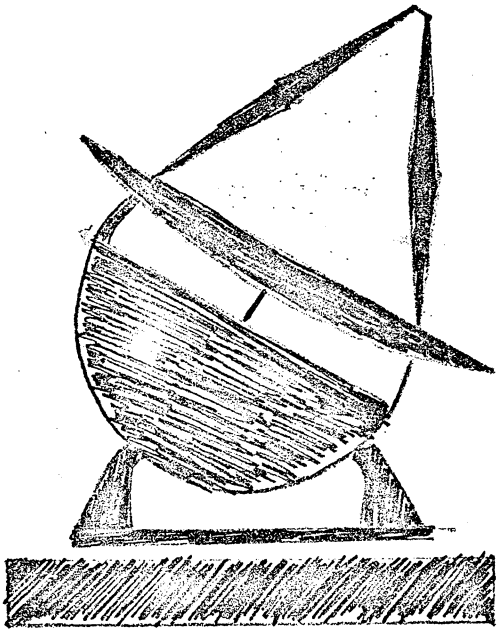
NATIONAL RADIO ASTRONOMY OBSERVATORY
GREEN BANK, WEST VIRGINIA

THE REBER DISH FOR RECEIVING 432 MHz AMATEUR EME SIGNALS



EDWARD TEYSSIER
WA6LCZ

SEPTEMBER 10, 1975

THE REBER DISH FOR RECEIVING 432 MHz AMATEUR EME SIGNALS

Edward Teyssier

Introduction:

These brief notes explain the method I used to hear 432 MHz EME (Earth-Moon-Earth) signals from amateur radio operators. While writing these notes I am also packing my things to return to California. Therefore, I must be brief, and small errors and omissions may be present. I hope these will be overlooked. In spite of what may be missing, it is hoped that sufficient information may be found here to enable others who are interested in moonbounce to attempt a similar set up. K2UYH was clearly heard on September 1, 1975, demonstrating that good results are possible using this set up. (See also C. Dunkle's file on the Reber Dish.)

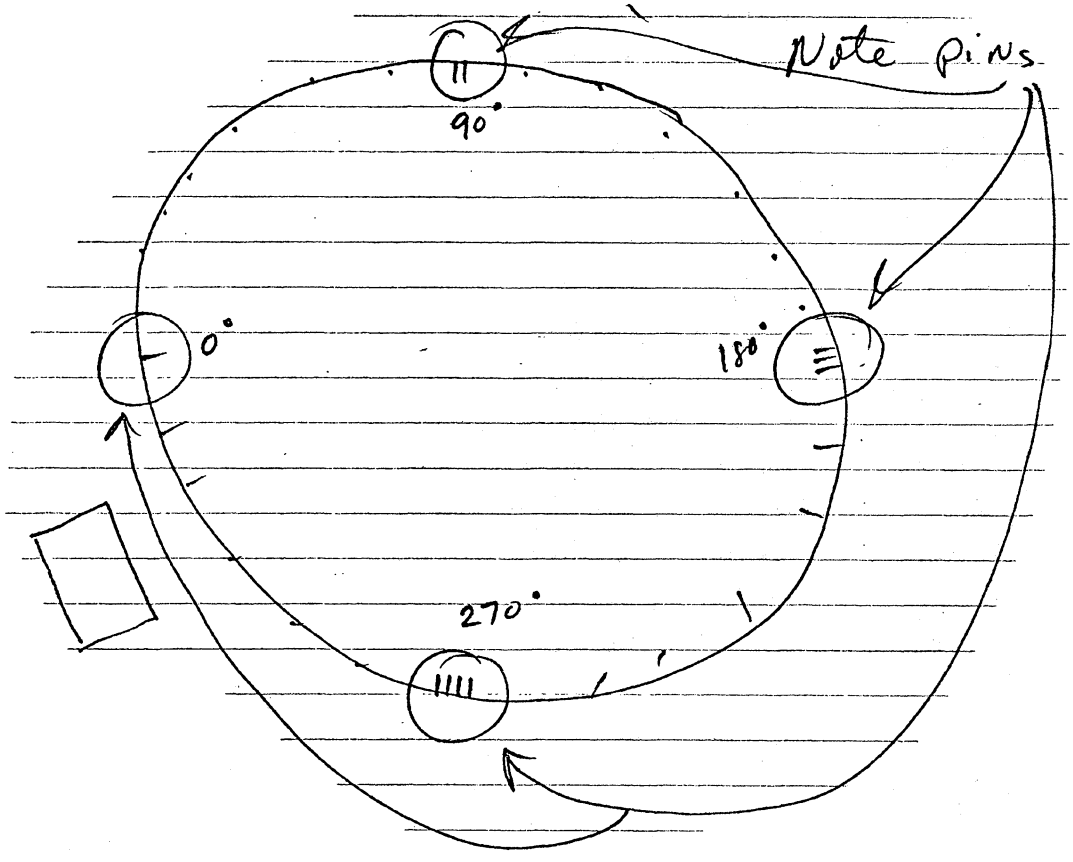
Problems:

There are several problems that must be overcome. I shall explain the problems and then provide the solutions that I used.

1. A low-noise front-end. The total receiver noise figure must be under $\sim$ 2 dB. This is a number usually found in the ham literature and is based on a typical station that has $\sim$ 500 watts at the antenna output on transmitter and an antenna that has about 25 dBi of gain. In other words, a ham who already has a station with these specifications could easily hear echos with a 2 dB noise figure receiver. The receiver preamps should be mounted at the feed.
2. An antenna. One that rotates in elevation and azimuth and is trackable.
3. A feed. A 10 dB edge taper would be optimum.
4. Method to calculate position of moon. For overcast nights.

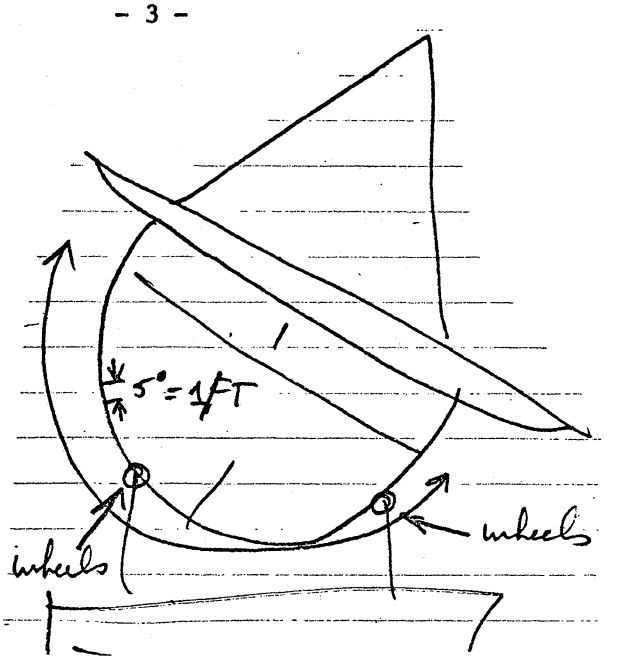
Solutions:

1. I already had 2 preamps, each with N.E.C. 2N5651 transistors, so this problem was easy. These 2 preamps and converter produced a total system noise figure of 1.8 dB.
2. The Reber dish was used.



Azimuth tracking: There is a switch under one of the wheels that at one time was used to hit a pin, or pins, every 10°. When the switch hit one of these pins a bell would go off. This bell system no longer works, but the pins are still there and by noting where the switch is, and which pin it will hit next gives azimuth tracking.

Elevation:



Around the circumference of the supporting hub that is used to carry the weight of the dish on trolley wheels, 1 foot of hub circumference is equal to 4.98° or approximately 5.0°.

There is a pointer on the rotating table that points at this circumference. By painting a spot every 1 foot on the hub, elevation can be read.

Feed:

I used the NRAO crossed dipole for 250-500 MHz that is associated with the antenna test range. I mounted that on a 27 3/4" square front-end front plate and put a cavity around it. Pattern plots are included in this report.

Circular polarization was used with the 90° hybrid coupler that comes with the dipole. Use the input port on the coupler. A 50 ohm load was placed on the isolation port. Final SWR was: $\sim$ 1.1/1. Edge for this F/D is at $\sim$ 4.4°, so feed is not optimum.

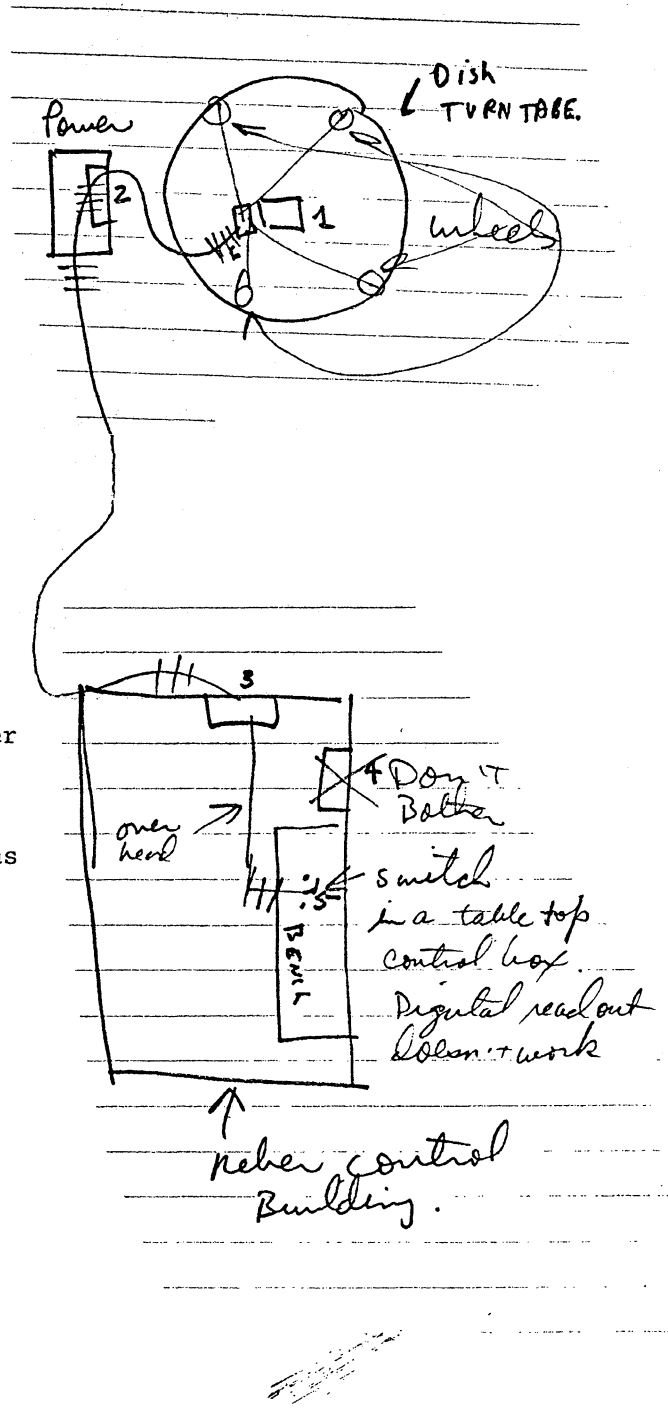
This assembly was then mounted as close the apex of the feed support arms as possible. Wire was used to tie everything in place.

Feed line was RG-9/U to the big box under the dish. From there a connection was made to a cable that went to the Reber control room. Power for the preamps was in a piece of stranded, insulated, #18 gauge wire that also made a connection to a wire in the box under the dish.

To get to the focus: Use scaffolding found in the machinists' yard. The feed is easy to reach from the top of the 3rd layer (18') when the dish is tilted way over.

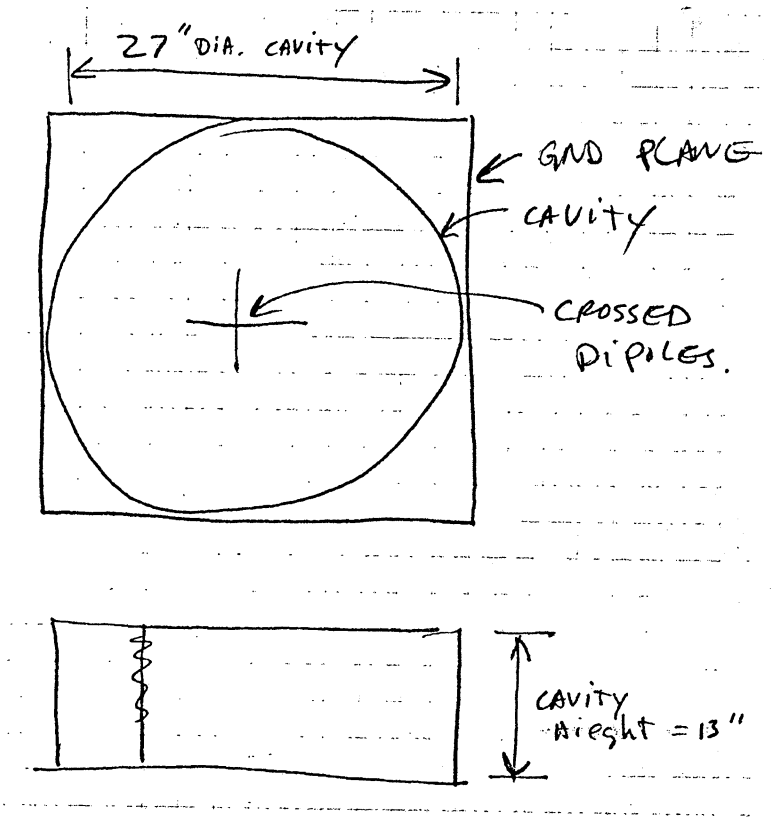
How to turn the dish:

1. Turn on power in box 2.
2. Be sure that unit in lower left hand side of box 2 is getting power. This unit is switched remotely by cables (3) from the Reber control room.
3. Go to Reber control room. The 3 wires that terminate there can control azimuth. Black-white is one direction. Black-green is the other direction.

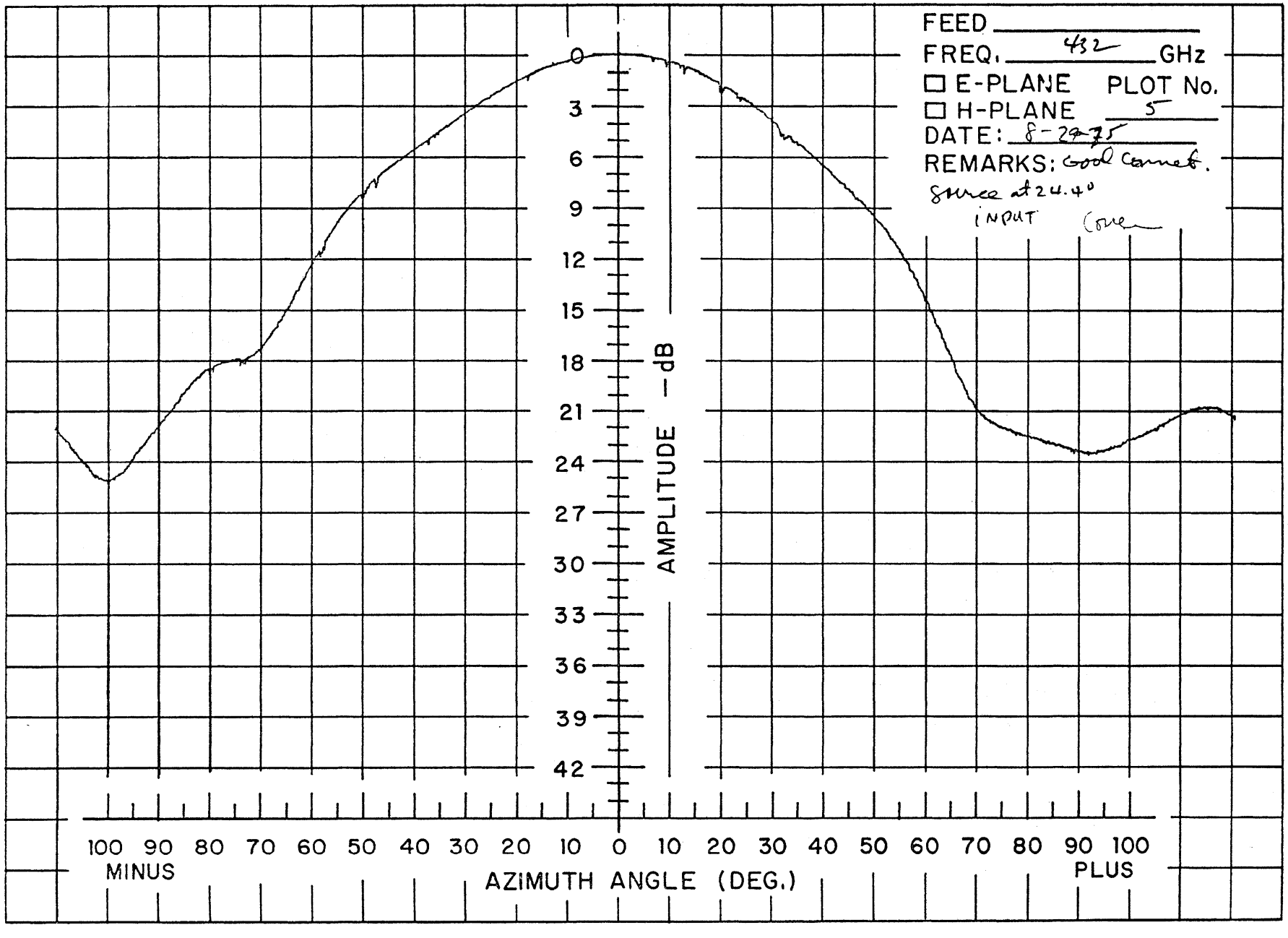


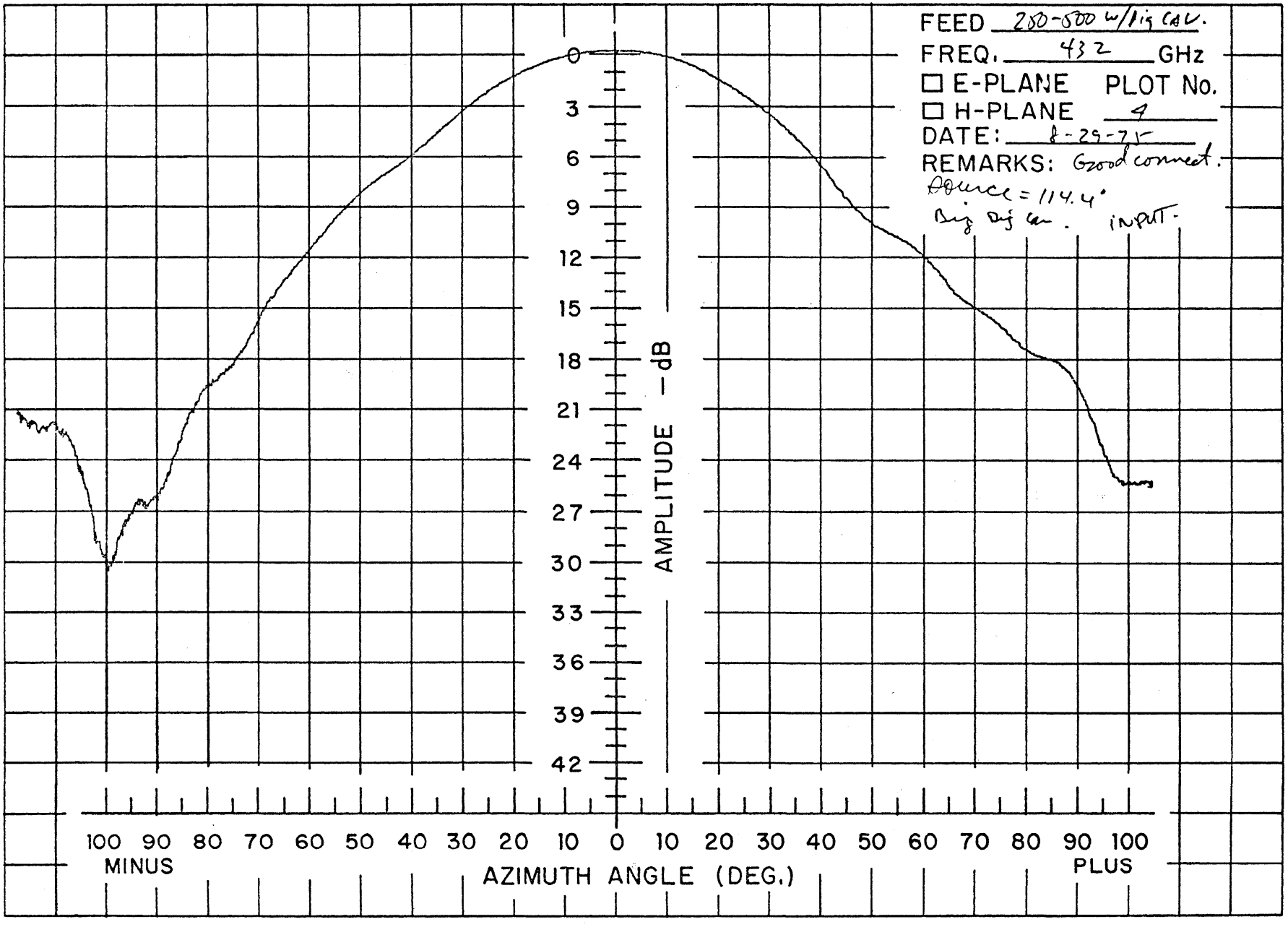
Note: Be sure dish is secured whenever leaving it for a long period of time. The dish blew over in winter of 1972 (?) and was very expensive to repair.

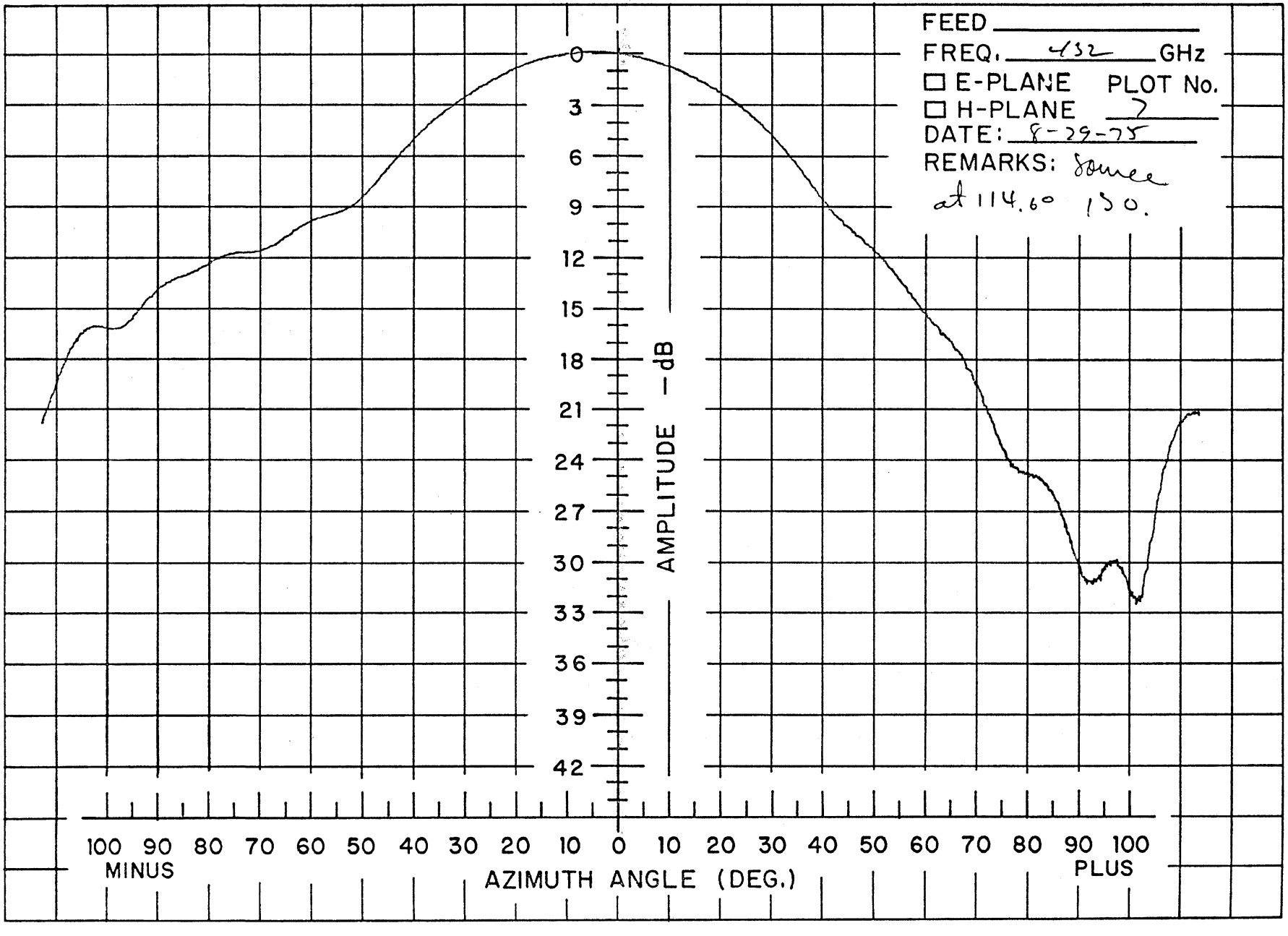
Feed dimensions were as follows:

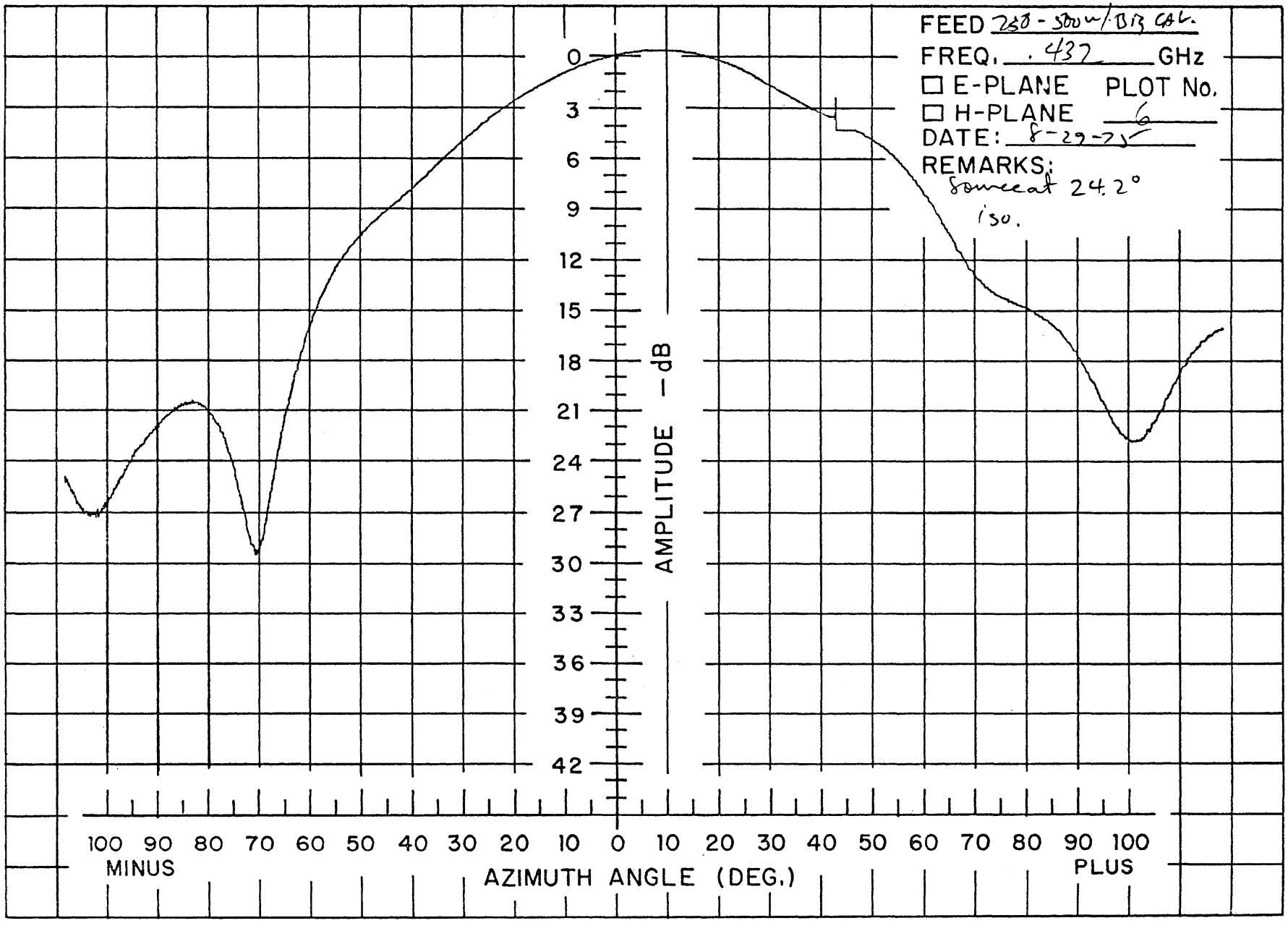


A better edge taper would probably be accomplished by a deeper cavity.


FEED
FREQ. 4.32 GHz
☐ E-PLANE PLOT No. 5
☐ H-PLANE
DATE: 8-29-75
REMARKS: Good Corrects.
Source at 24.4°
INPUT
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
AMPLITUDE — dB
100 90 80 70 60 50 40 30 20 10 0 10 20 30 40 50 60 70 80 90 100
MINUS
AZIMUTH ANGLE (DEG.)
PLUS


FEED 280-500 w/big CAL.
FREQ. 432 GHz
☐ E-PLANE PLOT No.
☐ H-PLANE 4
DATE: 8-29-75
REMARKS: Good connect.
Source = 114.4°
Big Dig Cal. INPUT.
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
AMPLITUDE — dB
100 90 80 70 60 50 40 30 20 10 0 10 20 30 40 50 60 70 80 90 100
MINUS
AZIMUTH ANGLE (DEG.)
PLUS


FEED
FREQ. 4.32 GHz
☐ E-PLANE PLOT No.
☐ H-PLANE 7
DATE: 8-29-75
REMARKS: Source at 114.60 150.
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
AMPLITUDE — dB
100 90 80 70 60 50 40 30 20 10 0 10 20 30 40 50 60 70 80 90 100
MINUS
AZIMUTH ANGLE (DEG.)
PLUS

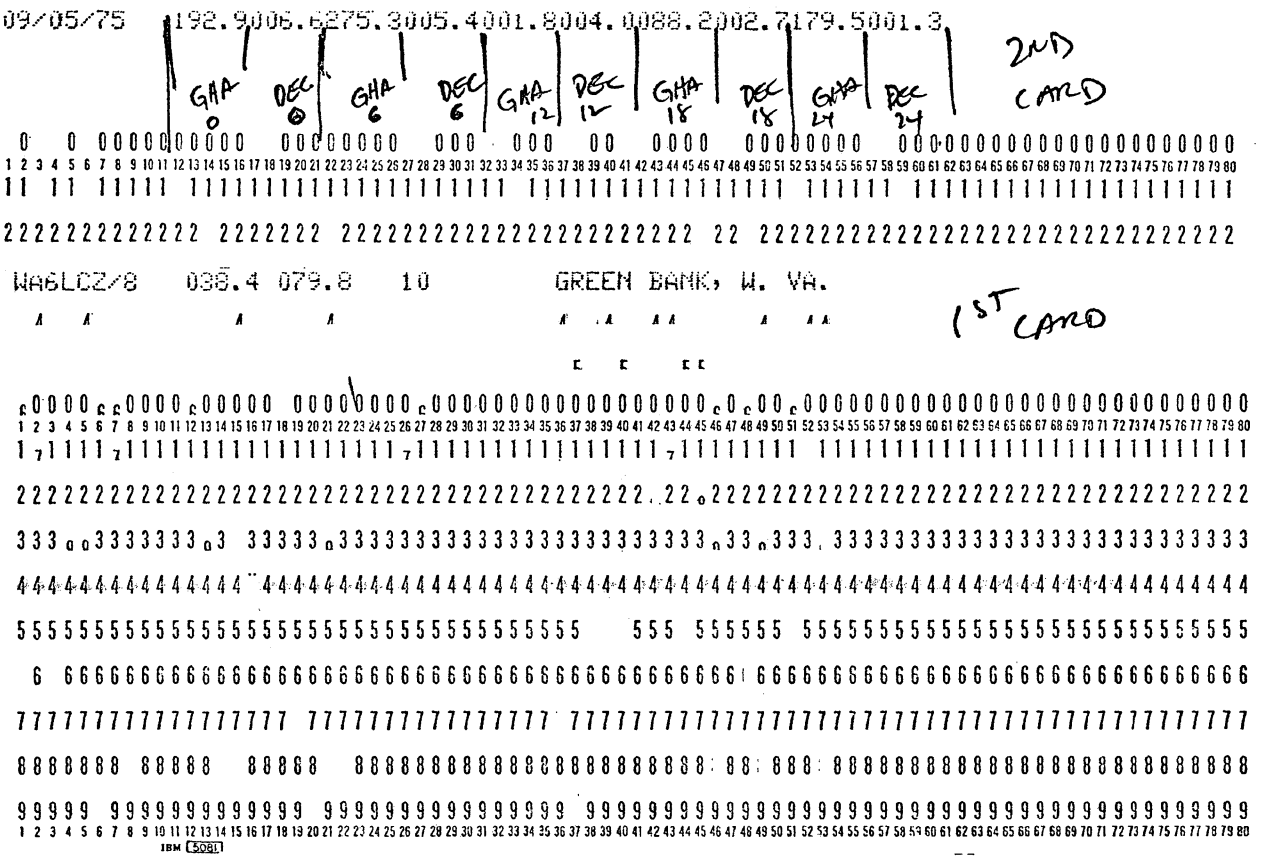

FEED 250 - 300w/BIG CAL.
FREQ. .437 GHz
☐ E-PLANE PLOT No. 6
☐ H-PLANE
DATE: 8-29-75
REMARKS:
Sourceat 24.2°
iso.
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
AMPLITUDE —dB
100 90 80 70 60 50 40 30 20 10 0 10 20 30 40 50 60 70 80 90 100
MINUS
AZIMUTH ANGLE (DEG.)
PLUS

Program Moon: How to locate the moon.

INPUT DATA: 2 cards for each day moon data ia desired.

Card #1

Column	Data	Example
1-8	Call sign	WA6LCZ/8
9-11	Blank	
12-16	Latitute in F5.1 format (degrees)	038.4
17	Blank	
18-22	Longitude in F5.1 format (degrees)	079.8
23-25	Blank	
27-27	Increment time in I2 Format (in minutes)	10
30-80	Any comment. Will be printed with output.	Green Bank, WV
Card #2		
1-8	Date	09/05/75
9-11	Blank	
12-61	GHZ (Greenwich Hour Angle) and declination of the moon for 0000 hours 0600 hours 1200 hours 1800 hours 2400 hours Data is 5 (2F5.1) and in degrees	On 09/05/75 at 0000 hours GMT: GHA Dec. 192.9° 6.6° At 0600 Hr GMT: 275.3° 5.4° At 1200 Hr GMT: 1.8° 4.0° etc.



Examples of Data Cards

```
0001                  DIMENSION X(2,6) ,COMENT(13)
0002                   REAL*8 OBSER ,DATE
0003                5  READ(5,1,END=303)OBSER,BLAT,BLONG,INTER,COMENT,DATE,
                      C(X(I,I),X(2,I),I=1,5)
0004                1  FORMAT( A8,3X,2(F5.2,1X),2X,I2,13A4,/,A8,3X,5(2F5.1))
0005                   ITIME=0
0006                   HOUR=0
0007                   JTIME=0
0008                   M=1
0009                   JB=1
0010                   JC=1
0011                   JD=1
0012                   JE=1
0013                   HTEST=600
0014                   PI=3.1415926
0015                   CONVT=PI/180.0
0016                   CONVTR=1.0/CONVT
0017                   CLAT=BLAT*CONVT
0018                   CSINL=SIN(CLAT)
0019                   CCOSL=COS(CLAT)
0020                   CTANL= CSINL/CCOSL
0021                   R1=BLONG+180.0
0022                   R2=BLONG-180.0
0023                   IF(R1.GE.360.0.OR.R2.LT.0.0)GOTO202
0024                   GOTO203
0025                202  IF(R1-360.0)205,204,204
0026                204  R1=R1-360.0
0027                205  IF(R2)206,203,203
0028                206  R2=R2+360.0
0029                   GOTO225
                    C;  ABOVE TESTS   AND SETS R1 AND R2 TO UNDER 360 DEG.
0030                203  JE=1
0031                224  ITIME=ITIME+INTER
0032                   IF (ITIME-60)210,208,208
0033                208  ITIME=ITIME-60
0034                   HOUR=HOUR+100
0035                   IF(HOUR-HTEST)210,209,209
0036                209  HTEST=HTEST+600
0037                   M=M+1
0038                   JC=1
0039                   JD=1
0040                210  JTIME=HOUR+ITIME
0041                   IF(JTIME-2400)225,225,300
                    C;  INCREMENTS TIME AND SETS TO HRS AND MINS, TESTS FOR 6 HR
                    C:   M INCREMENTS MATRIX ELEMENTS, 300 TAKES TO END OF DAY.
0042                225  IF(X(1,M+1)-X(1,M))211,301,212
0043                211  XIN=X(1,M)-360.0
                    C;     301 TAKES OUT FOR INVALID DATA.
0044                   GOTO213
0045                212  XIN=X(1,M)
                    C:   TEST FOR 0 TIME PERIODS AND SET INCREMENT TO 0.
0046                213  GOTO(220,221),JC
0047                220  GOTO(214,215,216,217,217),M
0048                214  IF(JTIME-0000)221,218,215
0049                215  IF(JTIME-0600)221,218,216
0050                216  IF(JTIME-1200)221,218,217
0051                217  IF(JTIME-1800)221,218,219
0052                219  IF(JTIME-2400)221,218,300
```

"Program Moon"

```
0053          218  XINCG=0.0
0054               XINCD=0.0
0055               JC=JC+1
0056               GOTO223
0057          221  GOTO(233,222),JD
0058          233  XINCG=(X(1,M+1)-XIN)*INTER/360.0
0059               XINCD=(X(2,M+1)-X(2,M))*INTER/360.0
0060               JD=JD+1
0061          222  X(1,M)=X(1,M)+XINCG
0062               IF(X(1,M)-360.0)235,236,236
0063          236  X(1,M)=X(1,M)-360.0
0064          235  X(2,M)=X(2,M)+XINCD
                  C;  INCREMENTS GHA AND DEC AND RETURNS TO TEST RANGE
                  C:   OUT OF INCREMENTS LOOP.  CALC AZ AND EL
0065          223  PSIA=X(1,M)
0066               IF(BLONG-180.0)226,227,227
0067          226  IF(BLONG-X(1,M))228,227,227
0068          228  PSIA=X(1,M)-360.0
0069               GOTO229
0070          227  IF((BLONG+180.0).GT.360.0)GOTO230
0071               GOTO229
0072          230  PSIA=X(1,M)+360.0
0073          229  PSI=BLONG-PSIA
                  C:  ABOVE TESTS FO LONGS UNDER 100 AND GHA NR 360
                  C:  CONVERT ANGLES  TO RADIANS.
0074               PSI=PSI*CONVT
0075               CXD=X(2,M)*CONVT
0076               CSIND=SIN(CXD)
0077               CCOSD=COS(CXD)
0078               CCOSP=COS(PSI)
0079               SEL=CCOSL*CCOSP*CCOSD+CSIND*CSINL
                  C:  TAKES OUT FOR NEGATIVE EL ANGLES.
0080               IF(SEL)203,260,260
0081          260  IF(SEL-1.0)243,242,243
0082          242  CEL=0.0
0083               TEL=9.999999E36
0084               GOTO 244
0085          243  CEL=SQRT(1.0-SEL**2)
0086               TEL=SEL/CEL
0087          244  CAZ1=CSIND/(CEL*CCOSL)-CTANL*TEL
0088               IF(CAZ-1.0)246,245,246
0089          245  CAZ=0.0
0090               TAZ=9.999999E36
0091                 GOTO247
0092          246  CAZ=SQRT(1.0-CAZ1**2)
0093               TAZ=CAZ/CAZ1
0094          247  ACAZ=ATAN(TAZ)
0095               ASEL=ATAN(TEL)
0096               ASEL=ASEL*CONVTR
0097               ACAZ=ACAZ*CONVTR
0098               GOTO(259,258),JE
0099          259  JE=JE+1
                  C:  TEST FOR ANGLES ACROSS 360.
0100          258  IF((BLONG-180.0).LT.0.0.OR.(BLONG+180.0).GT.360.0)GOT(
0101               GOTO241
                  C:  LONGITUDES 260 TO 360.
0102          256  IF((BLONG-180.0).LT.0.0) GOTO257
0103               IF(R2.GT.R1.AND.X(1,M).GE.R2)GOTO241
```

```
0104                GOTO240
                  C:  LONGITIUDES 000 TO100
0105          257   IF(X(1,M).LE.R1.AND.X(1,M).GE.(BLONG-180.0))GOTO241
0106                GOTO253
0107          241   IF(BLONG-X(1,M))240,253,253
0108          240   IF(CAZ1)250,250,251
0109          250   ACAZ=180.0-ACAZ
0110                GOTO237
0111          251   ACAZ=360.0-ACAZ
0112                GOTO237
0113          253   IF(CAZ1)254,237,237
0114          254   ACAZ=180.0+ACAZ
0115          237   GOTO(231,232),JB
0116          231   JB=JB+1
0117                WRITE(6,119)OBSER,COMENT
0118          119   FORMAT(//////,16H AZ-EL DATA FOR , A8,13A4)
0119                WRITE(6,127)BLONG,BLAT
0120          127   FORMAT(6H  LONG,3X,F5.1,5X,3HLAT,3X,F5.1/)
0121                WRITE(6,129)DATE
0122          129   FORMAT(1H , A8)
0123                WRITE(6,120)
0124          120   FORMAT(4H GMT,5X,3HGHA,6X,3HDEC,7X,2HAZ,7X,2HEL)
0125          232   WRITE(6,125)JTIME,X(1,M),X(2,M),ACAZ,ASEL
0126          125   FORMAT(I5,4(4X,F5.1))
0127                GOTO224
0128          301   WRITE(6,121)
0129          121   FORMAT(25H INPUT FOR GHA IS INVALID/)
0130          300   CONTINUE
0131          302   CONTINUE
0132                GOTO5
0133          303   STOP
0134                END
```

AZ-EL DATA FOR WA6LCZ/8
LONG 79.8 LAT 38.4

08/29/75

GMT	GHA	DEC	AZ	EL
330	335.8	19.1	66.5	1.4
340	338.3	19.1	68.0	3.2
350	340.7	19.1	69.5	4.9
400	343.1	19.1	70.9	6.7
410	345.5	19.1	72.3	8.5
420	347.9	19.2	73.7	10.4
430	350.3	19.2	75.1	12.2
440	352.8	19.2	76.5	14.0
450	355.2	19.2	77.8	15.9
500	357.6	19.2	79.2	17.7
510	0.0	19.2	80.6	19.6
520	2.4	19.2	82.0	21.5
530	4.8	19.3	83.4	23.4
540	7.3	19.3	84.8	25.3
550	9.7	19.3	86.2	27.2
600	12.1	19.3	87.6	29.1
610	14.5	19.3	89.1	31.0
620	16.9	19.3	90.5	32.9
630	19.3	19.3	92.1	34.8
640	21.8	19.3	93.6	36.7
650	24.2	19.4	95.2	38.6
700	26.6	19.4	96.9	40.5
710	29.0	19.4	98.6	42.3
720	31.4	19.4	100.4	44.2
730	33.8	19.4	102.2	46.1
740	36.3	19.4	104.2	47.9
750	38.7	19.4	106.2	49.8
800	41.1	19.4	108.4	51.6
810	43.5	19.4	110.7	53.4
820	45.9	19.5	113.2	55.1
830	48.3	19.5	115.9	56.9
840	50.8	19.5	118.7	58.6
850	53.2	19.5	121.8	60.2
900	55.6	19.5	125.2	61.8
910	58.0	19.5	128.9	63.3
920	60.4	19.5	132.9	64.7
930	62.8	19.5	137.3	66.1
940	65.3	19.5	142.2	67.3
950	67.7	19.6	147.5	68.4
1000	70.1	19.6	153.2	69.4
1010	72.5	19.6	159.4	70.1
1020	74.9	19.6	166.0	70.7
1030	77.3	19.6	172.9	71.1
1040	79.8	19.6	179.9	71.2
1050	82.2	19.6	186.9	71.1
1100	84.6	19.6	193.9	70.8
1110	87.0	19.6	200.5	70.2
1120	89.4	19.7	206.7	69.5
1130	91.8	19.7	212.5	68.6
1140	94.3	19.7	217.9	67.5
1150	96.7	19.7	222.8	66.3
1200	99.1	19.7	227.2	64.9
1210	101.5	19.7	231.3	63.5
1220	103.9	19.7	235.0	62.0
1230	106.3	19.7	238.4	60.4
1240	108.8	19.7	241.6	58.8
1250	111.2	19.8	244.4	57.1
1300	113.6	19.8	247.1	55.4
1310	116.0	19.8	249.6	53.6

Sample output

1320	118.4	19.8	251.9	51.9
1330	120.8	19.8	254.1	50.1
1340	123.2	19.8	256.2	48.2
1350	125.7	19.8	258.2	46.4
1400	128.1	19.8	260.1	44.5
1410	130.5	19.8	261.9	42.7
1420	132.9	19.9	263.6	40.8
1430	135.3	19.9	265.2	38.9
1440	137.7	19.9	266.9	37.1
1450	140.1	19.9	268.4	35.2
1500	142.5	19.9	270.0	33.3
1510	145.0	19.9	271.4	31.4
1520	147.4	19.9	272.9	29.5
1530	149.8	19.9	274.4	27.6
1540	152.2	19.9	275.8	25.8
1550	154.6	20.0	277.2	23.9
1600	157.0	20.0	278.6	22.0
1610	159.4	20.0	280.0	20.2
1620	161.9	20.0	281.4	18.3
1630	164.3	20.0	282.8	16.5
1640	166.7	20.0	284.1	14.6
1650	169.1	20.0	285.5	12.8
1700	171.5	20.0	286.9	11.0
1710	173.9	20.0	288.3	9.2
1720	176.3	20.1	289.8	7.4
1730	178.8	20.1	291.2	5.7
1740	181.2	20.1	292.6	3.9
1750	183.6	20.1	294.1	2.2
1800	186.0	20.1	295.6	0.5

AZ-EL DATA FOR WA6LCZ/8

LONG 79.8 LAT 38.4

08/30/75

GMT	GHA	DEC	AZ	EL
410	333.0	20.5	63.7	0.4
420	335.4	20.5	65.2	2.1
430	337.8	20.5	66.6	3.8
440	340.3	20.6	68.1	5.5
450	342.7	20.6	69.5	7.3
500	345.1	20.6	70.9	9.1
510	347.5	20.6	72.3	10.9
520	349.9	20.6	73.6	12.7
530	352.3	20.6	75.0	14.5
540	354.7	20.6	76.4	16.3
550	357.1	20.6	77.7	18.2
600	359.5	20.6	79.1	20.0
610	1.9	20.6	80.5	21.9
620	4.3	20.6	81.8	23.8
630	6.8	20.6	83.2	25.6
640	9.2	20.6	84.6	27.5
650	11.6	20.6	86.0	29.4
700	14.0	20.6	87.5	31.3
710	16.4	20.6	88.9	33.2
720	18.9	20.6	90.4	35.1
730	21.3	20.6	91.9	37.0
740	23.7	20.7	93.5	38.9
750	26.1	20.7	95.1	40.8
800	28.5	20.7	96.8	42.7
810	31.0	20.7	98.5	44.6
820	33.4	20.7	100.4	46.4
830	35.8	20.7	102.3	48.3
840	38.2	20.7	104.3	50.2
650	40.6	20.7	106.4	52.0
900	43.0	20.7	108.6	53.8
910	45.5	20.7	111.0	55.6
920	47.9	20.7	113.6	57.3

930	50.3	20.7	116.4	59.1
940	52.7	20.7	119.4	60.7
950	55.1	20.7	122.7	62.4
1000	57.6	20.7	126.3	63.9
1010	60.0	20.7	130.3	65.4
1020	62.4	20.7	134.7	66.8
1030	64.8	20.7	139.6	68.1
1040	67.2	20.8	144.9	69.3
1050	69.7	20.8	150.8	70.3
1100	72.1	20.8	157.1	71.2
1110	74.5	20.8	164.0	71.8
1120	76.9	20.8	171.2	72.2
1130	79.3	20.8	178.6	72.4
1140	81.8	20.8	186.0	72.3
1150	84.2	20.8	193.4	72.0
1200	86.6	20.8	200.4	71.4
1210	89.0	20.8	206.9	70.7
1220	91.4	20.8	213.0	69.8
1230	93.8	20.8	218.5	68.7
1240	96.2	20.8	223.5	67.4
1250	98.6	20.8	228.1	66.1
1300	101.0	20.8	232.2	64.6
1310	103.5	20.8	236.0	63.1
1320	105.9	20.8	239.4	61.5
1330	108.3	20.8	242.5	59.8
1340	110.7	20.8	245.4	58.2
1350	113.1	20.8	248.1	56.4
1400	115.5	20.8	250.5	54.7
1410	117.9	20.8	252.8	52.9
1420	120.3	20.8	255.0	51.1
1430	122.7	20.8	257.1	49.2
1440	125.1	20.8	259.0	47.4
1450	127.5	20.8	260.8	45.5
1500	129.9	20.8	262.6	43.7
1510	132.4	20.9	264.3	41.8
1520	134.8	20.9	265.9	39.9
1530	137.2	20.9	267.5	38.0
1540	139.6	20.9	269.1	36.1
1550	142.0	20.9	270.6	34.3
1600	144.4	20.9	272.0	32.4
1610	146.8	20.9	273.5	30.5
1620	149.2	20.9	274.9	28.6
1630	151.6	20.9	276.3	26.7
1640	154.0	20.9	277.7	24.9
1650	156.4	20.9	279.1	23.0
1700	158.8	20.9	280.4	21.1
1710	161.3	20.9	281.8	19.3
1720	163.7	20.9	283.2	17.4
1730	166.1	20.9	284.5	15.6
1740	168.5	20.9	285.9	13.8
1750	170.9	20.9	287.3	12.0
1800	173.3	20.9	288.7	10.2
1810	175.7	20.9	290.1	8.4
1820	178.1	20.9	291.5	6.6
1830	180.5	20.9	292.9	4.9
1840	182.9	20.9	294.3	3.2
1850	185.4	20.9	295.8	1.4

AZ-EL DATA FOR WA6LCZ/8

LONG 79.8 LAT 38.4

08/31/75

GMT	GHA	DEC	AZ	EL
500	332.3	20.9	63.0	0.1
510	334.8	20.9	64.5	1.8
520	337.2	20.9	66.0	3.5
530	339.6	20.9	67.4	5.3

540	342.0	20.9	68.8	7.0
550	344.4	20.9	70.2	8.8
600	346.8	20.9	71.6	10.6
610	349.2	20.9	73.0	12.4
620	351.6	20.9	74.4	14.2
630	354.0	20.9	75.7	16.0
640	356.4	20.9	77.1	17.8
650	358.8	20.9	78.5	19.7
700	1.2	20.9	79.8	21.5
710	3.7	20.9	81.2	23.4
720	6.1	20.9	82.6	25.2
730	8.5	20.9	84.0	27.1
740	10.9	20.9	85.4	29.0
750	13.3	20.9	86.8	30.9
800	15.7	20.9	88.3	32.8
810	18.1	20.9	89.7	34.6
820	20.5	20.9	91.2	36.5
830	22.9	20.9	92.8	38.4
840	25.3	20.9	94.4	40.3
850	27.7	20.9	96.0	42.2
900	30.1	20.9	97.7	44.0
910	32.6	20.8	99.5	45.9
920	35.0	20.8	101.4	47.8
930	37.4	20.8	103.4	49.6
940	39.8	20.8	105.4	51.4
950	42.2	20.8	107.6	53.2
1000	44.6	20.8	110.0	55.0
1010	47.0	20.8	112.5	56.8
1020	49.4	20.8	115.2	58.5
1030	51.8	20.8	118.1	60.2
1040	54.2	20.8	121.3	61.8
1050	56.6	20.8	124.8	63.4
1100	59.0	20.8	128.6	64.9
1110	61.5	20.8	132.8	66.4
1120	63.9	20.8	137.5	67.7
1130	66.3	20.8	142.6	68.9
1140	68.7	20.8	148.3	70.0
1150	71.1	20.8	154.4	70.9
1200	73.5	20.8	161.1	71.6
1210	75.9	20.8	168.1	72.1
1220	78.3	20.8	175.4	72.3
1230	80.7	20.8	182.9	72.4
1240	83.1	20.8	190.2	72.1
1250	85.5	20.8	197.3	71.7
1300	87.9	20.8	204.0	71.0
1310	90.4	20.8	210.3	70.1
1320	92.8	20.8	216.0	69.1
1330	95.2	20.7	221.3	67.9
1340	97.6	20.7	226.0	66.6
1350	100.0	20.7	230.3	65.2
1400	102.4	20.7	234.2	63.7
1410	104.8	20.7	237.8	62.1
1420	107.2	20.7	241.0	60.5
1430	109.6	20.7	244.0	58.8
1440	112.0	20.7	246.8	57.1
1450	114.4	20.7	249.3	55.4
1500	116.8	20.7	251.7	53.6
1510	119.3	20.7	253.9	51.8
1520	121.7	20.7	256.0	49.9
1530	124.1	20.7	258.0	48.1
1540	126.5	20.7	259.8	46.2
1550	128.9	20.7	261.6	44.4
1600	131.3	20.7	263.4	42.5
1610	133.7	20.7	265.0	40.6
1620	136.1	20.7	266.6	38.7
1630	138.5	20.6	268.2	36.9

1640	140.9	20.6	269.7	35.0
1650	143.3	20.6	271.2	33.1
1700	145.7	20.6	272.6	31.2
1710	148.2	20.6	274.1	29.3
1720	150.6	20.6	275.5	27.4
1730	153.0	20.6	276.9	25.5
1740	155.4	20.6	278.2	23.7
1750	157.8	20.6	279.6	21.8
1800	160.2	20.6	281.0	19.9
1810	162.6	20.6	282.3	18.1
1820	165.0	20.6	283.7	16.2
1830	167.4	20.6	285.0	14.4
1840	169.8	20.6	286.4	12.6
1850	172.2	20.6	287.8	10.8
1900	174.6	20.5	289.2	9.0
1910	177.0	20.5	290.6	7.2
1920	179.4	20.5	292.0	5.4
1930	181.8	20.5	293.4	3.7
1940	184.3	20.5	294.8	2.0
1950	186.7	20.5	296.3	0.3