AT/15.5/024

INTERFERENCE SURVEY - NO.IV

R.A.Kennedy, A.G.Little, M.J.Kesteven, G.F.Gerard & J.W.Brooks

6 July 1984

1.0 INTRODUCTION

One of the major reasons for conducting these interference surveys is to gather information to enable us to select the optimum band or bands for the low frequency (<1 GHz) operation of the Australia Telescope. In this report, the fourth in the series of interference measurements conducted at the various AT sites, we present our findings in three sections.

In Section A we show the geographical location and other parameters of radio transmitters (in the bands under consideration) in the state of NSW. We follow this up in Section B with our latest interference measurements taken at the three sites, viz. Parkes, Siding Spring and Culgoora, and attempt to identify some of our interfering signals, by comparing frequencies and direction of arrival of the interfering signal with information from Section A. in our final section (Section C) we endeavour to define a harmful level of interference for the AT and compare this to the sensitivity of our interference measuring equipment.

2.0 SECTION A - RF TRANSMITTERS

The Department of Communication's "Australian Master Frequency Register" Edition 76 contains a complete listing of radio transmitters together with various parameters. From this document we have plotted the following: In figure 1 we show the location of radio transmitters in NSW in the frequency band 317.4 MHz to 342.9 MHz, in figure 2, the frequency band is 401.1 MHz to 419.975 MHz, whilst in figure 3 the range is from 830.987 MHz to 855.0 MHz. The numbers in the diagram can be used with Tables A, B or C to determine the exact frequency and radiated power of the transmitter located at that position. Australia Telescope antenna sites are also shown on figures 1-3 as filled in diamonds. The 600 MHz band is reserved for mobile and military use, hence no transmitter locations are available.

The international frequency allocations for radio astronomy below 1 GHz are 322-328.6, 406.1-410 and 608-614 MHz. The first two are shared with "fixed and mobile services" on a no interference basis.

The best level of protection is at 406.1-410 MHz, where airborne (or spaceborne) transmitters are excluded over the band 406-420 MHz. The 608-614 MHz band is shared with TV broadcasting (terrestrial) and radionavigation services. In addition, the Molonglo Synthesis Telescope (situated near Canberra, ACT) has obtained the local transmitter licences, hence protection for the band 841-845 MHz.

317.4-342.9 MHz RA BAND

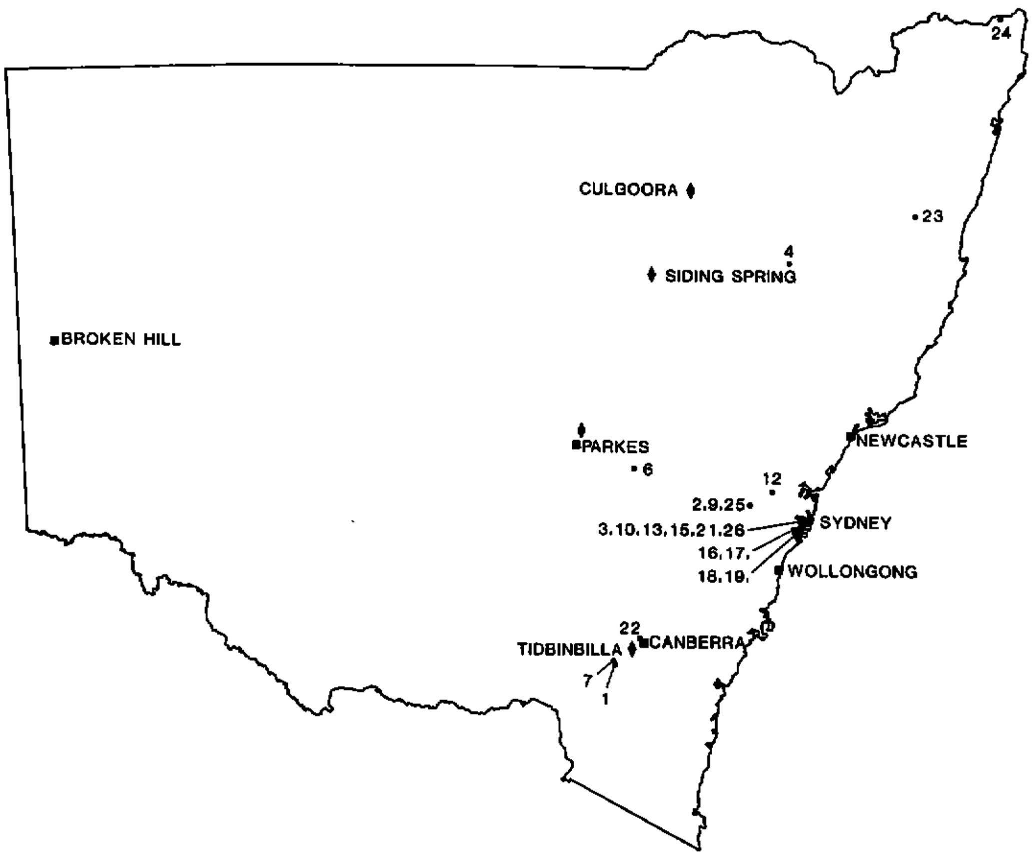


FIGURE 1

401.1 MHz - 419.975 MHz

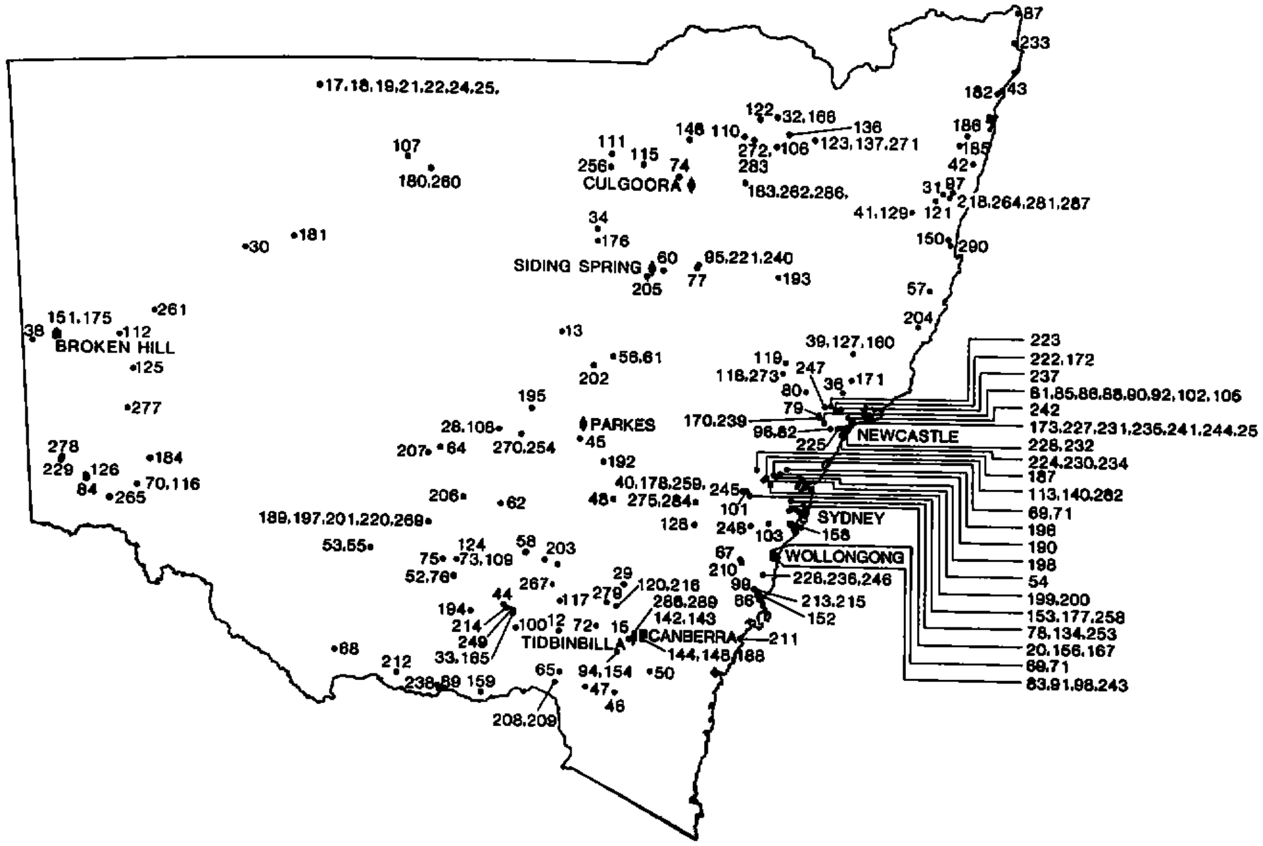
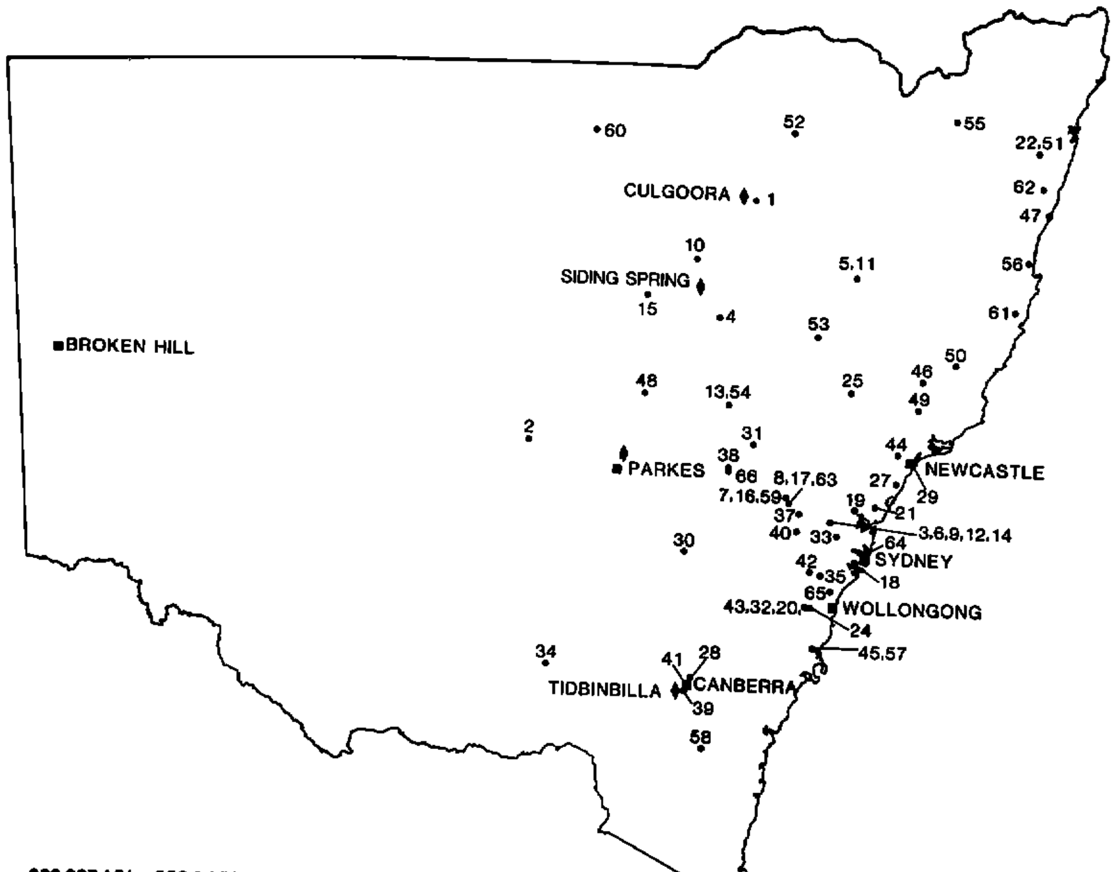


Figure 2



830.987 MHz - 856.0 MHz

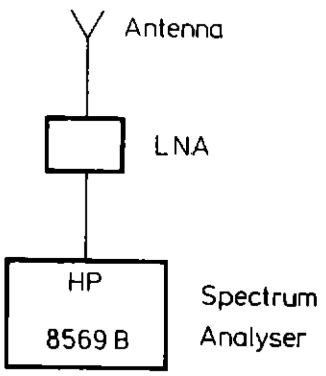
FIGURE 3

3.0 SECTION B - SURVEY RESULTS

The equipment is basically the same as used in previous surveys and is shown schematically in Figure 4. In all figures the power scale is in terms of the input to the spectrum analyzer; to ascertain actual received power due consideration must be taken of the LNA and antenna parameters. The observing technique used was to record azimuth scans at approximately 30° intervals; integration time for each scan is of the order of 10 seconds. The noise temperature of the low-noise amplifier (LNA) is 500K. The frequency bands covered are as shown below:

(a) 300 - 350 MHz
(b) 400 - 420 MHz
(c) 575 - 675 MHz
(d) 818 - 868 MHz and
(e) 1395 -1445 MHz (Parkes site only)

INTERFERENCE MEASUREMENT RECEIVER SCHEMATIC



Frequency (MHz)	Antenna			LNA	
	Type	Gain (db)	HPBW	Type	Gain (db)
327	YAG1	14	30°	Miteq	35
410	YAG1	14	30°	Miteq	35
625	HELIX	11	36°	Miteq	35
843	HELIX	11	36°	Miteq	35
*1420	HORN	17	24°	Miteq	35

*Only used for Parkes Site

Figure 4

3.1 Sites

3.1.1 Culgoora -

In Figures 5-8 we present the results obtained at 325, 410, 625 and 843 MHz respectively.

All but the 410 MHz band seem relatively free of strong interference. In the 410 MHz band the following transmitters have been identified:

Frequency (MHz)	Transmitter No.	Radiated Power(W)	SA Received Power(dBm)	Direction of Arrival (degs)
413.5	183	10	-66	90
415.5	262	10	-47	90
416.5	271, 272	10	-79	30
419.5	286	10	-77	90

In Figure 9 we present the results of a time survey at 410 MHz.

3.1.2 Siding Spring -

The azimuths scan at Siding Spring were done at two separate sites. The 270-0-90 degrees scans were done on the grass verge just north of the UK Schmidt Telescope, whilst the 90-180-270 degree scans were done approximately 50 metres south of the main building and some 5 metres higher. The agreement in the overlap areas is therefore not exact; the actual AT site is 50m lower and some 1 km to the east.

(i) 327 MHz results

The results of the 327 MHz survey are shown in Figures 10 and 11 with no identification possible of the interfering signals (most sources being outside our region of concern). However, within the frequency band of interest, one source of interference was detected with the following parameters:

Frequency (MHz)	Transmitter No.	Radiated power	SA Received power (dBm)	Direction of arrival (degs)
326.0	?	?	-76	210

(ii) 410 MHz

The 410 MHz results are shown in Figures 12 and 13. Tentative identifications are indicated in the table below:

CULGOORA 20/6/84
45 DEGREE POLARISATION

CTR 325.0 MHz SPAN 5 MHz/ RES BW 100 kHz VF OFF
REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO D AVG

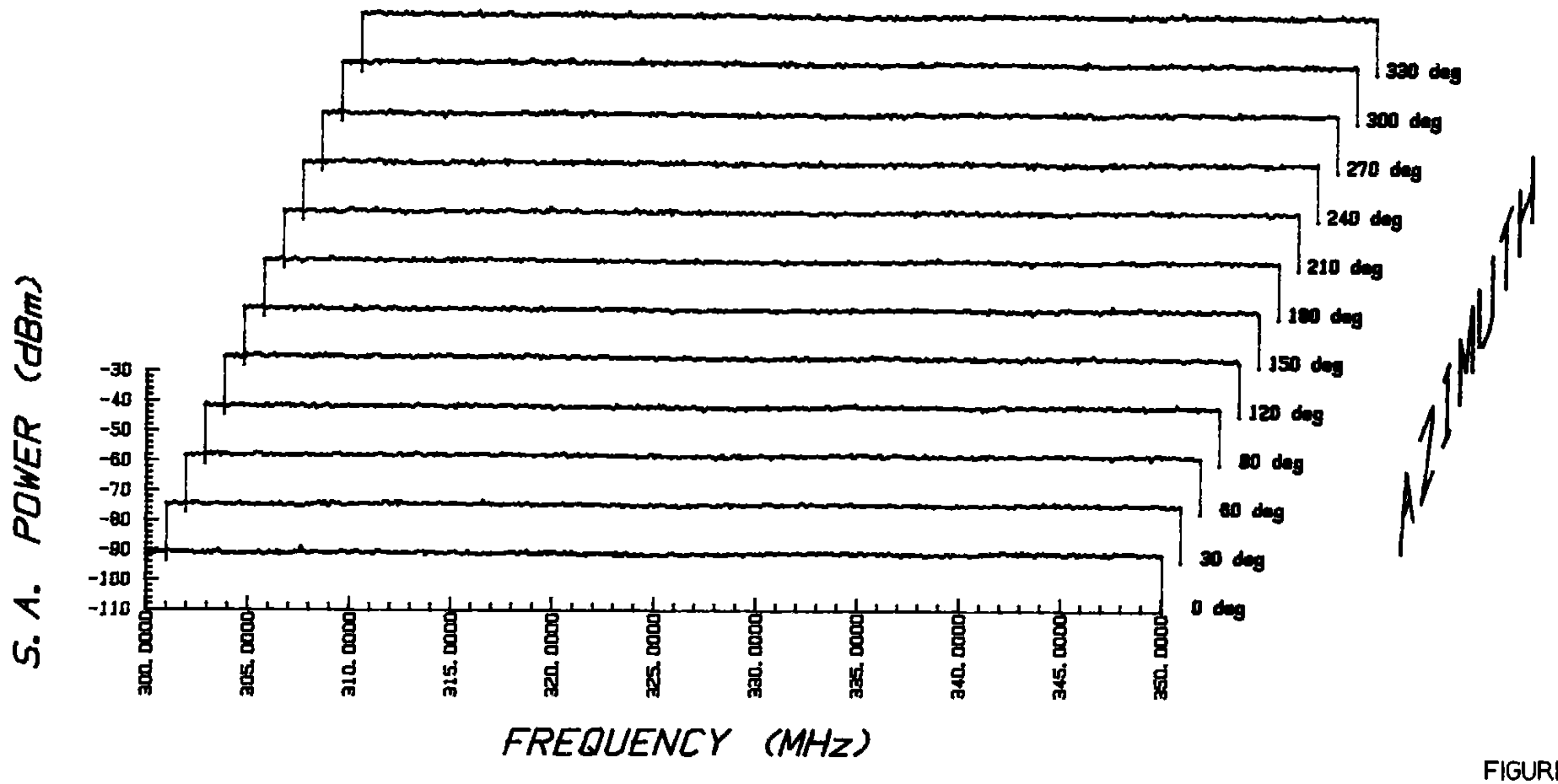


FIGURE 5

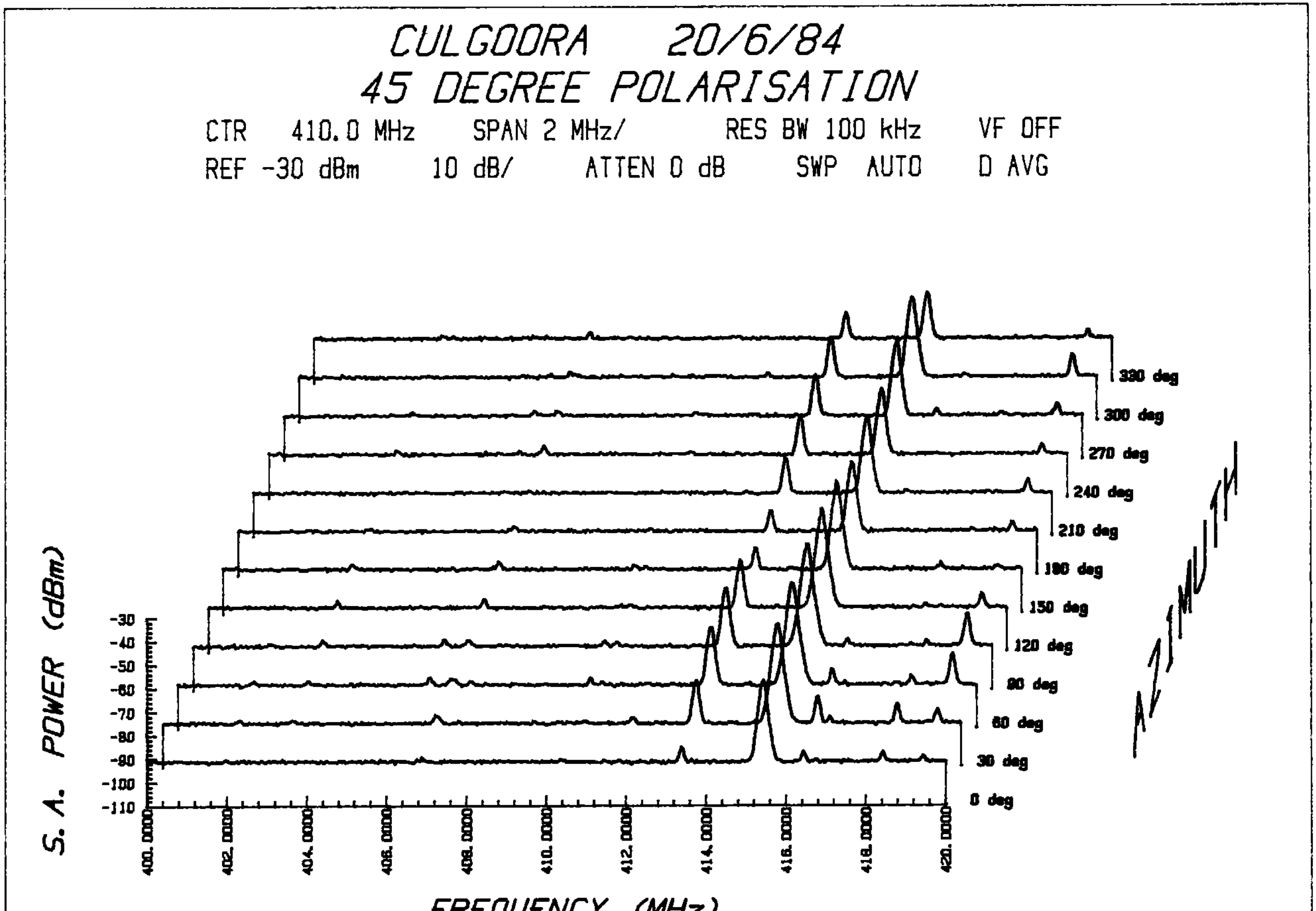

CULGOORA 20/6/84
45 DEGREE POLARISATION
CTR 410.0 MHz SPAN 2 MHz/ RES BW 100 kHz VF OFF
REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO D AVG
S. A. POWER (dBm)
-30
-40
-50
-60
-70
-80
-90
-100
-110
400.0000
402.0000
404.0000
406.0000
408.0000
410.0000
412.0000
414.0000
416.0000
418.0000
420.0000
FREQUENCY (MHz)
0 deg
30 deg
60 deg
90 deg
120 deg
150 deg
180 deg
210 deg
240 deg
270 deg
300 deg
330 deg
AZIMUTH

FIGURE 6

CULGOORA 20/6/84

CIRCULAR POLARISATION

CTR 625.0 MHz SPAN 10 MHz/ RES BW 100 kHz VF OFF

REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO D AVG

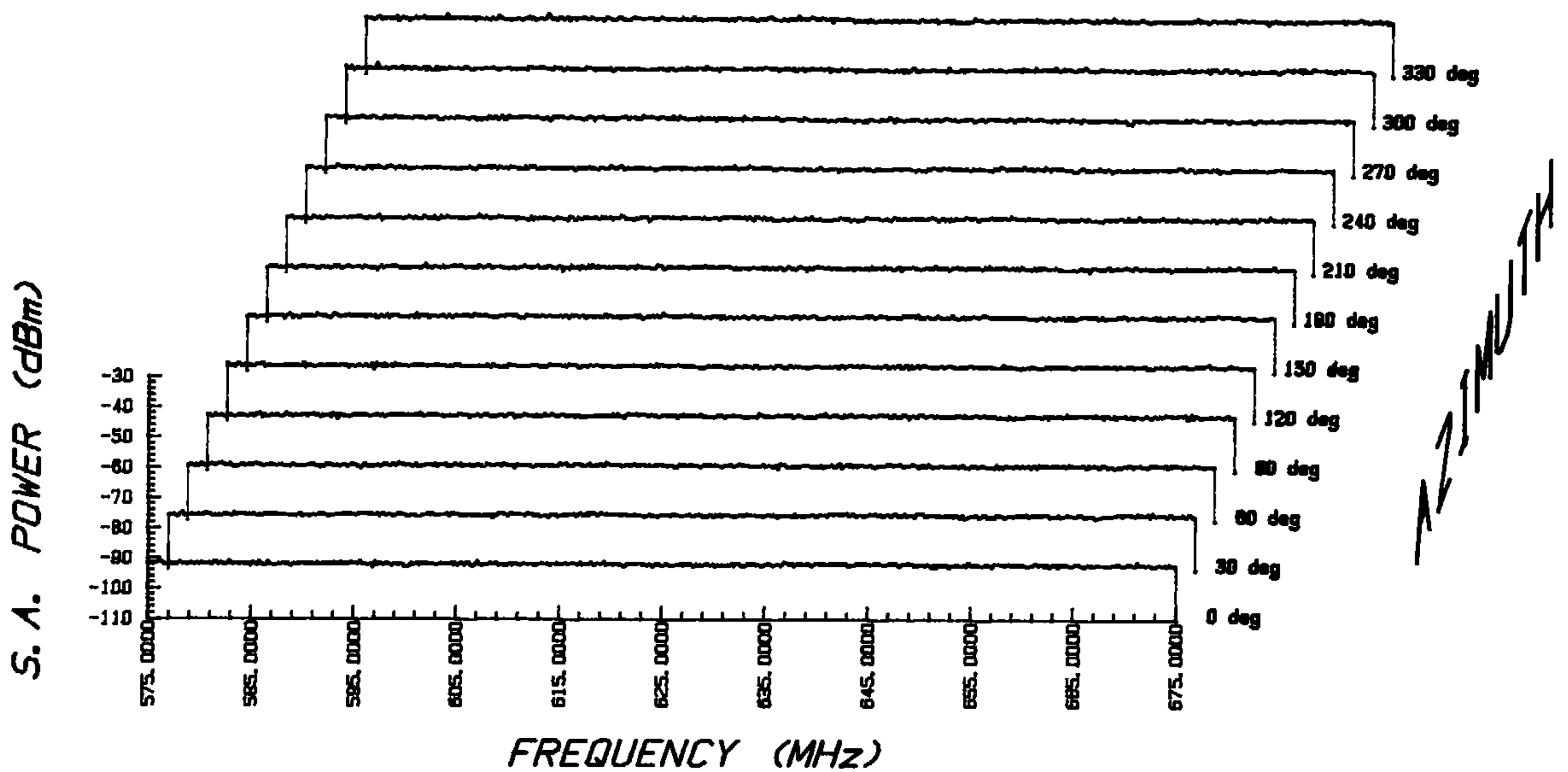


FIGURE 7

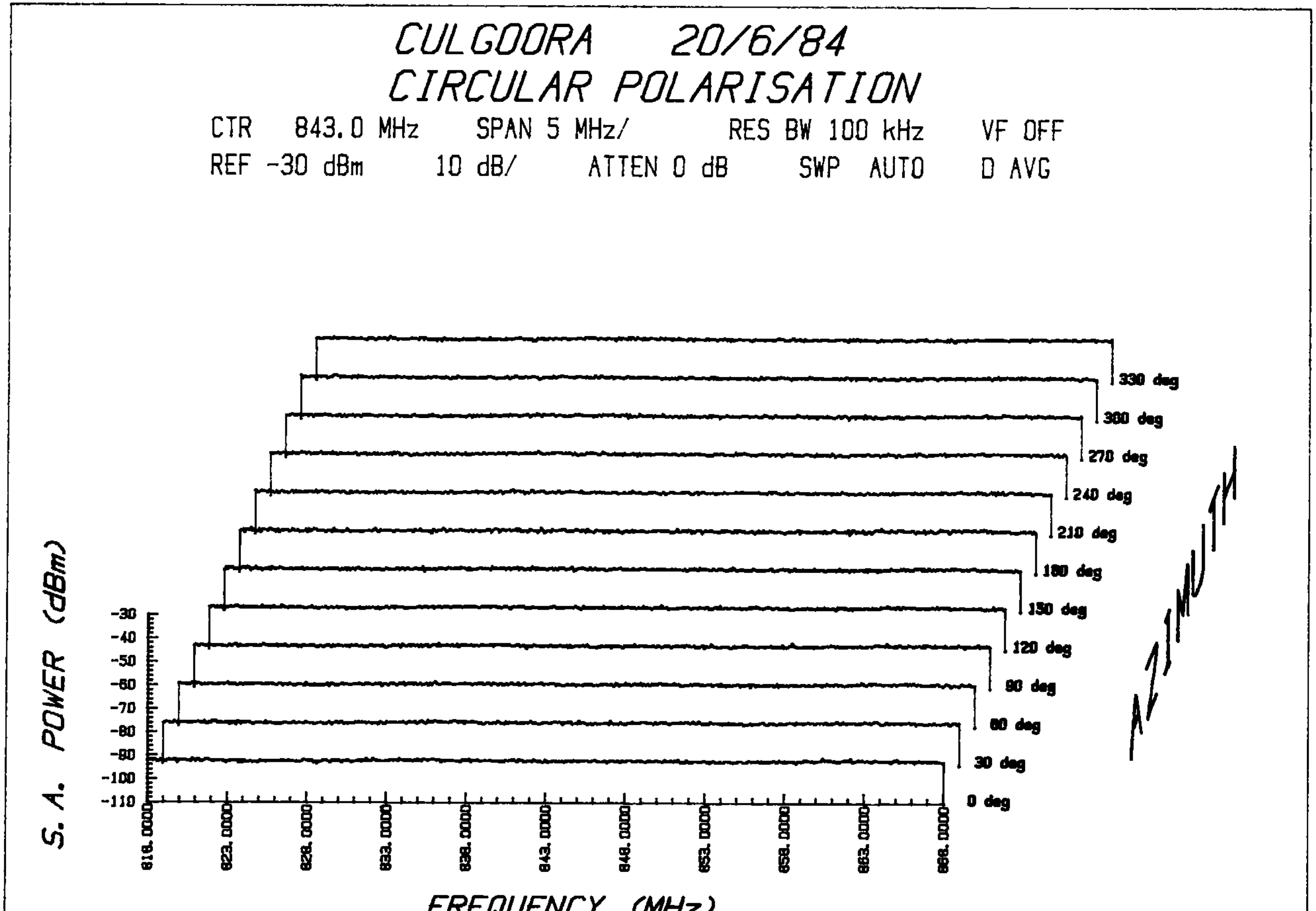

CULGOORA 20/6/84
CIRCULAR POLARISATION
CTR 843.0 MHz SPAN 5 MHz/ RES BW 100 kHz VF OFF
REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO D AVG
330 deg
300 deg
270 deg
240 deg
210 deg
180 deg
150 deg
120 deg
90 deg
60 deg
30 deg
0 deg
AZIMUTH
S. A. POWER (dBm)
-30
-40
-50
-60
-70
-80
-90
-100
-110
818.0000
823.0000
828.0000
833.0000
838.0000
843.0000
848.0000
853.0000
858.0000
863.0000
868.0000
FREQUENCY (MHz)

FIGURE 8

CULGOORA TIME SURVEY 408 MHz
20/6/84

CTR 410.0 MHz SPAN 2 MHz/ RES BW 100 kHz VF OFF
REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO 0 AVG

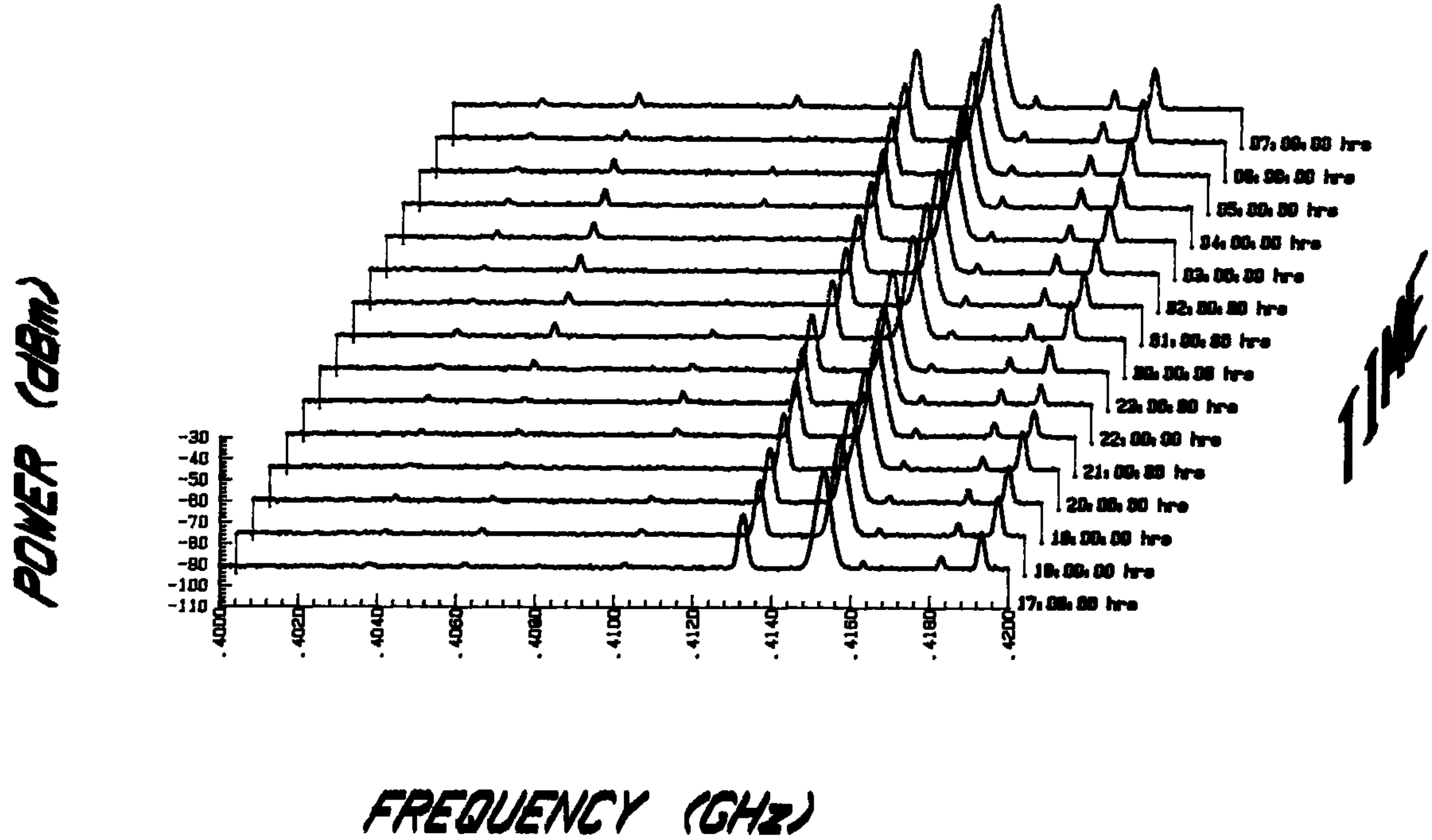
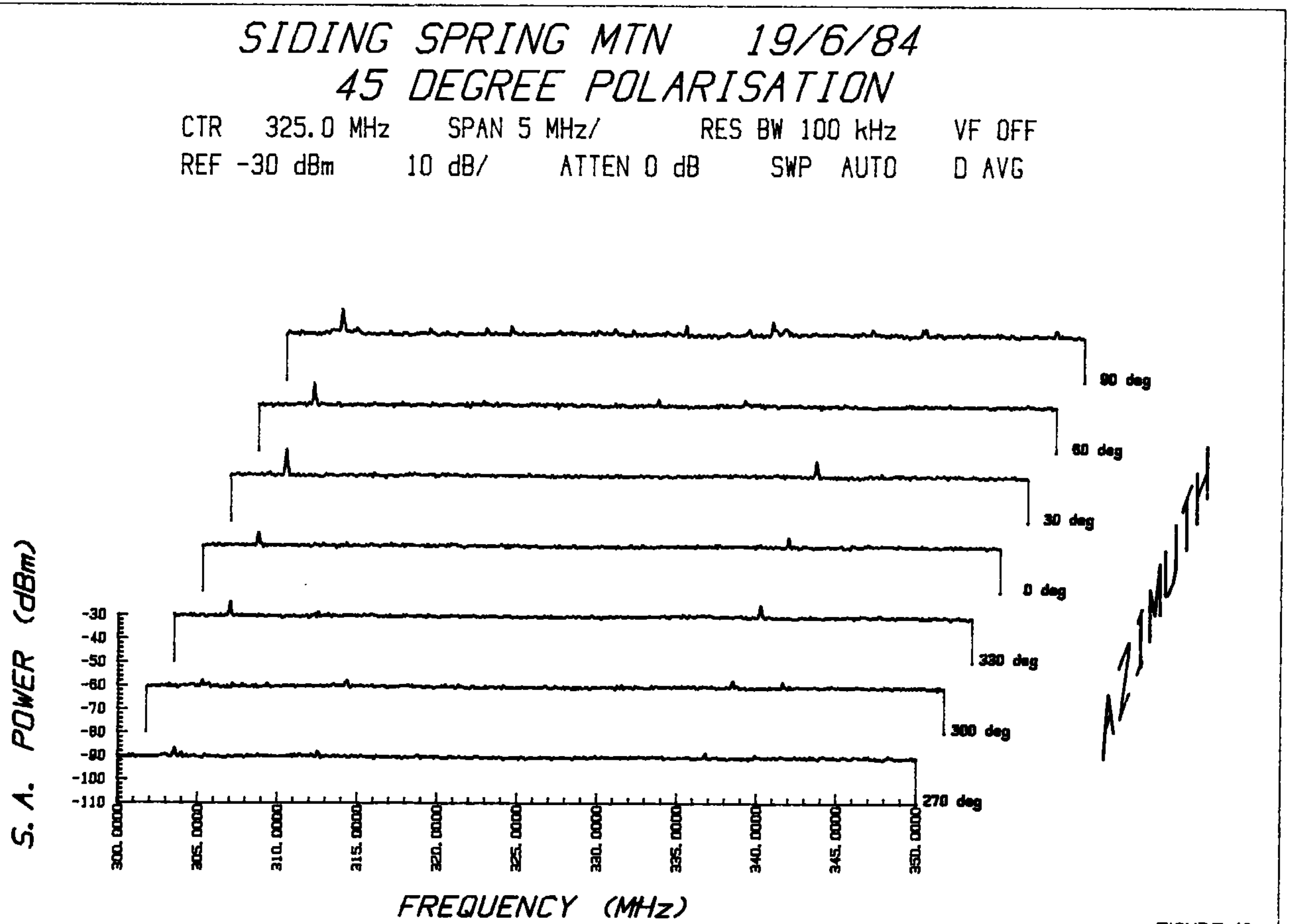


FIGURE 9



SIDING SPRING MTN 19/6/84
45 DEGREE POLARISATION
CTR 325.0 MHz SPAN 5 MHz/ RES BW 100 kHz VF OFF
REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO D AVG
90 deg
60 deg
30 deg
0 deg
330 deg
300 deg
270 deg
AZIMUTH
S. A. POWER (dBm)
-30
-40
-50
-60
-70
-80
-90
-100
-110
300.0000
305.0000
310.0000
315.0000
320.0000
325.0000
330.0000
335.0000
340.0000
345.0000
350.0000
FREQUENCY (MHz)

FIGURE 10

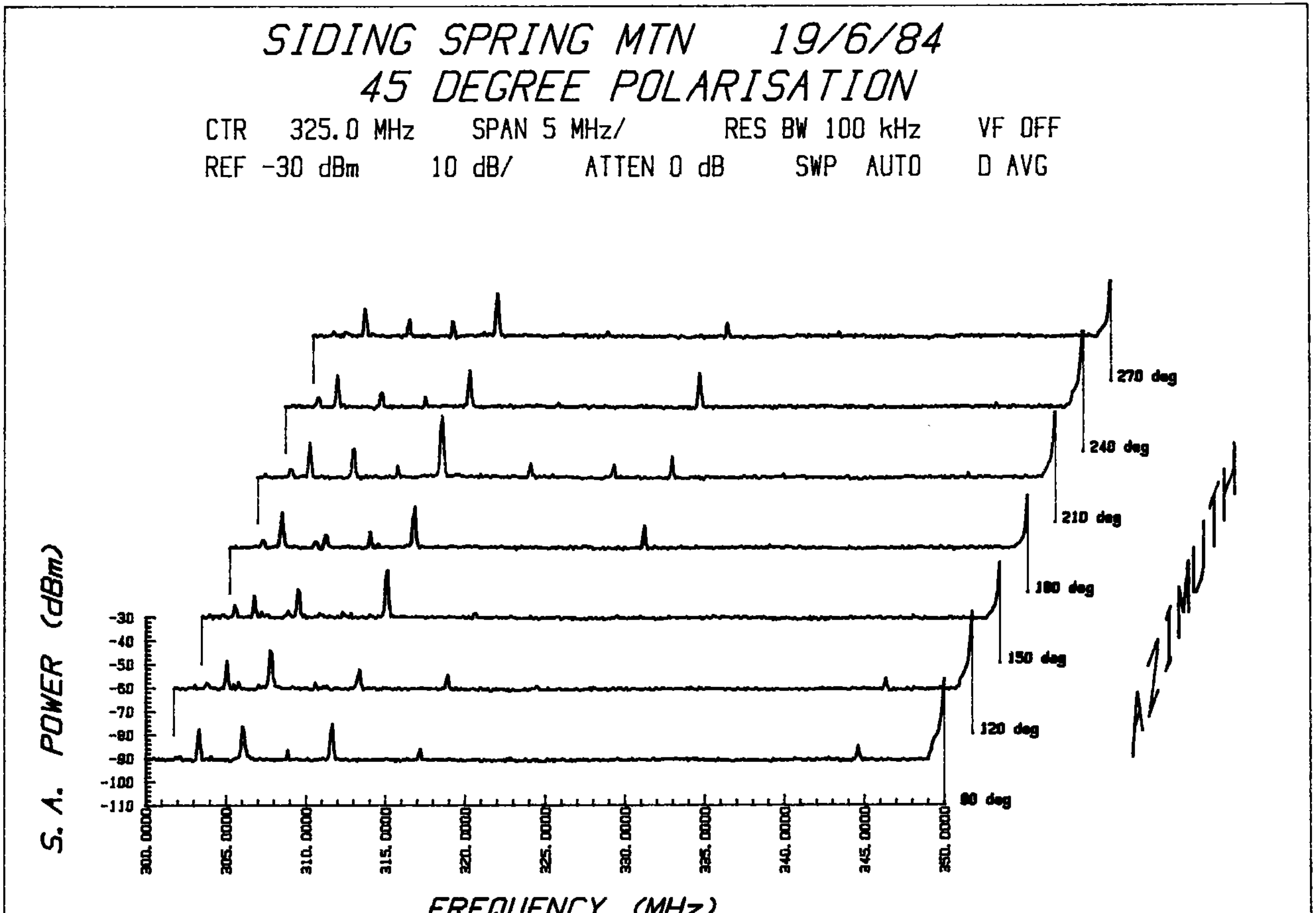

SIDING SPRING MTN 19/6/84
45 DEGREE POLARISATION
CTR 325.0 MHz SPAN 5 MHz/ RES BW 100 kHz VF OFF
REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO D AVG
270 deg
240 deg
210 deg
180 deg
150 deg
120 deg
90 deg
AZIMUTH
S. A. POWER (dBm)
-30
-40
-50
-60
-70
-80
-90
-100
-110
300.0000
305.0000
310.0000
315.0000
320.0000
325.0000
330.0000
335.0000
340.0000
345.0000
350.0000
FREQUENCY (MHz)

FIGURE 11

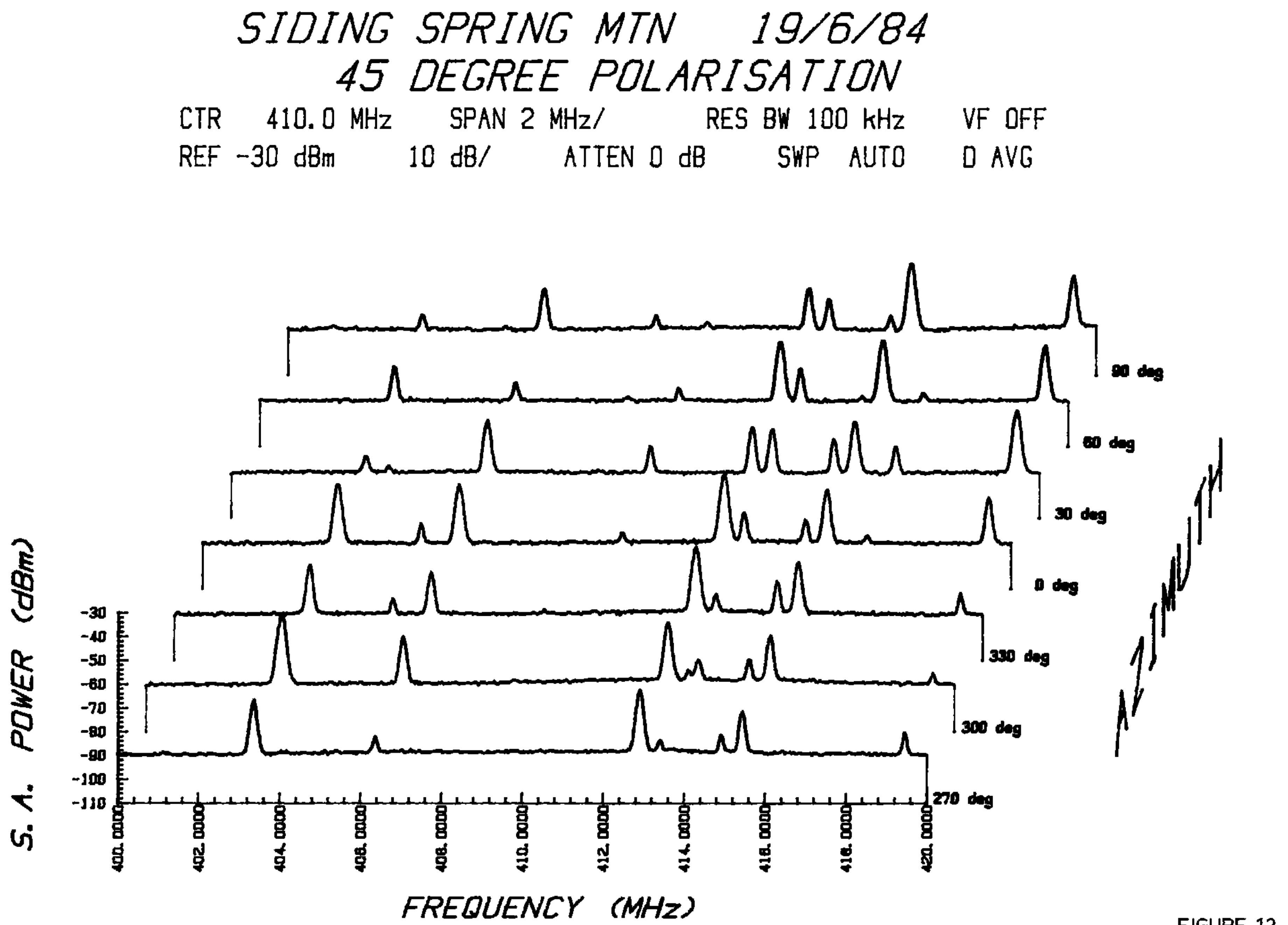
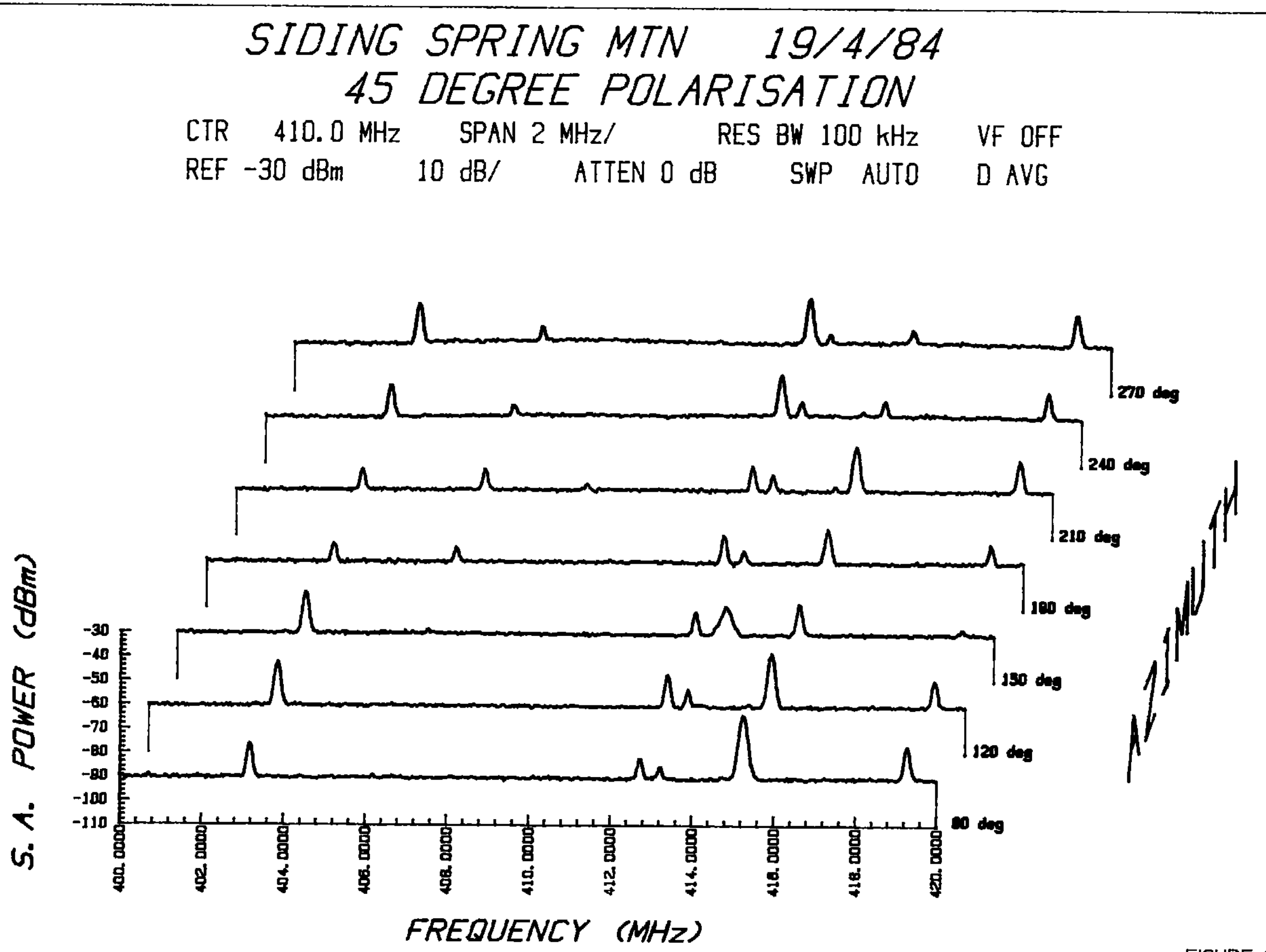

SIDING SPRING MTN 19/6/84
45 DEGREE POLARISATION
CTR 410.0 MHz SPAN 2 MHz/ RES BW 100 kHz VF OFF
REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO 0 AVG
90 deg
60 deg
30 deg
0 deg
330 deg
300 deg
270 deg
AZIMUTH
S. A. POWER (dBm)
-30
-40
-50
-60
-70
-80
-90
-100
-110
400.0000
402.0000
404.0000
406.0000
408.0000
410.0000
412.0000
414.0000
416.0000
418.0000
420.0000
FREQUENCY (MHz)

FIGURE 12



SIDING SPRING MTN 19/4/84
45 DEGREE POLARISATION
CTR 410.0 MHz SPAN 2 MHz/ RES BW 100 kHz VF OFF
REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO D AVG
S. A. POWER (dBm)
-30
-40
-50
-60
-70
-80
-90
-100
-110
400.0000
402.0000
404.0000
406.0000
408.0000
410.0000
412.0000
414.0000
416.0000
418.0000
420.0000
FREQUENCY (MHz)
90 deg
120 deg
150 deg
180 deg
210 deg
240 deg
270 deg
AZIMUTH

FIGURE 13

Frequency (MHz)	Transmitter No.	Radiated power	SA received power (dBm)	Direction of arrival(degs)
403.1	25	27 mW	-73	270
403.2	?		-72	120
403.5	34	10 W	-59	300
405.5	111	10 W	-82	0
406.0	113	20 W	-81	210
406.5	115	10 W	-65	0
409.1	134	15 W	-84	90
410.8	148	10 W	-79	30
412.7	167	5 W	-78	120
412.9	169	? W	-60	0
413.5	183	10 W	-60	30
415.5	262	10 W	-62	90
419.5	286	10 W	-64	30

(iii) 625.0 MHz Results

These results are shown in Figures 14 and 15. As no transmitter listings are available for this frequency, no identification was possible. Relevant parameters of interfering sources are shown below:

Frequency (MHz)	Transmitter No.	Radiated power	SA received power (dBm)	Direction of arrival(degs)
580.0	?	?	-78	240
613.3	?	?	-84	210
629.4	?	?	-83	270

(iv) 843 MHz Results

Results are shown in Figures 16 and 17 with the following tentative identifications:

Frequency (MHz)	Transmitter No.	Radiated power	SA received power (dBm)	Direction of arrival(degs)
820.6	?	?	-55	150
823.1	?	?	-31	0
824.7	?	?	-68	270
839.0	11	10	-85	90
859.8	?	?	-69	330

(c) Parkes

(i) 327 MHz results

Results are shown in Figure 18 with the following tentative

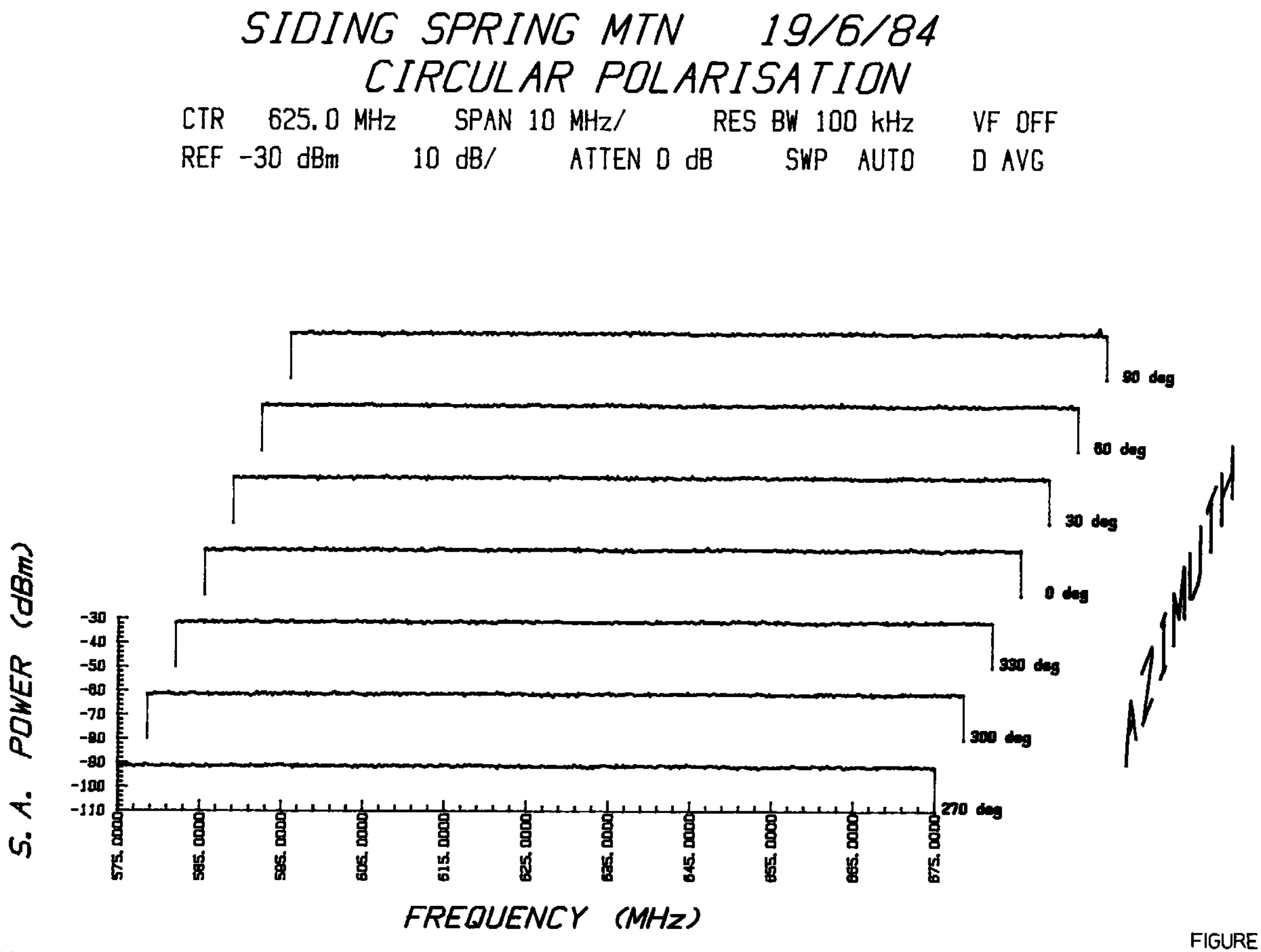

SIDING SPRING MTN 19/6/84
CIRCULAR POLARISATION
CTR 625.0 MHz SPAN 10 MHz/ RES BW 100 kHz VF OFF
REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO D AVG
90 deg
60 deg
30 deg
0 deg
330 deg
300 deg
270 deg
AZIMUTH
-30
-40
-50
-60
-70
-80
-90
-100
-110
S. A. POWER (dBm)
575.0000
585.0000
595.0000
605.0000
615.0000
625.0000
635.0000
645.0000
655.0000
665.0000
675.0000
FREQUENCY (MHz)

FIGURE 14

SIDING SPRING MTN 19/6/84
CIRCULAR POLARISATION

CTR 625.0 MHz SPAN 10 MHz/ RES BW 100 kHz VF OFF
REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO D AVG

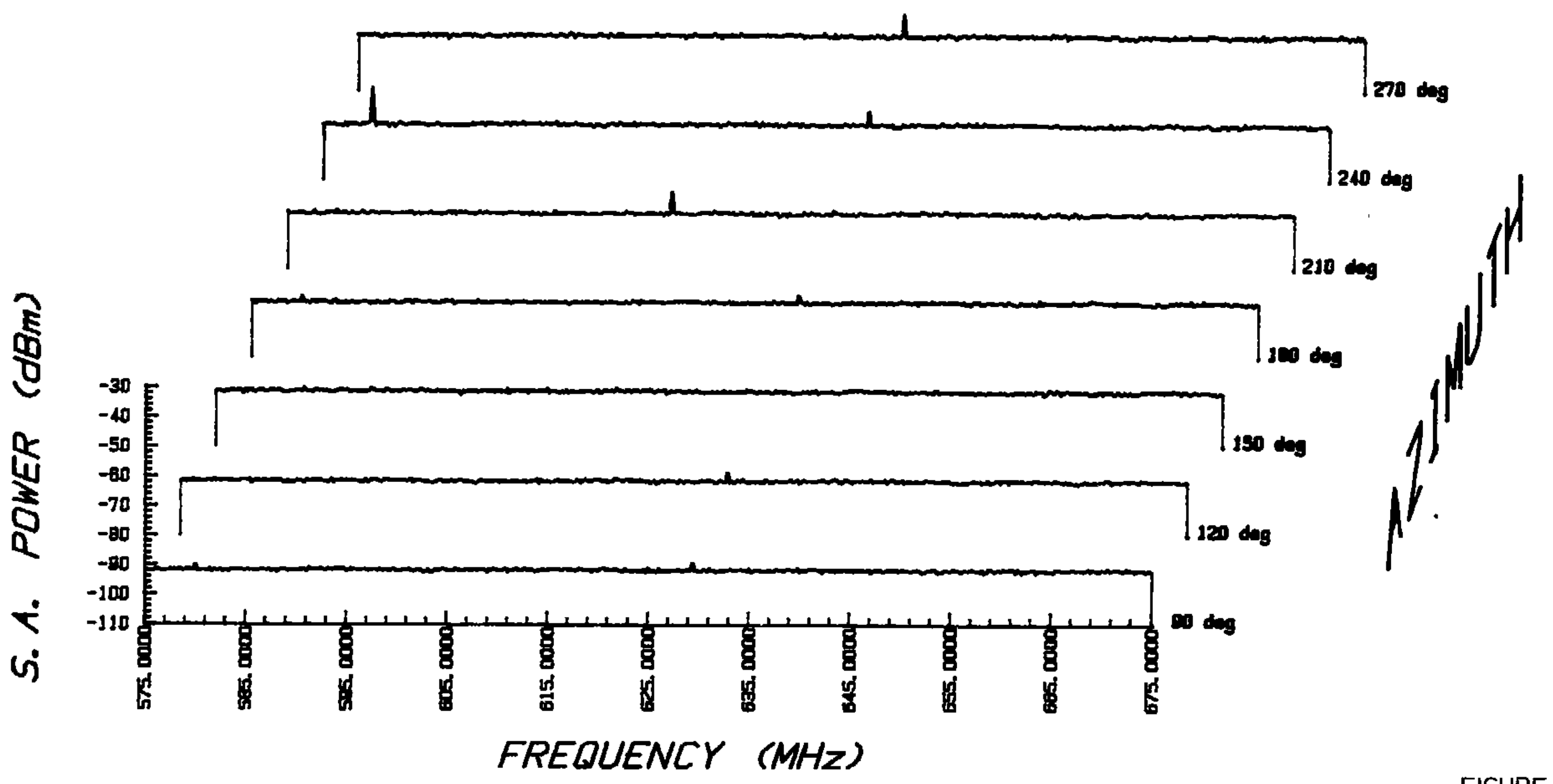


FIGURE 15

SIDING SPRING MTN 19/6/84

CIRCULAR POLARISATION

CTR 843.0 MHz SPAN 5 MHz/ RES BW 100 kHz VF OFF

REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO D AVG

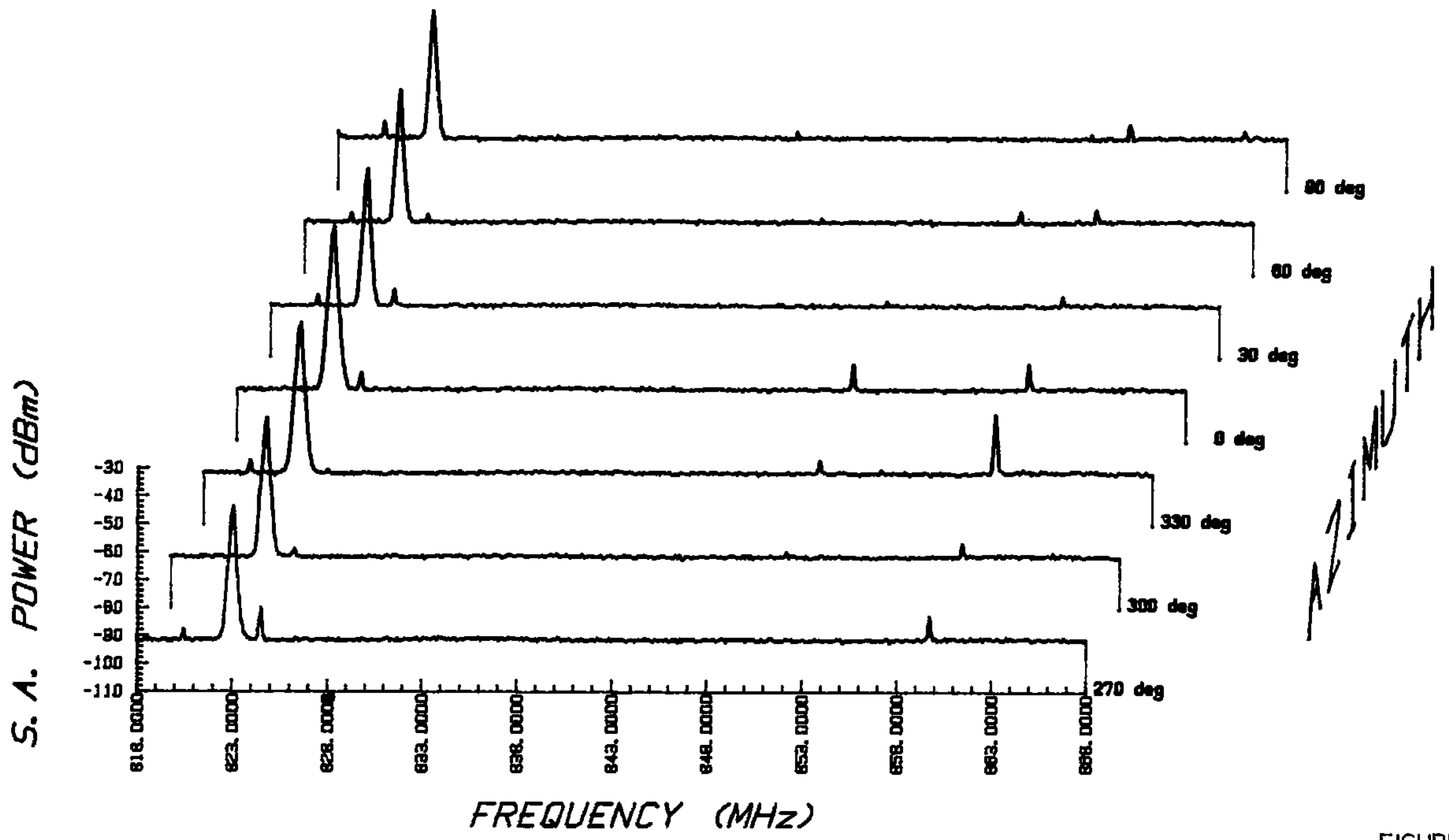


FIGURE 16

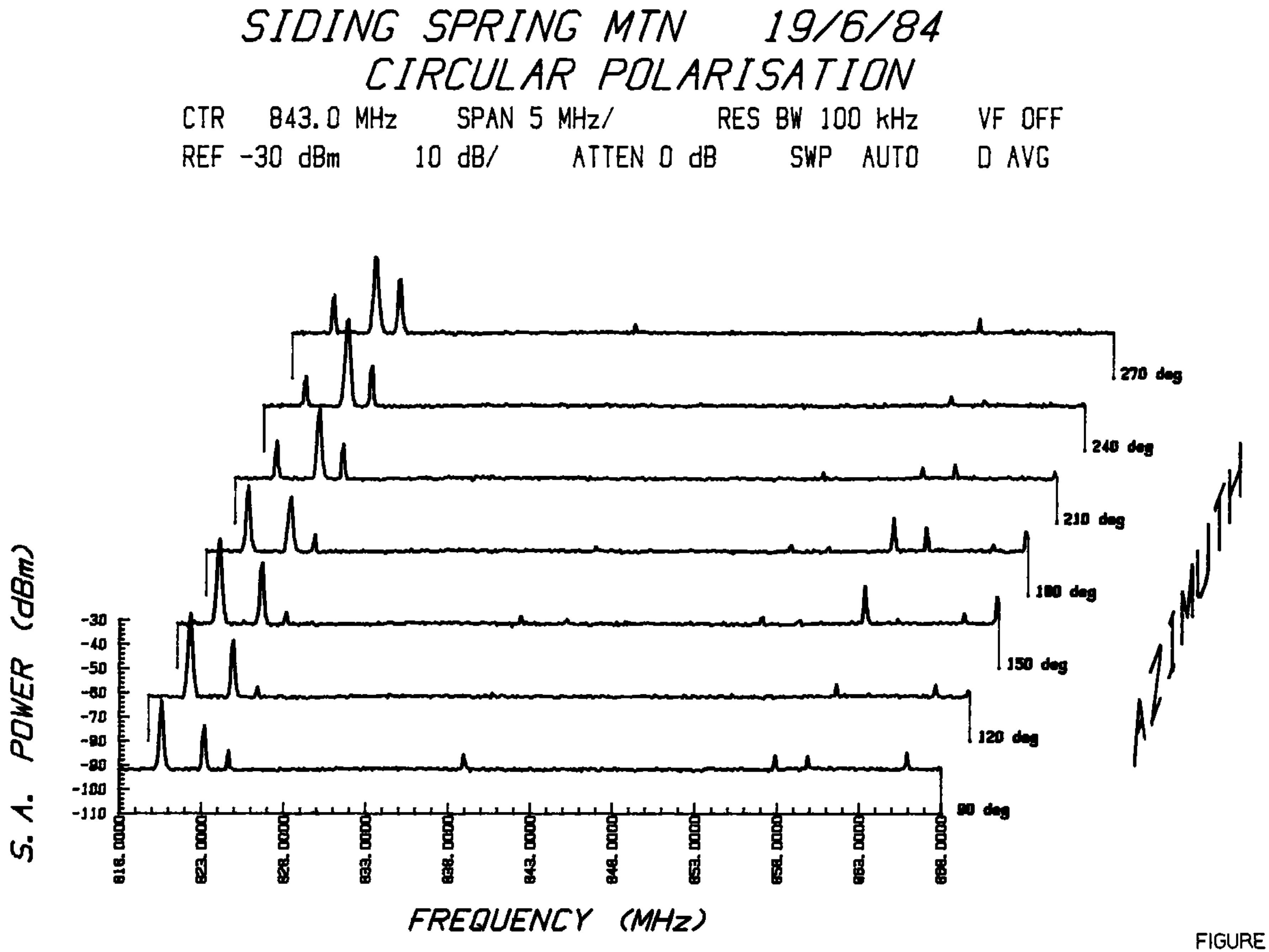

SIDING SPRING MTN 19/6/84
CIRCULAR POLARISATION
CTR 843.0 MHz SPAN 5 MHz/ RES BW 100 kHz VF OFF
REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO D AVG
270 deg
240 deg
210 deg
180 deg
150 deg
120 deg
90 deg
AZIMUTH
S. A. POWER (dBm)
-30
-40
-50
-60
-70
-80
-90
-100
-110
818.0000
823.0000
828.0000
833.0000
838.0000
843.0000
848.0000
853.0000
858.0000
863.0000
868.0000
FREQUENCY (MHz)

FIGURE 17

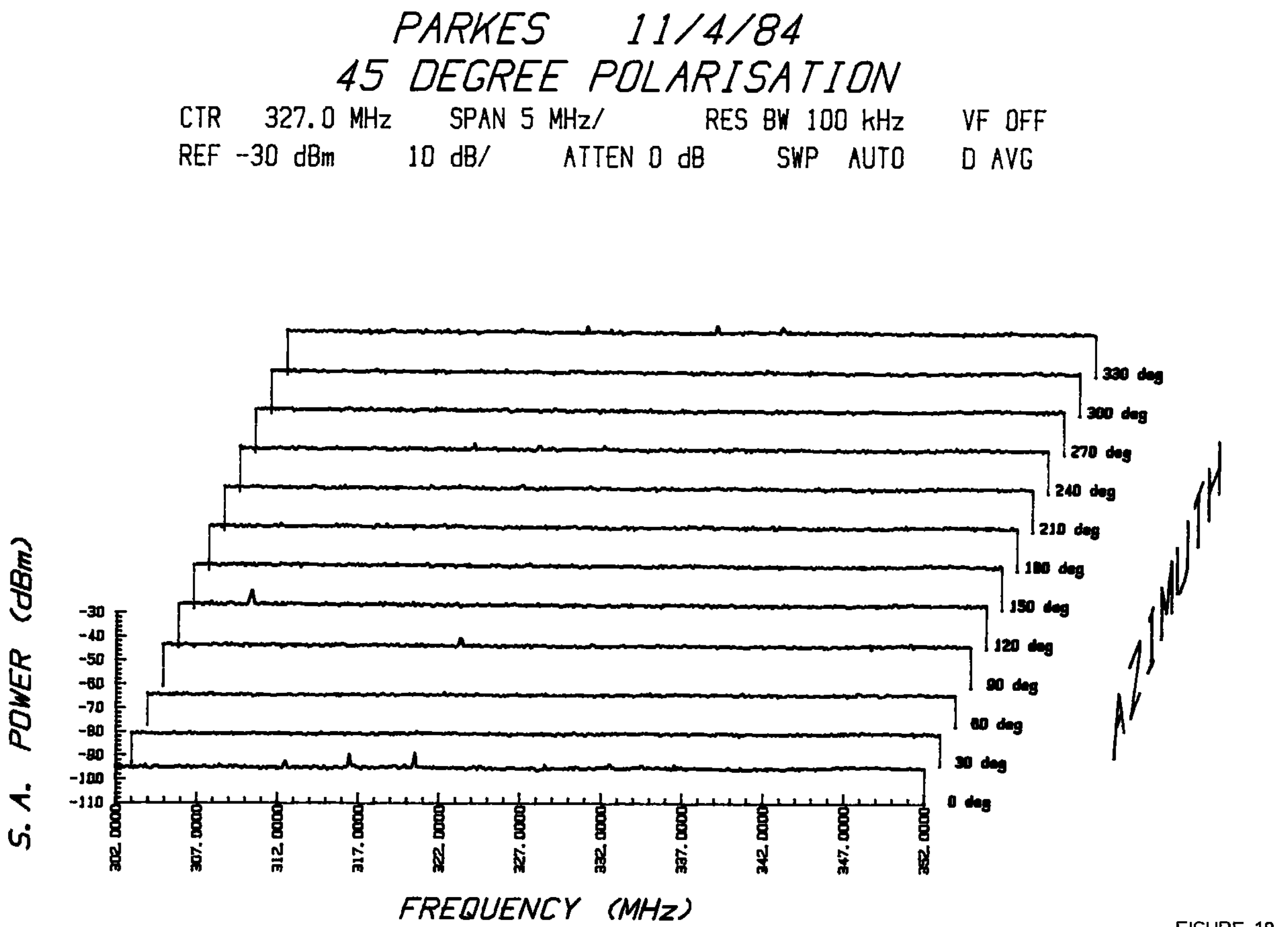

PARKES 11/4/84
45 DEGREE POLARISATION
CTR 327.0 MHz SPAN 5 MHz/ RES BW 100 kHz VF OFF
REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO D AVG
S. A. POWER (dBm)
-30
-40
-50
-60
-70
-80
-90
-100
-110
302.0000
307.0000
312.0000
317.0000
322.0000
327.0000
332.0000
337.0000
342.0000
347.0000
352.0000
FREQUENCY (MHz)
0 deg
30 deg
60 deg
90 deg
120 deg
150 deg
180 deg
210 deg
240 deg
270 deg
300 deg
330 deg
AZIMUTH

FIGURE 18

identifications:

Frequency (MHz)	Transmitter No.	Radiated power	SA received power (dBm)	Direction of arrival(degs)
306.6	?	?	-86	120
316.5	?	?	-89	0
320.5	?	?	-88	0

(ii) 408 MHz results

No detectable transmitters, see Figure 19.

(iii) 625.0 MHz results

No detectable transmitters, see Figure 20.

(iv) 843.0 MHz results

Results are shown in Figure 21, with the following interfering source parameters:

Frequency (MHz)	Transmitter No.	Radiated power	SA received power (dBm)	Direction of arrival (degs)
862.2	?	?	-66	60

(v) 1420.0 MHz results

No detectable transmitters, see Figure 22.

Two time surveys were done at Parkes: one at 327.0 MHz (Figure 23) and the other at 408 MHz (figure 24).

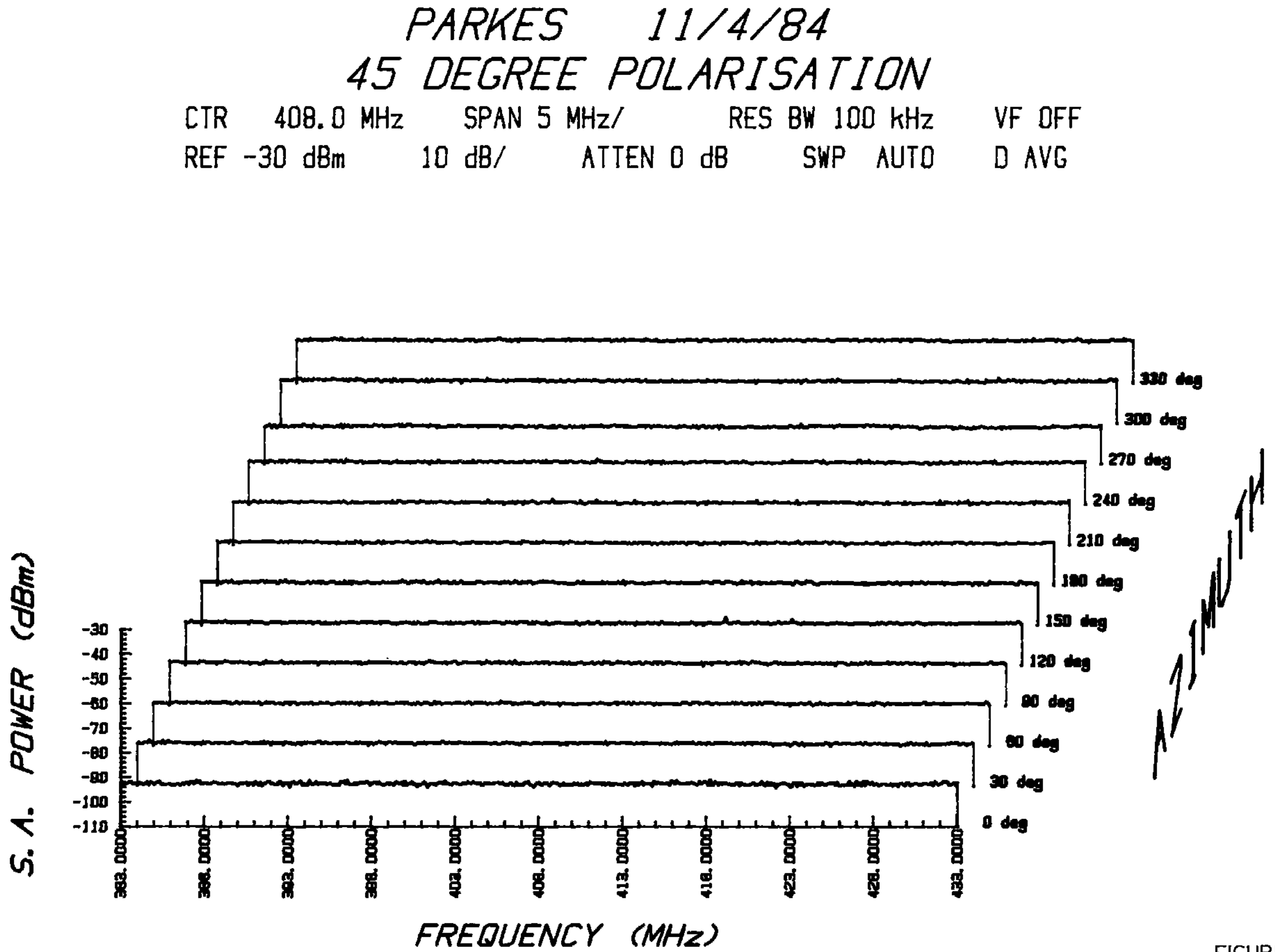

PARKES 11/4/84
45 DEGREE POLARISATION
CTR 408.0 MHz SPAN 5 MHz/ RES BW 100 kHz VF OFF
REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO D AVG
S. A. POWER (dBm)
-30
-40
-50
-60
-70
-80
-90
-100
-110
383.0000
388.0000
393.0000
398.0000
403.0000
408.0000
413.0000
418.0000
423.0000
428.0000
433.0000
FREQUENCY (MHz)
0 deg
30 deg
60 deg
90 deg
120 deg
150 deg
180 deg
210 deg
240 deg
270 deg
300 deg
330 deg
AZIMUTH

FIGURE 19

PARKES 11/4/84
CIRCULAR POLARISATION

CTR 625.0 MHz SPAN 10 MHz/ RES BW 100 kHz VF OFF
REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO D AVG

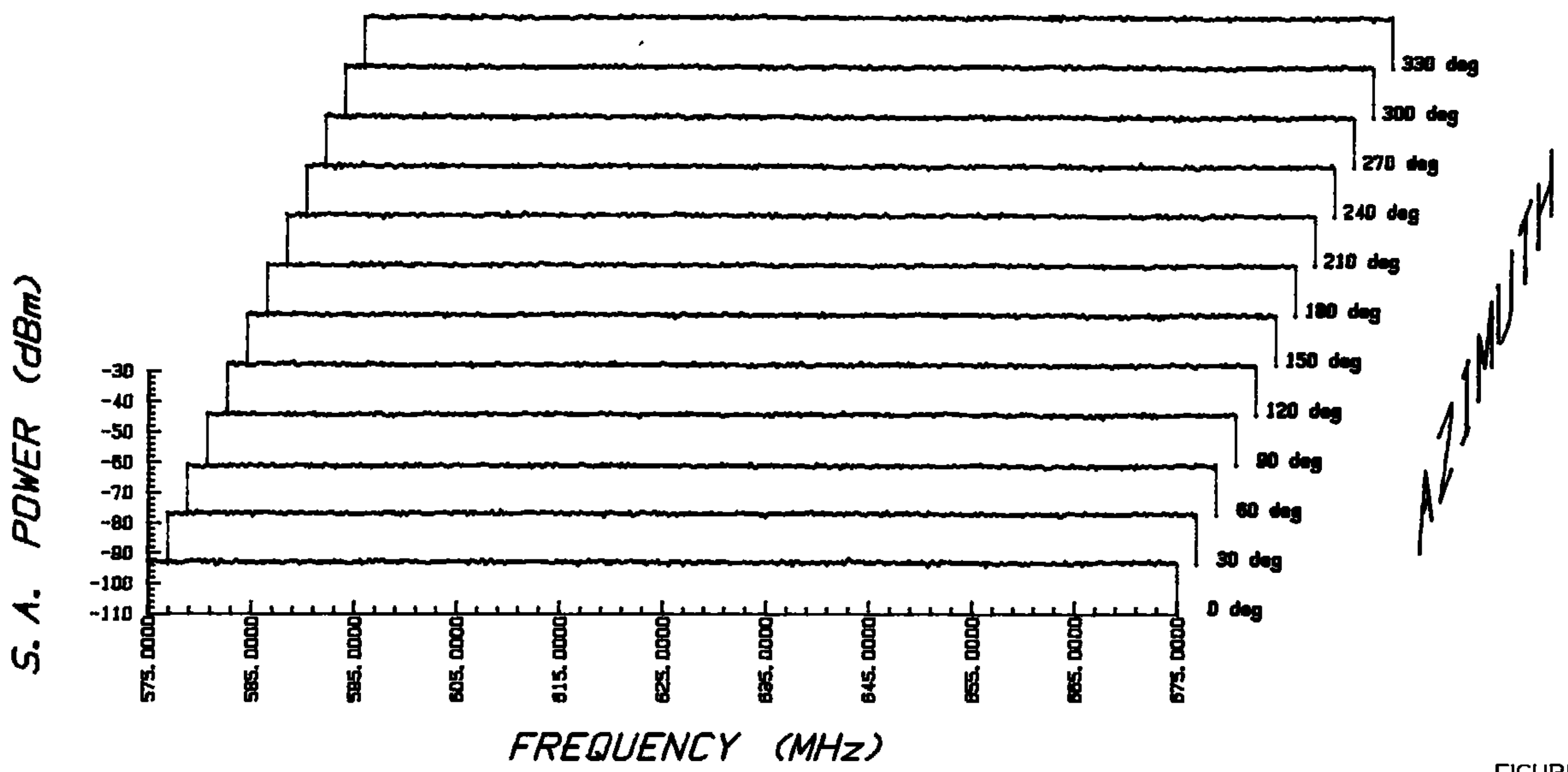


FIGURE 20

PARKES 11/4/84
CIRCULAR POLARISATION

CTR 843.0 MHz   SPAN 5 MHz/   RES BW 100 kHz   VF OFF

REF -30 dBm   10 dB/   ATTEN 0 dB   SWP AUTO   D AVG

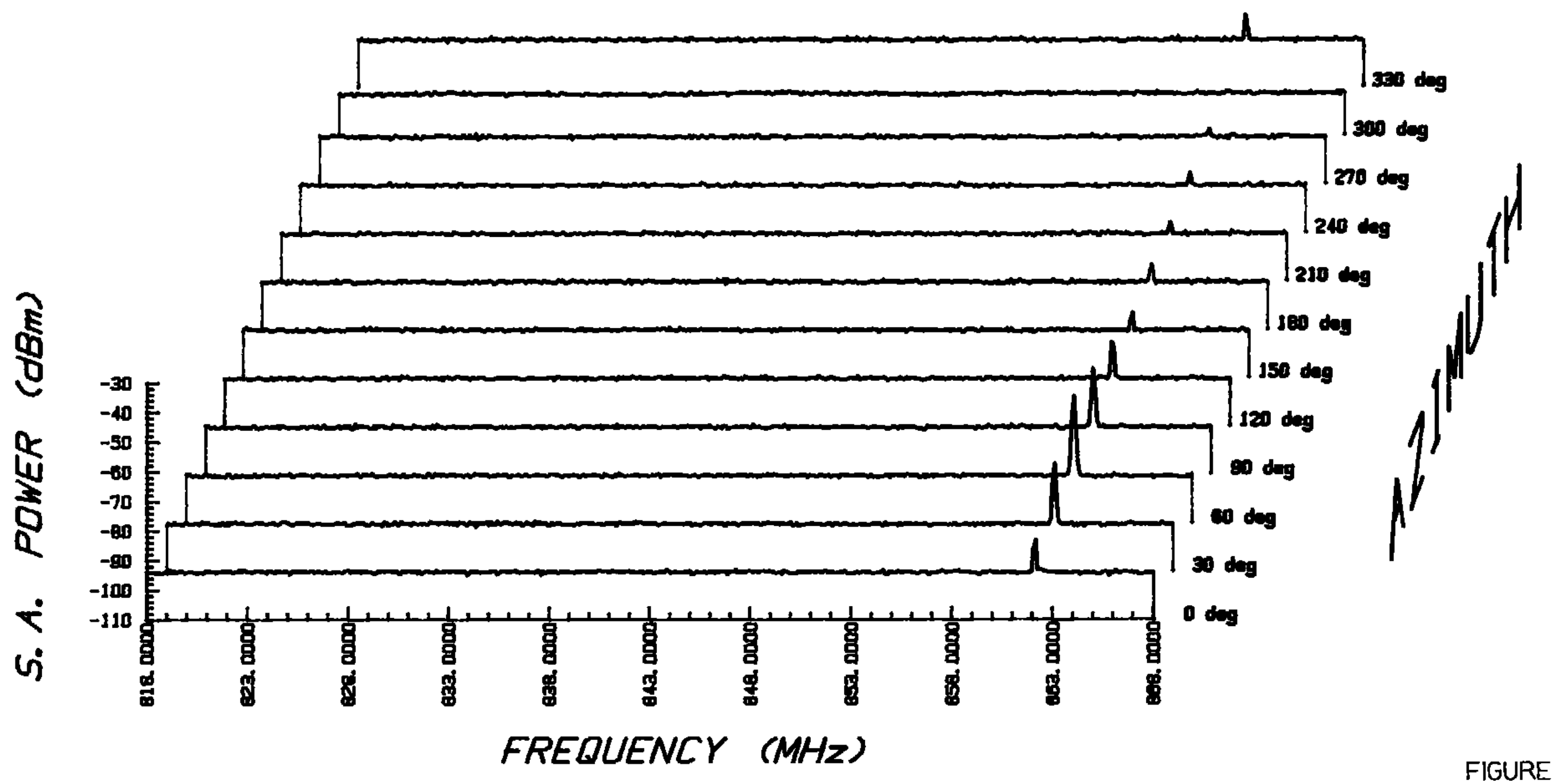


FIGURE 21

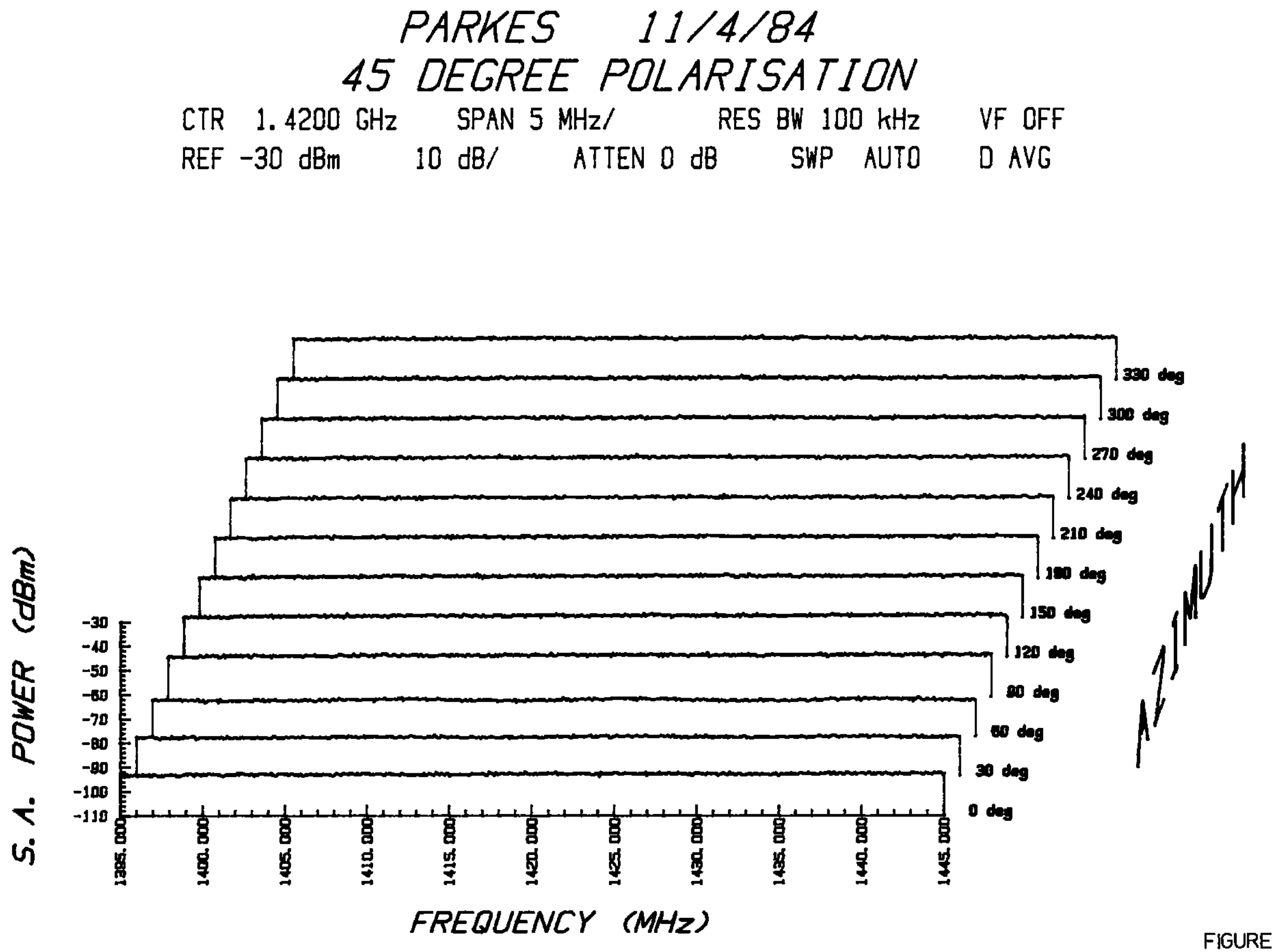

PARKES 11/4/84
45 DEGREE POLARISATION
CTR 1.4200 GHz
SPAN 5 MHz/
RES BW 100 kHz
VF OFF
REF -30 dBm
10 dB/
ATTEN 0 dB
SWP AUTO
D AVG
330 deg
300 deg
270 deg
240 deg
210 deg
180 deg
150 deg
120 deg
90 deg
60 deg
30 deg
0 deg
AZIMUTH
-30
-40
-50
-60
-70
-80
-90
-100
-110
S. A. POWER (dBm)
1395.000
1400.000
1405.000
1410.000
1415.000
1420.000
1425.000
1430.000
1435.000
1440.000
1445.000
FREQUENCY (MHz)

FIGURE 22

PARKES PEAK SURVEY AT 327MHz
11/4/84

CTR 327.0 MHz SPAN 5 MHz/ RES BW 100 kHz VF .01
REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO

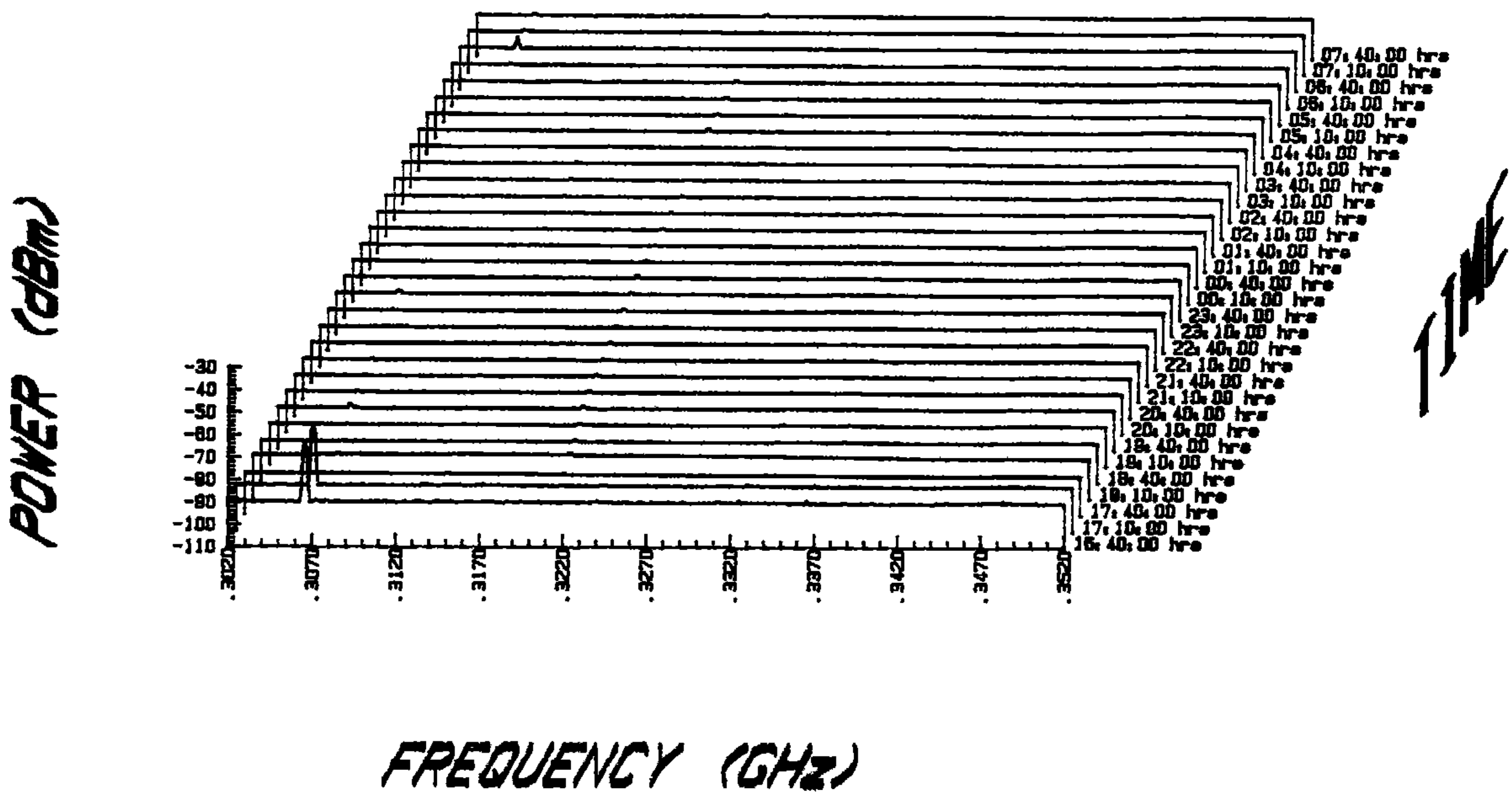


FIGURE 23

PARKES TIME SURVEY AT 408MHz
10/4/84

CTR 408.0 MHz SPAN 5 MHz/ RES BW 100 kHz VF OFF
REF -30 dBm 10 dB/ ATTEN 0 dB SWP AUTO 0 AVG

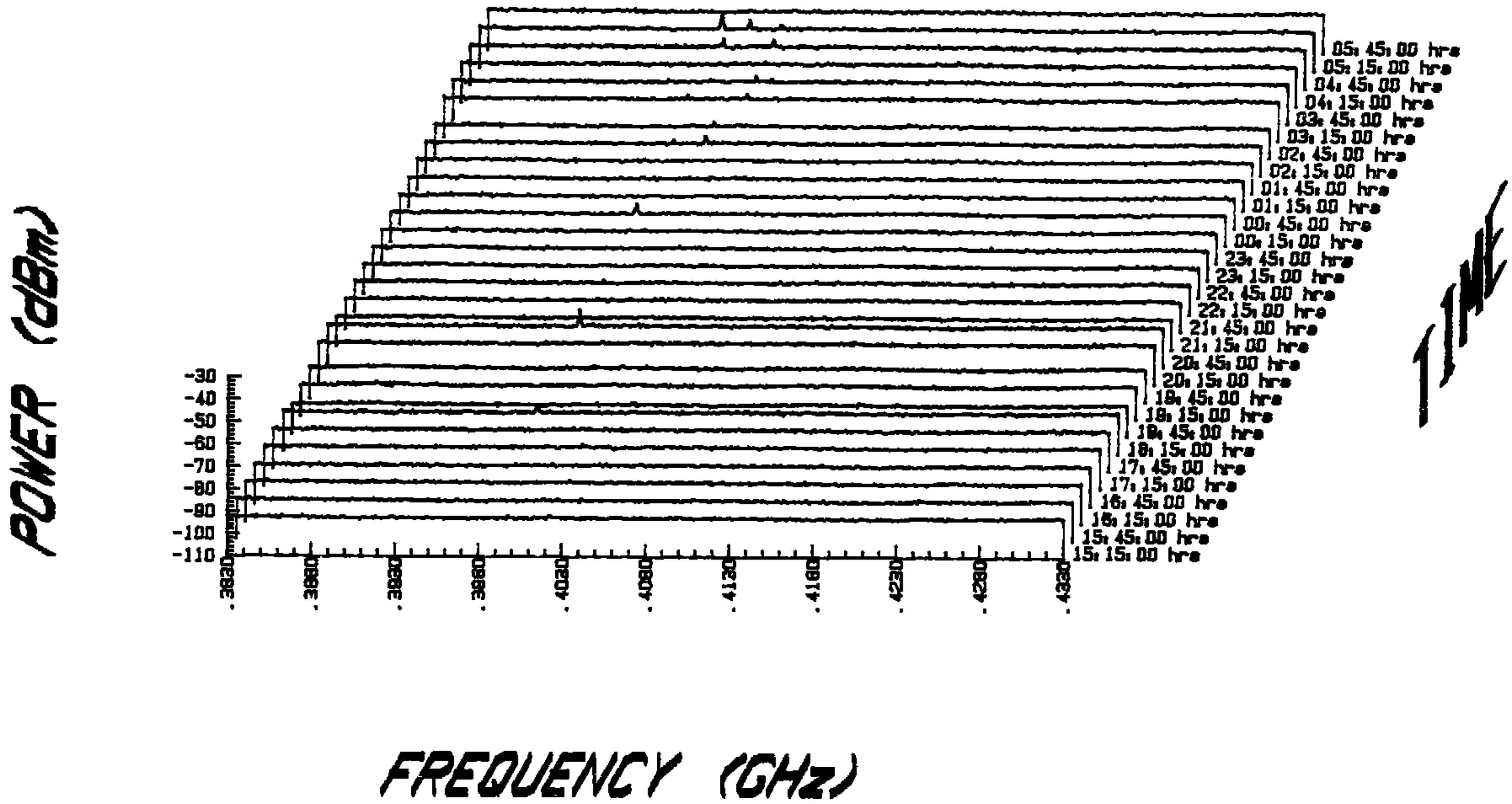


FIGURE 24

4.0 SECTION C

4.1 Radio Interference and the AT

In this section we determine approximate values for harmful levels of interference to the AT. We will only be concerned with the compact array since it is unlikely that the same source of terrestrial interference will be strong enough at all three stations - Siding Spring, Parkes, Culgoora - to cause problems.

As noted in the Appendix D of AT/15.5/020 (1), the effects of interference depend upon many factors and a good discussion of these is given by Thompson (2). In his paper he has derived an expression for the level of interference which is harmful to a synthesis array. A harmful level in this case is considered to be one which is about one tenth of the rms noise level of the system.

A different criterion was used in ASTDOC/58/RHF/BJR/PAGS (3) in which the interference levels from the Woodlawn copper mine were compared with the confusion level. Since this can be higher than the noise level, the use of the latter leads to a conservative estimate of the tolerable interference level.

Using Thompson's approach then, we can calculate a value for this harmful interference for the Australia Telescope. His expression (15) can be reduced to:

$$Si = \frac{1.04 \times 10^{-23}}{\lambda^2 \sqrt{B}} \left[\frac{\frac{1}{N}\sum_N q'}{\lambda} \right]^{\frac{1}{2}} \ Wm^{-2}\ Hz^{-1}$$

where Si is the harmful interference level, B is the bandwidth in Hz and λ wavelength in metres. The quantity in square brackets is a measure of the number of baselines used in the array. For the VLA compact array it has the value $\left[\frac{436 \text{metre}}{\lambda}\right]$, for example.

The effects of interference are in fact worst when the array is in its most compact form, for then the "washing out" of the fringes due to the unwanted signal is least.

Thus for the AT the 1.5km array is the most compact and will therefore be a worst case situation. On any one day for this array there are only 10 spacings and the most compact arrangement is on day 1 [see AT/10.1/036; AT/17.2/003, fig. 3.1] (4).

The mean spacing, $\frac{1}{N} \sum_N q' = 606$m.

Using this value some calculated interference levels are given in the following table:

TABLE I

Wavelength cms	100	30	21	10	3
Bandwidth Hz	10×10^{6}	10×10^{6}	160×10^{6}	160×10^{6}	160×10^{6}
W/M^2	8×10^{-19}	1.6×10^{-17}	1.6×10^{-16}	1×10^{-15}	2×10^{-14}
dB below 1 W/M^2	-181 db	-168 dB	-158 dB	-150 dB	-137 dB
Jansky	8	165	100	632	13000
$dB/W/M^2/Hz$	-250	-238	-240	-232	-220

These numbers are not precise and probably Thompson's approach is more applicable to the VLA with its larger number of baselines. Nevertheless they are probably good enough for "ball park" figures.
As other days are added, the effect of the interference is diminished, but not by a large factor. For example: after 11 days the full 1.5km baseline is covered and hence the average spacing is about 750m, so that the tolerable interference level can be increased by $\sqrt{\frac{750}{600}}$ -not a large factor. [This factor only covers a range of about 8-9 in any case for spacings from 20m to 1500m.] A conservative approach might be to accept the interference level for a one day observation rather than the possible higher level for several days' combined results.

An alternative calculation for the interference levels is based on the effect of interference to a single Fourier spacing produced by a pair of antennas. For this one assumes a source of interference equidistant to the two antennas of a single baseline. The baseline tracks a field at declination δ - the tracking phase will therefore be imposed on the interference - we will have, at the correlator, a signal of phase

$$\phi = -2\pi\frac{L}{\lambda}\sin H\cos\delta$$

where L = distance between antenna elements and H = hour angle. If we were to sample the (u,v) plane at very fine intervals, then FT to obtain a map, we would see, for the interfering signal:

$$u = \frac{L}{\lambda}\cos H$$

$$v = \frac{L}{\lambda}\sin H\,\mathrm{cosec}\,\delta$$

$$f_i(u,v) = S_i e^{-j2\pi\frac{L}{\lambda}\cos\delta\sin H}$$

where S_i is its amplitude.

$$F(x,y) = \int f(u,v)\, e^{j2\pi(xu+yv)}\, du\, dv \quad .$$

Since circular symmetry obtains in the (u,v) plane, transform to (R,H): $(R = \frac{L}{\lambda})$.

$$F(x,y) = \int f(R,H)\, R\, e^{j2\pi R(x \cos H + y \sin H)},\, dRdH$$

To simplify the algebra, put x = 0 (we know the interference will show up as mighty E-W ridges - it's the amplitude that's the question).

$$F(o,y) = \int f(R)\, e^{-j2\pi R \cos\delta \sin H}\; e^{j2\pi R\, y \sin H} dHdR$$

$$= \int f(R) \exp j\, [2\pi R(y-\cos\delta) \sin H]\, dHdR$$

$$= S_i \times 2\pi R\Delta R\, J_0[2\pi R(y-\cos\delta)] \quad .$$

Since R is large we can use the approximation for J_0, and pick out the peak:

$$F_{(max)} \sim \frac{2\pi R\Delta R}{\sqrt{2\pi R \cos\delta}} \times S_i \quad .$$

A point source at the field centre would have $\phi = 0$ and $F(o,o) = 2\pi R\Delta R \times S_S$.

Thus the interference is reduced, compared to a point source in the ratio

$$\frac{1}{\sqrt{2\pi \left[\frac{L}{\lambda}\right] \cos\delta}}$$

4.2 The 12 hour sensitivity:

The conversion between temperature and flux at 1 metre wavelength is found from:

$$KT = G \frac{\lambda^2}{4\pi} \times 10^{-26}: \quad \text{or } T = G \times 5.76 \times 10^{-5} \text{ K/Jy}$$

where G is the main beam power gain.

The noise level is given by

$$\Delta T_{rms} = \frac{50}{\sqrt{6.6 \times 10^6 \times 12 hr}} = 10^{-4} \text{ K}$$

where T_S = 50K, B = 6.6 MHz, etc.

Therefore RMS noise is approx. $\frac{1.63}{G}$ Jy.

$$\left[= \frac{T_{sys}}{\sqrt{B\tau}} \cdot K = \frac{T_{sys}}{\sqrt{B\tau}} \cdot \frac{4}{\lambda^2} \cdot \frac{k}{G \times 10^{-26}} \text{ Jy} \right]$$

The criterion we adopted was for interference level Si to be one tenth of rms noise, i.e. Si = $\frac{0.16}{G}$ Jy. Now assuming that the interference comes in mainly through sidelobes, it can be greater than the above by the ratio of the main beam gain G to the sidelobe level which we will take as 0 dB_i. So

$$S_i = 0.16 \text{ Jy}$$

$\frac{L}{\lambda}$ ranges from 20 - 6000 for the compact array at λ = 1 m. At $\delta = -45^o$ this leads to a reduction factor of $\frac{0.47}{\sqrt{20}}$ to $\frac{0.47}{\sqrt{6000}}$ or 0.11 to 0.006 and hence interfering flux limits of $\simeq$ 1 to 16 Jy.

Thus for a simple 2 element interferometer, the level of interference which can be tolerated in 12 hours is of the same order as calculated previously using Thompson's approach for the 1.5km array at 1m wavelength.

It is worth noting that, as pointed out by Thompson, the interference produces bands largely in an east-west direction. Although this result is for a 12 hour synthesis, in fact the damage is done at the start and end - probably half an hour or so at start and finish - with the rest of the time spent reducing the impact of the interference.

It is perhaps not surprising therefore that the level of tolerable interference in a 10 second period is not very different from the 12 hour value. For example, let us calculate the level of interference which is one tenth the noise level in a period corresponding to one integration period - namely 10 seconds. In this case Si is increased by $\left[\frac{12x60x60}{10}\right]^{1/2}$ or 64 times, which makes it 64 x 0.16 Jy or 10 Jy and since for short spacings we would not expect any large fringe rotation factor for this short period, 10 Jy is the level of interference which can be tolerated. This is not very different from the 12 hour value.

4.3 <u>The Effect of Confusion</u>

Now at the long wavelength particularly, the noise level is lower than the confusion level so that we might be able to tolerate a higher interference level. Some approximate confusion levels are shown in Table II following:

TABLE II

Spacing	408 MHz			1420 MHz		
	Single dish	Inter-ferometer	Noise level	Single dish	Inter-ferometer	Noise level
60m		300 mJy	after 12 hrs		30 mJy	after 12 hrs
600m		3	10 MHz b/w		0.3-1.0	10 MHz b/w
1200m	1 Jy	0.75	0.54mJy	0.1 Jy	.075-0.26	0.4mJy
6000m		0.03			.003-.01	

The confusion figures given in the table are based on 408 MHz data from Pooley and Ryle (5) and from those given in ATDOC/58/RHF/BJR/PAGS. It is only at spacings < 1000m that the confusion level is sufficiently above the noise level to be able to tolerate higher interference levels. Since maps will rarely be made with short spacings, the reference level should be the noise level - give or take a few dB.

4.4 Relation to Interference Testing System

To relate this now to the measurements of interference reported in AT/15.5/020, there are some different points of view. Firstly, in that document, a value of 10 dBi was taken for the sidelobe level instead of 0 dBi used here and secondly, the reference is taken as the fraction of the total noise power and not the fluctuation level which really is the more relevant. The criterion of 20 dB below noise as used in the VLBA memo number 8 and which was used in AT/15.5 refers of course to the total power since correlated interference signal at each antenna was not considered relevant. This 20 dB level is quite important however, when considering intermodulation and saturation effects in the front ends and seems to be a good conservative figure from that point of view. it gives much higher figures for the levels of interference however, than could be tolerated for synthesis.

In the interference measuring system currently used, we can calculate the equivalent flux density of the receiver system temperature (taken here as 500K). Adopting 14 dB gain for the test antenna as used, S system = 7×10^5 Janskys at 300 MHz ($S = \frac{2KT\ 4\pi}{G\lambda^2}$ Jy). Since the interference is assumed to be narrow band, then the narrower the spectrum analyzer bandwidth, the easier will the signal be seen. So to compare the test system with the calculated damaging interference level, it will be easier to compare watts/m^2 rather than Janskys. This is done in Figure 25 where the power flux from Table I is plotted together with the test receiver noise level in similar units for the two bandwidths used, 100 kHz and 300 kHz. The test system is clearly not good enough to detect the interference levels as calculated in the first section - by about 10-20 dB. If confusion is the reference level then at least for the close spacings the test system would be adequate. Also plotted are the tolerable interference levels for single dishes taken from CCIR Report (6).

Of course for line observations the interference levels which can be tolerated have to be lower by $\sqrt{\frac{B}{B_{line}}}$ which at 300 MHz is $\sqrt{\frac{10x10^6}{600}}$, or a factor of 21 dB. At higher frequencies the factor is 32 dB.

4.5 Continuum Interference

Broadband interference of the type from Woodlawn mine (ASTDOC/58/RHF/BJR/PAGS) falls into this category. The level of tolerable interference for broadband interference is given by the last line in Table I - assuming there are no decorrelaton effects due to delay differences. These numbers can be compared to the values which can be calculated by the approach used in ASTDOC/58. The reduction, R, is the combined effect of (a) the reduction due to the fact that the interference is in a sidelobe, not the main beam; (b) the reduction in the grating response as the source moves further away from the pole; and (c) the grating ring is reduced by smearing of the ring due to the finite bandwidth. Values for broadband interference calculated this way are given in Table III. These numbers are different from those in ASTDOC/58 since they use the up-to-date values for main beam gain for the AT and 0 dBi as the sidelobe level (7).

TABLE III

Baseline	300 MHz		1400 MHz					
metres	10 MHz B/W		10 MHz		50 MHz		160 MHz	
	R(dB)	Si(dB)	R(dB)	Si(dB)	R(dB)	Si(dB)	R(dB)	Si(dB)
60	53	-250	62	-241	70	-233	74	-229
600	58	-245	77	-226	85	-218	89	-214
1200	63	-240	81	-222	89	-214	94	-209
6000	73	-230	92	-210	100	-203	104	-199

The tolerable interference level Si is based on one tenth the noise level or about 0.05 mJy (from Table II)(-43 dB below 1 Jy) i.e., for a reduction of 53 dB the level Si is -260-43+53 = -250 dB below 1 Jy. Figure 26 shows the range of tolerable interference levels for continuum interference between the two extreme baselines, together with the noise level of the interference measuring system. (It might be possible to detect signals which are less than the noise level in this system.)

5.0 CONCLUSION

It is clear that using the criterion chosen here of one tenth rms noise, the test receiver system cannot detect the level corresponding to the allowable interference, neither for continuum nor narrowband signals. It falls short on the low frequencies by about 20 dB. So ANY signals seen on the measuring system in the operating band can be considered as potentially harmful. how bad a threat they are would have to be determined carefully in each case; The obvious safe strategy is to choose an operating band in which there are no known (listed) transmitters within some tens of kilometres. If this is impossible and the transmitter cannot be seen on the test system, it could be worth while trying to increase the sensitivity of the measuring system to measure the field strength. The actual effect on the array will not be known however, until it is all finally put together. Provided the signal level is small, then there is a good chance that it could be filtered successfully if really necessary. In the event that an unknown (not listed) strong signal is detected which is in the operating band, the only recourse we have is to identify it and hopefully have it switched off! The plot of positions and strengths of all known transmitters is therefore of great value in trying to decide on a clear operating band.

Whilst the actual numbers calculated in Section C are obviously of limited precision, they should form a useful quantity against which measured interference can be gauged, always remembering that it might be possible to operate with higher levels than one tenth the rms noise, particularly for long baseline observations.

NARROW BAND INTERFERENCE

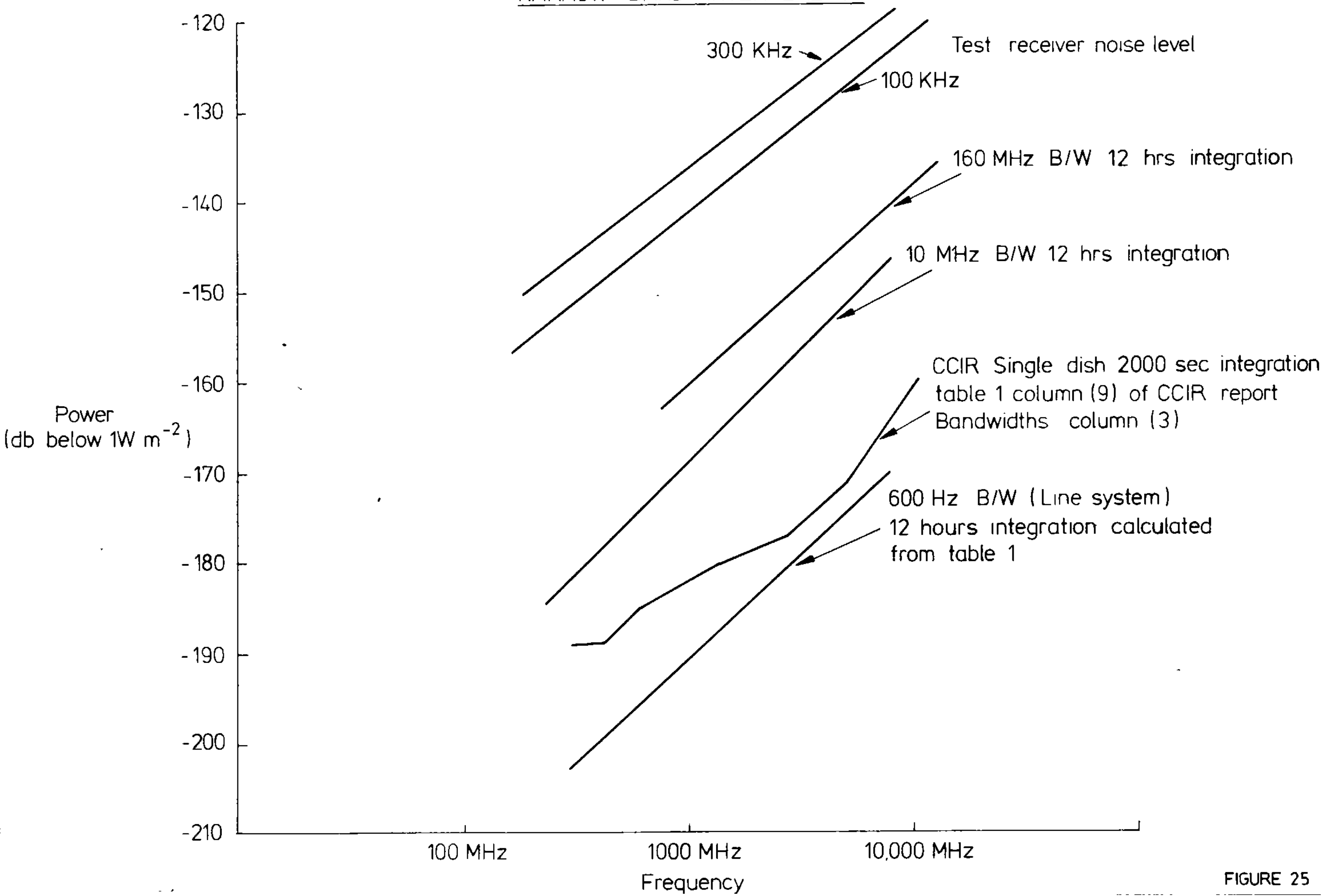


FIGURE 25

CONTINUUM INTERFERENCE

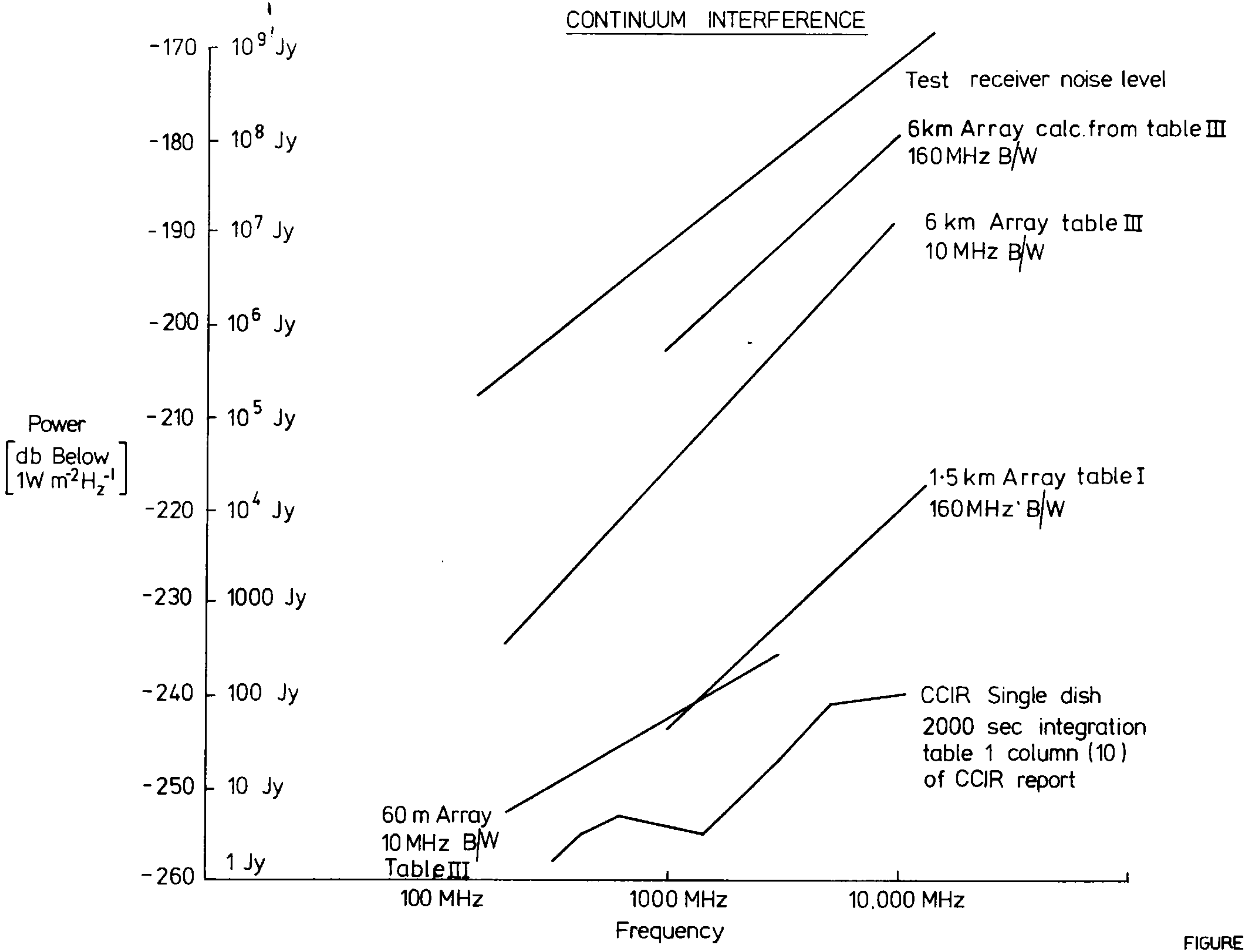


FIGURE 26

6.0 SUMMARY AND RECOMMENDATIONS

Given the lack of sensitivity of our measuring equipment the following points can still be made (see Table IV for summary of test results).

1. From the absolute number and geographic location of radio transmitters relative to our AT sites, it would appear unrealistic to expect to obtain high bandwidths (>15 MHz); further, at least initially, we should concentrate on the radio astronomy bands afforded some degree of protection (see table IV).

2. From Figs 1-3 the 300 MHz region is least polluted with radio transmitters in NSW, therefore our first choice would be the low frequency band 322.0-328.6 MHz). The unidentified source (Siding Spring site only) at 326.0 MHz would need to be more fully identified and removed. Recent suggestions that the Army might utilize the Pilliga region (located between Siding Spring and Culgoora) as a military practice area might affect this choice dramatically. Note that military bands include the 240-320 MHz region!!

3. The 841-845 MHz band also appears quite usable for the same reasons.

4. The 600 MHz band, because of its allocation to mobile and military use, is difficult to assess, particularly with regard to future changes in the electromagnetic environment that may occur in this band.

5. Suppression of strong out-of-band sources to decrease intermodulation etc. problems will also need to be looked into for all AT low frequency receivers.

TABLE IV

Suggested AT operating band (MHz)	Comments: Culgoora	Siding Spring	Parkes
322-328.6	-	326.0 MHZ (-76 dBm)	- (strong source at 320.5 MHz)
406.1-410	- (strong sources at 413.5,415.5)	406.5 MHz (-65dBm) 409.1 MHz (-84dBm) (strong sources at 403.5, 405.5,406.0, 410.8,412.7,412.9, 413.5,415.5 and 419.5 MHz)	-
608-614	-	613.3 MHz (-84 dBm)	-
841-845	-	- (strong source at 839.9 MHz)	-

7.0 REFERENCES

1. AT/15.2/020 - "AT Interference Survey No. 2"

2. A.R. Thompson: "The Response of a Radio Astronomy Synthesis Array to Interfering Signals", IEE Transactions on Antennas and Propagation, Vol. , AP-30, No. 3, May 1982

3. ASTDOC58/RHF/BJR/PAGS - 12FEB81: "Asessment of Potential Interference from mining Operations near Parkes"

4. AT/10.1/036 and AT/17.2/003: "A Configuration for the AT Compact Array"

5. G.G. Pooley and M. Ryle: "The Extension of the Number-Flux Density Relation for Radio Sources to Very Small Flux Densities", Mon.Not.R. Astron.Soc. (1968) 139, 515-528

6. Report No. 224-5, CCIR "Interference Protection Criteria for the Radioastronomy Service"

7. AT/21.1.1/045 "Some Revisions and Additions to the Electromagnetic Performance of the AT Dual-Reflector Antenna"

TABLE A

NO.	FREQUENCY (MHz)	TRANSMITTER LOCATION			POWER (W)	USER	
		ZONE	EASTING	NORTHING			
1	317.4	55	662	6065	100	DTA	Cont.
2	317.5	56	257	6262	100	DTA	"
3	317.5	56	331	6244	100	DTA	"
4	319.1	56	295	6558	100	DTA	"
5	319.2	57	417	6646	100	DTA	"
6	319.9	55	683	6301	100	DTA	"
7	319.9	55	661	6067	100	DTA	"
8	322.4	56	475	6978	100	DTA	"
9	328.5	56	257	6262	100	DTA	"
10	328.5	56	331	6244	100	DTA	"
11	329.0	Mobile			10	"	Telecom
12	330.2		Richmond	Air Base	200	DEF	ILS
13	332.595	56	331	6244	20	DTA	"
14	332.6		Fairbairn, ACT		20	DTA	"
15	332.605	56	331	6244	20	DTA	"
16	333.795	56	331	6243	20	DTA	"
17	333.805	56	331	6243	20	DTA	"
18	334.395	56	332	6240	20	DTA	"
19	334.405	56	332	6240	20	DTA	"
20	335.3	Mobile			10	DTA	Comm
21	335.5	56	331	6244	100	DTA	Cont
22	335.6	55	691	6098	100	DTA	Appr
23	338.3	56	442	6627	100	DTA	Cont
24	338.3	56	526	6876	100	DTA	"
25	342.9	56	257	6262	100	DTA	"
26	347.9	56	331	6244	100	DTA	"

TABLE B

NO.	FREQUENCY (MHz)	TRANSMITTER LOCATION ZONE	EASTING	NORTHING	POWER (W)	USER
1	399.968	Satellite				DOS
2	400.05-400.15	Satellite				CSIRO
3	401.1	Sydney	Balloon		5mW	Macquarie Uni.
4	401.575	Aust.wide	Radiosonde		350mW	MET
5	"	Brisbane		"	350mW	"
6	"	Mascot		"	"	"
7	"	Williamtown		"	"	"
8	"	Cobar		"	"	"
9	"	Moree		"	"	"
10	"	Wagga		"	"	"
11	"	Nowra		"	"	DEF
12	"	55 Canberra	590	6092	"	CSIRO
13	"	55	590	6461	100mW	"
14	401.6	NSW wide			5mW	Elec. Comm.
15	401.65	55	677	6083	3	DOS
16	403	Mobile	NSW wide		350mW	CSIRO
17	403.05	55	289	6762	27mW	Agric.
18	403.06	55	289	6762	"	"
19	403.07	"	"	"	"	"
20	403.075	56	319	6248	?	Rail SRA
21	403.08	55	289	6762	27mW	Agric.
22	403.09	"	"	"	"	"
23	403.1	Aust. wide			5	CSIRO
24	403.1	55	289	6762	27mW	Agric.
25	403.11	55	289	6762	27mW	Agric.
	403.12	"	"	"	"	"
	403.13	"	"	"	"	"
	403.14	"	"	"	"	"
26	403.15	Sydney	Radiosonde		3mW	U of S
27	403.4	Mobile			?	Rail
	403.5					
28	403.5	55	514	6339	10	Tel.
29	403.5	55	670	6149	10	"
30	403.5	54	786	6560	10	"
31	403.5	56	478	6650	10	"
32	403.5	56	265	6729	"	"
33	403.5	55	534	6112	"	"

TABLE . B

	NO.	FREQUENCY (MHz)	TRANSMITTER LOCATION			POWER (W)	USER
			ZONE	EASTING	NORTHING		
	34	403.5	55	631	6590	10	Tel.
	35	403.525	Mobile				Rail
	36	403.525	56	373	6399	8.3	Water
	37	403.55	Mobile				Rail
	38	403.55	54	516	6454	10	Tel
	39	404	56	383	6447	10	DTA
	40	404	55	774	6251	20	DTA
	41	404	56	442	6627	10	DTA
	42	404.05	56	512	6690	1	Shire Council
	43	404.05	56	542	6779	1	Tel
	44	404.05	55	524	6122	1	Grain Auth.
arkes	45	404.05	55	613	6328	8.3	" "
	46	404.075	55	660	6015	8.3	Police
	47	404.075	55	625	6021	"	"
	48	404.075	55	655	6253	1	Grain Auth.
	49	404.075	55	649	5970	8.3	Police
	50	404.075	55	707	6041	"	"
	51	404.075	55	686	5986	"	"
	52	404.075	55	460	6156	1	Grain Auth.
	53	404.1	55	356	6191	8.3	Health Comm.
	54	404.125	56	279	6283	10	Prospect C/C
	55	404.2	55	356	6191	1	Police
	56	404.25	55	652	6431	1	Grain Auth.
	57	404.25	56	470	6532	1	Elec.
	58	404.25	55	549	6187	1	Grain Auth.
	59	404.3	55	587	6172	5	Priv.
oona	60	404.3	55	717	6538	1	Grain Auth.
	61	404.3	55	652	6431	1	" "
	62	404.3	55	519	6245	1	" "
	63	404.3	56	398	6953	8.3	TV link
	64	404.325	55	442	6315	1	Police
	65	404.425	55	591	6040	1	Forests/Shire
	66	404.475	56	280	6141	1	Health Comm.
	67	404.475	56	263	6181	1	Ambulance
	68	404.475	55	316	6065	5	"
	69	404.475	56	303	6191	1	"
	70	404.5	54	630	6272	10	Tel
	71	404.5	56	303	6191	8.3	Ambulance

TABLE B

NO.	FREQUENCY (MHz)	TRANSMITTER LOCATION			POWER (W)	USER
		ZONE	EASTING	NORTHING		
72	404.5	55	636	6099	8.3	Ambulance
73	404.5	55	464	6176	8.3	"
74	404.5	55	735	6654	10	Tel
75	404.7	55	446	6177	1	Shire
76	404.7	55	459	6156	8.3	"
77	404.8	55	763	6541	1	Private
78	404.8125	56	320	6258	15	DEF
79	404.825	56	345	6368	?	Shire
80	404.825	56	329	6396	?	"
81	404.85	56	363	6359	1	Private
82	404.875	56	360	6354	1	"
83	404.875	56	306	6189	1	Tel
84	404.9	54	570	6282	10	Tel
85	404.9	56	363	6360	8.3	Tel
86	404.925	56	363	6359	1	Boral
87	404.95	56	554	6876	1	Private
88	404.95	56	363	6360	1	Tel
89	404.975	55	444	6016	1	Shire
90	404.975	56	363	6357	1	Private
91	404.975	56	306	6189	1	Tel
92	404.985	56	363	6359	1	Private
93	405	Khancoban			15	SMHEA
94	405	55	661	6067	20	DTA
95	405	55	766	6544	1	Private
96	405	56	360	6354	1	"
97	405	56	489	6654	10	Tel
98	405	56	305	6189	1	Ambulance
99	405.025	56	275	6147	1	Private
100	405.025	55	539	6095	1	Shire
101	405.025	56	252	6266	1	Rail
102	405.025	56	363	6359	1	Private
103	405.025	56	291	6230	1	Coal
104	405.025	55	750	5978	1	DMR
105	405.025	56	363	6359	1	Private
106	405.5	56	266	6693	10	Tel
107	405.5	55	398	6671	10	Tel
108	405.5	55	514	6339	10	Tel
109	405.5	55	464	6176	5	Tel

TABLE B

NO.	FREQUENCY (MHz)	TRANSMITTER LOCATION			POWER (W)	USER
		ZONE	EASTING	NORTHING		
110	405.5	56	225	6701	10	Tel
111	405.55	55	655	6680	10	Tel
112	405.55	54	618	6457	10	Tel
113	406	56	268	6295	20	DTA
114	406.5	55	713	5947	10	Tel
115	406.5	55	687	6668	10	"
116	406.5	54	630	6272	10	"
117	406.55	55	591	6129	10	"
118	407.4	56	298	6417	Mobiles	Shire
119	407.4	56	301	6428	1	Shire
120	407.5	55	660	6123	10	Tel
121	407.5	56	469	6643	10	"
122	407.5	56	242	6724	10	"
123	407.5	56	317	6704	10	"
124	407.5	55	464	6176	5	"
125	407.55	54	633	6415	10	"
126	408	54	570	6284	1	"
127	408	56	383	6447	10	DTA
128	408	55	773	6225	20	"
129	408	56	441	6627	10	"
130	408.1	Aust. wide mobile				Rail
131	408.4	"	"	"		"
132	408.7	"	"	"		"
133	409	"	"	"		"
134	409.1875	56	320	6258	15	DEF
135	409.3	Aust. wide mobile				Rail
136	409.5	56	283	6707	10	Tel
137	409.5	56	318	6704	10	Tel
138	409.6	Aust. wide mobile				Rail
139	409.9	"	"	"		"
140	410	56	268	6295	20	DTA
141	410.2	Aust. wide mobile				Rail
142	410.3	55	683	6090	1	Police
143	410.4	"	"	"	1	"
144	410.475	55	693	6083	1	"
145	410.475	55	693	6083	?	"
146	410.5	Aust. wide mobile				Rail
147	410.5	55	713	5947	10	Tel

TABLE B

NO.	FREQUENCY (MHz)	TRANSMITTER LOCATION			POWER (W)	USER
		ZONE	EASTING	NORTHING		
148	410.5	55	748	6699	10	Tel
149	410.525	Aust. wide mobile			8.3	Cars
150	410.525	56	489	6596	10	Tel
151	410.55	54	543	6465	5	Private
152	410.95	56	283	6141	5	"
153	411	56	257	6262	20	DTA
154	411	55	661	6067	20	DTA
155	411.5	Aust. wide				?
156	411.525	56	319	6248	5	SRA
157	411.525	55	627	5975	5	Private
158	411.55	56	329	6230	8.3	SRA
159	411.75	55	496	6013	5	Private
160	412	56	384	6447	20	DTA
161	412.1	Aust. wide				Rail
162	412.35	Mobile			1	Pipeline A&L
163	412.4	Aust. wide mobile				Rail
164	412.425	" " "				"
165	412.5	55	534	6112	5	Tel
166	412.5	56	265	6729	10	"
167	412.525	56	319	6248	5	Rail
168	412.6	Aust. wide Bio-telemetry				CSIRO
169	412.9	Aust. wide mobile				Rail
170	412.975	56	346	6366	1	Water Board
171	412.975	56	383	6413	8.3	"
172	412.975	56	365	6377	8.3	"
173	412.975	56	384	6356	8.3	"
174	413	Aust. wide mobile				Rail
175	413	54	544	6465	10	Tel
176	413	55	633	6574	10	Tel
177	413	56	257	6262	20	DTA
178	413	55	774	6251	20	DTA
179	413	56	665	6067	20	"
180	413	55	427	6659	10	Tel
181	413	55	253	6574	10	"
182	413.5	56	536	6775	1	"
183	413.5	56	228	6646	10	"
184	413.5	54	647	6303	10	"
185	413.5	56	494	6710	1	Shire

TABLE B

NO.	FREQUENCY (MHz)	TRANSMITTER LOCATION			POWER (W)	USER
		ZONE	EASTING	NORTHING		
186	413.5	56	503	6722	1	"
187	413.5	56	312	6299	1	Elec.
188	413.525	55	693	6083	8.3	Police
189	413.525	55	429	6224	1	Grain Auth.
190	413.525	56	283	6285	1	Elec.
191	413.525	55	669	5993	8.3	Police
192	413.525	55	642	6300	1	Grain Auth.
193	413.525	56	280	6534	8.3	" "
194	413.55	55	481	6114	1	" "
195	413.55	55	554	6365	1	" "
196	413.55	56	295	6287	1	Elec.
197	413.55	55	429	6224	8.3	Ambulance
198	413.575	56	399	6287	1	Elec
199	413.6	56	288	6281	1	"
200	413.625	56	292	6279	1	"
201	413.65	55	429	6224	1	Police
202	413.7	55	630	6420	1	Grain Auth.
203	413.7	55	572	6179	50	" "
204	413.7	56	459	6486	1	Elec
205	413.75	55	693	6530	1	Grain Auth.
206	413.75	55	472	6253	1	" "
207	413.775	55	427	6308	1	Police
208	413.875	55	586	6027	1	Shire
209	413.9	55	586	6027	1	Forest Comm.
210	413.925	56	264	6183	1	Ambulance
211	413.925	56	258	6086	8.3	"
212	413.925	55	391	6037	8.3	"
213	413.95	56	278	6146	1	"
214	413.95	55	528	6114	8.3	"
215	413.95	56	278	6146	8.3	"
216	414	55	660	6123	10	Tel
217	414	?	Mt. Berrico		20	DTA
218	414	56	486	6646	10	Tel
219	414	?	Mt Tootie		20	DTA
220	414.2	55	429	6224	8.3	Shire
221	414.25	55	767	6544	1	Private
222	414.3	56	365	6377	1	"

TABLE B

NO.	FREQUENCY (MHz)	TRANSMITTER LOCATION			POWER (W)	USER
		ZONE	EASTING	NORTHING		
223	414.3	56	359	6380	1	Private
224	414.325	56	375	6345	1	"
225	414.325	56	374	6353	1	"
226	414.325	56	288	6166	1	Tel
227	414.325	56	384	6356	1	Private
228	414.35	56	380	6353	8.3	Tel
229	414.35	54	541	6306	10	"
230	414.375	56	375	6343	1	Private
231	414.375	56	383	6357	1	"
232	414.4	56	380	6353	1	Tel
233	414.4	56	552	6830	1	Private
234	414.425	56	375	6343	1	"
235	414.425	56	383	6356	1	"
236	414.425	56	289	6166	1	Tel
237	414.425	56	371	6378	1	Private
238	414.425	55	441	6022	1	Shire
239	414.45	56	346	6365	1	Private
240	414.45	55	768	6544	1	"
241	414.45	56	384	6356	1	"
242	414.45	56	382	6367	1	"
243	414.45	56	305	6188	1	Ambulance
244	414.475	56	383	6357	1	Private
245	414.475	56	248	6267	1	Rail
246	414.475	56	289	6166	1	Tel
247	414.475	56	352	6378	1	Private
248	414.475	56	263	6226	1	"
249	414.475	55	534	6115	1	Shire
250	414.475	55	743	5917	1	DMR
251	414.485	56	383	6356	1	Private
252	414.5	55	517	5799	5	Tel
253	414.5	56	320	6258	1	Def
254	414.5	55	540	6334	10	Tel
255	414.5	56	237	6699	10	Tel
256	415.0	55	646	6664	10	"
257	415.0		Khancoban		15	SMHEA
258	415.0	56	257	6262	20	DTA
259	415.0	55	774	6250	20	DTA
260	415.0	55	427	6659	10	Tel

TABLE B

NO.	FREQUENCY (MHz)	TRANSMITTER LOCATION			POWER (W)	USER
		ZONE	EASTING	NORTHING		
261	415	54	661	6487	10	Tel
262	415.5	56	228	6646	10	"
263	415.5	55	687	5986	10	"
264	415.5	56	486	6646	10	"
265	415.5	54	598	6258	10	"
266	416.0		Mt Berrico		20	DTA
267	416.0	55	582	6146	10	Tel
268	416.0		Point LKT		20	DTA
269	416.5	55	429	6224	5	Tel
270	416.5	55	541	6334	10	"
271	416.5	(56)	(318)	(6704)	10	"
272	416.5	56	237	6699	10	"
273	416.85	56	298	6417	50	Shire
274	417.0	5	Kings Tableland		20	DTA
275	417.0	55	774	6250	20	"
276	417.0		Mt Ginini		20	"
277	417.0	54	624	6366	10	Tel
278	417.5	54	542	6310	1	"
279	418.0	55	647	6127	10	"
280	418.0		Mt Berrico		20	DTA
281	418.0	56	486	6646	10	Tel
282	418.0	56	268	6295	20	DTA
283	418.5	56	237	6699	10	Tel
284	419.0	55	774	6250	20	DTA
285	419.5	55	700	5911	10	Tel
286	419.5	56	228	6646	10	"
287	419.5	56	486	6645	10	"
288	419.8	55	683	6089	1	Police
289	419.9	55	683	6089	1	"
290	419.975	56	492	6590	10	Tel

420-450 MHz is Radar Band

TABLE . C

NO.	FREQUENCY (MHz)	TRANSMITTER LOCATION			POWER (W)	USER
		ZONE	EASTING	NORTHING		
1	830.9875	55	765	6640	5	Shire
2	832.0	55	509	6362	8	Tel
3	832.0	56	291	6280	10	"
4	833.0	55	726	6507	10	"
5	833.0	56	301	6558	10	"
6	835.0	56	291	6280	10	"
7	836.0	56	221	6304	0.1	"
8	836.0	56	227	6299	10	"
9	838.0	56	291	6280	10	"
10	839.0	55	697	6574	10	"
11	839.0	56	301	6558	10	"
12	841.0	56	291	6280	10	"
13	842.0	55	741	6407	10	"
14	844.0	56	291	6280	10	"
15	845.0	55	639	6533	10	"
16	845.0	56	221	6304	0.1	"
17	845.0	56	227	6299	10	"
18	846.0	56	326	6238	8	"
19	847.0	56	320	6297	10	"
20	848.2	56	264	6183	1	Broadcast 2ST
21	849.2	56	343	6302	5	Elec
22	849.4	56	494	6716	5	2GF
23	849.4	55	756	5952	5	2BE
24	849.4	56	269	6183	1	2ST
25	849.4	56	305	6428	5	Tel
26	849.4	56	479	6977	5	"
27	849.6	56	364	6330	5	Elec
28	851.2	55	698	6100	5	Tel
29	851.2	56	380	6353	5	Tel
30	851.2	55	687	6241	5	"
31	851.2	55	778	6360	5	"
32	851.2	56	264	6183	5	"
33	851.2	56	302	6265	5	"
34	851.2	55	534	6112	5	"
35	851.8	56	284	6219	5	"
36	851.8	56	478	6977	5	"
37	852.0	56	246	6286	8	"
38	852.0	55	743	6335	5	"

TABLE C

NO.	FREQUENCY (MHz)	TRANSMITTER LOCATION			POWER (W)	USER
		ZONE	EASTING	NORTHING		
39	852.4	55	689	6083	5	Tel
40	852.8	56	244	6266	10	Tel
41	853.0	55	692	6089	5	"
42	853.0	56	267	6223	5	"
43	853.0	56	264	6183	5	"
44	853.0	56	363	6360	5	"
45	853.2	56	280	6138	5	"
46	854.0	56	384	6446	3.5	Rail
47	854.0	56	513	6647	3.5	"
48	854.0	55	638	6418	5	Tel
49	854.0	56	383	6414	3.5	Rail
50	854.0	56	421	6468	3.5	"
51	854.0	56	493	6715	8	"
52	854.0	56	211	6717	8	"
53	854.0	56	255	6487	10	"
54	854.0	55	740	6407	10	"
55	854.0	56	400	6745	8	"
56	854.0	56	492	6591	3.5	Rail
57	854.0	56	281	6138	8	Tel
58	854.0	55	717	6020	10	"
59	854.0	56	221	6304	0.1	"
60	854.0	55	577	6718	8	"
61	854.0	56	481	6535	3.5	Rail
62	854.0	56	501	6675	3.5	"
63	854.0	56	227	6299	10	Tel
64	854.0	56	339	6248	5	"
65	855.0	56	300	6201	5	Private
66	855.0	55	743	6332	8	Tel

317.4-342.9 MHz RA BAND

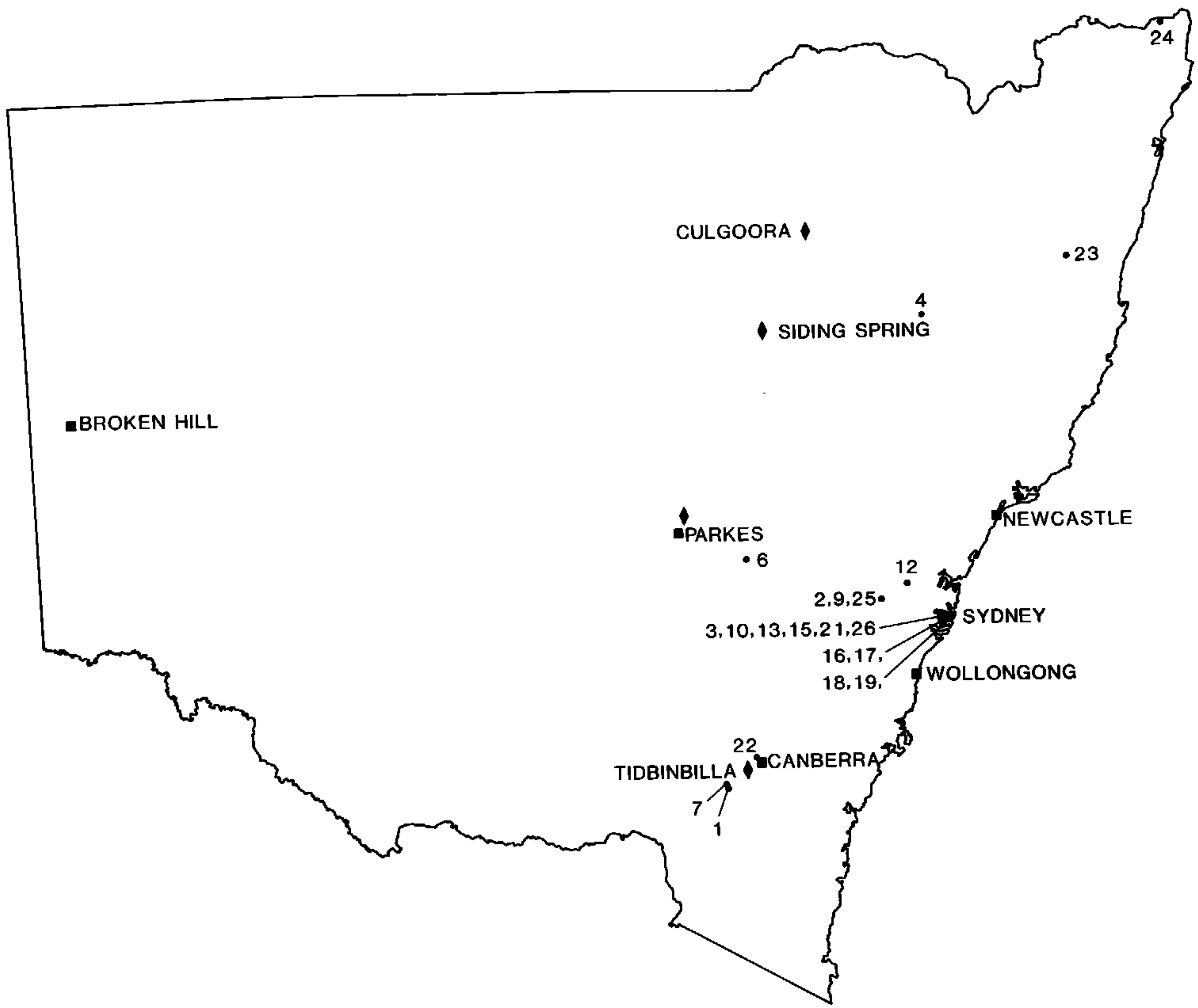
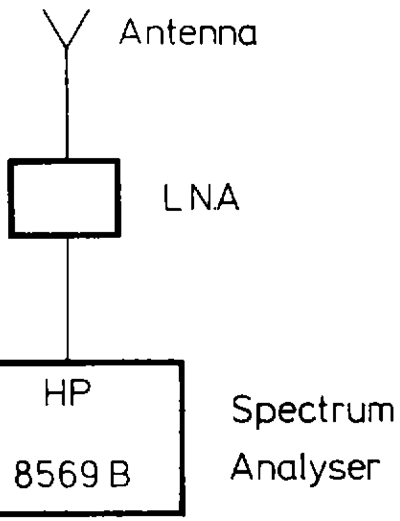


FIGURE 1

INTERFERENCE MEASUREMENT RECEIVER SCHEMATIC



Frequency	Antenna			L.N.A.	
(MHz)	Type	Gain (db)	HPBW	Type	Gain (db)
327	YAG1	14	30°	Miteq	35
410	YAG1	14	30°	Miteq	35
625	HELIX	11	36°	Miteq	35
843	HELIX	11	36°	Miteq	35
* 1420	HORN	17	24°	Miteq	35

* Only used for Parkes Site

FIGURE 4

830.987 MHz-855.0 MHz

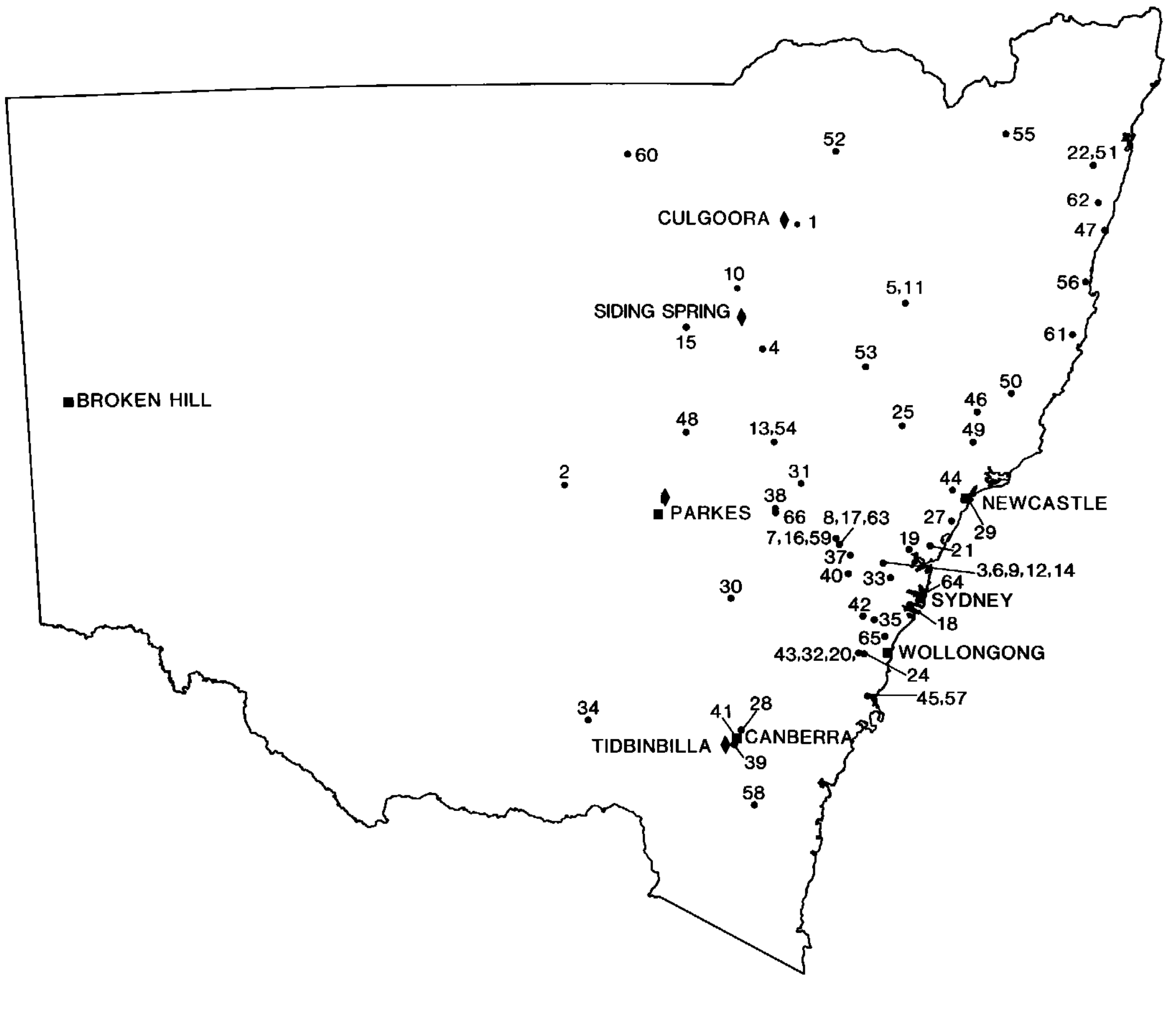


FIGURE 3

401.1 MHz -419.975 MHz

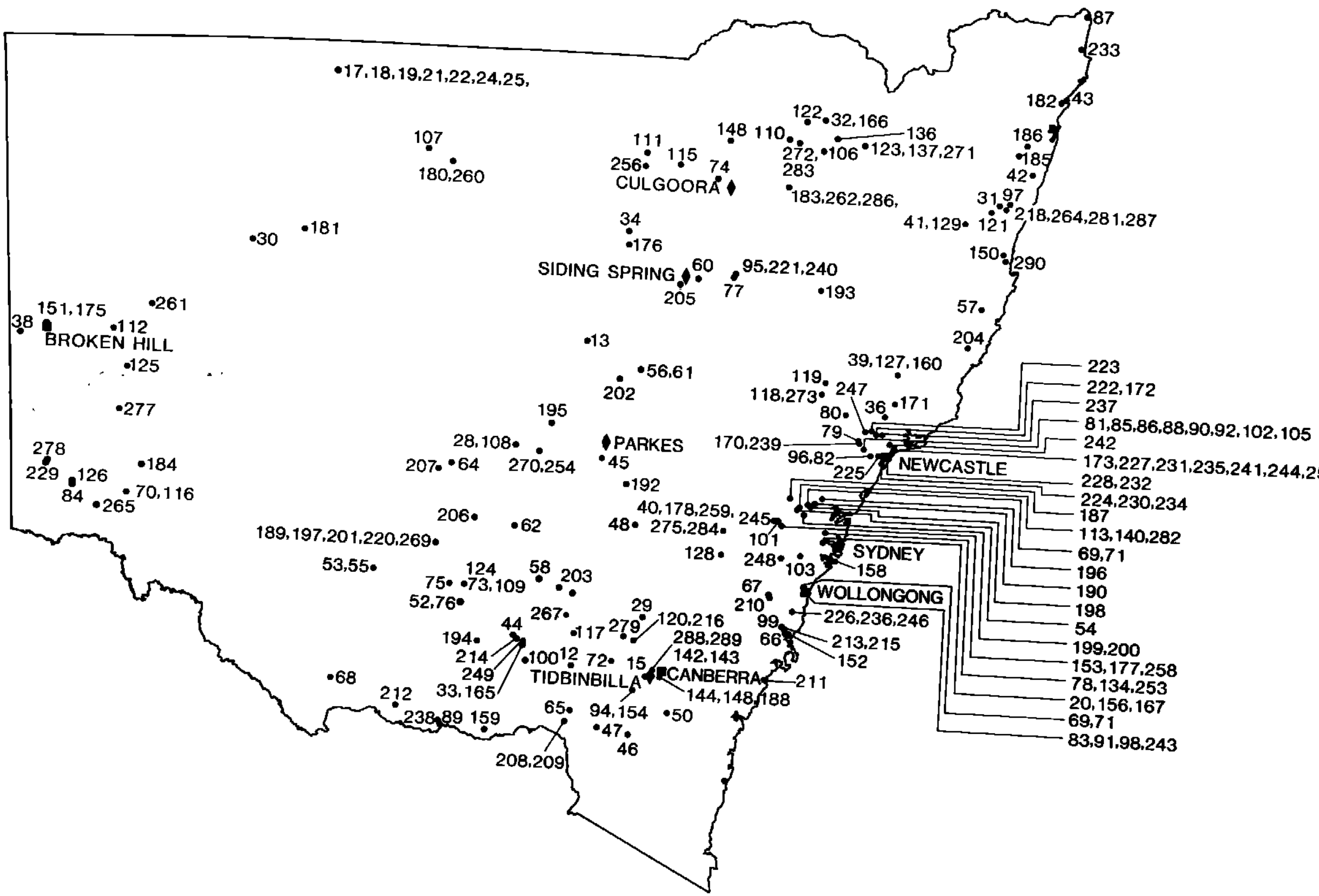


FIGURE 2