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A CONTRIBUTION ON THE GEOMETRY OF CIRRUS BANDS AS

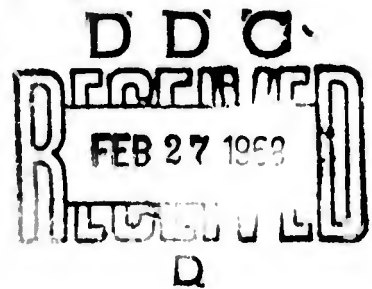
RELATED TO METEOROLOGICAL CONDITIONS

- Preliminary Results -

by

J. REUSS

Institut für Physik der Atmosphäre  
der FLUGWISSENSCHAFTLICHEN  
FORSCHUNGSANSTALT E.V. MÜNCHEN (FFM),  
Außenstelle Darmstadt



Technical Report No. 2

Prepared for the European Office of Aerospace Research of the  
AIR FORCE CAMBRIDGE RESEARCH LABORATORIES

under

Contract AF 61(052)-620

of the European Office, Aerospace Research  
and Prof. Dr. H. Koschmieder

August 1963

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### Foreword

Like Techn. Rep. No. 1, the present report restricts mainly to the empirical facts; the latter, in the one case reported here, are pronounced to such degree as to nearly imply their interpretation. This, in connection with many figures, has enabled to keep the amount of text at a minimum. An "abstract" was hence omitted.

For their good help in preparing the material for this report, the author thanks Miss M.LUCZKA and Mr. R.MEISSNER.

Beside the support given to this research with a share in funds of approximately one third by the FLUGWISSENSCHAFTLICHE FORSCHUNGSANSTALT E.V. München (FFM), by two thirds the research work reported in this document has been sponsored by the U.S. AIR FORCE CAMBRIDGE RESEARCH LABORATORIES through the EUROPEAN OFFICE, AEROSPACE RESEARCH, UNITED STATES AIR FORCE.

### Introduction

The cirrus band case of 13 May. 1963, which is reported here, presents a typical example for similar, but less pronounced cases which have been reported in Techn. Rep. No. 1. In that first report a working hypothesis has been laid down, which is corroborated by the data described in the following. Since the photogrammetric measurements were not yet done into details, the results are denoted as preliminary.

- P. 2

Preliminary Results

On 13 May 1963, bands which stretched from horizon to horizon were observed from 7:00 until 16:00 z; at 17:00 z, drizzling rain started.

Single and stereo photographs were taken according to the following table:

Table I

time	kind of photographs	example see Fig. (i)
7:15 - 7:30	single, sporadic	(1)
8:30 - 9:35	single, by one stereo camera 2-minute intervals, plus panorama	(2)
10:56 -12:25	stereo, at 3-minute intervals	(3)
13:40 -13:49	single series by one stereo camera plus panorama	(4)
15:06 -15:15	single, by one stereo camera at sporadic intervals	-

The essential results of photogrammetric measurements as well as of the synoptic exploration are as follows:

Table II

1	2	3	4		5	6	7
<u>time</u> (GMT)	<u>bands</u> <u>depicted</u> <u>in Fig. (1)</u>	<u>altitude</u> (km)	<u>plane motion vector:</u> <u>bands</u> <u>moving from</u>	<u>velocity</u> (m/sec)	<u>band</u> <u>orientation</u>	<u>tangent isotherm</u> <u>orientation at</u> <u>Darmstadt</u>	<u>streak</u> <u>orientation</u>
7:15	(1)	7.2 *	NW *	not known	3° ↔ 183°	**	
8:30	(2)	7.2 *	323°	11	5° ↔ 185°	at 12:00 Z: 10° ↔ 190°	
11:30	(3)	6.85	296°	11	356° ↔ 176°	at 500 mb 5° ↔ 185°	
13:40	(4)	6.85	not exact- ly known		12° ↔ 192°	at 400 mb 10° ↔ 190° at 300 mb	293° ↔ 113°

\* Estimates of the Bismarckturn weather station at Darmstadt

\*\* for information on the 0:00 and 24:00 Z isotherms see Figs. 7,8,9,10

From Table II, in connection with the figures, the following becomes evident:

- (1) Moving relatively slow, the bands prevail through a relatively long period and with relatively great extent. Their orientation is at considerable angle ( $\approx 60^\circ$ ) to their direction of motion.
- (2) The bands parallel the isotherms (Figs. 7-10); the mean orientation of both differ by a few degrees only.
- (3) Both bands and isotherms approximately parallel the lines of equal cloud cover (Fig. 6). The latter decrease from west toward east almost independent of time.
- (4) The thermal winds at intervals ranging from 600 to 200 mb, of 6:00 and 12:00 z, are nearly in the same vertical plane which is approximately of North  $\longleftrightarrow$  South orientation (Fig. 5). The corresponding wind profiles (Fig. 11) which hence were plotted cross the wind which prevails at cloud level, show a good approximation to the KÜTTNER wind profile and its  $\partial^2 u / \partial z^2$  value<sup>1)</sup> (here, u should be replaced by the thermal wind  $u_{th}$ ). Figure 12, which has been made in accordance with the working hypothesis laid down in Techn. Report No. 1, gives a schematic interpretation.
- (5) The orientation of the streaks, which are only by a small height interval below the bands is not reflected by the isotherm orientations. The mean shear direction within the layer between bands and streaks, however, was found to parallel the streaks, by tracing identified points of both systems.

The figures 14-25 may serve to illustrate the large-scale synoptic

<sup>1)</sup> underlay of Fig. 11 is Fig. 5, Stuttgart (St) hodogram

<sup>2)</sup>  $u_{th}$  here is defined as the thermal wind with respect to the 500 mb wind; (i.e. the wind above 500 mb which results if the 500 mb wind is being subtracted).

situations of the 00Z observations at 500 and 300 mb. An account on more detailed photogrammetric results as well as on the dynamic and thermal stability of the troposphere, will be given in a final report.

References

H.KOSCHWIEDER, J.REUSS (1963a):

Empirical Results on the Geometry of Cirrus Bands  
as Related to Meteorological Conditions.

Techn. Report No. 1 under contract AF 61(052)-620  
with EOAR, AFCRL; Darmstadt 1963

J.REUSS (1963b):

Cirren in vertikaler Windscherung,  
Beiträg. Phys. Atmos. 36, 1/2, 1963

Fig. 1 : 13 May 1963 : Photo-  
graph taken at 7:15  
toward North. Orien-  
tation of faintly  
visible band is  
 $3^{\circ} \leftrightarrow 183^{\circ}$ .



Fig. 2 : 13 May 1963 : Single Photograph taken from right stereo  
camera at 8:50 toward  $332^{\circ}$  (NNW).



Fig. 3: 13 May 1963: Eastern camera  
stereo photograph toward zenith,  
at 11:34.



Fig. 4: 13 May 1963: Western camera single  
photograph at 13:40 toward 120°

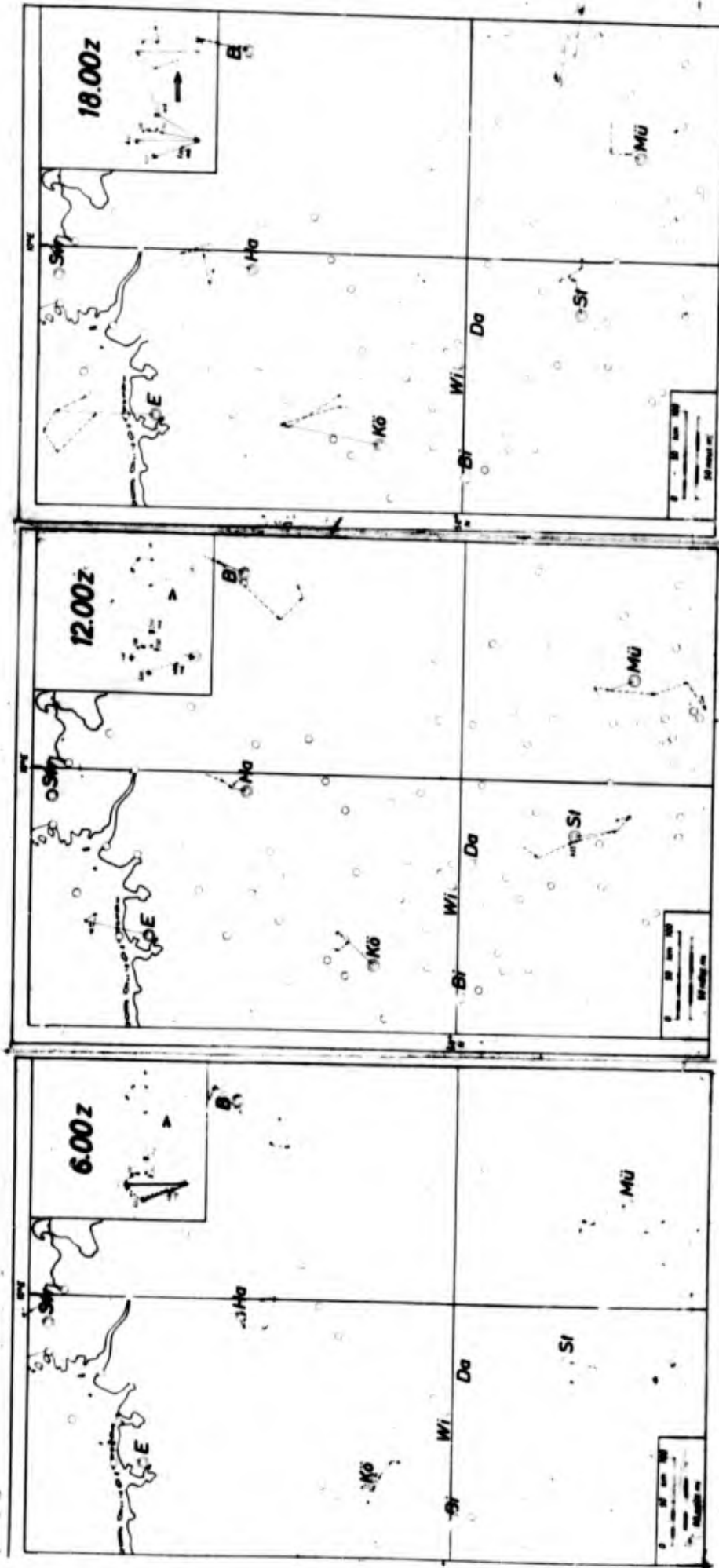
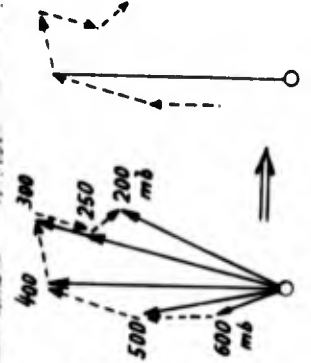


Fig. 5 : 13 May 1963 : Vertical wind shear directions, obtained in principle in the way described at lower right of this figure . The wind at cloud level (at 430 mb) over Darmstadt (Da), as described in Table II, must approximately be the wind vector mean of this level at Stuttgart (St) and Köln (Kö).



1) dashed

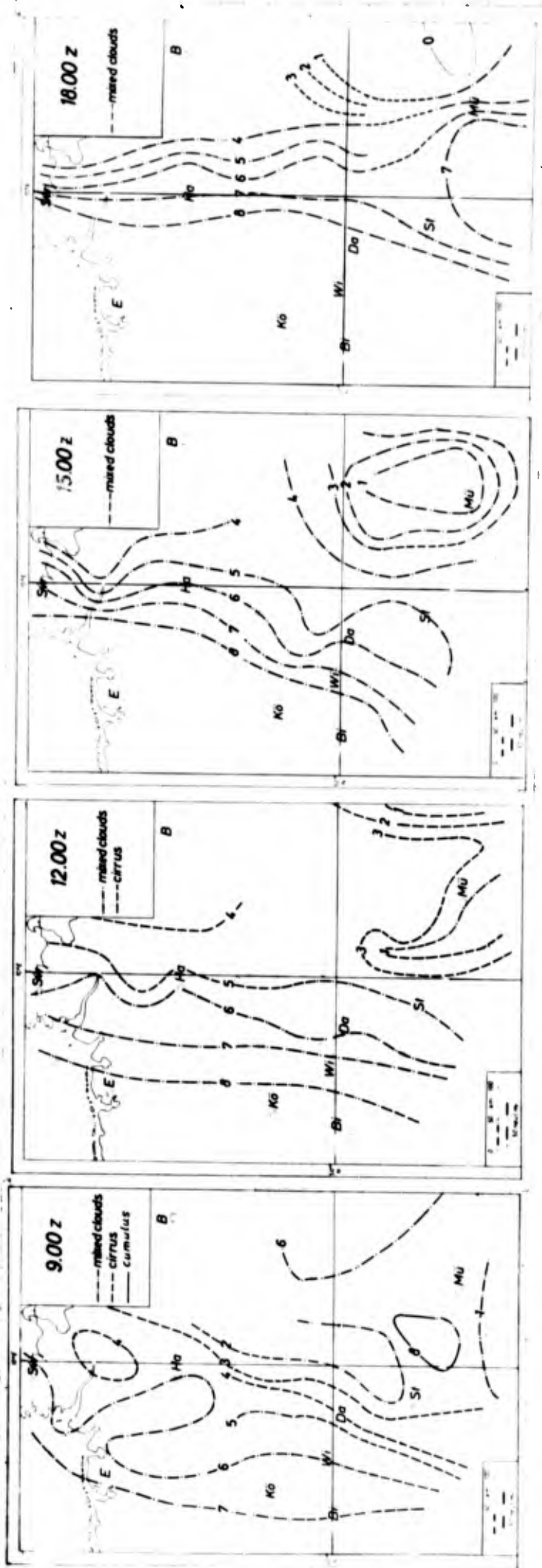


FIG. 6 : 13 May 1963 : Cloud cover ( $8 \hat{=} 100\%$ ); Note that the lines of equal cloud cover parallel the general orientation of the isotherms in Figs. 7, 8, 9, 10, while, except for mountainous regions, the decrease of cloud cover toward east is nearly independent of time at least within 9:00 til 18:00 Z.

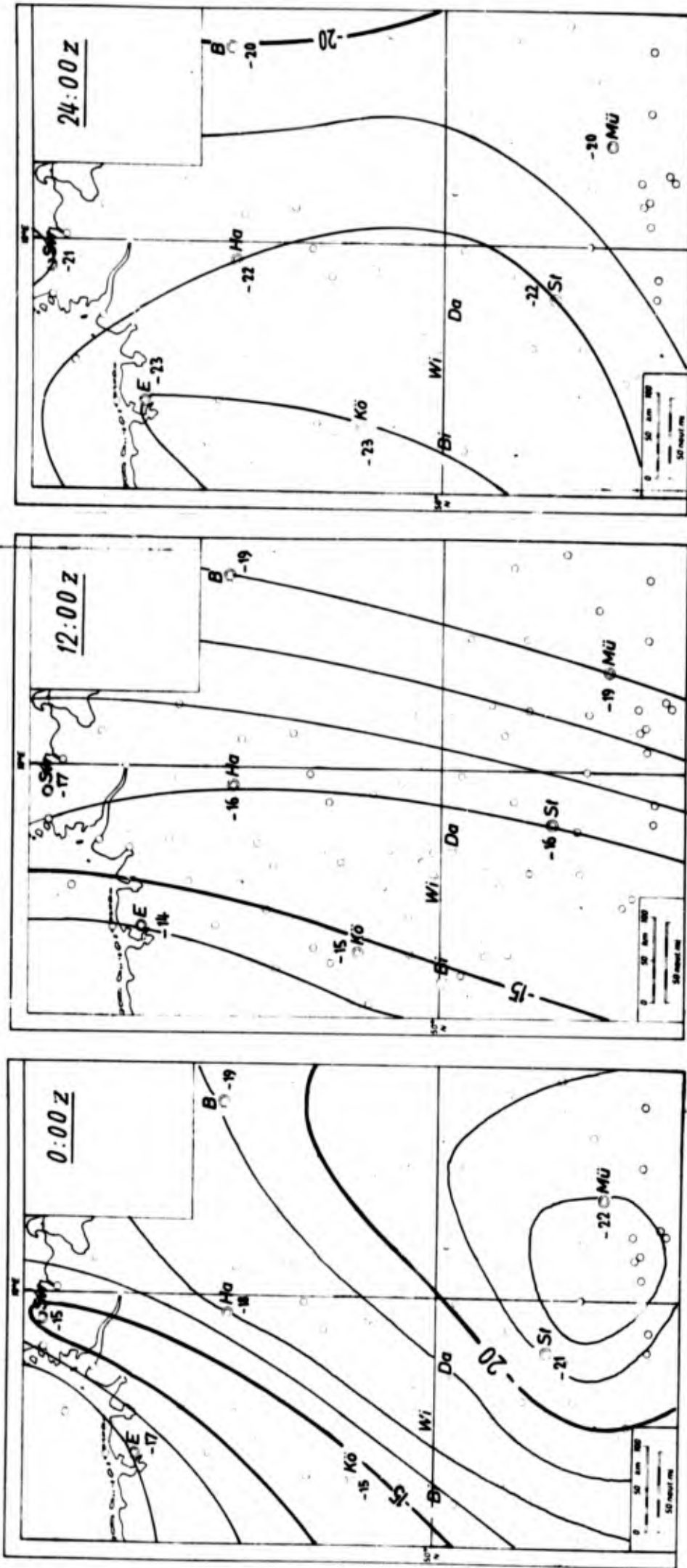
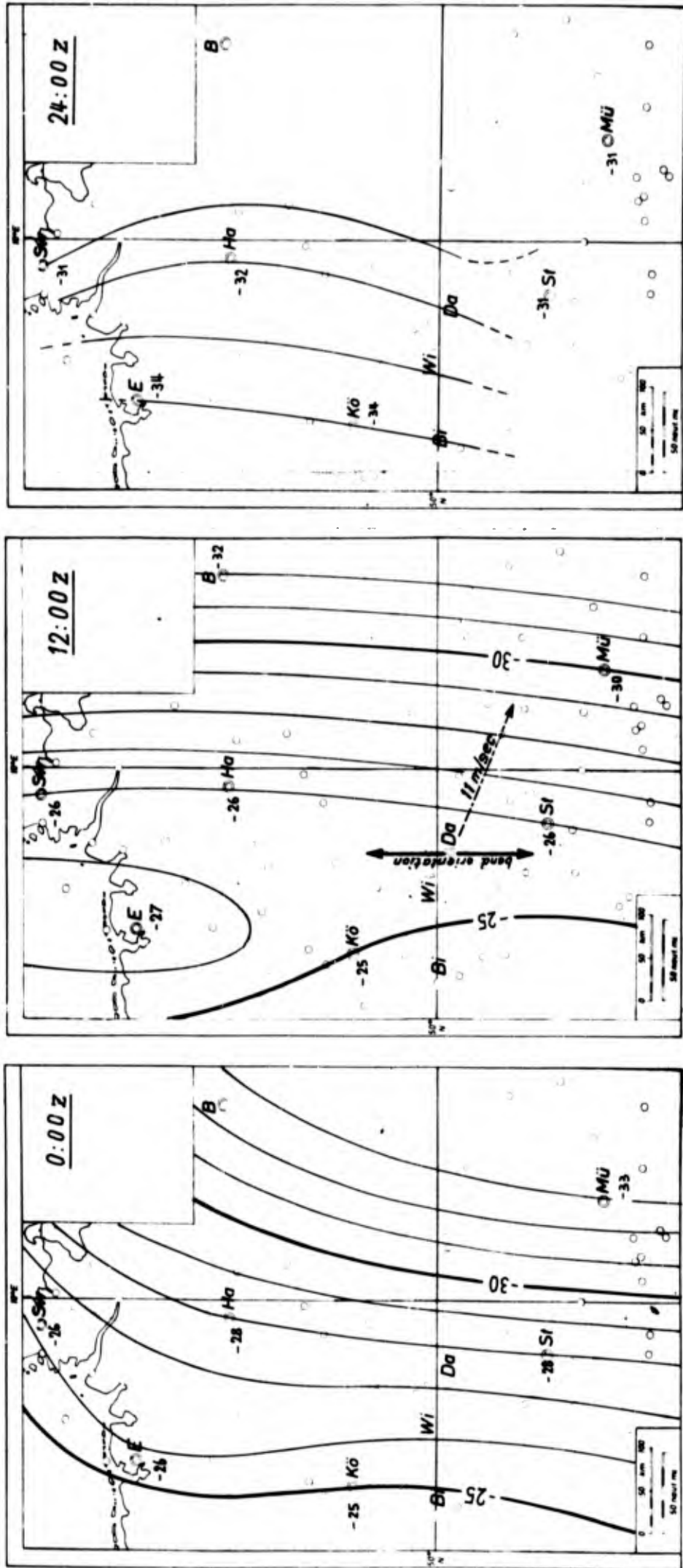


Fig. 7 : 13 May 1963 : 500 mb-isotherms.



**Fig. 8 :** 13 May 1963 : 400 mb-isotherms. Note that the 12:00 Z chart is most similar to the 500 and 300 mb charts of the same time in Figs. 7, 9. 24:00 Z chart is uncertain.



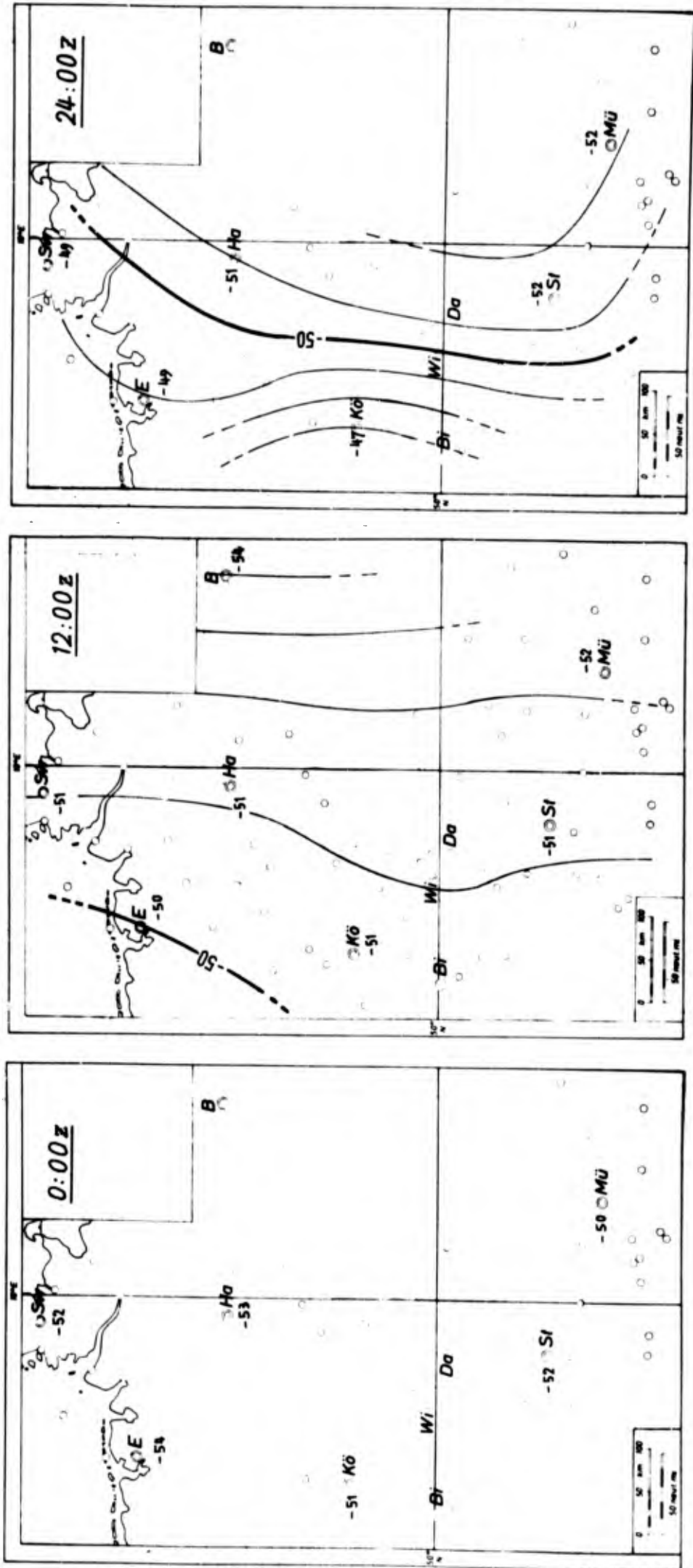


Fig. 10 : 13 May 1963 : 250 mb-isotherms. Isotherms of left chart were omitted due to uncertainty; right chart not very reliable either.

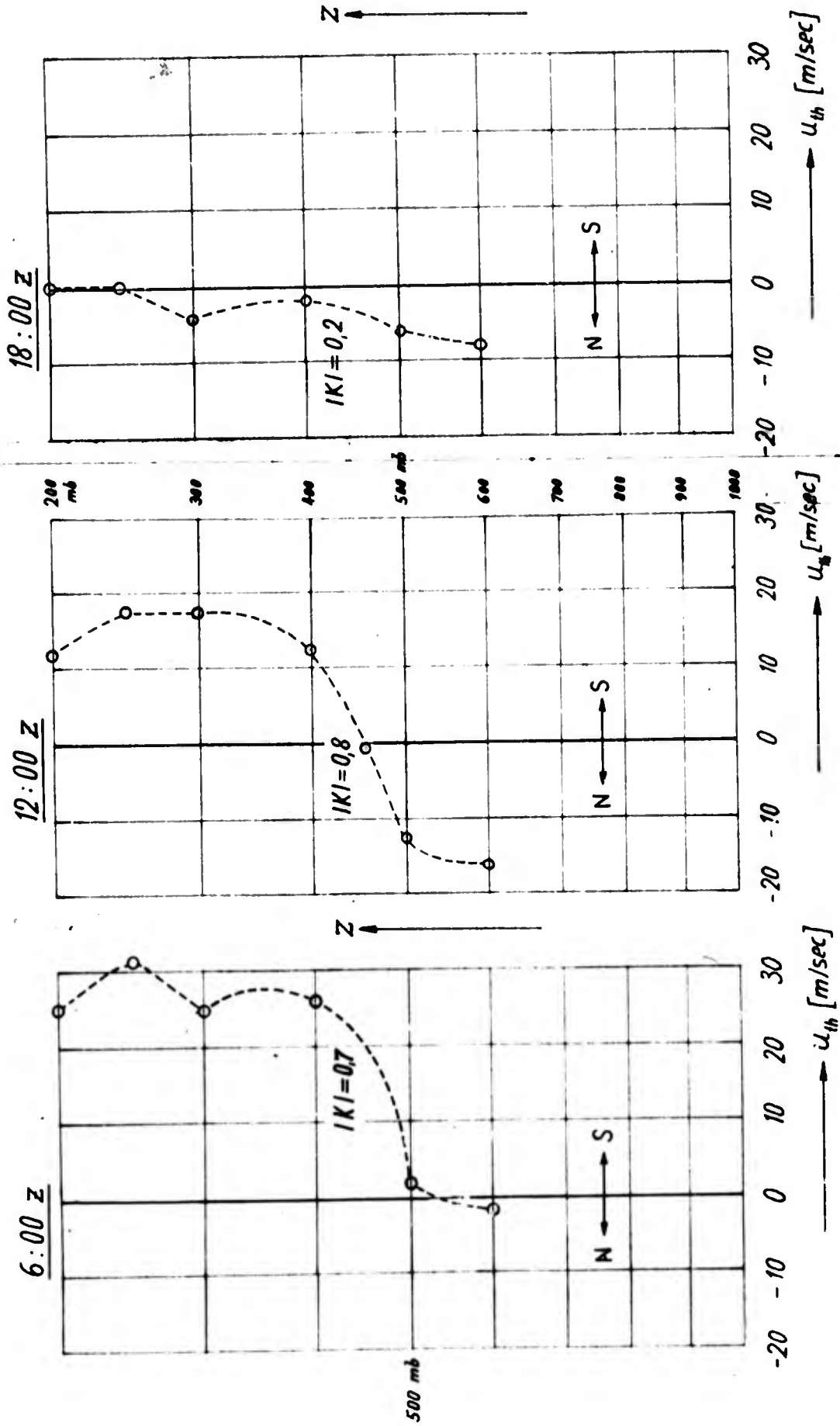
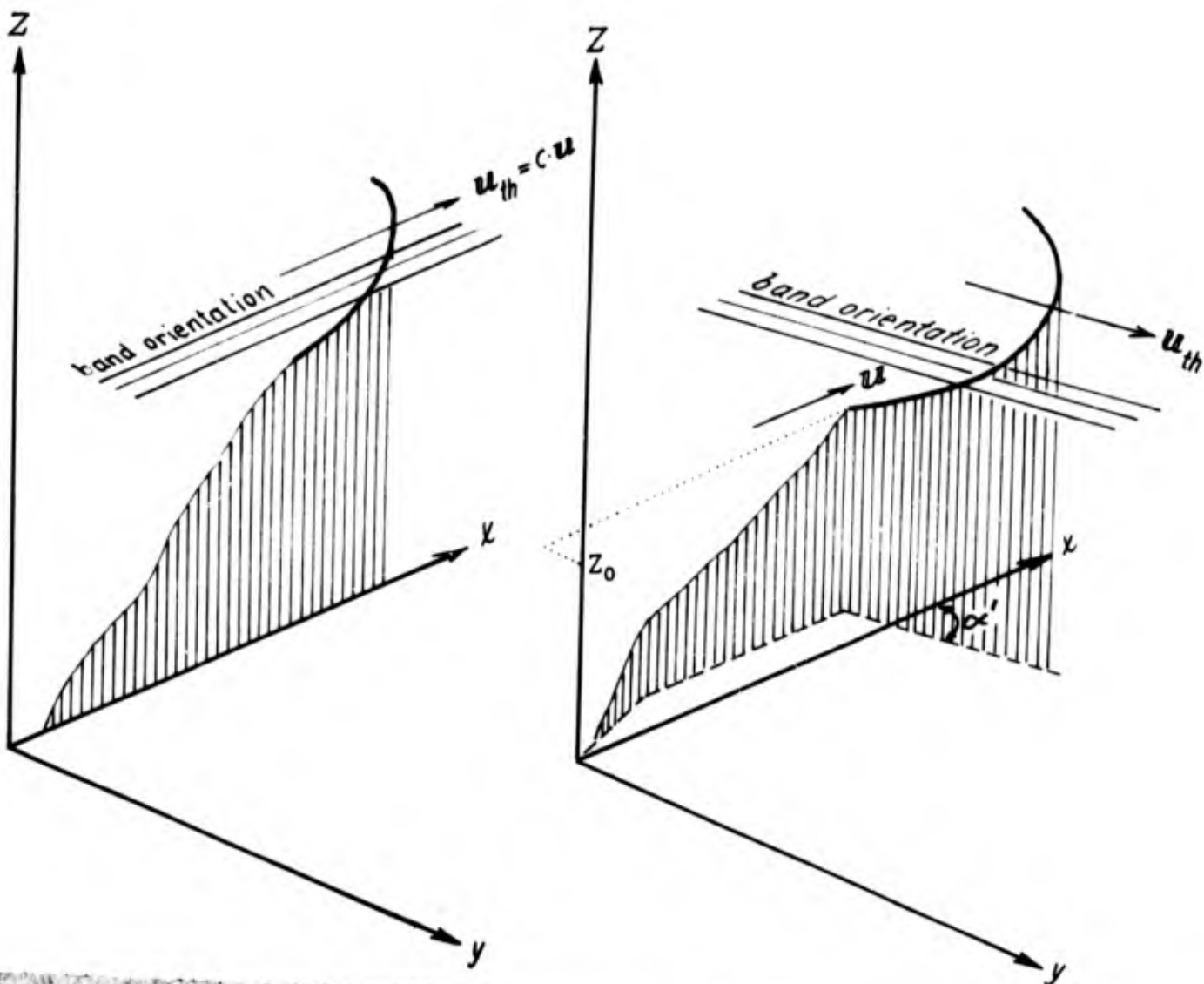


Fig. 11 : 13 May 1963 : Stuttgart (St) wind profiles, taken in North-South direction, underlay is Fig. 5. Wind at cloud level over Darmstadt (Da), at least from 6:00 till 18:00 Z, blows into the plane of this Figure. (Compare to Fig. 12).  $|K|$  denotes the absolute value of  $(\partial^2 u_{th} / \partial z^2)$  in units of  $10^{-5} \text{ m}^{-1} \text{ sec}^{-1}$ ,  $u_{th}$  being defined as the thermal wind with respect to the level of  $Z_0 \approx 500 \text{ mb}$ .



**Fig. 12 :** Schematic representation of different orientations of the KÜTTNER (thermal) wind profile with respect to the general flow direction :

In the case depicted at left, the thermal wind  $u_{th}$  in the upper troposphere parallels the general wind direction; both winds may thus add up to a strong wind (Jet Stream case). In the case depicted at right, the thermal wind lies at considerable angle ( $\alpha'$ ) with respect to the general flow direction. Since in this case  $u_{th}$  does not add favourably to the wind adjacent below, the wind velocity resulting for the band level will in most cases be smaller than in the first (left) case (this is in agreement with the statistics made earlier [of. REUSS, 1963]).

The directional wind change near the surface due to friction was neglected in the left chart.

It is assumed that  $u_{th}$ , defined as the thermal wind with respect to the wind at a  $p=\text{const.}$  level ( $z_0$ ), obeys  $(\partial^2 u_{th} / \partial z^2) \approx -1 \cdot 10^{-5} \text{m}^{-1} \text{sec}^{-1}$ , analogous to the KÜTTNER wind profile. (The latter is marked by thick line).



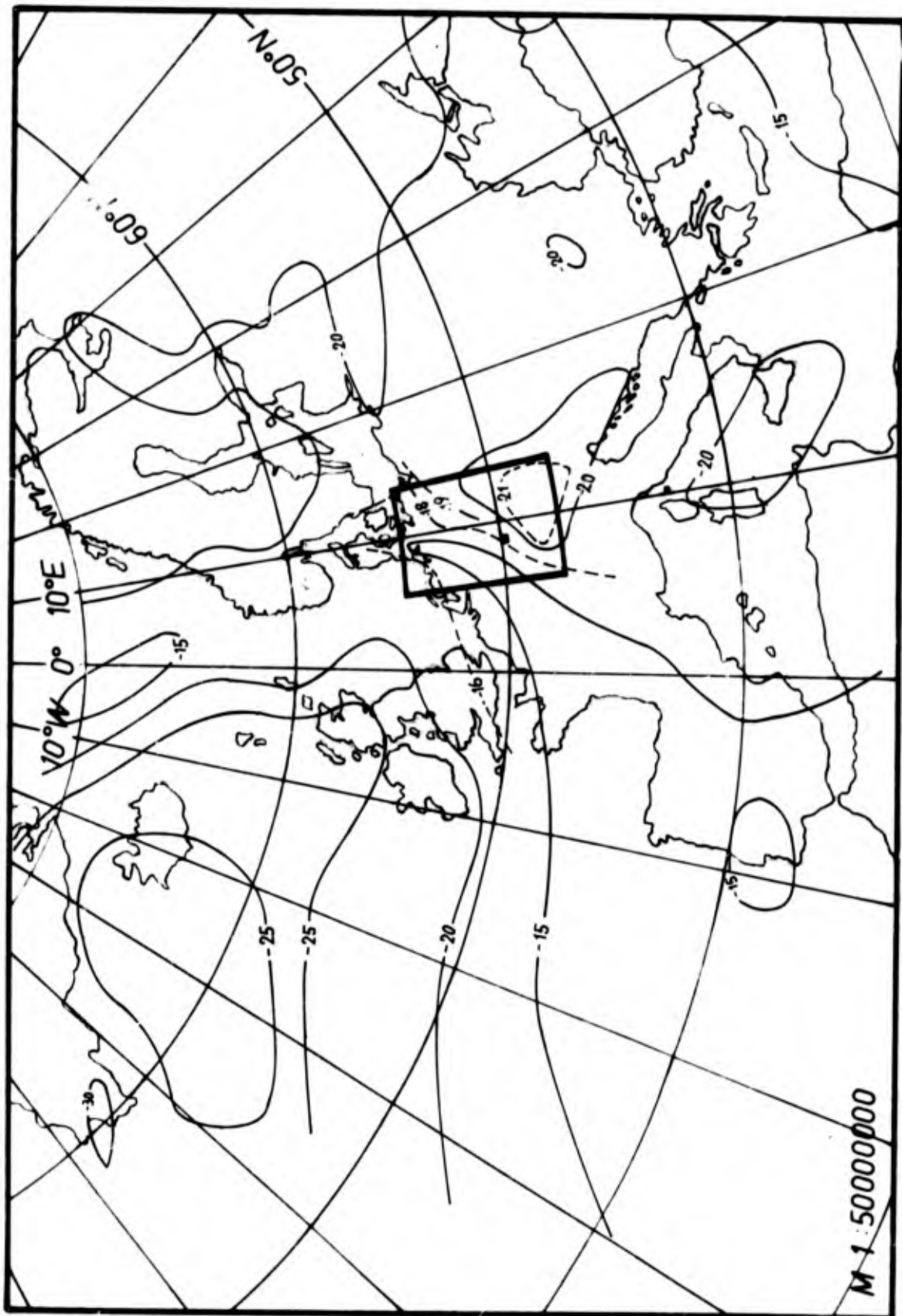


FIG. 14 : 13 May 1963, 0:00 Z : 500 mb-isotherms [°C] over Europe

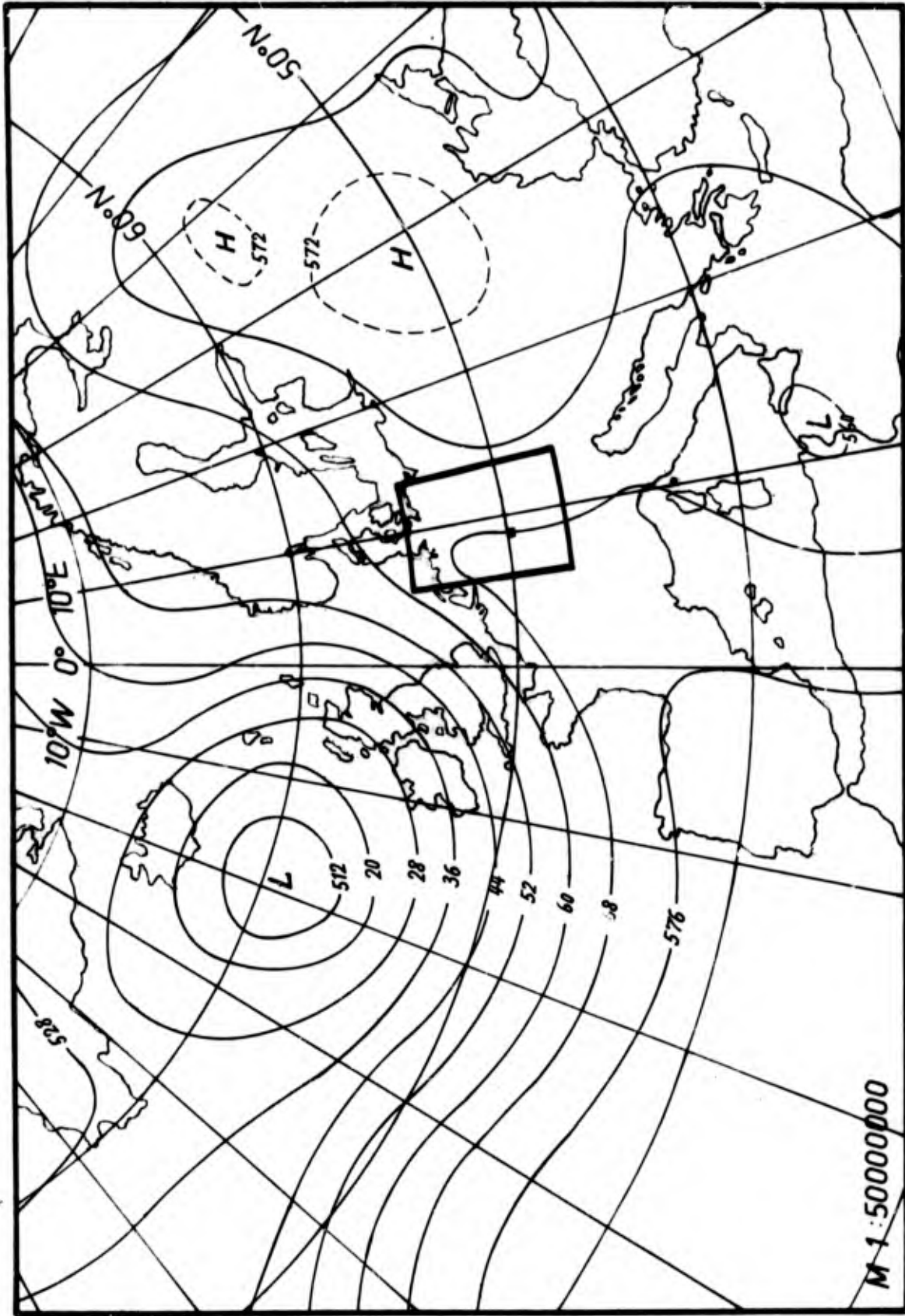


Fig. 15 : 13 May 1963, 0:00 Z : 500 mb-contours [10 gpm] over Europe

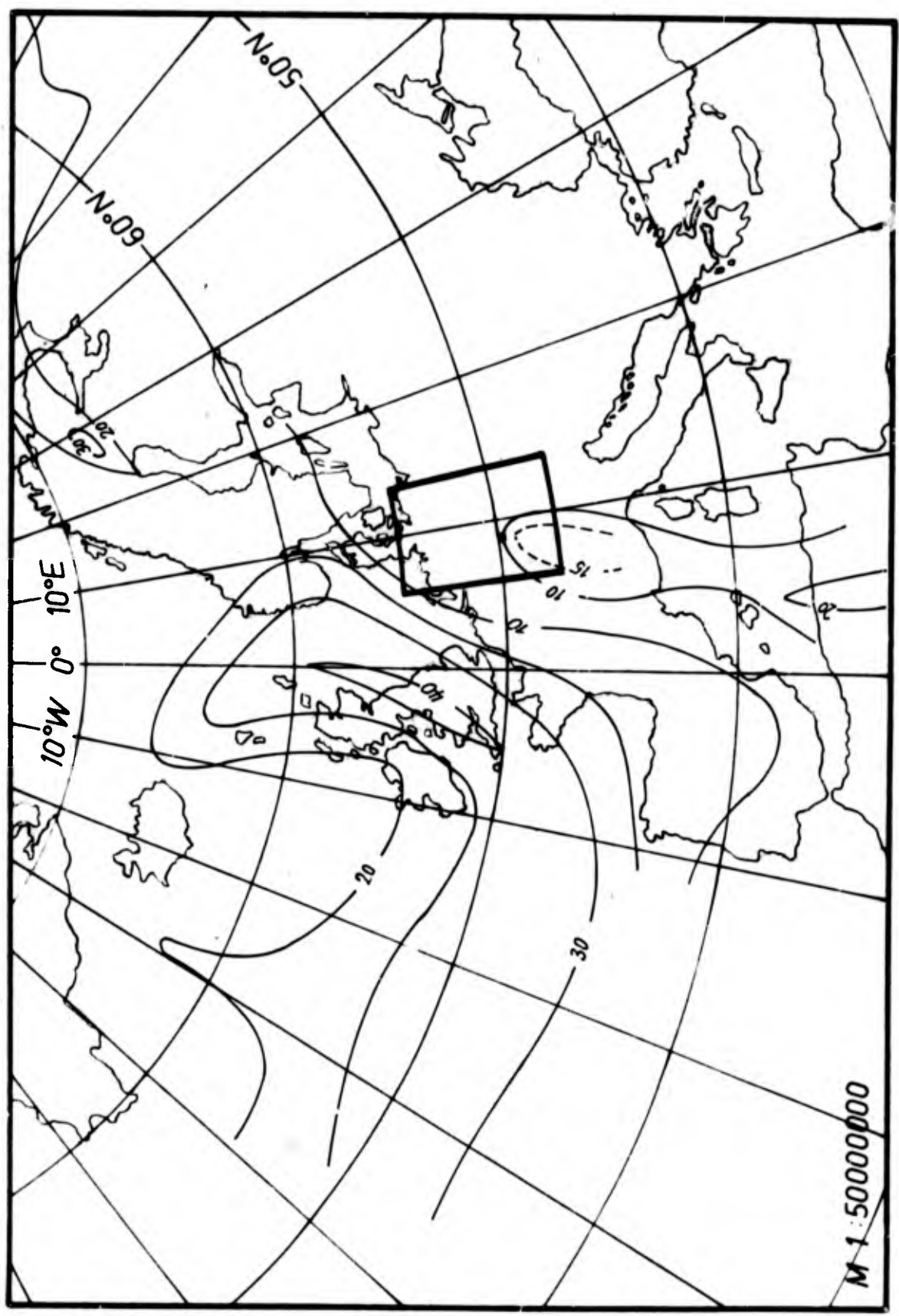


Fig. 16 : 13 May 1963, 0:00 Z : 500 mb-isotachs [m/sec] over Europe

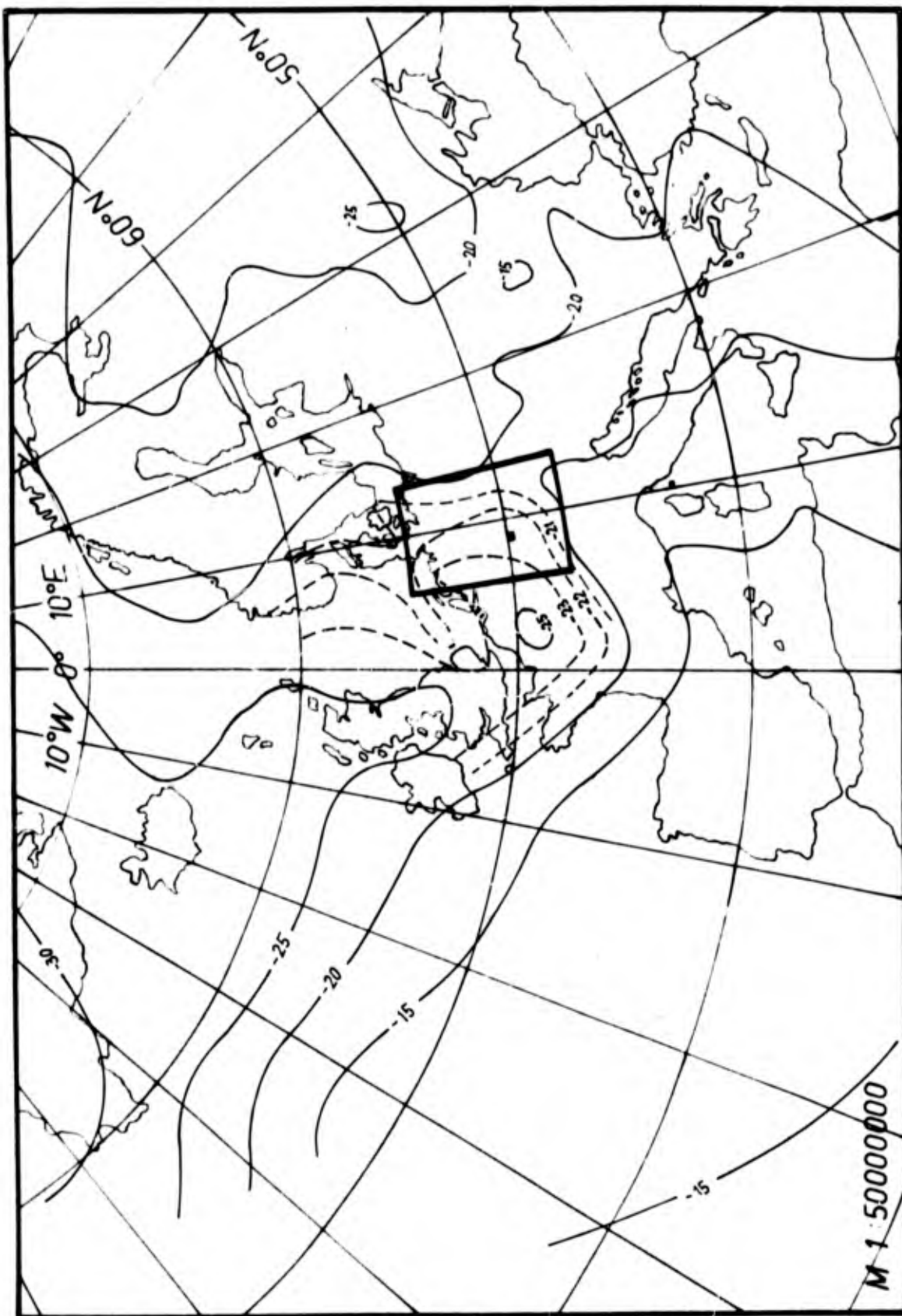


Fig. 17 : 13 May 1963, 24:00 Z : 500 mb-isotherms [ $^{\circ}$ C] over Europe

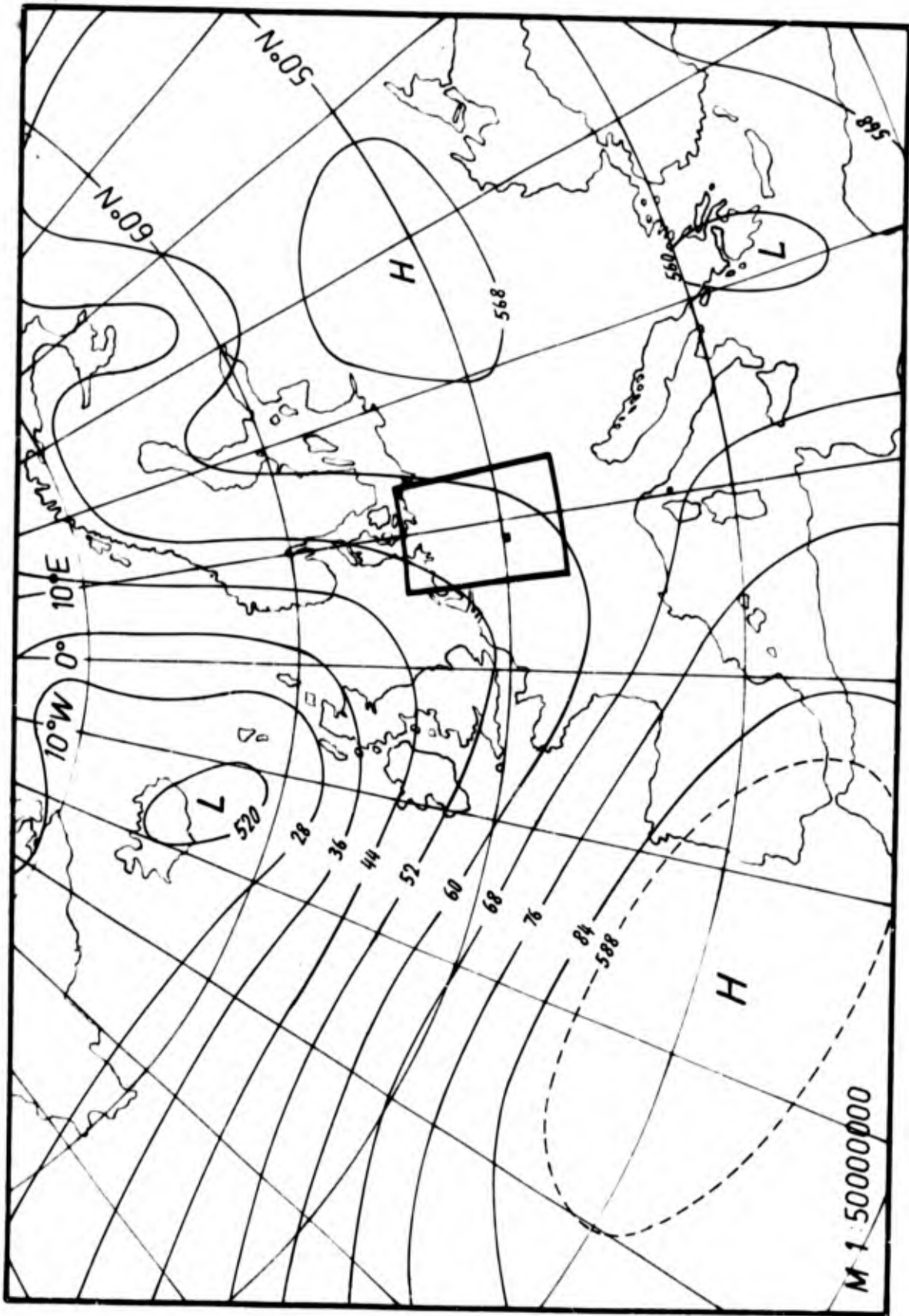


FIG. 18 : 13 May 1963, 24:00 Z : 500 mb-contours [10 gpm] over Europe

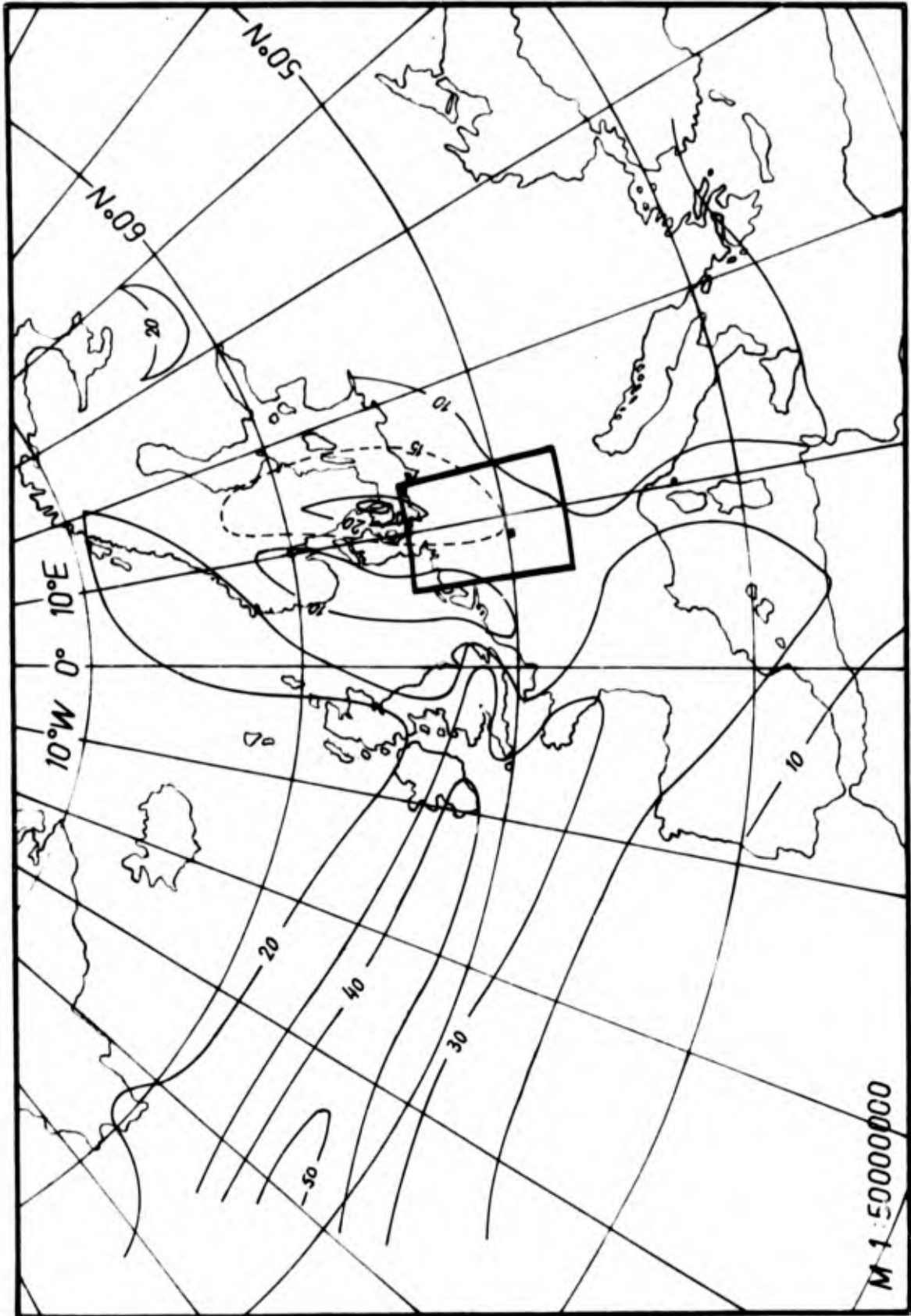


FIG. 19 : 13 May 1963, 24:00 Z : 500 mb-isotachs [m/sec] over Europe

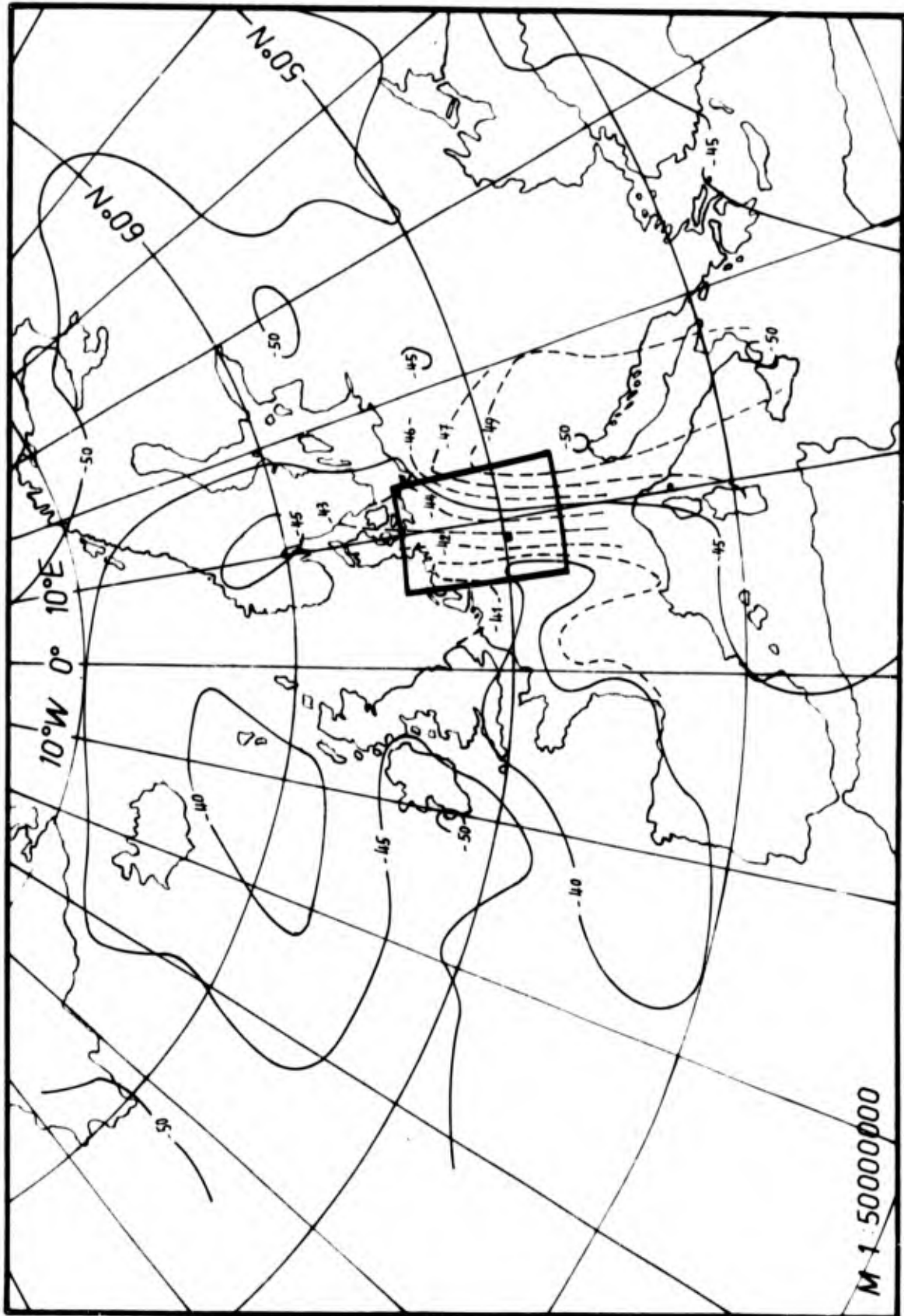


Fig. 20 : 13 May 1963. 0:00Z : 700 mb-isotherms [ $^{\circ}$ C] over Europe

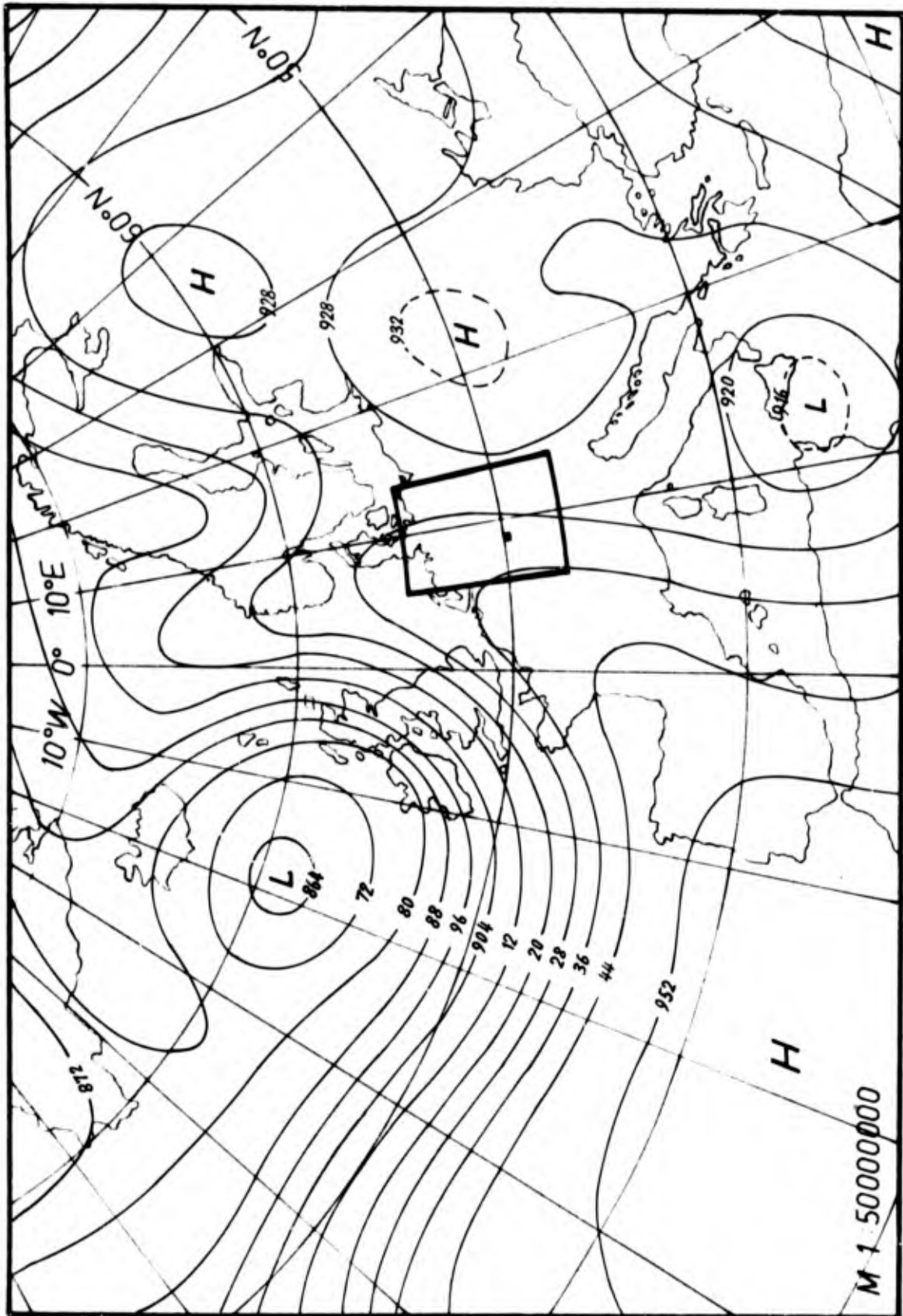


FIG. 21 : 13 May 1967, 0:00 Z : 300 mb-contours [10 gpm] over Europe

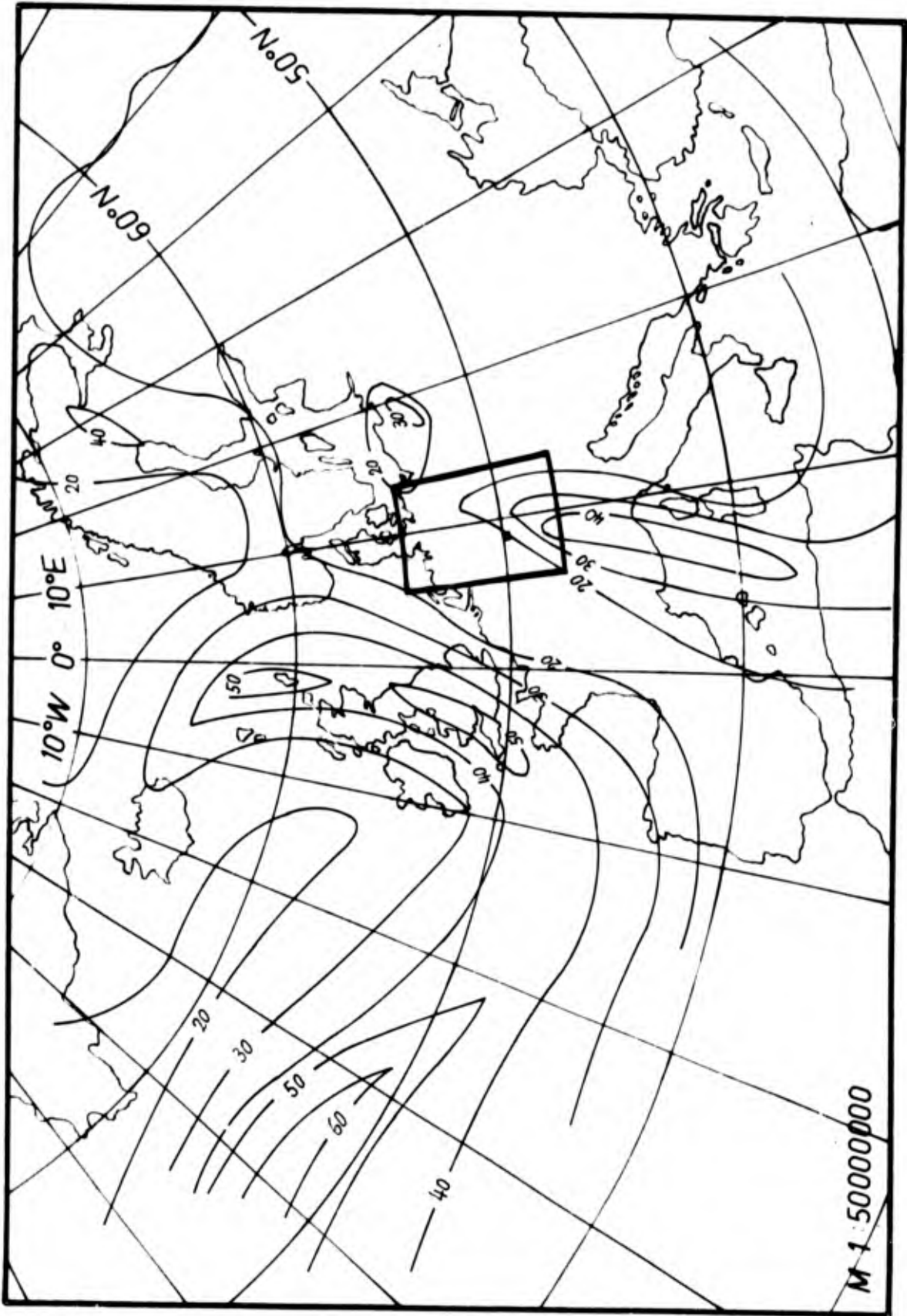


FIG. 22 : 13 May 1963, 0:00 Z : 300 mb-isotachs [m/sec] over Europe

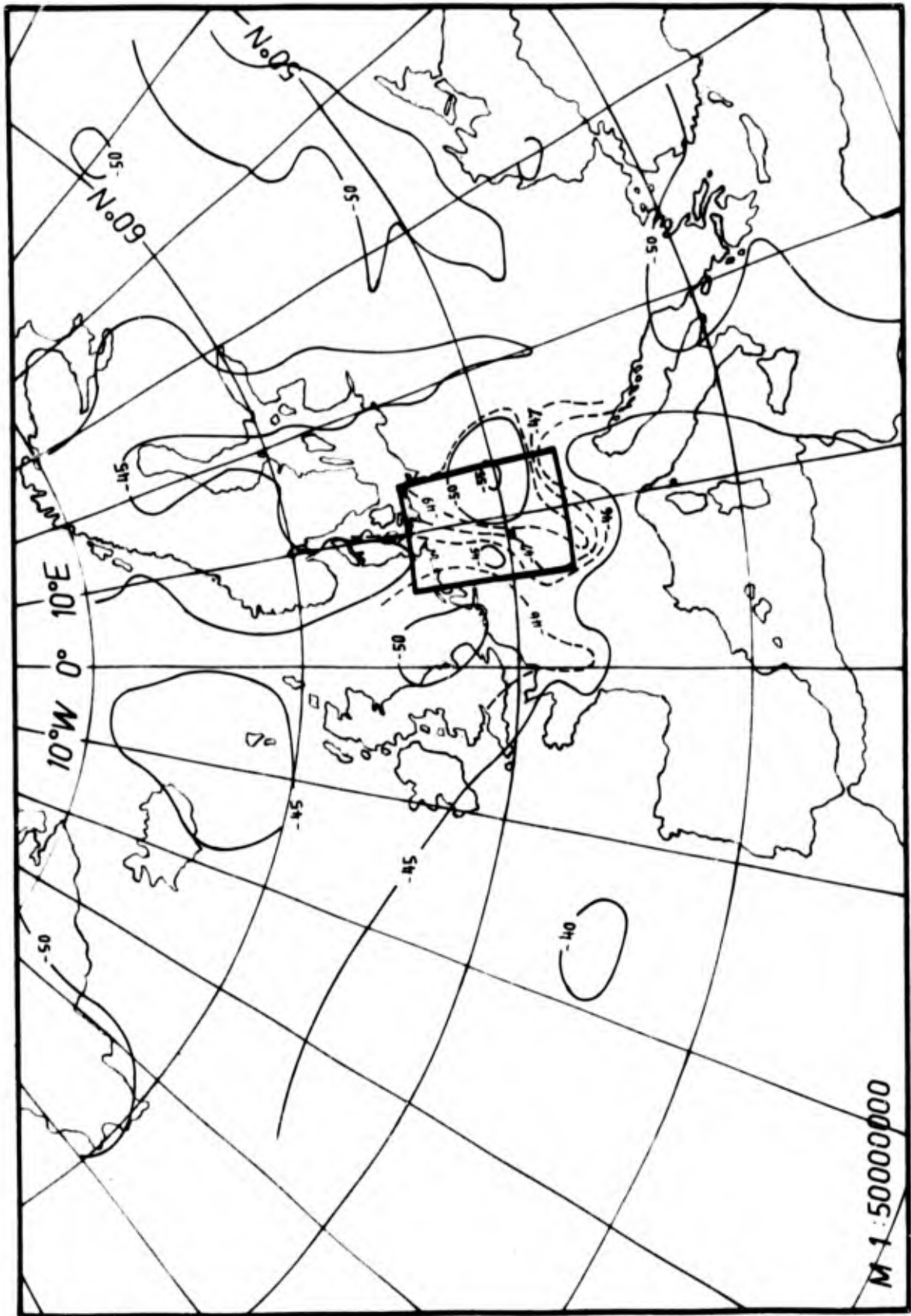


Fig. 23 : 13 May 1963, 24:00 UTC : 500 mb isotherms [ $^{\circ}$ C] over Europe

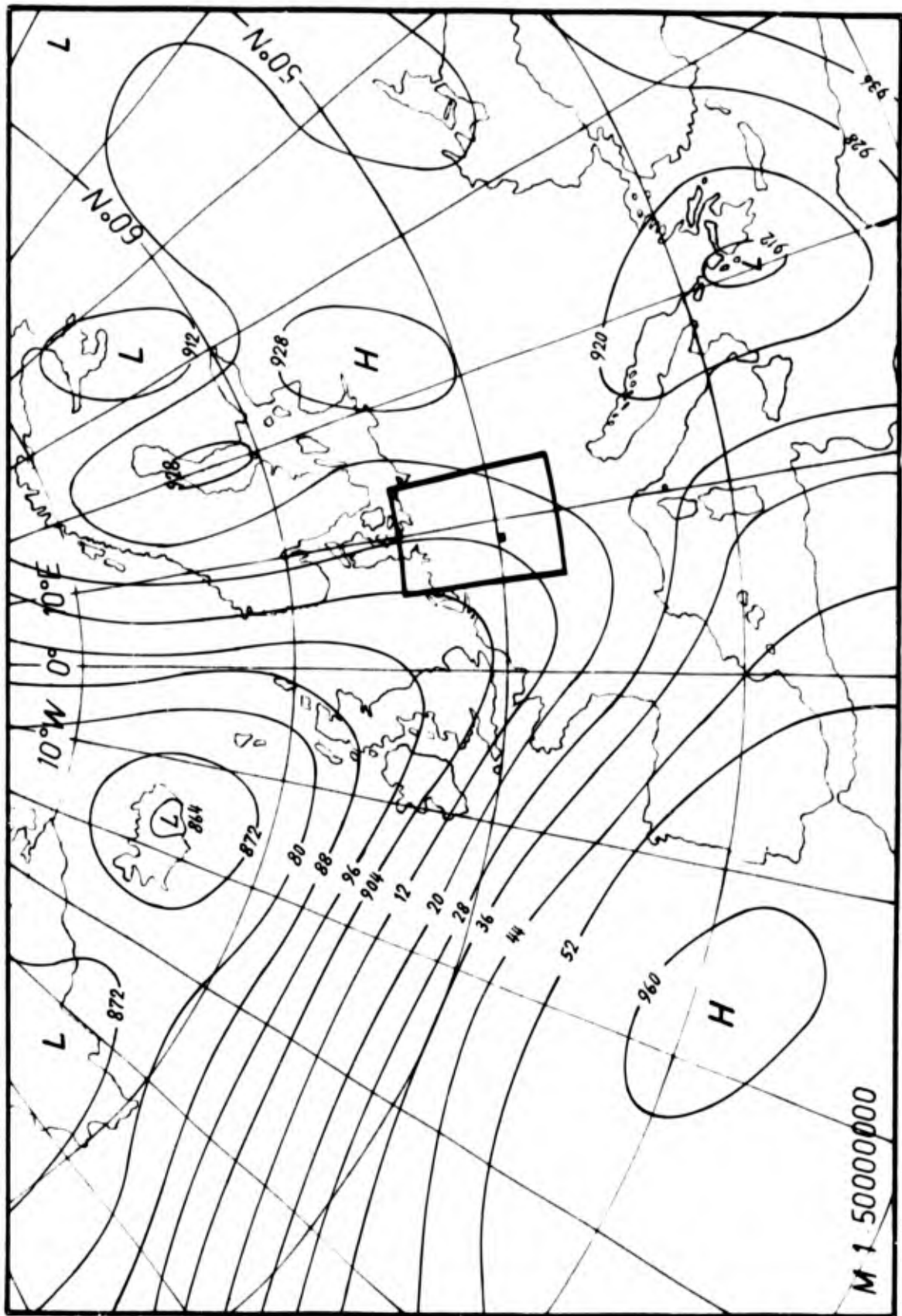


FIG. 24 : 13 May 1963, 24:00 Z : 300 mb-contours [10 gpm] over Europe

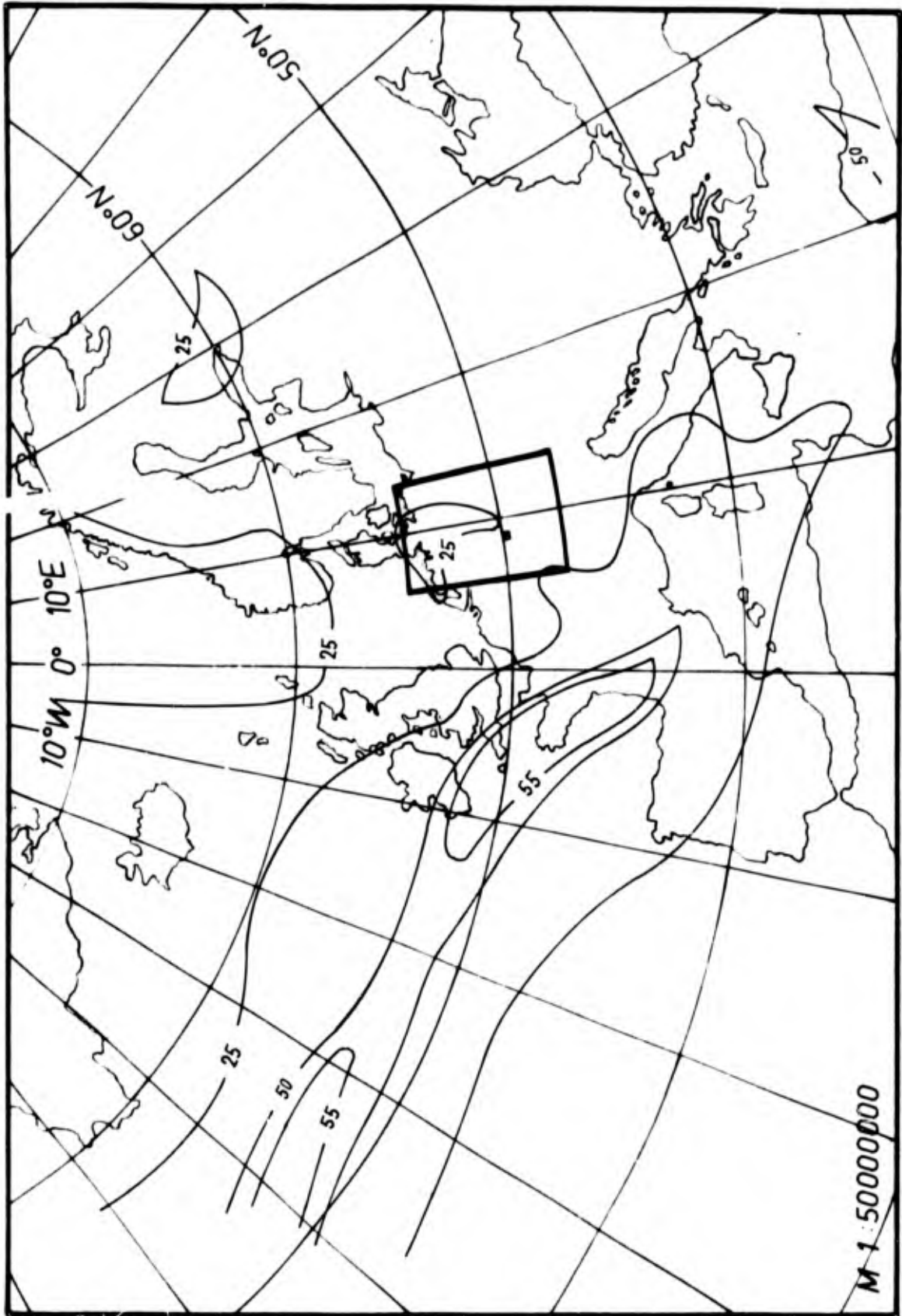


Fig. 25 : 13 May 1963, 500 Z : 500 mb-isotachs [m/sec] over Europe