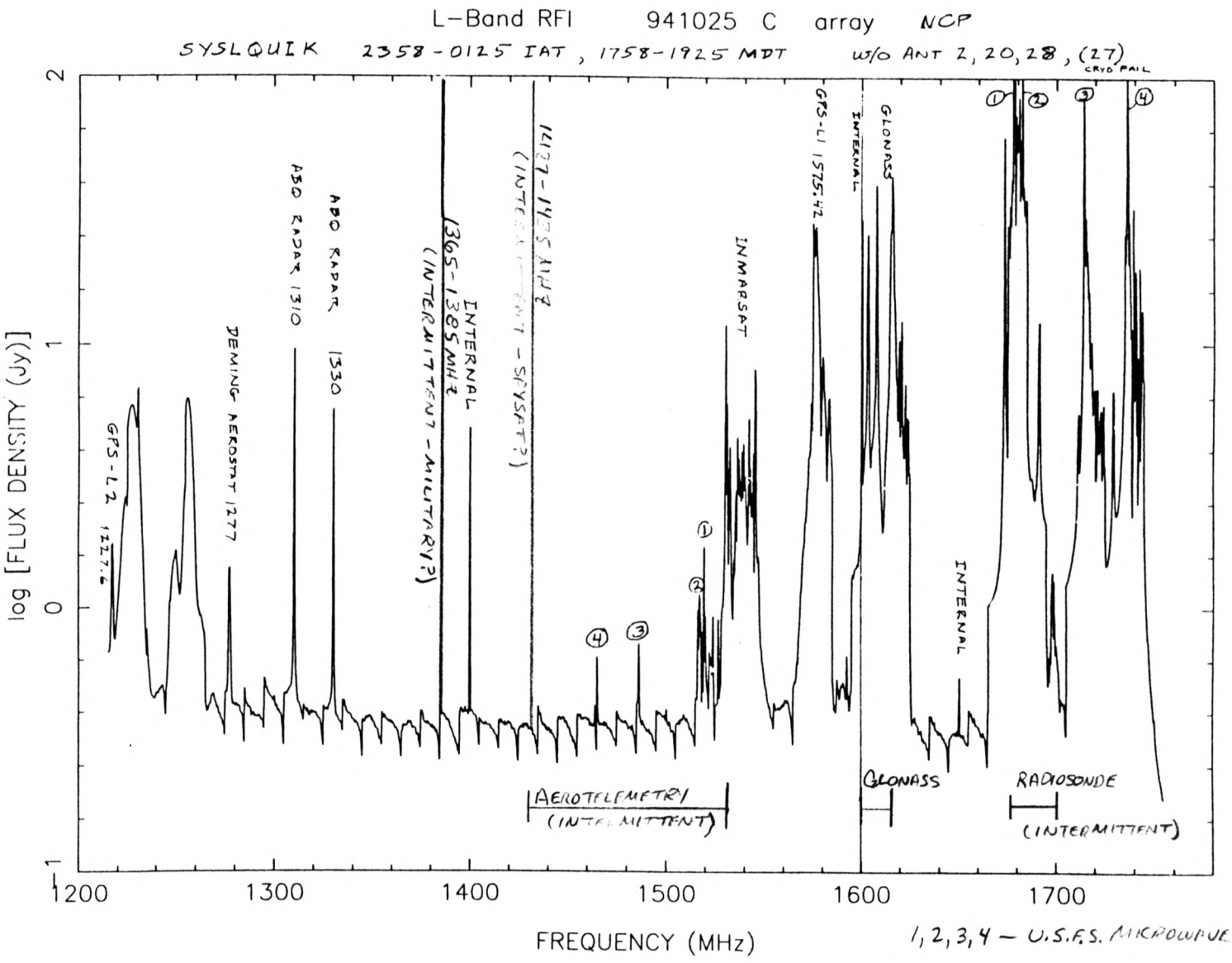

L-Band RFI 941025 C array NCP
SYSLQUIK 2358-0125 IAT, 1758-1925 MDT w/o ANT 2, 20, 28, (27)
CRYO FAIL
log [FLUX DENSITY (Jy)]
2
1
0
-1
1200
1300
1400
1500
1600
1700
FREQUENCY (MHz)
GPS-L2 1227.6
DEMING AEROSTAT 1277
ABQ RADAR 1310
ABQ RADAR 1330
INTERNAL 1365-1385 MHz (INTERMITTENT - MILITARY?)
(INTERMITTENT - SPYSAT?)
1712.5-1717.5 MHz
INMARSAT
GPS-L1 1575.42
INTERNAL
GLONASS
INTERNAL
AEROTELEMETRY (INTERMITTENT)
GLONASS
RADIOSONDE (INTERMITTENT)
1, 2, 3, 4 — U.S.F.S. MICROWAVE

FIG 9