Interoffice

ENGINEERING MEMO # 118

National Radio Astronomy Observatory

Green Bank, West Virginia

November 3, 1977

To: Barry Turner

From: K. I. Kellermann

Subject: 140-ft short cm wavelength performance

Beam Shape: Previous observations showed that as the antenna was tilted, a second beam was formed always in the vertical direction. This was first described in the report by Mezger et al. in 1966 (see Figure 13), and observations made since that time have confirmed the original effect, but have never shown any evidence for a third beam. This was true even at 9 mm wavelength. I wonder if the complex beam shape is due in part to a combination of the known astigmatism and the asymmetric geometry. It might be instructive to try a prime focus 1.3 cm receiver.

Pointing: Between October 29 and November 2 a number of pointing observations were made at 2.8 cm as part of the VLBI observations. Except for a possible error of ∿ +1 sec of time in RA at far eastern hour angles, there was no evidence of any systematic deviations from the normal pointing corrections. Except for one day the peak pointing deviations were ∿ 20 arc seconds although there were day to night temperature variations of ∿ 40° F. During one daytime period the error reached 30 arc seconds.

I conclude that the 140-ft pointing has not changed with time and that the apparent pointing problems at 1.3 cm are peculiar to that system, possibly to the subreflector assembly. When the Cassegrain system was first installed, pointing was done at 6 cm and no significant deviation was found from the prime focus curves, except for the expected effect of the feed offset. Moreover, it is difficult to understand why there should be any difference. The structure should deform in essentially the same manner since the nutator-subreflector system weighs about the same as a prime focus receiver box. Aside from the obvious problem of defining the pointing with such a complex beam shape, pointing errors of the magnitude observed might occur due to the off axis feed, if the subreflector assembly is moved in the radial direction to compensate for changes in the focal length which occur with elevation and temperature. This correction can be, but has not yet been programmed into the Cassegrain pointing.

While further observations are needed to understand the cause of the apparent pointing discrepancies and complex beam shape, it would be premature to spend any lengthy time calibrating the pointing, the beam shape, or the gain, since these will all change with the installation of the deformable subreflector.

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NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

October 28, 1977

MEMORANDUM

To: Addressee

From: B. E. Turner

Subj: Preliminary Study of the 140-ft Telescope Performance at 1.35 cm Wavelength

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We used the unprecedented sensitivity and stability of the new K-band maser receiver and new software for controlling the 140-ft telescope to study the performance of the telescope during an observing session in mid-October 1977.

A. Beam

Figures 1 to 11 show maps of the 140-ft beam using the point H_2O maser sources:

W3 OH	02 23 17.25	61 38 57.4	(1950)
DR21 OH	20 37 14.0	42 12 03	
W51	19 21 26.5	14 24 41	
W Hya	13 46 12.2	-28 07 03	

at several hour angles. These were observed with a raster scanning of the telescope, the scans being in RA. Spacing between RA scans is 30" in declination over a range ±4' in DEC about the source position. RA scan length is $\pm 36^s$ about the source position, sample time is $0^s.2$, RA scan rate is 30 arcmin/min. Scale on the figures is the same (in terms of angle measure) for RA and DEC, i.e., a round beam appears round for all declinations. Contour labels refer to antenna temperature (K) based on a noise tube value of 12 K. The coordinate scales are centered on the position of the H_2O point source as determined by interferometry. Before performing a map, the telescope was peaked up on the source, and offsets were entered to correct the pointing error. Thus deviations of the "beam center" of these maps from the source position (center of coordinate scales) reflect only uncertainties in ability to peak up, not actual pointing errors, which are larger(see below).

Figures 1 to 11 show that:

1) Declination astigmatism is present in some cases where expected (e.g., Fig. 11), but the beam is more complex than this in other cases where only declination astigmatism is expected (e.g., Figs. 9 and 10).

2) RA astigmatism is present in some cases where expected (e.g., Figs. 1, 6, 8), but the beam is more complex than this in other cases where RA astigmatism is expected (e.g., Fig. 4).

3) The "coma lobe" shows up often to the east of the main beam (Figs. 4, 5, 8?, 9, 11), but sometimes to the west (Fig. 1) or other directions (Fig. 2).

4) Multi-beams occur in several cases (Figs. 3, 4, 9, 10, 11). These cases are often most severe at the meridian rather than east or west, and are not obviously correlated with elevation angle.

Insufficient data exist to test several possibly relevant factors, such as possible lateral defocussing, resonant effects of the feed legs (due to wind or mechanical vibrations from the nutator), incorrect polarization angle of the (asymmetric) subreflector, etc. We can make the following points:

1) Maps taken on successive days (2 cases) reproduce well, even under weather conditions of sunshine on one day, snow on the other.

2) A map taken with and without nutating (the receiver was extremely stable) agree very well (see Fig. 12), so there is no obvious problem of vibration or pointing error caused by the nutation. However this test has been performed only for a case where the beam was relatively clean.

B. Pointing

Pointing is obviously complicated by the complex beam shapes. Pointing was accomplished by manual peaking up on the above H_2O sources (using the strip chart in "continuum" mode) and the continuum sources 3C 84, 3C 273. Computer-controlled pointing was not debugged during our run and anyway was confused by the complex beam pattern.

Figure 13 shows pointing corrections in RA in arc sec as a function of H.A., for several declinations. Figure 14 shows the pointing corrections in DEC. The following sources were used: DEC -28: Sgr B_2 (δ = -28) and W Hya (δ = -28); DEC 0: 3C 273 (δ = +02), and Ori A (δ = -05); DEC +14: W 51 (δ = +14); DEC +41: 3C 84 (δ = 41), and DR 21/DR 21 OH (δ = 42).

These pointing corrections are derived relative to the best determined PVLS which, along with the pointing curves for the Cassegrain system, are already entered. Best determined PVLS hold good for less than a 2^h period, after which the pointing typically changes by as much as 30" in either coordinate (sometimes worse). The estimated uncertainty (3 sigma) in a single determination of the pointing is about 12" in either coordinate.

Two conclusions seem possible:

1) A trend in pointing errors as a function of H.A. occurs in some instances, suggesting the pointing curves for the Cassegrain system have not been adequately determined.

2) After subtracting out effect 1), the peak-to-peak (5 sigma) scatter in R.A. appears to be close to 60", or the rms scatter 12". Several points lie well outside this.

3) The peak-to-peak (5 sigma) scatter in DEC appears to be larger than in RA. It is noticeably larger at DEC -28°. Inadequate handling of refraction may be involved.

4) Although not shown, the scatter in pointing errors did not seem to differ on days when the sun was shining and days when it was completely overcast (or even snowing). There is some impression that scatter may have been a little smaller at night, but not very significantly so.

5) In attempting to do any serious science, even of the line-detection variety in sources $\sim 1'$ in size, we certainly concluded that pointing every 2^h at maximum, and usually more often, was necessary. Ignoring the occasional pathological case where the pointing seemed to jump by $\gtrsim 1'$ (pointing on wrong beam?), we found typical pointing changes of 30" in $\lesssim 2^h$ and often $\sim$45" changes over such periods.

I thank T. R. Cram and E. B. Stobie for help with the software in producing the beam maps, and L. J Rickard for collaboration in the observations.

BET/pj

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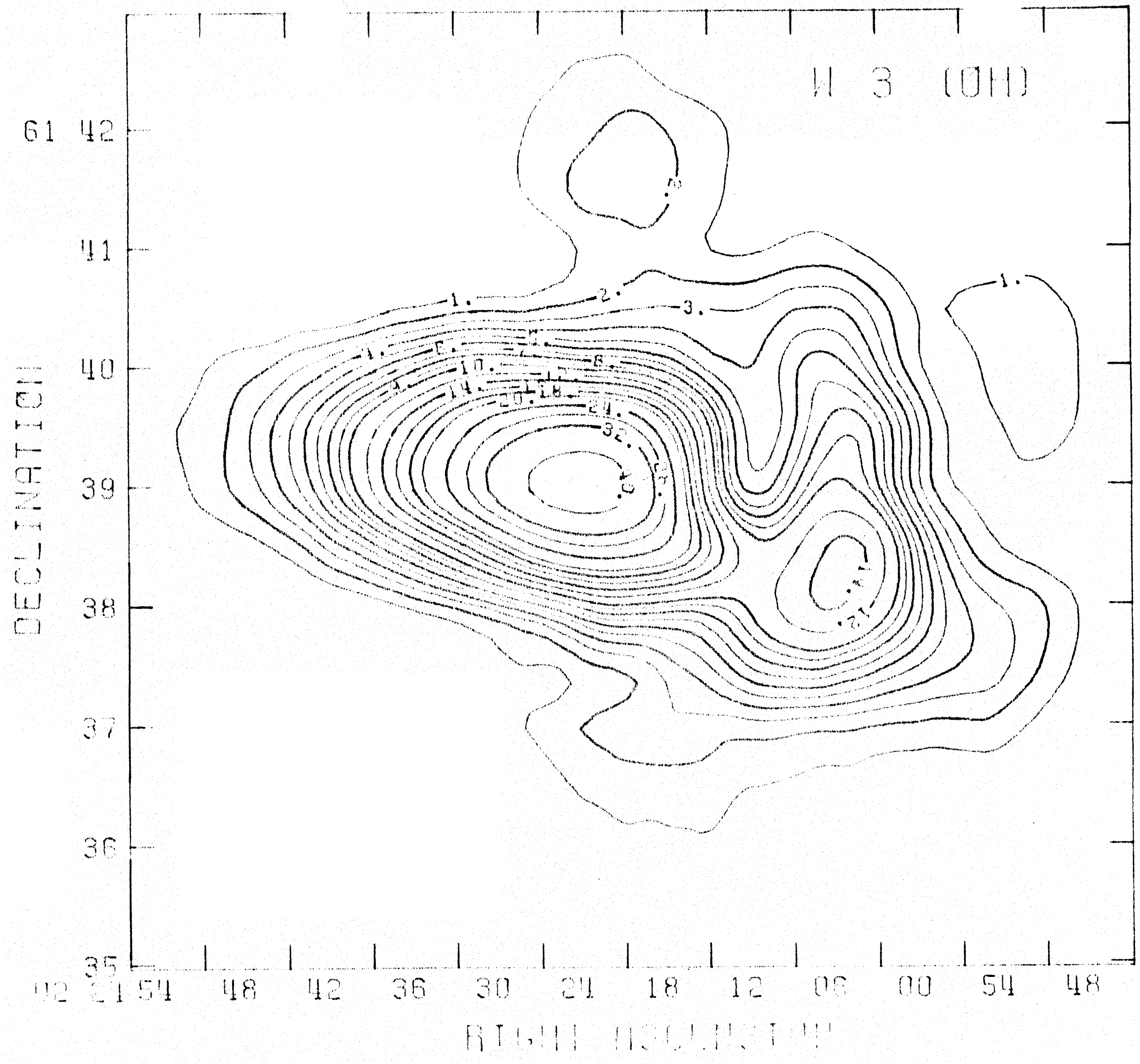
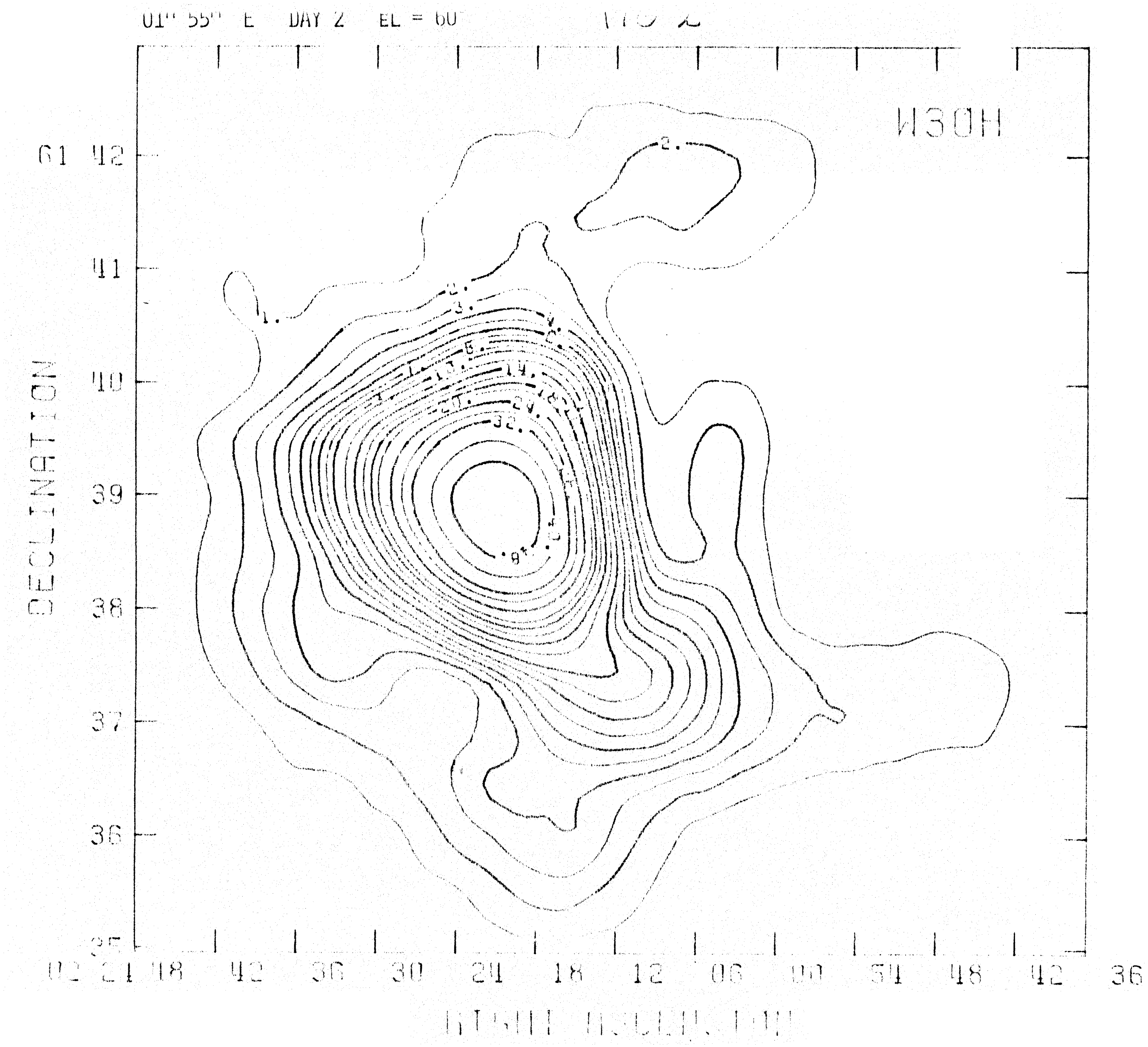
04^H 50^M E DAY 3 EL = 40° FIG 1





W3OH
DAY 2
EL = 60
DECLINATION
61 42
41
40
39
38
37
36
42
36
30
24
18
12
06
00
54
48
42
36

$00^H\ 00^M$ W DAY 2 EL = 67°

FIG 3

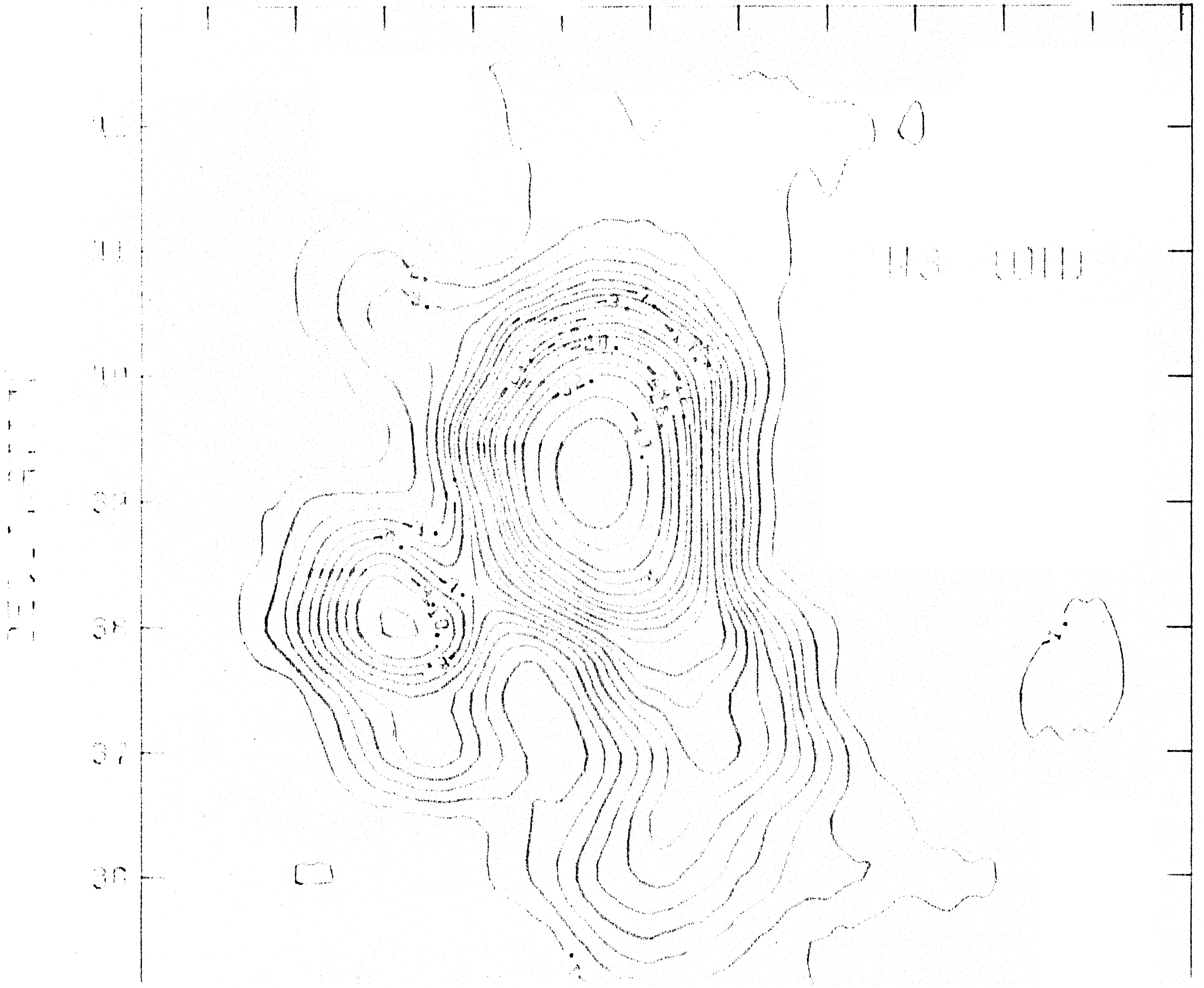
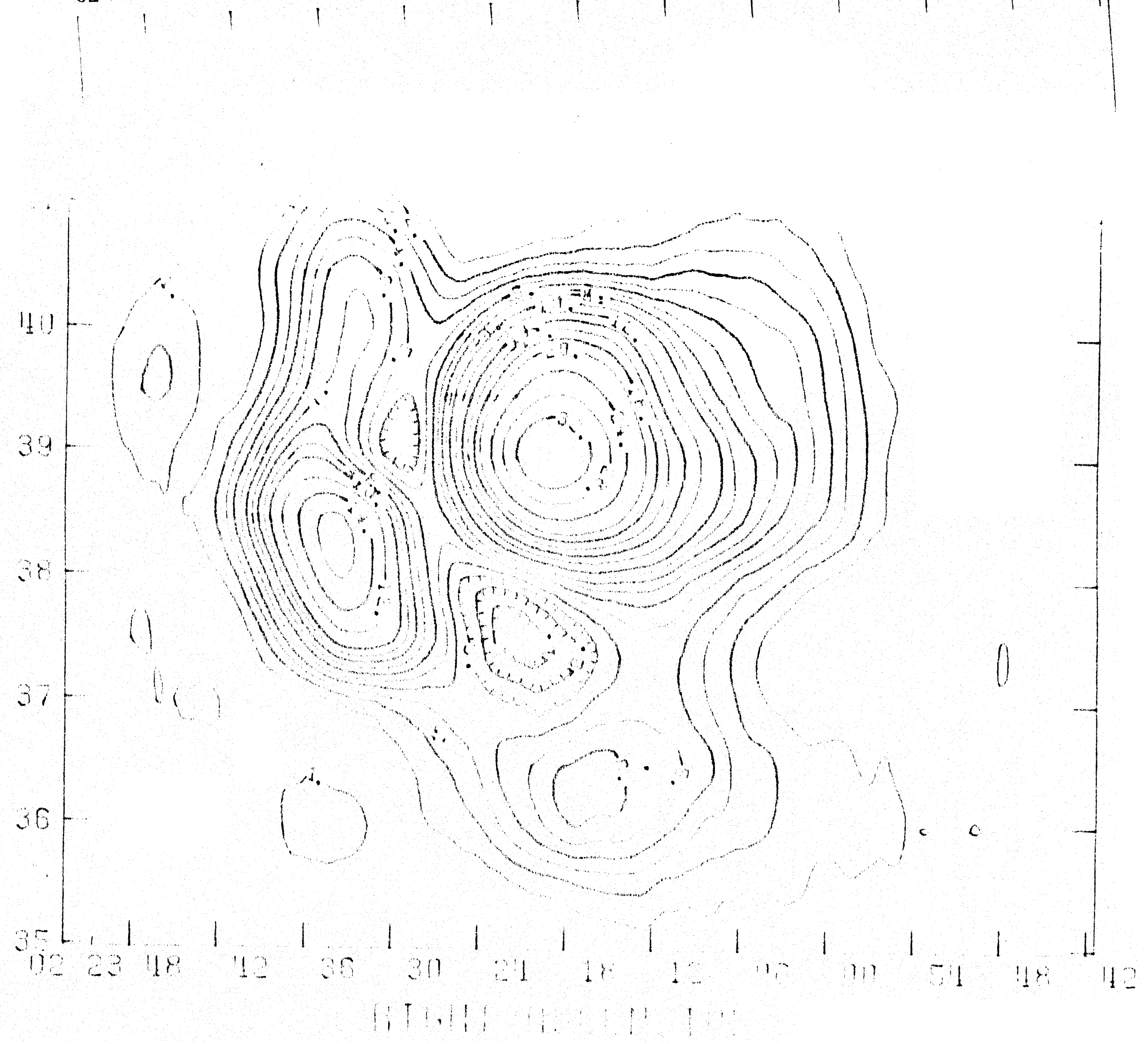


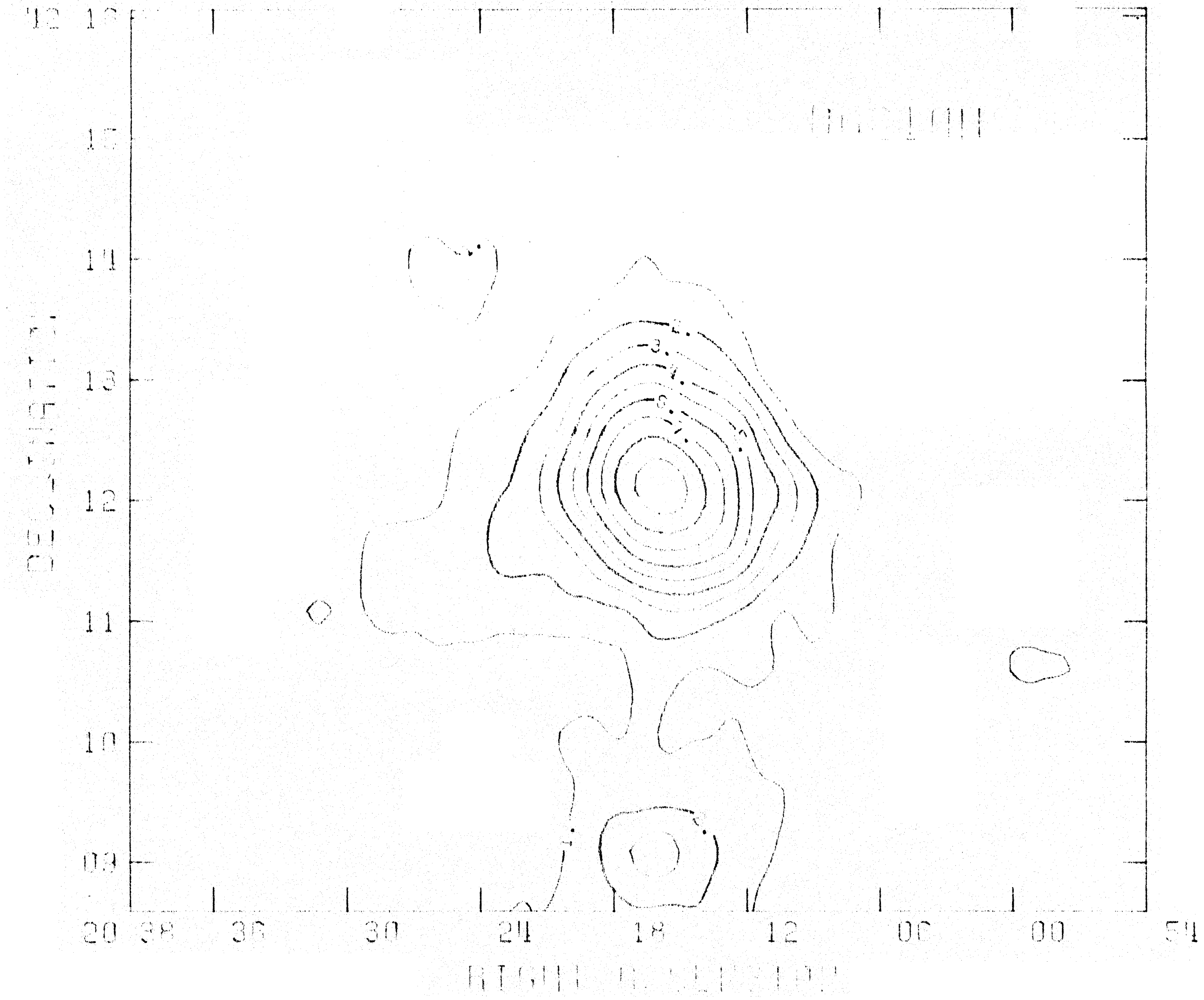
FIG 4

02H 10M W DAY 2 EL = 59°



$00^H\ 25^M$ W DAY 2 EL = 84°

FIG 5



02^{H} 45^{M} W DAY 1 EL = 59°

Fig 6

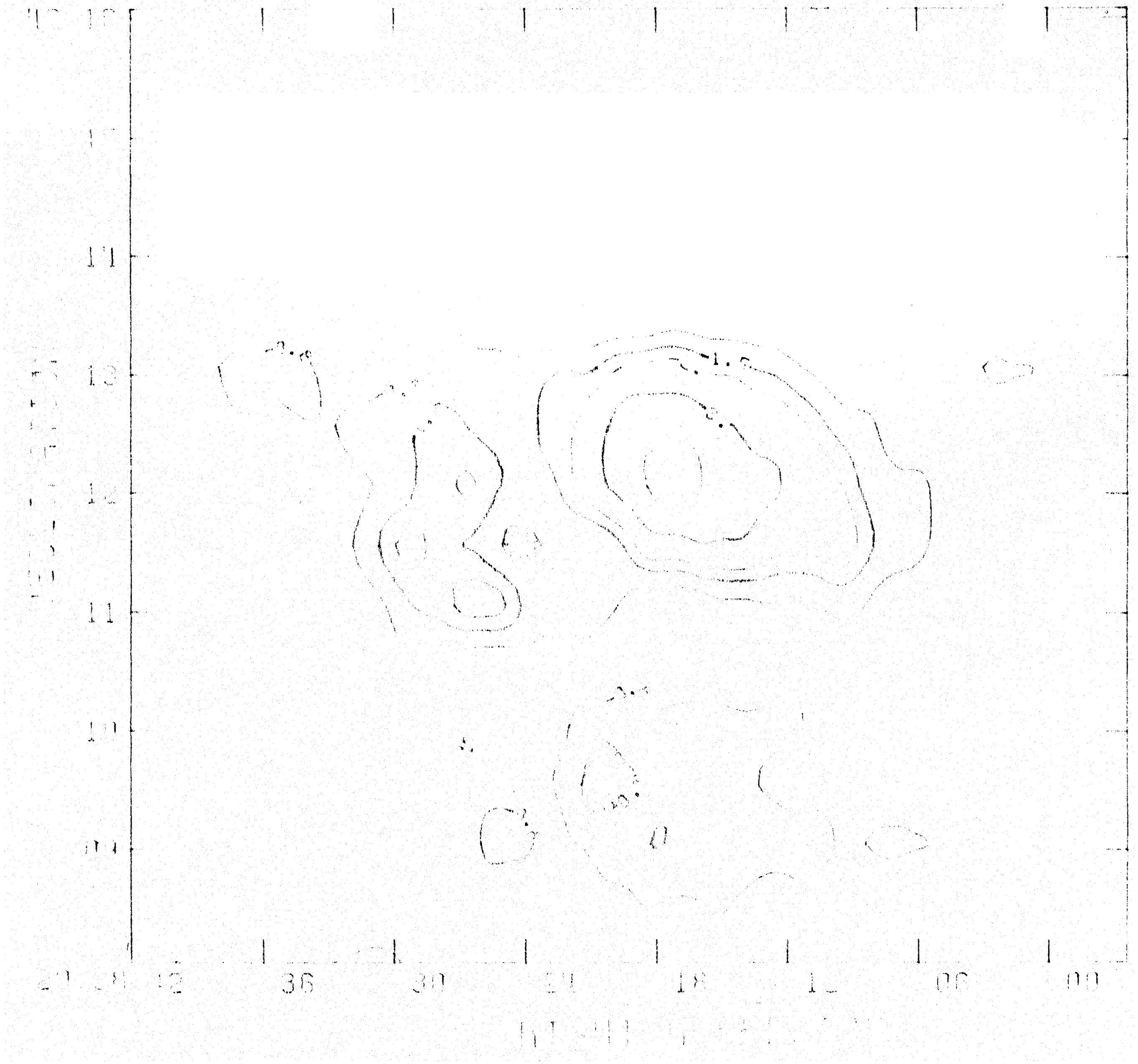
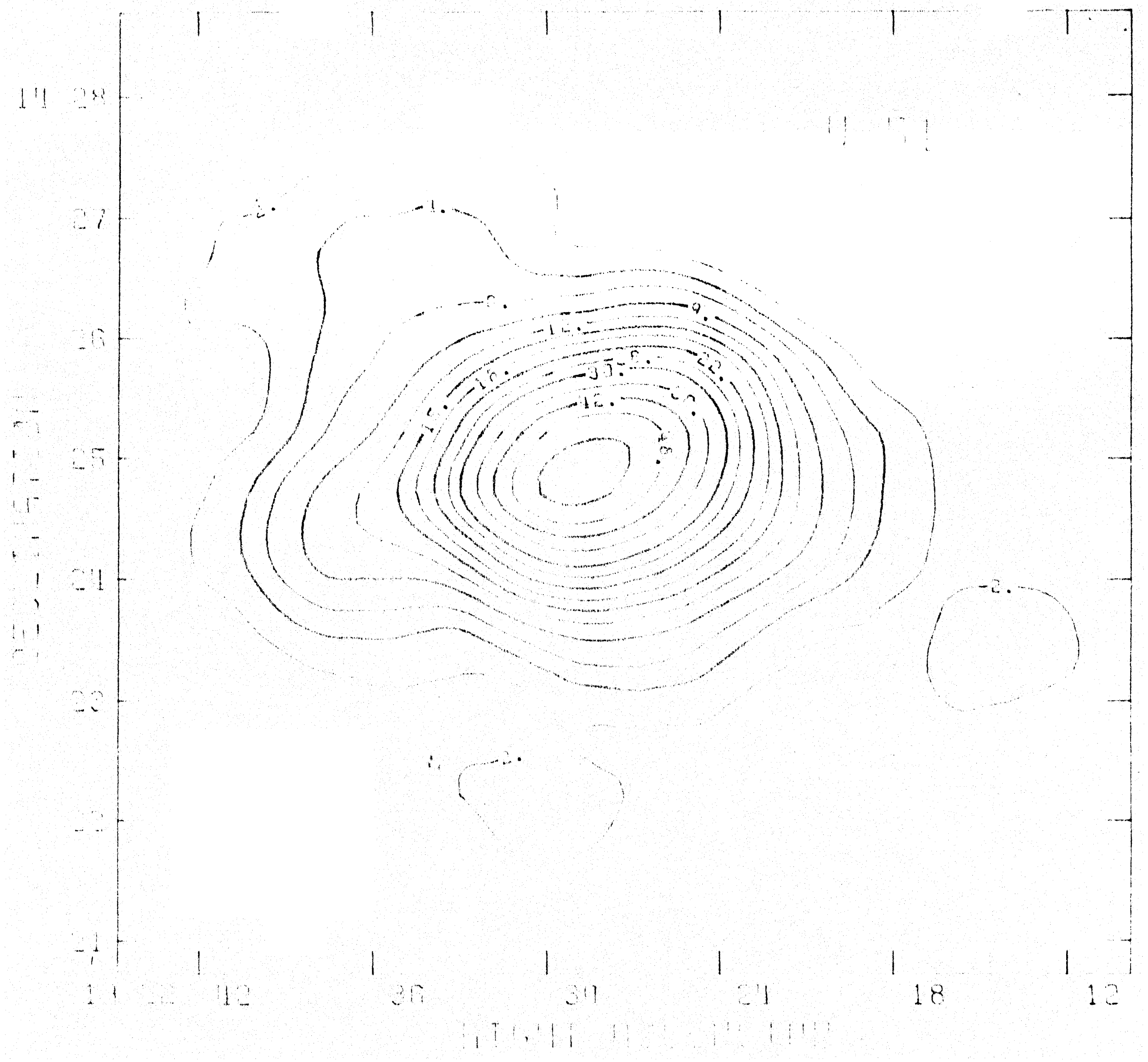
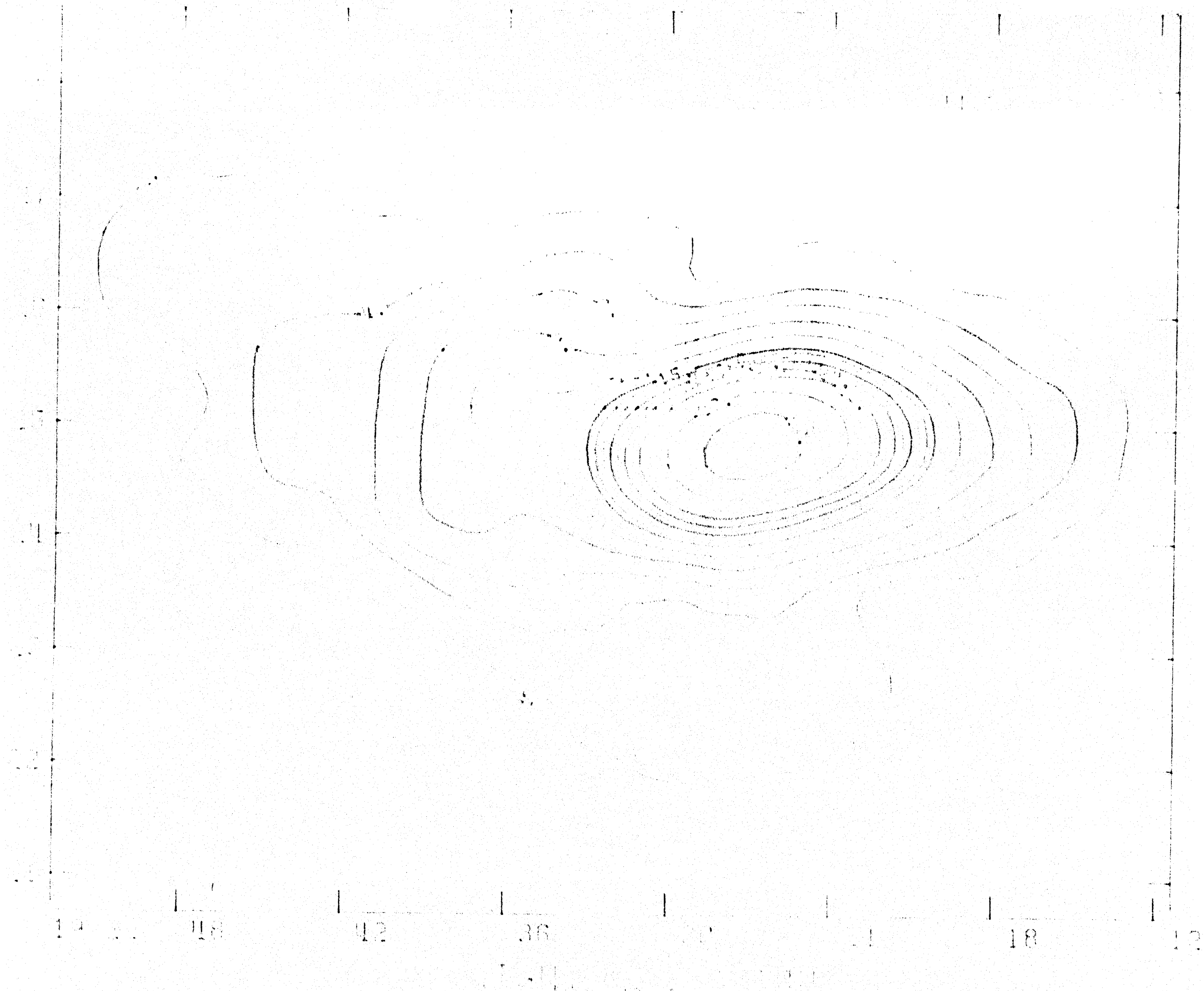


FIG 4


01H 05M W DAY 3 EL = 60°
DECLINATION
RIGHT ASCENSION
14 28
27
26
25
24
23
22
21
13 42
36
30
24
18
12
-1.
-2.
-8.
-9.
-14.
-16.
-22.
-33.
-42.
-48.

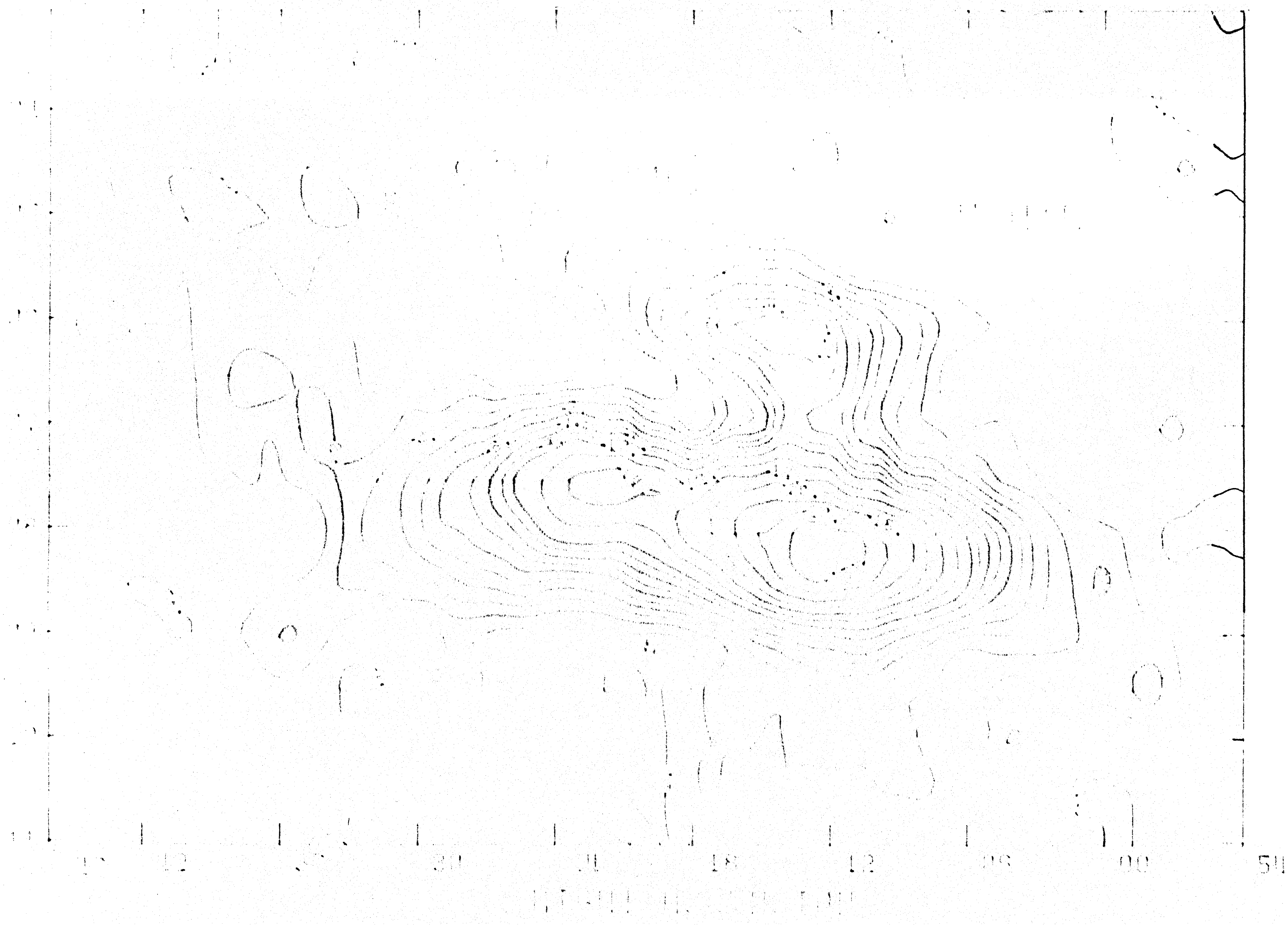
03H 30M W DAY 2 EL = 37°

FIG 8

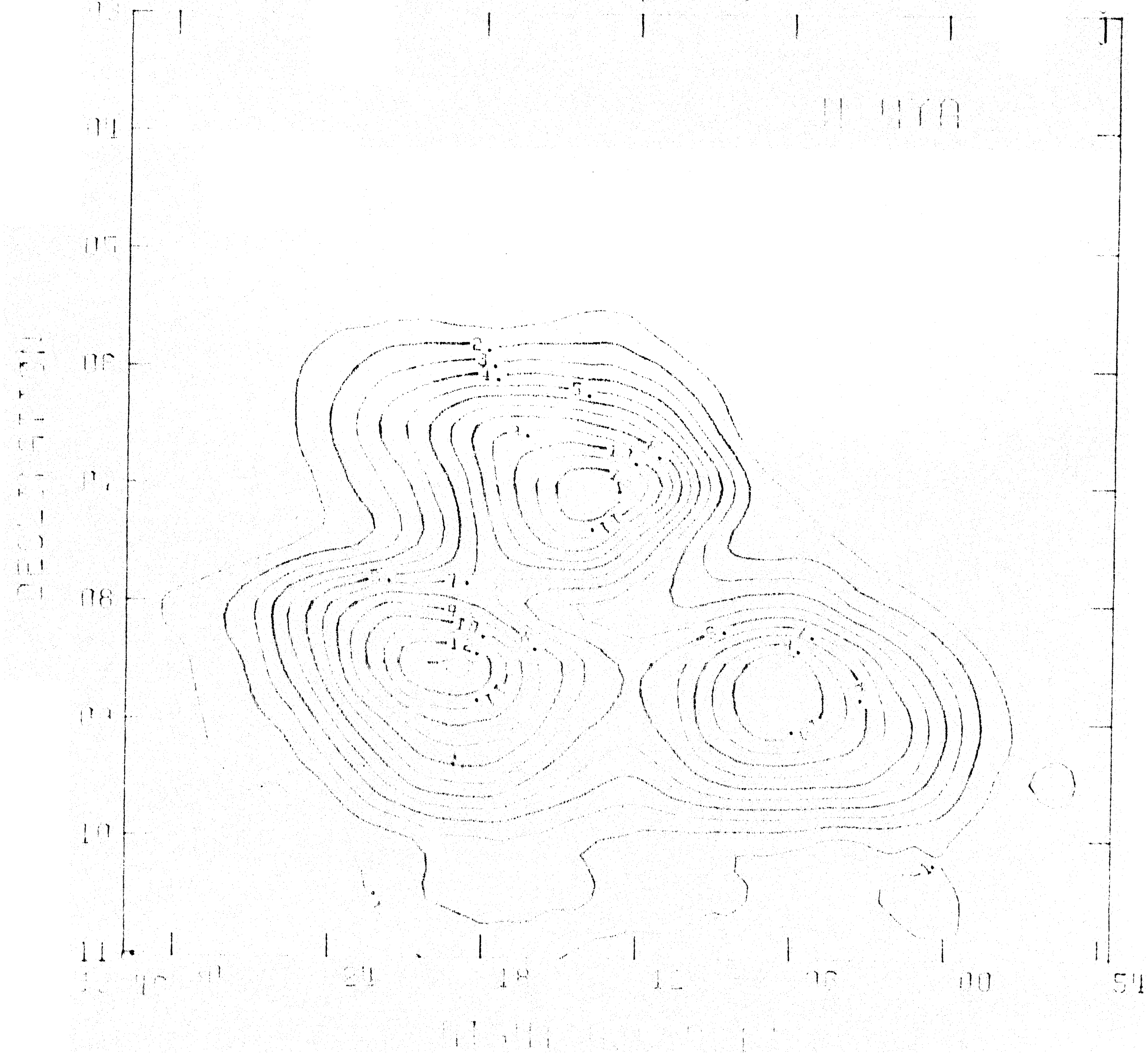


$02^{H}\ 20^{M}$ E DAY 2 EL = 16°

FIG 9



00° 15' W DAY 2 EL = 24° FIG 10



02^{H} 15^{M} W DAY 2 EL = 16°

FIG 11

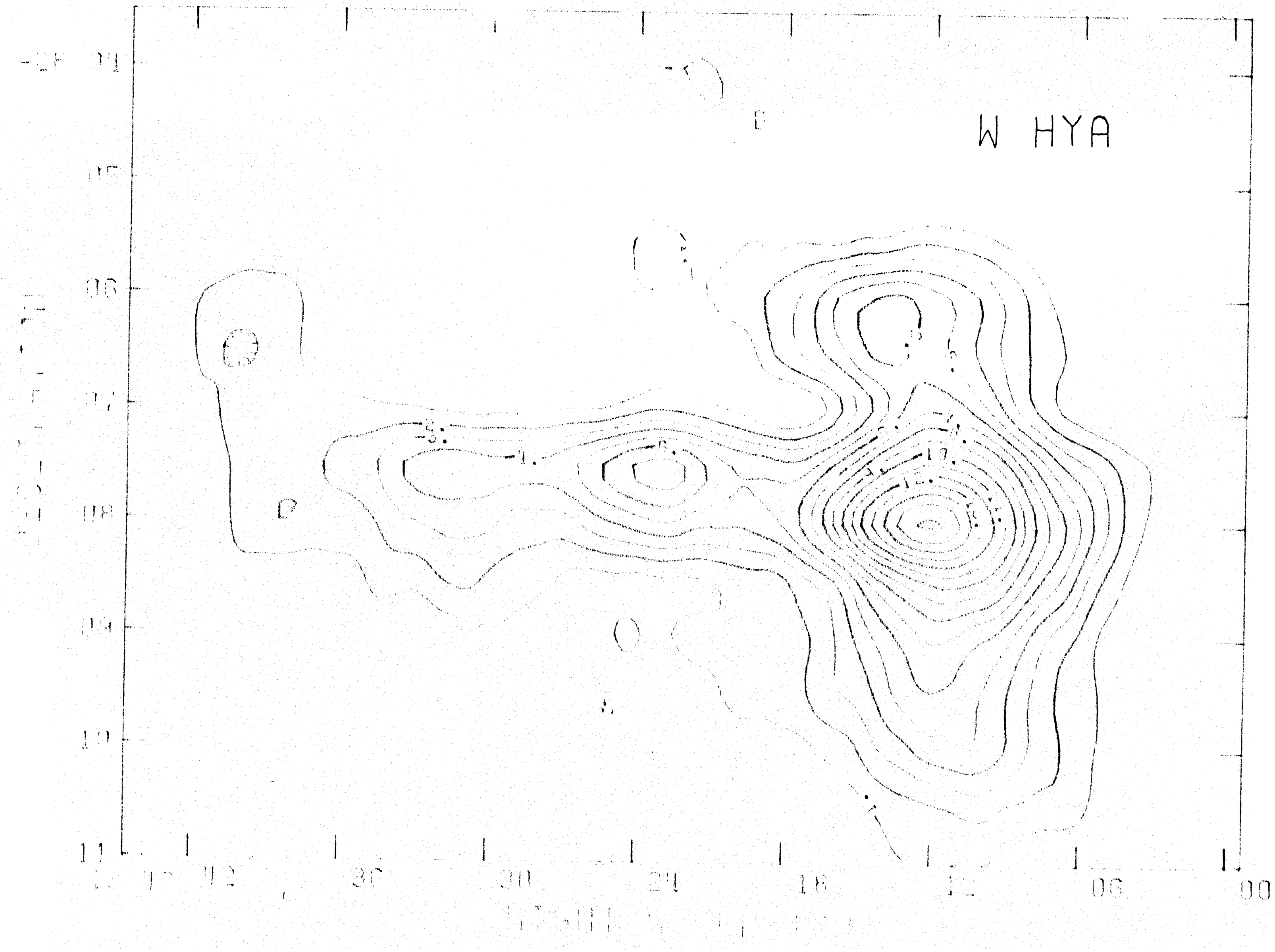
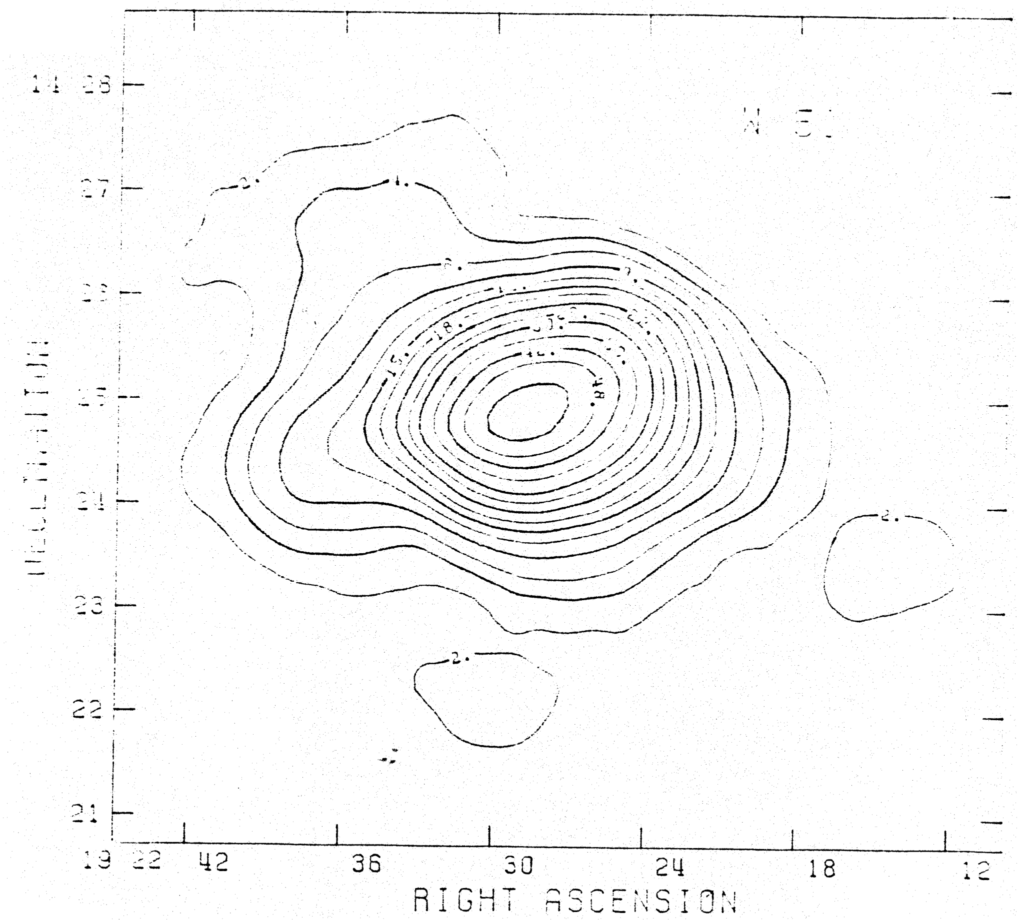
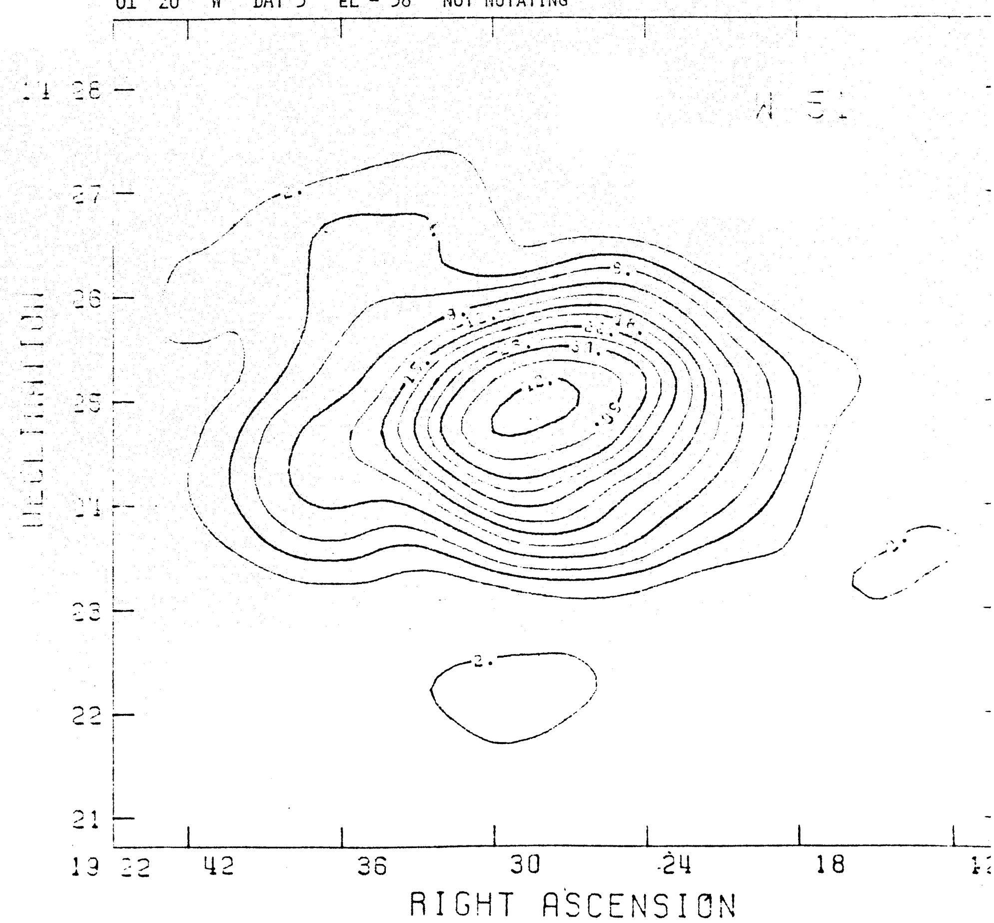


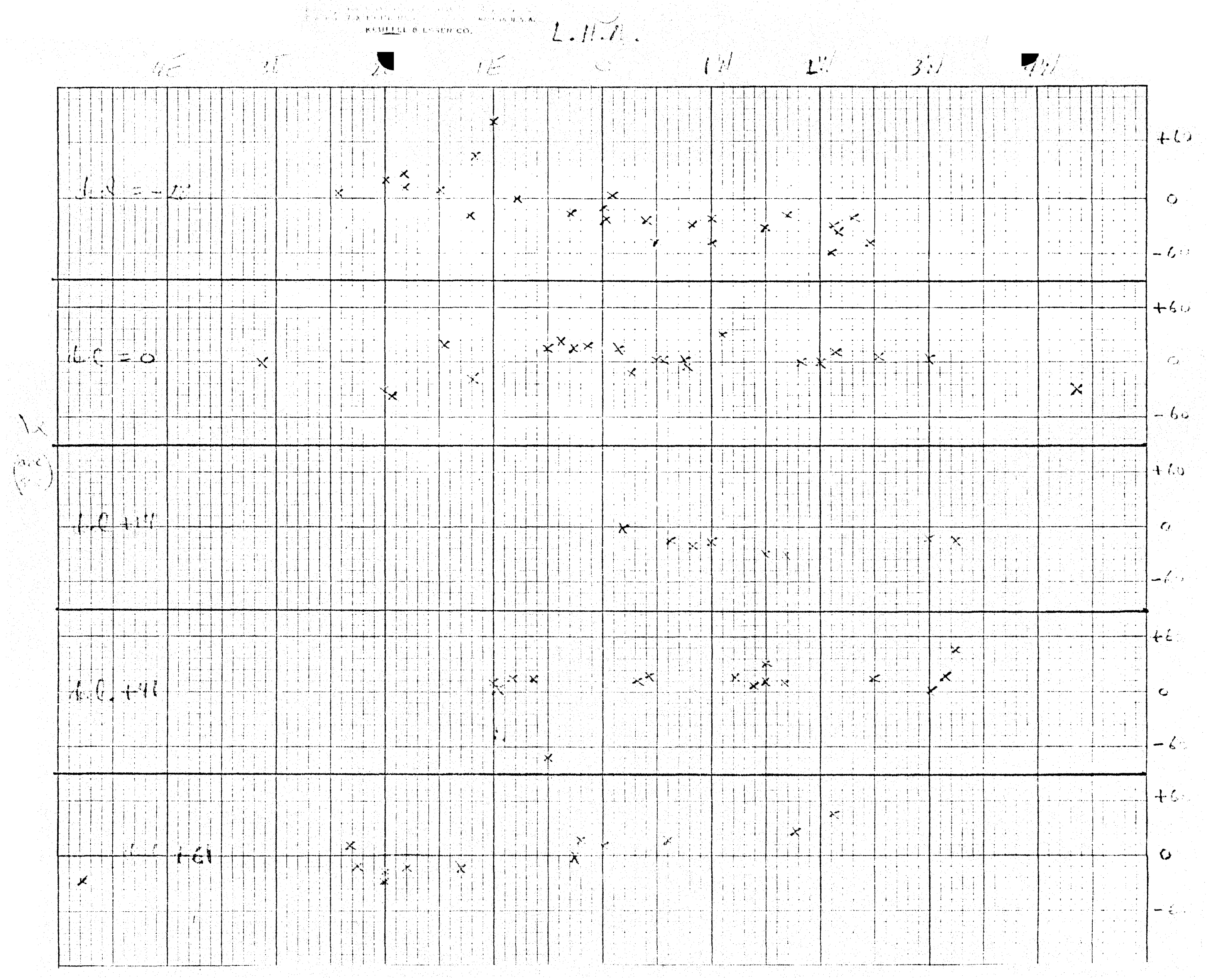
FIG 12

$01^H\ 05^M$ W DAY 3 EL = 60°



$01^H\ 20^M$ W DAY 3 EL = 58° NOT NUTATING




L.H.R.
+60
0
-60