LP

MET O 11 TECHNICAL NOTE NO.94

COMPARISON OF VERSIONS OF THE CENTRED OCTAGON ON STAGGERED AND UNSTAGGERED GRIDS

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1. INTRODUCTION

The explicit centred octagon model was modified by changing from a staggered to an unstaggered grid and incorporating the same conservative horizontal advection finite difference scheme as is used in the 11-level σ - coordinate model.

Five 3-day integrations were done using the new explicit model and these were compared with the corresponding semi-implicit centred octagon forecasts and with the actuals. On one occasion, an explicit centred octagon forecast was also obtained for comparison. The results of 3 of these case studies are included in this report.

2. GRIDS AND FINITE DIFFERENCE EQUATIONS

The centred octagon grid is shown in Fig 1(A), and the 11-level model grid is shown in Fig 1(B). Both grids are unstaggered in time.

The finite difference equations of the modified model are as follows -

$$u_{2t} + \mu(\bar{u}^x \bar{u}^x)_x + \mu(\bar{v}^y \bar{u}^y)_y + (\omega \bar{u}^p)_p + \tfrac{1}{2}(u^2+v^2)\mu_x + g h_{2x} - f v = 0 \qquad (1)$$

$$v_{2t} + \mu(\bar{u}^x \bar{v}^x)_x + \mu(\bar{v}^y \bar{v}^y)_y + (\omega \bar{v}^p)_p + \tfrac{1}{2}(u^2+v^2)\mu_y + g h_{2y} + f u = 0 \qquad (2)$$

$$h'_{2t} + \mu(\bar{u}^p h')_{2x} + \mu(\bar{v}^p h')_{2y} + \beta\omega + h'\omega_{2p} = 0 \qquad (3)$$

$$h^{1000}_{2t} + \mu(u h^{1000})_{2x} + \mu(v h^{1000})_{2y} + \frac{\partial}{\partial p}(\omega h) - \mu(u H_{2x} + v H_{2y}) = 0 \qquad (4)$$

$$T_{2t} + \mu(\bar{u}^{px} \bar{T}^x)_x + \mu(\bar{v}^{py} \bar{T}^y)_y + (\omega T)_{2p} = 0 \qquad (5)$$

In equation (4) the expression

$$\frac{\partial}{\partial p}(\omega h) = h\frac{\partial \omega}{\partial p} + \omega\frac{\partial h}{\partial p} = \frac{1}{50}(\omega_{1000} - \omega_{950})h_{1000} - \frac{1}{100}\omega_{1000} h'_{950}$$

is used to be consistent with the continuity equation

$$u_{2x} + v_{2y} + \omega_p = 0 \qquad (6)$$

Writing $h' = h'_I + h'_0$ and $h^{1000} = h^{1000}_I + h^{1000}_0$ where I and 0 refer to the ICAO value and the departure for ICAO respectively, equations (3) and (4) become

$$(h'_0)_{2t} + \mu(\bar{u}^p h'_0)_{2x} + \mu(\bar{v}^p h'_0)_{2y} + \beta\omega + h'_0 \omega_{2p} = 0 \qquad (3a)$$

with $\beta = \beta_I + \beta_0$

and

$$(h^{1000}_0)_{2t} + \mu(u h^{1000}_0)_{2x} + \mu(v h^{1000}_0)_{2y} + h^{1000}_0 \frac{\partial \omega}{\partial p} + \omega \frac{\partial h}{\partial p} - \mu(u H_{2x} + v H_{2y}) = 0 \qquad (4a)$$

with

$$\frac{\partial \omega}{\partial p} = \frac{1}{50}(\omega_{1000} - \omega_{950})$$

$$\frac{\partial h}{\partial p} = -\frac{1}{100}(h'_I + h'_0)_{950}$$

These equations differ from the 11-level model equations mainly in the vertical advection terms in equation (3). β is evaluated in terms of potential temperature (see Burridge and Gadd, 1975).

The σ - model conserves total energy. The new pressure coordinate model conserves energy in the horizontal, but the vertical advection terms in equation (3) are not conservative.

3. EXPERIMENTS

The new explicit model (referred to as M20) was run to 3 days using a 5 minute time-step on five occasions (data times 12Z on 7/11/76, 21/11/76, 2/1/77, 9/1/77 and 23/1/77) and the resulting forecasts were compared with those obtained using the semi-implicit centred octagon (referred to as TU) and with the actuals. On 23/1/77 a 3-day forecast was also obtained using the explicit version of the centred octagon (with a 2½ minute timestep).

4. RESULTS

The forecasts produced by the M20 model are very similar to those produced by the TU model. In general, the M20 forecasts are slightly worse particularly at MSL pressure; lows are slightly less deep, highs are less high and the forecast is a bit rougher especially over topography. The lows and highs are usually, but not always, worse in the M20 model.

At 500 mb the forecasts are even more similar, though the M20 model tends to produce lows whose depths are closer to the actual. Again, it is a little rougher than the TU model.

The differences between the forecasts are due probably almost entirely to the differences in the grids rather than the differences in the finite difference scheme. An experiment (described in Forrester, 1977) was carried out to change the horizontal advection finite difference scheme in the Centred Octagon (but keeping the same grid) and it was found that this produced very little change in the forecast at 3 days. There were some changes (smaller than the changes found in the M20 experiment) in the depths and heights of features at MSL and 500 mb but no changes in their positions, and there was no overall improvement in the case considered.

It is concluded that the unstaggered grid gives slightly worse results than the staggered grid especially at MSL. The improvement in the depths of 500 mb lows might be due to the coarser grid or to the finite difference scheme or to both.

The PMSL and H500 charts for 3 of the 5 integrations are included in this report, and a brief discussion of the basic differences between the various forecasts and the actuals follows in Section 5.

5. DISCUSSION OF THE FORECASTS

The main differences between the M20 and TU forecasts and the actuals for 3 case studies are given below. The explicit TU model is included in the last case study to indicate that there are very few differences between the explicit and the semi-implicit schemes on the same grid. The explicit model is slightly better. For further discussion of this point in connection with the rectangle see Burridge (1975).

(1) 7/11/76

PMSL The Newfoundland low has a similar (wrong) shape but is less deep in M20 (worse).

The UK low is deeper in M20 (worse).

The Atlantic high is the same (correct)

The Great Lakes low is similar (wrong).

The Pacific low is better positioned in M20 but is less deep (worse).

The Asia high is less high in M20 (worse).

The Japan Sea low is similar (wrong).

H500 The Atlantic ridge is the same in both models (about right).

The UK low is slightly deeper in M20 (Better).

The Caspian cut-off is deeper in M20, but not deep enough.

The Pacific trough is the same in both models (too far west).

The Rockies ridge, is the same in both models (too weak).

The Labrador low has the centre better positioned in M20, but the Western part is better in TU.

The Polar low is deeper in M20 but not quite deep enough.

(2) <u>2/1/77</u>

PMSL The Arctic low is not quite so deep in M20 (worse).

The European high is less high in M20 (worse) and has the same (slightly wrong) position.

The Atlantic high is too high in M20, but too low in TU.

The flow over the southern UK is more cyclonic in M20 (better).

The Pacific low - M20 has a double centre (correct), but the position of the secondary centre is wrong. The position of the main centre is better in M20 than in TU. The main centre is less deep in M20 (correct).

The Asia high is less high in M20 (worse), and is very rough.

The low south of Newfoundland is noticeably less well positioned in M20.

H500 The Spain low is less deep in M20 (worse) and has a similar (wrong) position.

The Alaska low is not really present in M20.

Neither forecast predicts the flow over the Rockies correctly.

(3) <u>23/1/77</u>

PMSL The North Atlantic low is less deep in M20 (better) and the position is slightly further north (worse).

The Atlantic ridge is weaker in M20, but there is the same major error in both models.

The West America high is better in M20, but is not high enough.

The Pacific low is less deep in M20 (worse).

The Kurile low has the correct depth in M20.

The Japan low is more developed in M20 than in TU or actual.

The Polar high is less high in M20 (worse).

M20 is very rough over Asia.

H500 The Atlantic low is less deep in M20, but closer to actual.

The Scandinavian low is similar (wrong) in both models.

The Canada low is deeper in M20, closer to actual.

The East Asia low is deeper in M20, closer to actual.

The Polar high has the same height (not high enough) in M20, but the position is worse.

The West Atlantic ridge is less intense in M20 (worse).

(3)(i) 23/1/77 Comparison of TU(EXPLICIT) and TU(SEMI-IMPLICIT)

PMSL The forecasts are very similar, but there are some small differences.

The UK low has slightly higher pressure in TU(EX) (better).

The Pacific low is better positioned in TU(EX).

The Pacific high is less high in TU(EX) (better).

The North Siberian high is less high in TU(EX) (worse).

H500 There are very few differences.

The East Siberian low is deeper in TU(EX) (better).

The Scandanavian low is slightly deeper in TU(EX), but rather different for the actual.

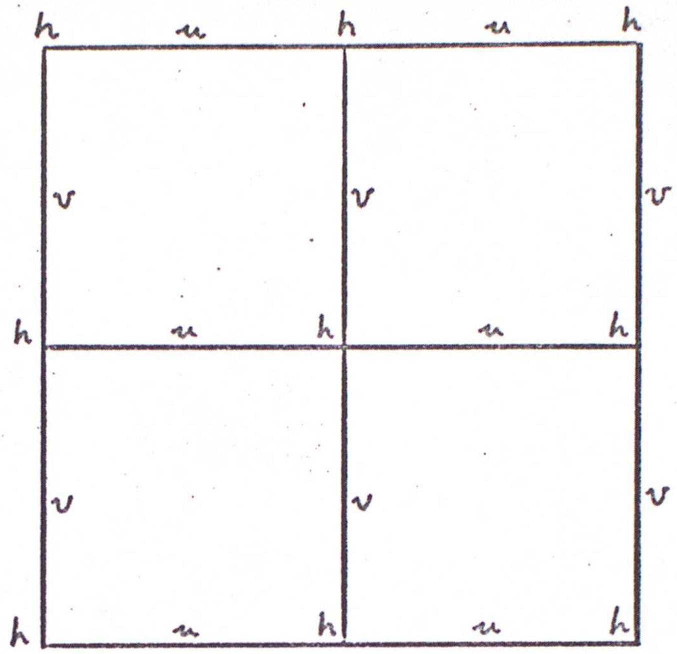
6. PROGRAMMING NOTES

The relevant source modules are named NBOLDMN, NBOCTEW, NBOCTEM, NBADDTH, NBEVENUV, NBEVENTH, NBEVENHØ, NBEVENR, NBOCTDF2, NBOCTSF, and the load module is NBUCOCT.

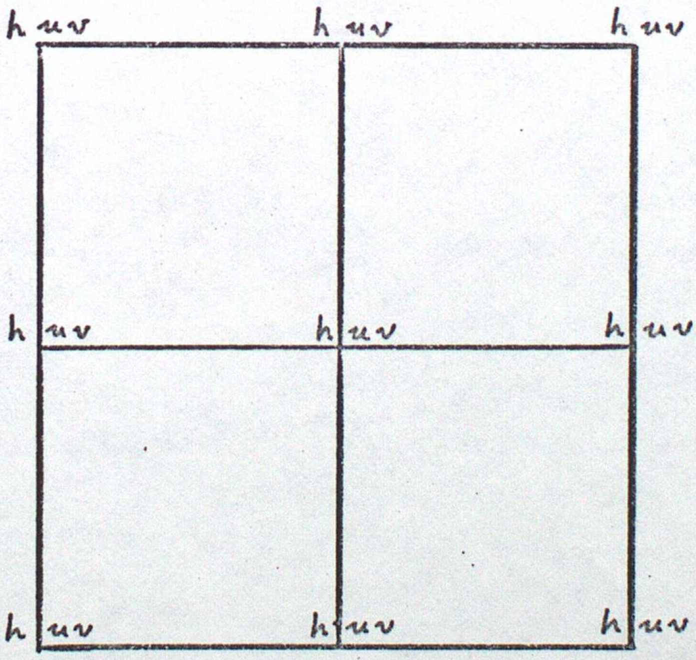
The programs N2ØINT and NCORI1 set up the initial data.

REFERENCES

BURRIDGE, D.M.	1975	Q.J.R. Met. Soc. 101, 777.
BURRIDGE, D.M. and GADD, A.	1975	Met O 11. Technical Note No. 48.
FORRESTER, D.A.	1977	Met O 11. Technical Note No. 90.



GRID A

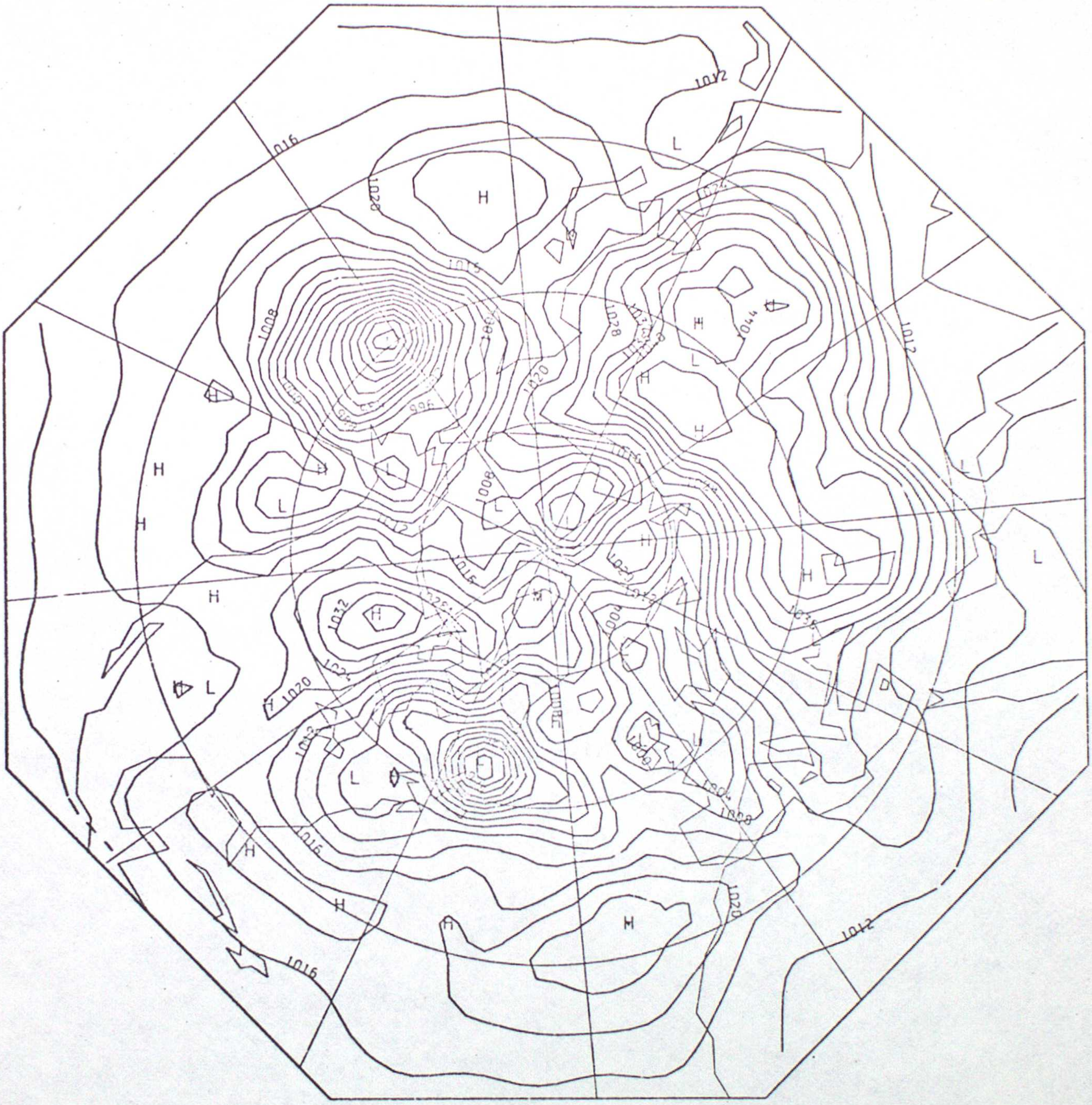


GRID B

FIGURE (1)

M.S.L. PRESSURE ISOBARS AT 4MB INTERVALS

O HR.FORECAST. DATA TIME 12 Z 10 / 11 / 76. VERIFICATION TIME 12 Z 10 / 11 / 76



1(a) ACTUAL SURFACE PRESSURE 10/11/76

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

72 HR.FORECAST. DATA TIME 12 Z 7 / 11 / 76. VERIFICATION TIME 12 Z 10 / 11 / 76

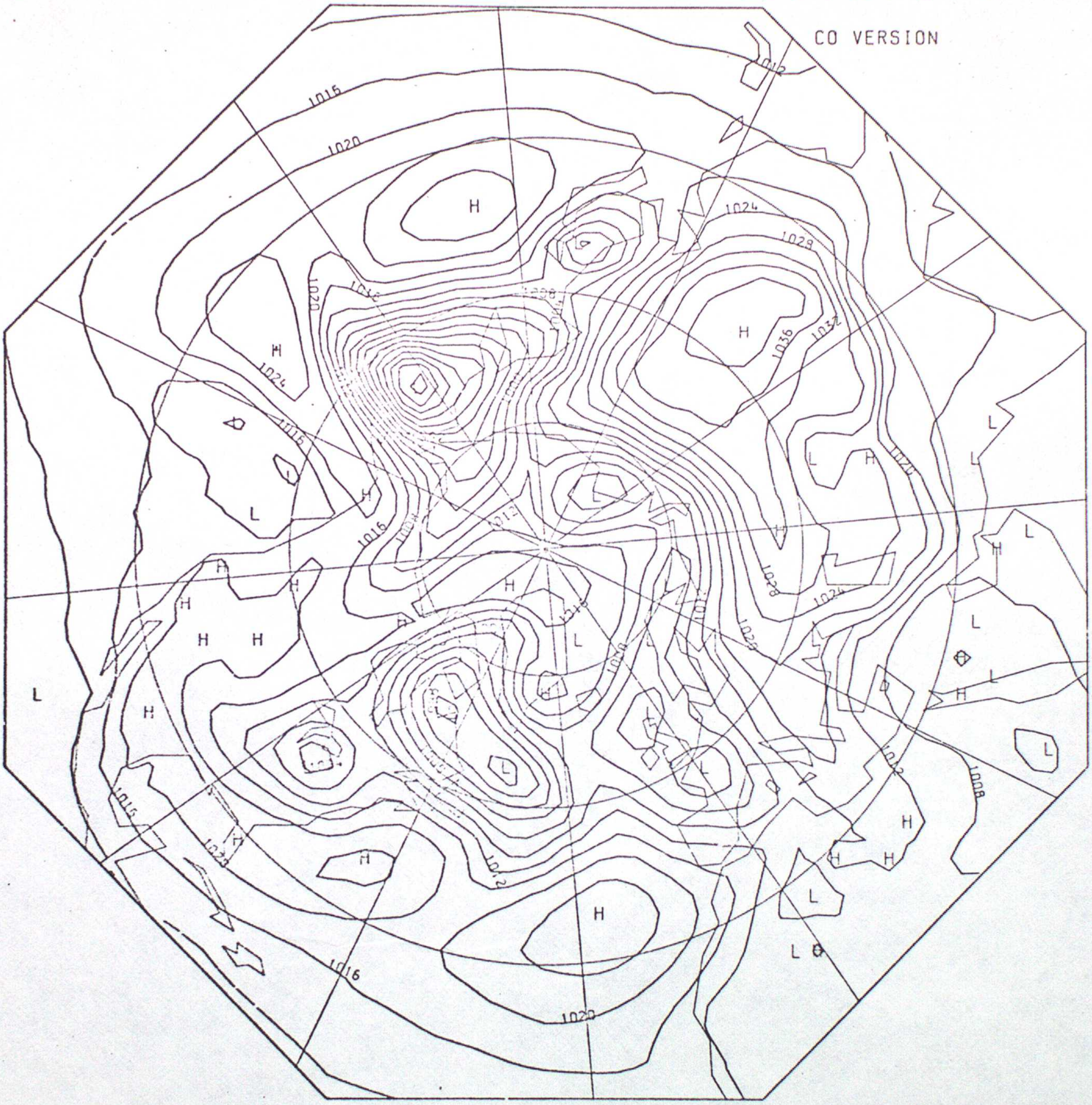
SI VERSION

1(b) M20 SURFACE PRESSURE 10/11/76

SURFACE PRESSURE   ISOBARS AT 4MB INTERVALS

72 HR.FORECAST. DATA TIME 12 Z 7 / 11 / 76. VERIFICATION TIME 12 Z 10 / 11 / 76

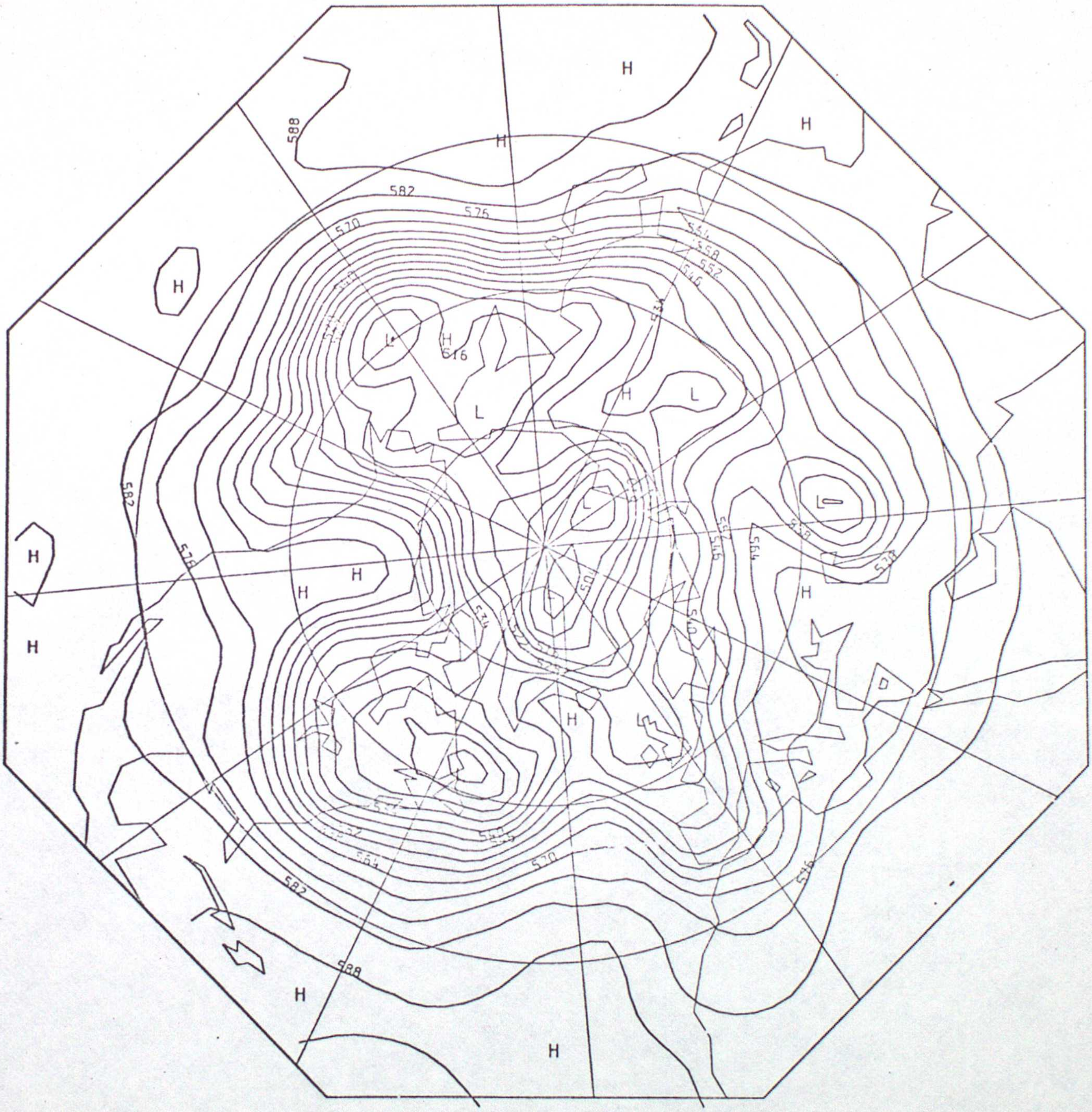
CO VERSION



1(c)   TU   SURFACE PRESSURE   10/11/76

500 MB HT CONTOURS AT 6 DM INTERVALS

0 HR.FORECAST. DATA TIME 12 Z 10 / 11 / 76. VERIFICATION TIME 12 Z 10 / 11 / 76



1 (d) ACTUAL 500MB HEIGHTS 10/11/76

500 MB CONTOURS CONTOUR LINES AT 6 DECAMETER INTERVALS

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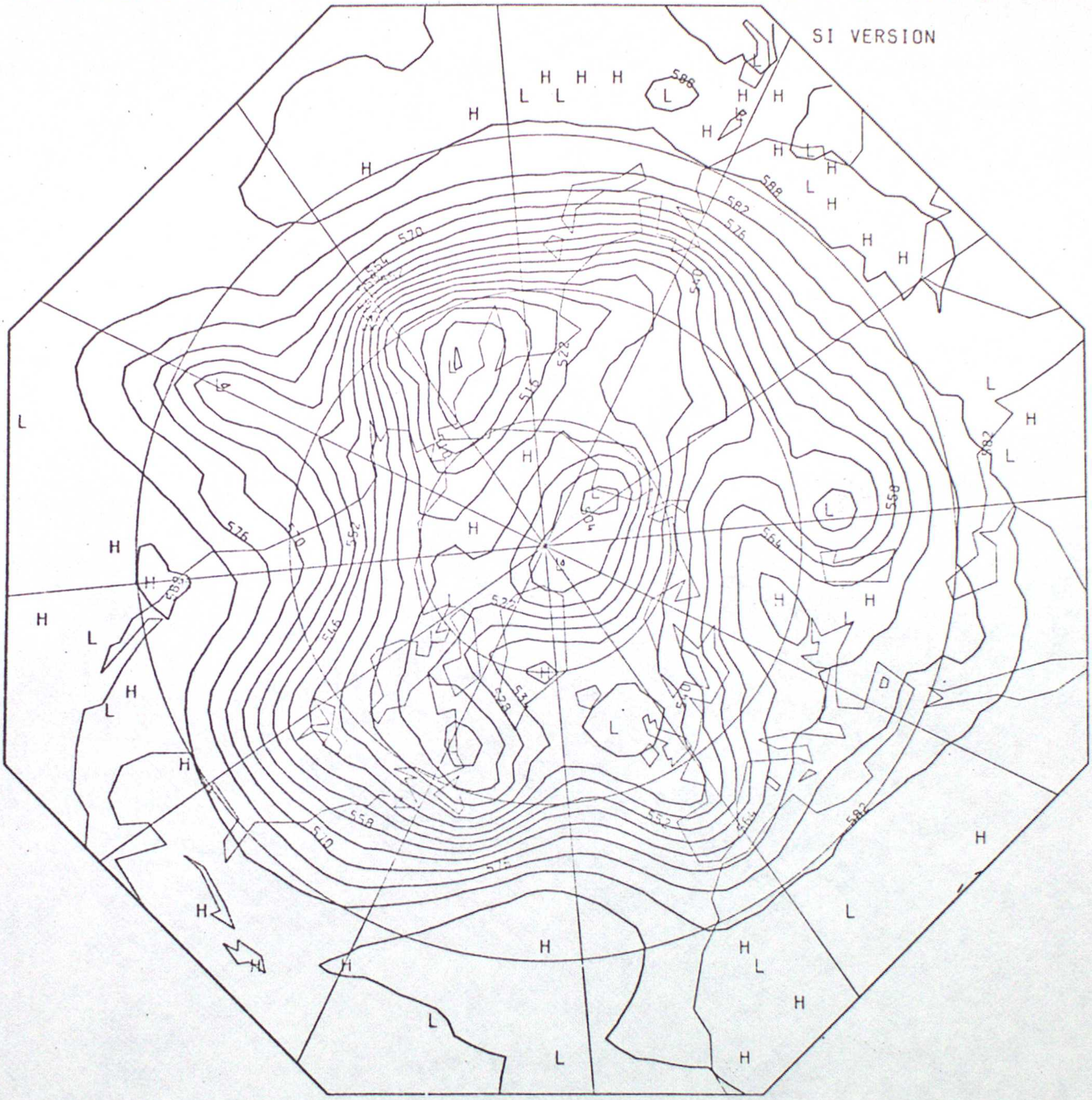
SI VERSION



1 (e) M20 500MB HEIGHTS 10/11/76

500 MB CONTOURS CONTOUR LINES AT 6 DECAMETER INTERVALS

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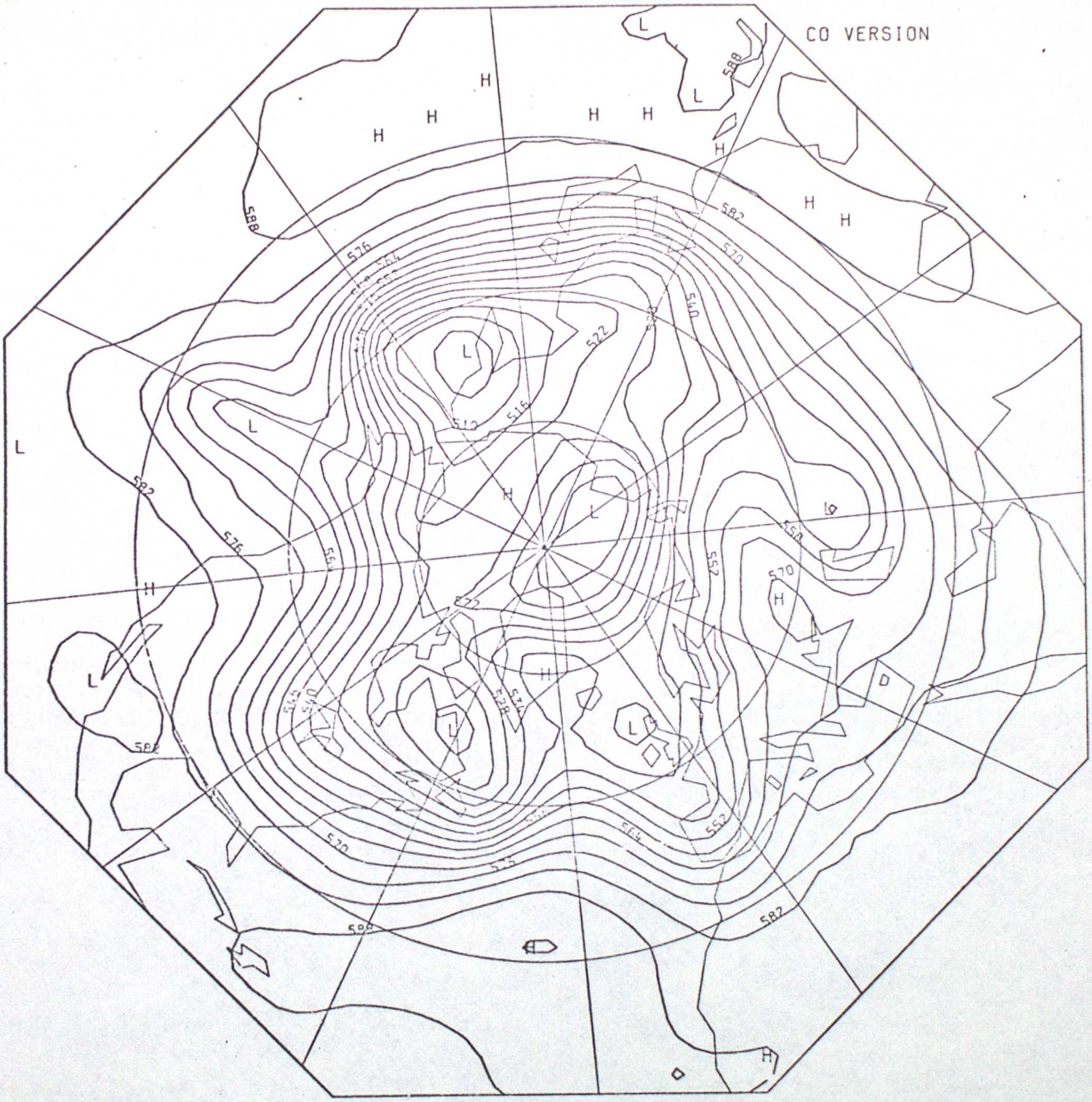
CO VERSION

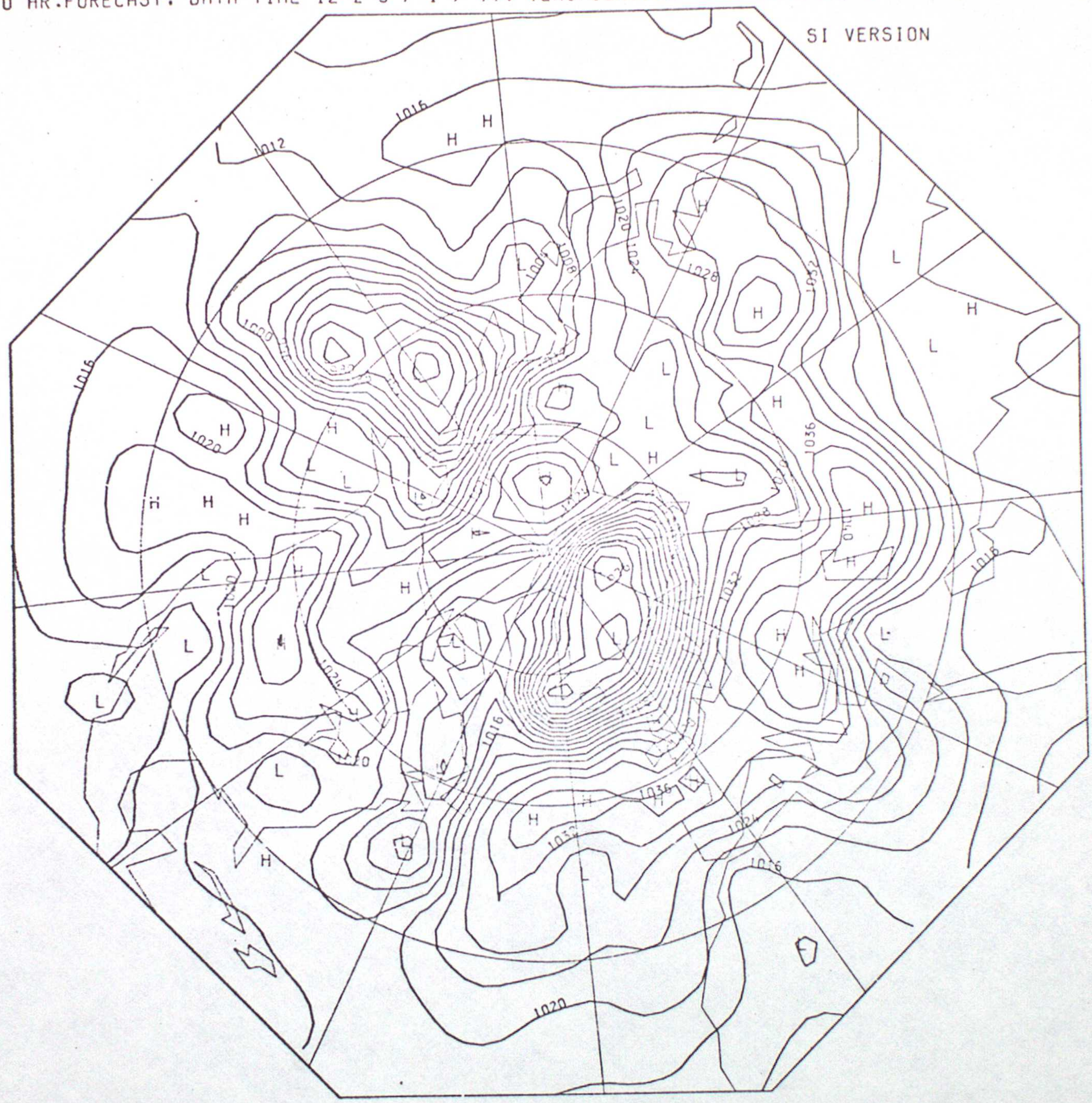


1(f) TU 500MB HEIGHTS 10/11/76

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

0 HR.FORECAST. DATA TIME 12 Z 5 / 1 / 77. VERIFICATION TIME 12 Z 5 / 1 / 77

SI VERSION



2 (a) ACTUAL SURFACE PRESSURE 5/1/77

SURFACE PRESSURE   ISOBARS AT 4MB INTERVALS

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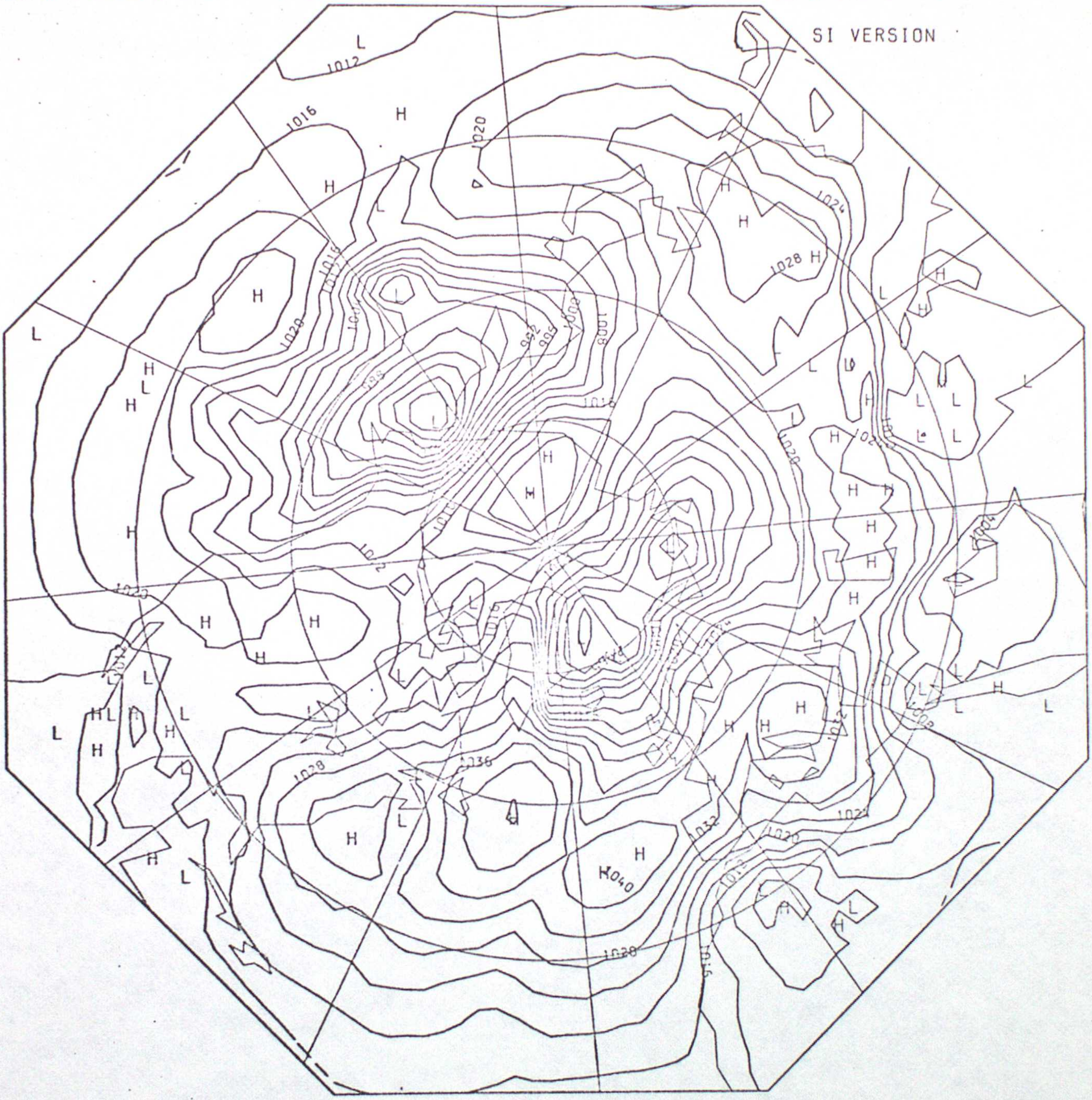
SI VERSION

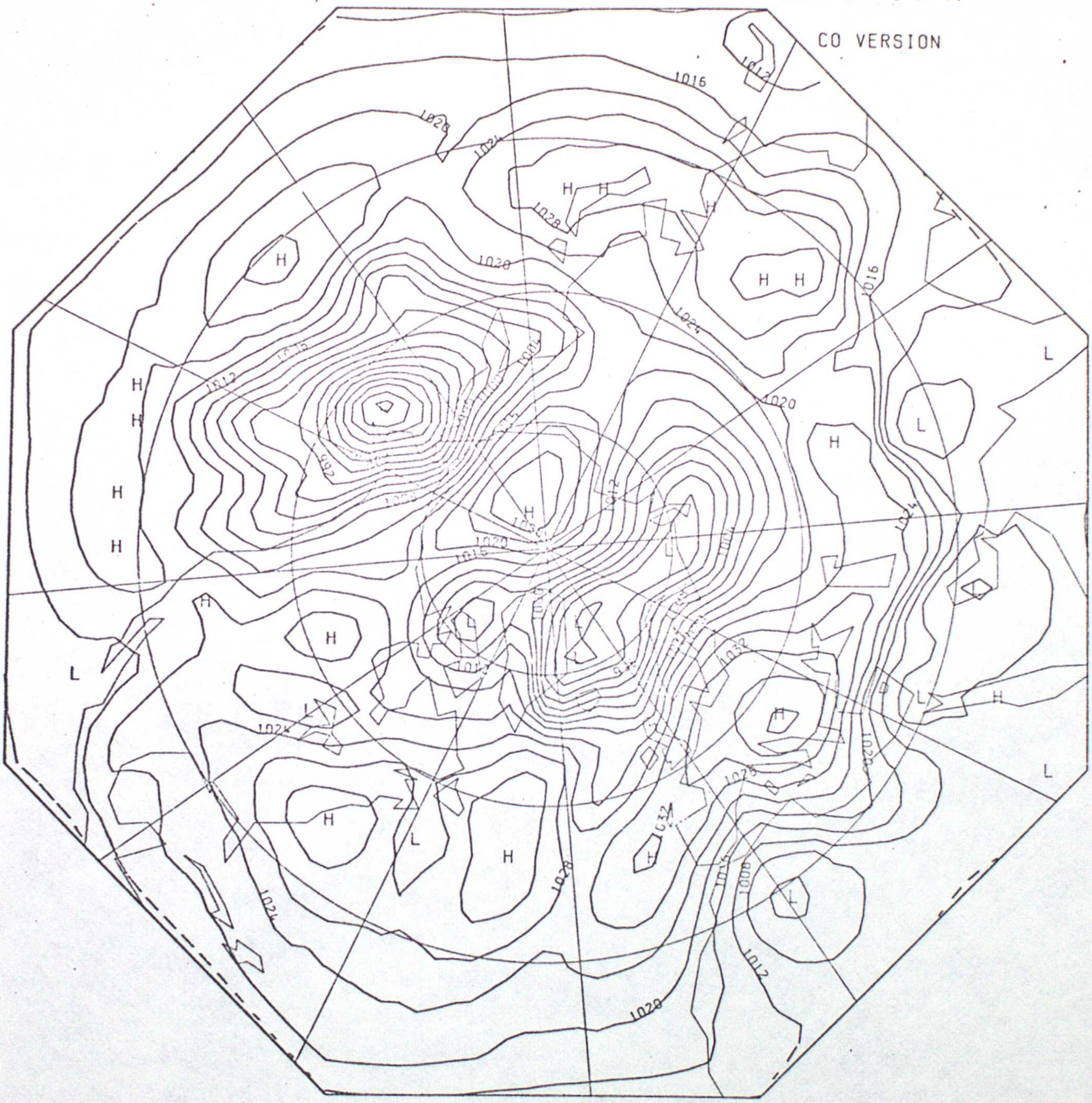


2 (b) M20 SURFACE PRESSURE 5/1/77

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

72 HR.FORECAST. DATA TIME 12 Z 2 / 1 / 77. VERIFICATION TIME 12 Z 5 / 1 / 77

CO VERSION

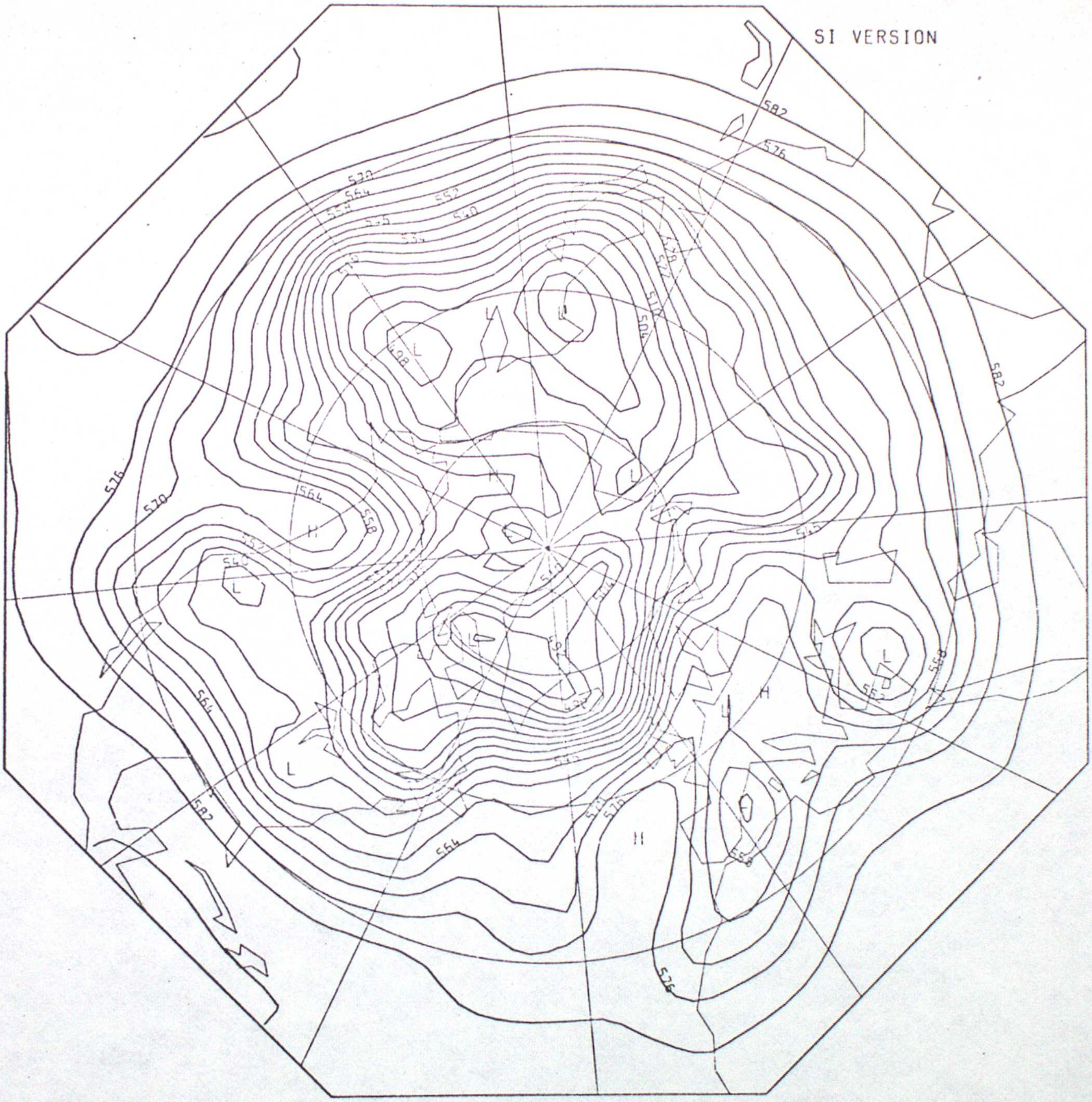


2 (c) TU SURFACE PRESSURE 5/1/77

500 MB CONTOURS CONTOUR LINES AT 6 DECAMETER INTERVALS

0 HR.FORECAST. DATA TIME 12 Z 5 / 1 / 77. VERIFICATION TIME 12 Z 5 / 1 / 77

SI VERSION

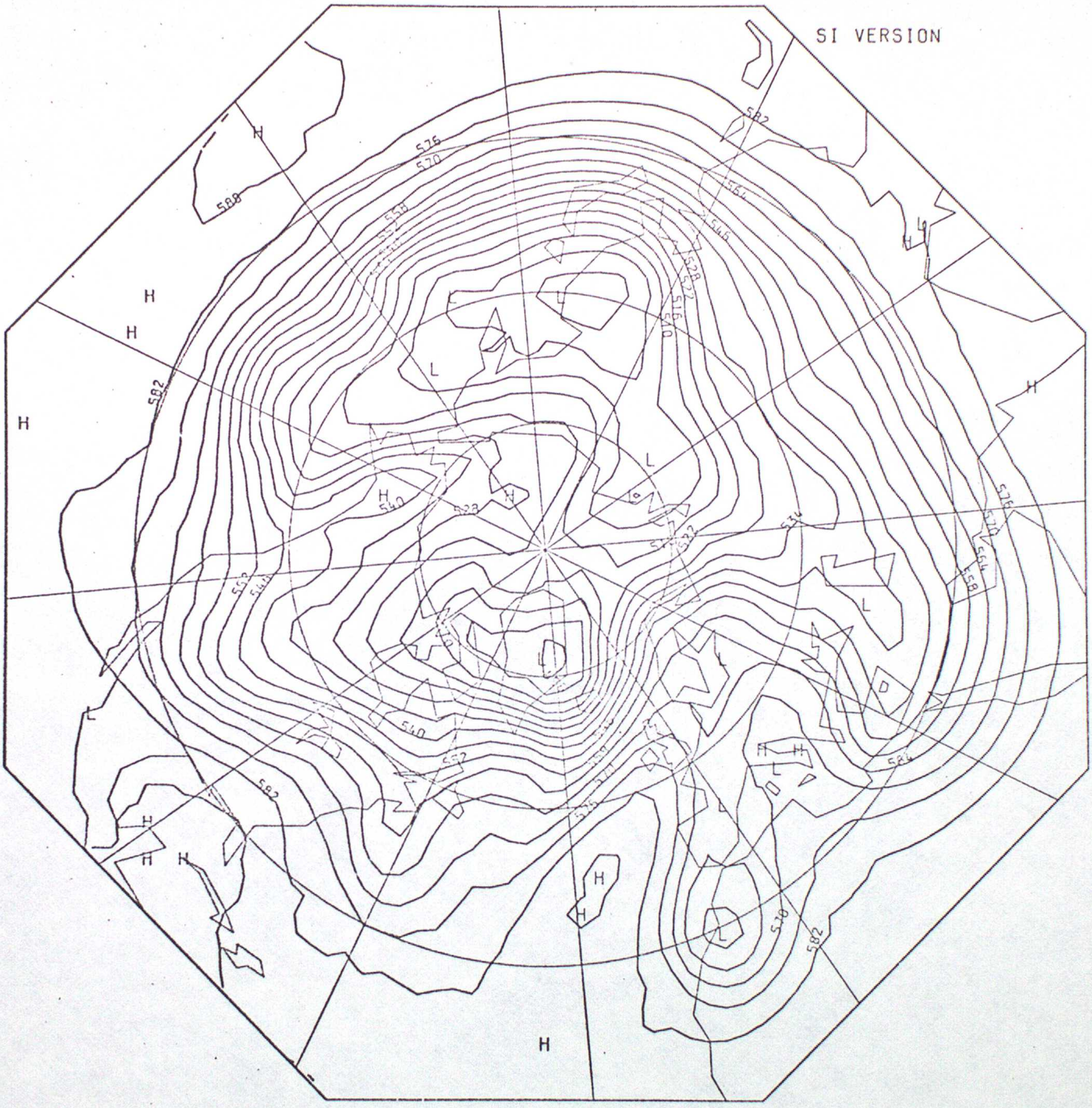


2 (a) ACTUAL 500MB HEIGHTS 5/1/77

500 MB CONTOURS CONTOUR LINES AT 6 DECAMETER INTERVALS

72 HR.FORECAST. DATA TIME 12 Z 2 / 1 / 77. VERIFICATION TIME 12 Z 5 / 1 / 77

SI VERSION

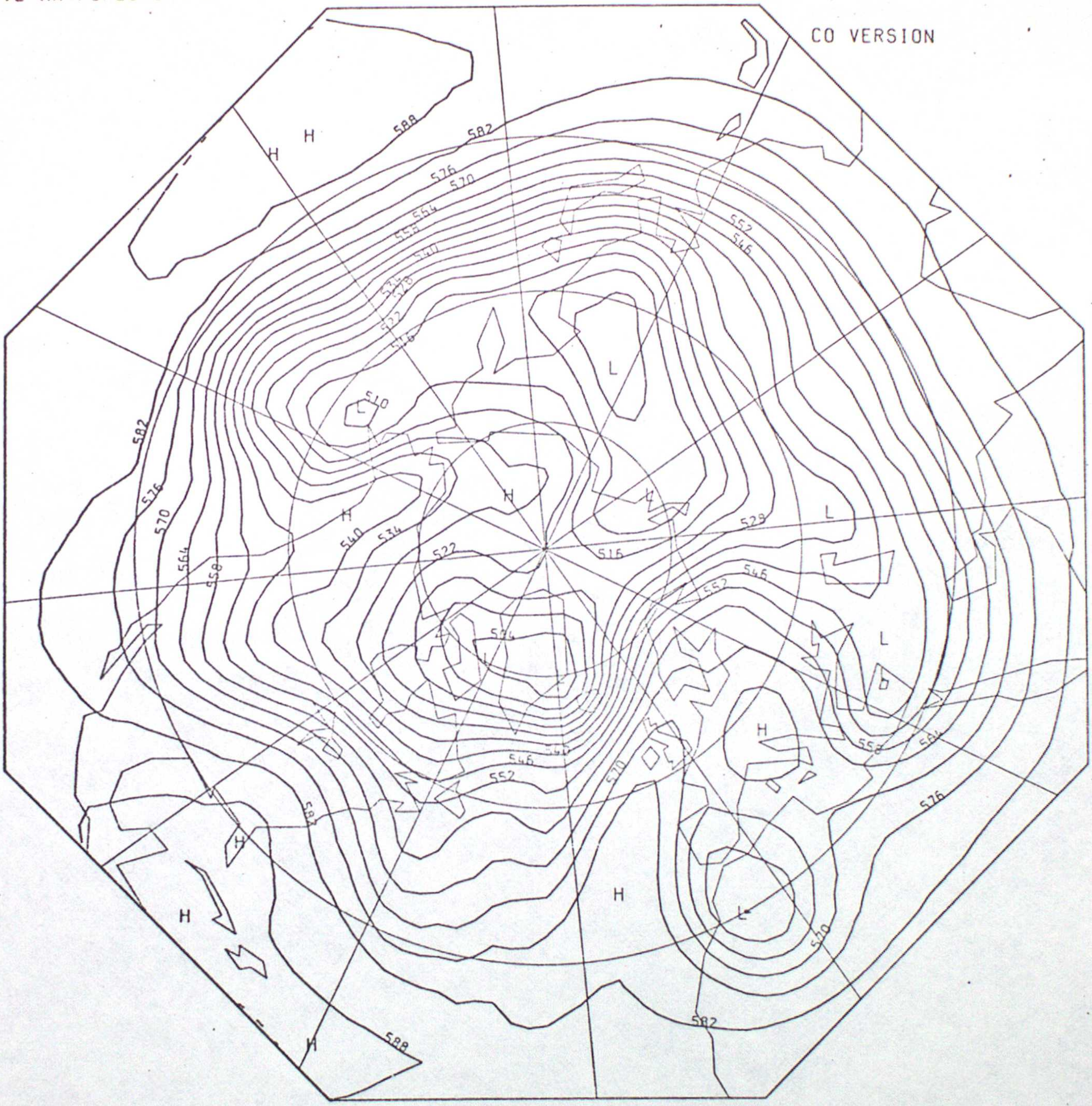


2(e) M20 500MB HEIGHTS 5/1/77

500 MB CONTOURS   CONTOUR LINES AT 6 DECAMETER INTERVALS

72 HR.FORECAST. DATA TIME 12 Z 2 / 1 / 77. VERIFICATION TIME 12 Z 5 / 1 / 77

CO VERSION

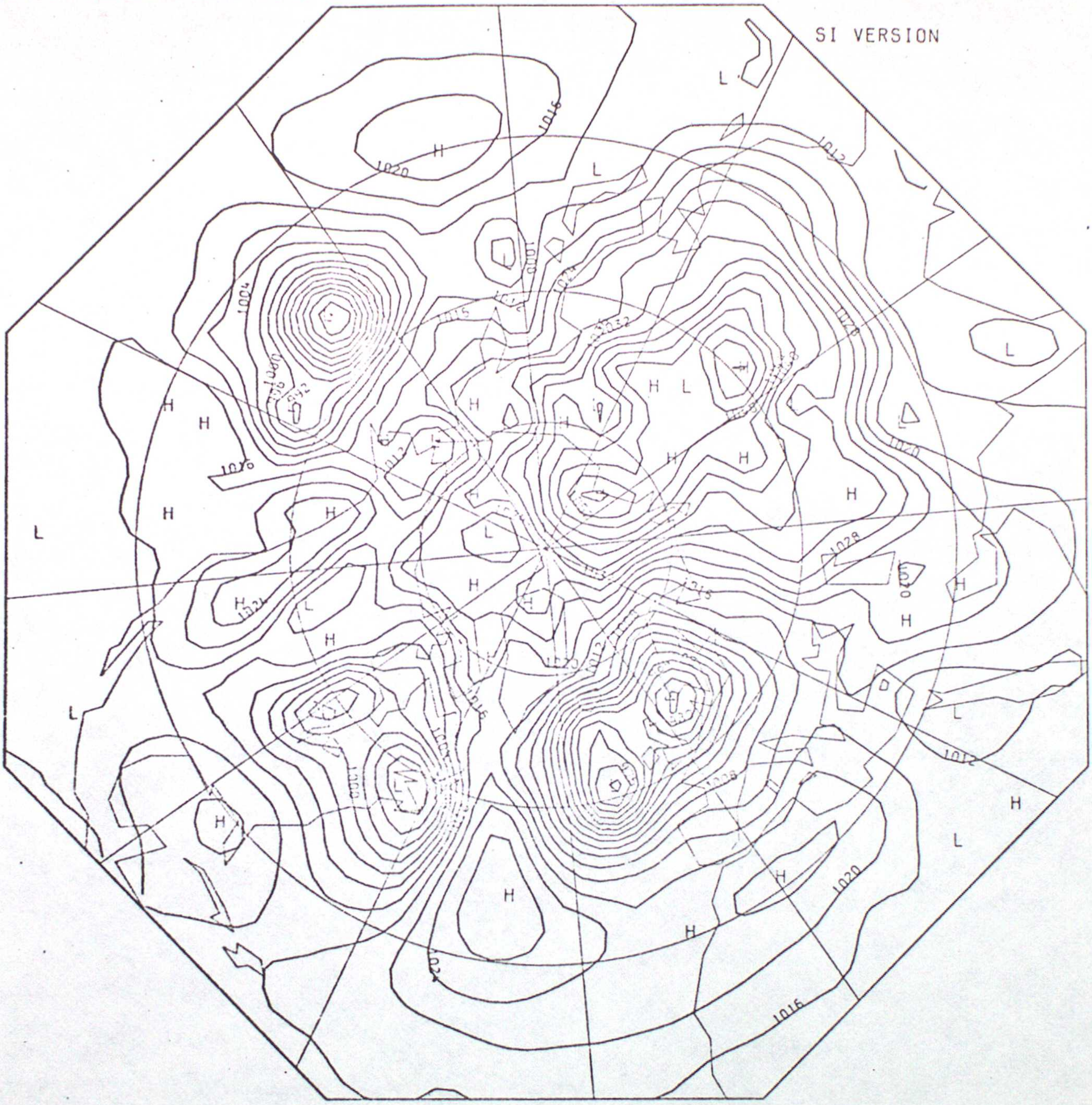


2 (f) TU 500MB HEIGHTS 5/1/77

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

0 HR.FORECAST. DATA TIME 12 Z 26 / 1 / 77. VERIFICATION TIME 12 Z 26 / 1 / 77

SI VERSION

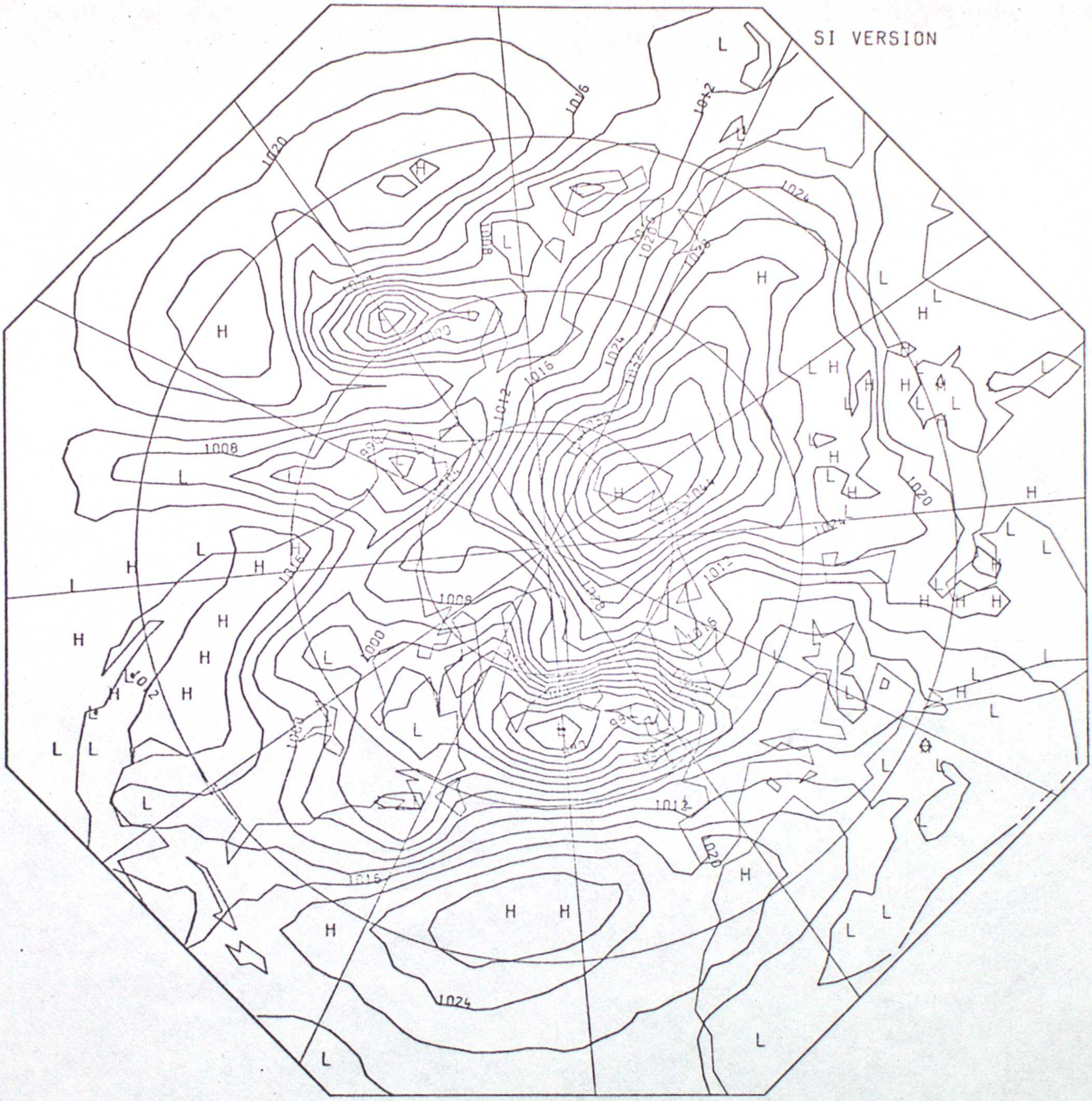


3 (a) ACTUAL SURFACE PRESSURE 26/1/77

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

72 HR.FORECAST. DATA TIME 12 Z 23 / 1 / 77. VERIFICATION TIME 12 Z 26 / 1 / 77

SI VERSION



3 (b) M20 SURFACE PRESSURE 26/1/77

SURFACE PRESSURE ISOBARS AT 4MB INTERVALS

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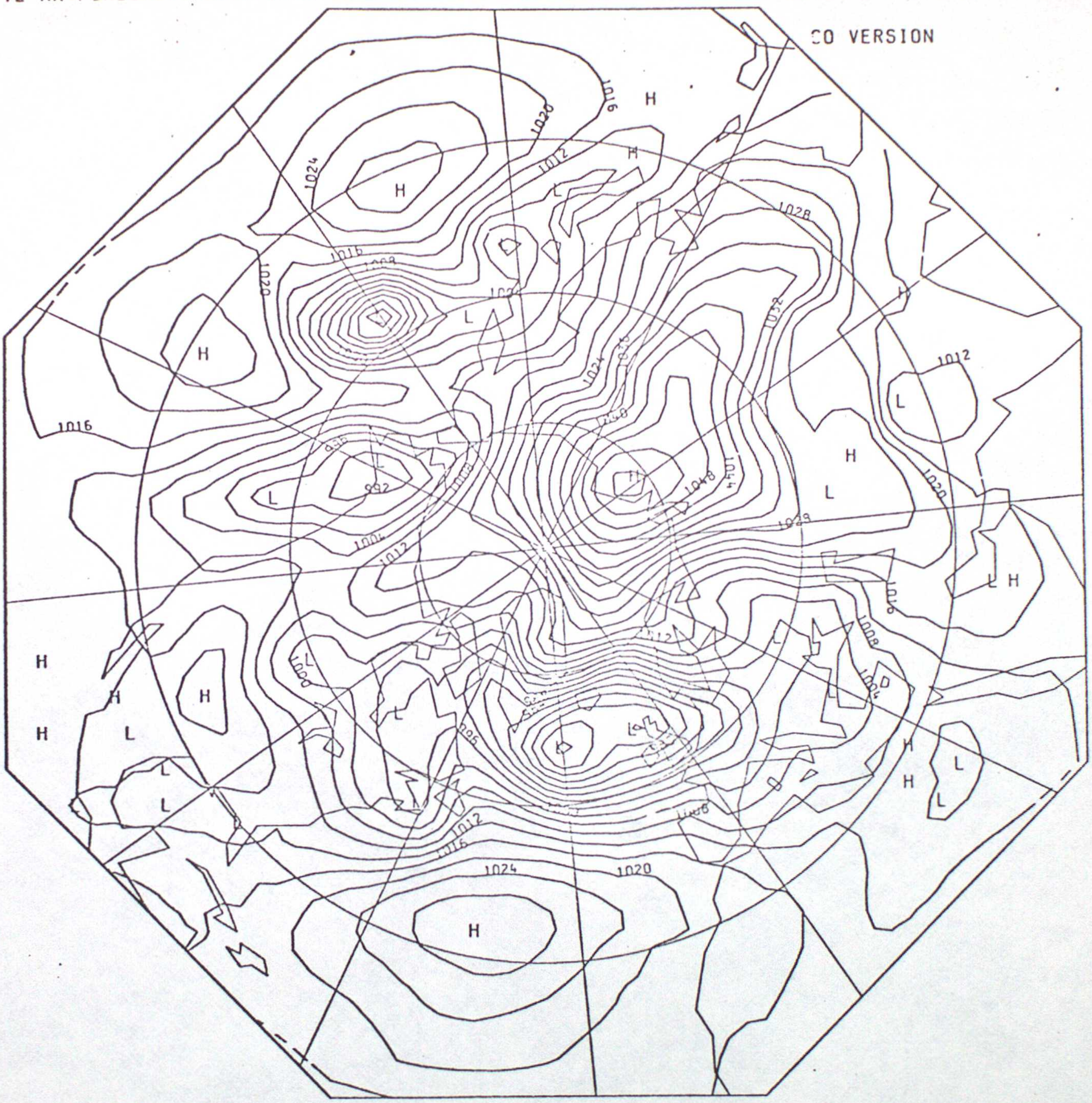
CO VERSION

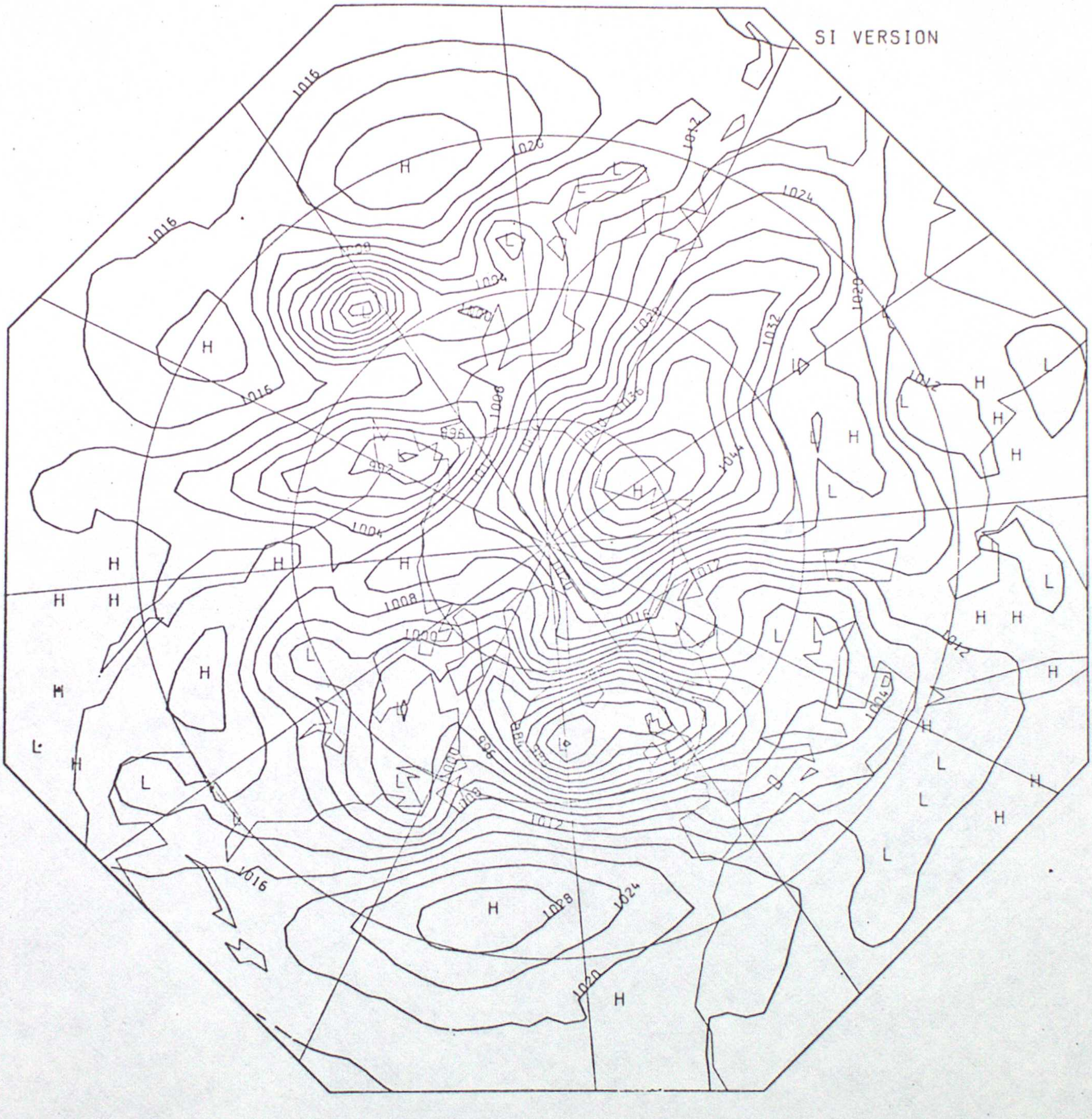


3 (c) TU SURFACE PRESSURE 26/1/77

SURFACE PRESSURE   ISOBARS AT 4MB INTERVALS

72 HR.FORECAST. DATA TIME 12 Z 23 / 1 / 77. VERIFICATION TIME 12 Z 26 / 1 / 77

SI VERSION



3 (c) (i) TU (EXPLICIT) SURFACE PRESSURE
26/1/77

500 MB CONTOURS CONTOUR LINES AT 6 DECAMETER INTERVALS

0 HR.FORECAST. DATA TIME 12 Z 26 / 1 / 77. VERIFICATION TIME 12 Z 26 / 1 / 77

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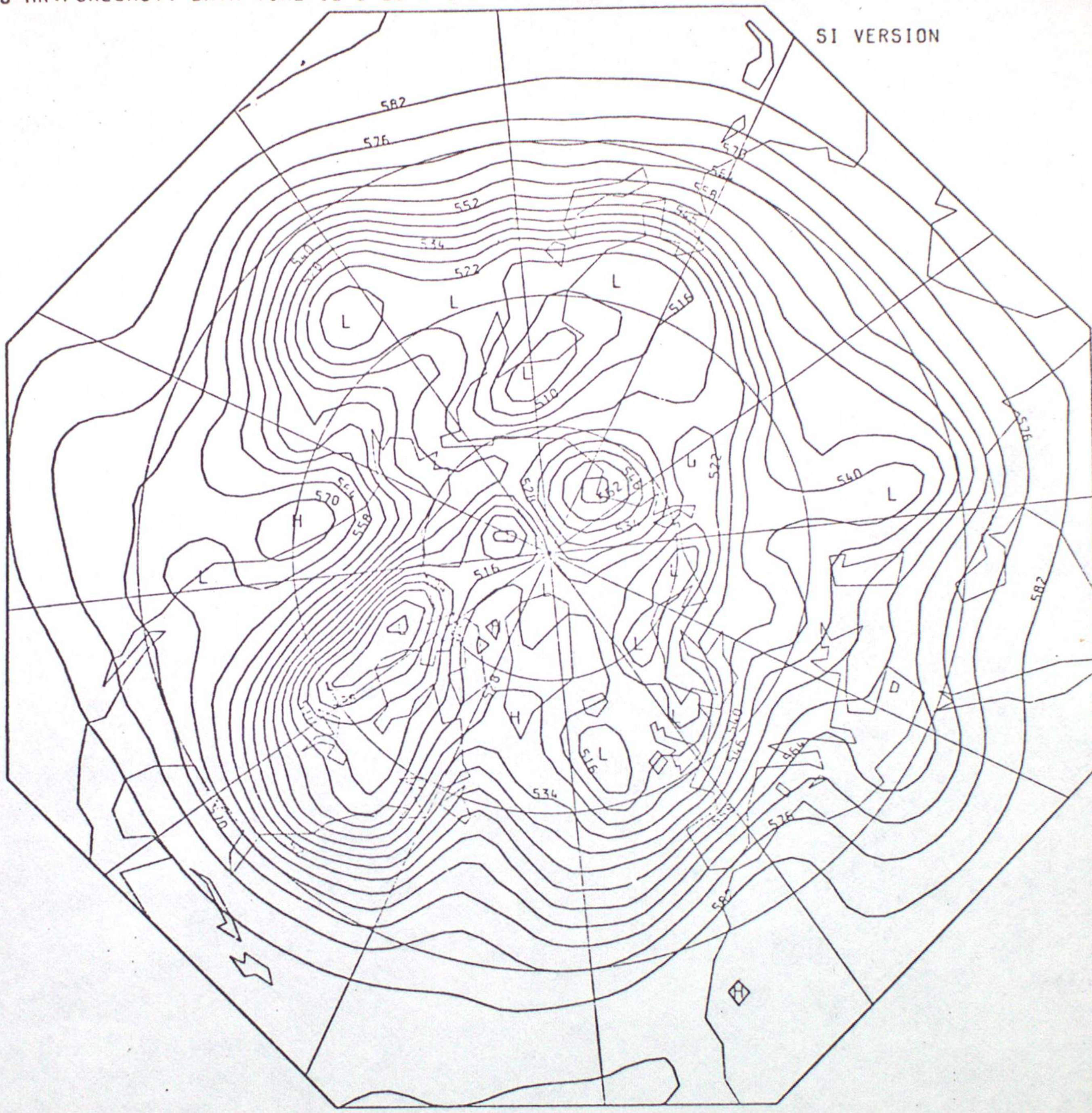

3 (a) ACTUAL 500MB HEIGHTS 26/1/77

500 MB CONTOURS CONTOUR LINES AT 6 DECAMETER INTERVALS

72 HR.FORECAST. DATA TIME 12 Z 23 / 1 / 77. VERIFICATION TIME 12 Z 26 / 1 / 77

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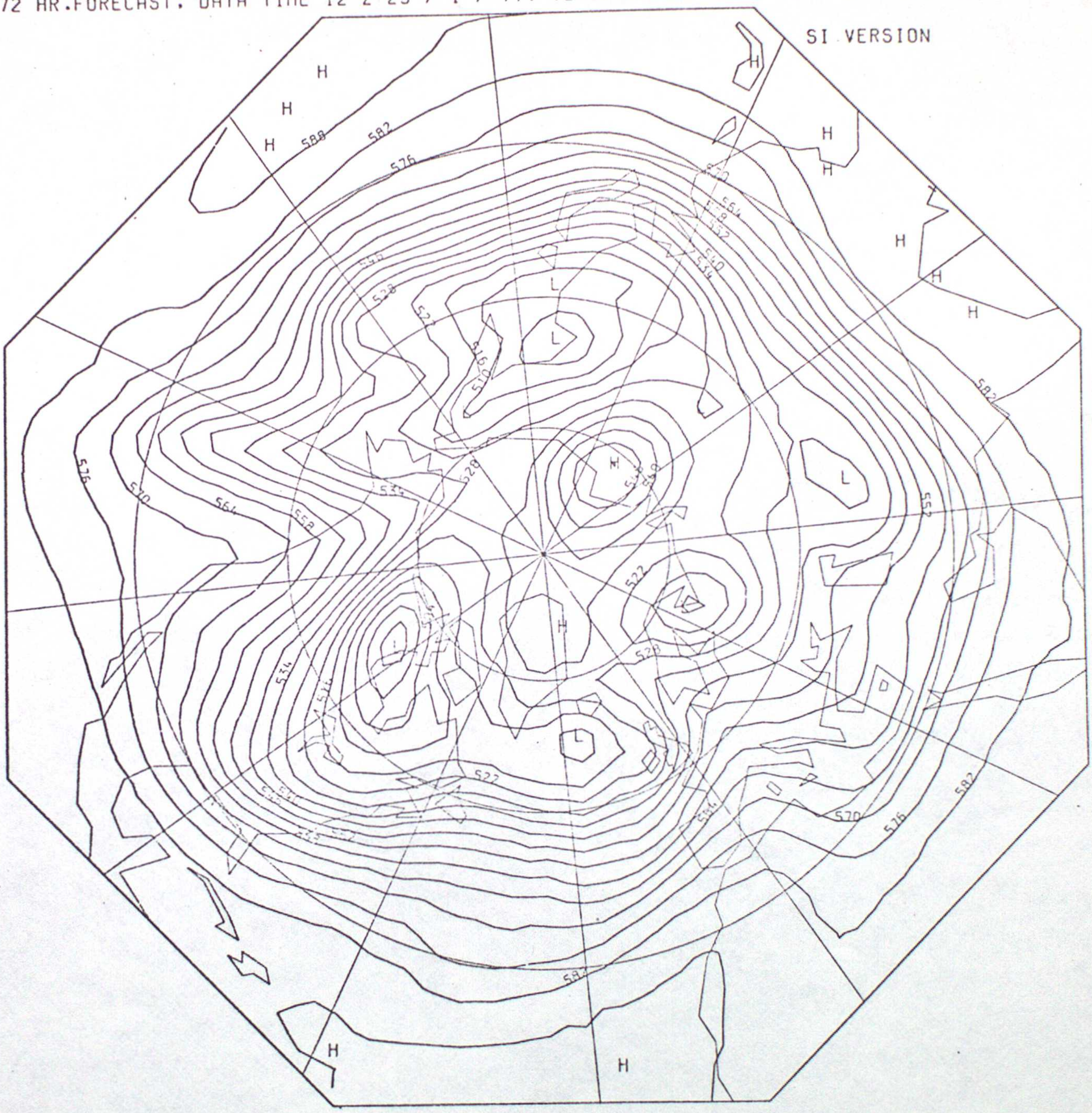

3 (e) M20 500MB HEIGHTS 26/1/77

500 MB CONTOURS CONTOUR LINES AT 6 DECAMETER INTERVALS

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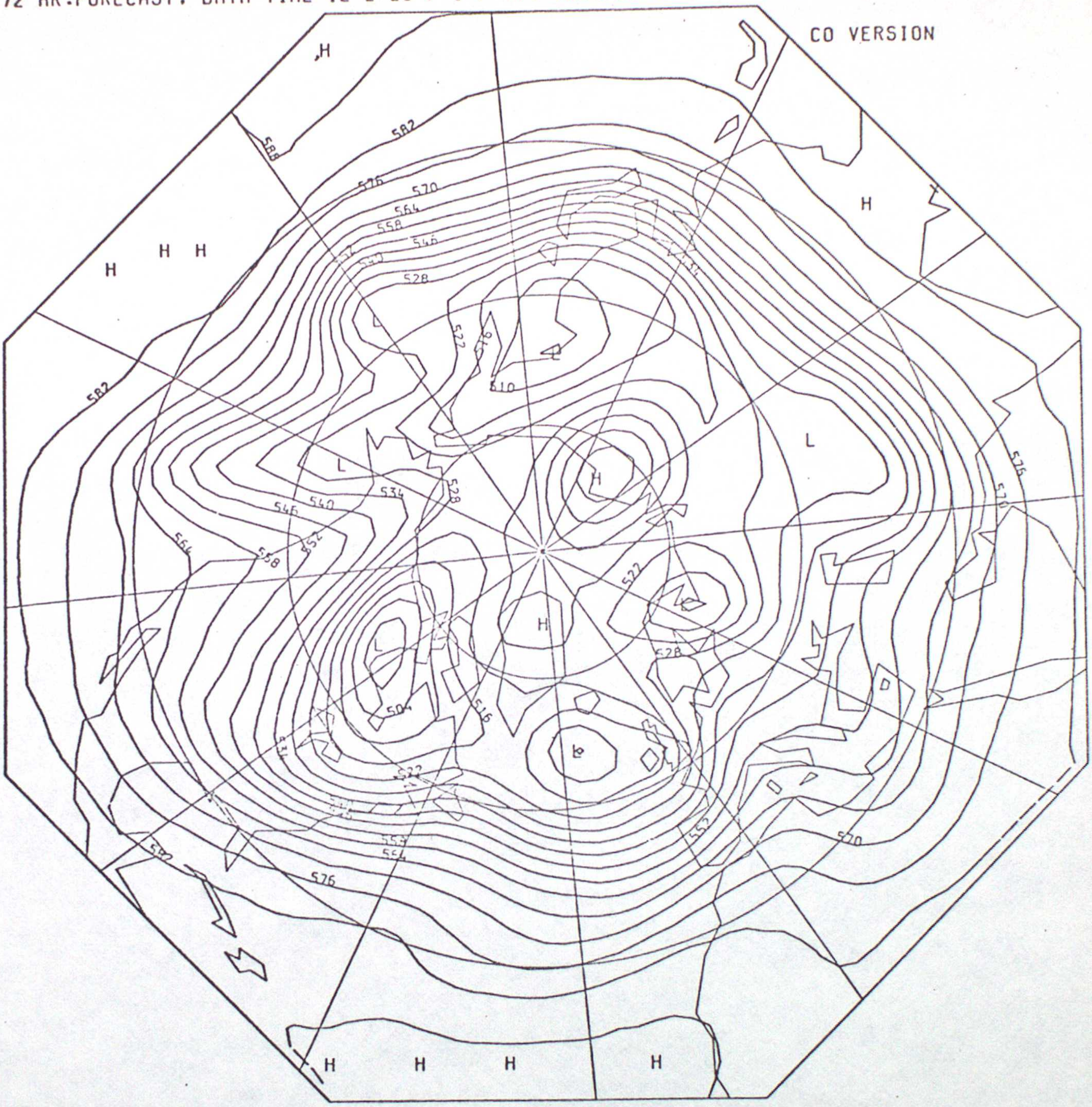
CO VERSION



3 (f) TU 500MB HEIGHTS 26/1/77

500 MB CONTOURS CONTOUR LINES AT 6 DECAMETER INTERVALS

72 HR.FORECAST. DATA TIME 12 Z 23 / 1 / 77. VERIFICATION TIME 12 Z 26 / 1 / 77

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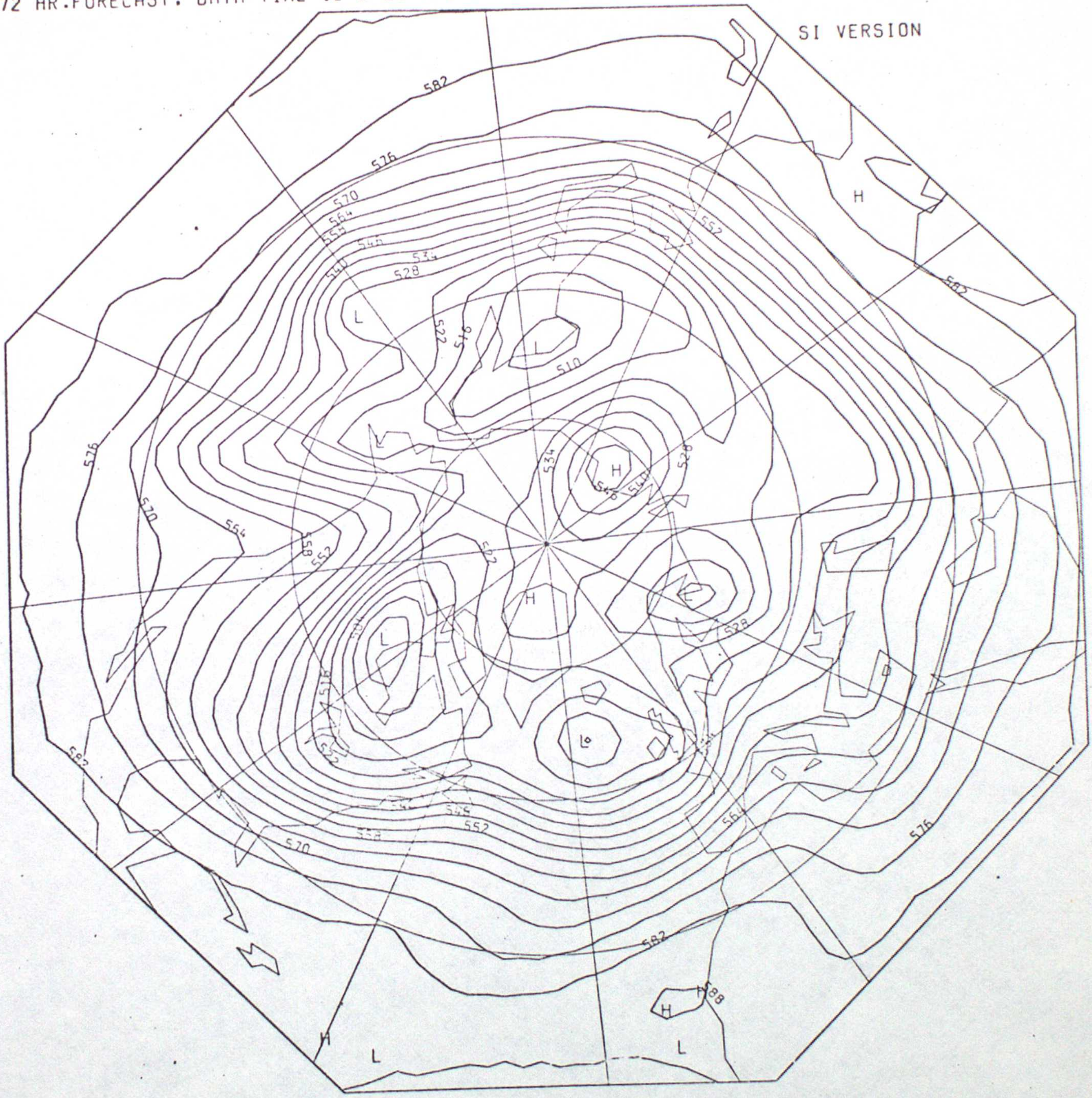

3(f) (i) TU (EXPLICIT) 500MB HEIGHTS
26/1/77