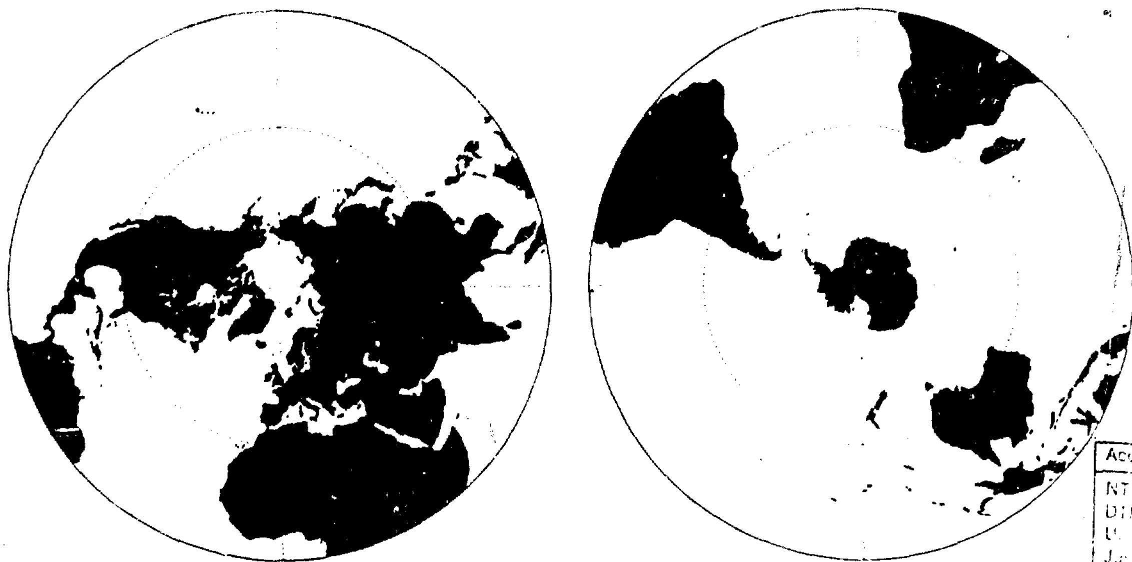
NAVAIR 50-1C-9
AWS/TR-89/009

JOINT U.S. NAVY/U.S. AIR FORCE CLIMATIC STUDY OF THE UPPER ATMOSPHERE

VOLUME 9 - SEPTEMBER

NOVEMBER, 1989



PREPARED BY
NAVAL OCEANOGRAPHY COMMAND DETACHMENT
ASHEVILLE, N.C.

PREPARED UNDER THE AUTHORITY OF
COMMANDER, NAVAL OCEANOGRAPHY COMMAND
STENNIS SPACE CENTER, MS 39529-5000

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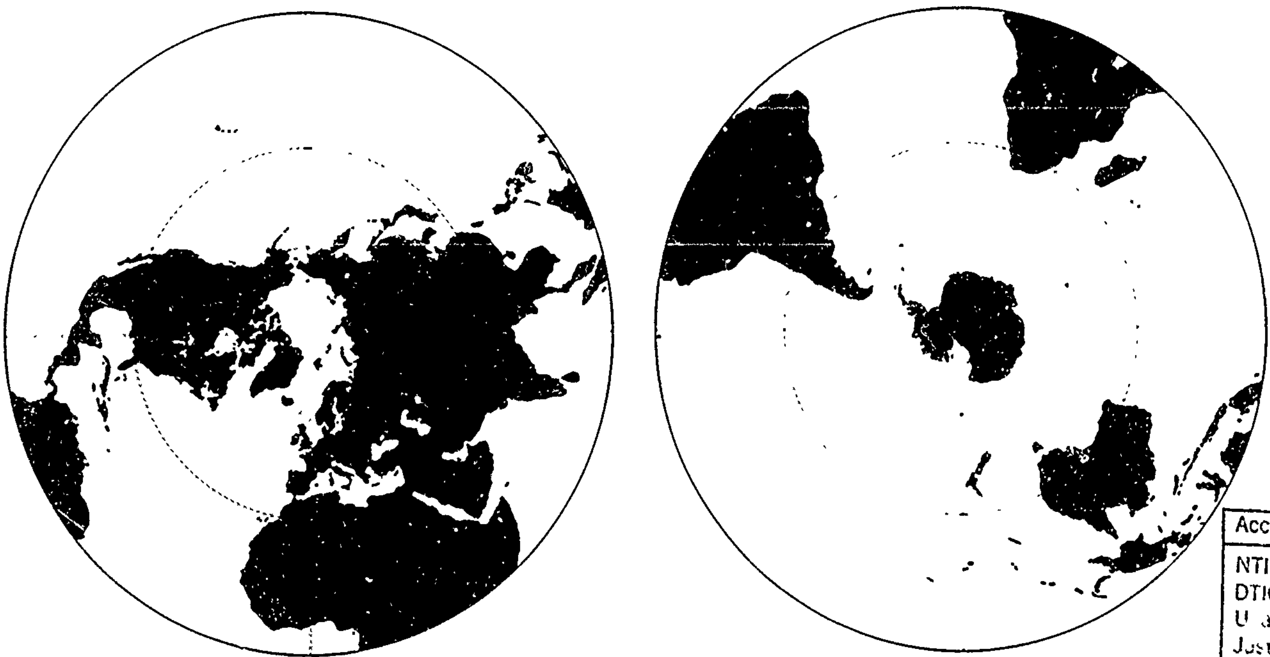

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's joint Navy and Air Force atmospheric atmospheric data is

This study of the upper atmosphere is based on 1980-85 twice daily gridded analysis produced by the European Centre for Medium Range Weather Forecasts. Included are global analyses of (1) Mean Temperature/Standard Deviation, (2) Mean Geopotential Height/Standard Deviation, (3) Mean Density/Standard Deviation, (4) Height and Vector Standard Deviation. All for 13 pressure levels - 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30 mb. In addition, analyses of (5) Mean Dew Point/Standard Deviation - levels 1000 through 300 mb, (6) jet stream (mean scalar speed) - levels 500 through 30 mb. Also included are global 5 degree grid point wind roses for the 13 pressure levels. (mm)

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HEIGHT/WIND STANDARD DEVIATION	201-227

The Joint U.S. Navy/U.S. Air Force Climatic Study of the Upper Atmosphere was prepared by the Officer in Charge, Naval Oceanography Command Detachment, Asheville, North Carolina under the authority of Commander, Naval Oceanography Command. Additional funding was provided by the Air Weather Service as a result of Tri-Services Climatology initiatives. The work was performed at the National Climatic Data Center (NCDC). Specific acknowledgement of the NCDC staff is made to Mr. M.J. Changery, project leader; Mr. C.N. Williams, Jr. for data processing and software development; and Messrs. M.G. Burgin and D.A. McKittrick for drafting skills. Special acknowledgement is made to the European Centre for Medium-range Weather Forecasts for providing the basic gridded analyses.

INTRODUCTION

During the past decade, improvements in the collection and assimilation of data required for more accurate representations of the atmosphere have resulted in data sets useful for developing a more definitive climatology of the global atmosphere. Such a climatology has uses in aircraft operations and planning, indirect assessments of atmospheric transport as well as a standard state from which atmospheric anomalies can be analyzed.

Prior climatologies, U.S. Navy (1959), U.S. Navy (1966), Naval Weather Service Command (1969), and Naval Weather Service Command (1970), were produced from individual station data with varying periods of record, and the resulting summarized data were analyzed. A serious deficiency was the lack of reporting locations in the major ocean basins. Analyses over the oceans were derived by extrapolating from known analyses over coastal regions as well as the few island or ocean vessels available. An additional complication was the manually intensive effort required to ensure horizontal and vertical consistency of the data.

With the advent, in the 1970s, of more powerful computers and data collection and assimilation systems, the initial analyses used for input into forecast models had a three-fold advantage over the station analyses utilized in the prior climatologies. First, the data assimilation system utilized a greater variety of information for production of an analysis. The normal array of land-based upper air reporting stations was supplemented by ship-based reporting stations, cloud reports, pilot reports and, most importantly, satellite-derived temperature, moisture and wind data. Consequent analyses more accurately represented the state of the atmosphere at a given observation time. Second, the assimilation system quality-controlled all incoming data and ensured the horizontal and vertical consistency of the resulting analyses. Finally, through the computer-based system, global data were available and archived in grid-point form.

A number of analysis sets produced by various national and international meteorological services were investigated. It is recognized that improvements to the data assimilation and analysis systems occurred within any analysis set produced, and that current analyses more accurately reflect the atmosphere's state than do the earlier analyses. It is also recognized that specific parameter or geographic-based deficiencies exist in all analysis sets. However, the intent of this upper-air climatology effort is the production of analyses to serve the needs of the operational meteorologist. A climatology derived from global analyses achieves this goal. Based on known capabilities and technical reviews of the various systems, as well as recommendations from the professional numerical modeling community, the analyses produced by the European Centre for Medium-range Forecasts were selected for processing.

ECMWF DATA

The European Centre for Medium-range Weather Forecasts (ECMWF) is an international organization established in 1973 and supported by 17 member states. It is responsible for providing global forecasts to the European community. Their data assimilation system consists of multivariate optimal interpolation analysis allowing the incorporation of a variety of observations with differing error characteristics and spatial distributions. A relatively comprehensive coverage of global data is ensured through the data collection schedule. A unique feature of the ECMWF system is the method of grid point analysis. Rather than analyzing individual grid points, varying sized boxes (depending on data density) are created containing groups of grid points. Grid point analysis uses data from within the box as well as adjacent boxes, thereby assuring a consistent analysis between all the grid points.

The system also includes internal quality control which examines the climatological reasonability of incoming data as well as the internal consistency of the data.

In addition, the system utilizes a model initialization process which ensures that harmful gravity waves, caused by imbalances in the analysis, with the potential to create problems in subsequent forecast fields, are suppressed. Through the initialization process, the atmosphere's mass and wind fields are adjusted so that only a portion of the gravity wave balanced by dynamic and physical processes is retained. Further information on the ECMWF system is available in Lorenc (1981), Shaw, et al. (1984), Lonnberg, et al. (1986), and ECMWF (1988).

The resulting initialized analyses are vertically interpolated to these 13 standard pressure levels: 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, and 30 mb, and include the geopotential height, temperature, and wind for all levels with moisture included for the 1000 through 300 mb levels.

Six years (1980-1985) of individual analysis were obtained from ECMWF on a 2.5° global grid. Although the analyses were permanently archived as spherical harmonic coefficients, ECMWF reconstituted the analyses for use in the data processing. Synoptic analyses at six-hour intervals were received for the six-year period, but only the 00 and 12Z analyses were re-sorted into a grid point sort. Given the quality control performed by ECMWF on collected data and the requirements for horizontal and vertical data consistency imposed by the assimilation system, minimal quality control was performed prior to summarization. Primary quality control was limited to comparison of level data against known/estimated climatological extremes.

The summarized grid point data were objectively analyzed, machine-contoured by parameter and level on polar stereographic (0°-90°N and S) and cylindrical equidistant (0°-60°N and S) projections with resulting contours machine-labeled. In addition, individual wind observations were consolidated into eight 45° segments centered on directions north, northeast, ... through northwest for display as wind roses on a series of cylindrical equidistant projections.

Since the ECMWF analyses were archived as spectral harmonic coefficients, the grid point reconstitution process provides data for all global 2.5° grid points. This naturally includes (for the 1000 through 700 mb levels) selected grid points at which the land elevations exceed the height of the pressure surface. For these grid points, a blanking program was used to eliminate both contours and grid point wind roses.

ANALYSES

1. Pressure-Height

Grid point geopotential height values (in dekameters) are summarized by month for 13 levels from 1000 mb to 30 mb with solid and dashed contours of mean values presented on pressure height charts. Standard deviation of height is calculated from the individual daily values with contours presented on a separate chart series including the standard deviation of vector mean wind. Local points of highest and lowest pressure are designated with H's and L's on the analyzed charts. Not all pressure centers are enclosed by closed contours. Vector mean wind in 5-knot increments are calculated for selected grid points considered adequate to depict flow for the hemisphere with wind shaft orientation related to specific latitude/longitude lines. Vector mean winds less than 2.5 knots are depicted as a shaft with no barbs. Contours of mean geopotential height and vector mean wind barbs are presented for the northern/southern hemispheres on polar stereographic projection and for 0° to 60° north and south on cylindrical equidistant projections with blanking for appropriate high elevation land areas on the 1000 through 700 mb charts.

2. Wind Roses

Wind roses for 10° grid points from 5° to 85° north and south are presented by month for all levels from 1000 mb to 30 mb. Each hemisphere is divided into three longitudinal zones: 60°W to 60°E, 60°E to 180°E, and 180°W to 60°W. Each rose presents:

a) Scalar mean speed

b) Percent frequency of occurrence from each of 8 cardinal point wind directions proportional to shaft length with dots on the shafts representing 5 percentile intervals.

c) Mean speed for each of the 8 cardinal wind directions rounded to the nearest 5 knots.

Roses for grid points on the 1000 mb through 700 mb level charts are blanked whenever the land elevation exceeds the mean geopotential height of the specified level.

3. Temperature

Grid point temperature data (in °C) are summarized by month for 13 levels from 1000 mb to 30 mb with solid and dashed contours of mean values presented on pressure height charts. Temperature standard deviation derived from the individual observations are shown on the same charts with dotted contours. Contours are presented for both the northern and southern hemispheres on a polar stereographic projection and for the zone from 0° to 60° north and south on cylindrical equidistant projections with blanking for appropriate high elevation land areas on the 1000 through 700 mb charts.

4. Dew Point

Grid point moisture data were received as mixing ratios for the period through April 19, 1982 and as relative humidity thereafter for the 1000 through 300 mb levels. All moisture data were converted to dew point values. These are summarized by month with solid and dashed contours of mean values presented on pressure height charts. Dew point standard deviation derived from the individual observations are shown on the same charts with dotted contours. Contours are presented for both the northern and southern hemispheres on a polar stereographic projection and for the zone from 0° to 60° north and south on cylindrical equidistant projections with blanking for appropriate high elevation land areas on the 1000 through 700 mb charts.

5. Density

Grid point density data were computed from the daily values of temperature and pressure from the equation of state in the form

$$\rho = \frac{P}{RT}$$

where ρ is the density, P is the pressure, T is the temperature, and R is the gas constant. Density was computed for moist air through 300 mb and for dry air from 250 mb to 30 mb. Density data (in Kg/m^3) are summarized by month for all 13 levels with solid and dashed contours of mean values presented on pressure height charts. Density standard deviation derived from individual observations are shown on the same charts with dotted contours. Contours are presented for both the northern and southern hemispheres on a polar stereographic projection and for the zone from 0° to 60° north and south on cylindrical equidistant projections with blanking for appropriate high elevation land areas on the 1000 through 700 mb charts.

6. Standard Deviation of Height and Vector Mean Wind

Standard deviation of the height and vector mean wind data presented on the pressure height charts are presented on monthly charts for the 1000 through 30 mb levels. Height standard deviations (in dekameters) are presented as solid contours and vector wind standard deviations (in knots) as dashed contours. Contours are presented for both the northern and southern hemispheres on a polar stereographic projection and for the zone from 0° to 60° north and south on cylindrical equidistant projections with blanking for appropriate high elevation land areas on the 1000 through 700 mb charts.

7. Jet Stream

Grid point scalar mean wind speed (in knots), as presented by the value in the center of the wind rose octagons, are summarized by month and analyzed for 500 through 30 mb. All speeds exceeding 50 knots are shaded with shading intensity increasing by 25-knot increments. Contours are presented for both the northern and southern hemispheres on a polar stereographic projection and for the zone from 0° to 60° north and south on cylindrical equidistant projections.

DATA AVAILABILITY

Monthly summarized grid point data for the period of record for all levels from 1000 through 30 mb have been retained on magnetic tape. Data available, per level, include:

Number of observations
Mean zonal wind component and standard deviation
Mean meridional wind component and standard deviation
Vector mean wind and standard deviation
Mean temperature and standard deviation
Mean dew point (through 300 mb) and standard deviation
Mean geopotential height and standard deviation
Mean density and standard deviation
Mean scalar wind speed and percentage of observations for each designated direction

Similarly summarized data for each half-month of the 1980-85 period are also available on magnetic tape. Summaries can be provided on magnetic media or in listing form by the National Climatic Data Center.

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PRESSURE - HEIGHT
(13 LEVELS, 1000 TO 30 MB)

- Contours of mean height (solid and dashed lines) in geopotential dekameters; example: 580 is 5800 geopotential meters; solids labeled, dashed intermediates unlabeled

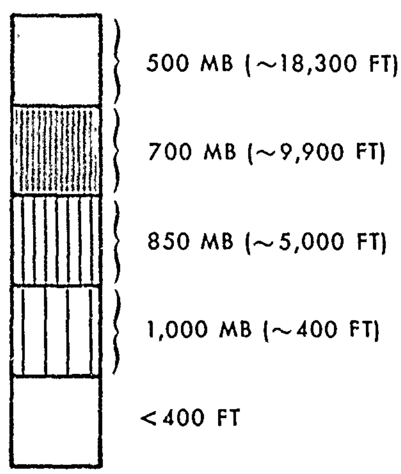
- Height labeled interval:

  6 dekameters (60 meters) - 1000 MB to 400 MB
  12 dekameters (120 meters) - 300 MB to 200 MB
  8 dekameters (80 meters) - 150 MB to 30 MB

- Vector mean wind in knots

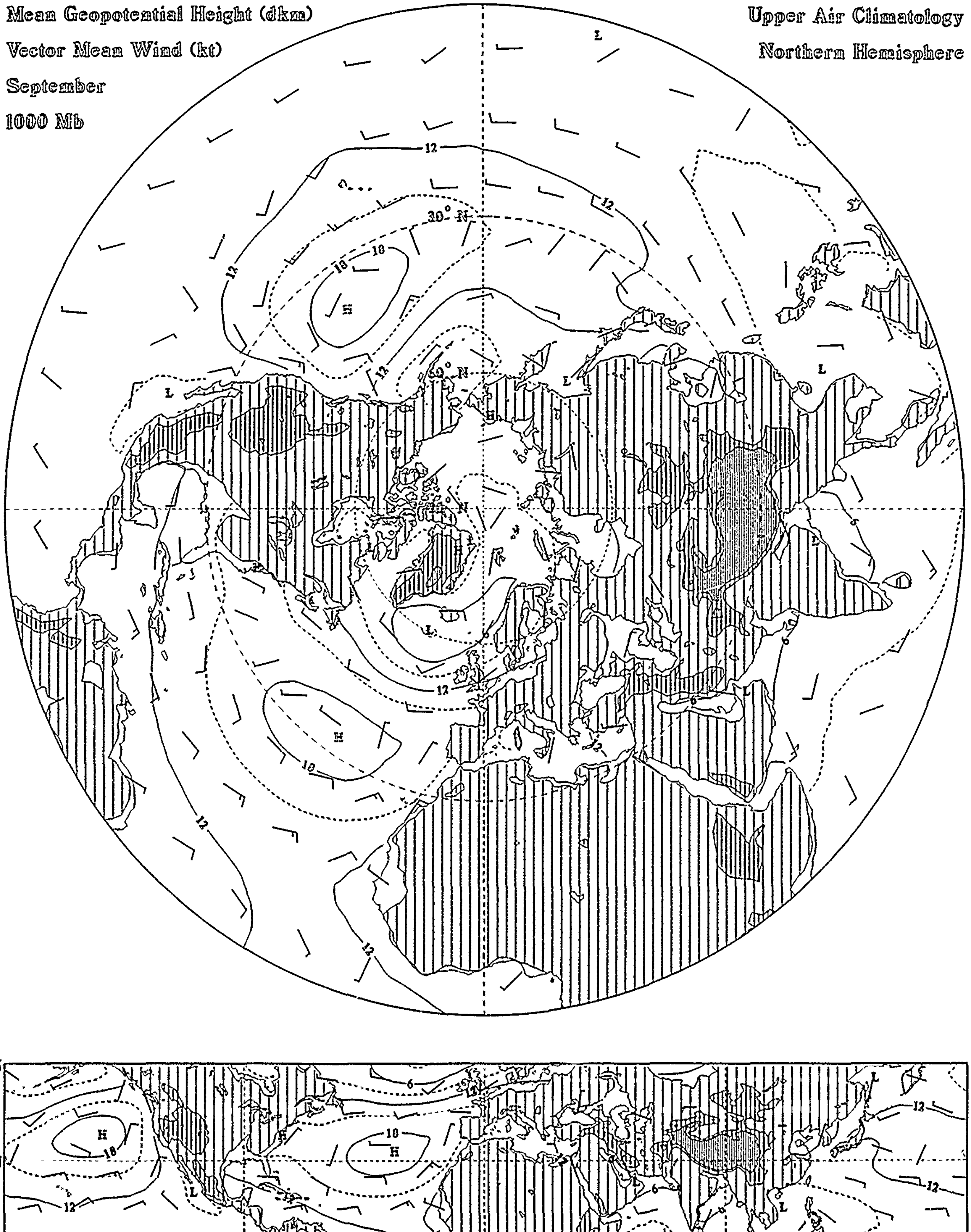
- Contours blanked for geographic areas with elevations exceeding specified geopotential heights

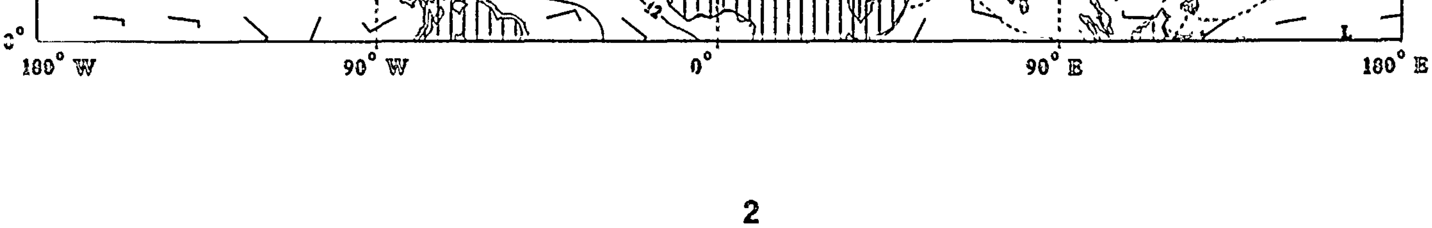
ELEVATION SCALE

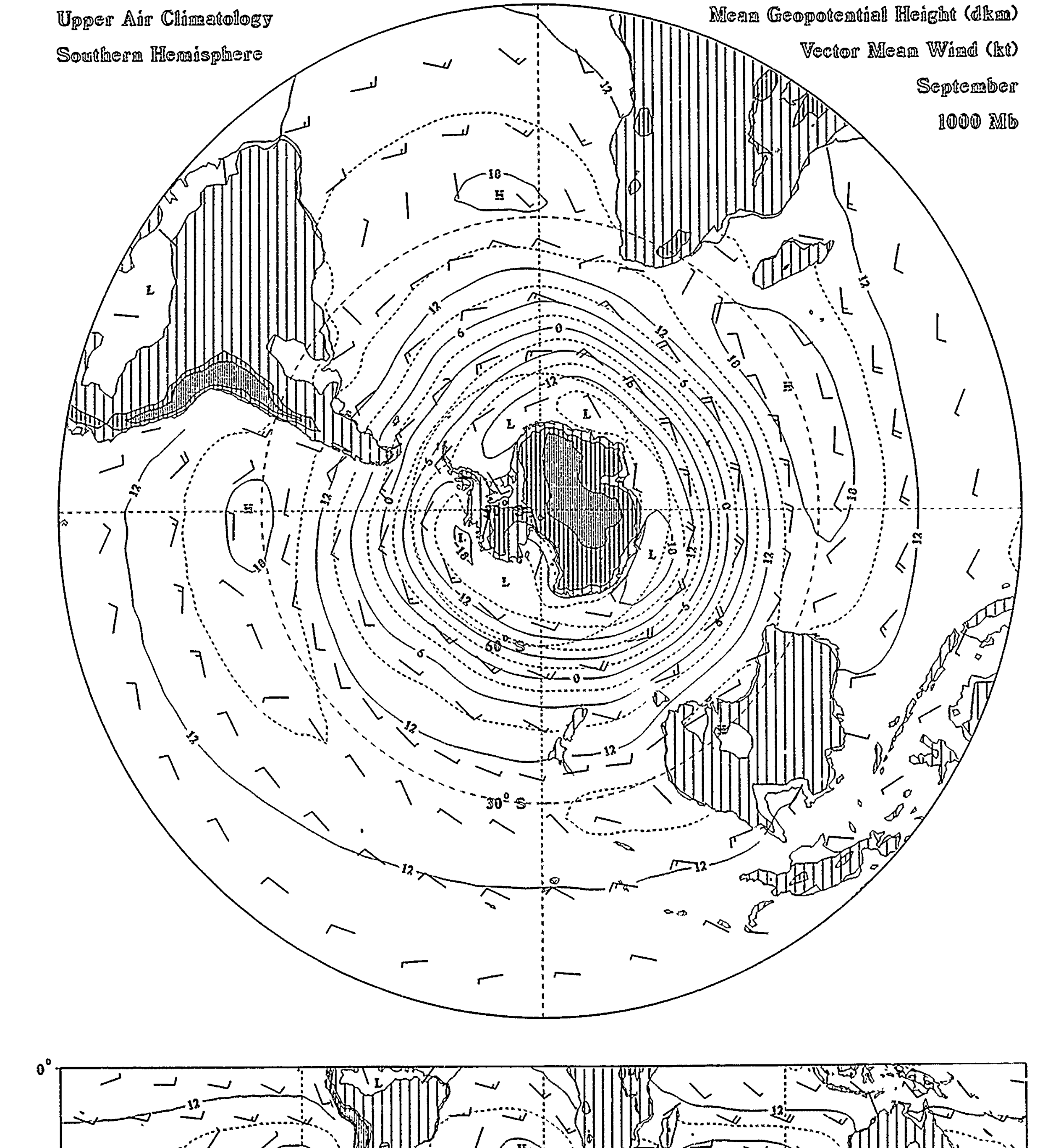


Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
1000 Mb

Upper Air Climatology
Northern Hemisphere



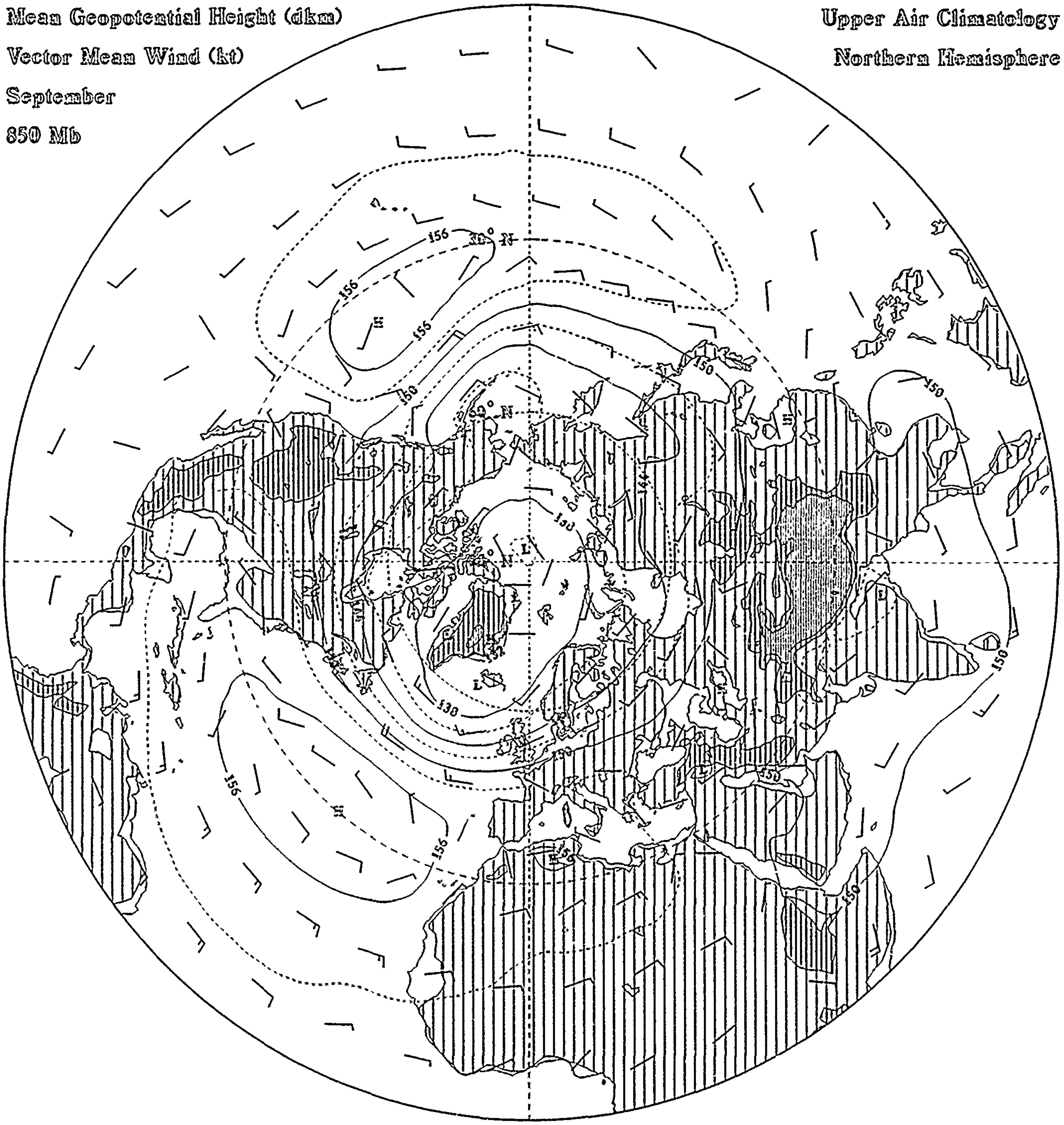


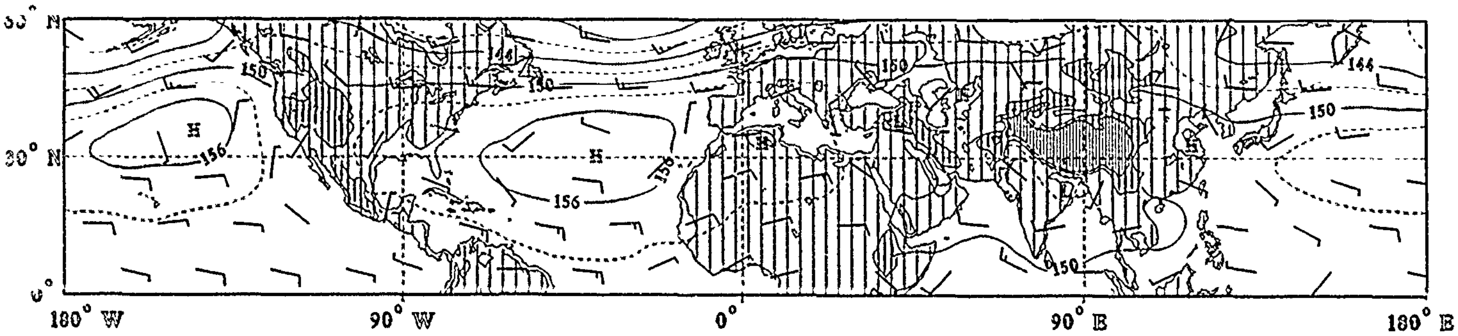


Upper Air Climatology
Southern Hemisphere
Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
1000 Mb
60° S
30° S
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
850 Mb

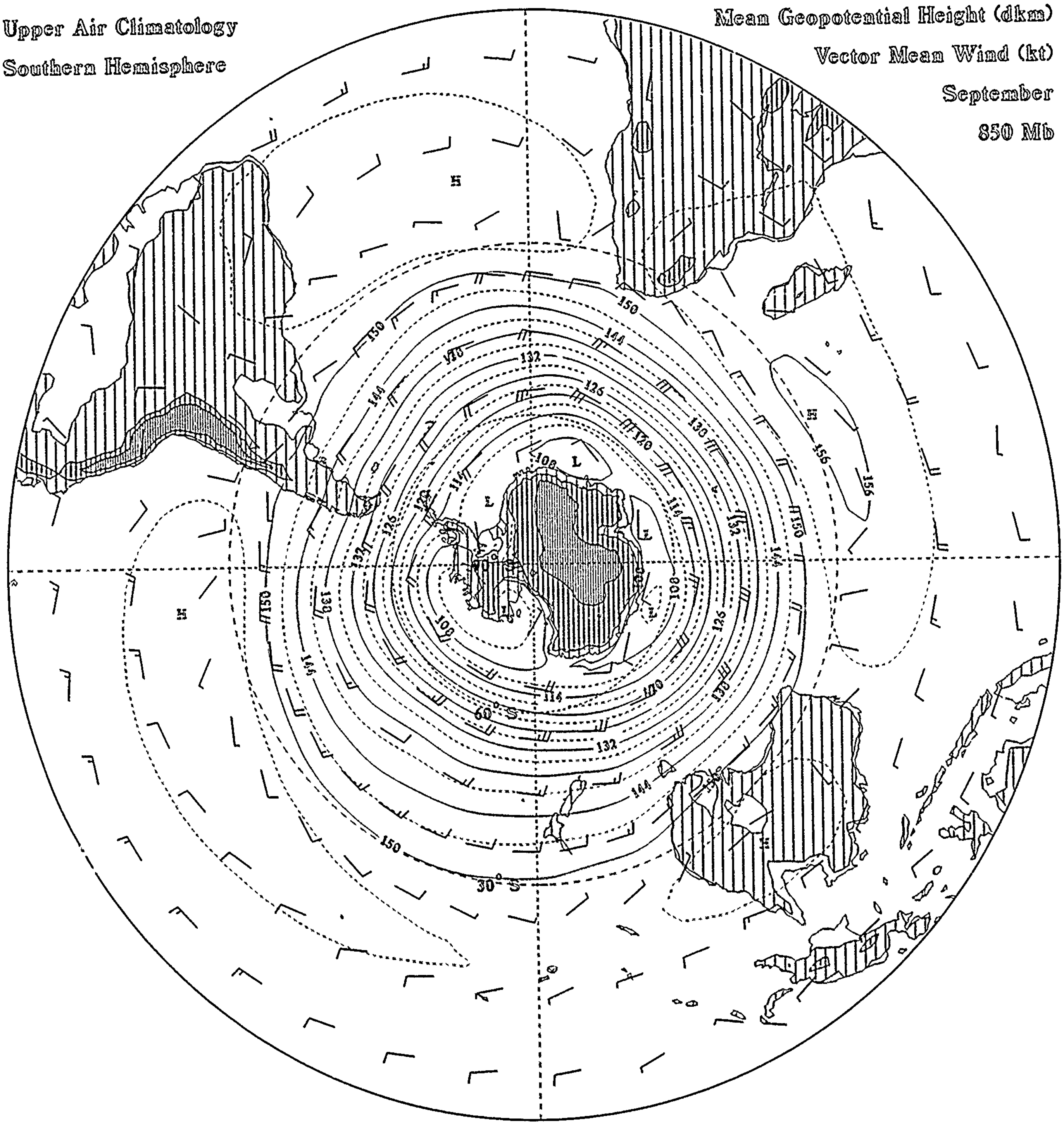
Upper Air Climatology
Northern Hemisphere

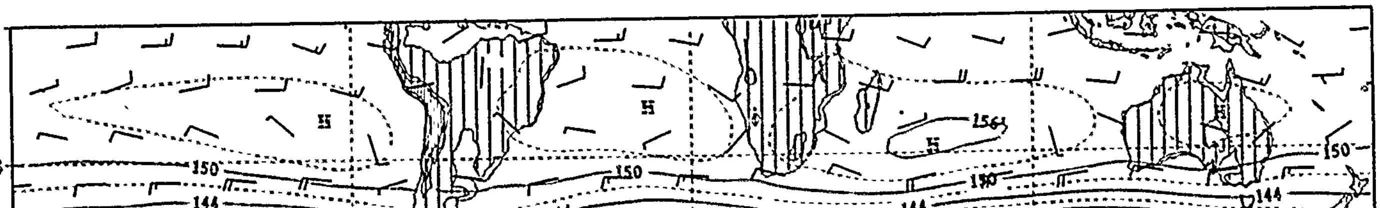




Upper Air Climatology
Southern Hemisphere

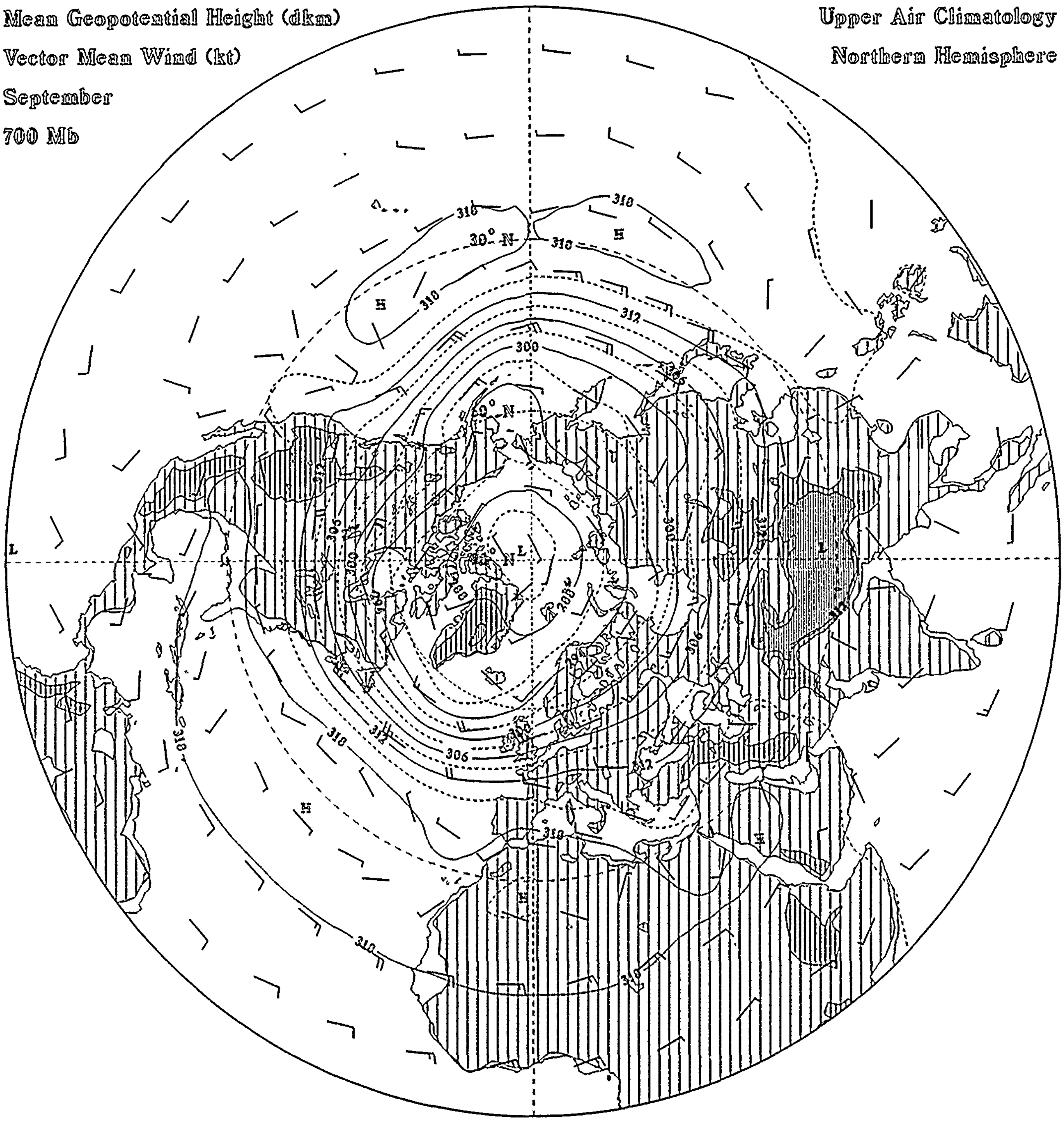
Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
850 Mb

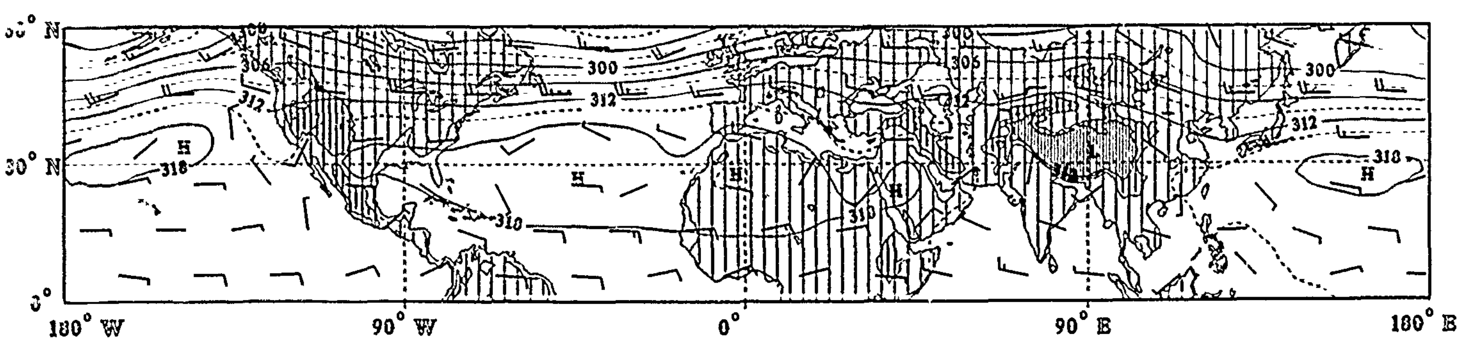




Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
700 Mb

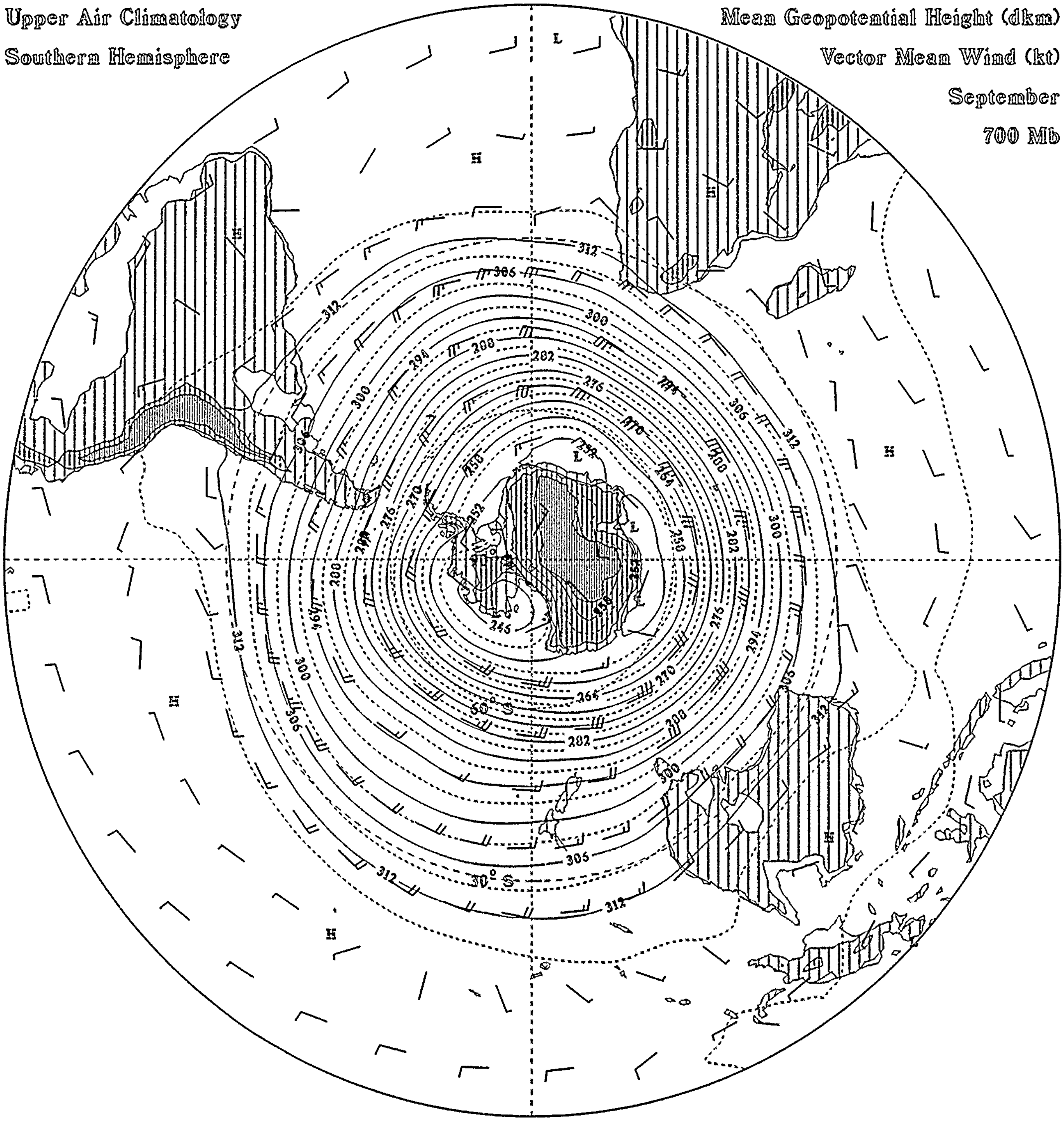
Upper Air Climatology
Northern Hemisphere

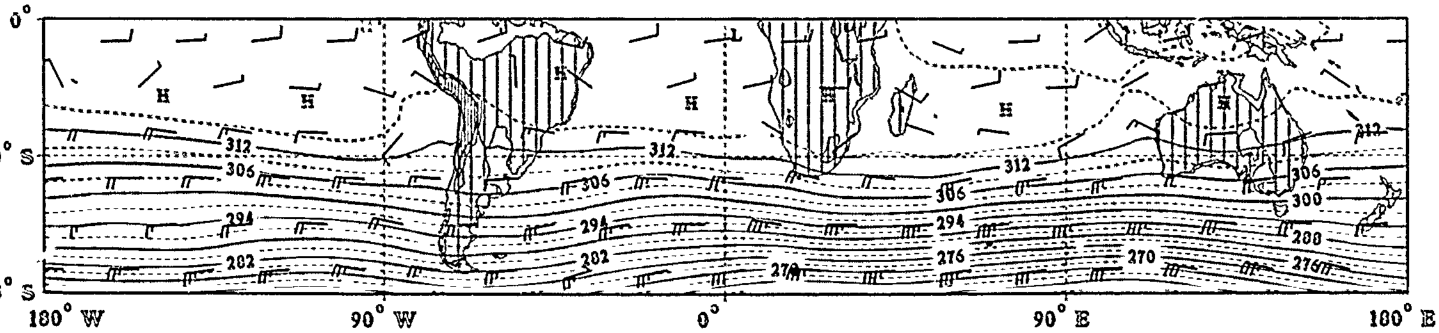




Upper Air Climatology
Southern Hemisphere

Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
700 Mb





Mean Geopotential Height (dkm)

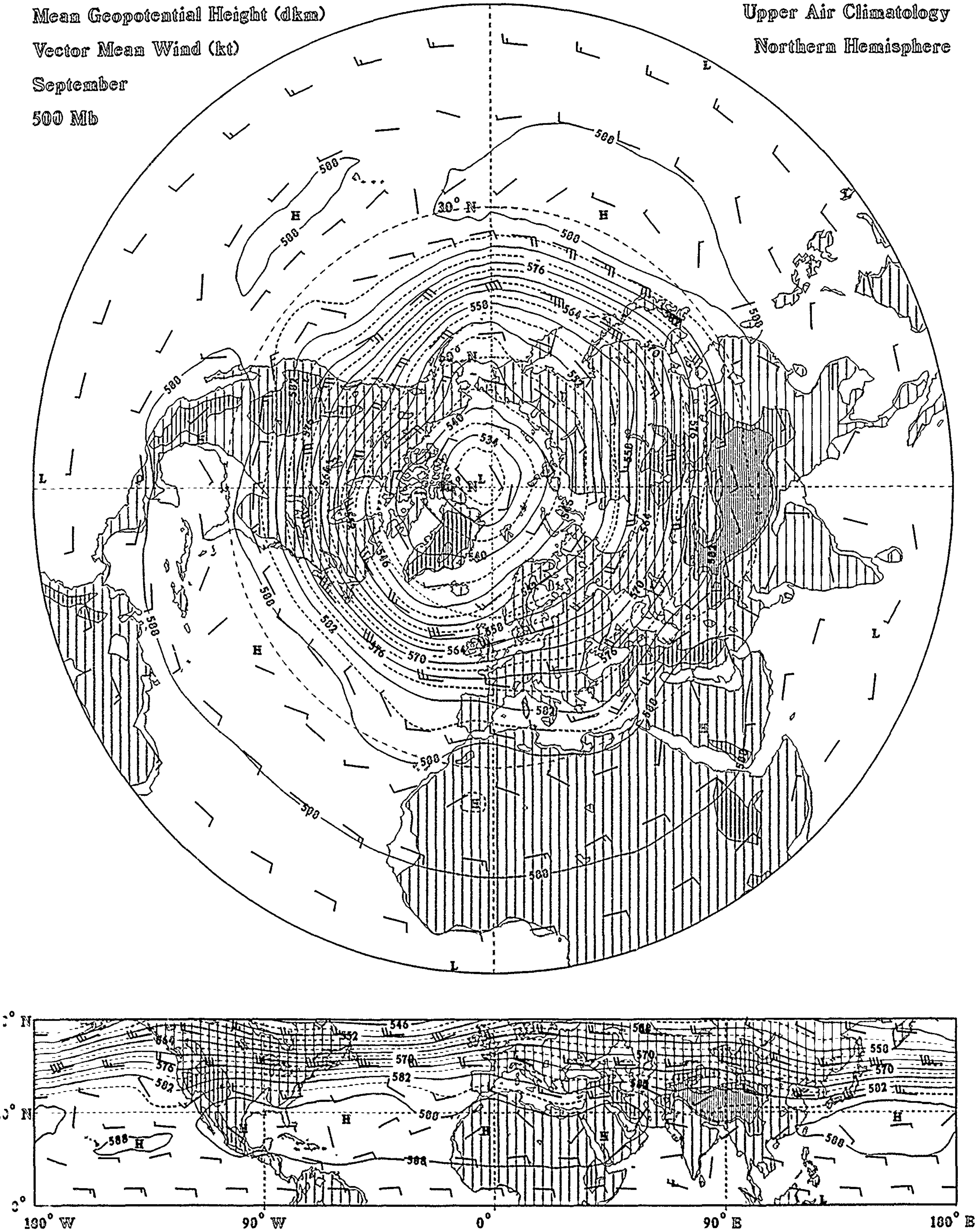
Vector Mean Wind (kt)

September

500 Mb

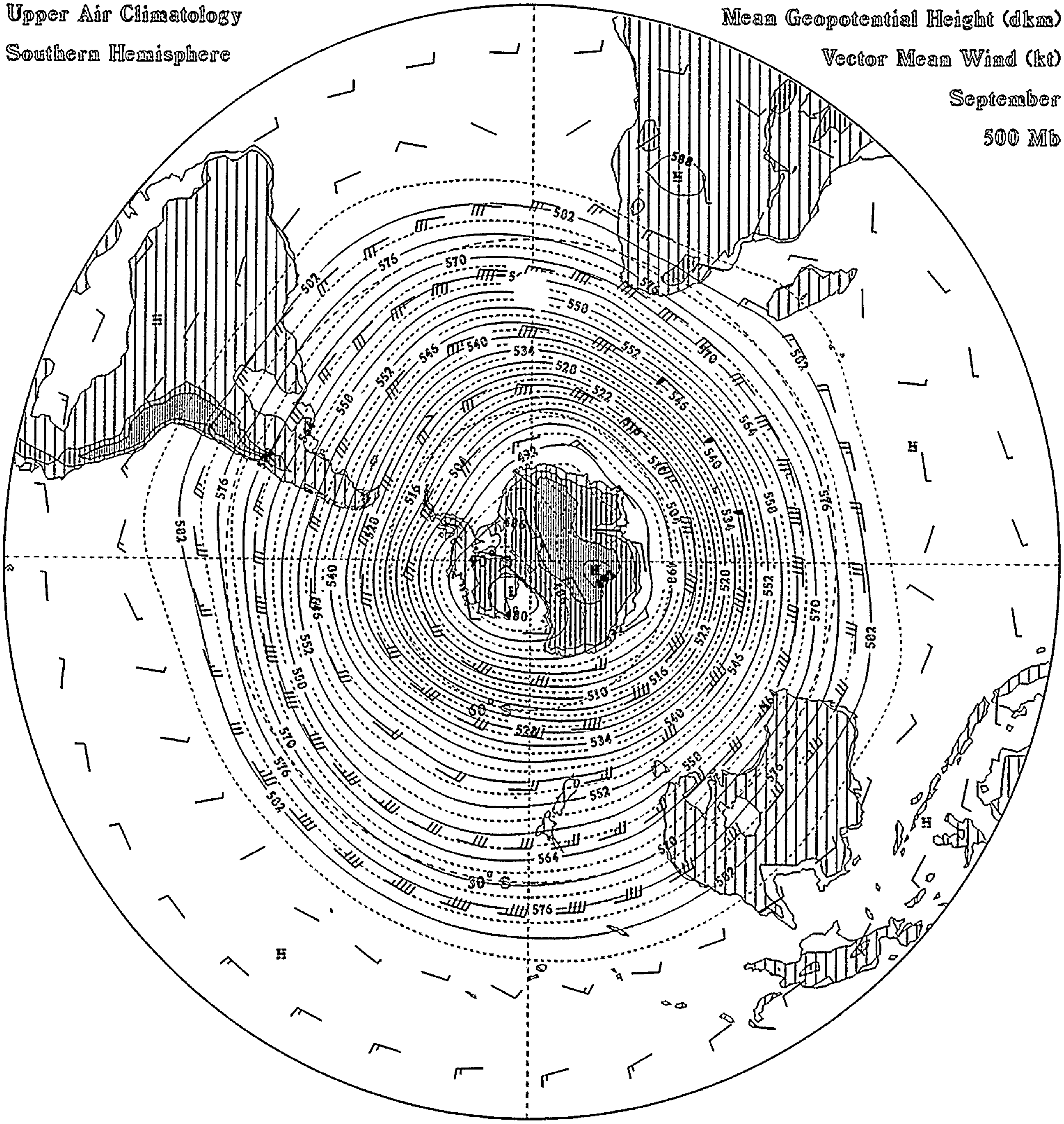
Upper Air Climatology

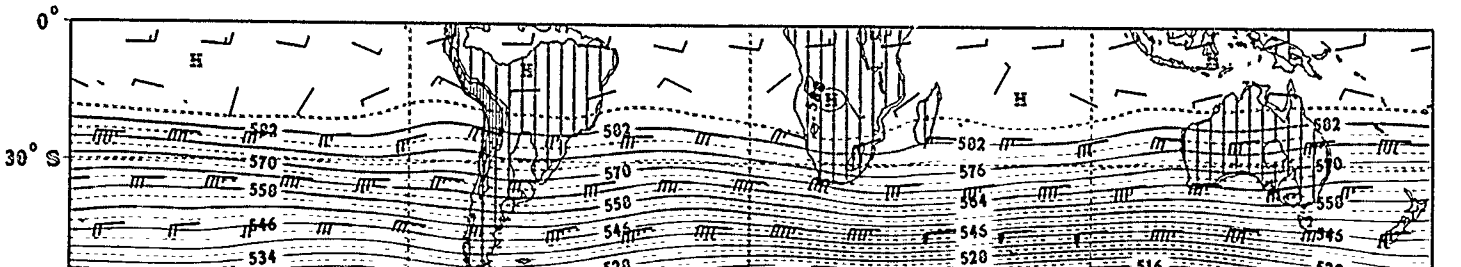
Northern Hemisphere



Upper Air Climatology
Southern Hemisphere

Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
500 Mb





Mean Geopotential Height (dkm)

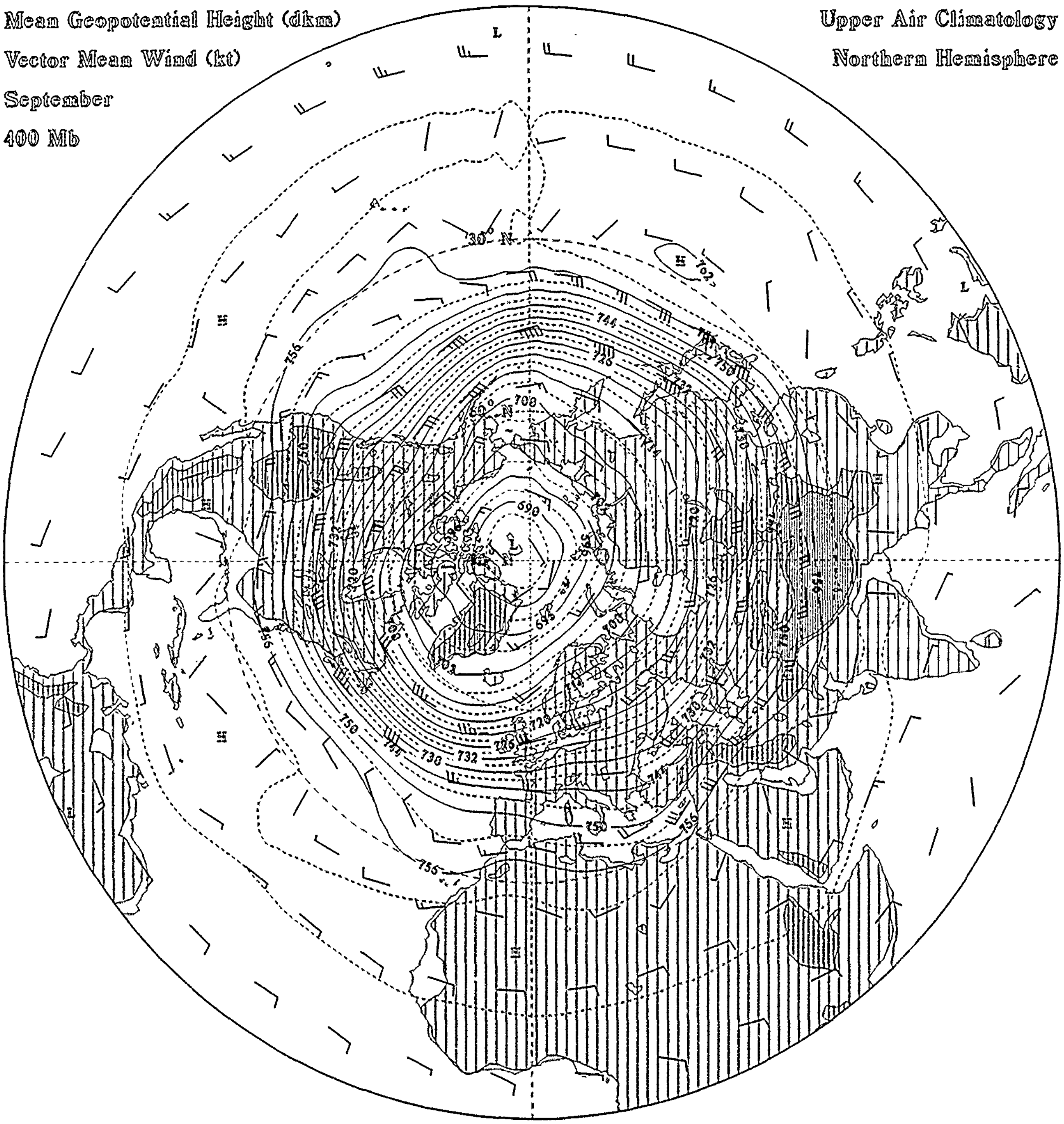
Vector Mean Wind (kt)

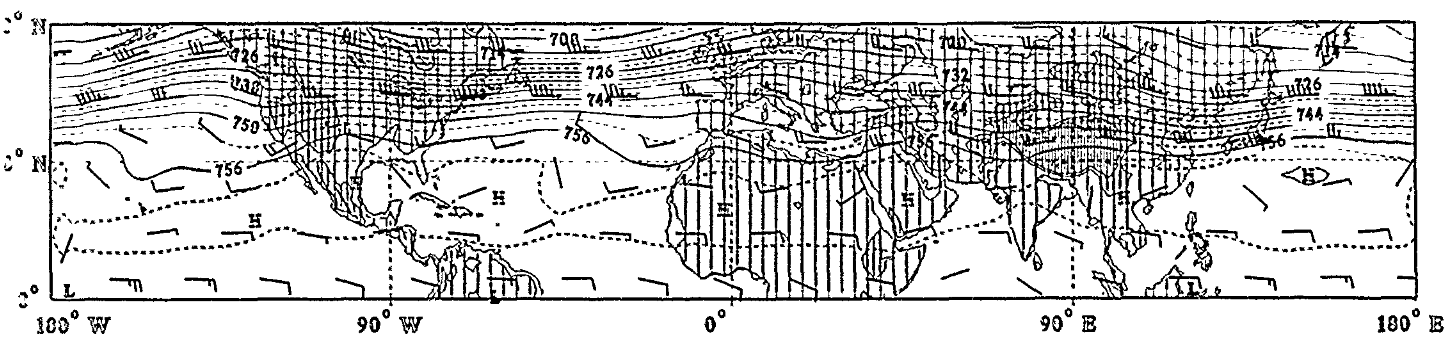
September

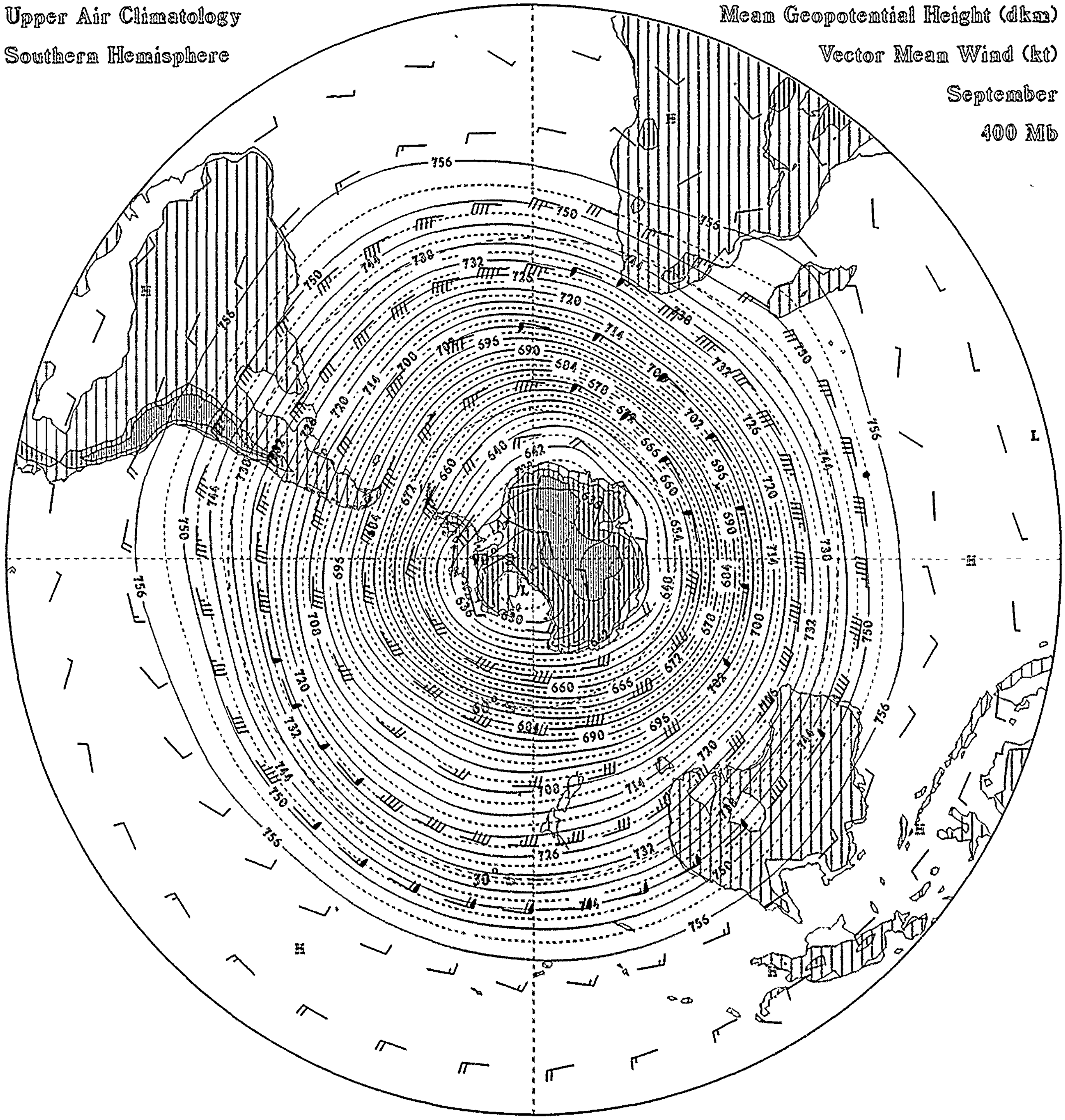
400 Mb

Upper Air Climatology

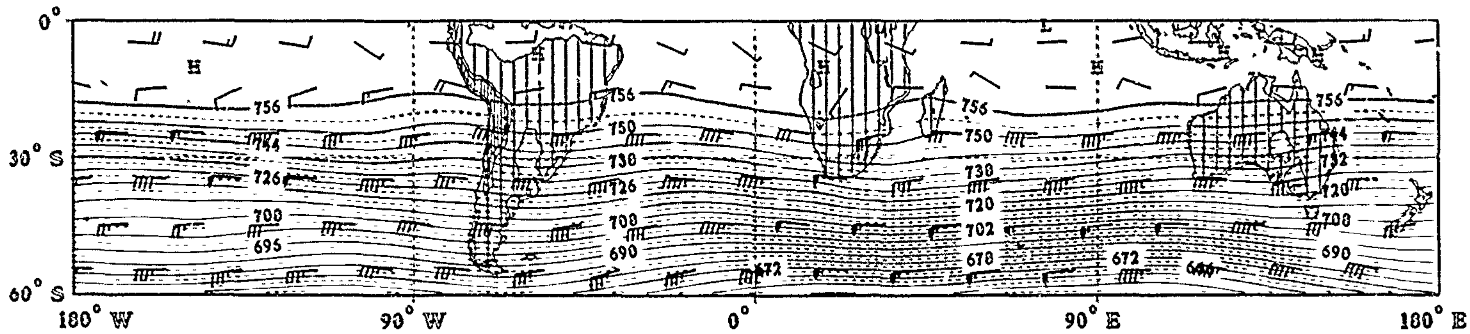
Northern Hemisphere







Upper Air Climatology
Southern Hemisphere
Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
400 Mb



0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

Mean Geopotential Height (dkm)

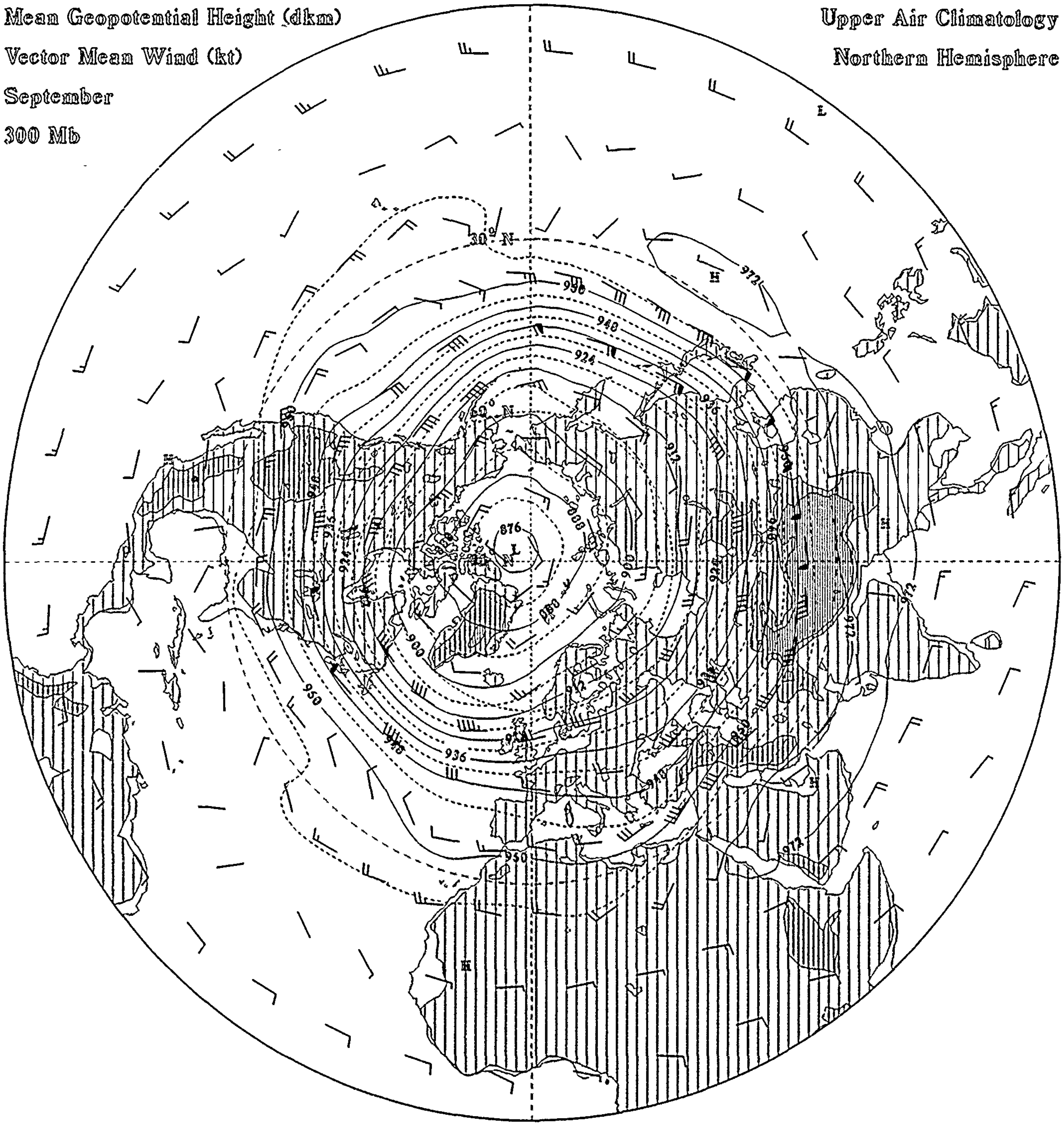
Vector Mean Wind (kt)

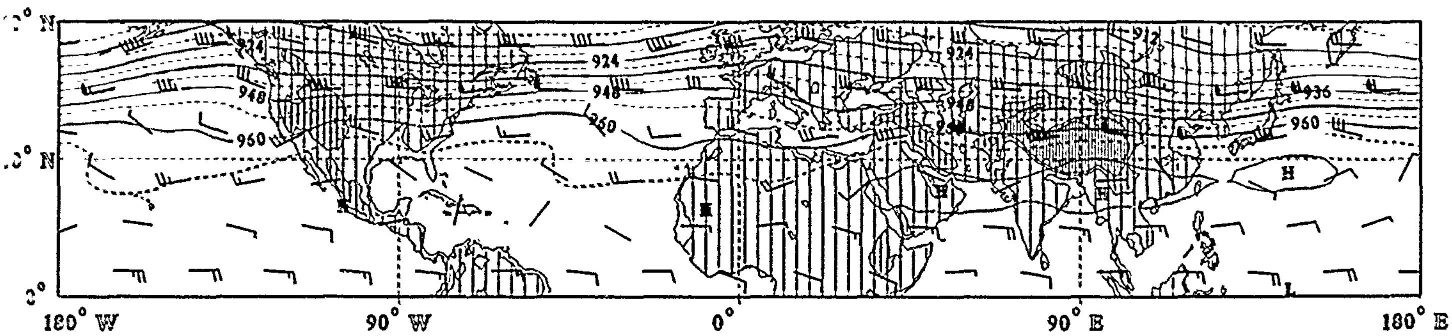
September

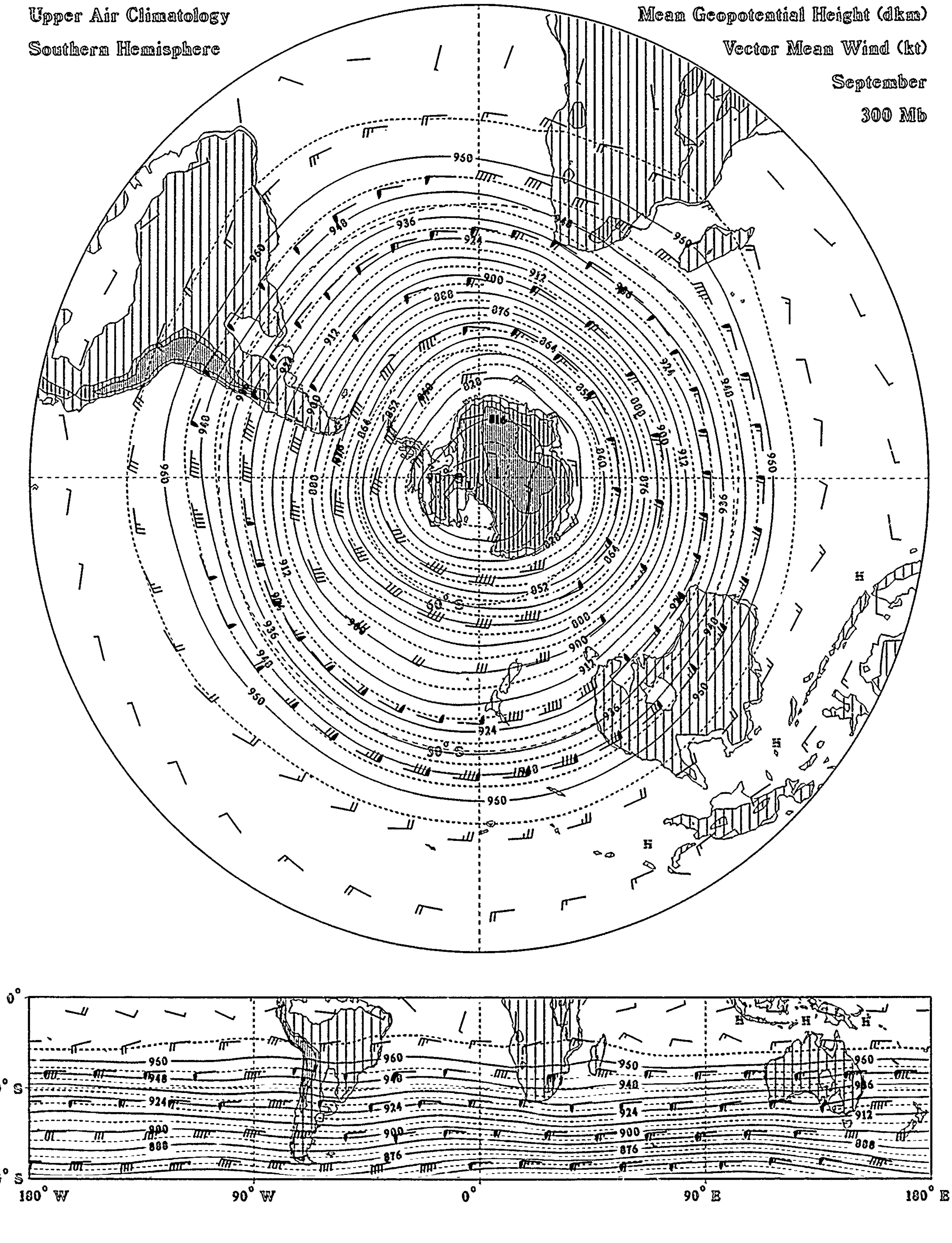
300 Mb

Upper Air Climatology

Northern Hemisphere






Upper Air Climatology
Southern Hemisphere
Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
300 Mb
960
948
936
924
912
900
888
876
864
852
840
828
816
60° S
30° S
0°
180° W
90° W
90° E
180° E

Mean Geopotential Height (dkm)

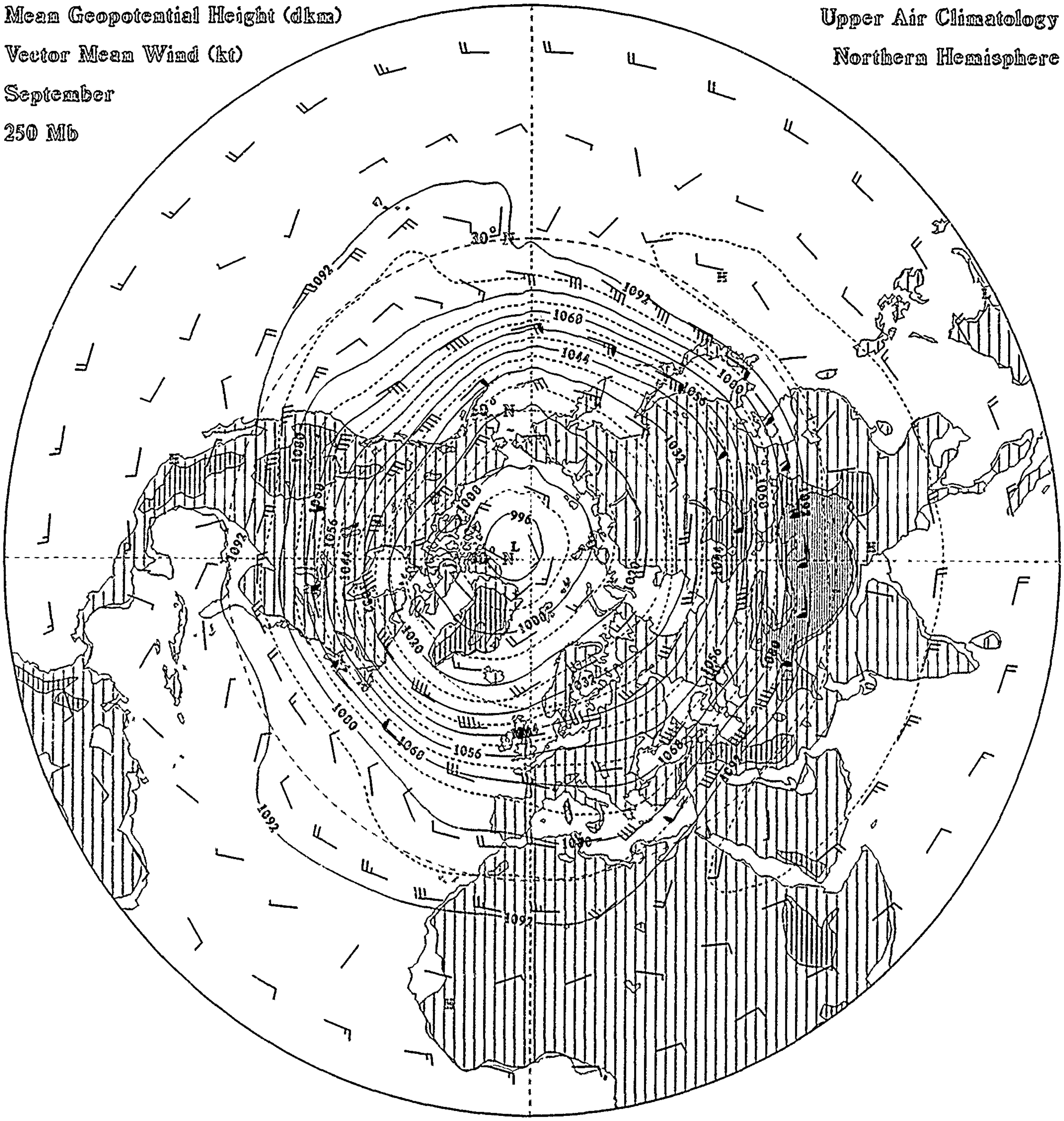
Vector Mean Wind (kt)

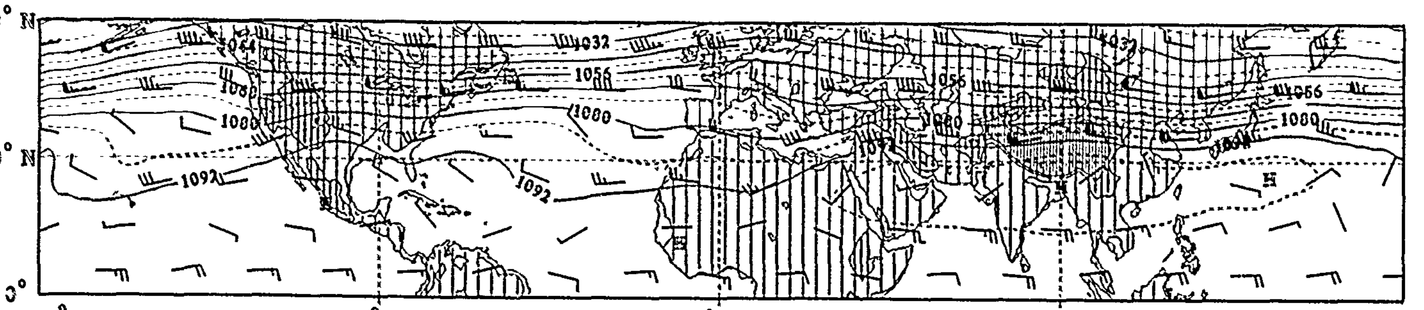
September

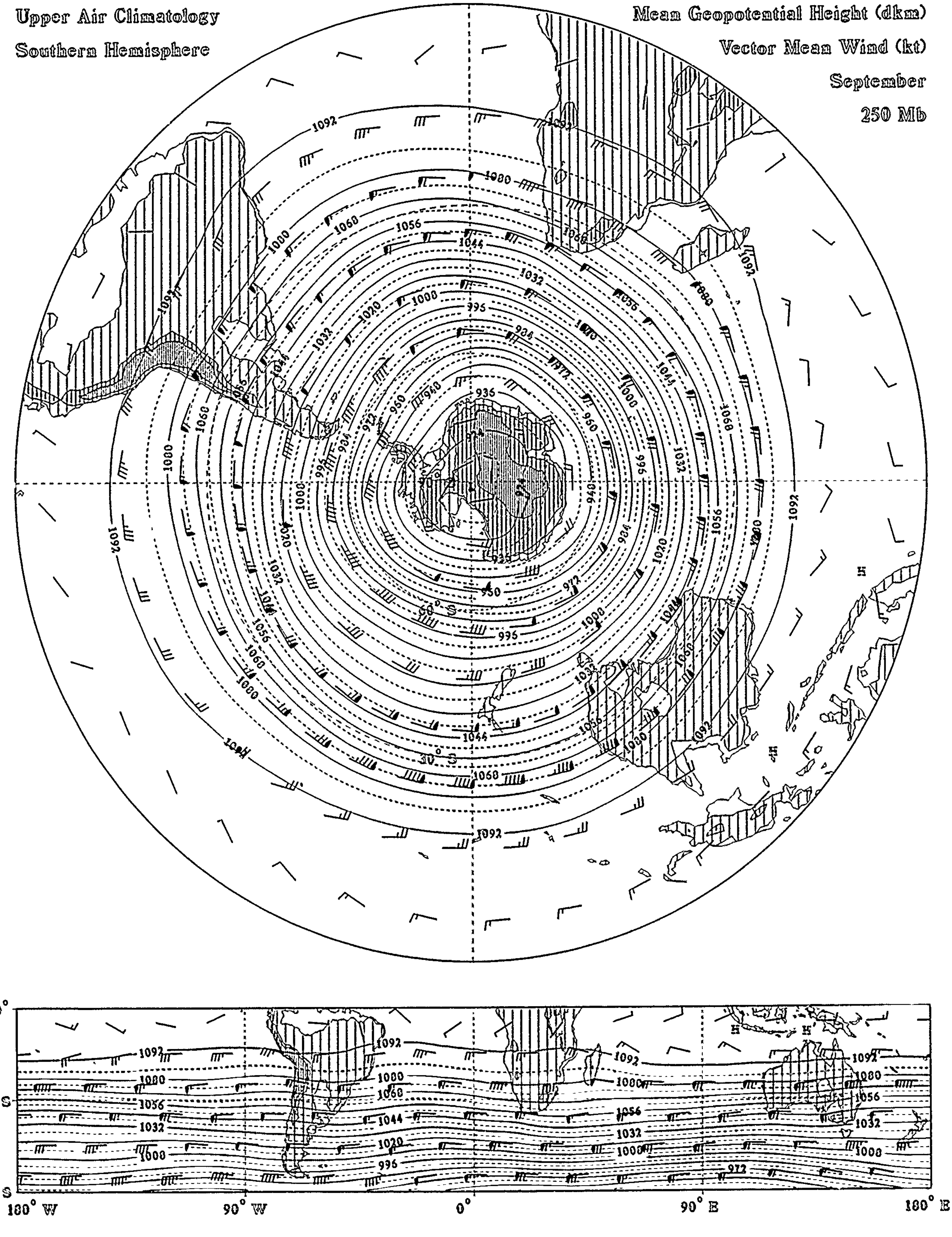
250 Mb

Upper Air Climatology

Northern Hemisphere






Upper Air Climatology
Southern Hemisphere
Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
250 Mb
60° S
30° S
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

Mean Geopotential Height (dkm)

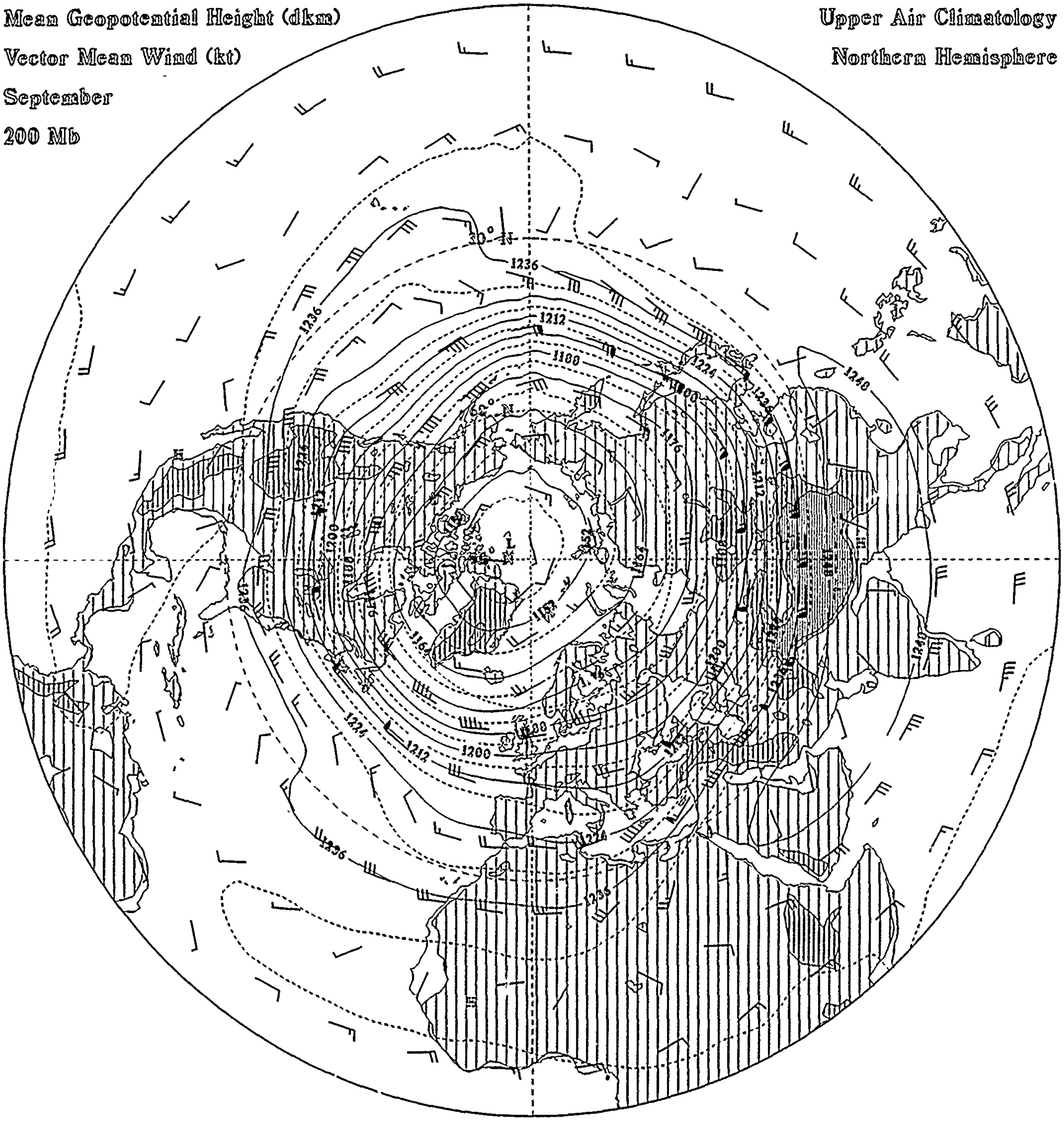
Vector Mean Wind (kt)

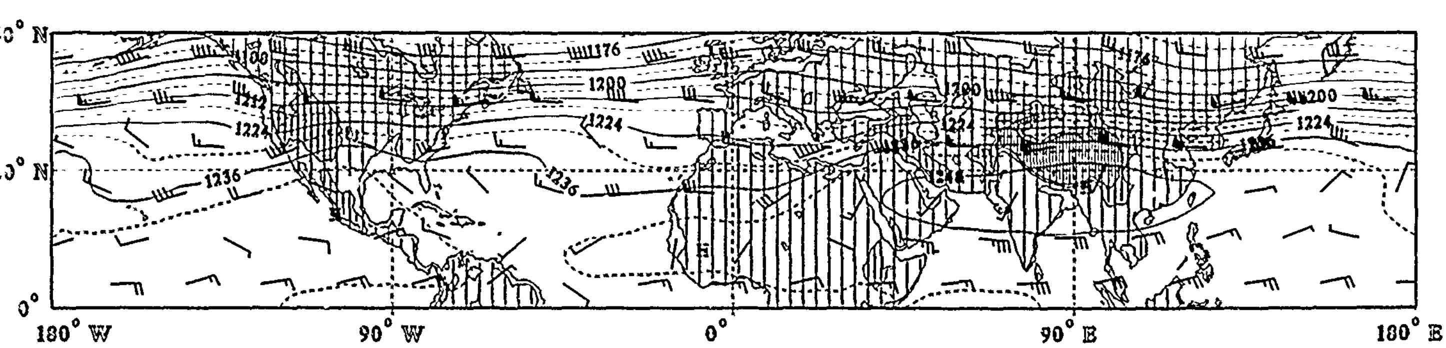
September

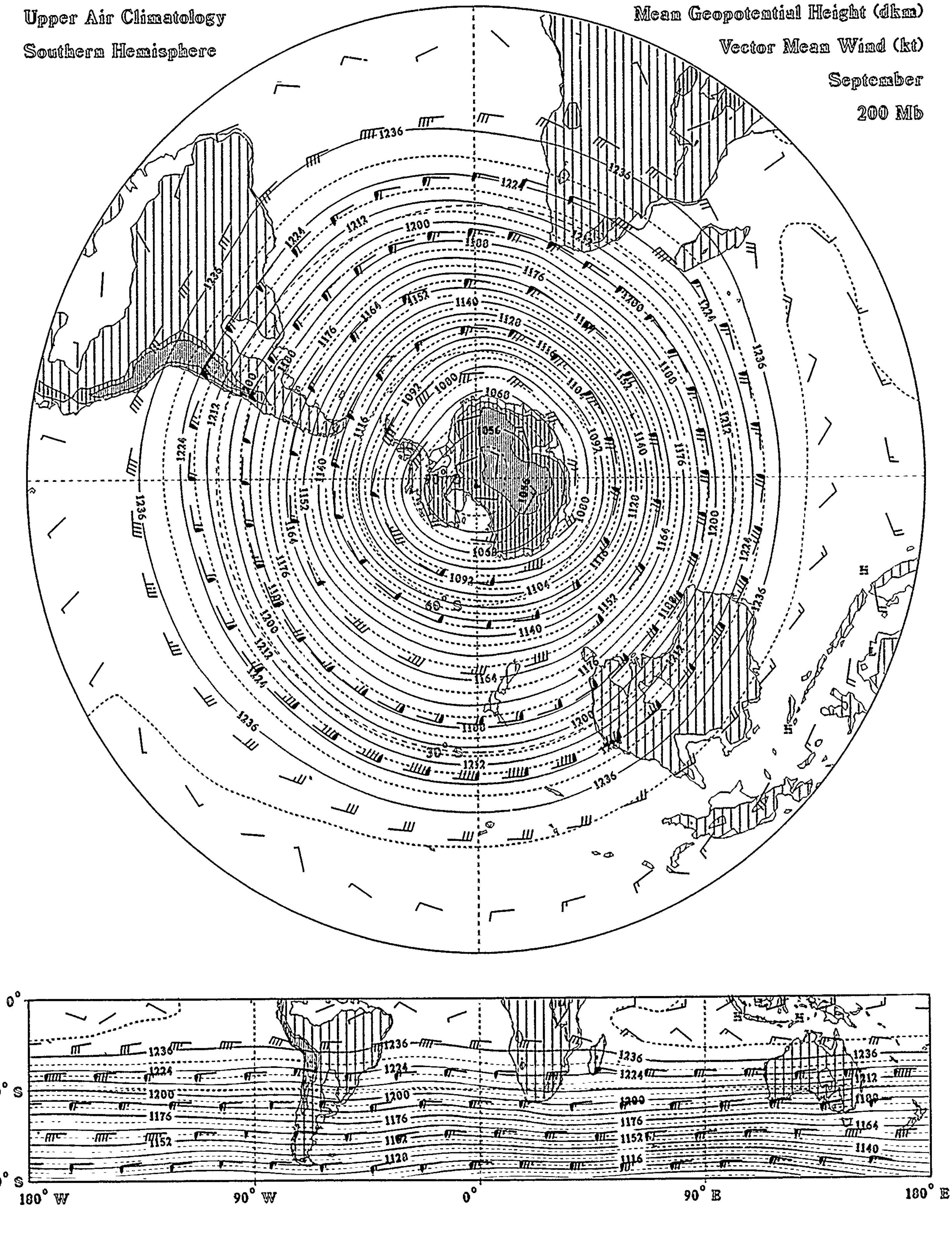
200 Mb

Upper Air Climatology

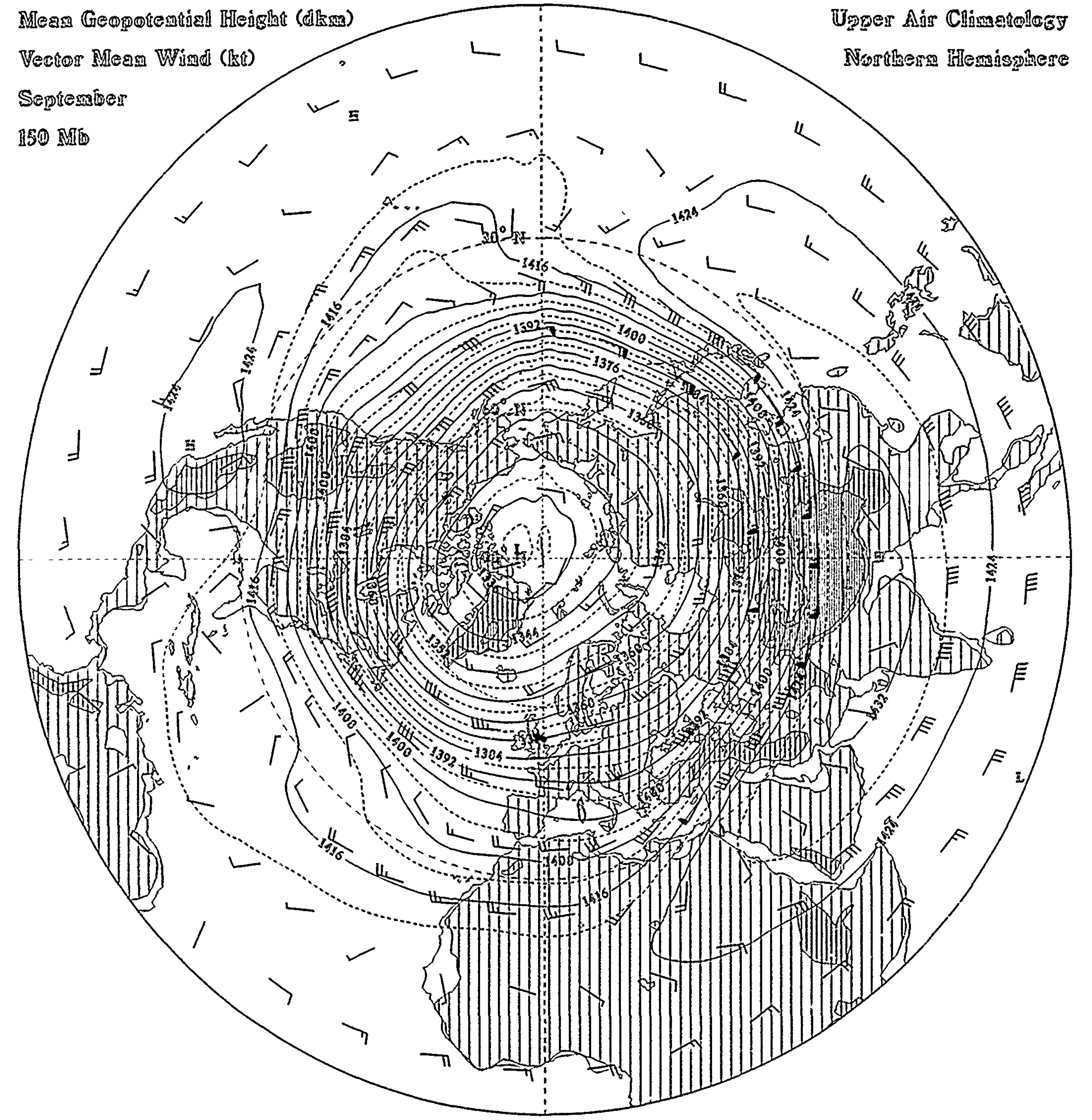
Northern Hemisphere

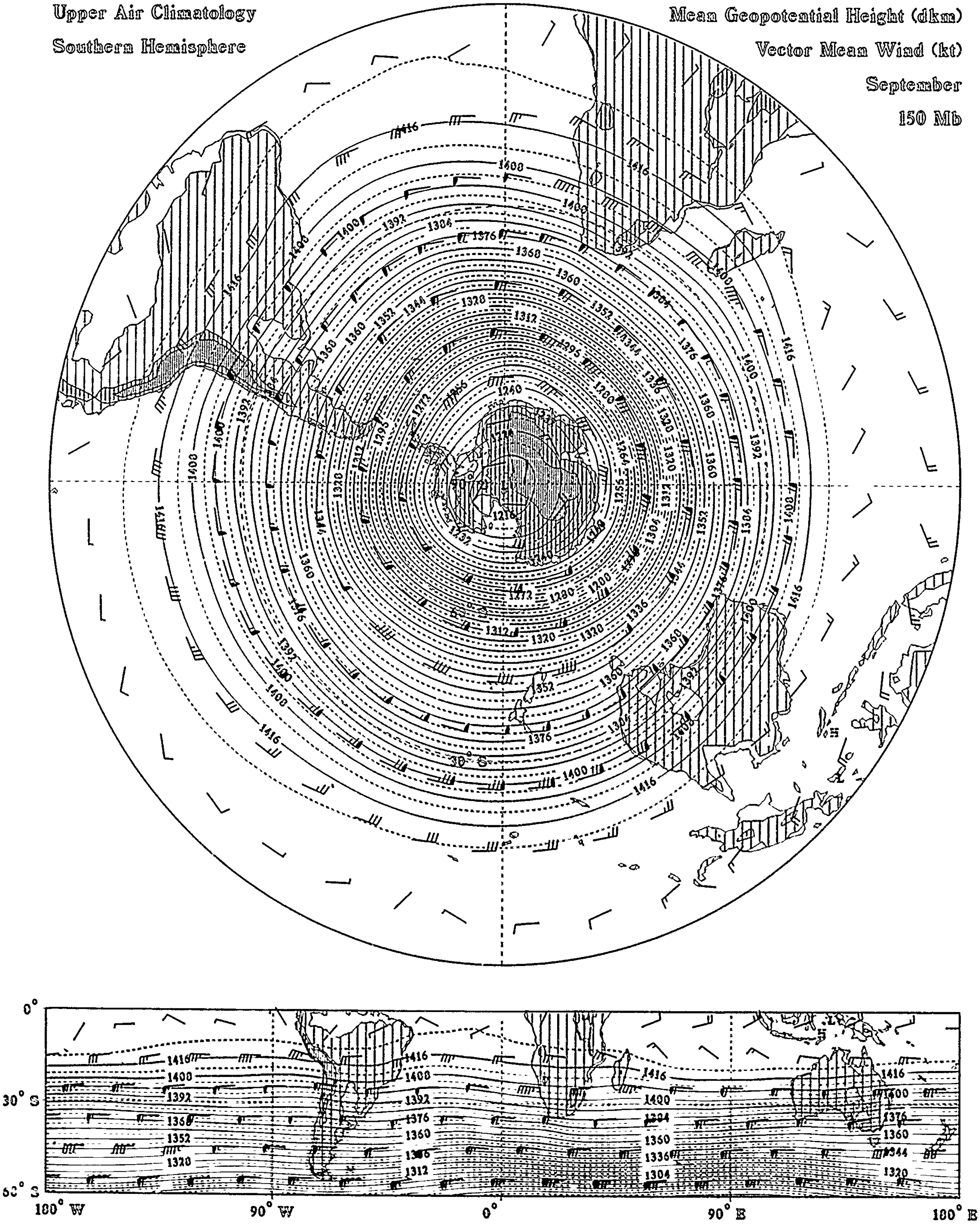


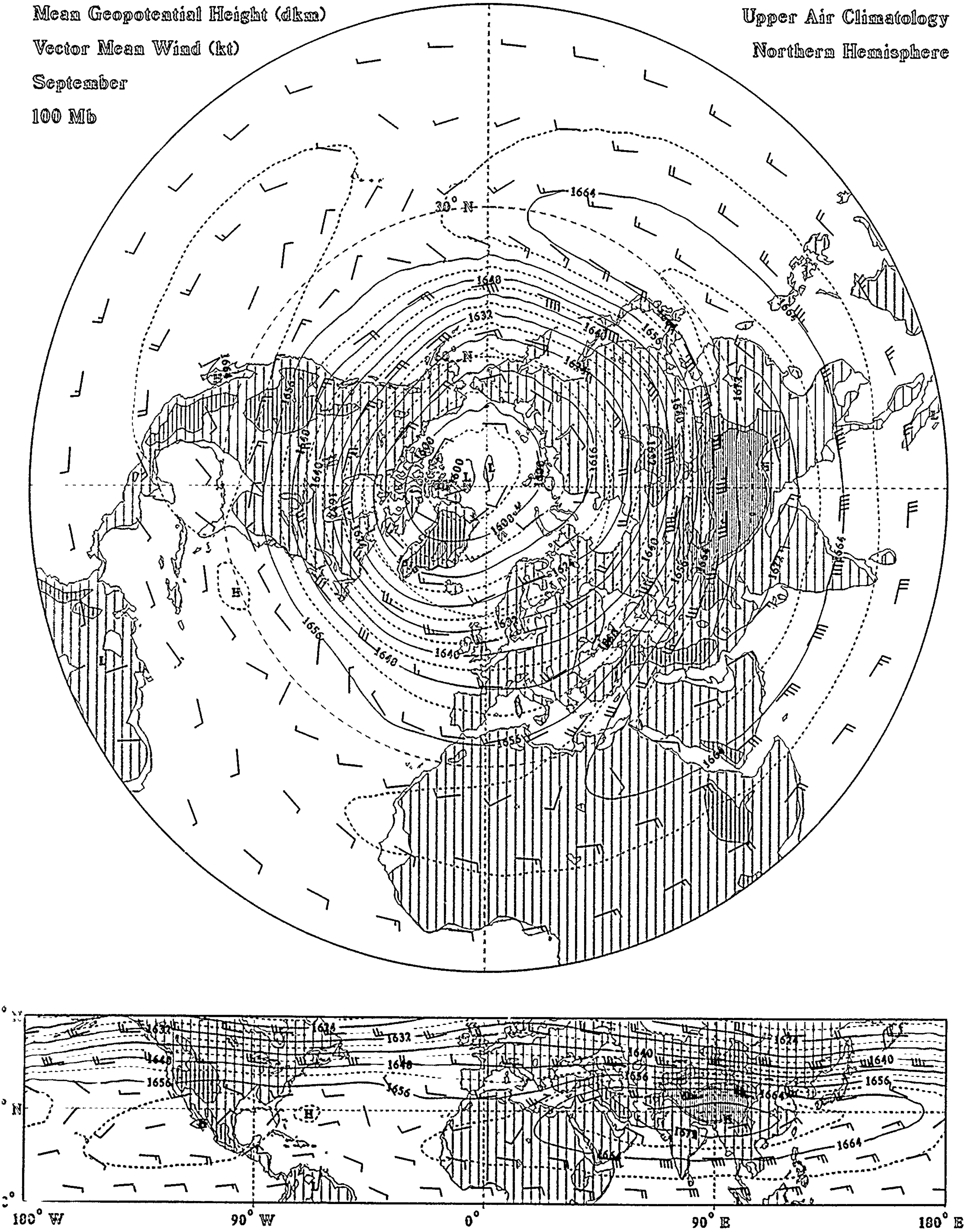




Upper Air Climatology
Southern Hemisphere
Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
200 Mb
60° S
30° S
0°
180° W
90° W
90° E
180° E


Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
150 Mb
Upper Air Climatology
Northern Hemisphere
180° W
90° W
0°
90° E
180° E

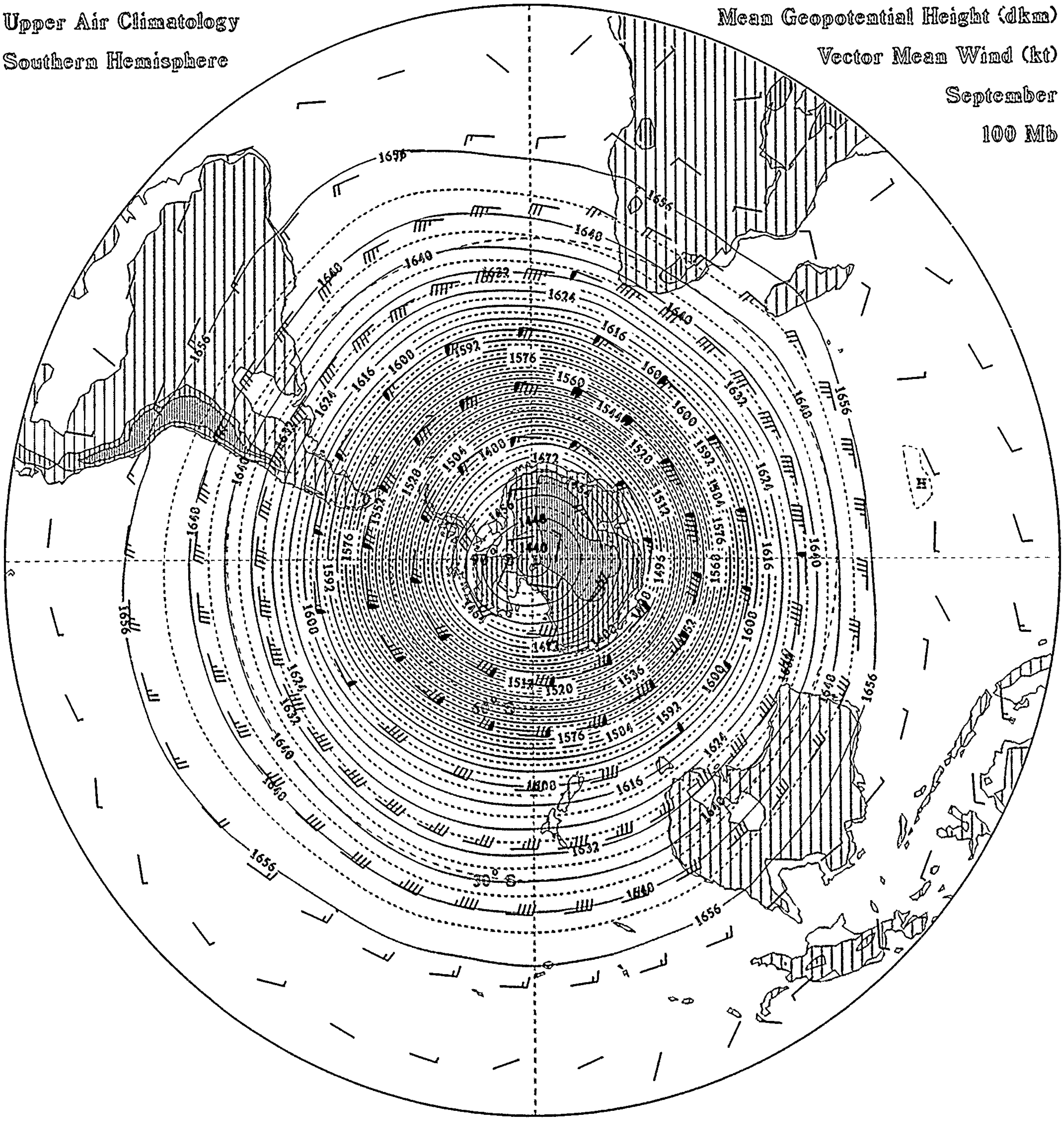

Upper Air Climatology
Southern Hemisphere
Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
150 Mb
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

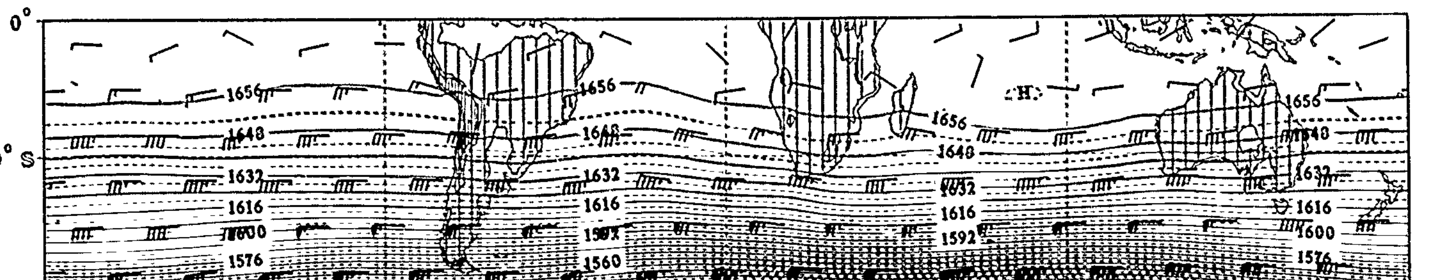


Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
100 Mb
Upper Air Climatology
Northern Hemisphere
180° W
90° W
0°
90° E
180° E

Upper Air Climatology
Southern Hemisphere

Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
100 Mb





Mean Geopotential Height (dkm)

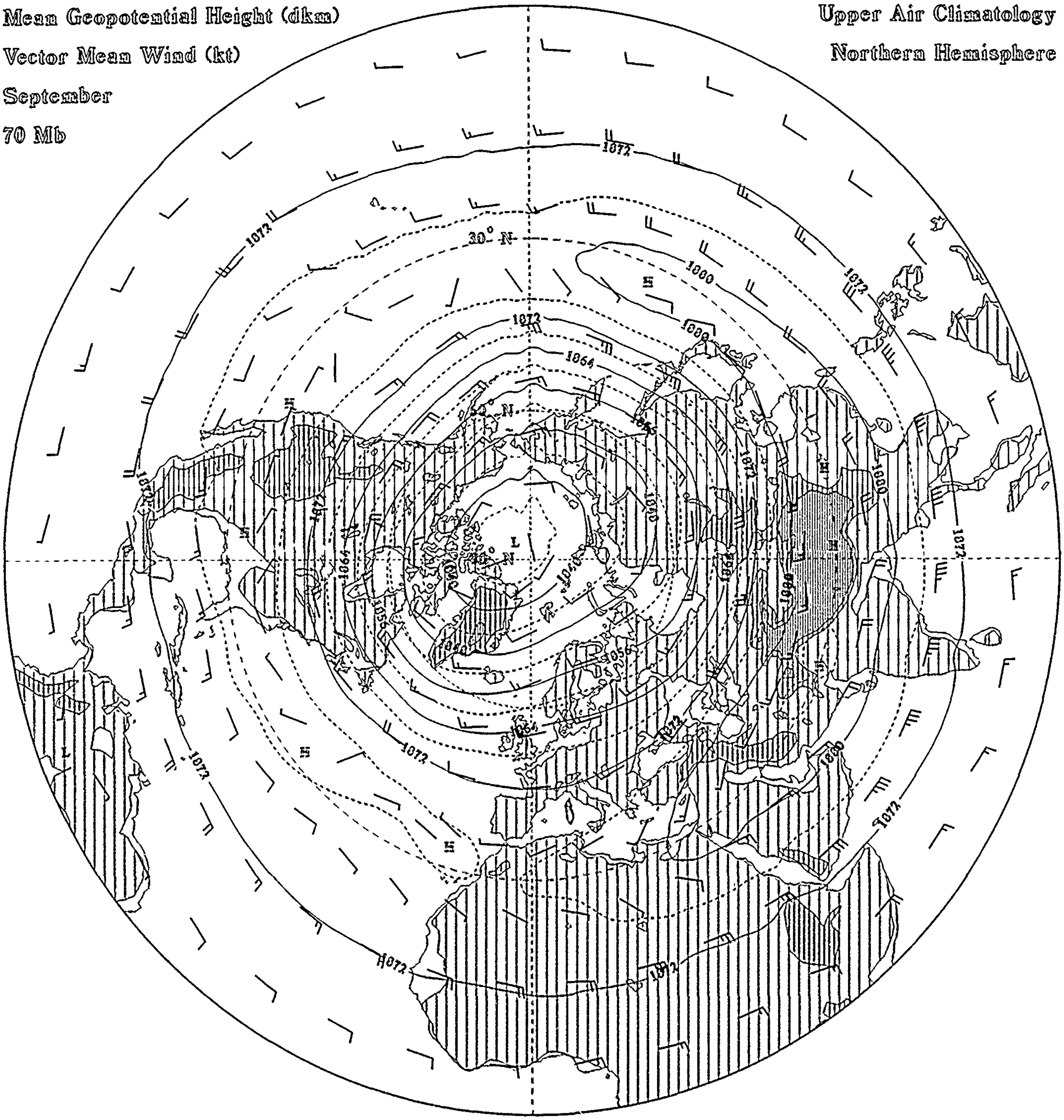
Vector Mean Wind (kt)

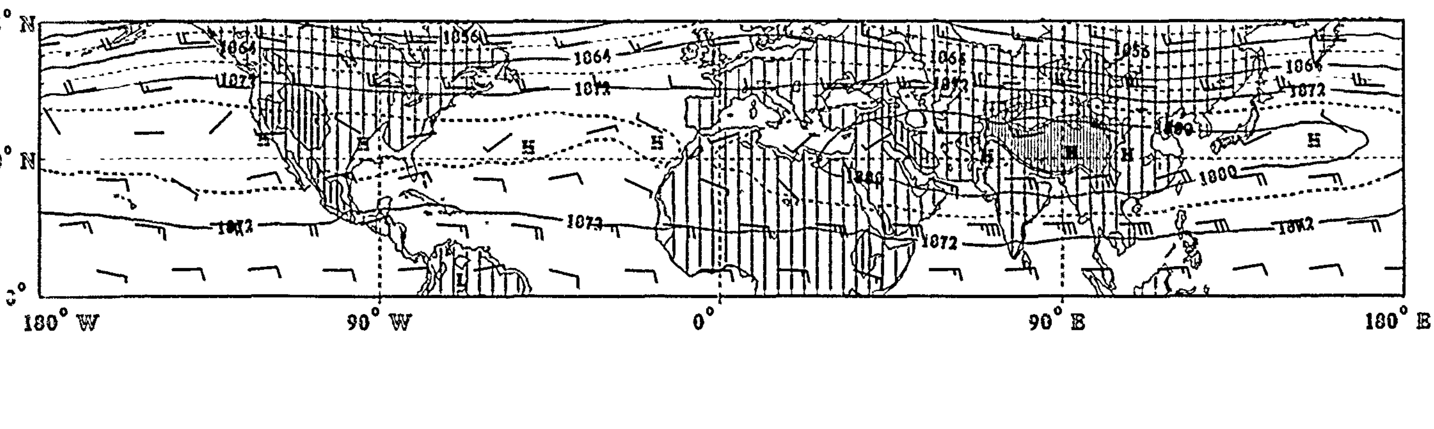
September

70 Mb

Upper Air Climatology

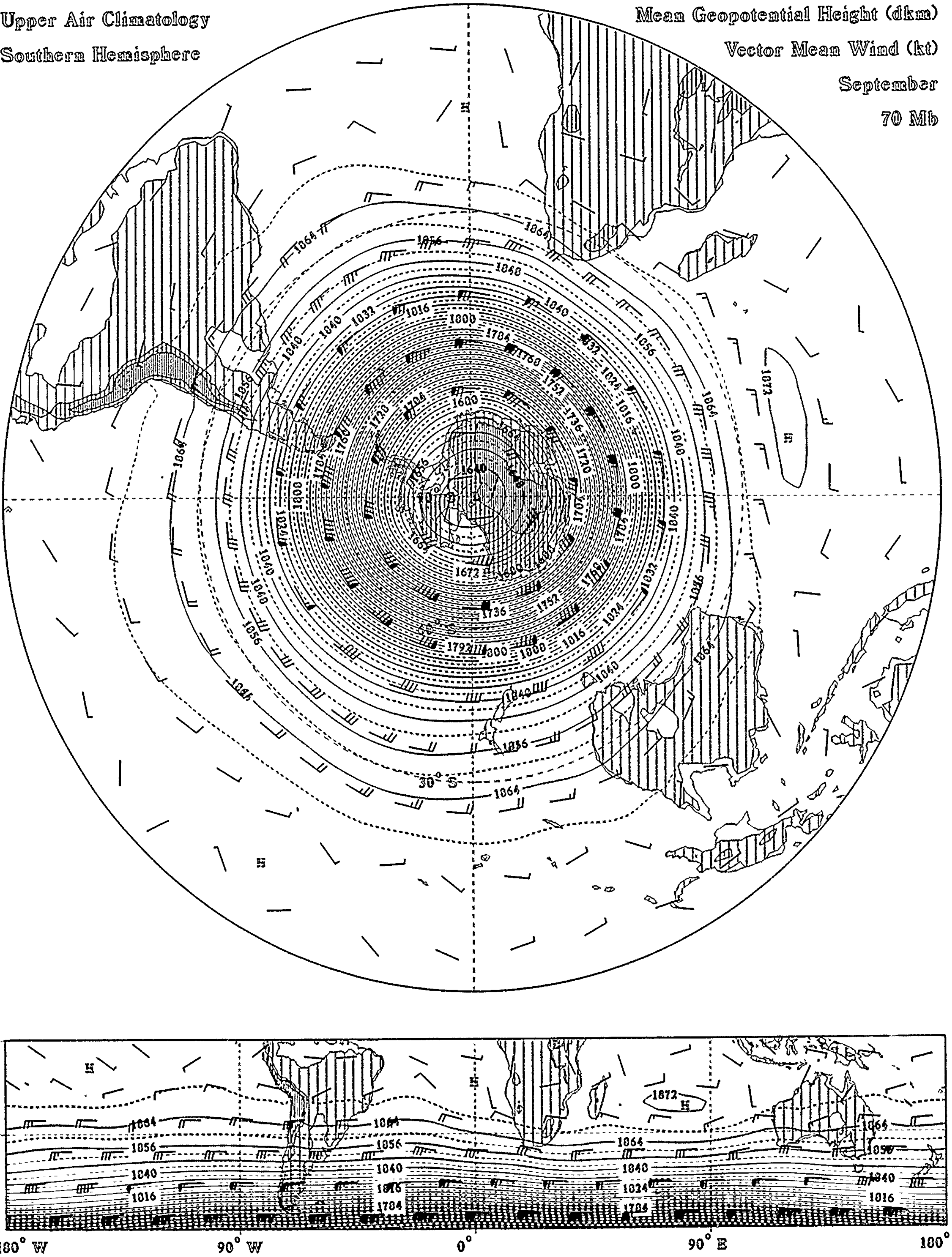
Northern Hemisphere

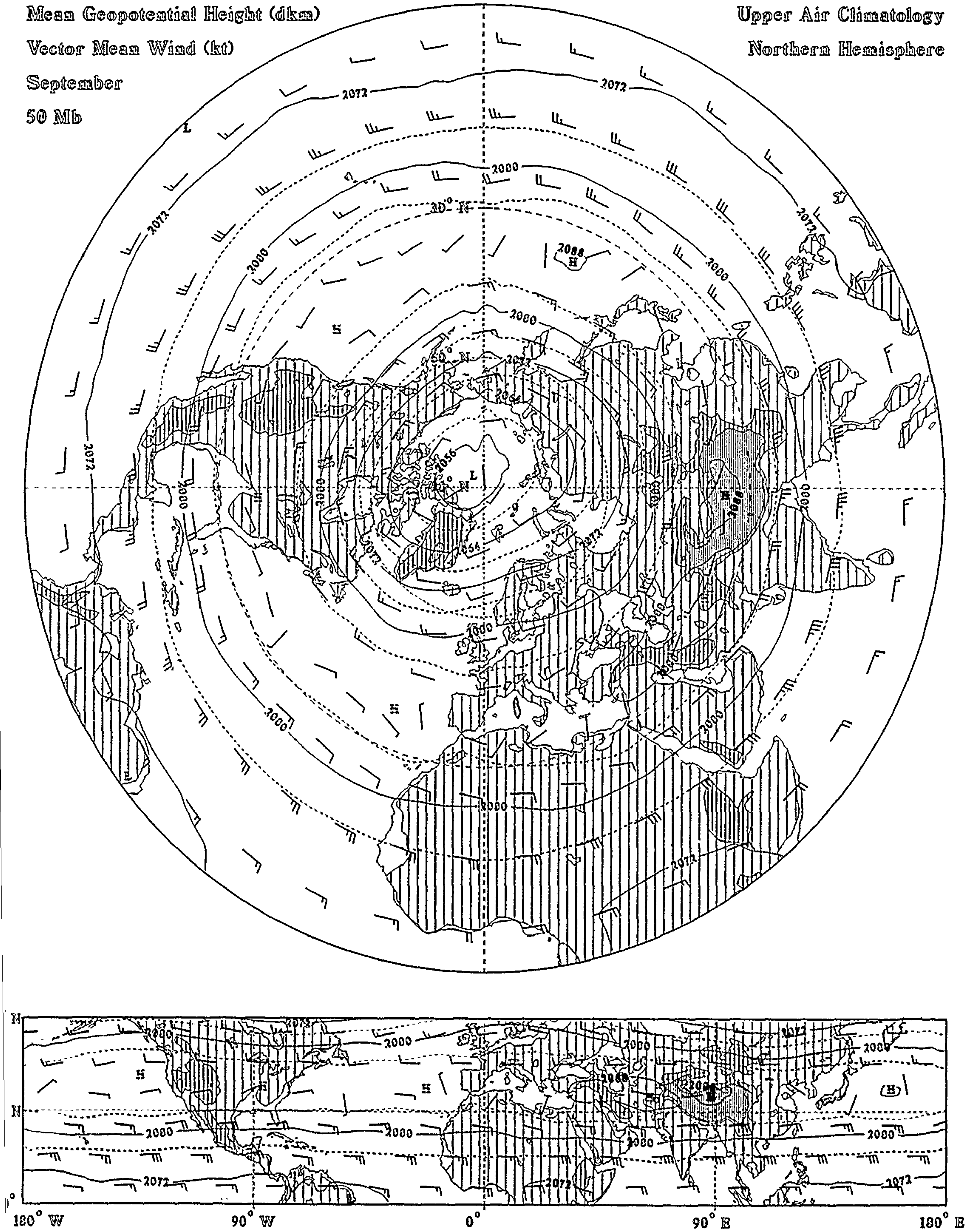




Upper Air Climatology
Southern Hemisphere

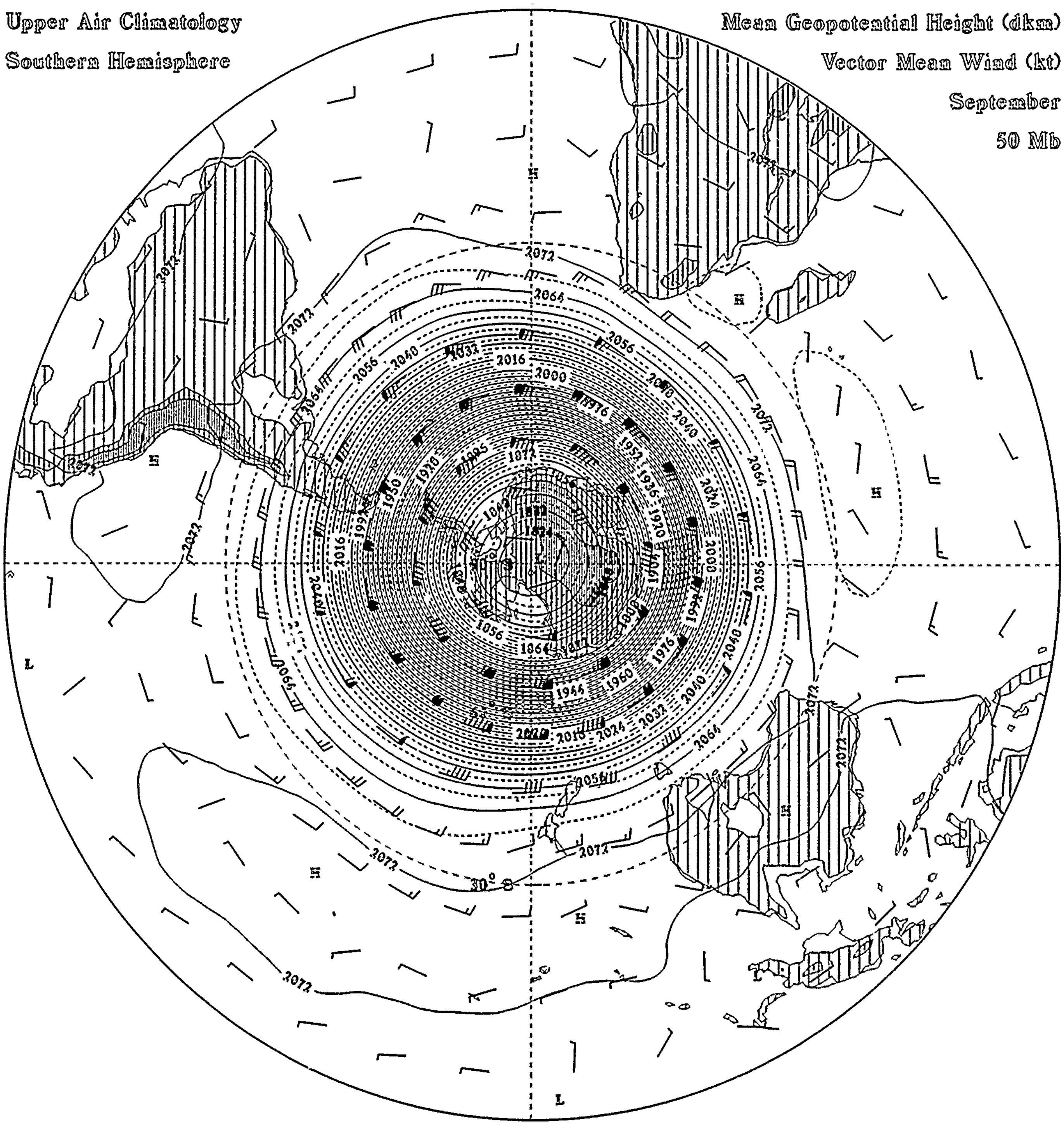
Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
70 Mb

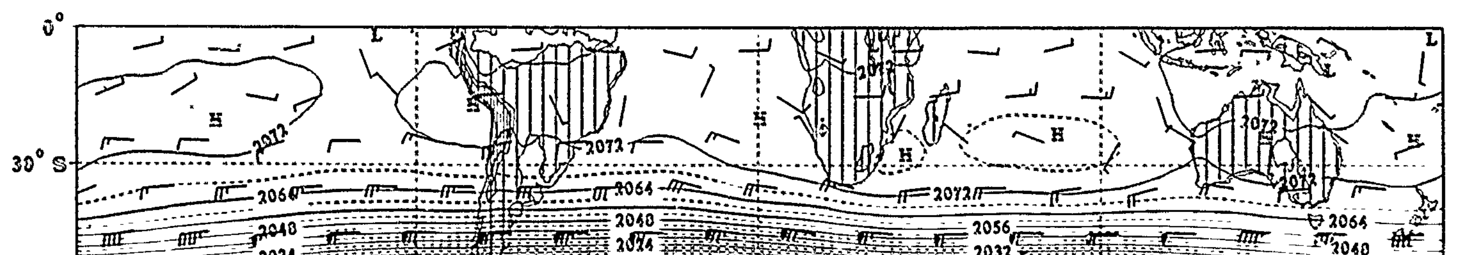



Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
50 Mb
Upper Air Climatology
Northern Hemisphere
180° W
90° W
0°
90° E
180° E

Upper Air Climatology
Southern Hemisphere

Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
50 Mb





Mean Geopotential Height (dkm)

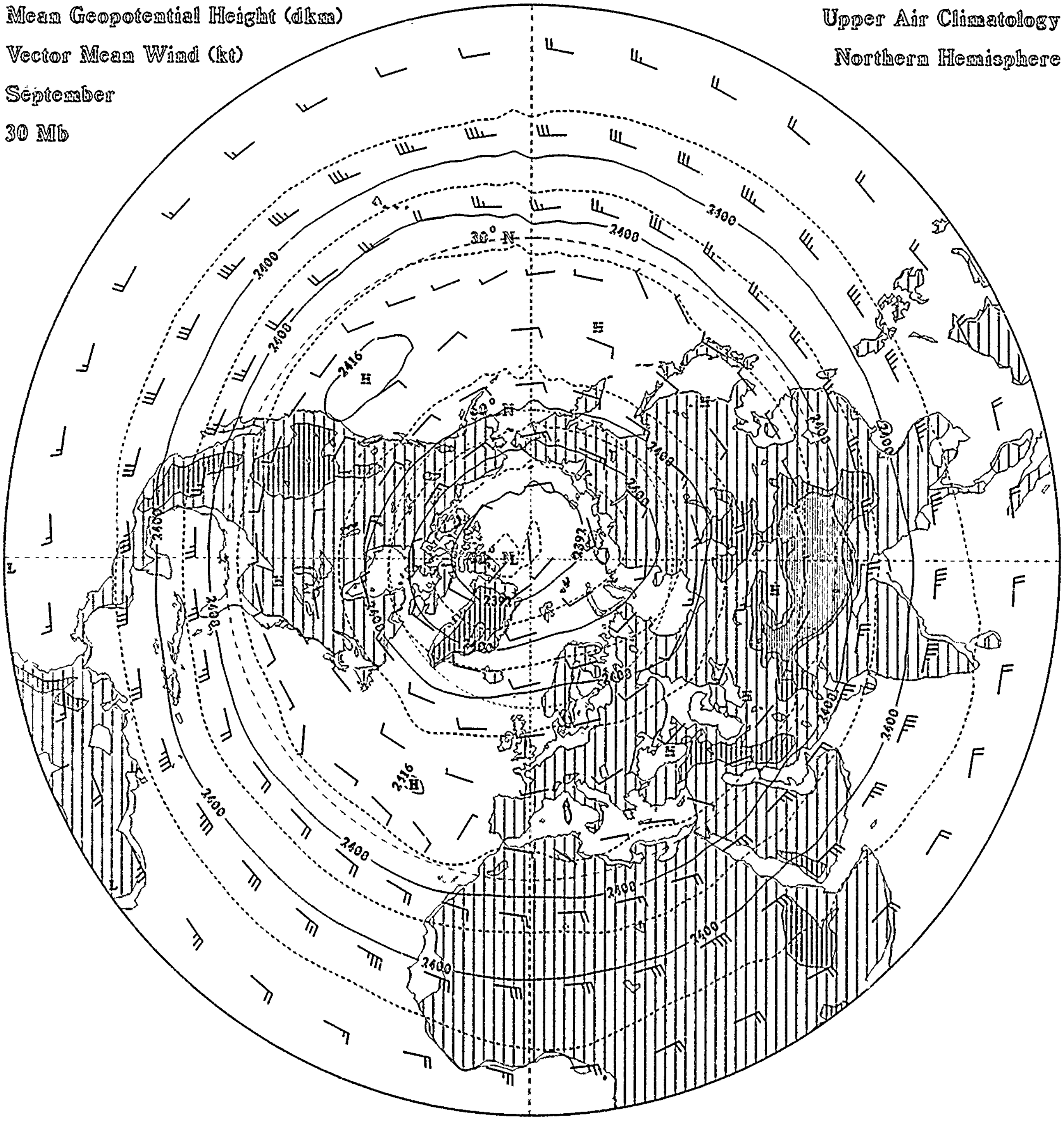
Vector Mean Wind (kt)

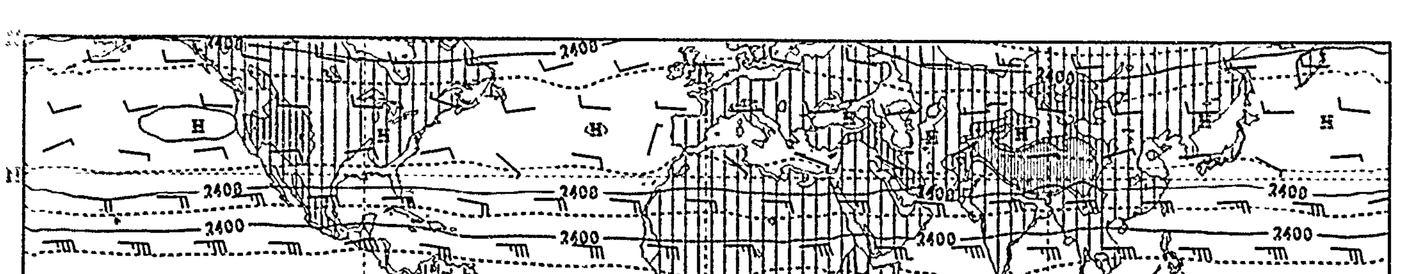
September

30 Mb

Upper Air Climatology

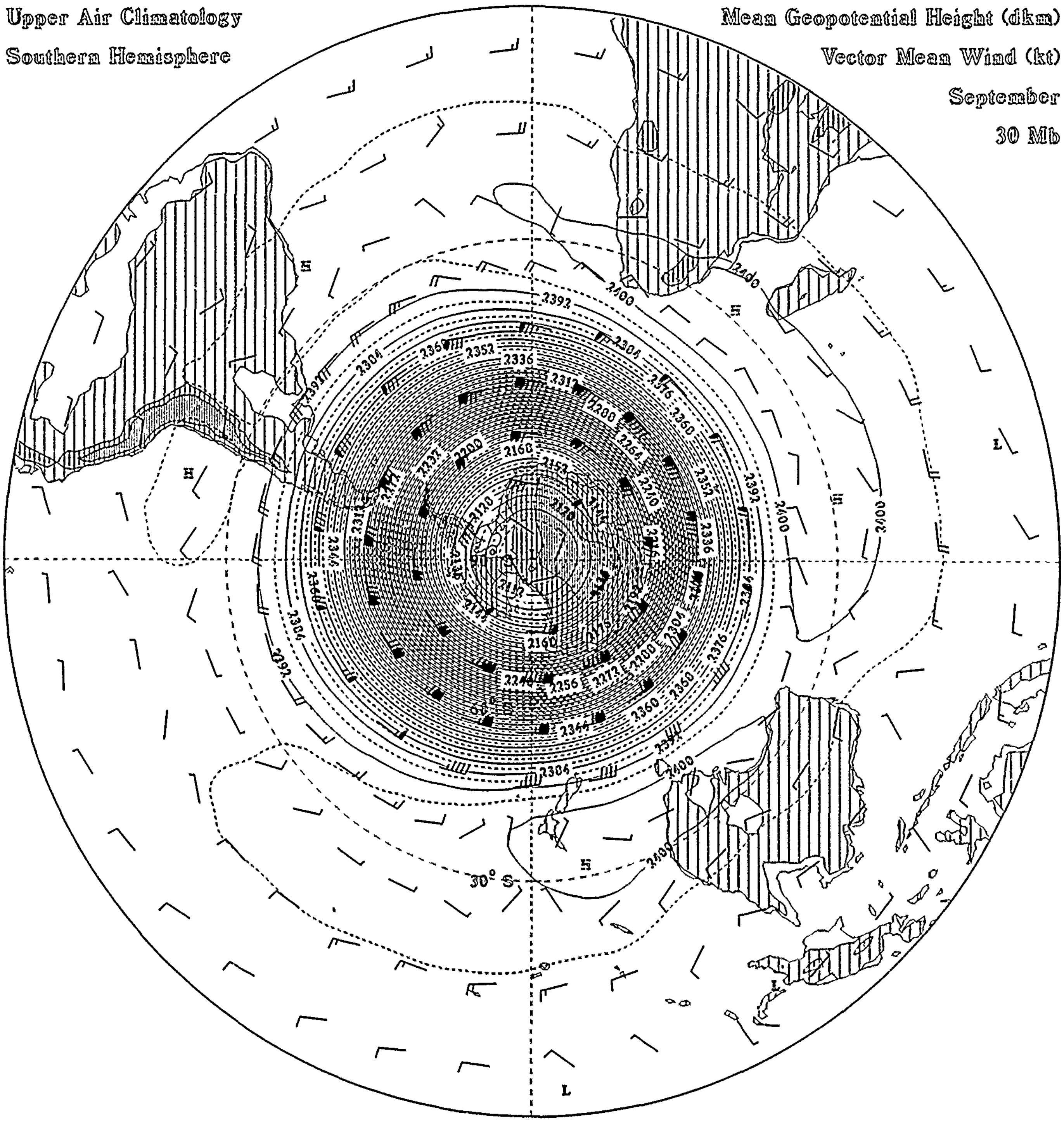
Northern Hemisphere

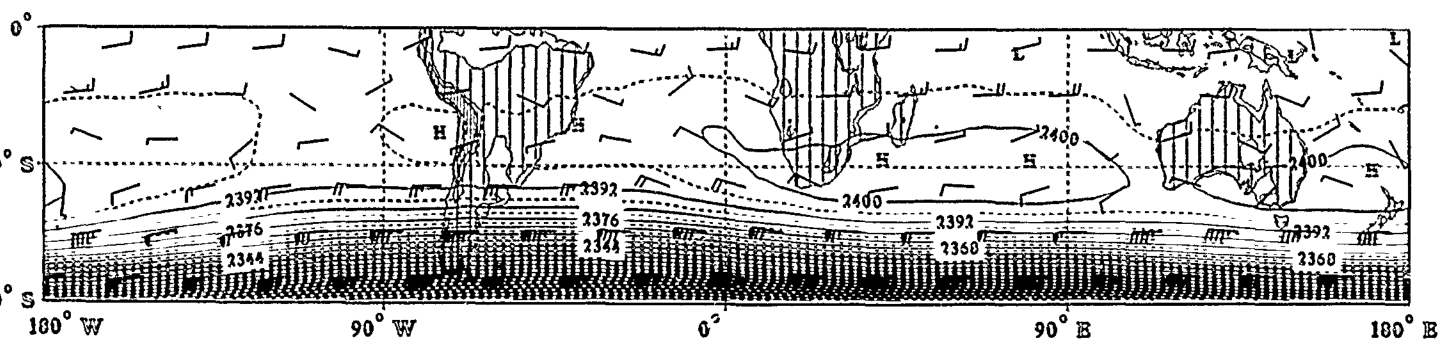




Upper Air Climatology
Southern Hemisphere

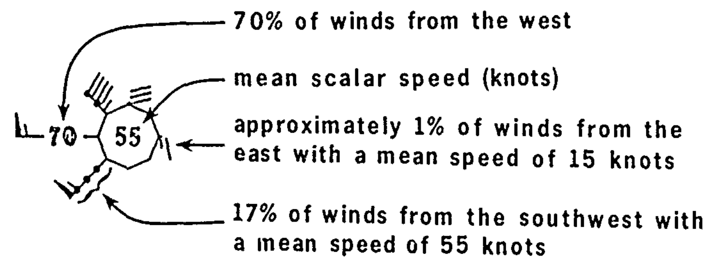
Mean Geopotential Height (dkm)
Vector Mean Wind (kt)
September
30 Mb



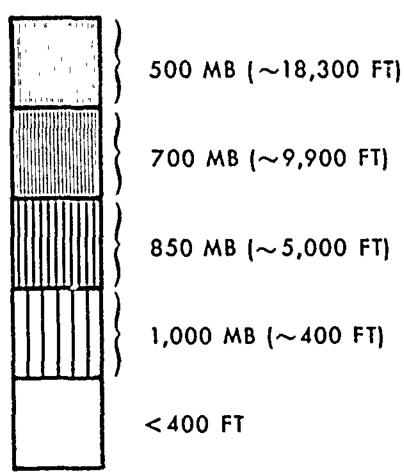


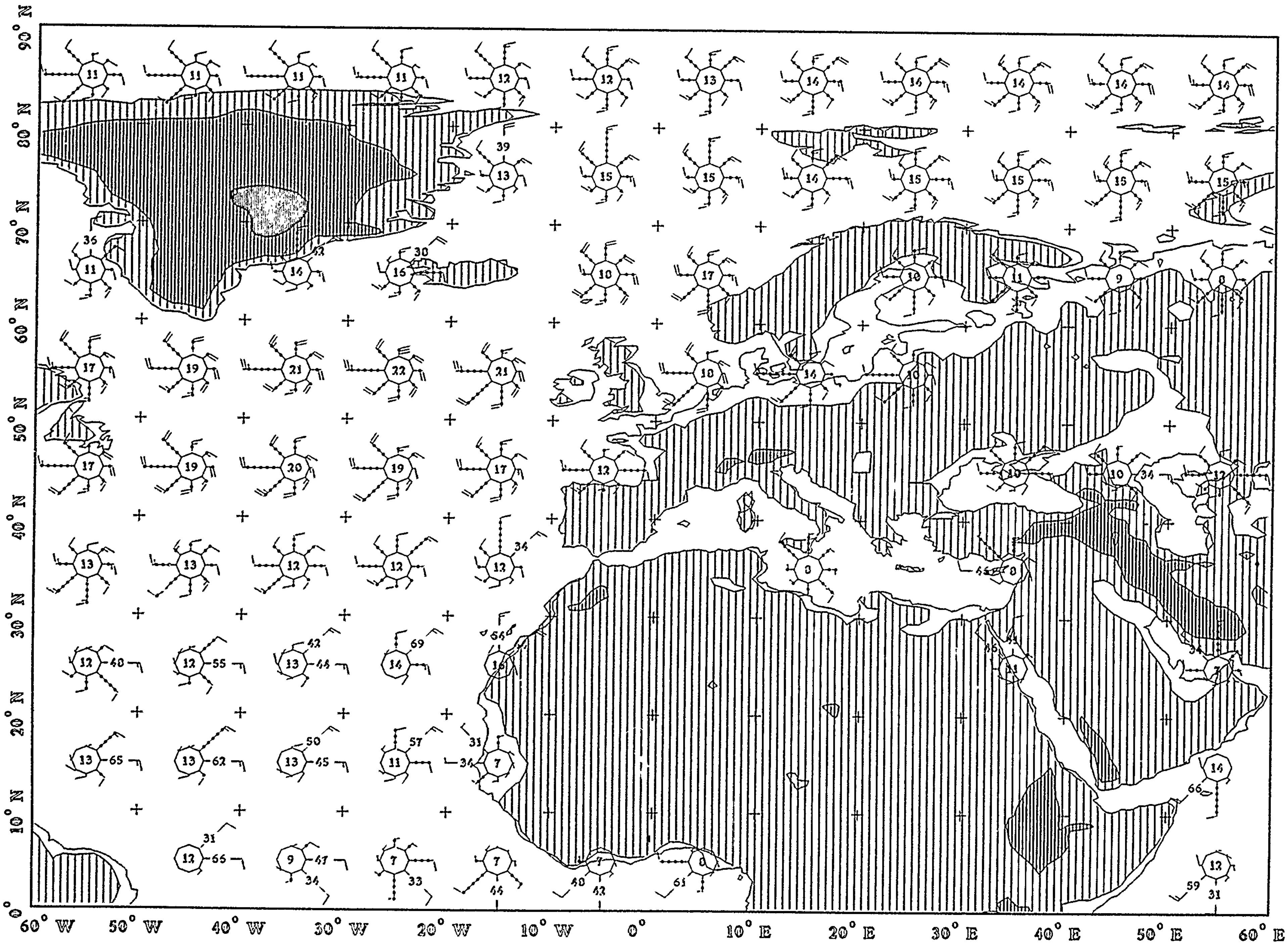
WIND ROSES
(13 LEVELS, 1000 TO 30 MB)

- Wind roses at 10 degree latitude/longitude grid points
- Directional mean wind speed in 5 knot increments
- Frequency proportional to barb length with individual dots representing 5% increments. Values greater than 30% are plotted directly on the barb.
- Roses blanked at grid points with elevations exceeding specified geopotential heights.
- Sample rose explanation:



ELEVATION SCALE

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80° N
70° N
60° N
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30° N
20° N
10° N
0°
60° W
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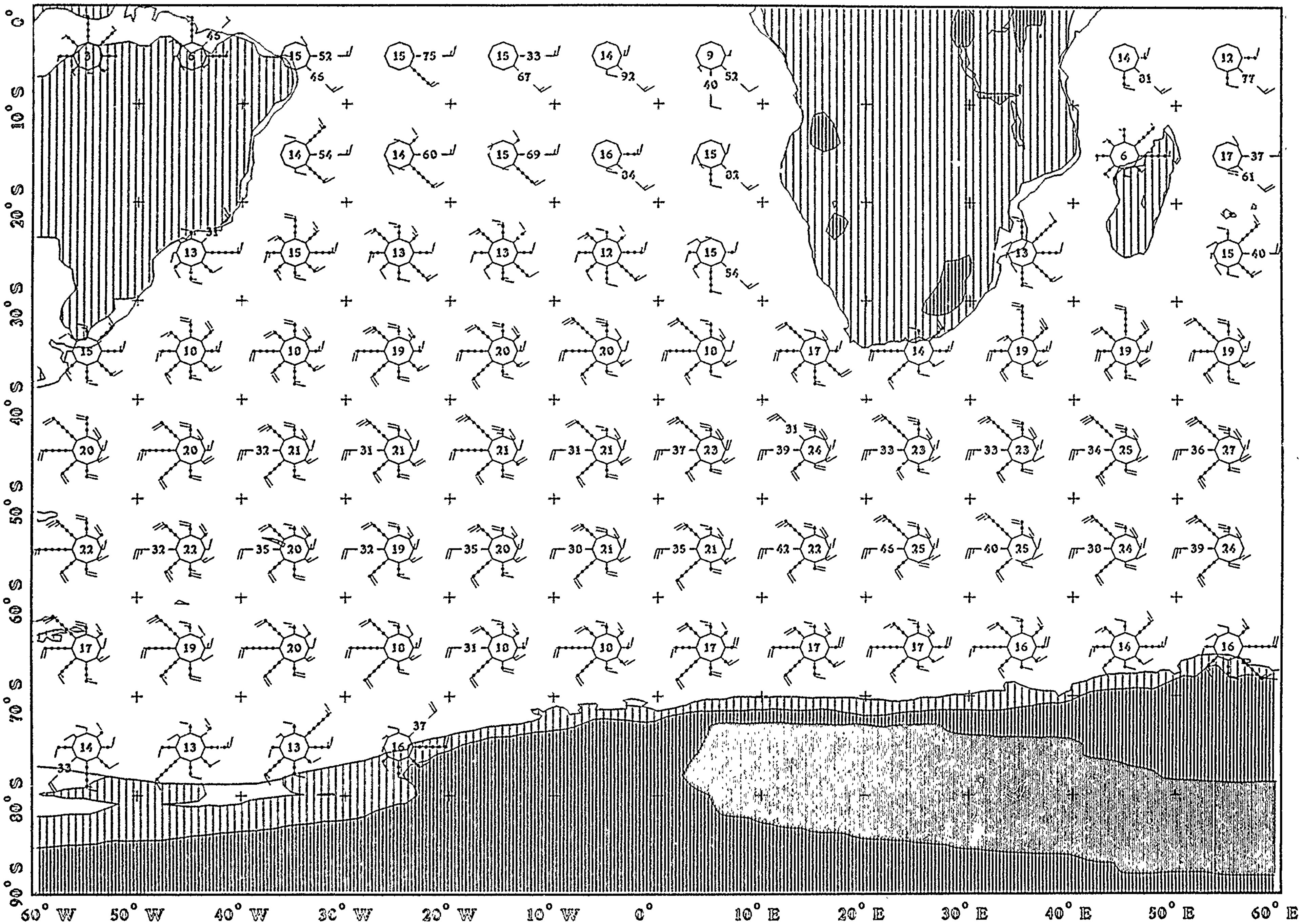
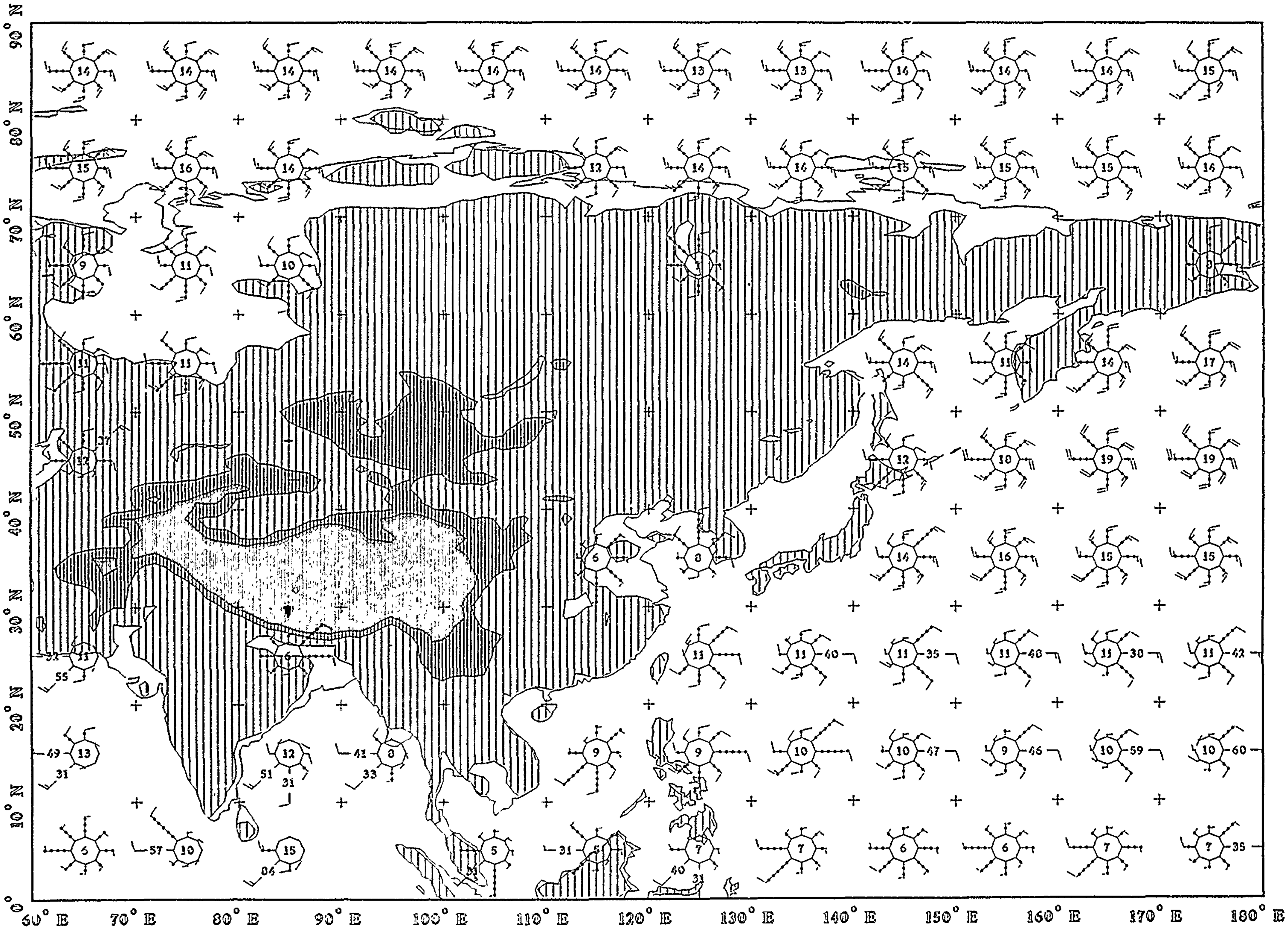
40° E
50° E
60° E



September
1000 Mb

60W TO 60E
Wind Roses

Upper Air Climatology
Southern Hemisphere


90° N
80° N
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60° E
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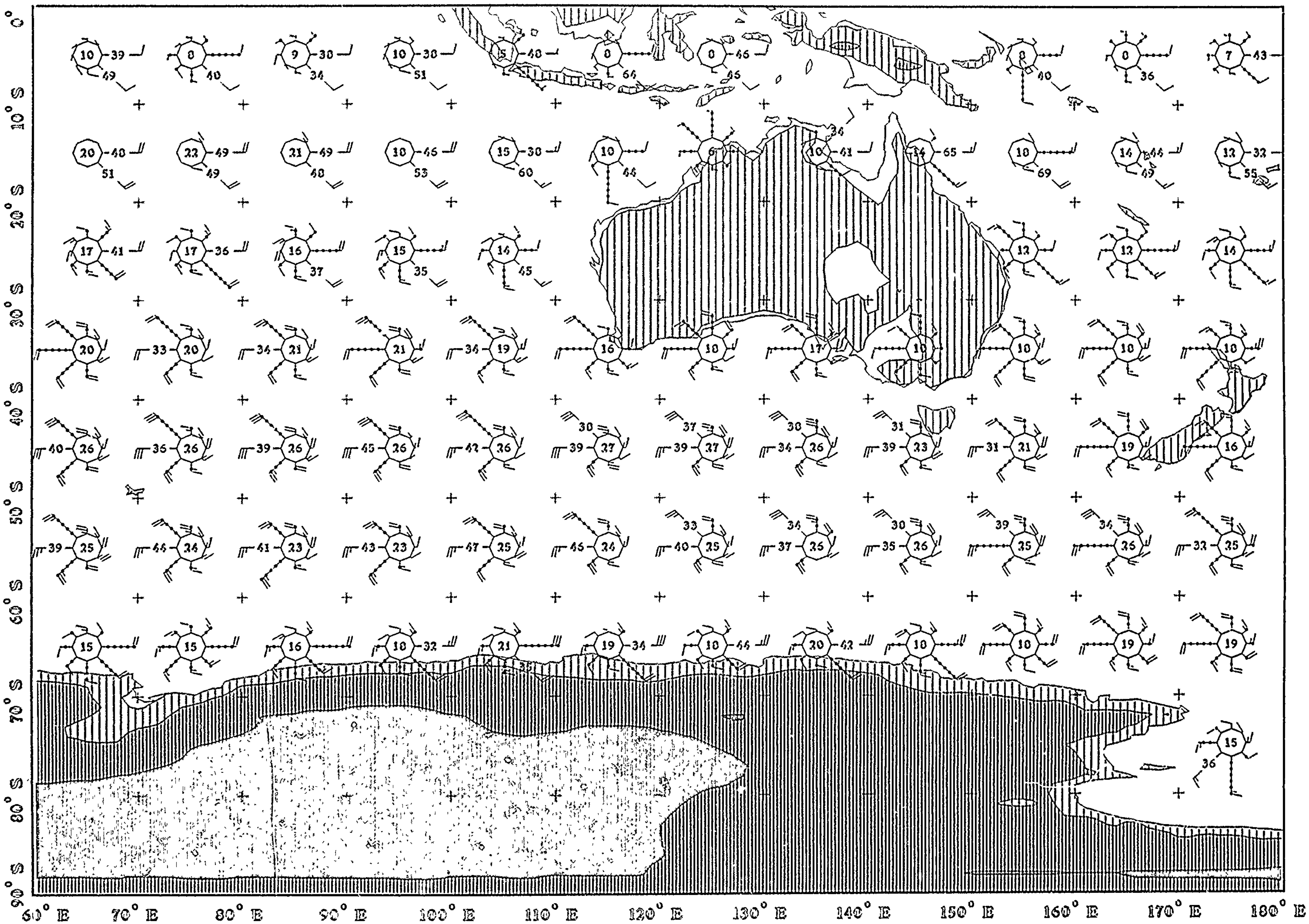
150° E
160° E
170° E
180° E



September
1000 Mb

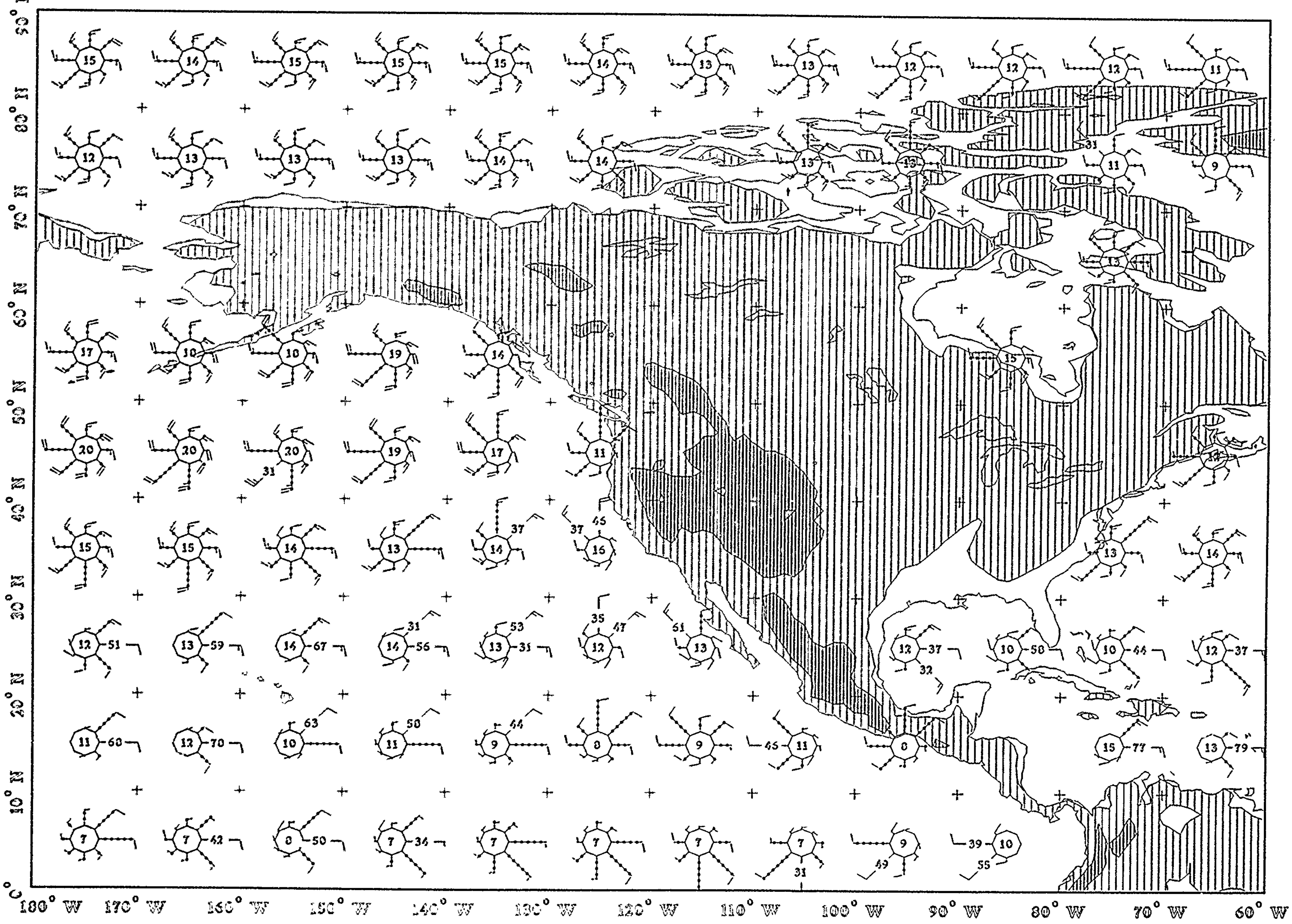
60E TO 180E
Wind Roses

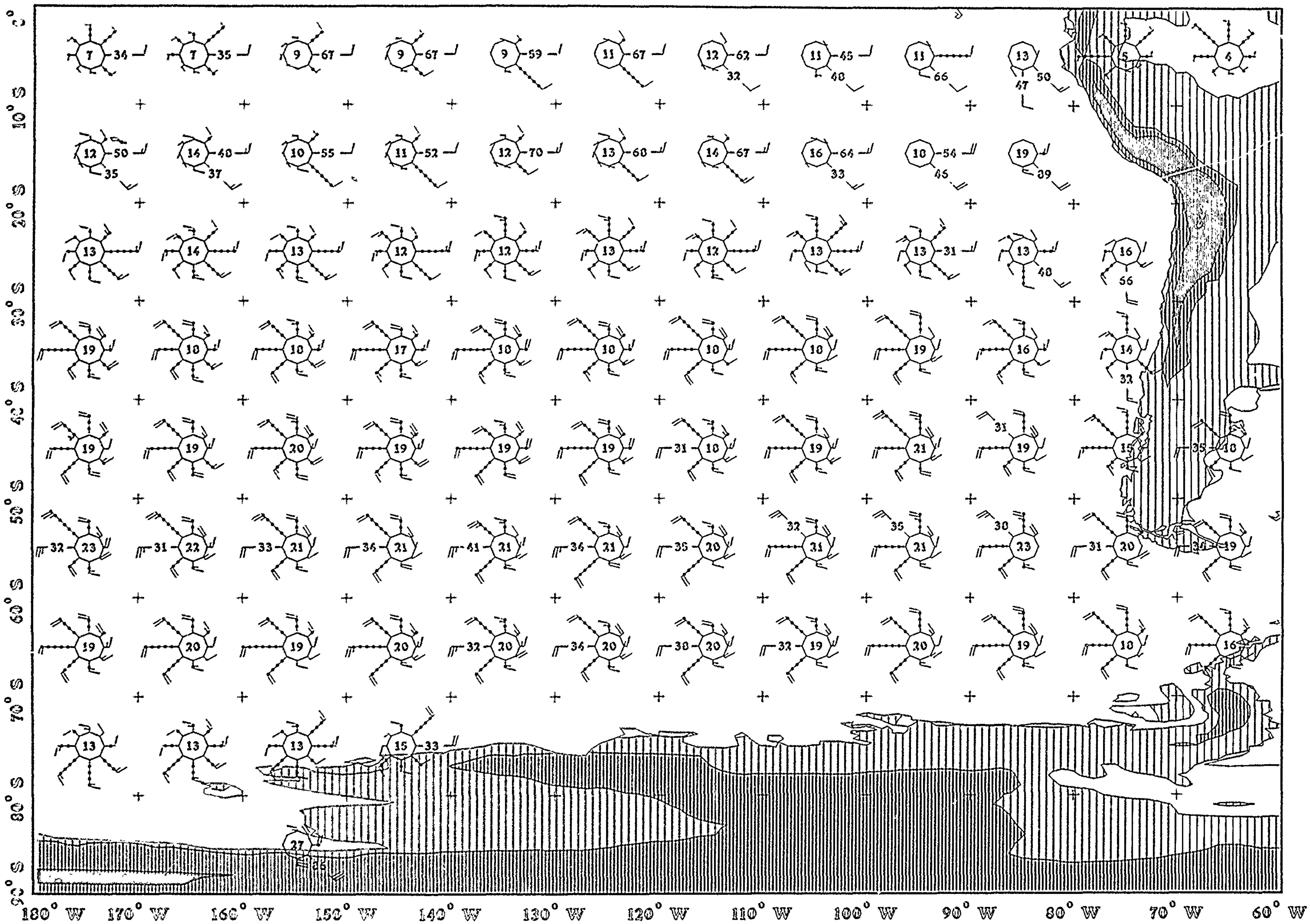
Upper Air Climatology
Southern Hemisphere

September
1000 Mb

180W TO 60W
Wind Roses

Upper Air Climatology
Northern Hemisphere

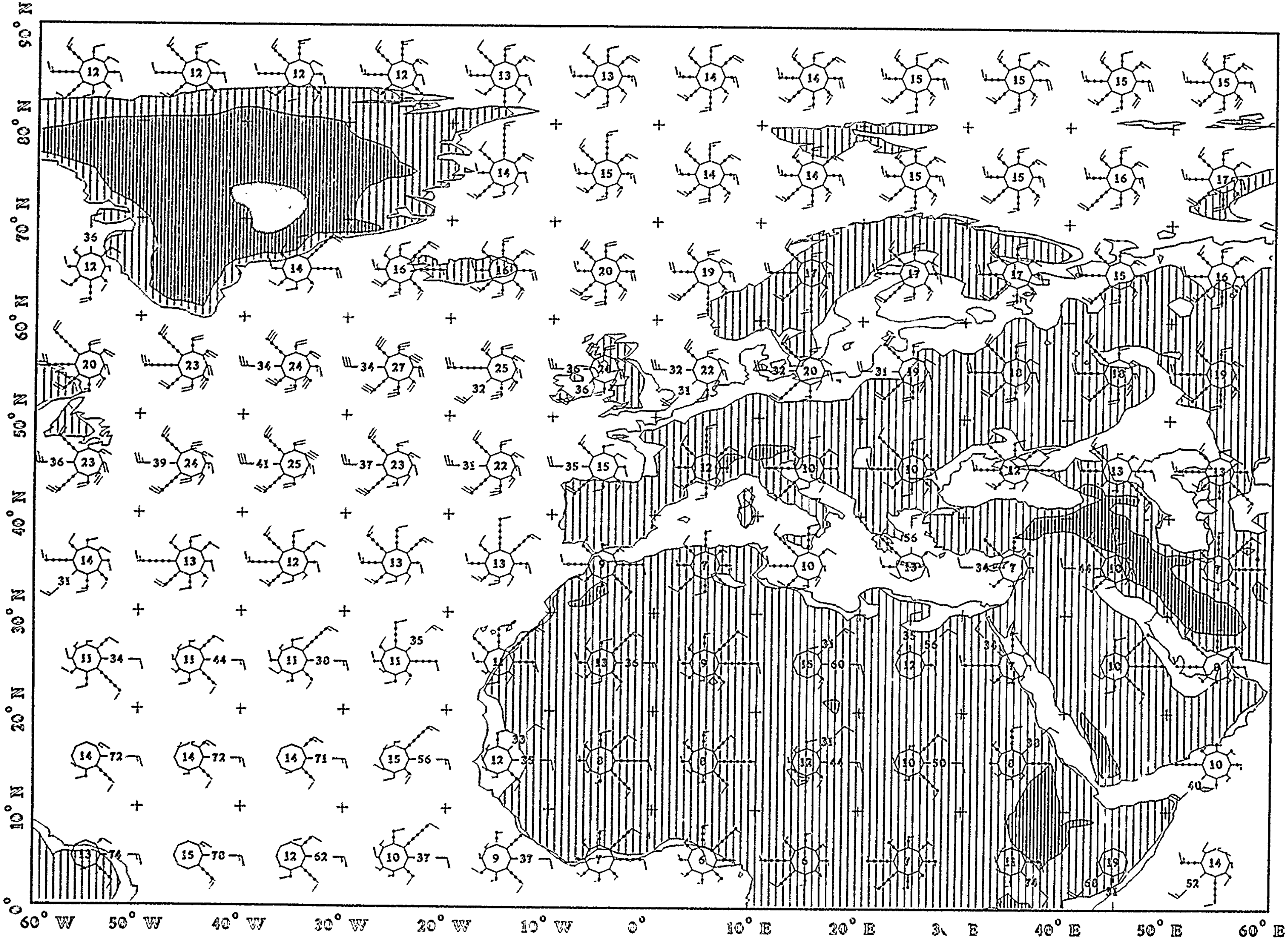




September
1000 Mb

180W TO 60W
Wind Roses

Upper Air Climatology
Southern Hemisphere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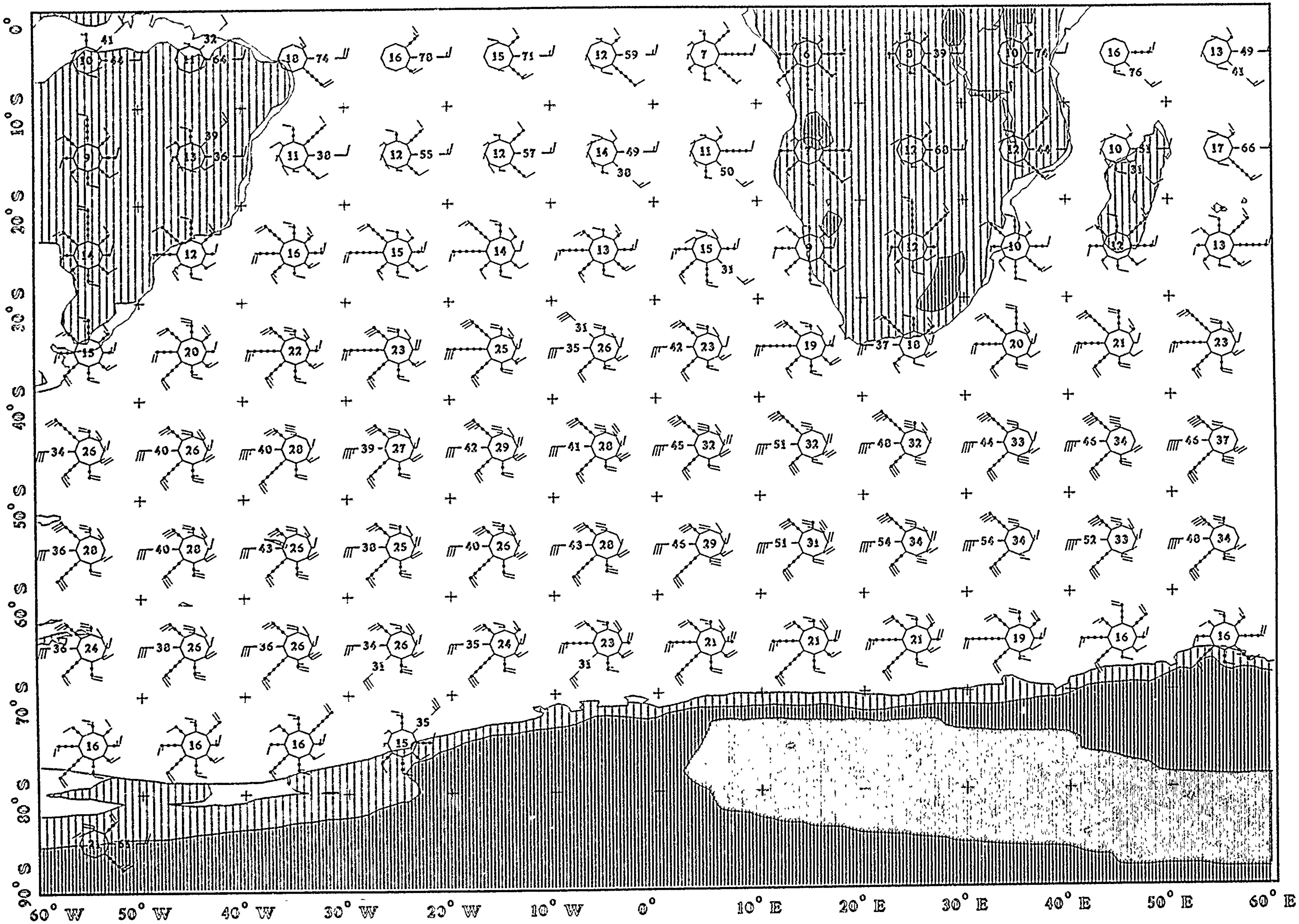
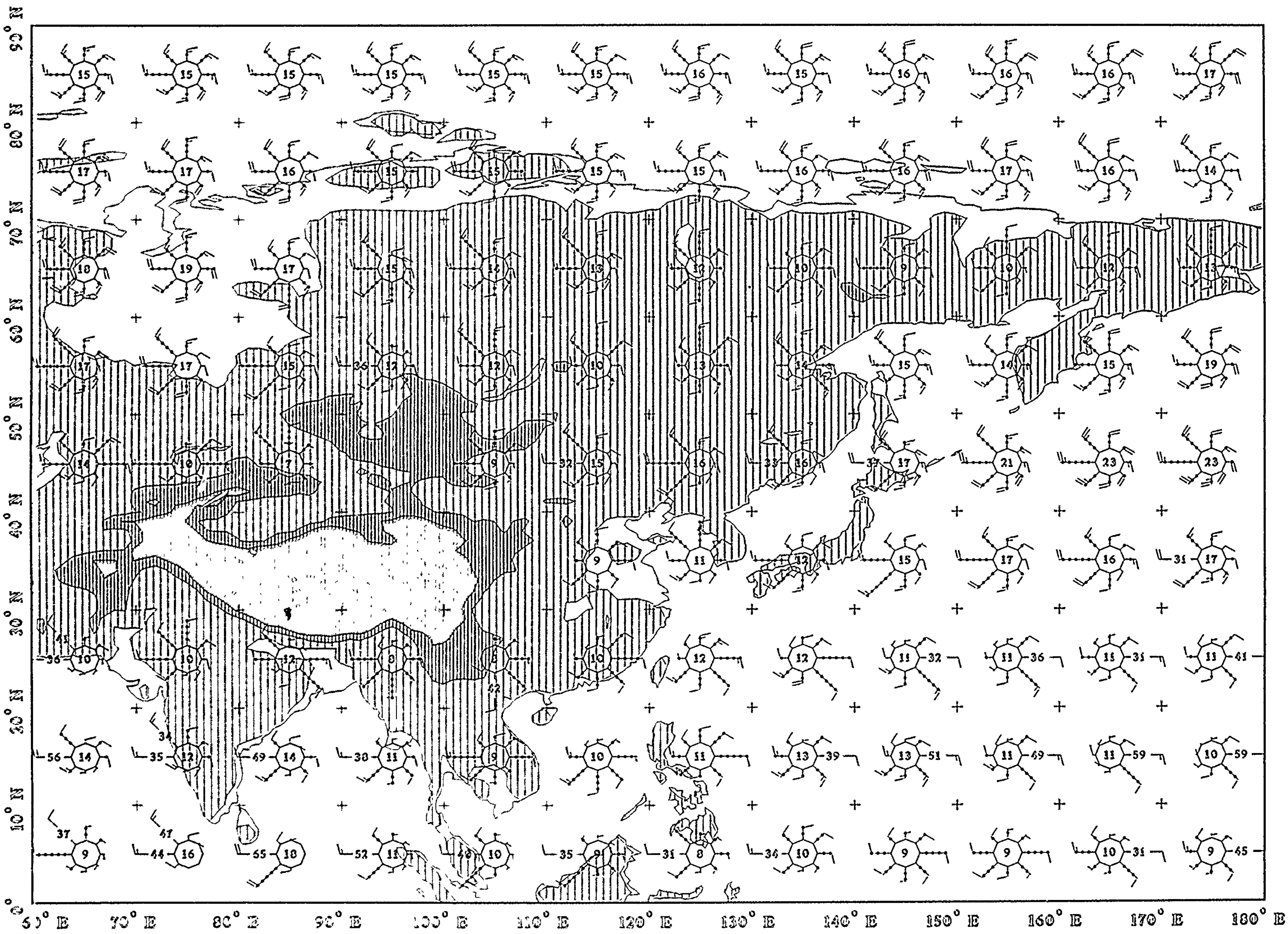
50° E
60° E



September
850 Mb

60W TO 60E
Wind Roses

Upper Air Climatology
Southern Hemisphere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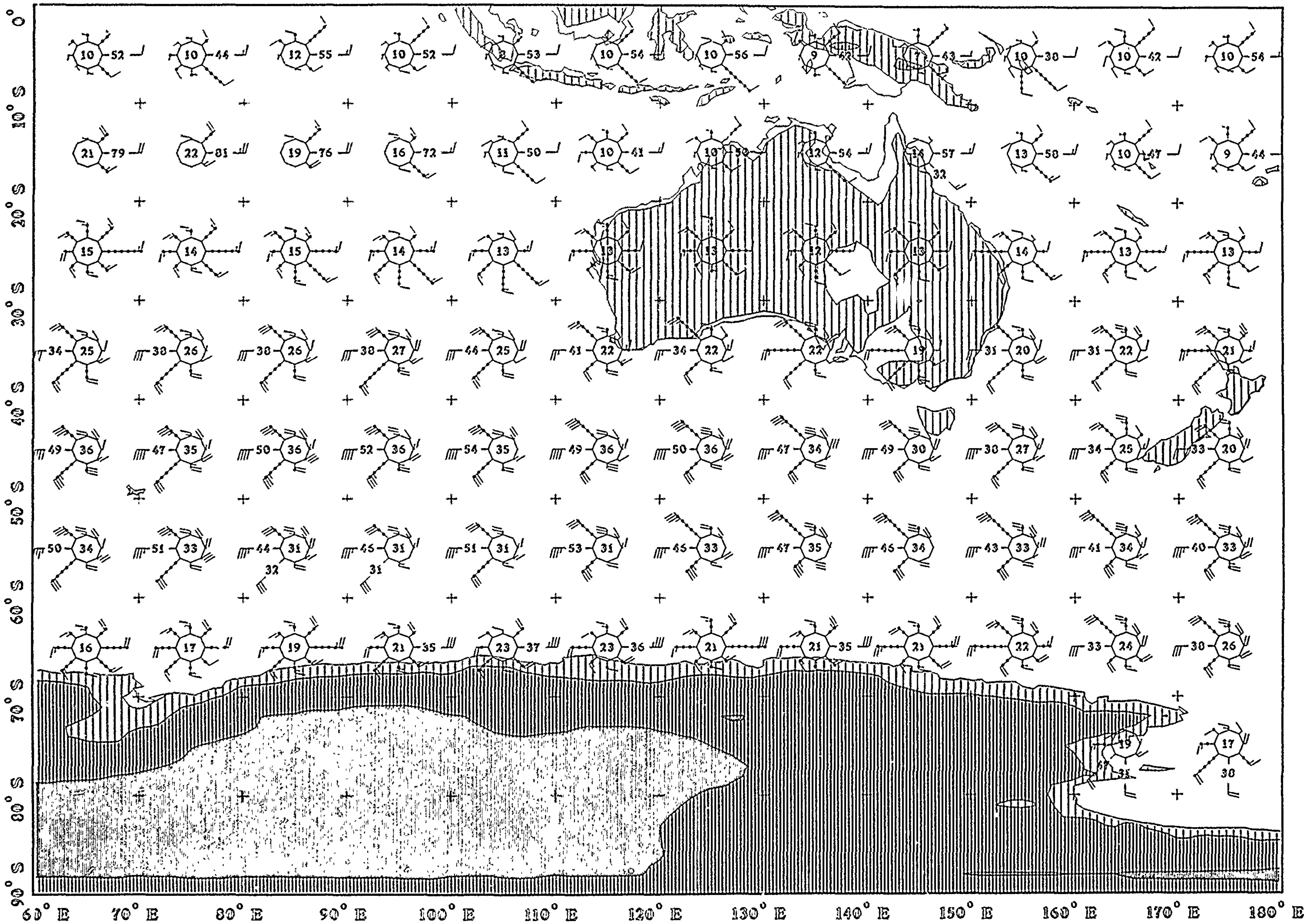
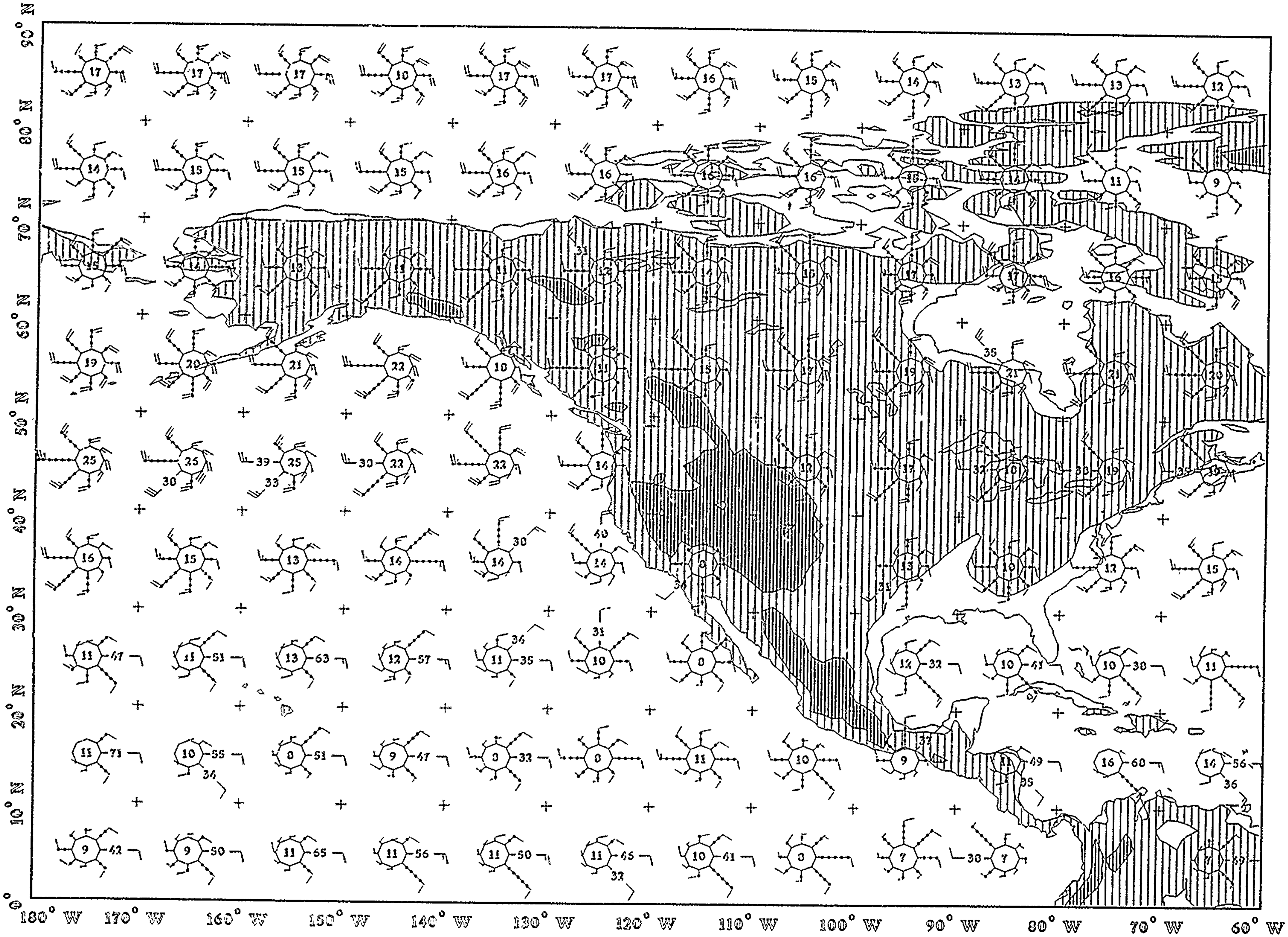


September
850 Mb

60E TO 180E
Wind Roses

Upper Air Climatology
Southern Hemisphere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180° W
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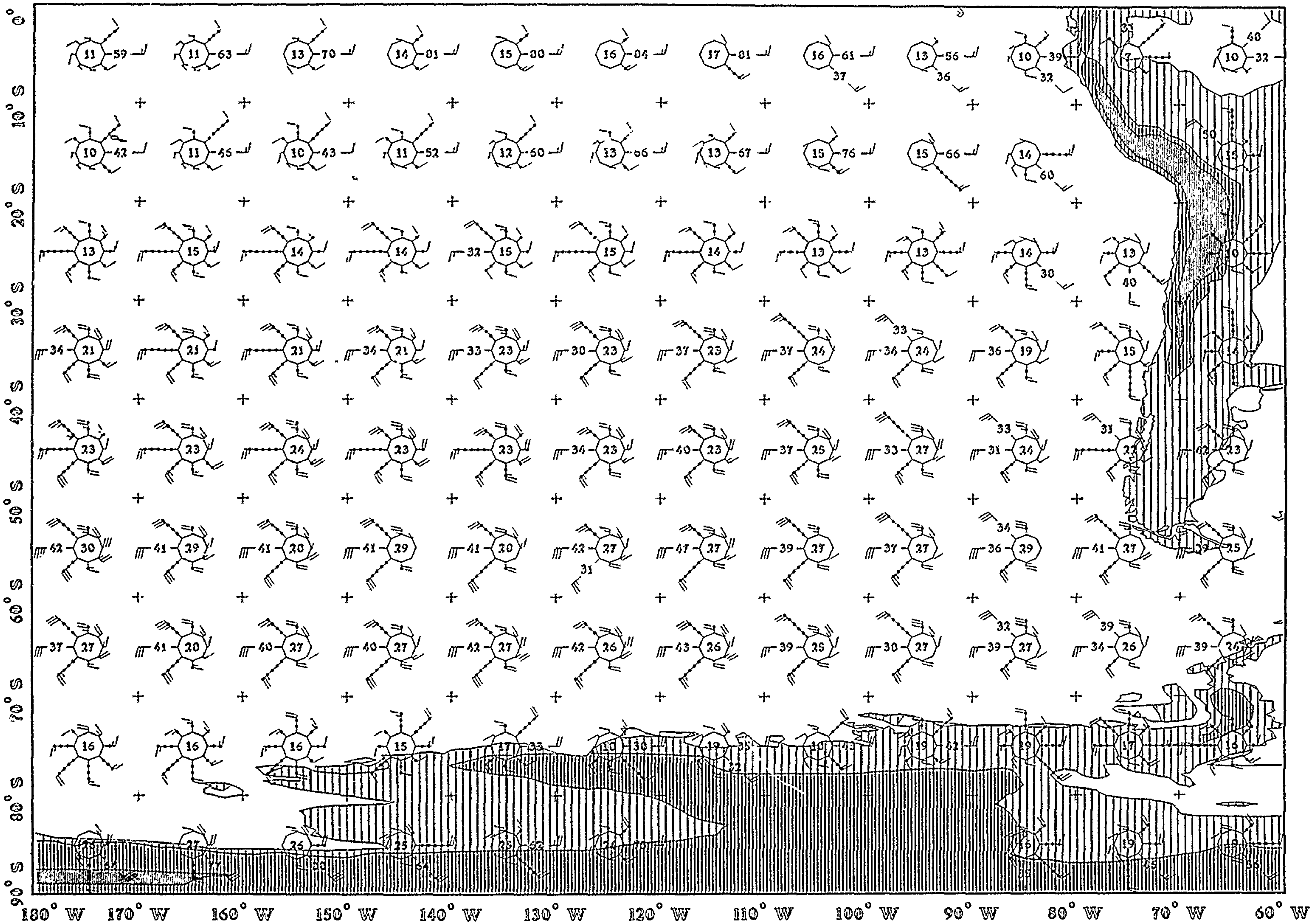
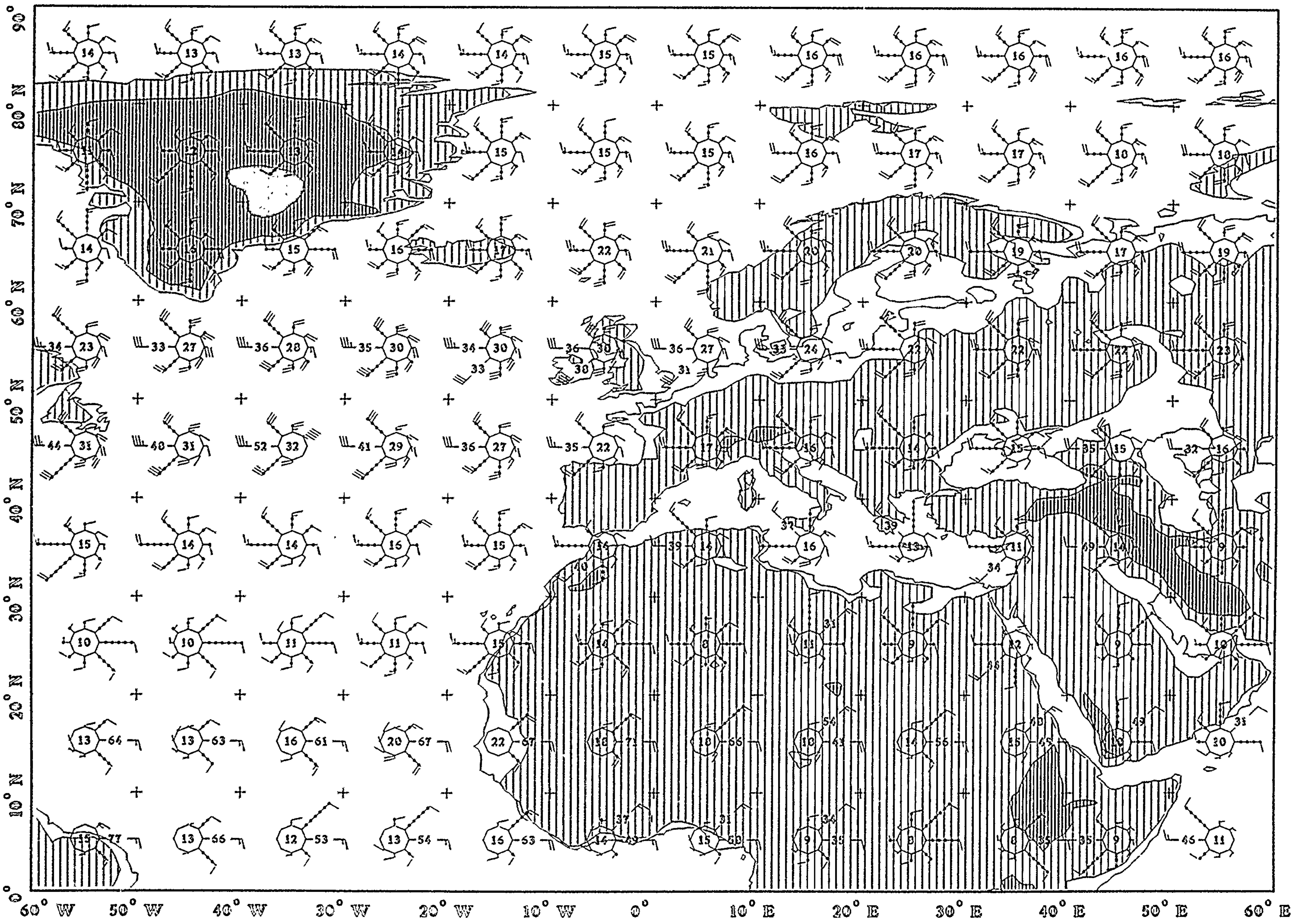
80° W
70° W
60° W



September
850 Mb

180W TO 60W
Wind Roses

Upper Air Climatology
Southern Hemisphere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60° W
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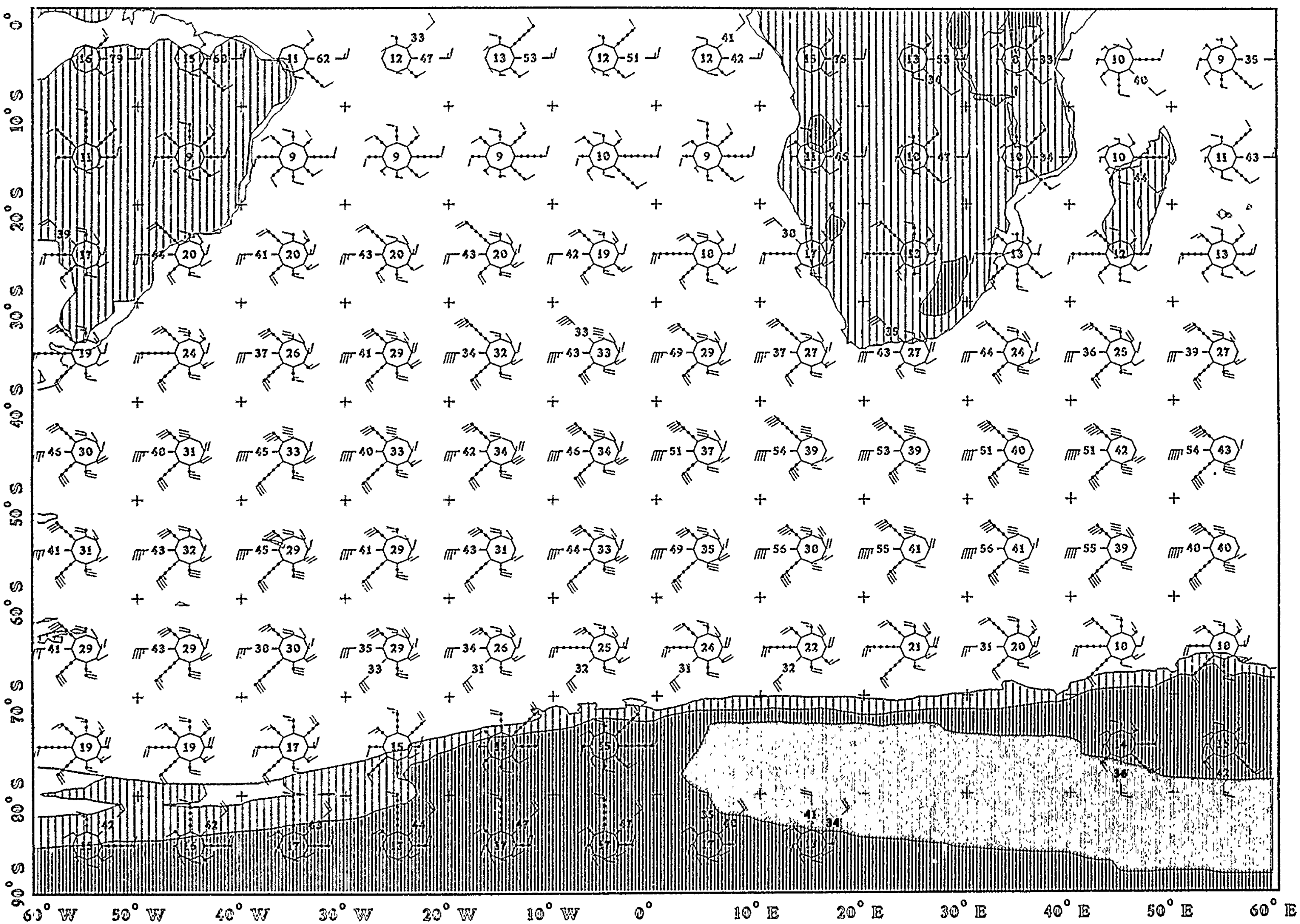


September
700 Mb

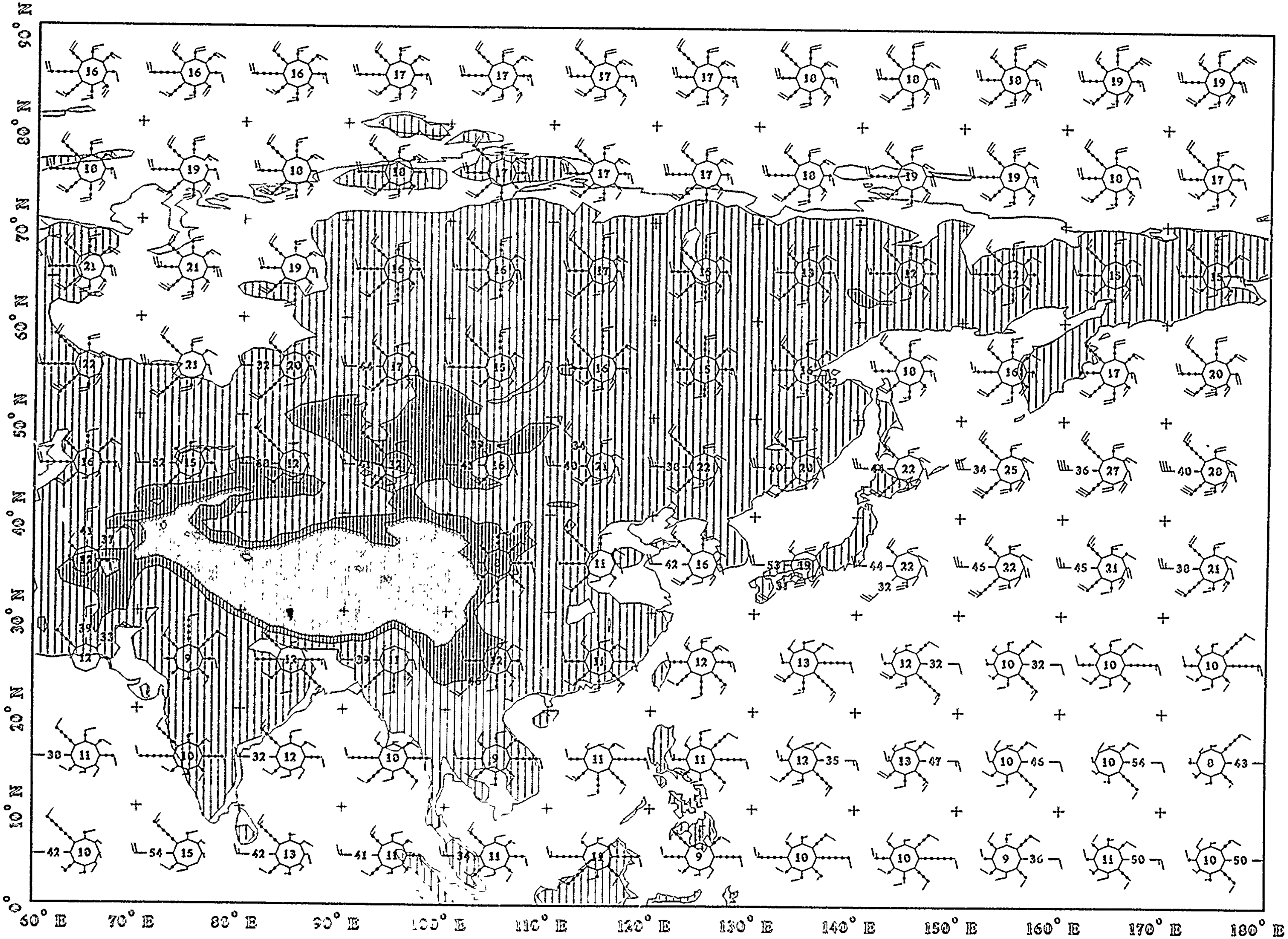
60W TO 60E
Wind Roses

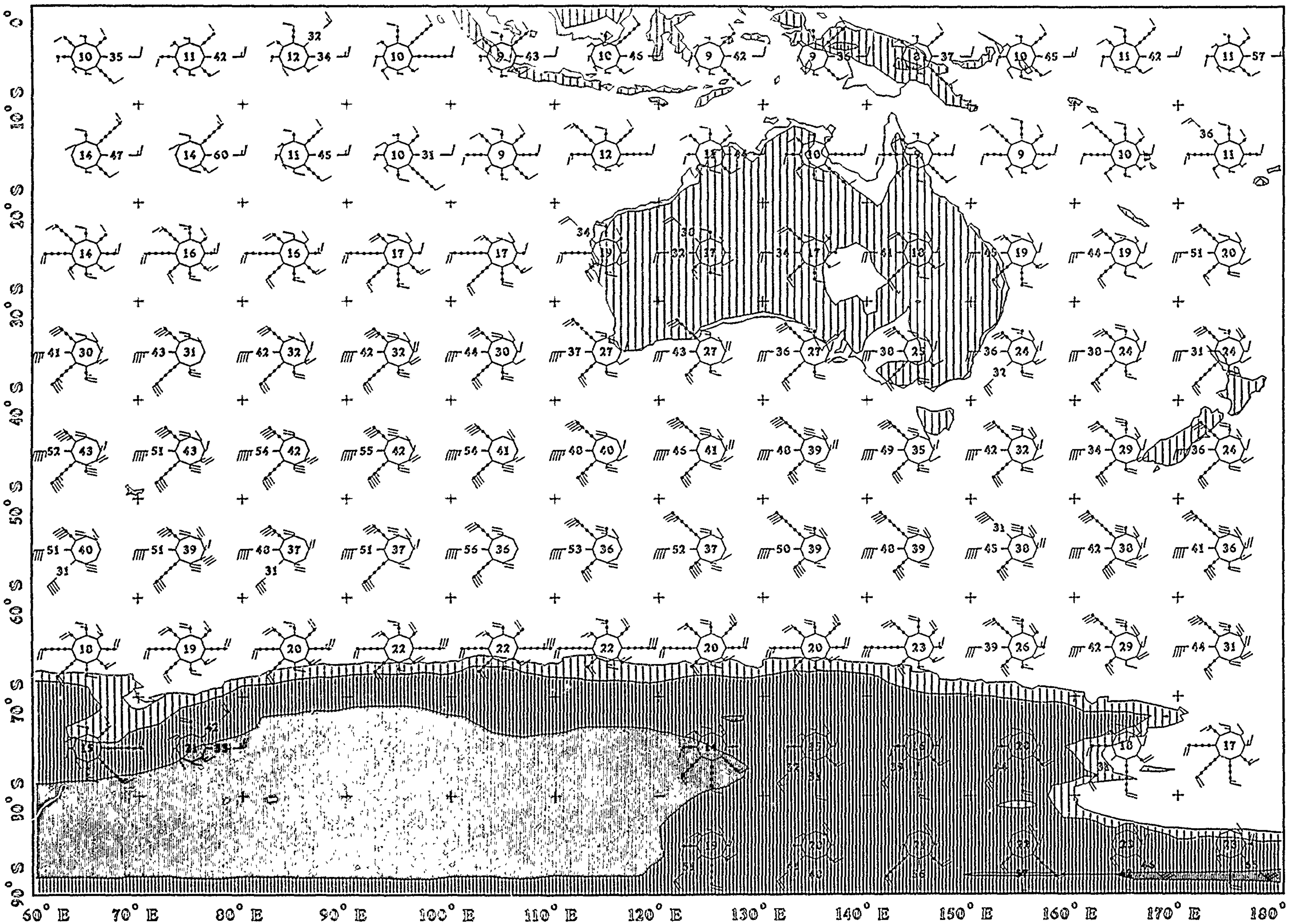
Upper Air Climatology
Southern Hemisphere

September
700 Mb

60E TO 180E
Wind Roses

Upper Air Climatology
Northern Hemisphere

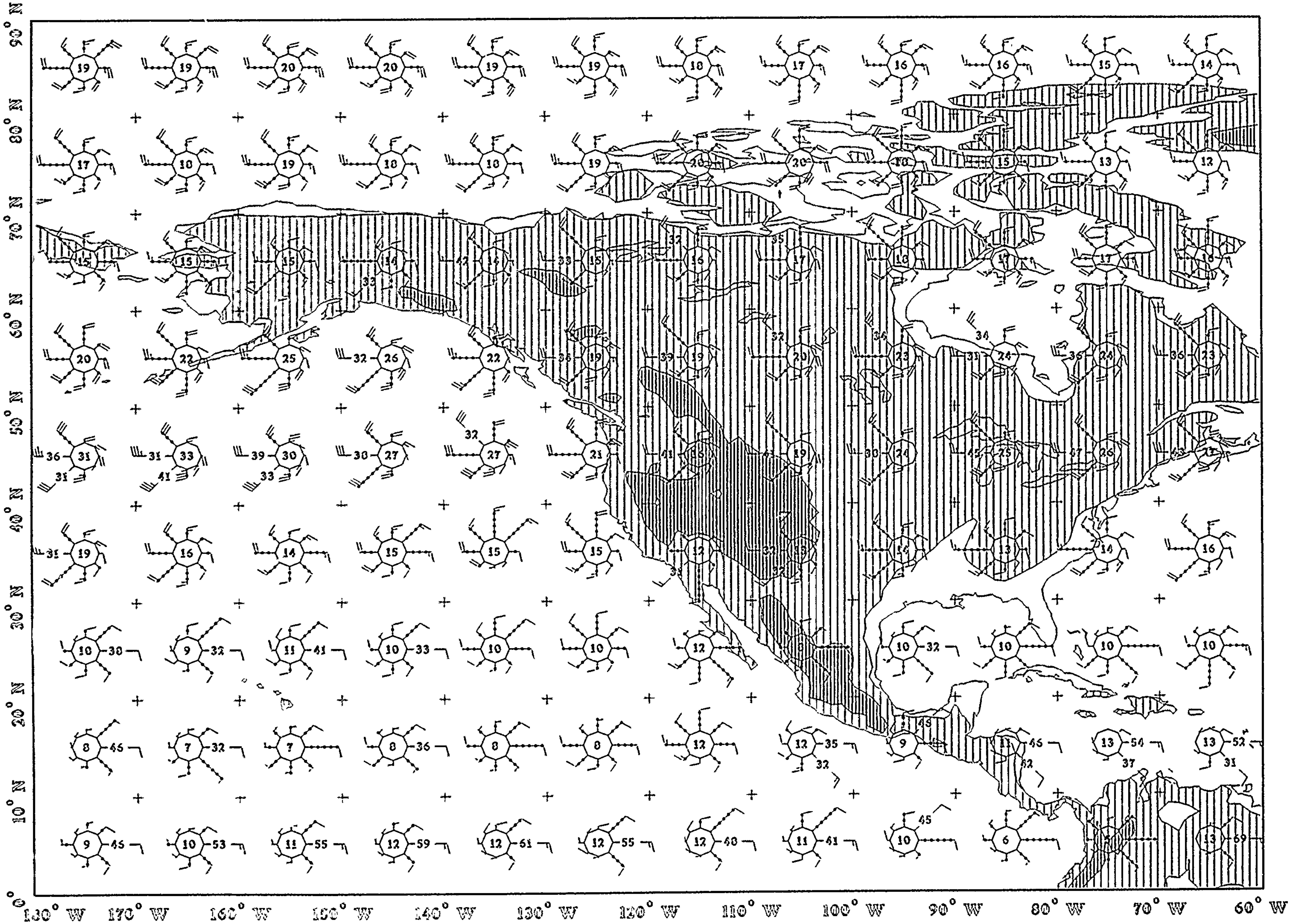




September
700 Mb

60E TO 180E
Wind Roses

Upper Air Climatology
Southern Hemisphere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20° N
10° N
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180° W
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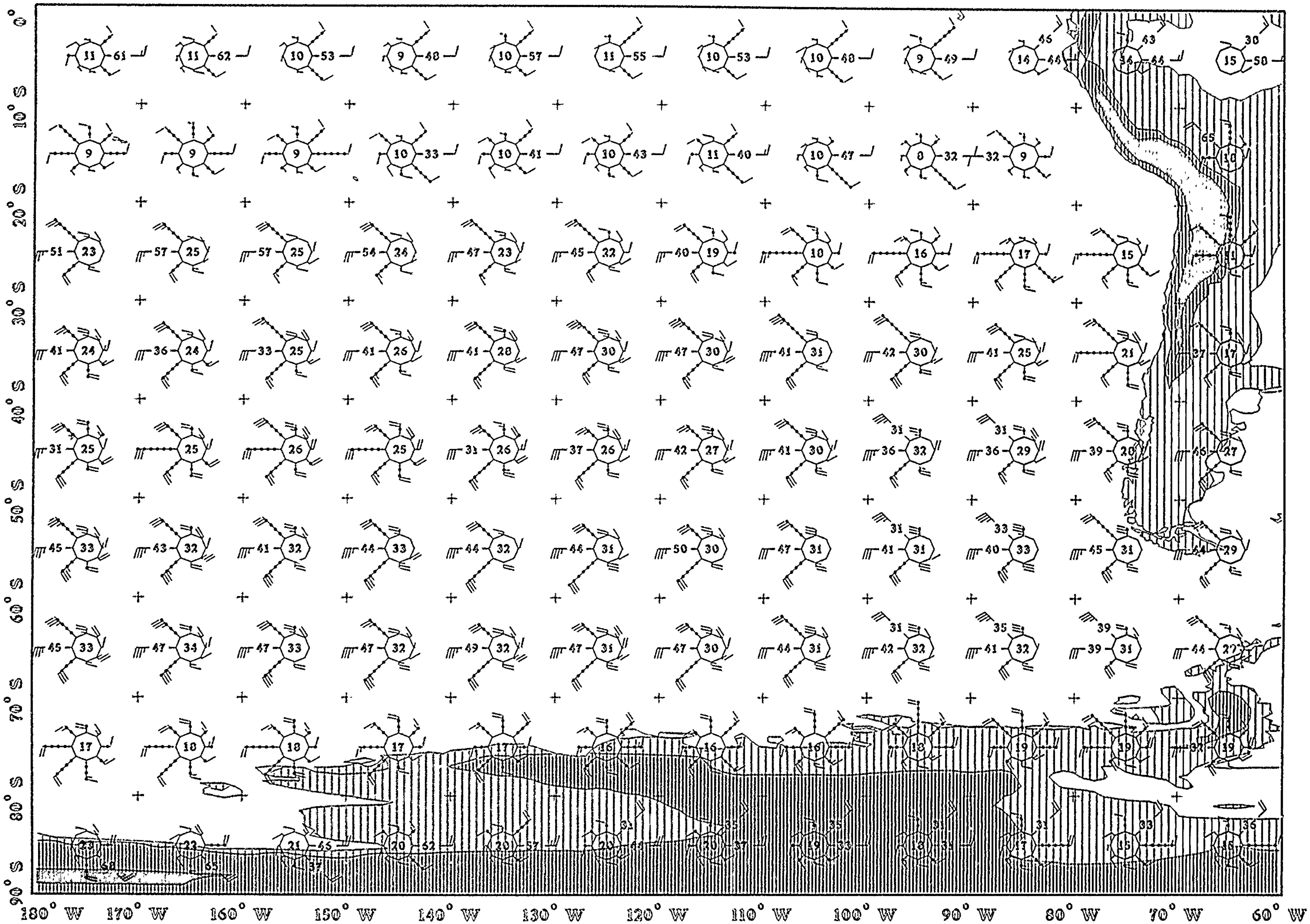
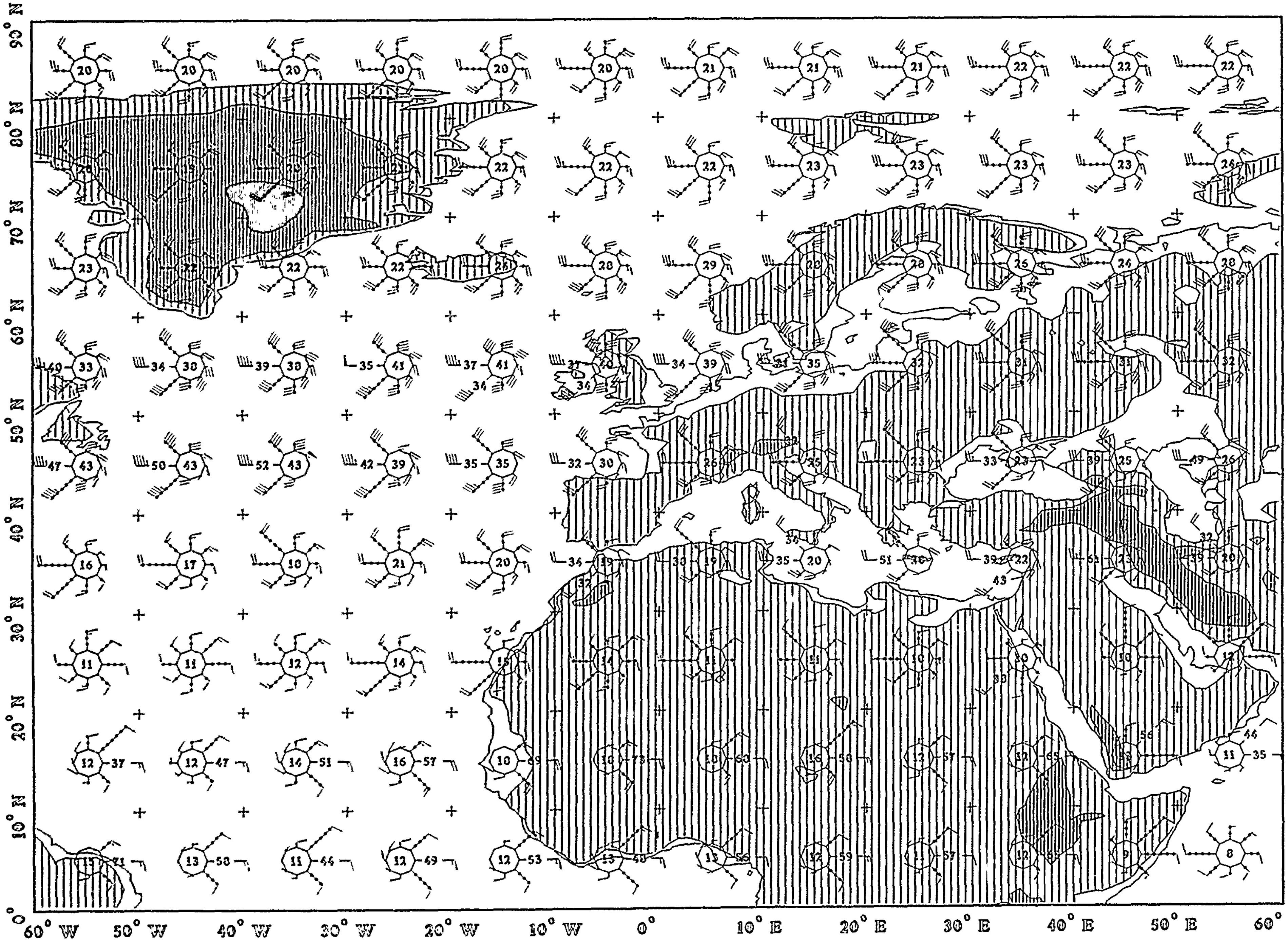
80° W
70° W
60° W



September
7 0 Mb

180W TO 60W
Wind Roses

Upper Air Climatology
Southern Hemisphere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40° E
50° E
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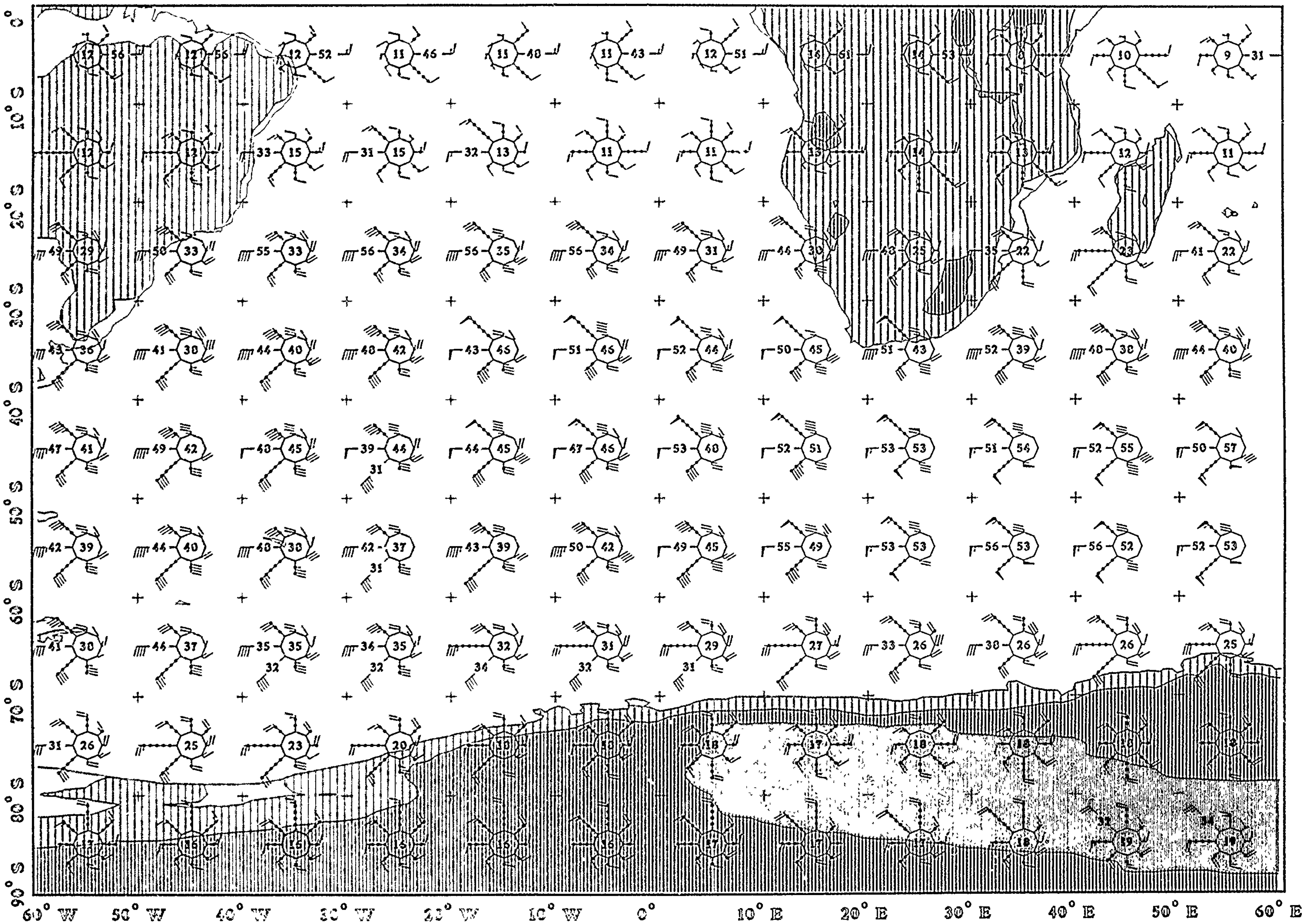
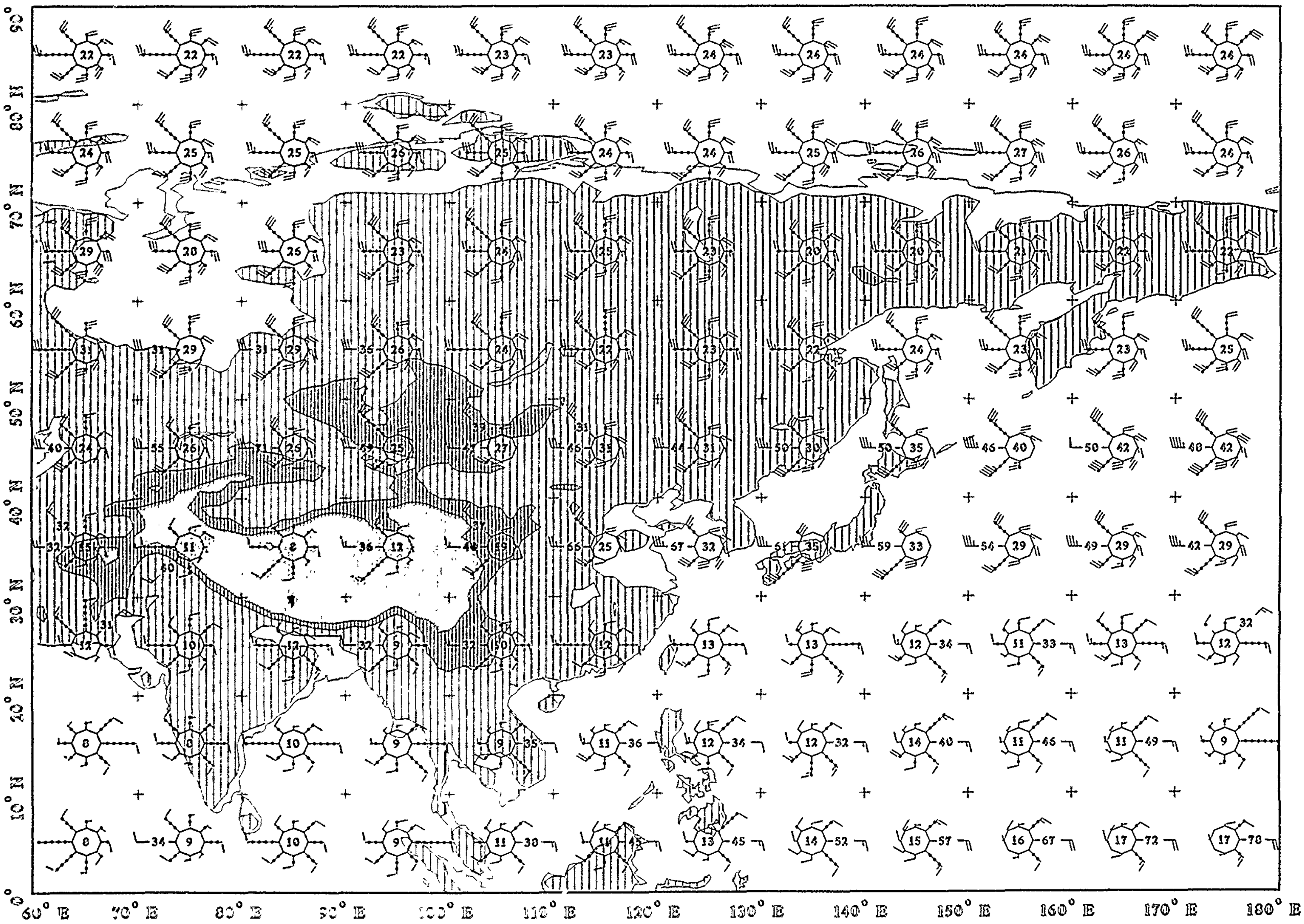


September
500 Mb

60W TO 60E
Wind Roses

Upper Air Climatology
Southern Hemisphere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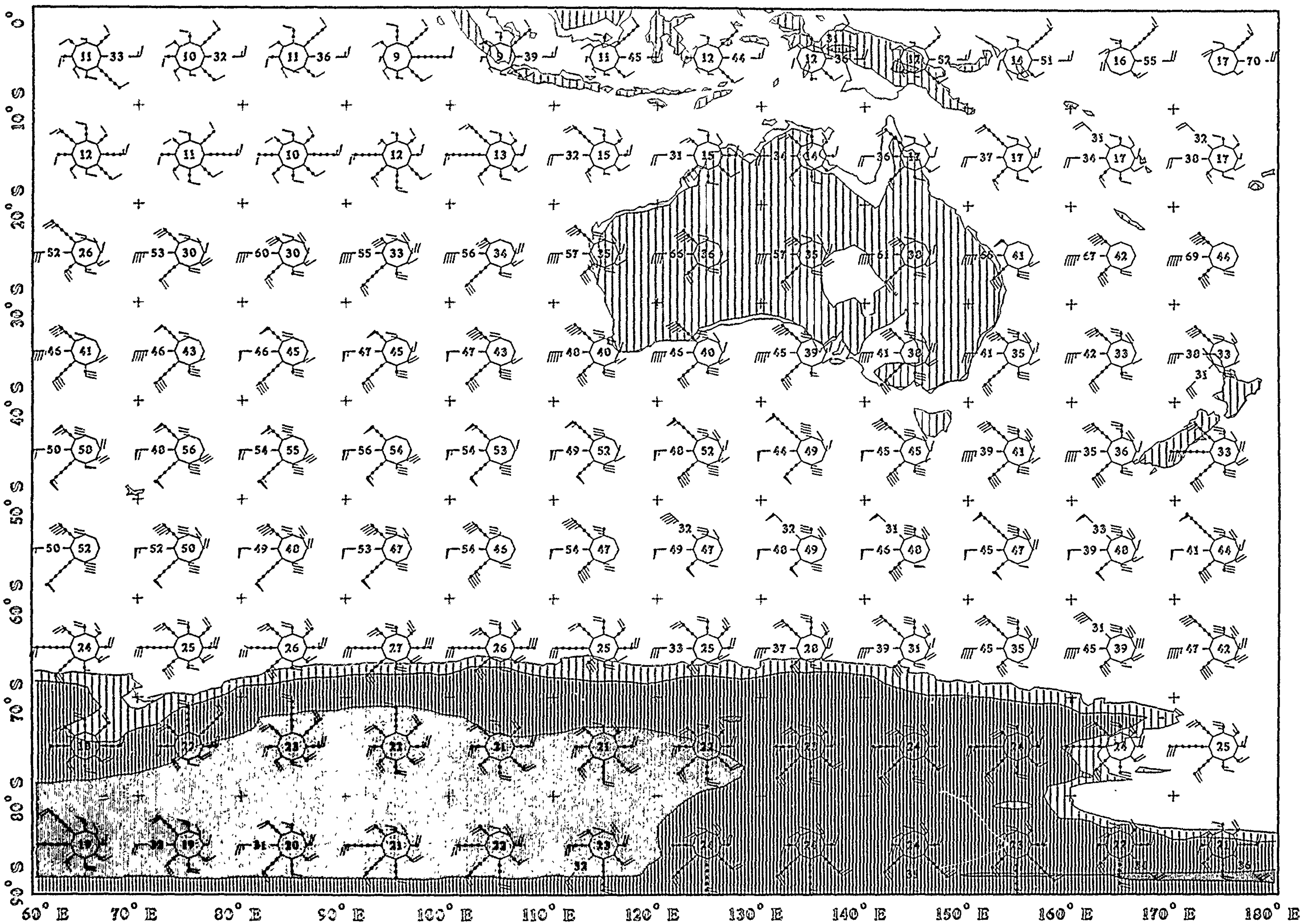
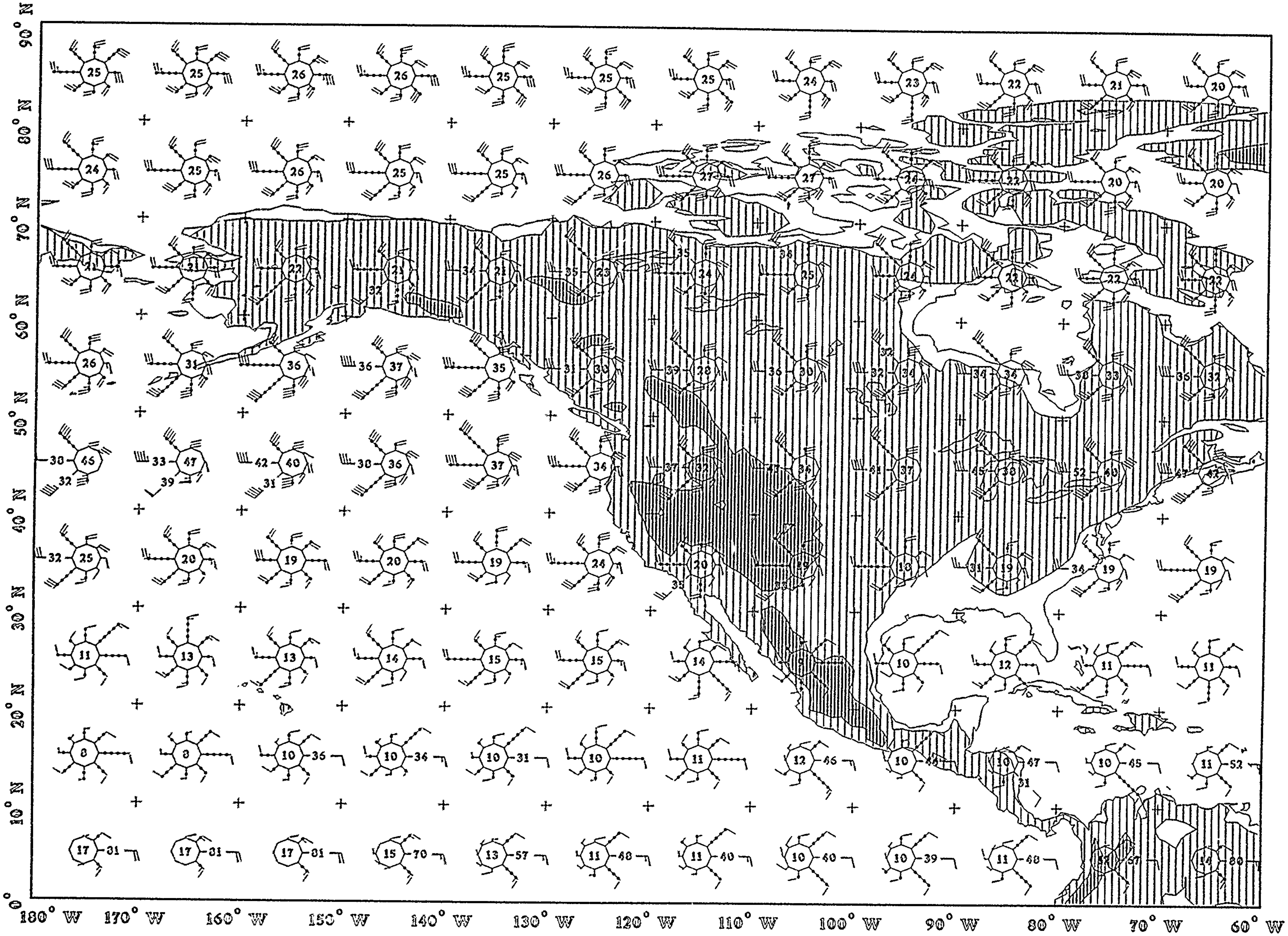
170° E
180° E



September
500 Mb

60E TO 180E
Wind Roses

Upper Air Climatology
Southern Hemisphere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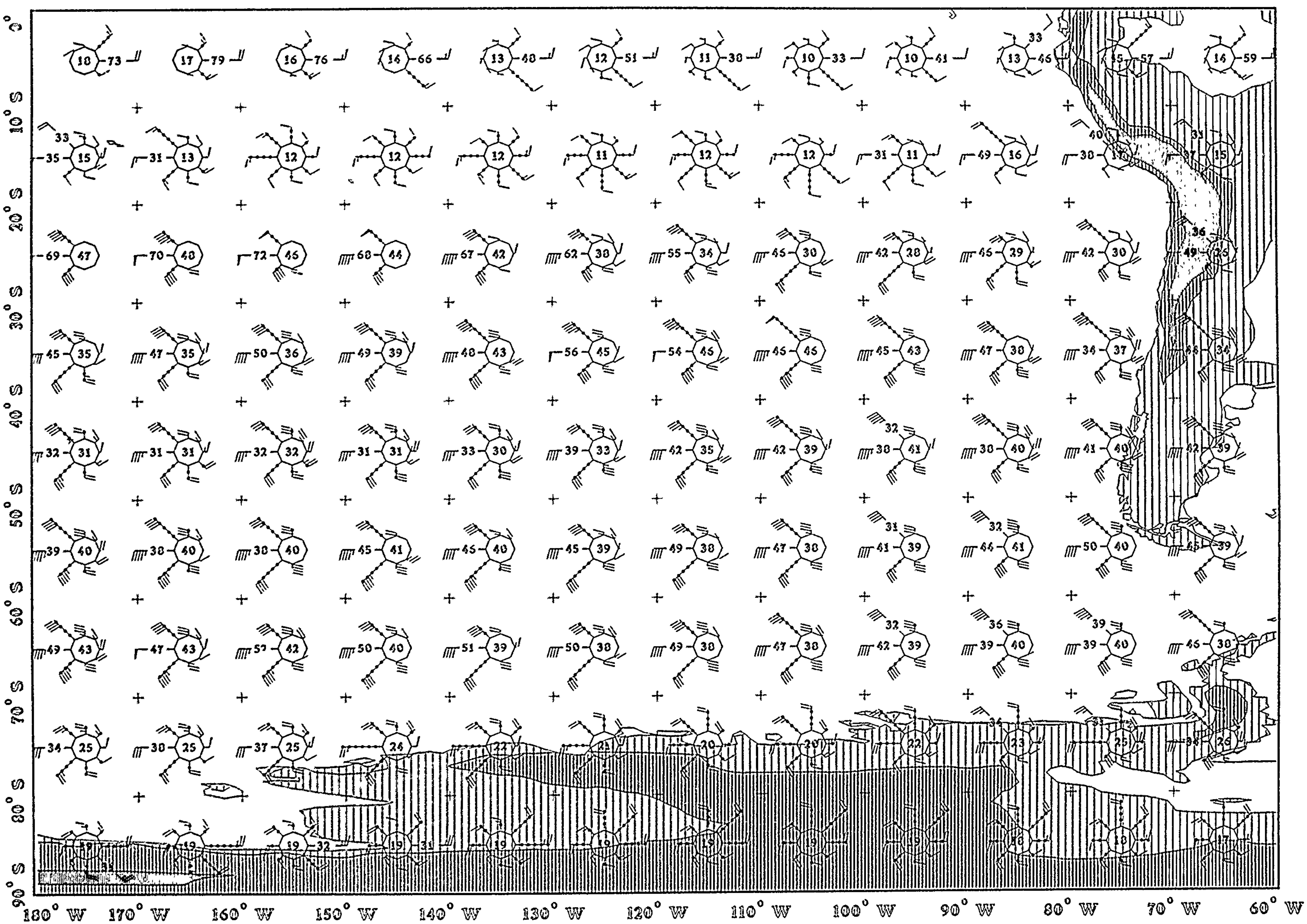
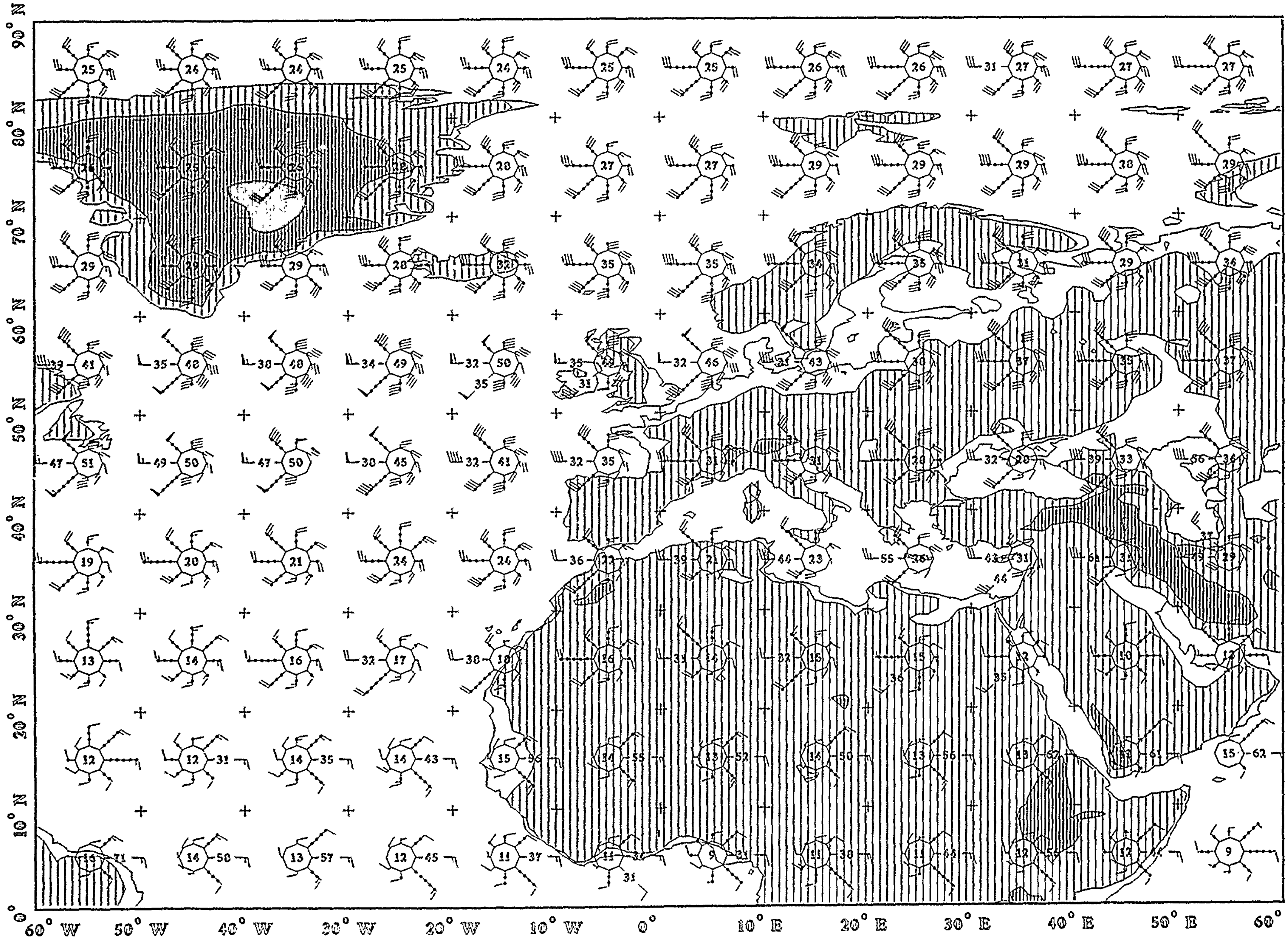


September
500 Mb

180W TO 60W
Wind Roses

Upper Air Climatology
Southern Hemisphere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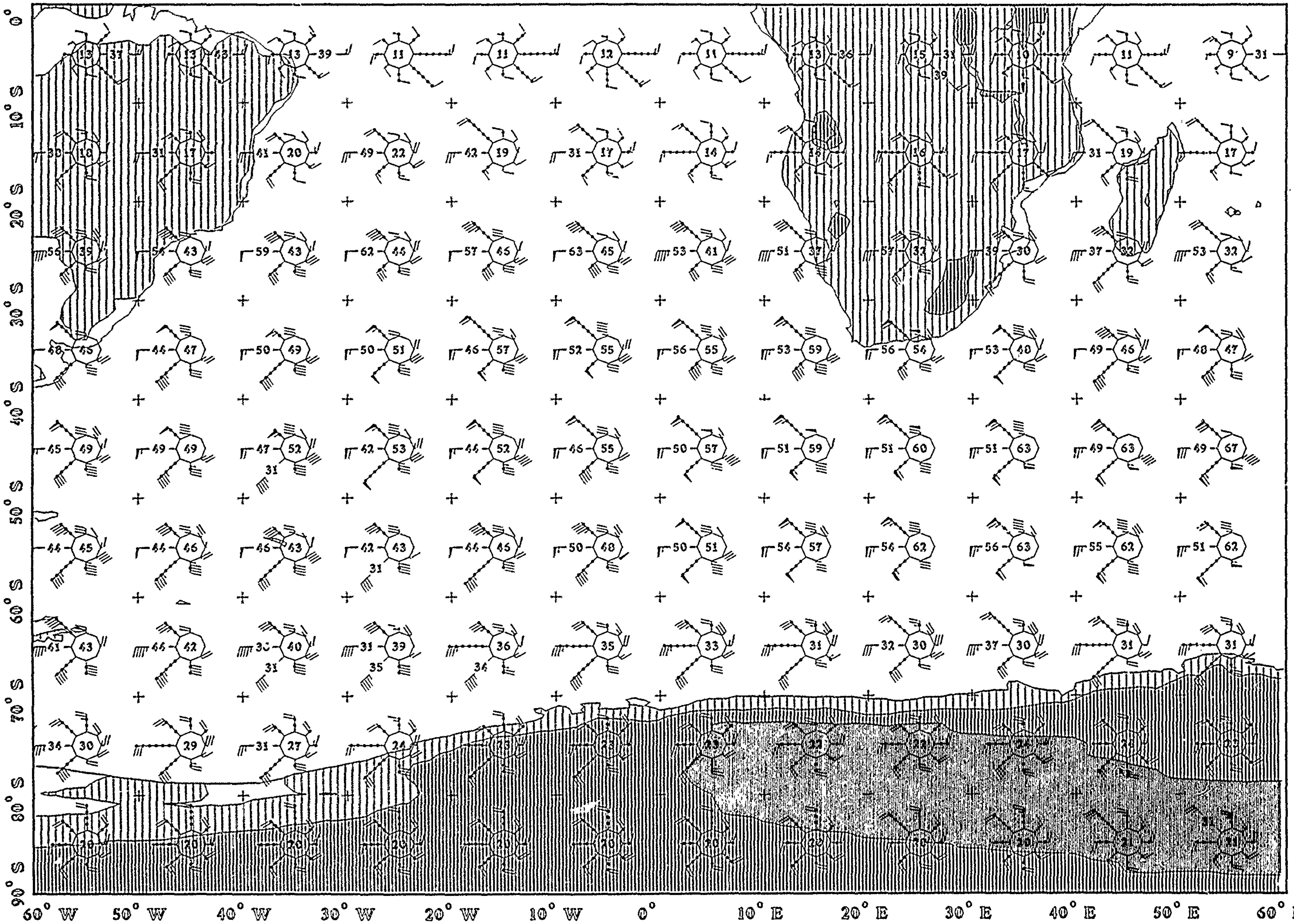
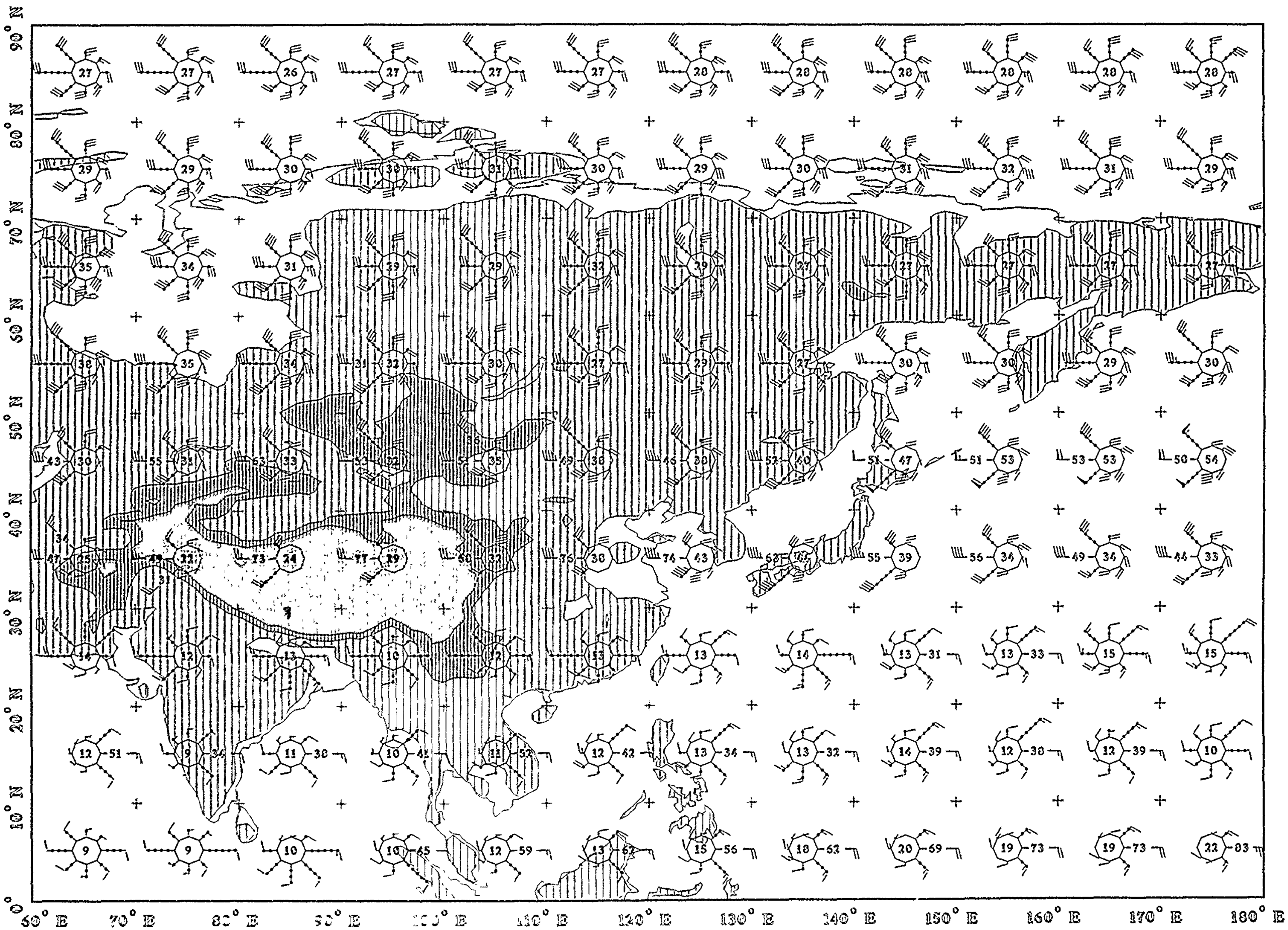


September
400 Mb

60W TO 60E
Wind Roses

Upper Air Climatology
Southern Hemisphere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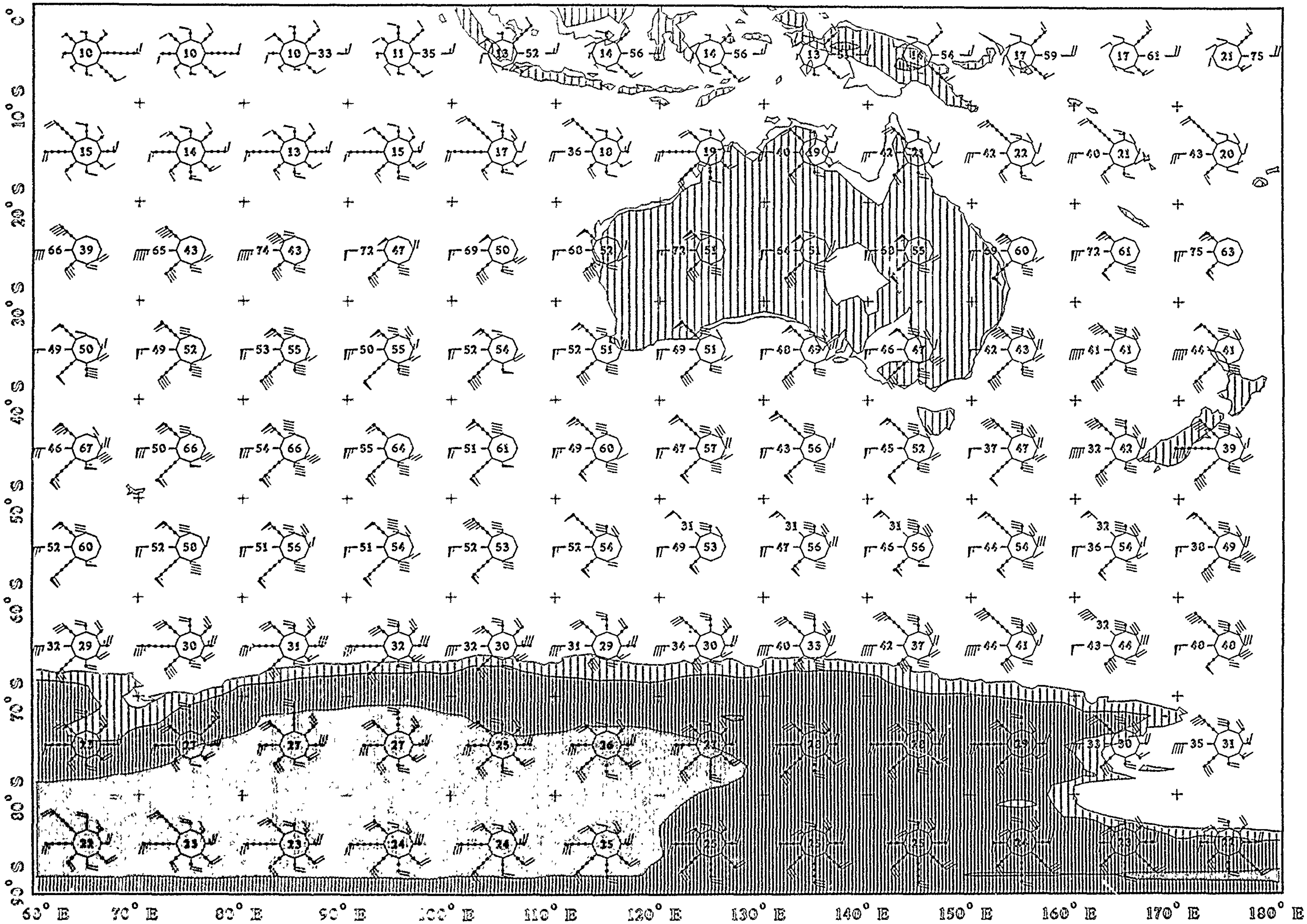
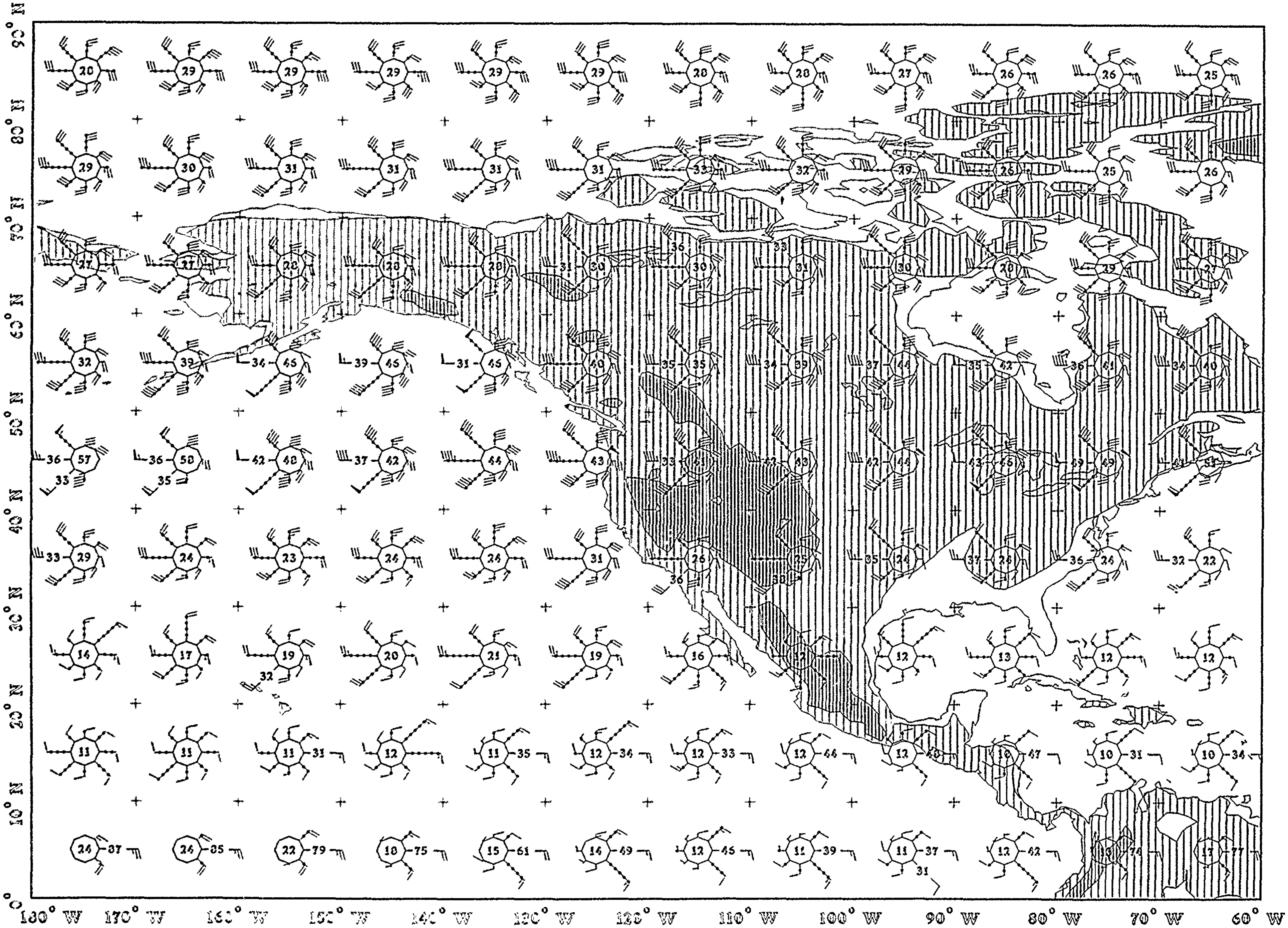


September
400 Mb

60E TO 180E
Wind Roses

Upper Air Climatology
Southern Hemisphere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70° N
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40° N
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180° W
170° W
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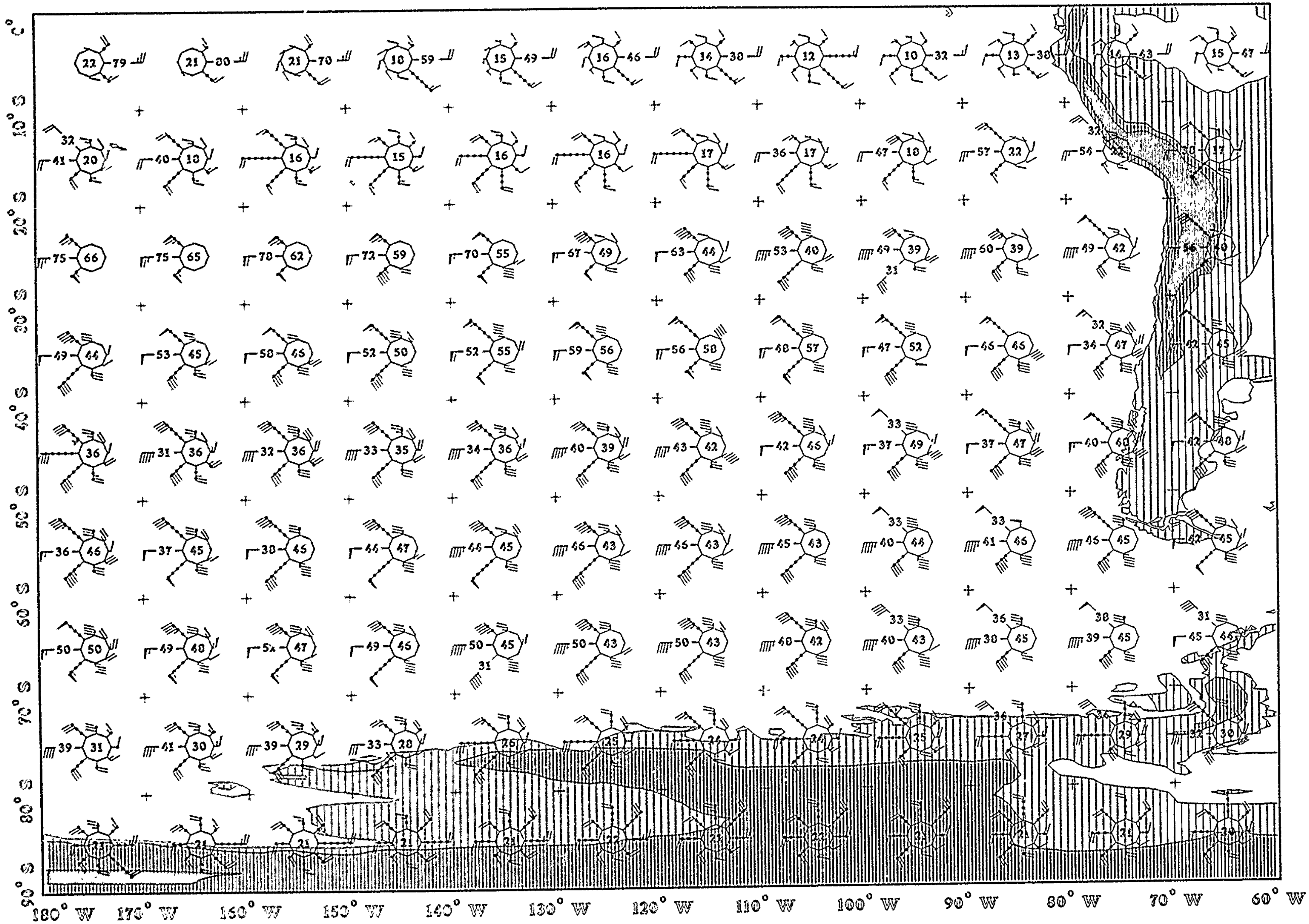
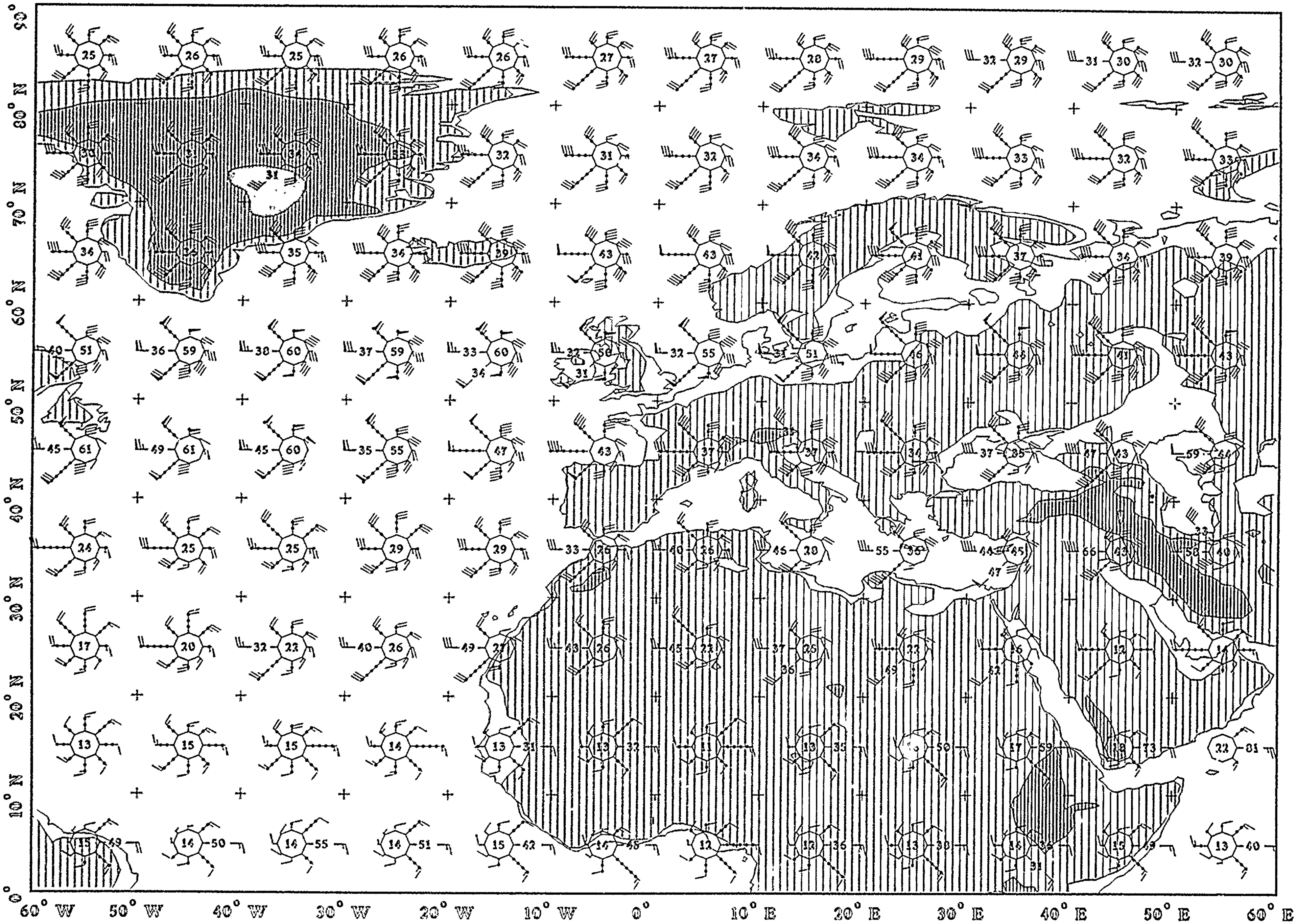
80° W
70° W
60° W



September
400 Mb

180W TO 60W
Wind Roses

Upper Air Climatology
Southern Hemisphere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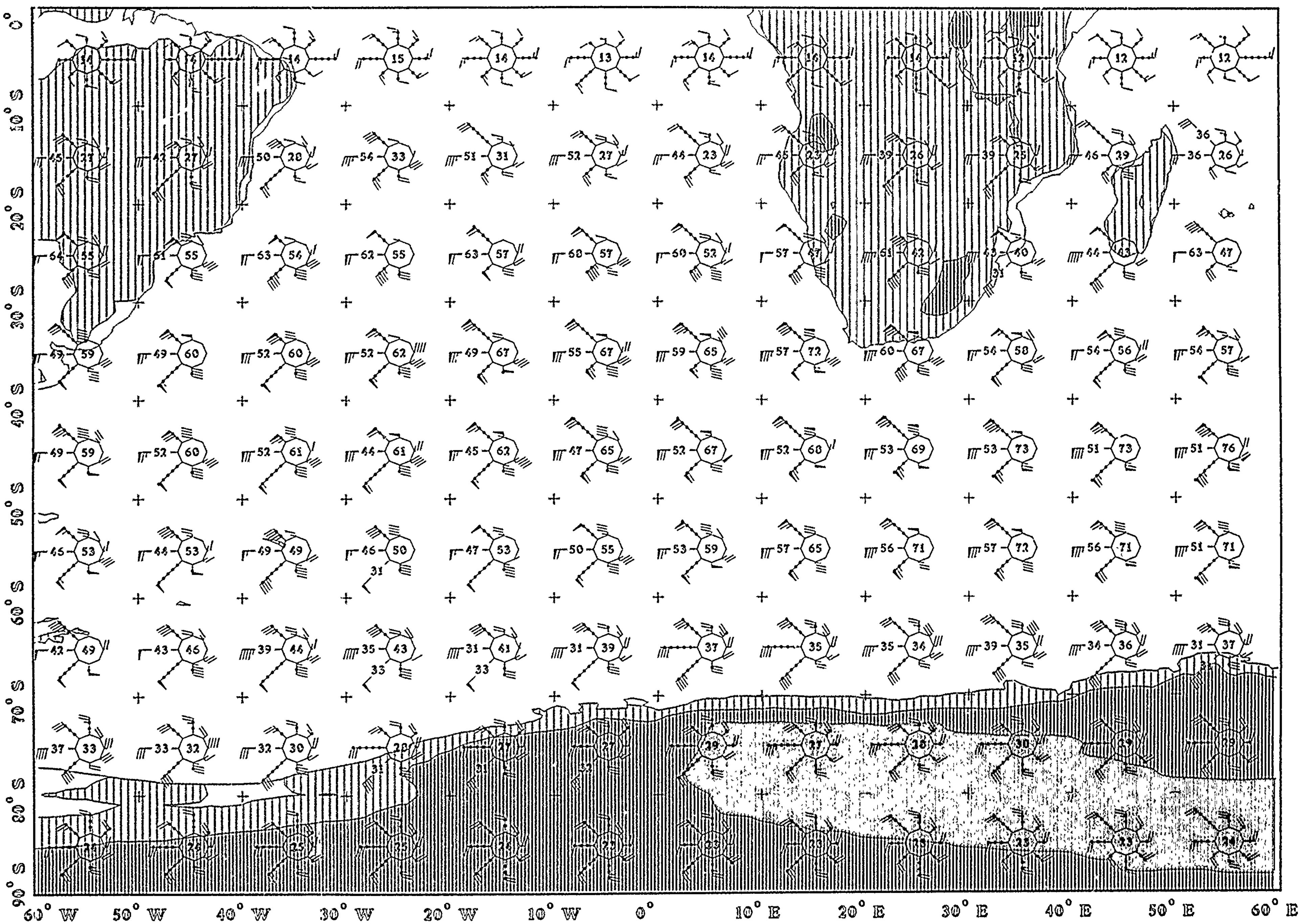
50° E
60° E

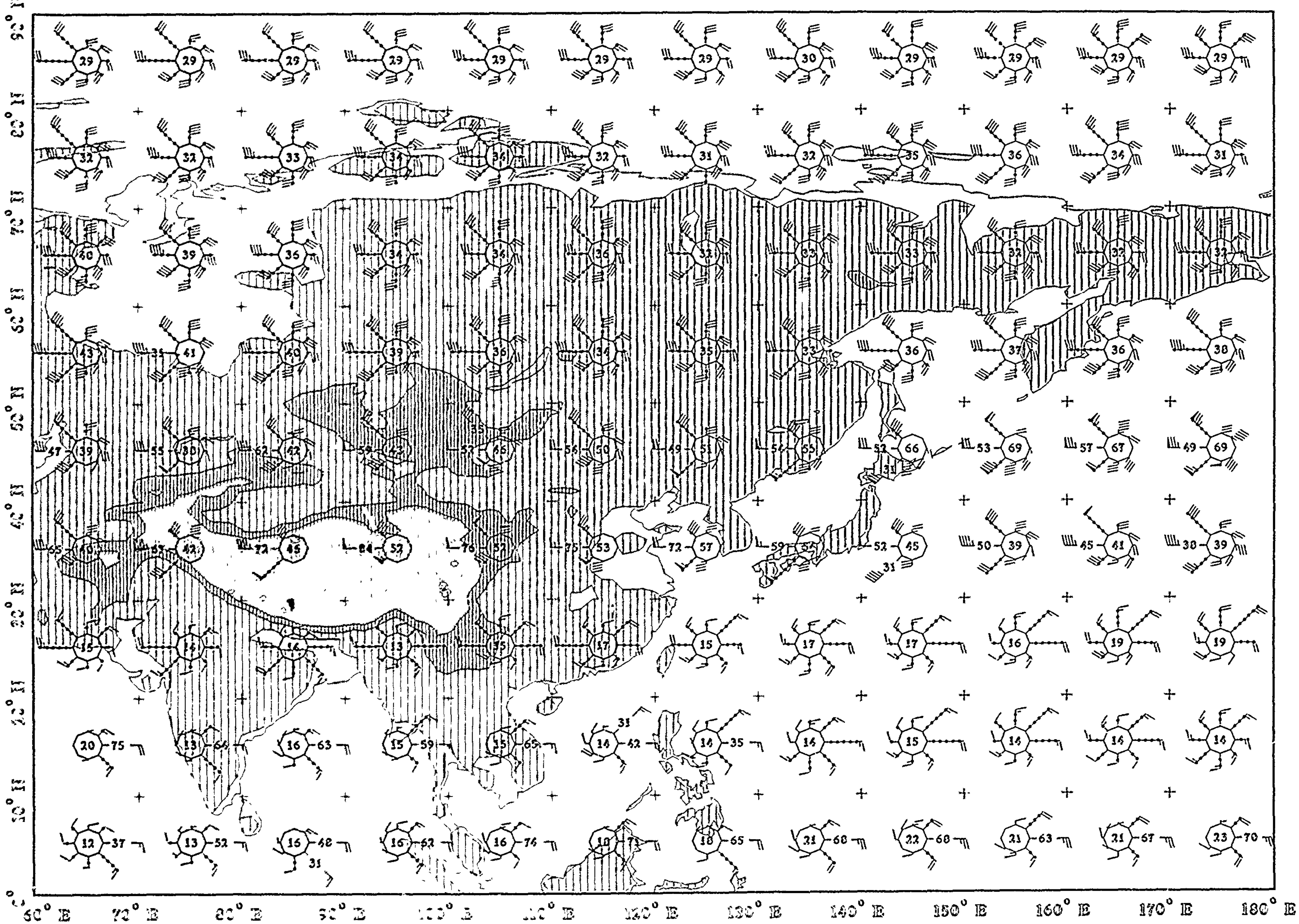


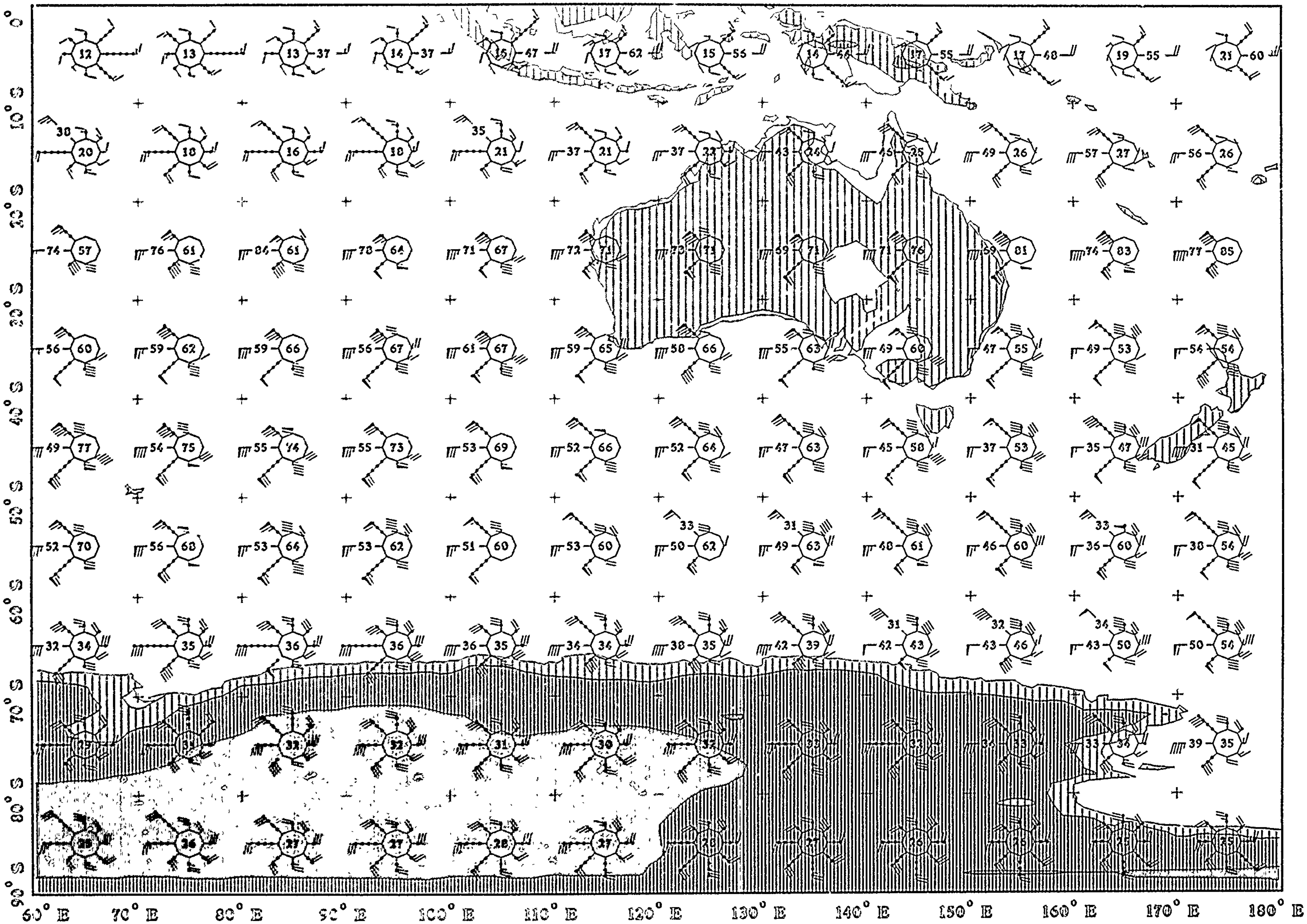
September
300 Mb

60W TO 60E
Wind Roses

Upper Air Climatology
Southern Hemisphere

60E TO 180E
Wind Roses

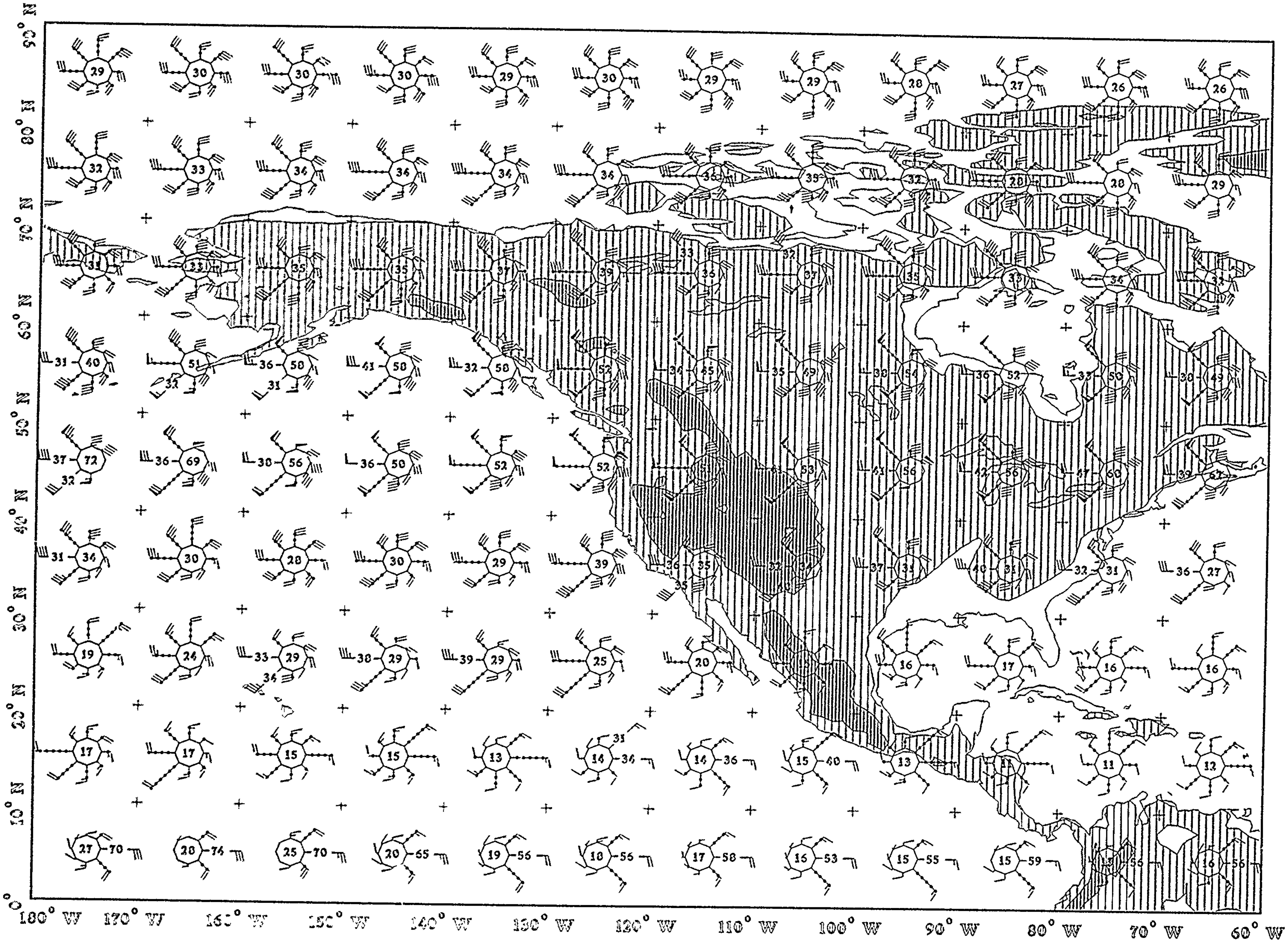




September
300 Mb

60E TO 180E
Wind Roses

Upper Air Climatology
Southern Hemisphere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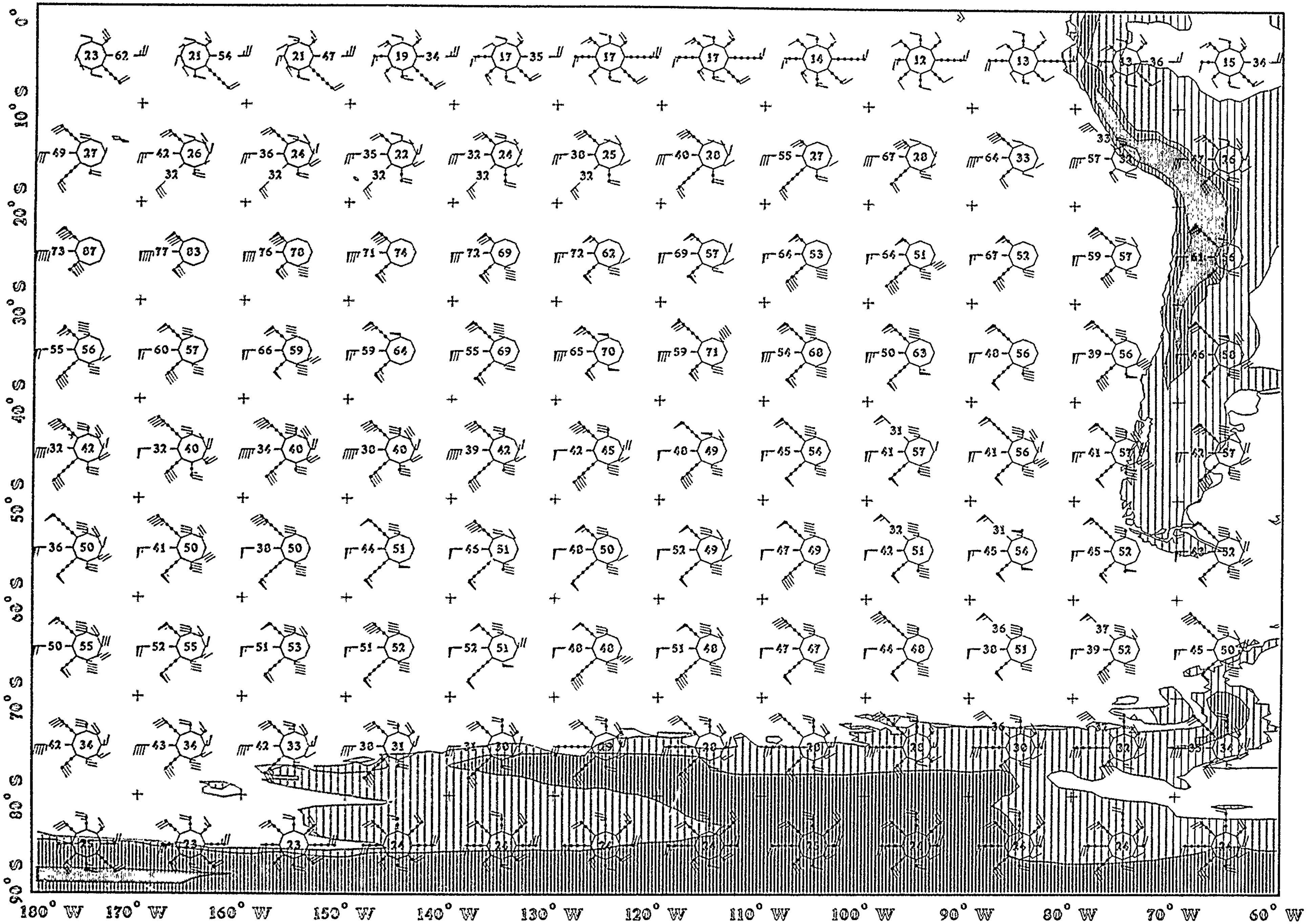
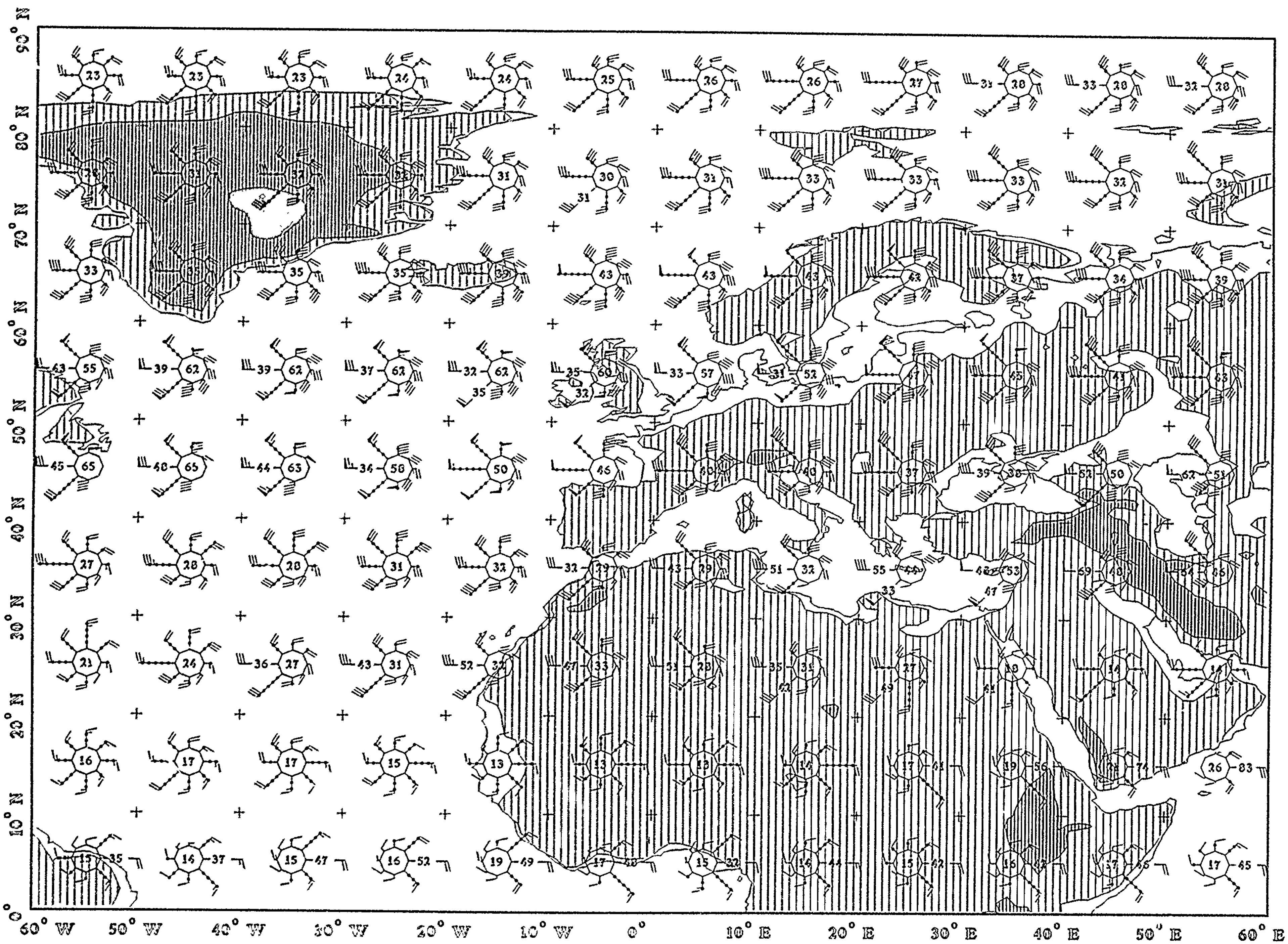


September
300 Mb

180W TO 60W
Wind Roses

Upper Air Climatology
Southern Hemisphere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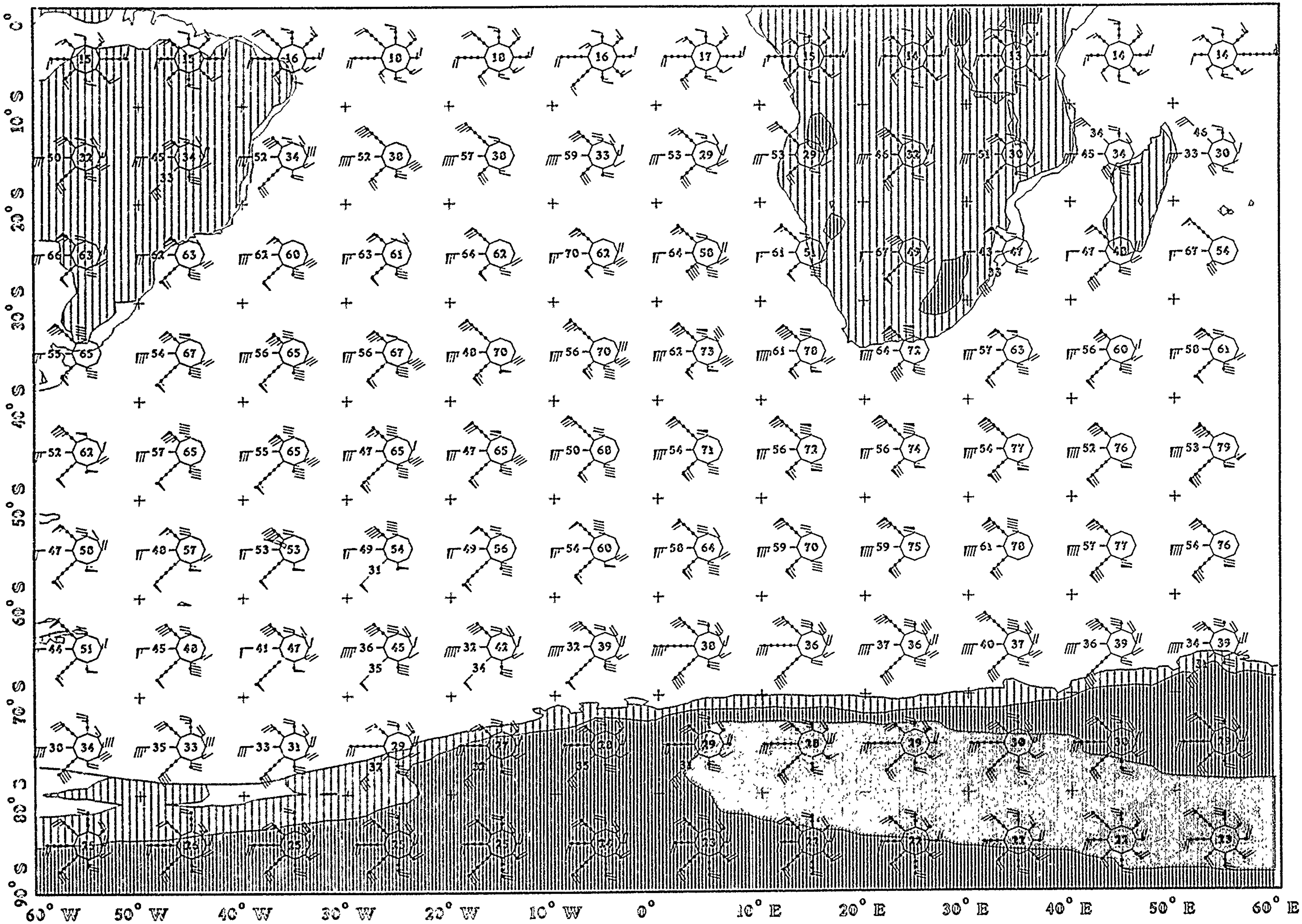
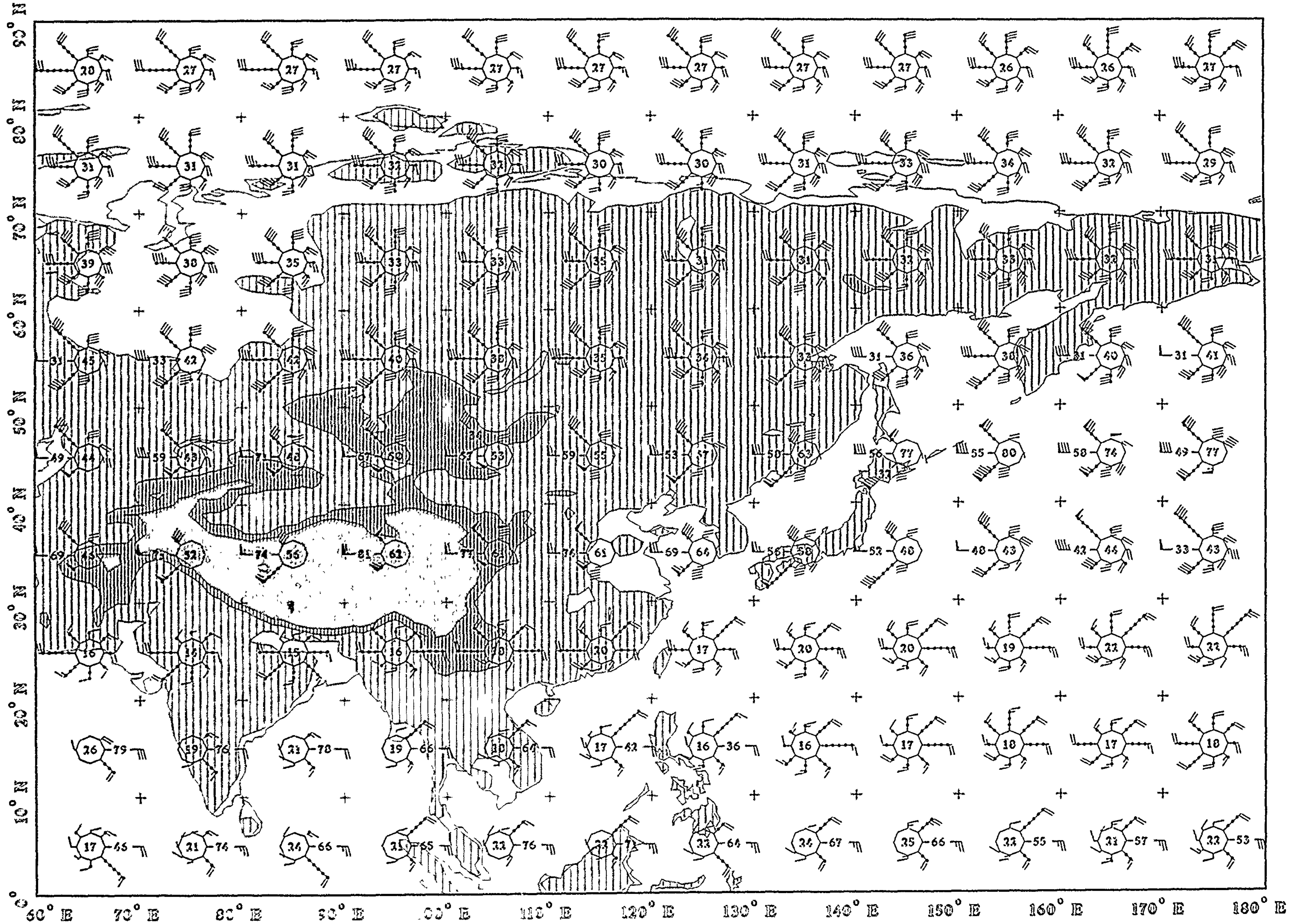


September
250 Mb

60W TO 60E
Wind Roses

Upper Air Climatology
Southern Hemisphere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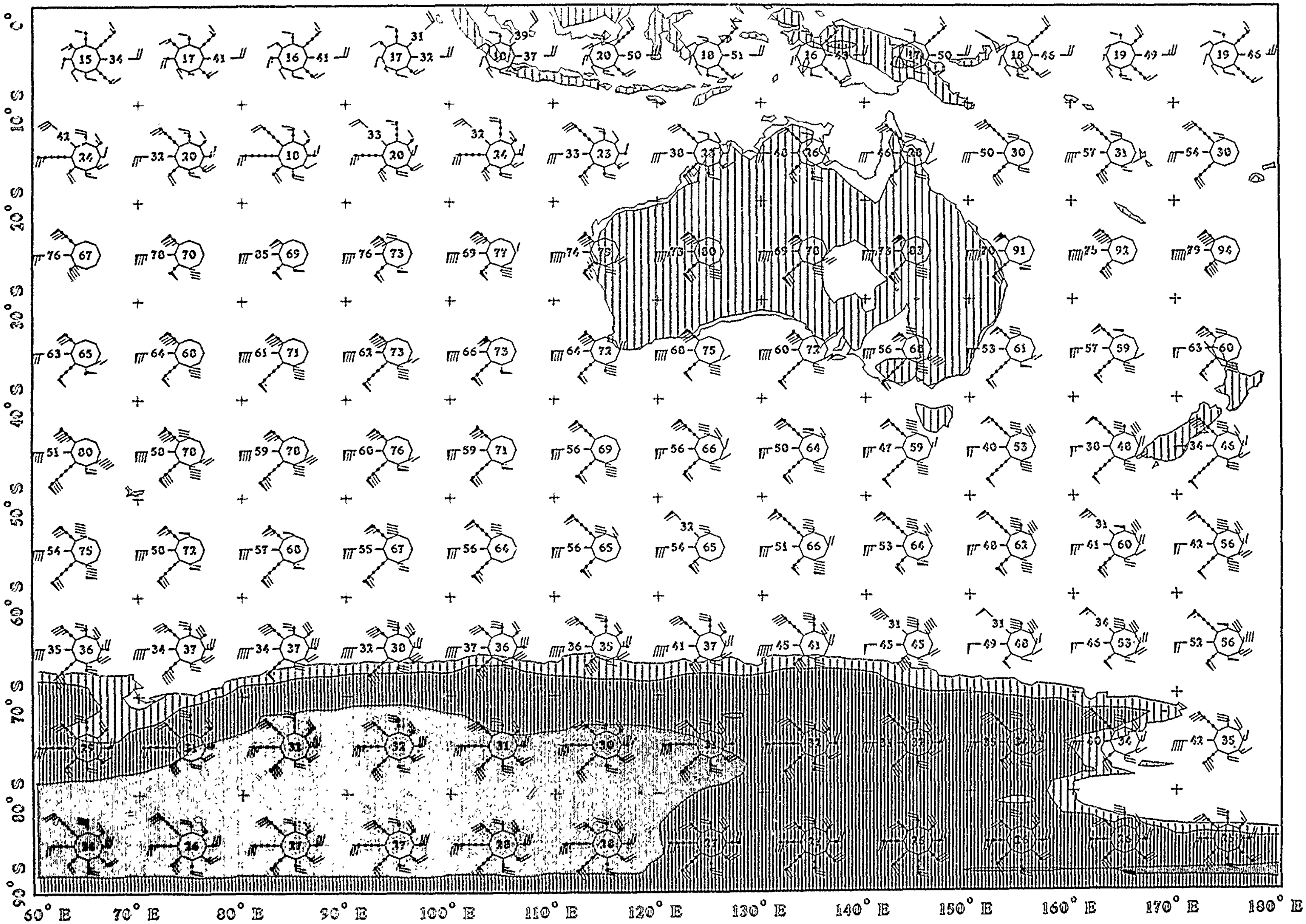
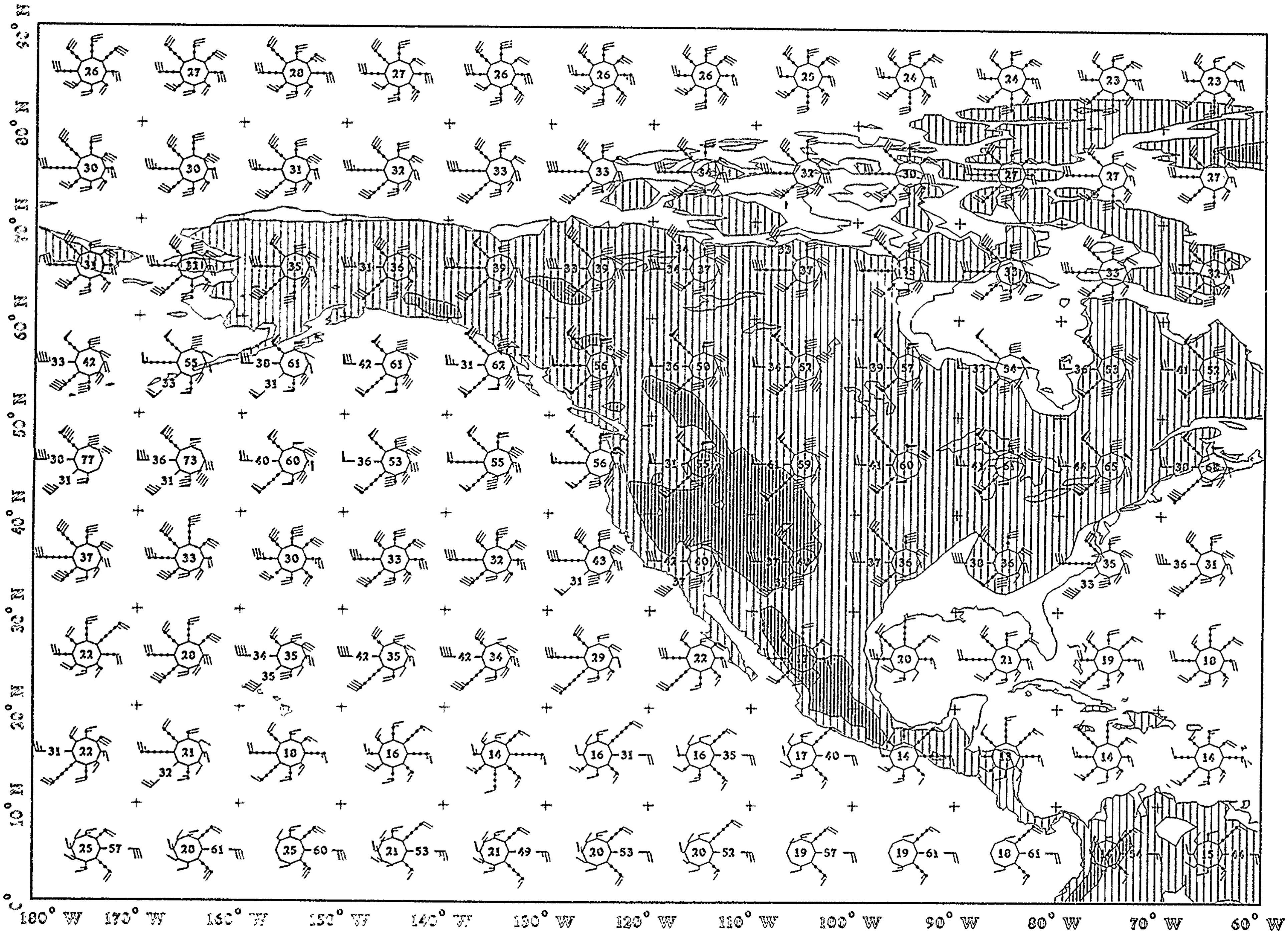


September
250 Mb

60E TO 180E
Wind Roses

Upper Air Climatology
Southern Hemisphere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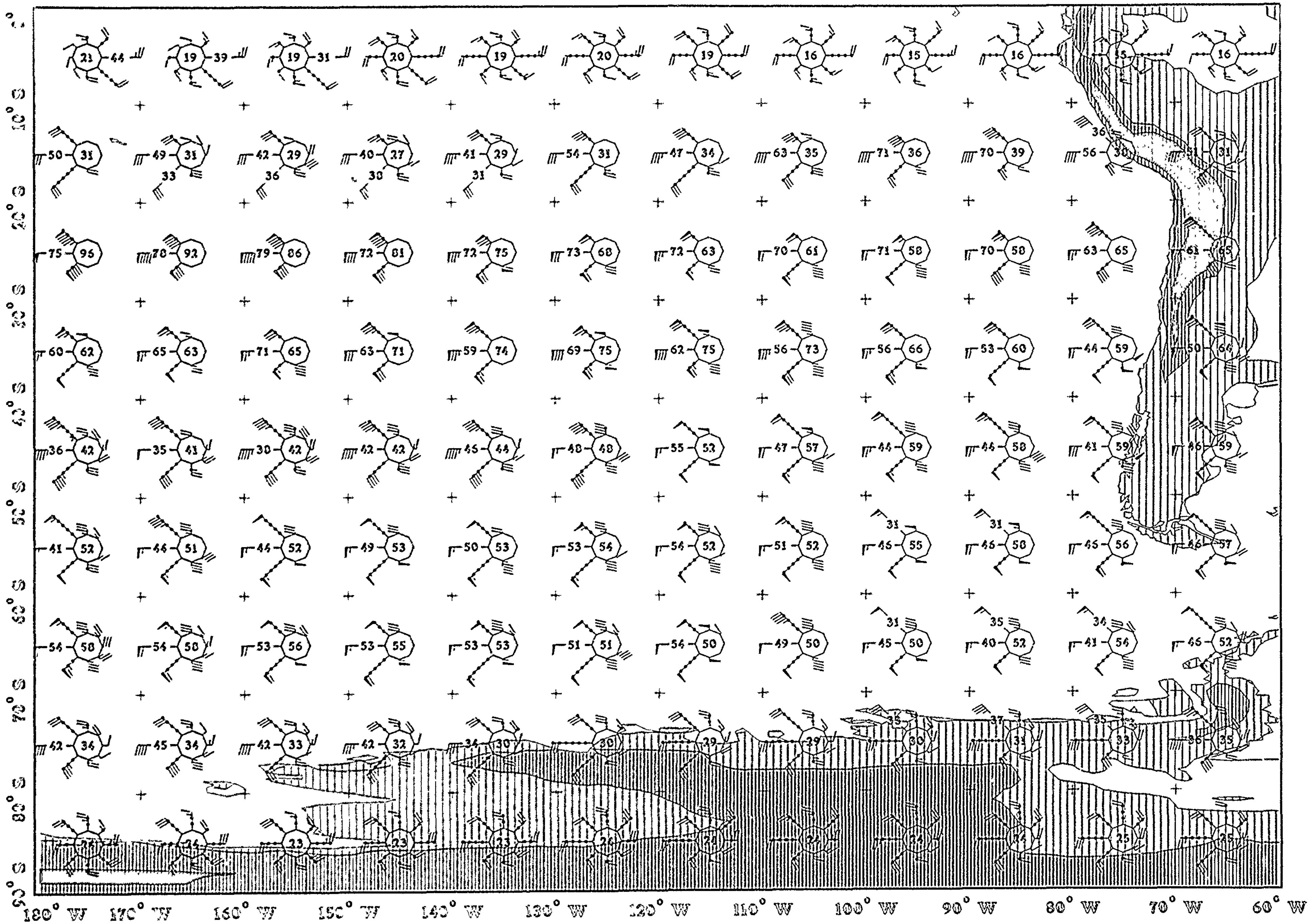
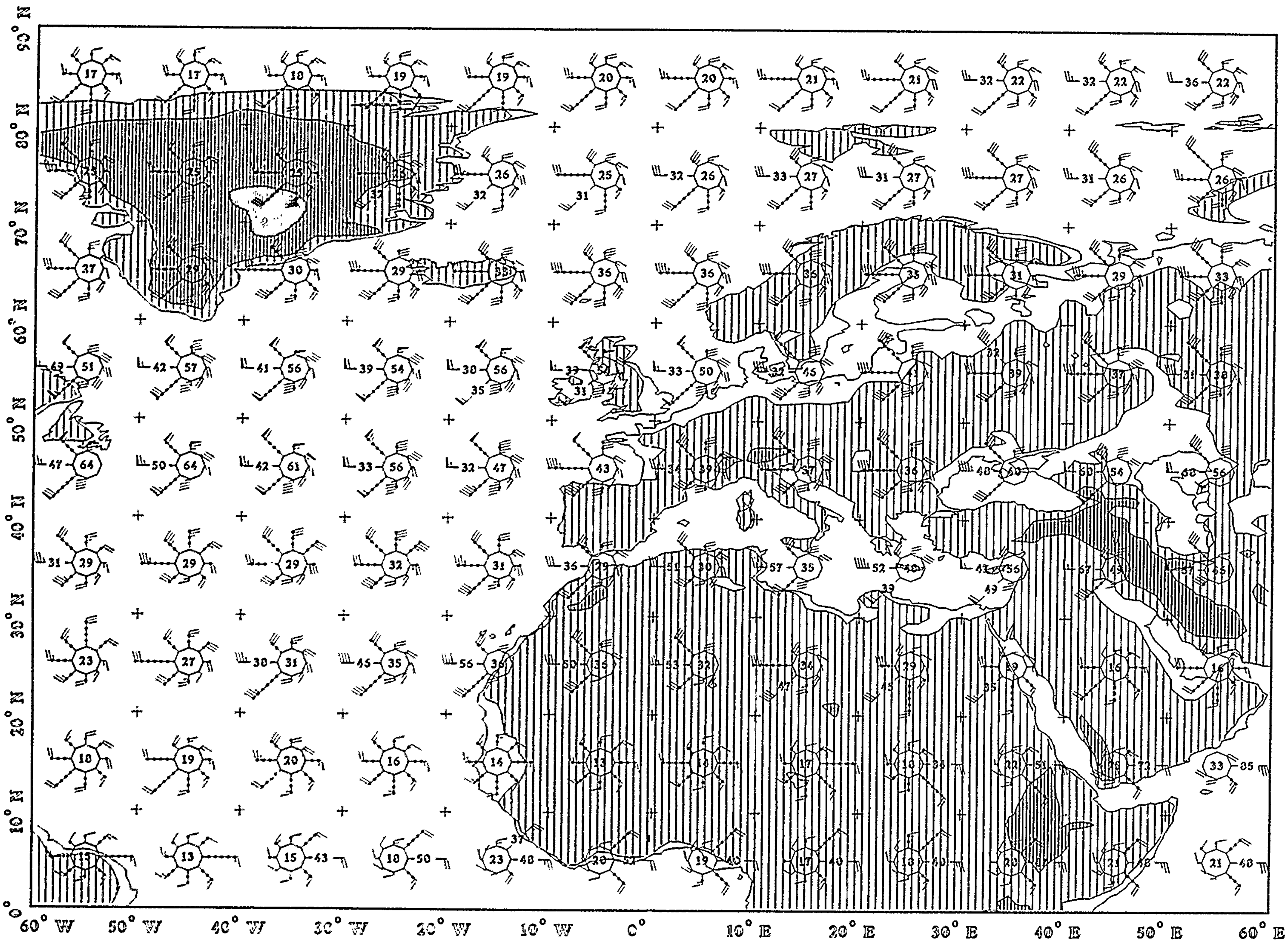


September
250 Mb

180W TO 60W
Wind Roses

Upper Air Climatology
Southern Hemisphere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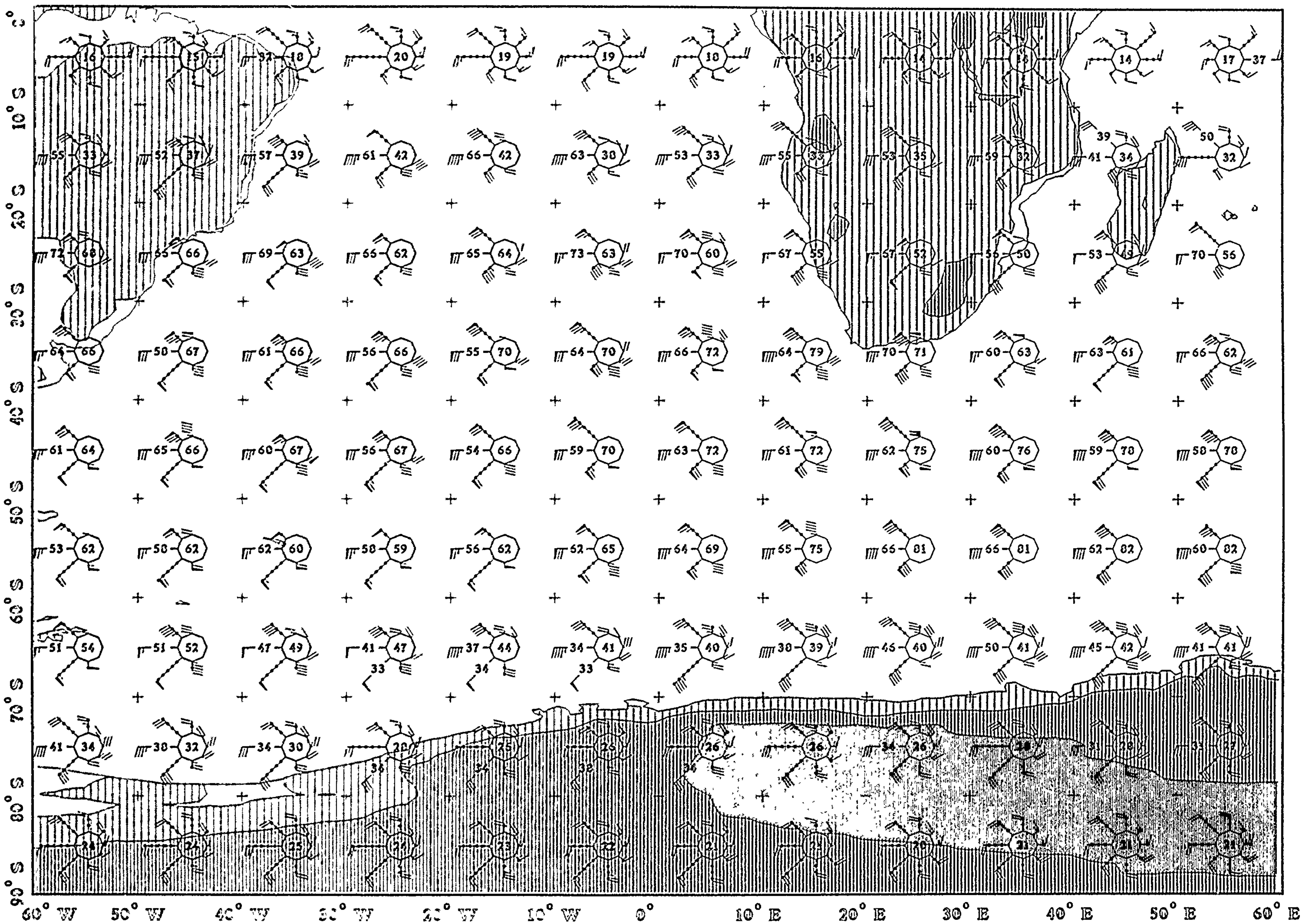

September
200 Mb

60W TO 60E
Wind Roses

Upper Air Climatology
Southern Hemisphere


90° N
80° N
70° N
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30° N
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60° E
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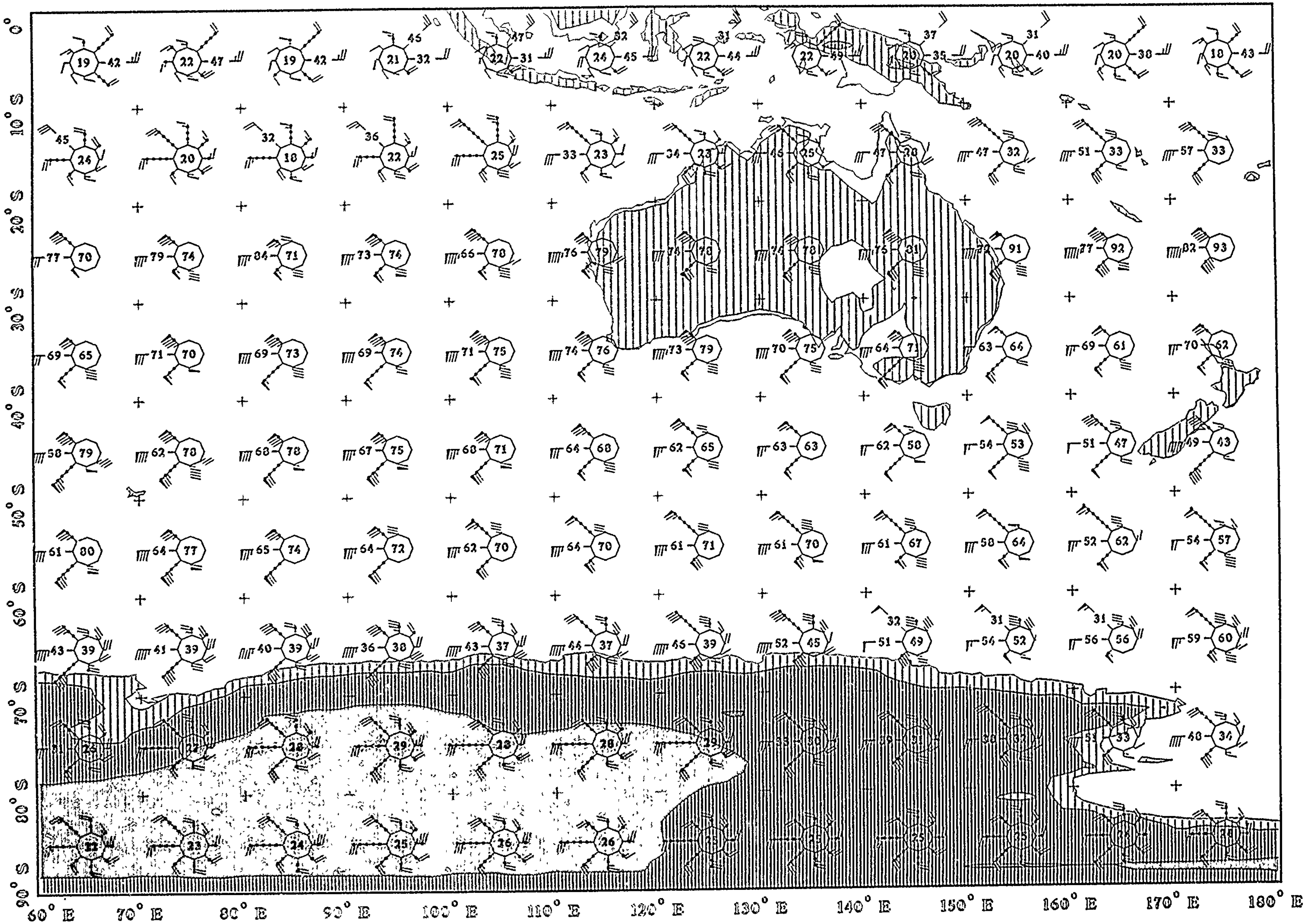
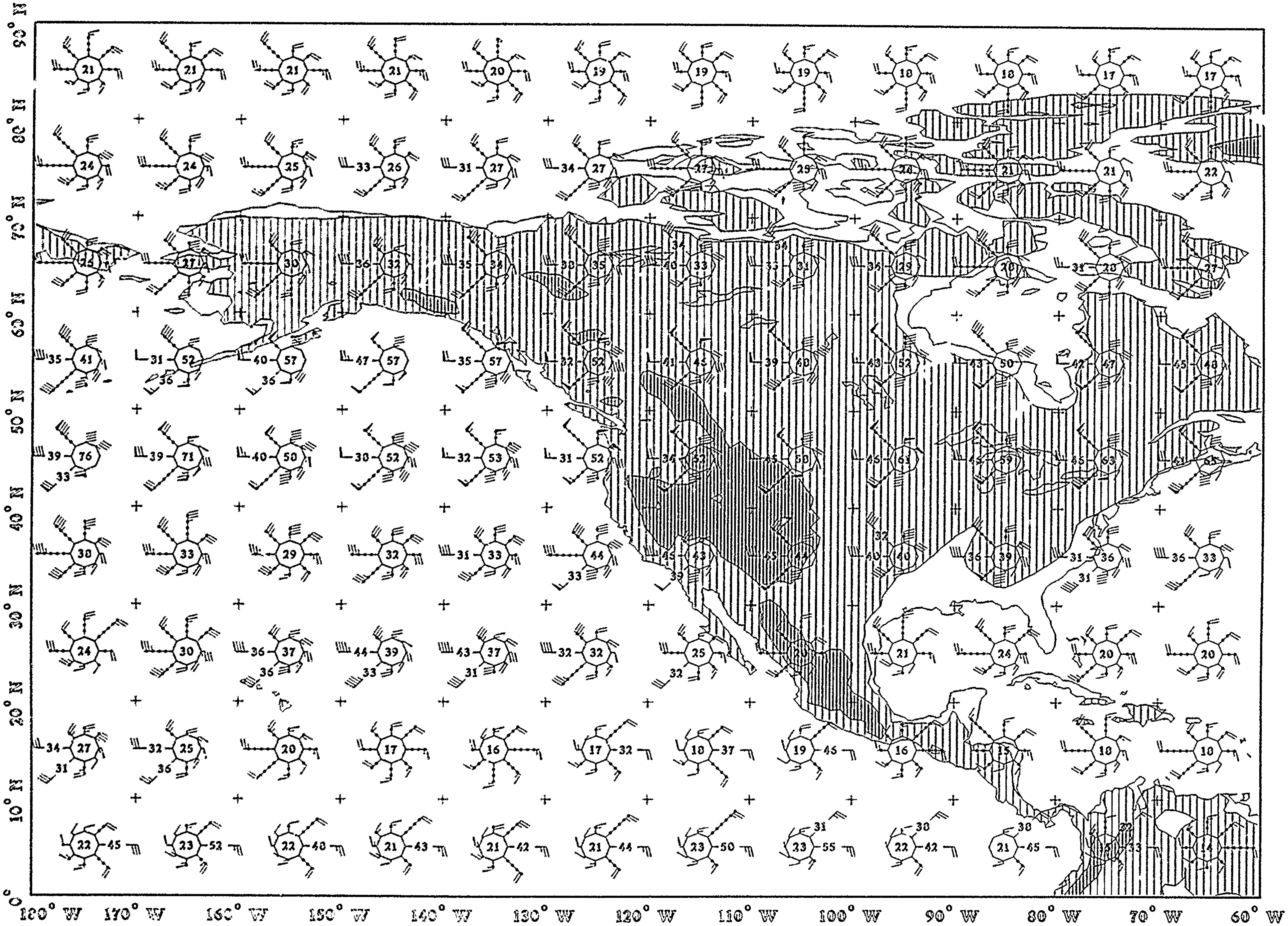


September
200 Mb

60E TO 180E
Wind Roses

Upper Air Climatology
Southern Hemisphere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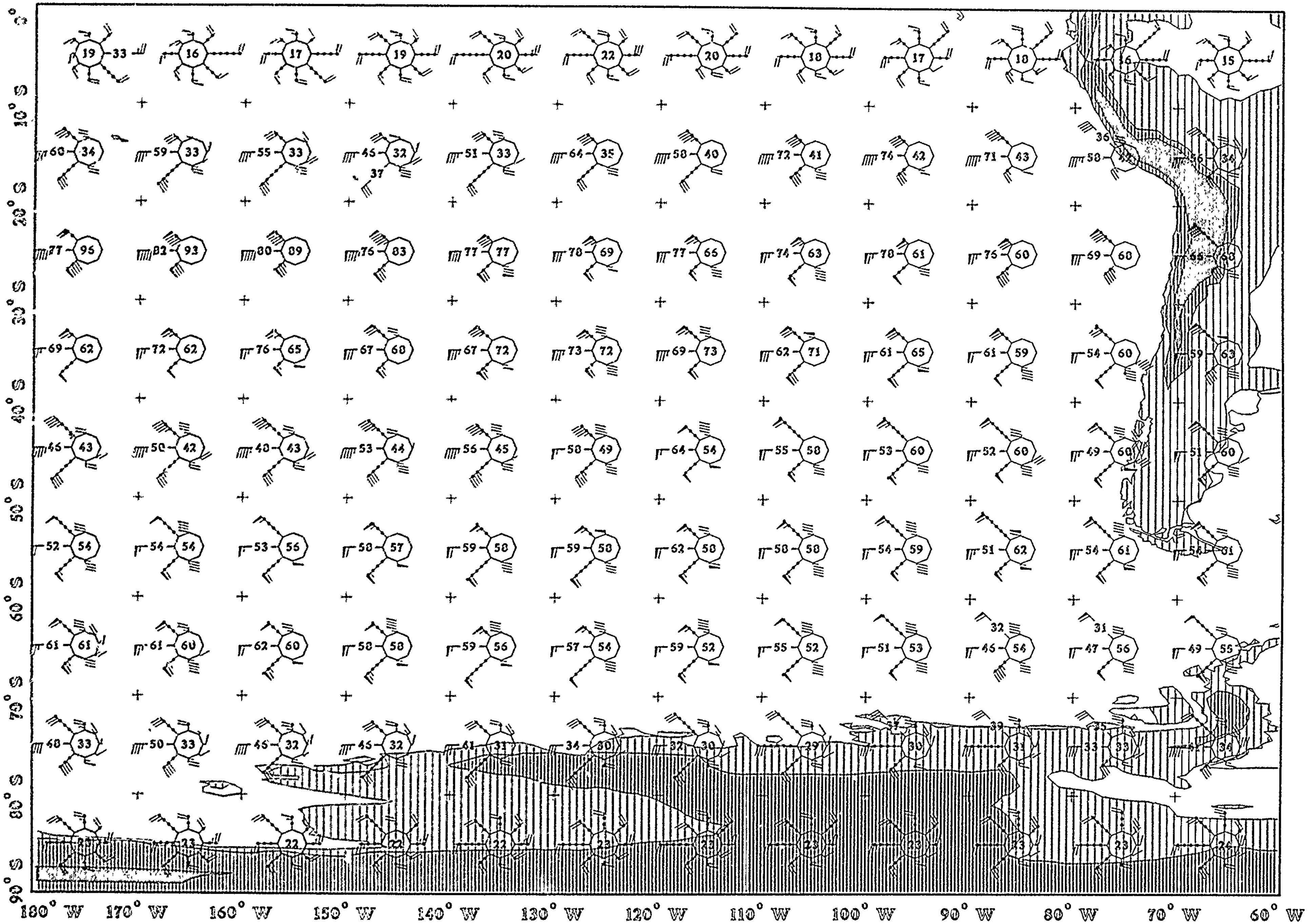
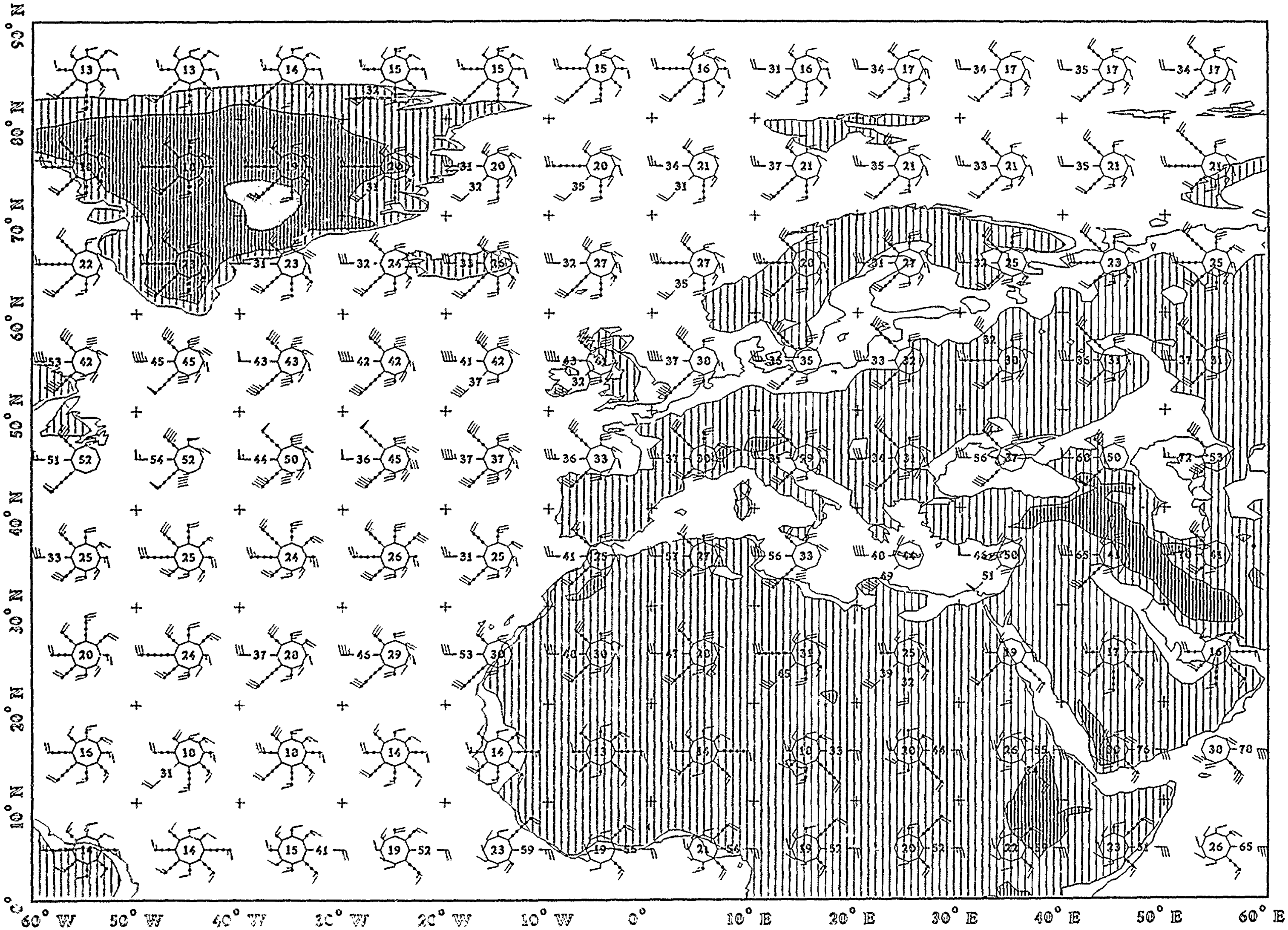


September
200 Mb

180W TO 60W
Wind Roses

Upper Air Climatology
Southern Hemisphere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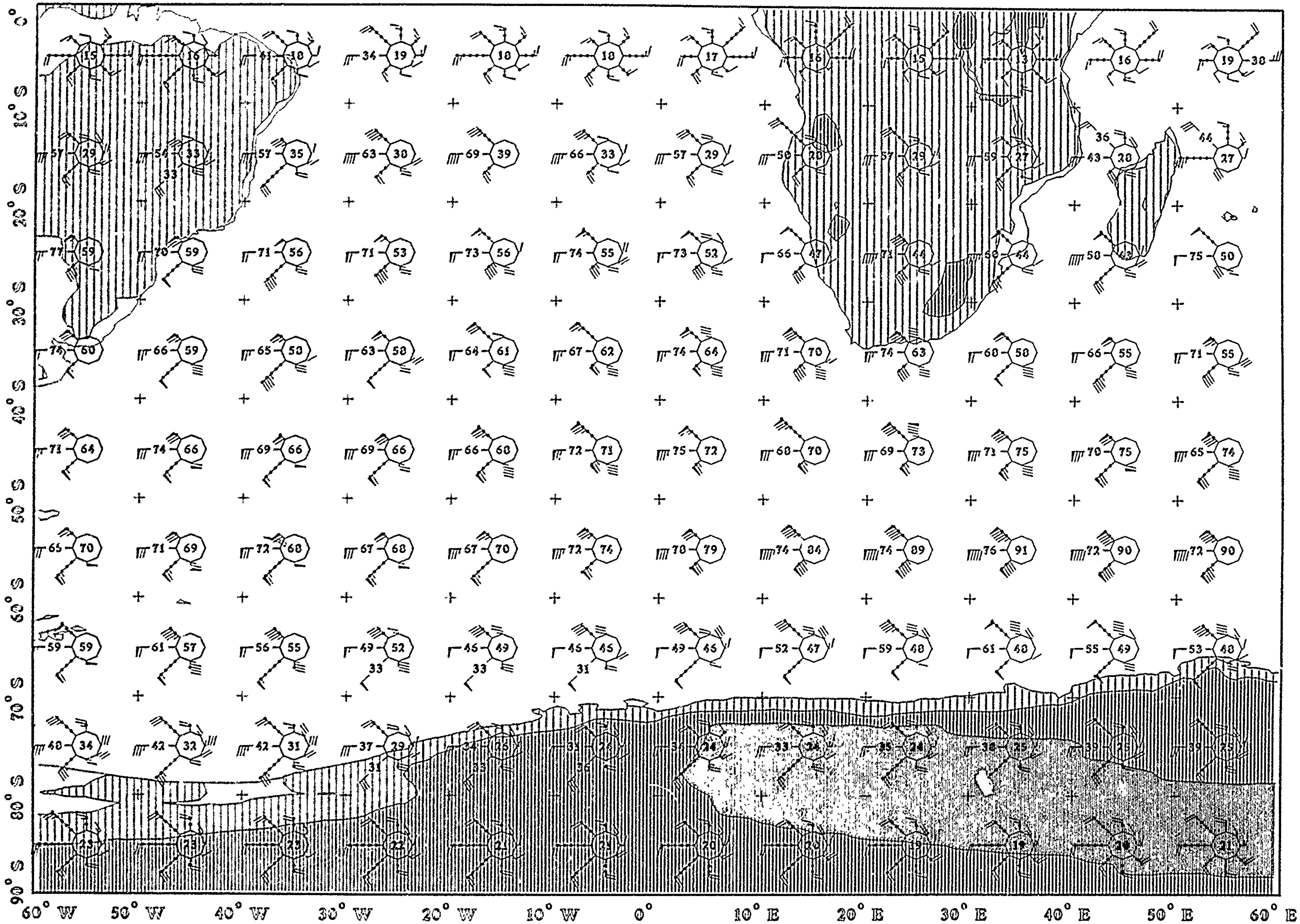
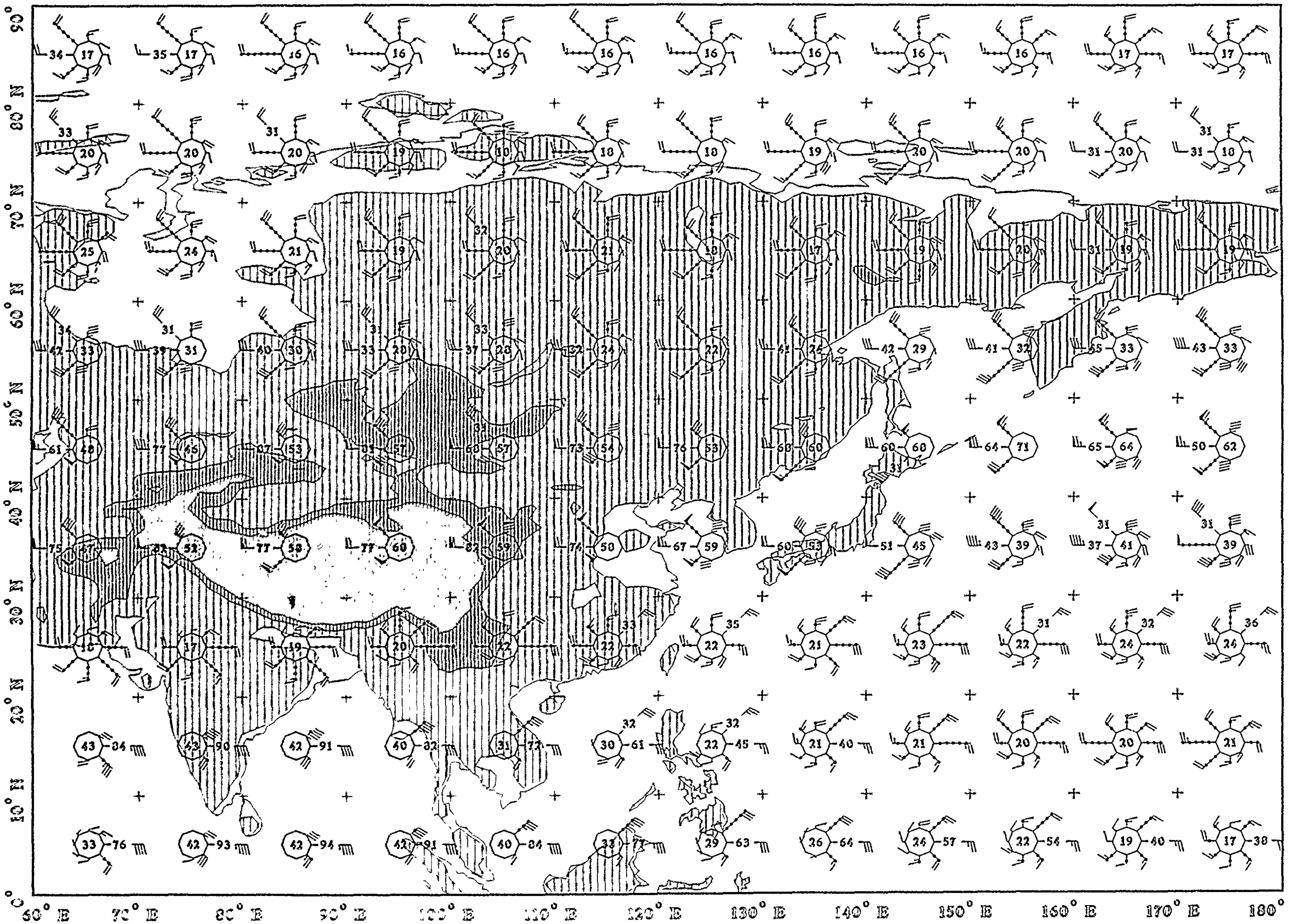


September
150 Mb

60W TO 60E
Wind Roses

Upper Air Climatology
Southern Hemisphere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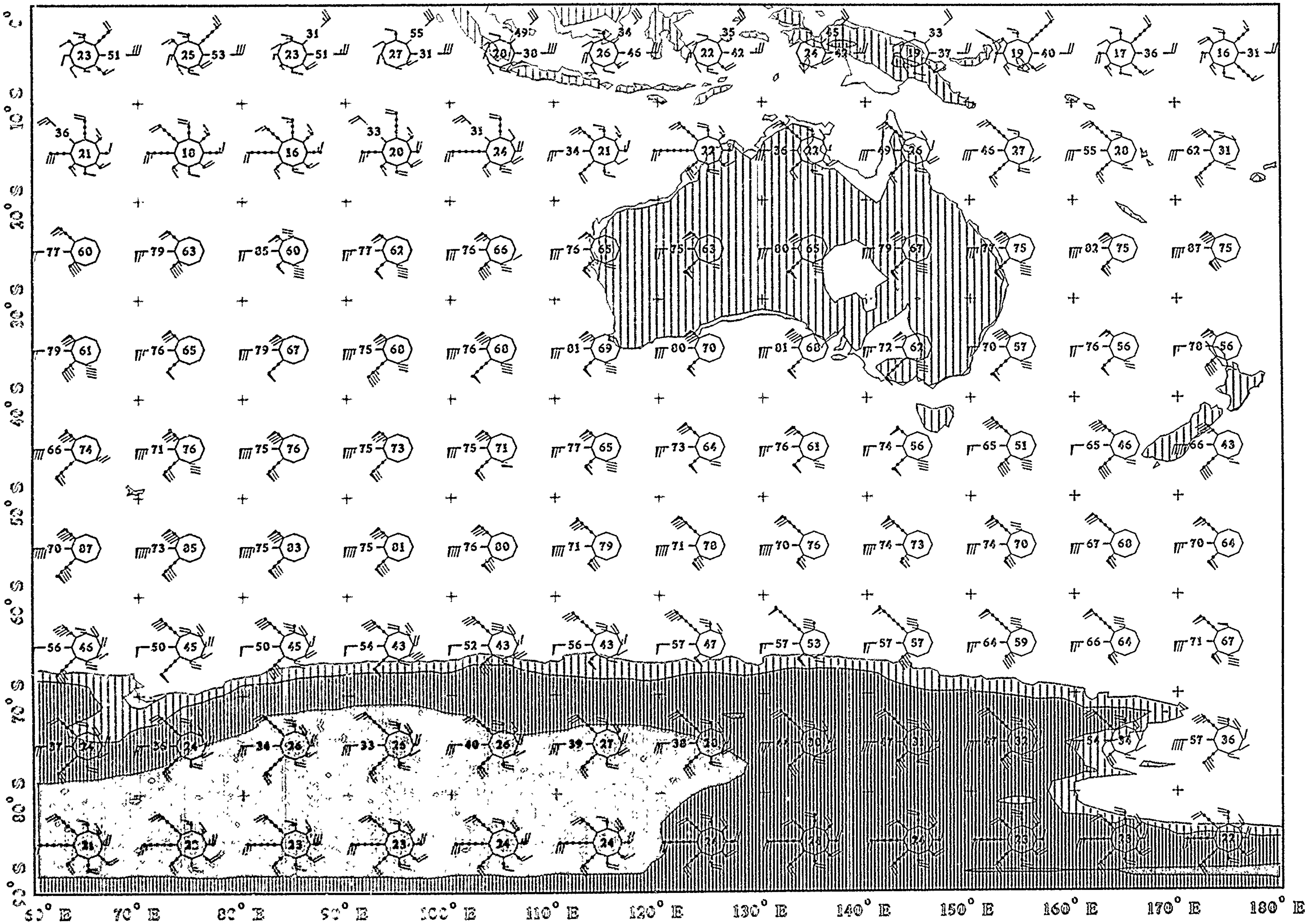
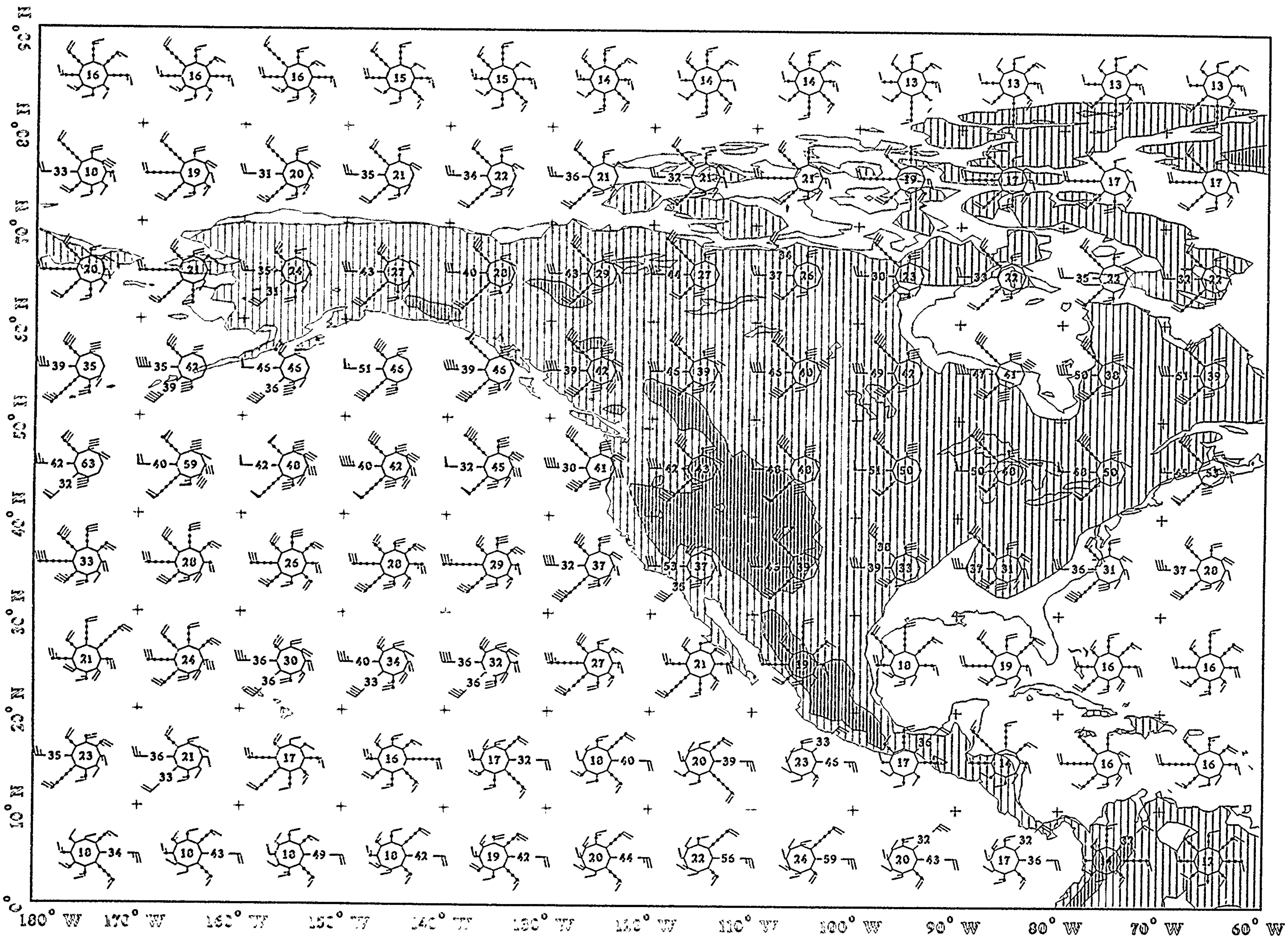


September
150 Mb

60E TO 180E
Wind Roses

Upper Air Climatology
Southern Hemisphere



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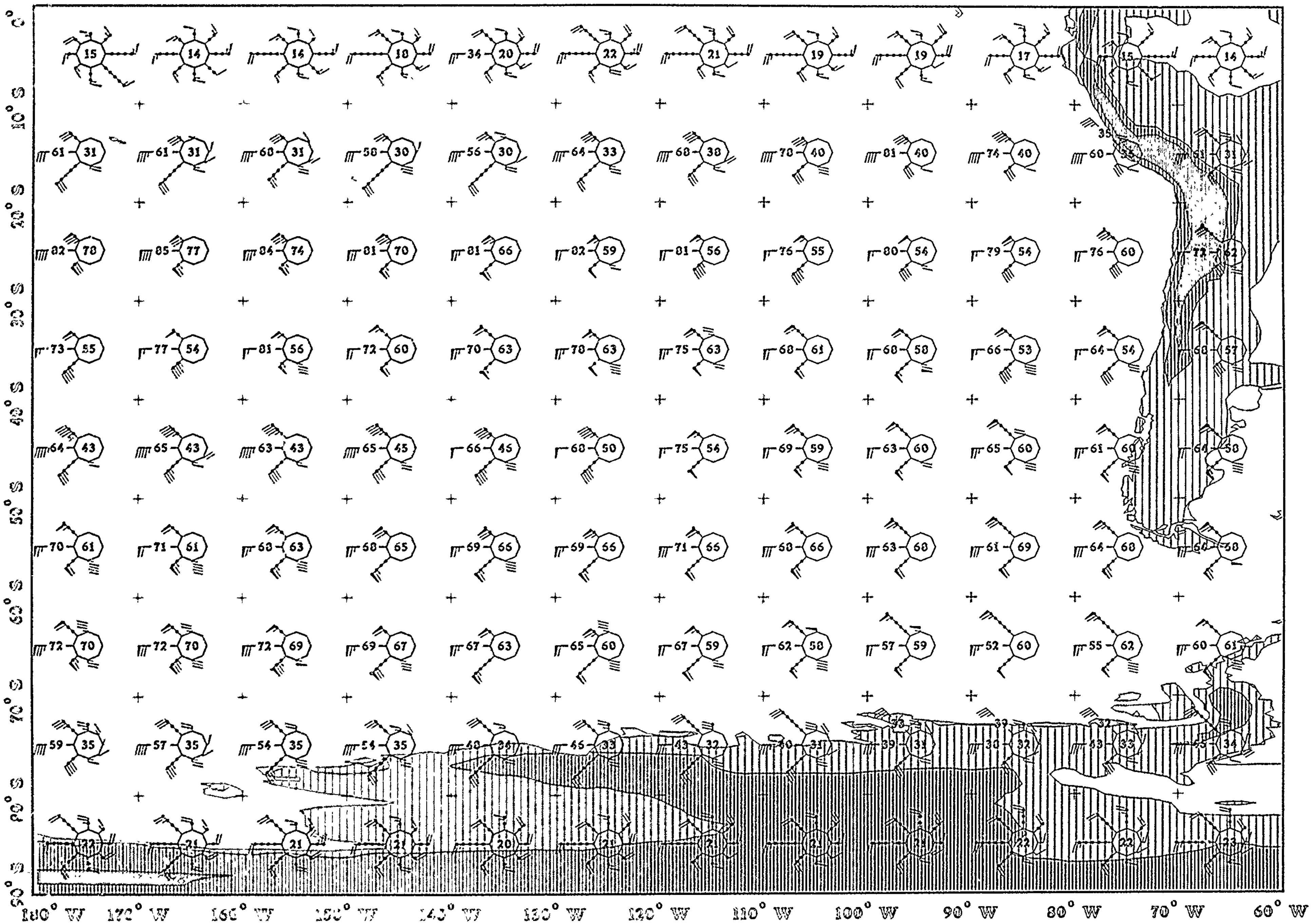
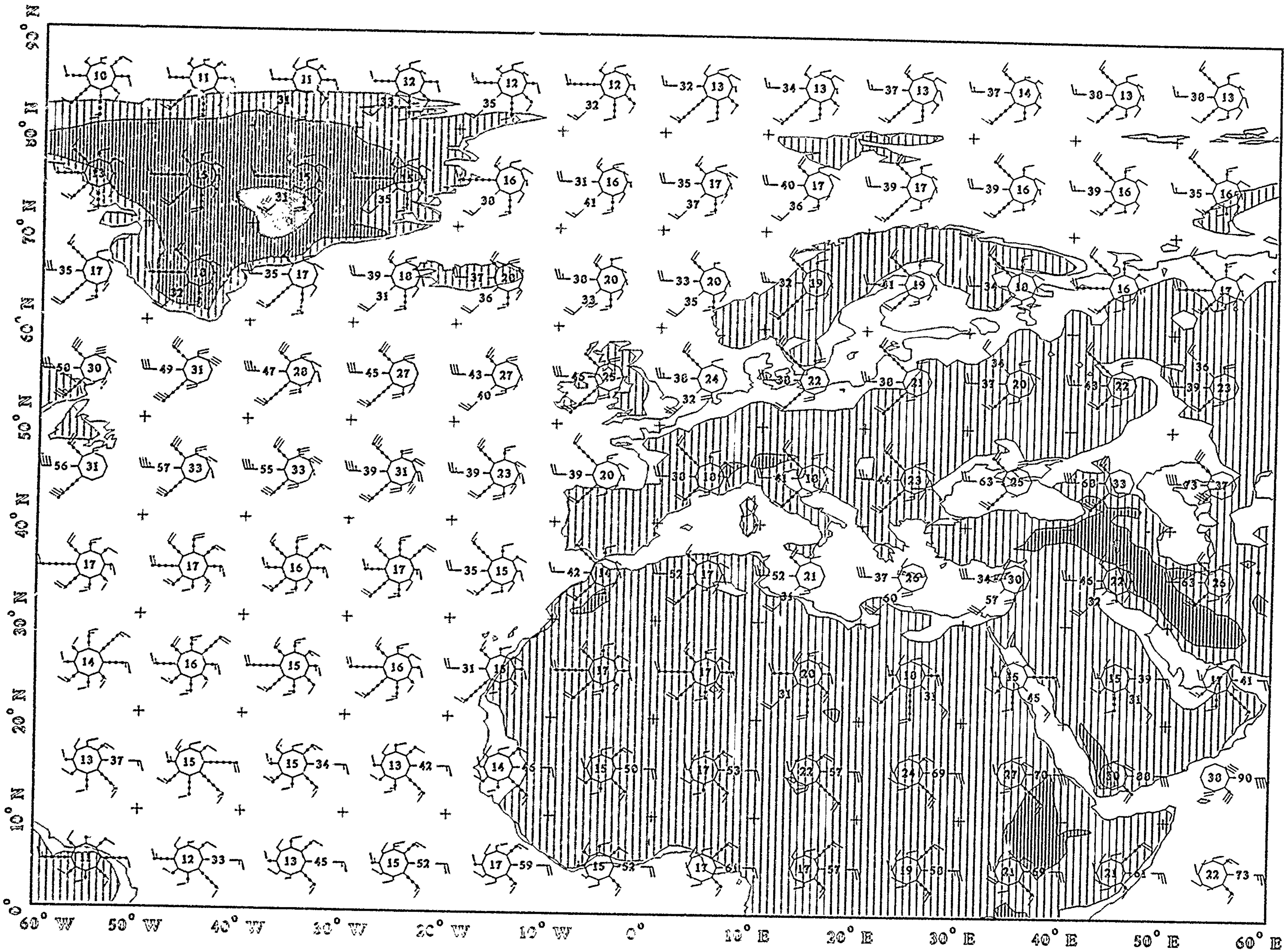
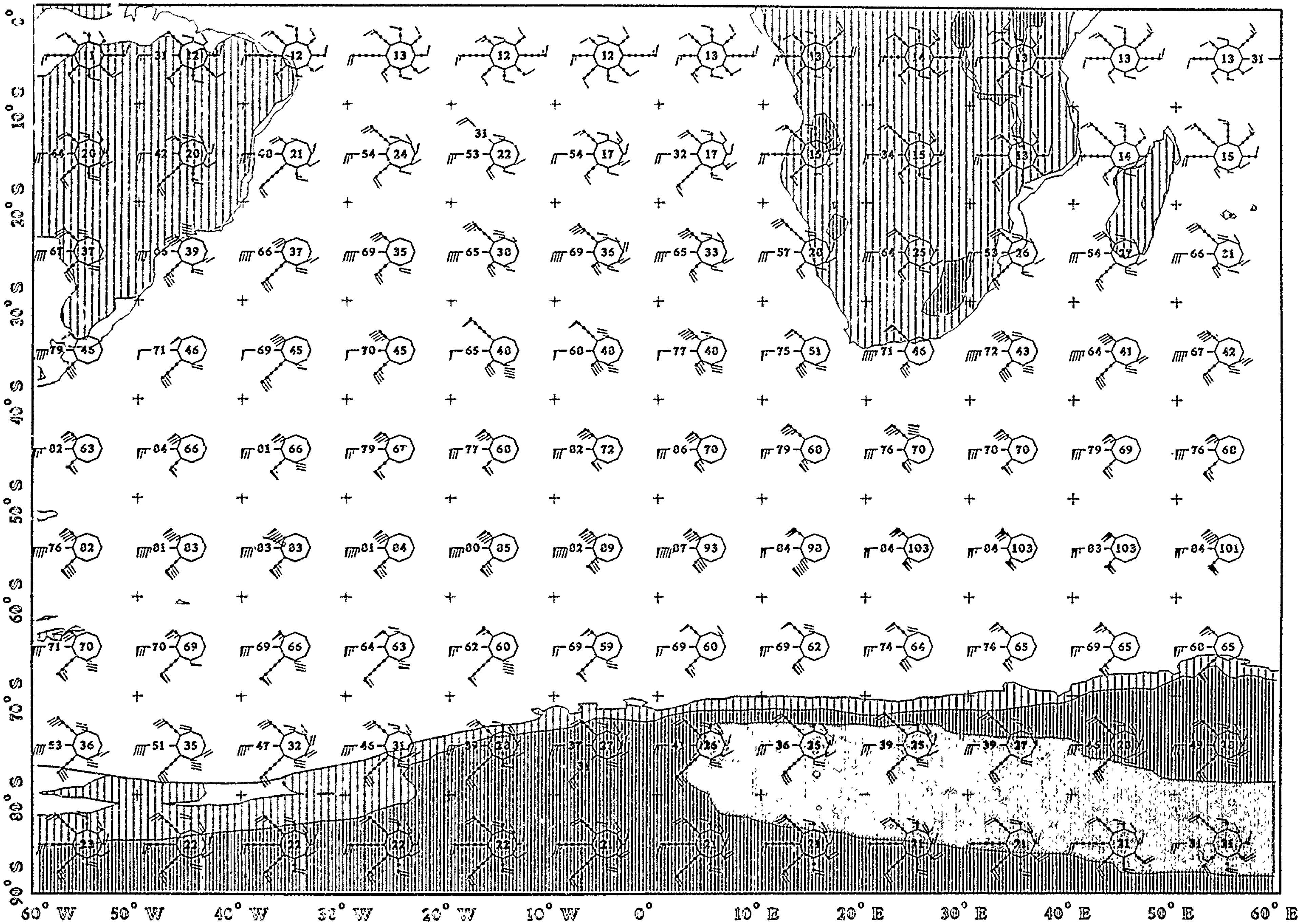


September
150 Mb

180W TO 60W
Wind Roses

Upper Air Climatology
Southern Hemisphere

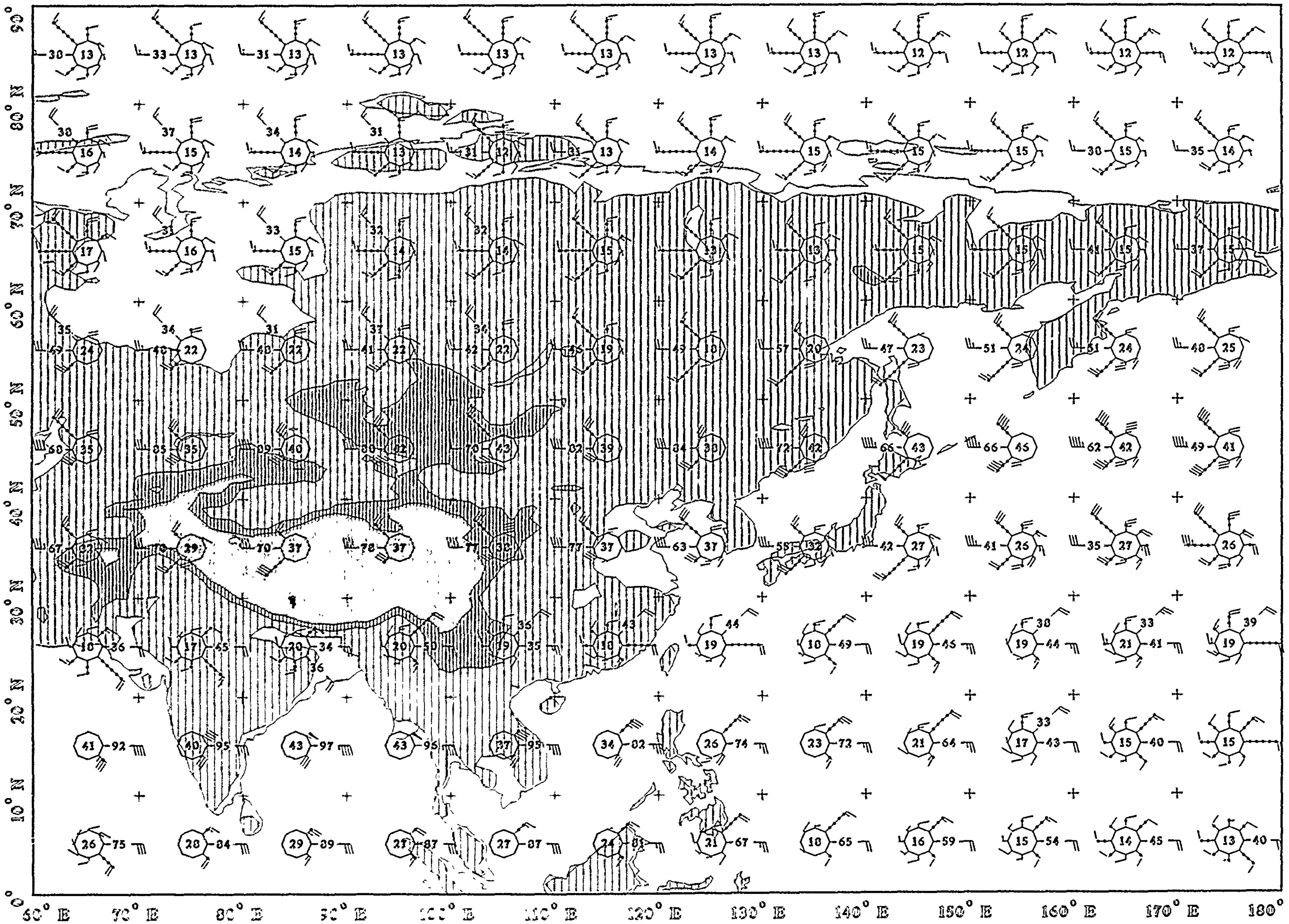




September
100 Mb

60W TO 60E
Wind Roses

Upper Air Climatology
Southern Hemisphere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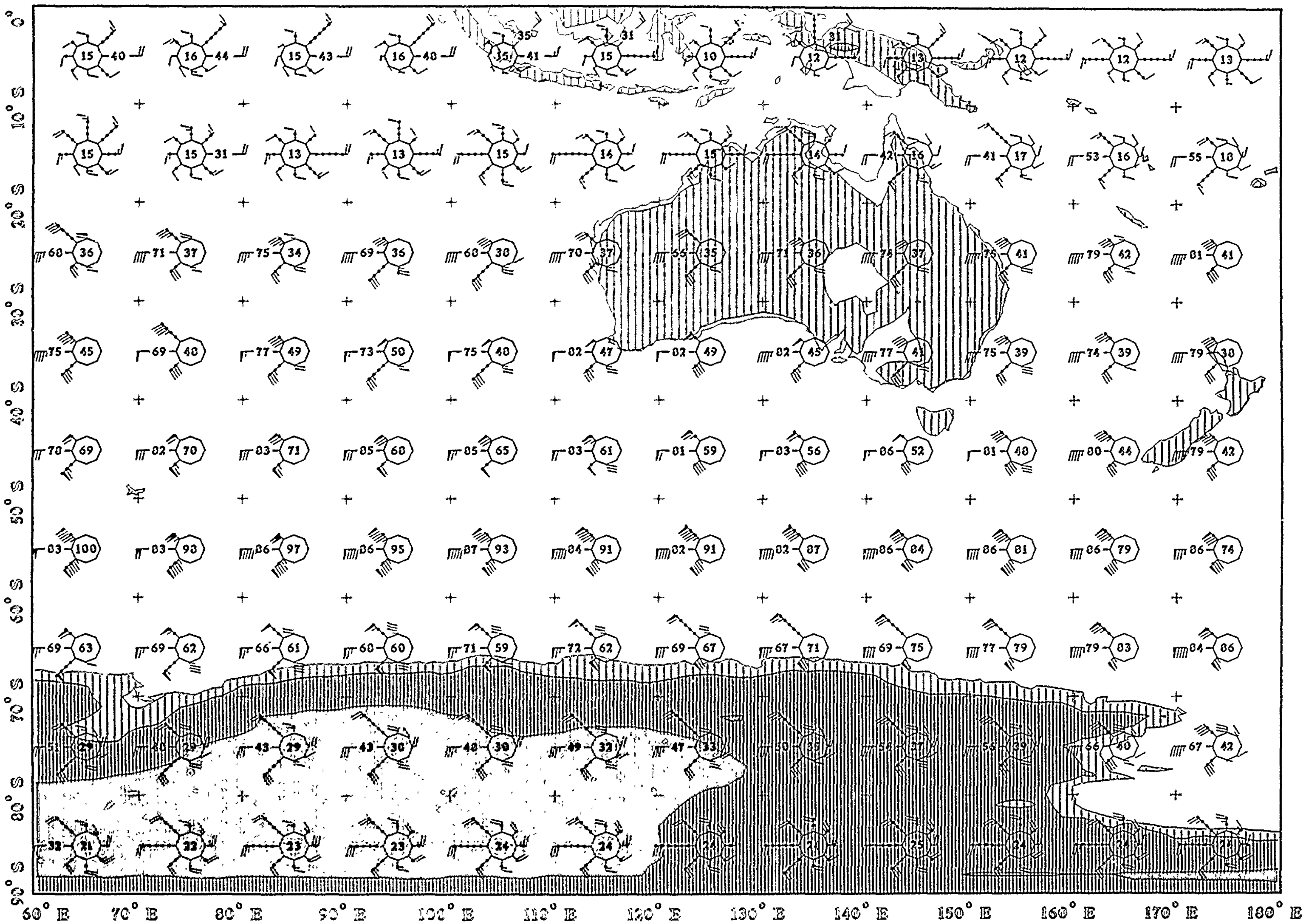
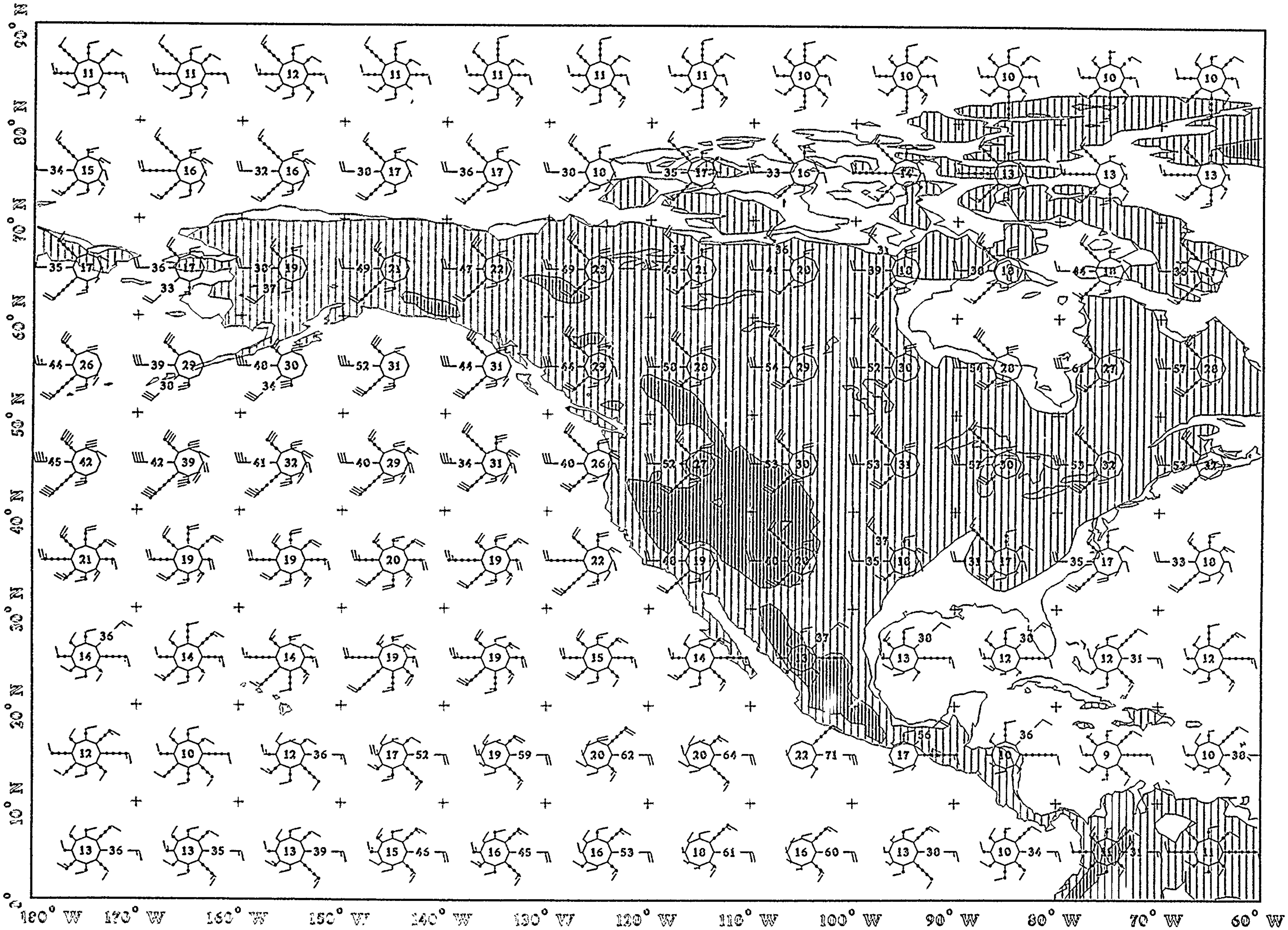


September
100 Mb

60E TO 180E
Wind Roses

Upper Air Climatology
Southern Hemisphere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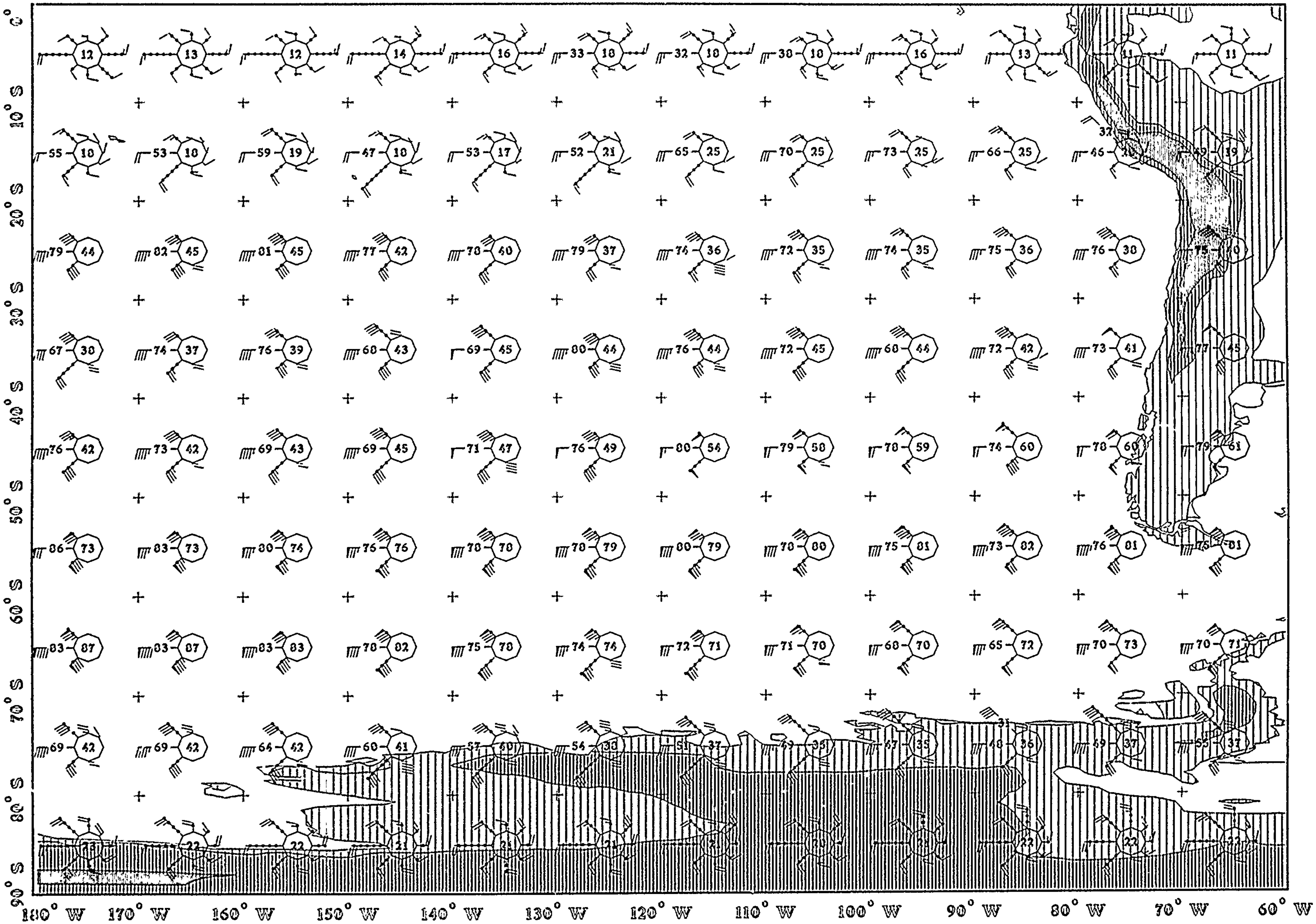


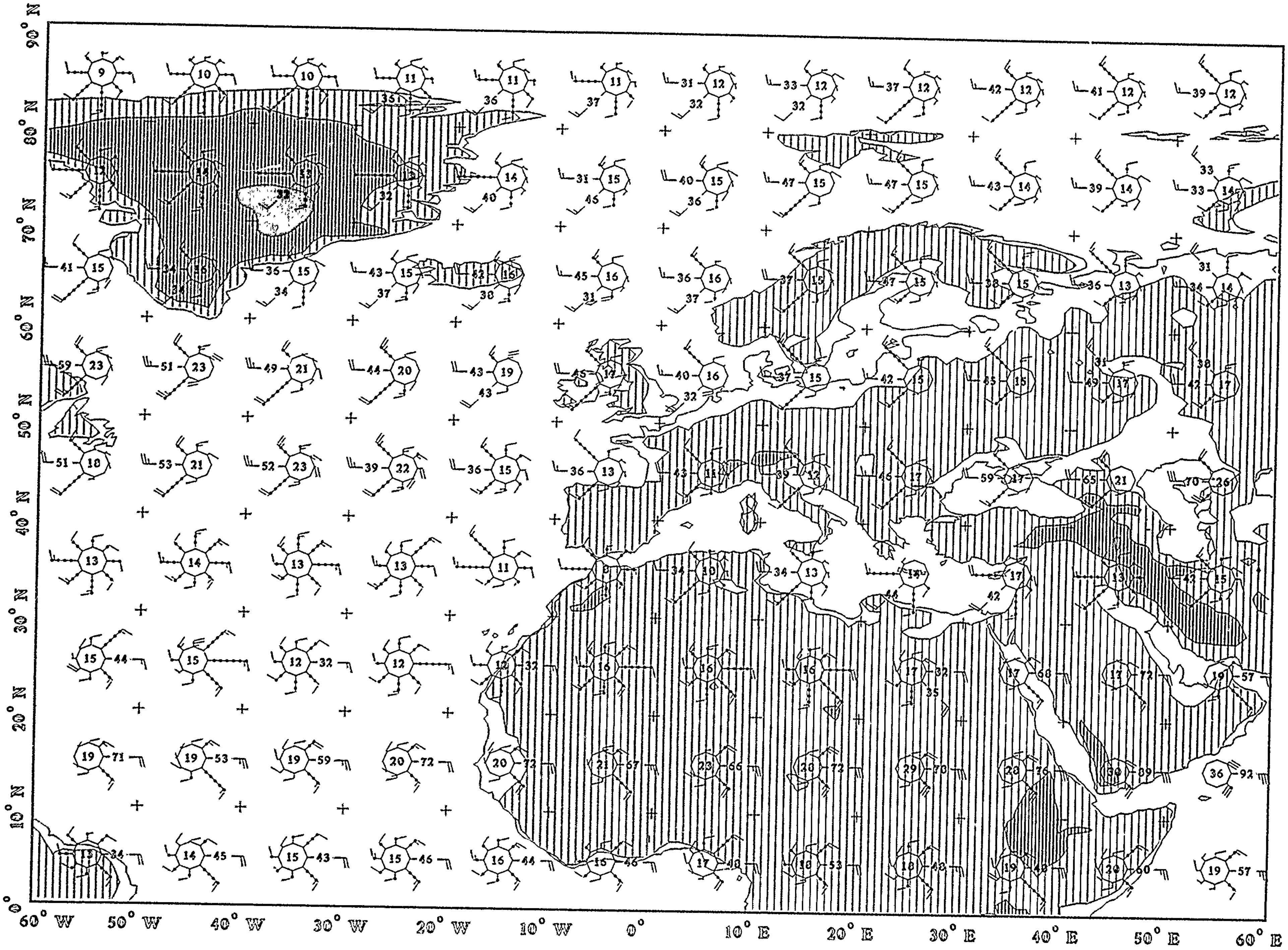
September
100 Mb

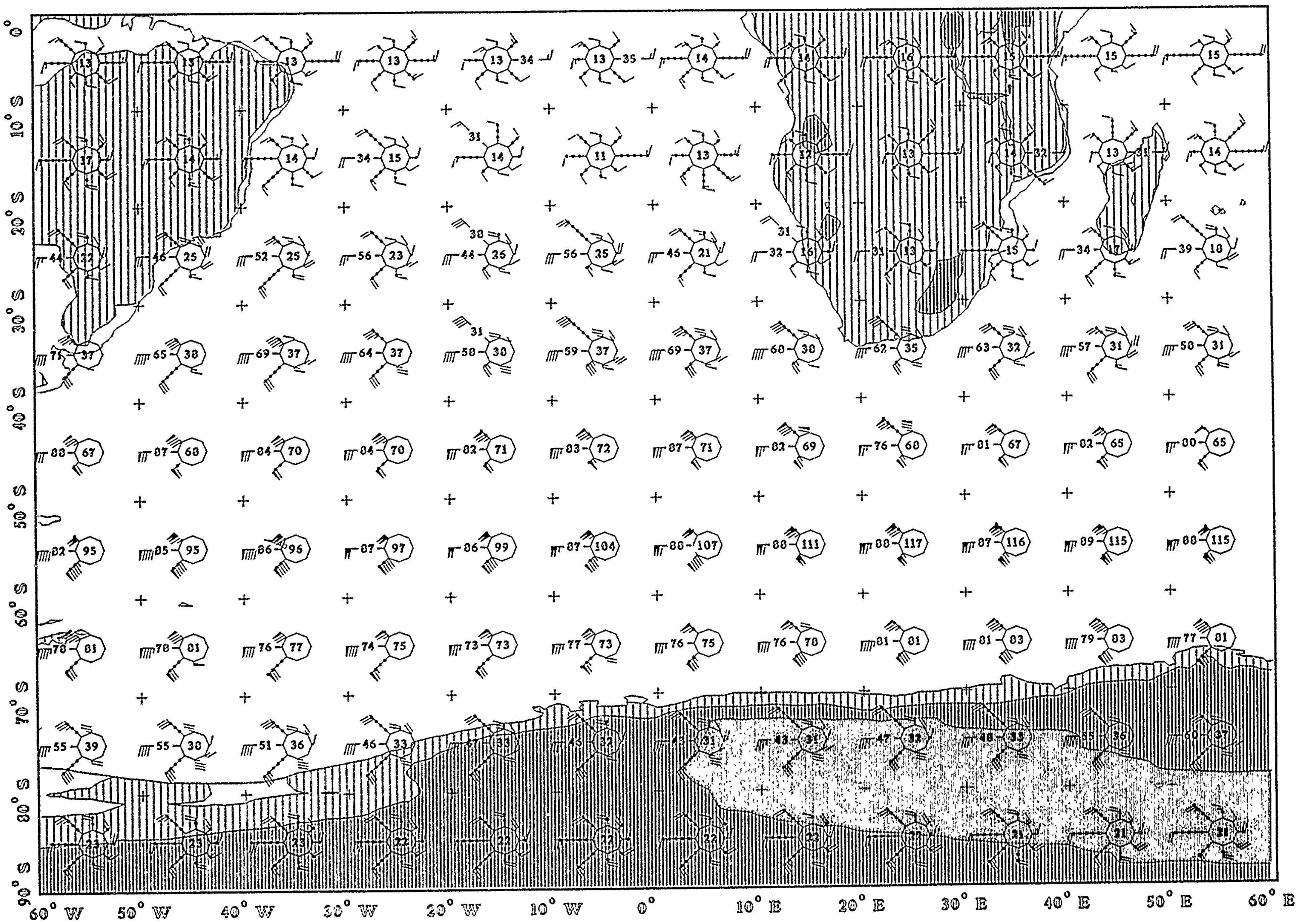
180W TO 60W
Wind Roses

Upper Air Climatology
Southern Hemisphere

September
70 Mb

60W TO 60E
Wind Roses

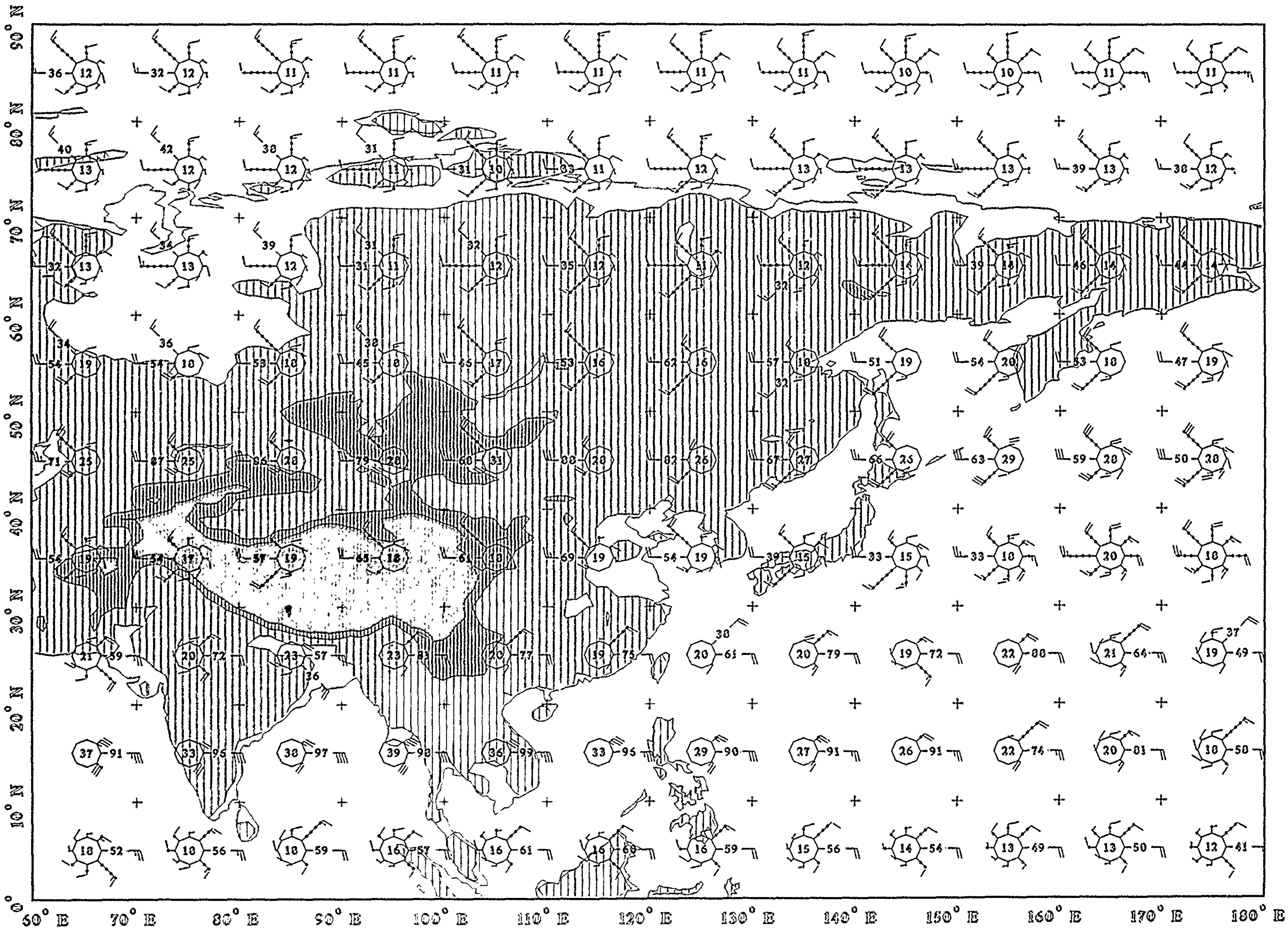




September
70 Mb

60W TO 60E
Wind Roses

Upper Air Climatology
Southern Hemisphere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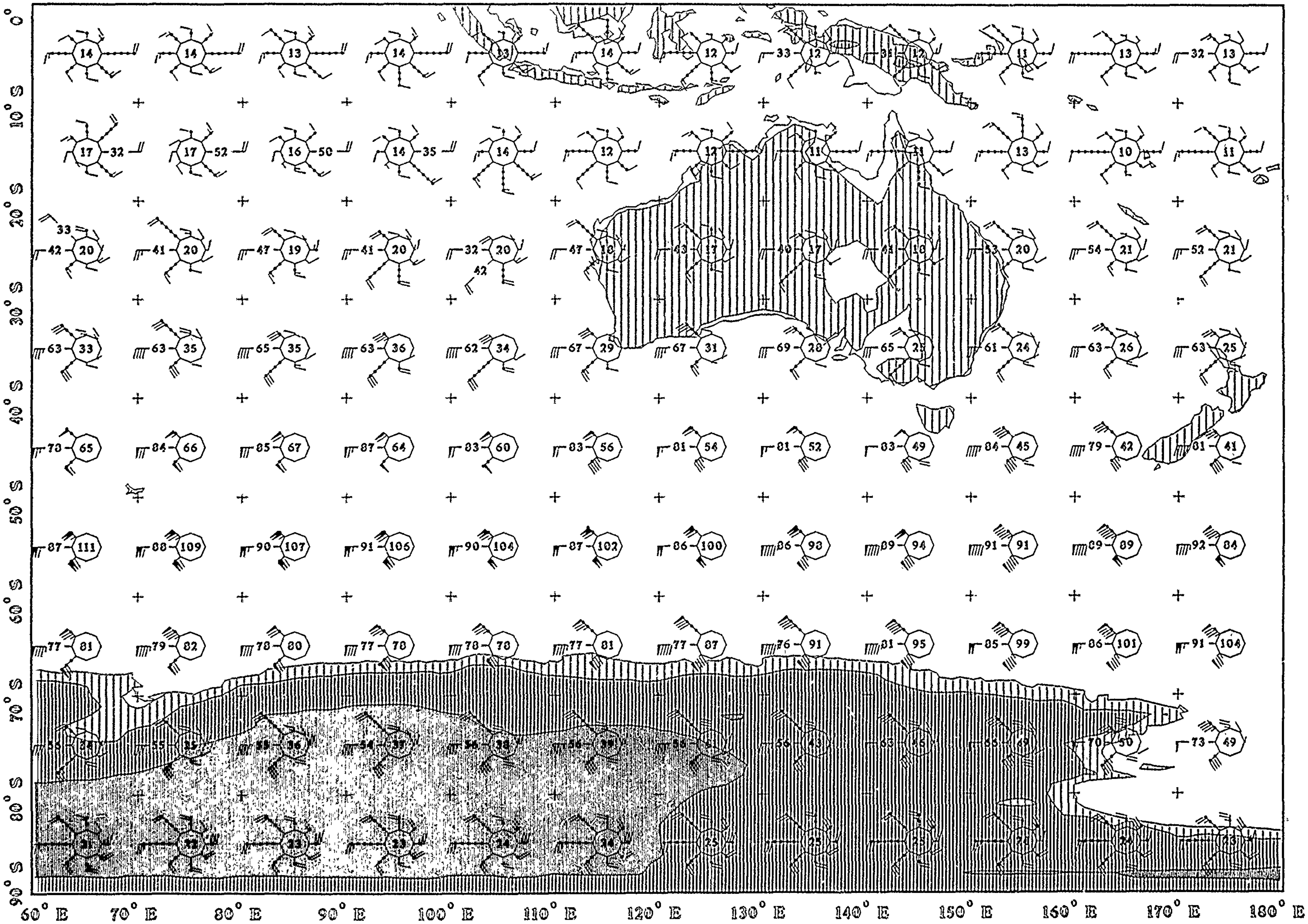


September
70 Mb

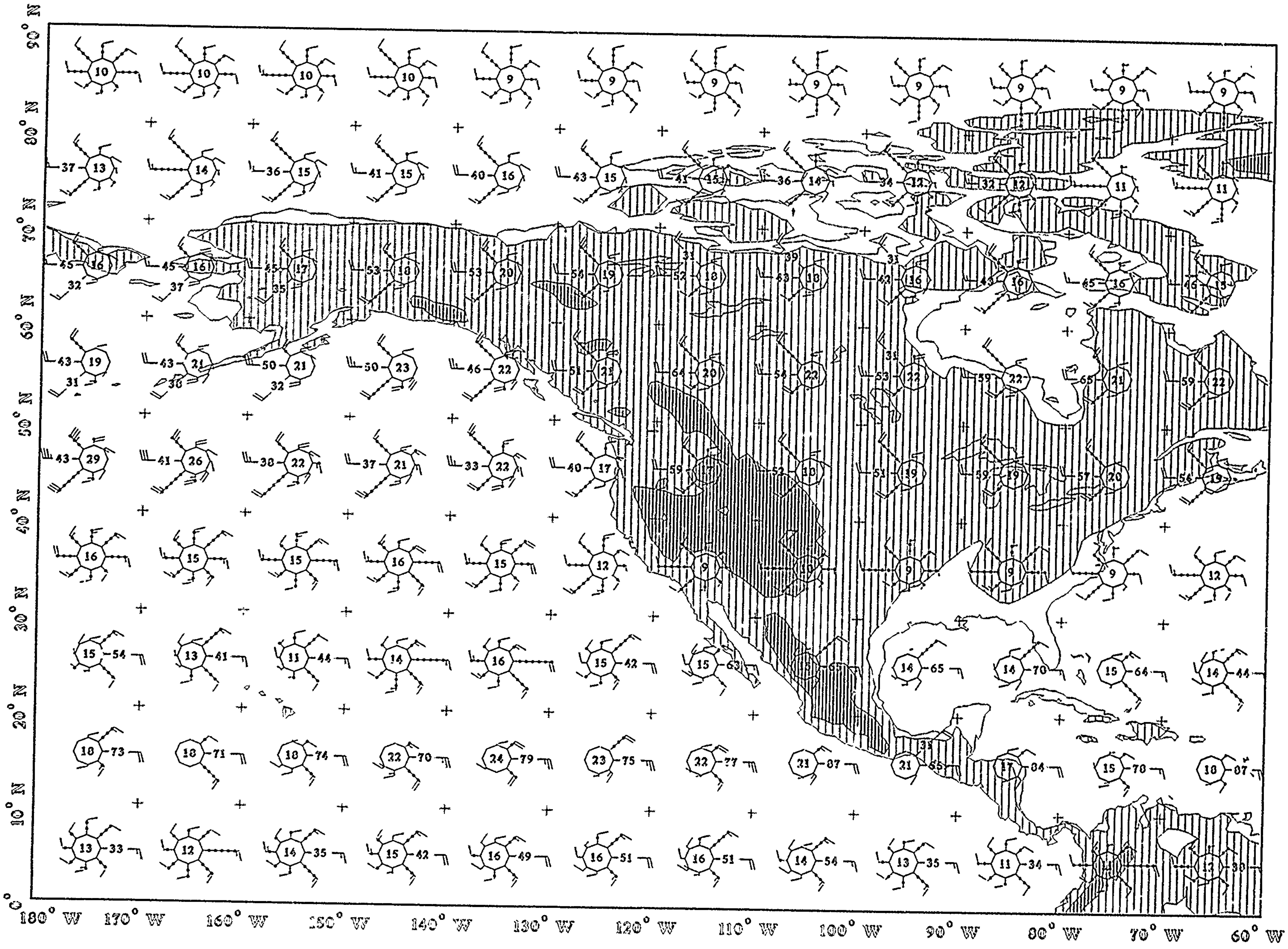
60E TO 180E
Wind Roses

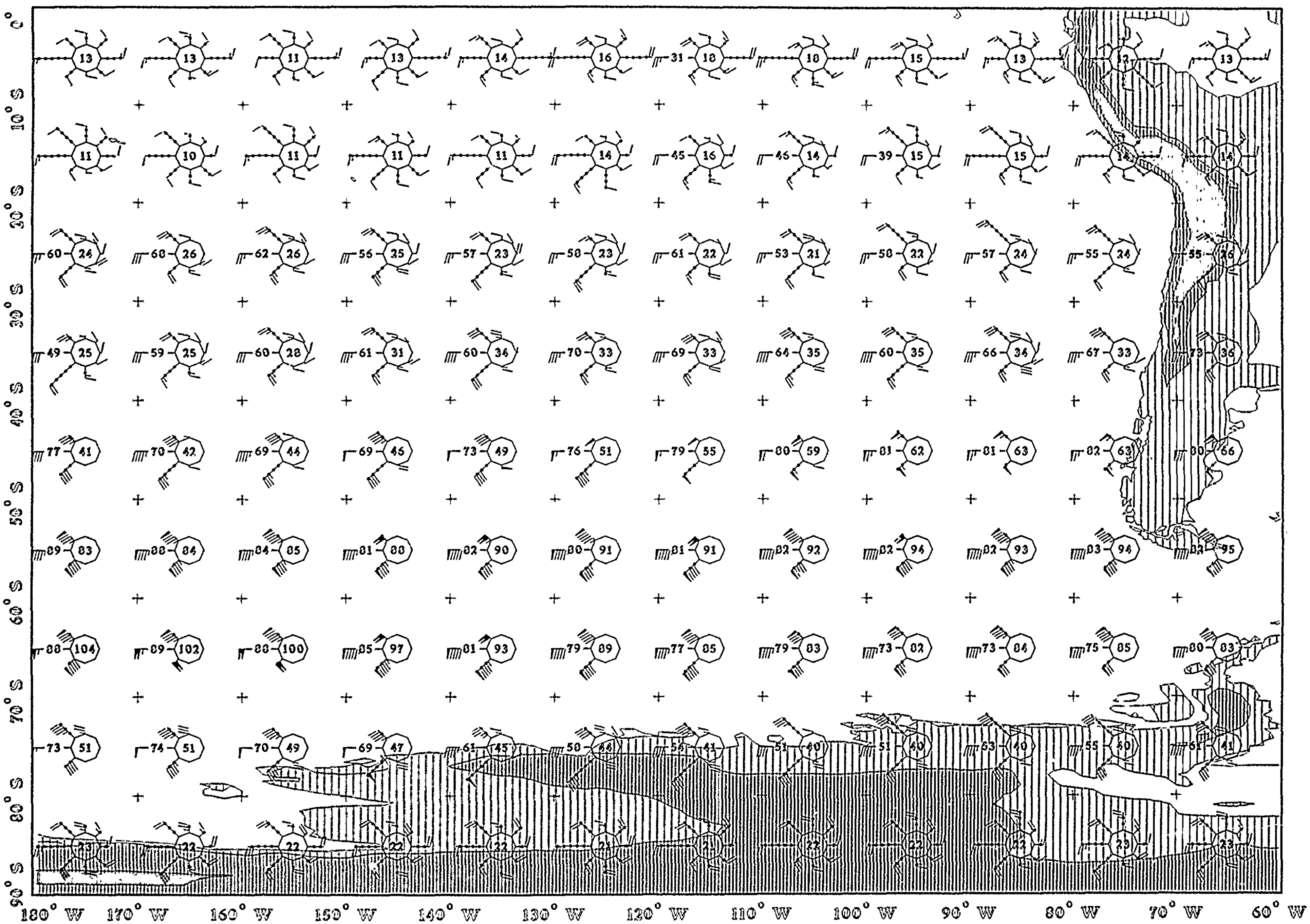
Upper Air Climatology
Southern Hemisphere

September
70 Mb

180W TO 60W
Wind Roses

Upper Air Climatology
Northern Hemisphere

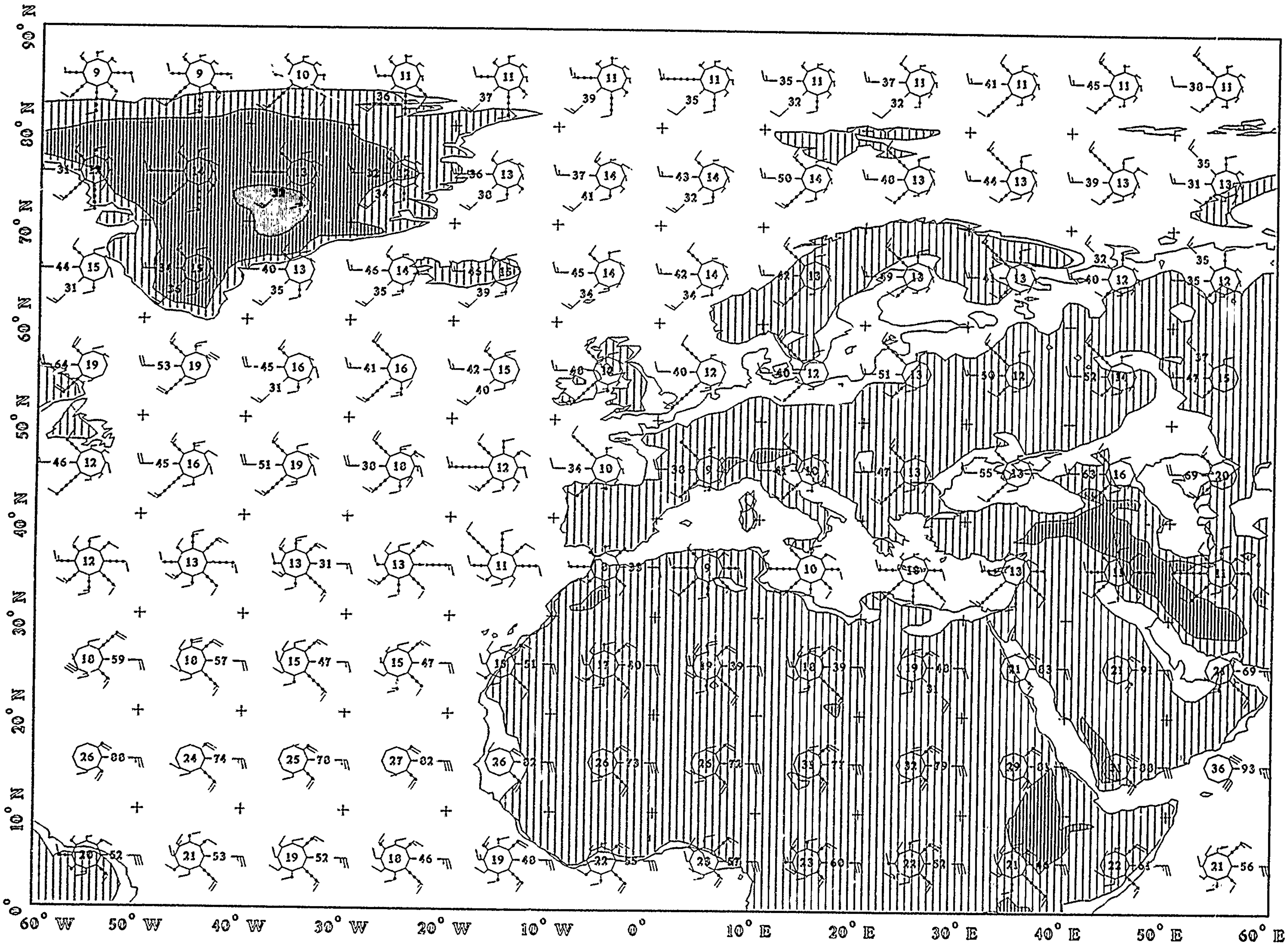




September
70 Mb

180W TO 60W
Wind Roses

Upper Air Climatology
Southern Hemisphere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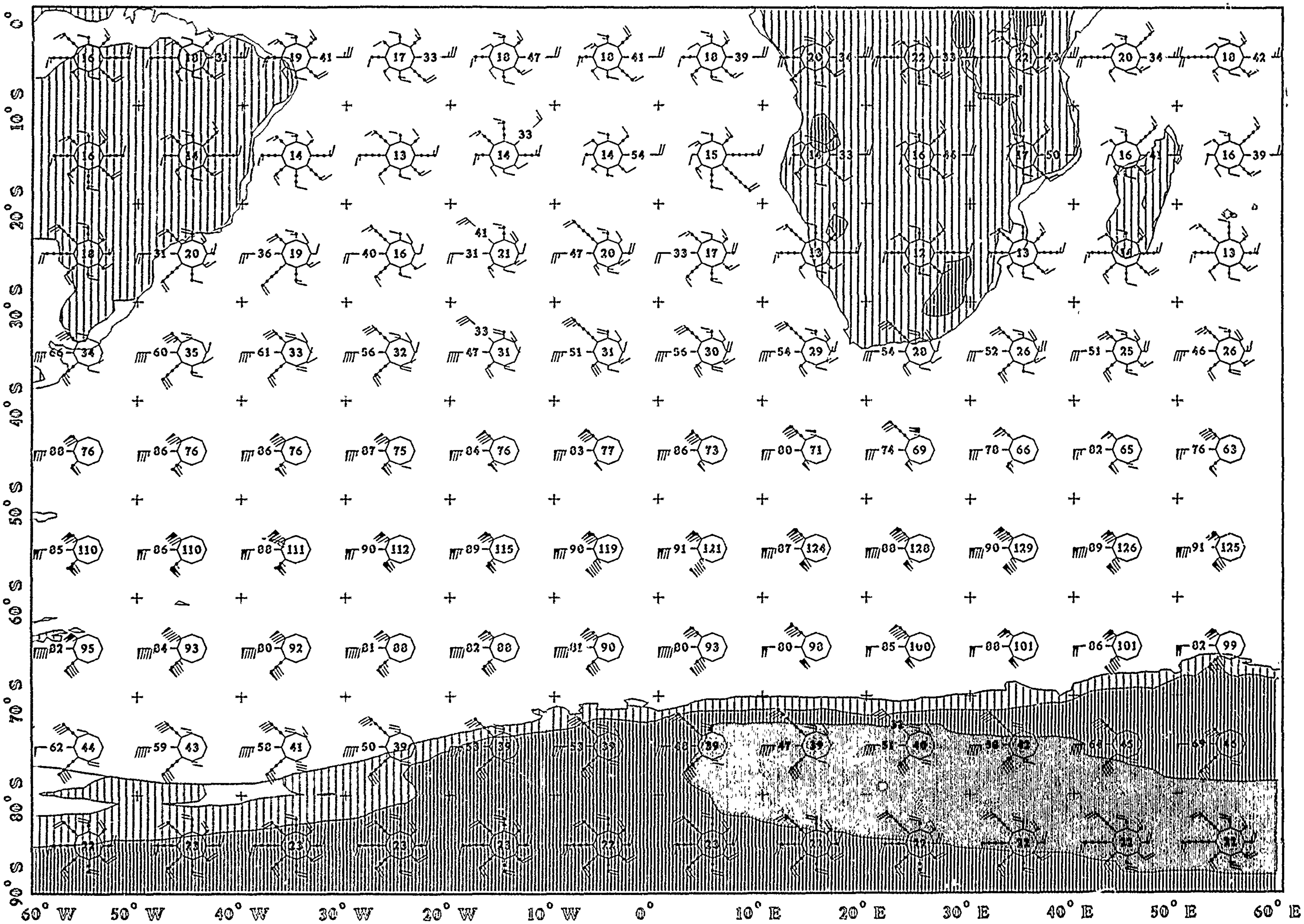
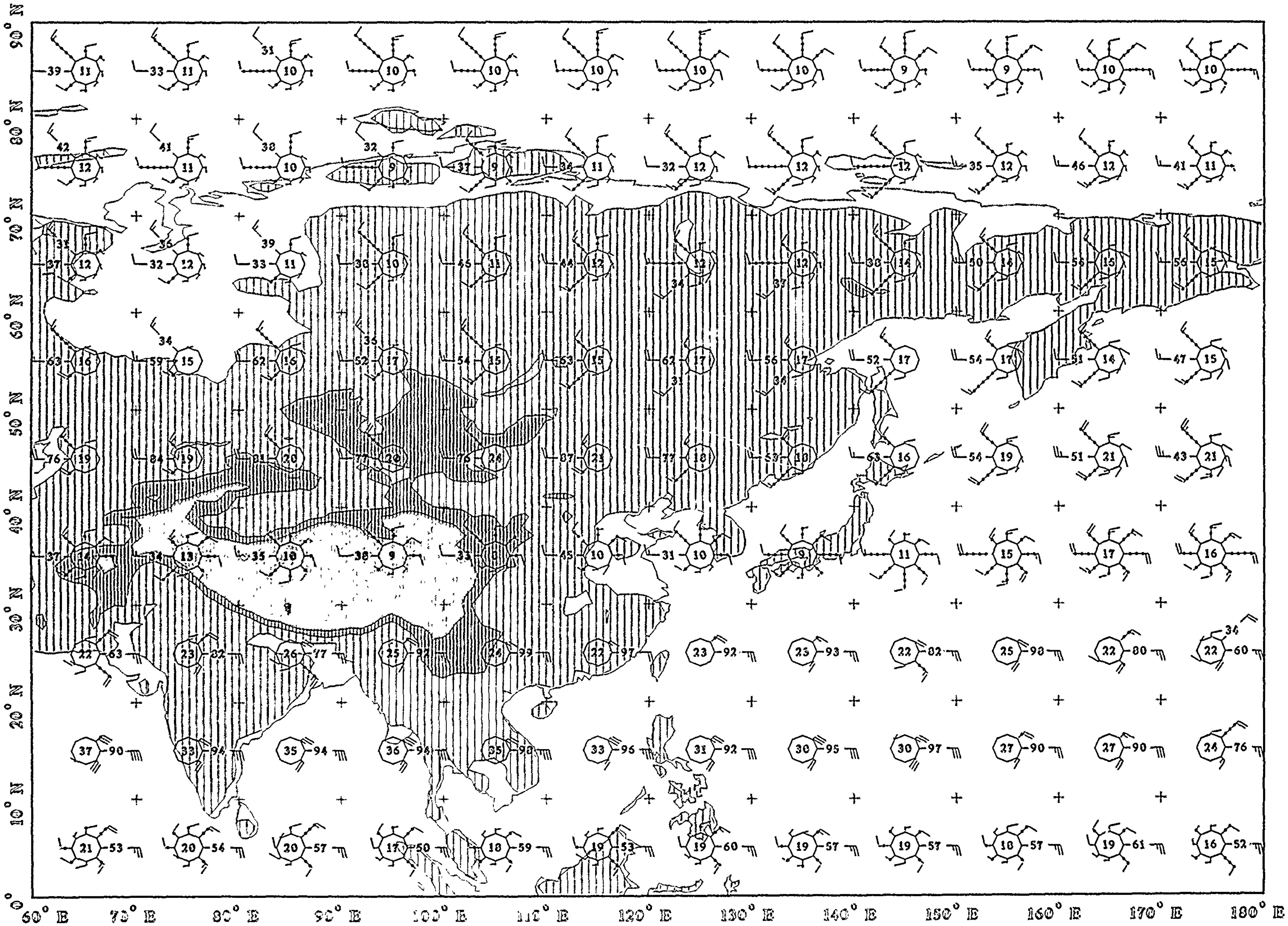


September
50 Mb

60W TO 60E
Wind Roses

Upper Air Climatology
Southern Hemisphere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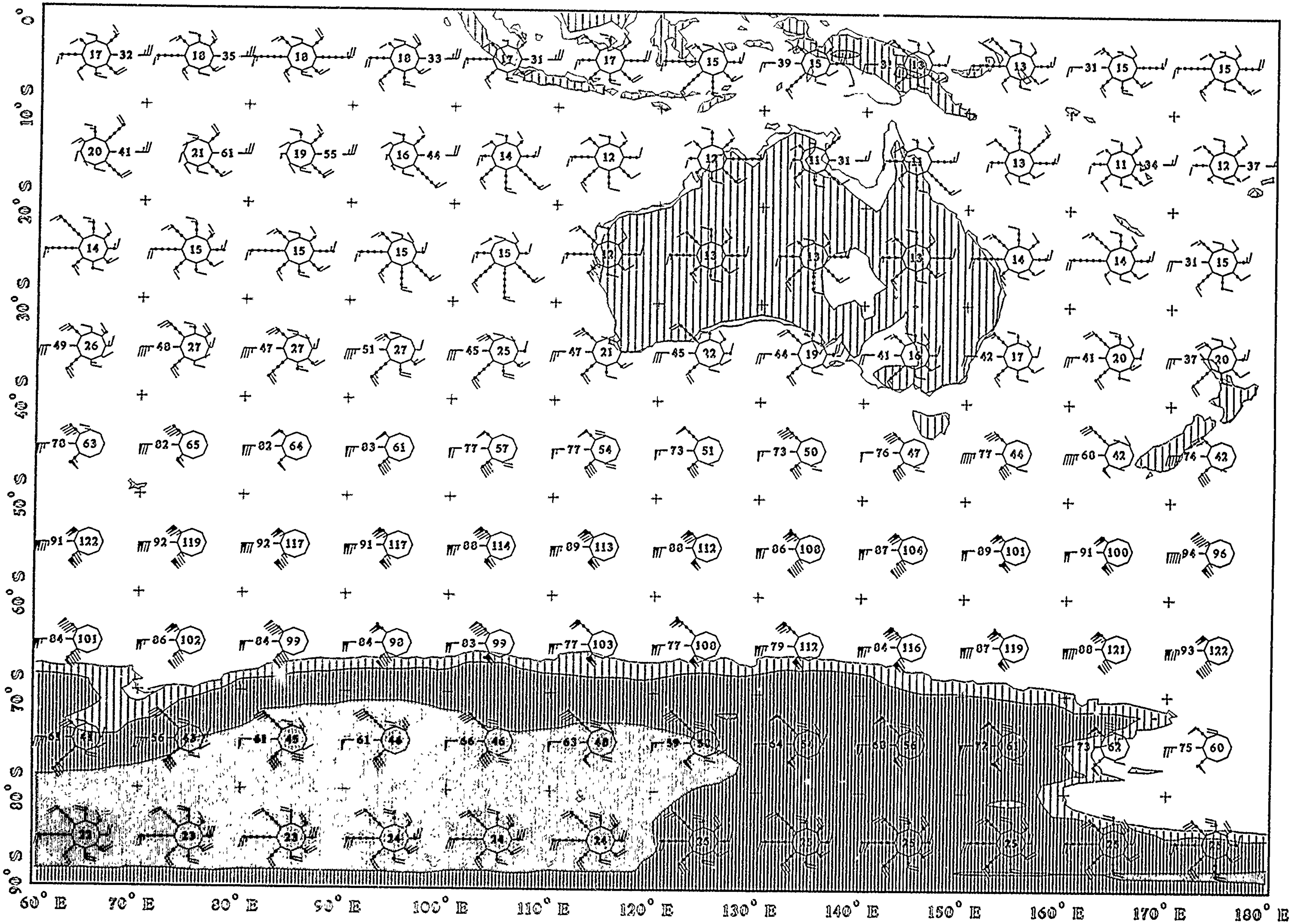
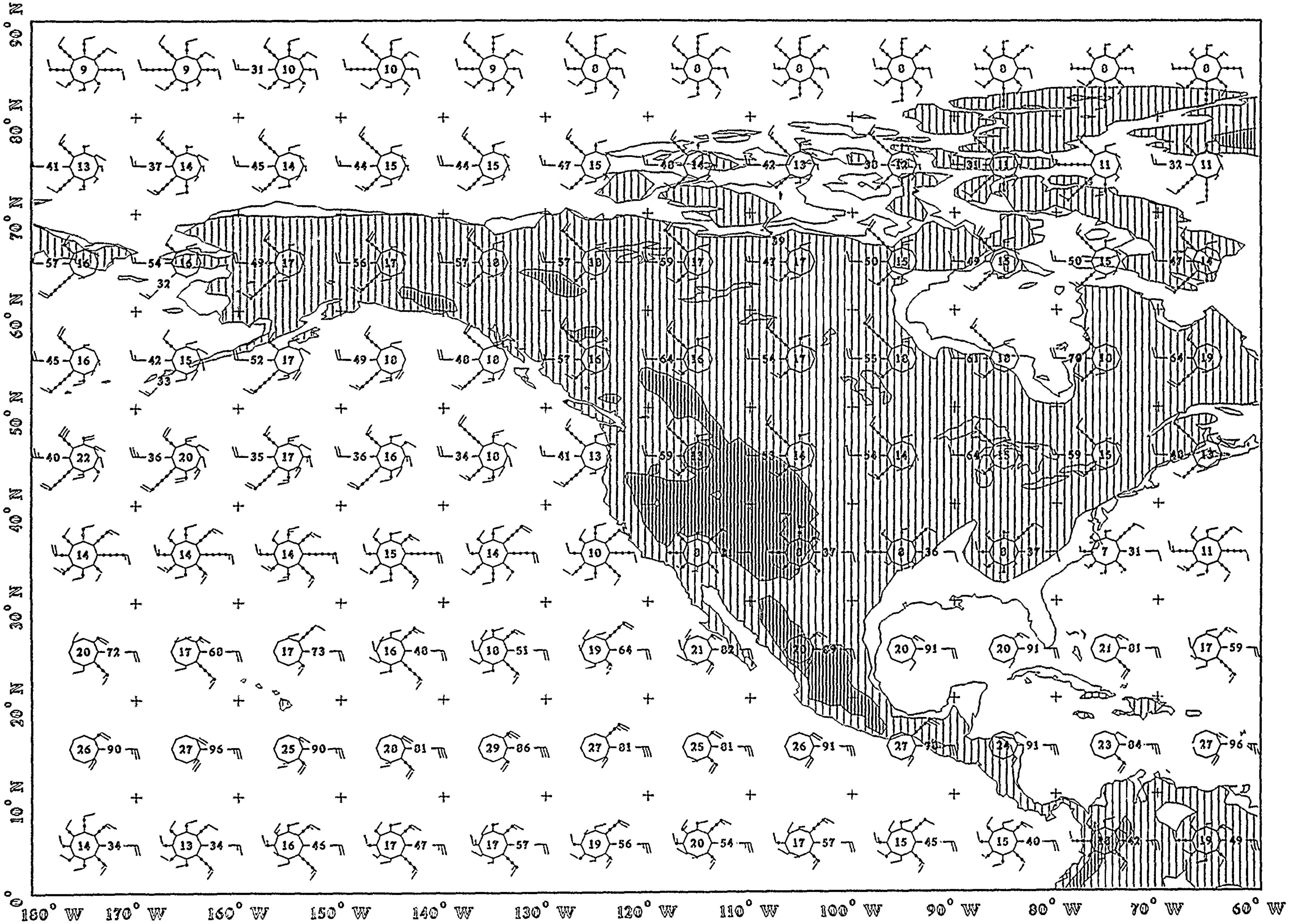


September
50 Mb

60E TO 180E
Wind Roses

Upper Air Climatology
Southern Hemisphere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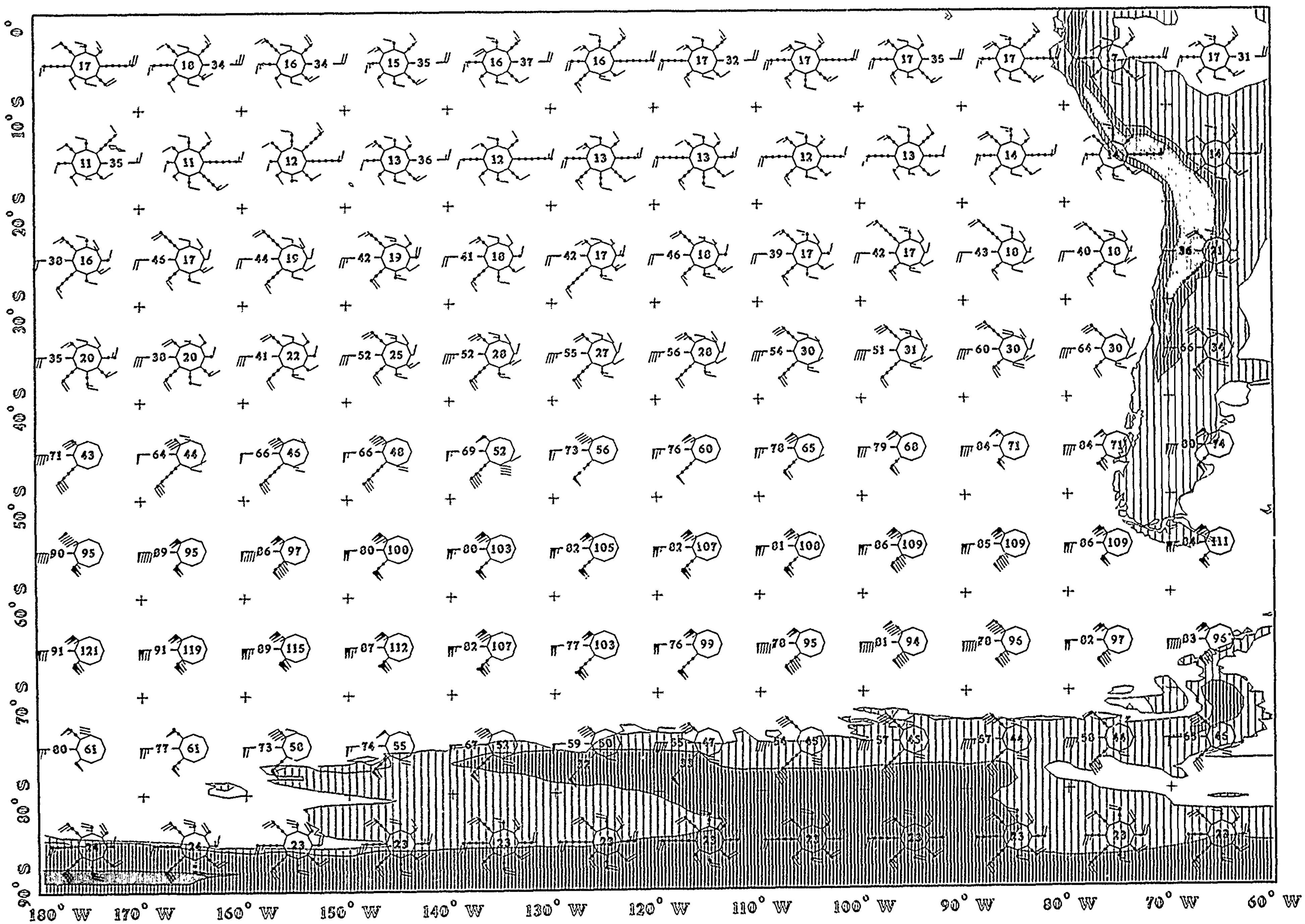
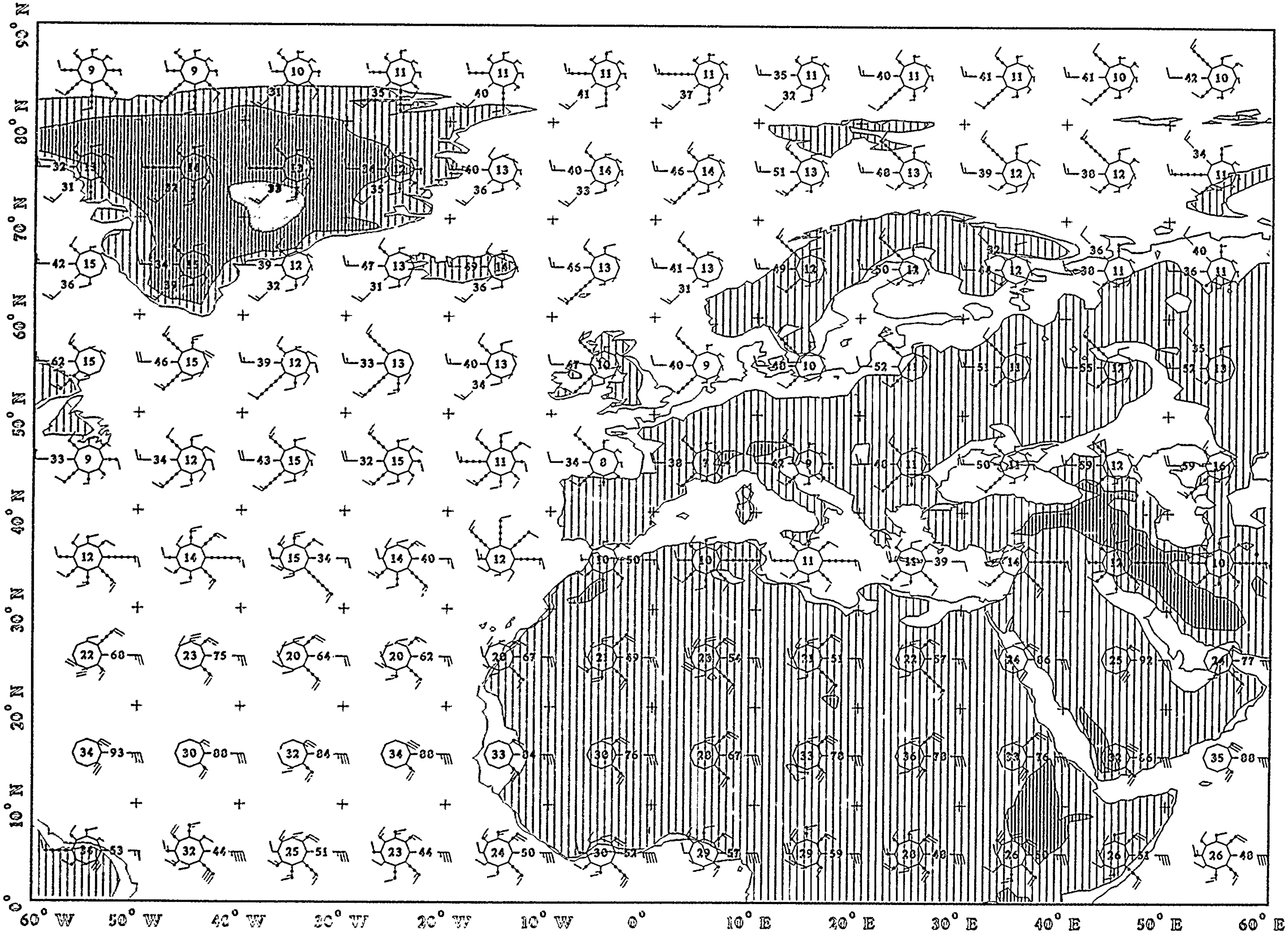


September
50 Mb

180W TO 60W
Wind Roses

Upper Air Climatology
Southern Hemisphere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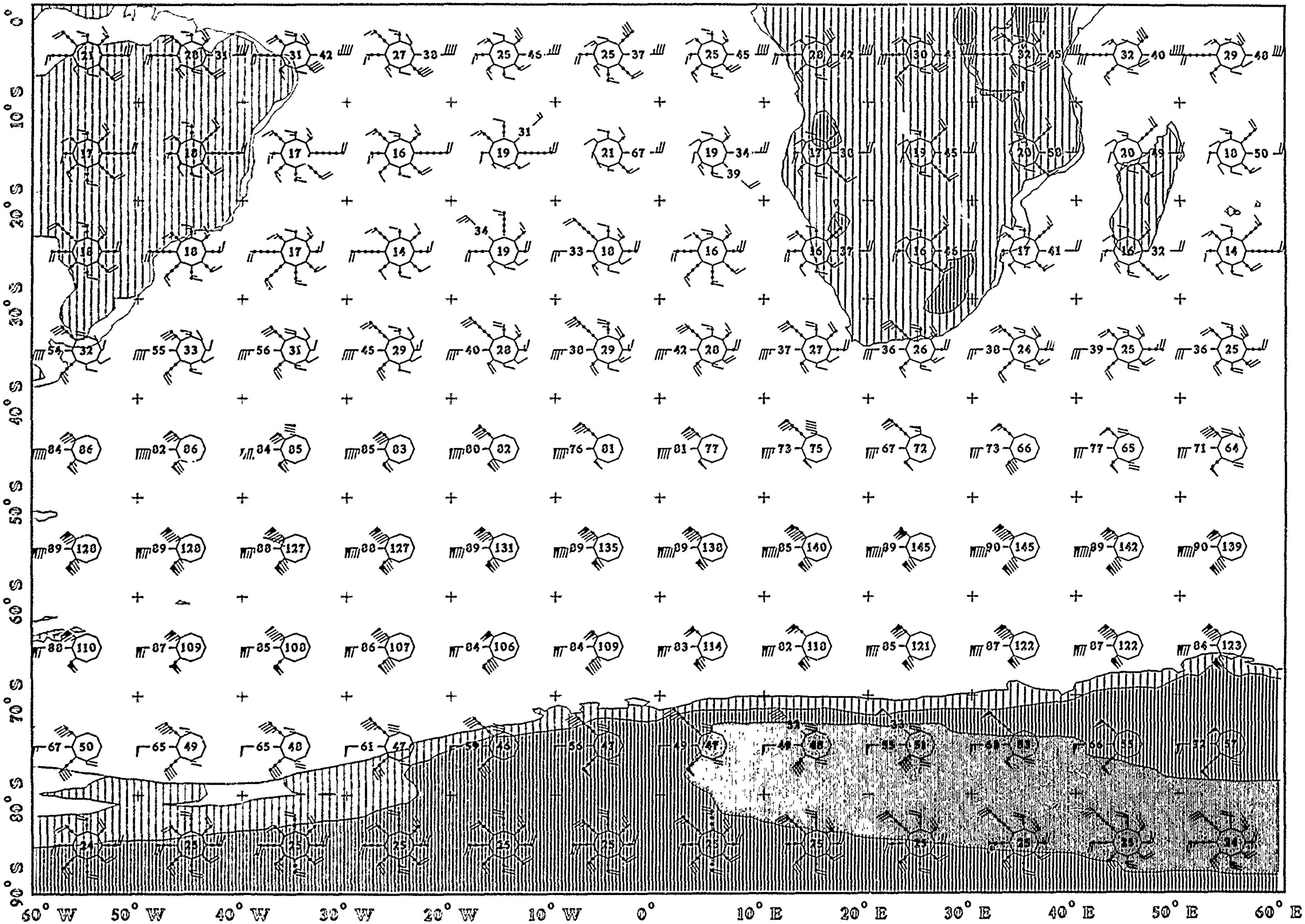
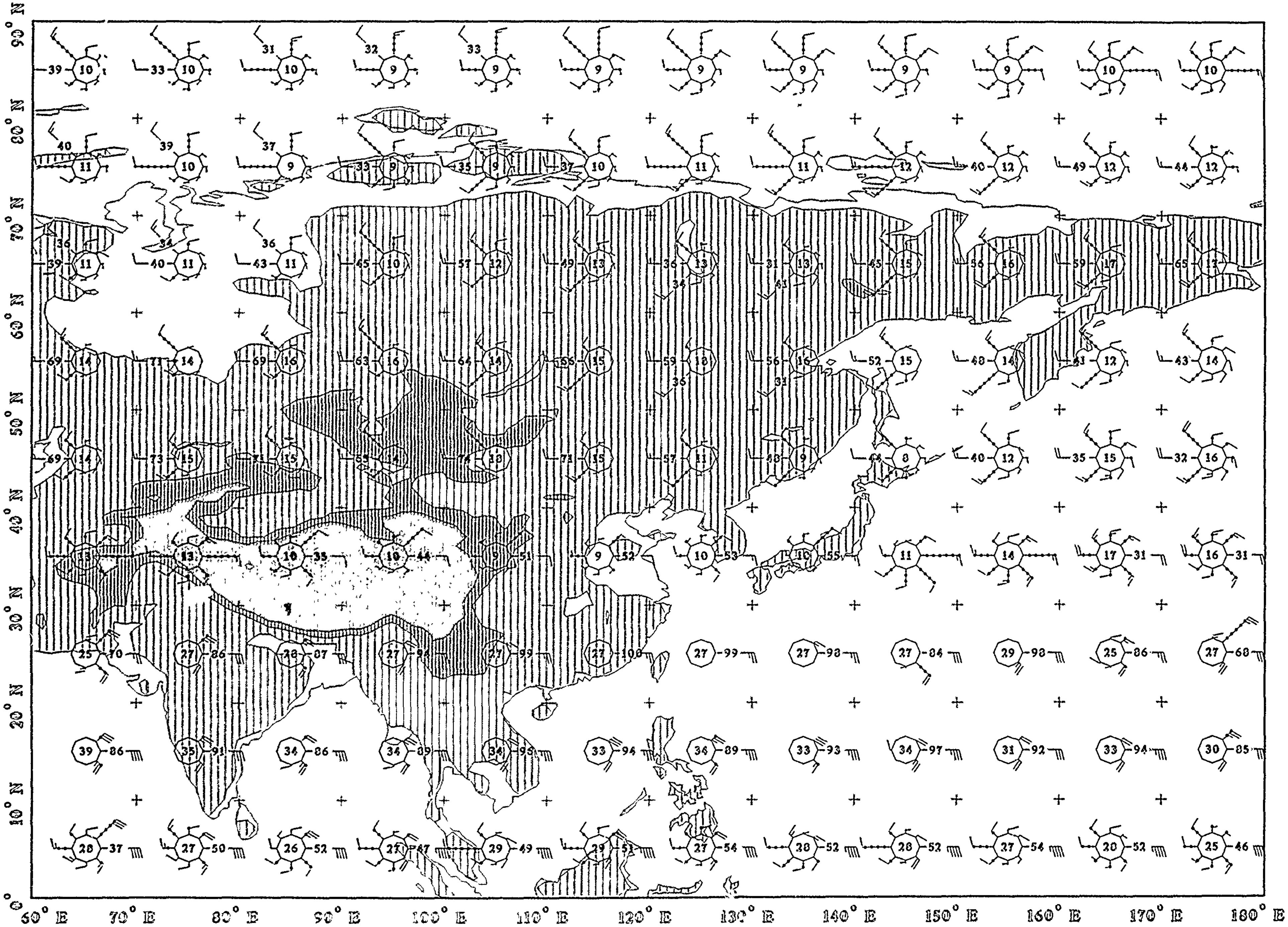


September
30 Mb

60W TO 60E
Wind Roses

Upper Air Climatology
Southern Hemisphere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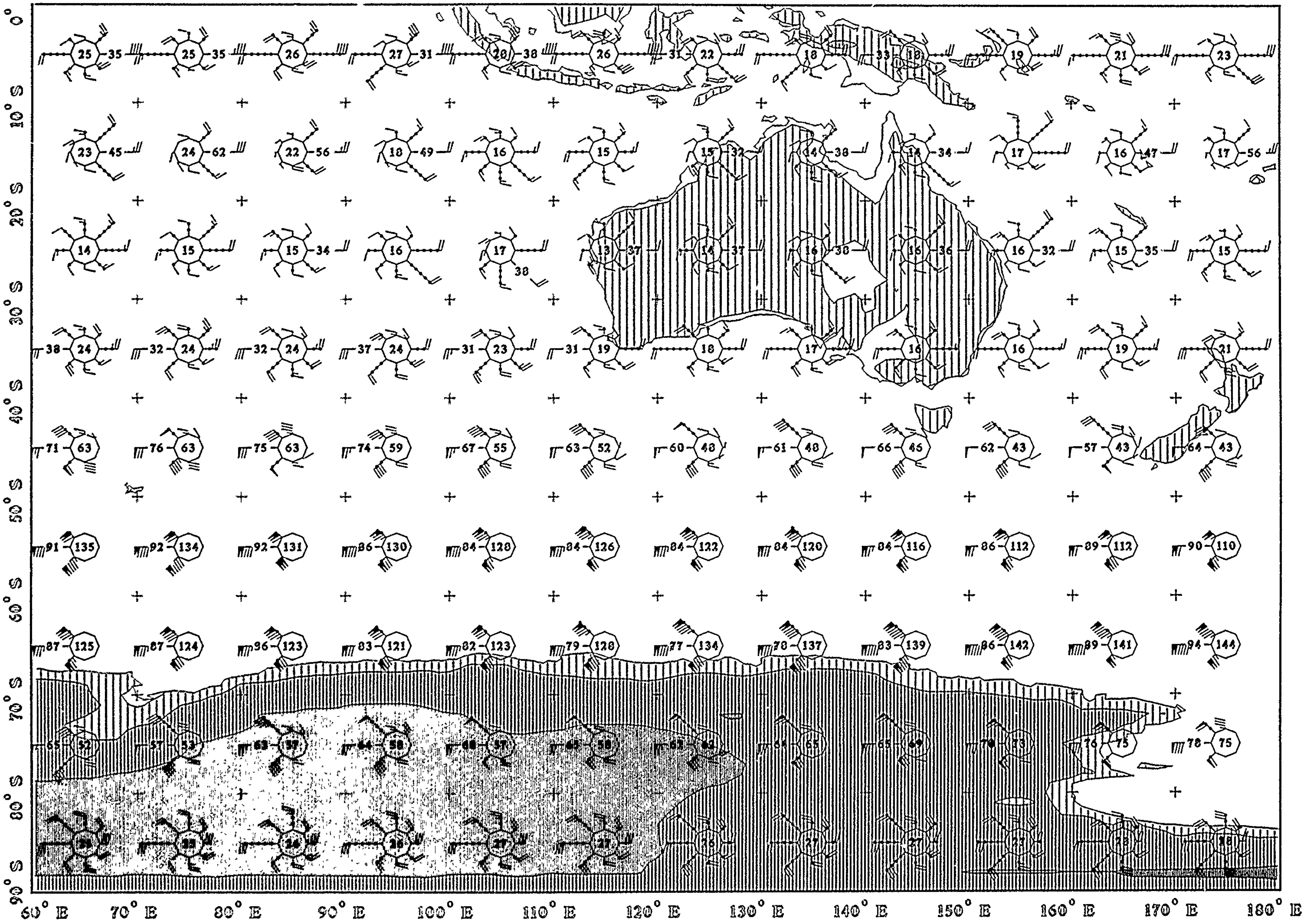
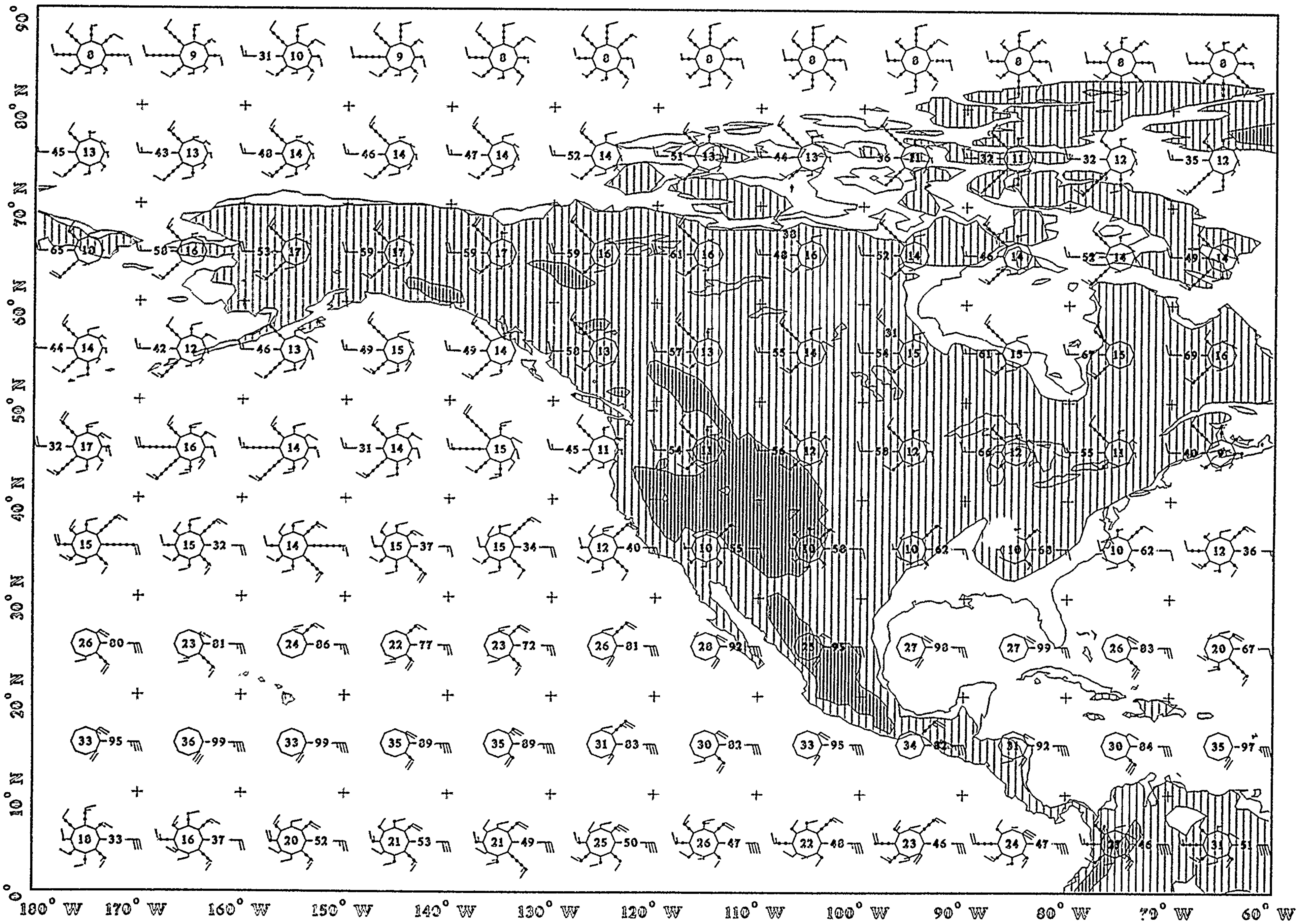


September
30 Mb

60E TO 180E
Wind Roses

Upper Air Climatology
Southern Hemisphere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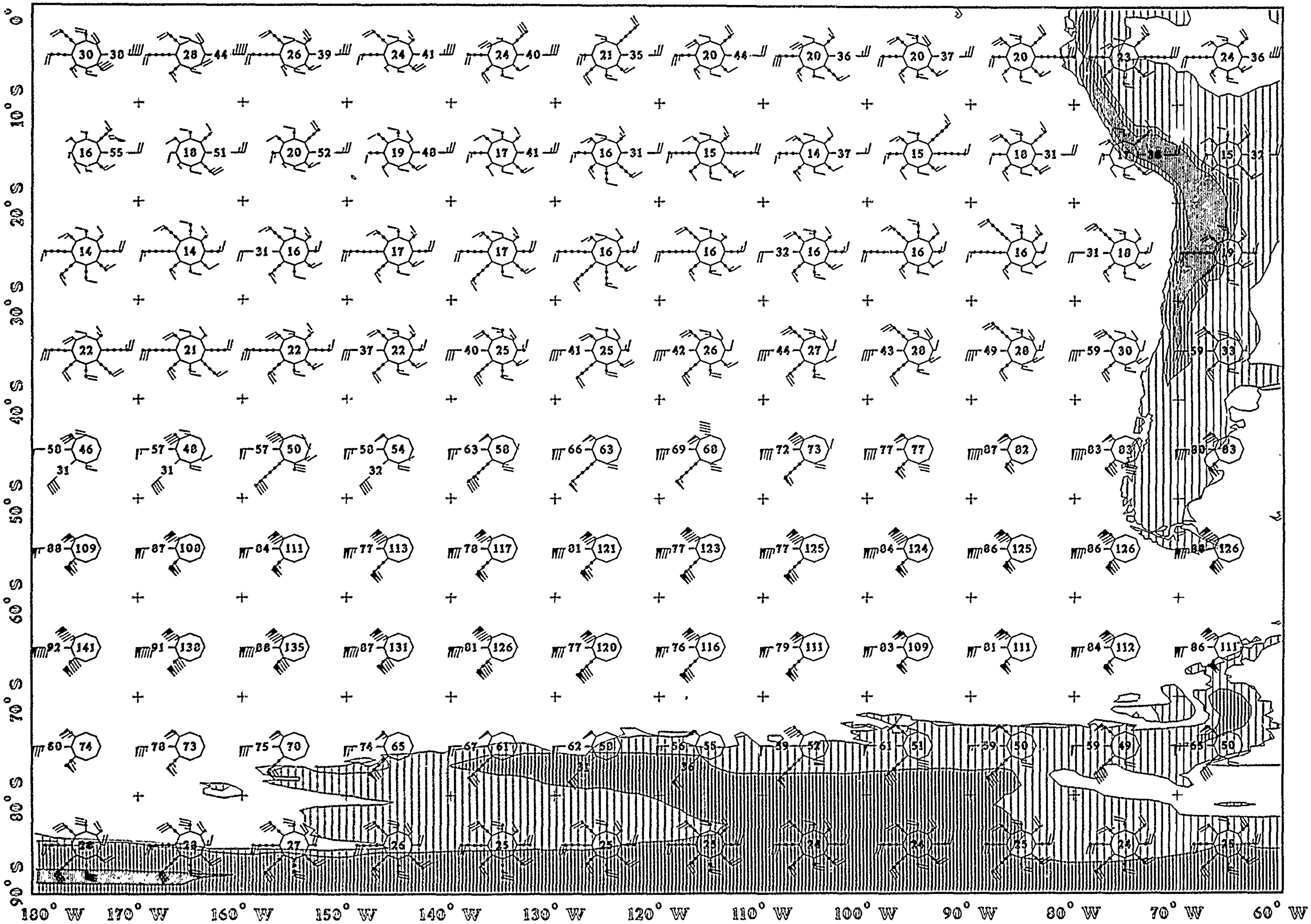


September
30 Mb

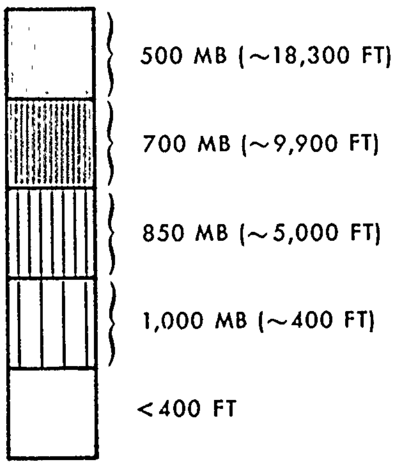
180W TO 60W
Wind Roses

Upper Air Climatology
Southern Hemisphere

JET STREAM
(10 LEVELS, 500 TO 30 MB)

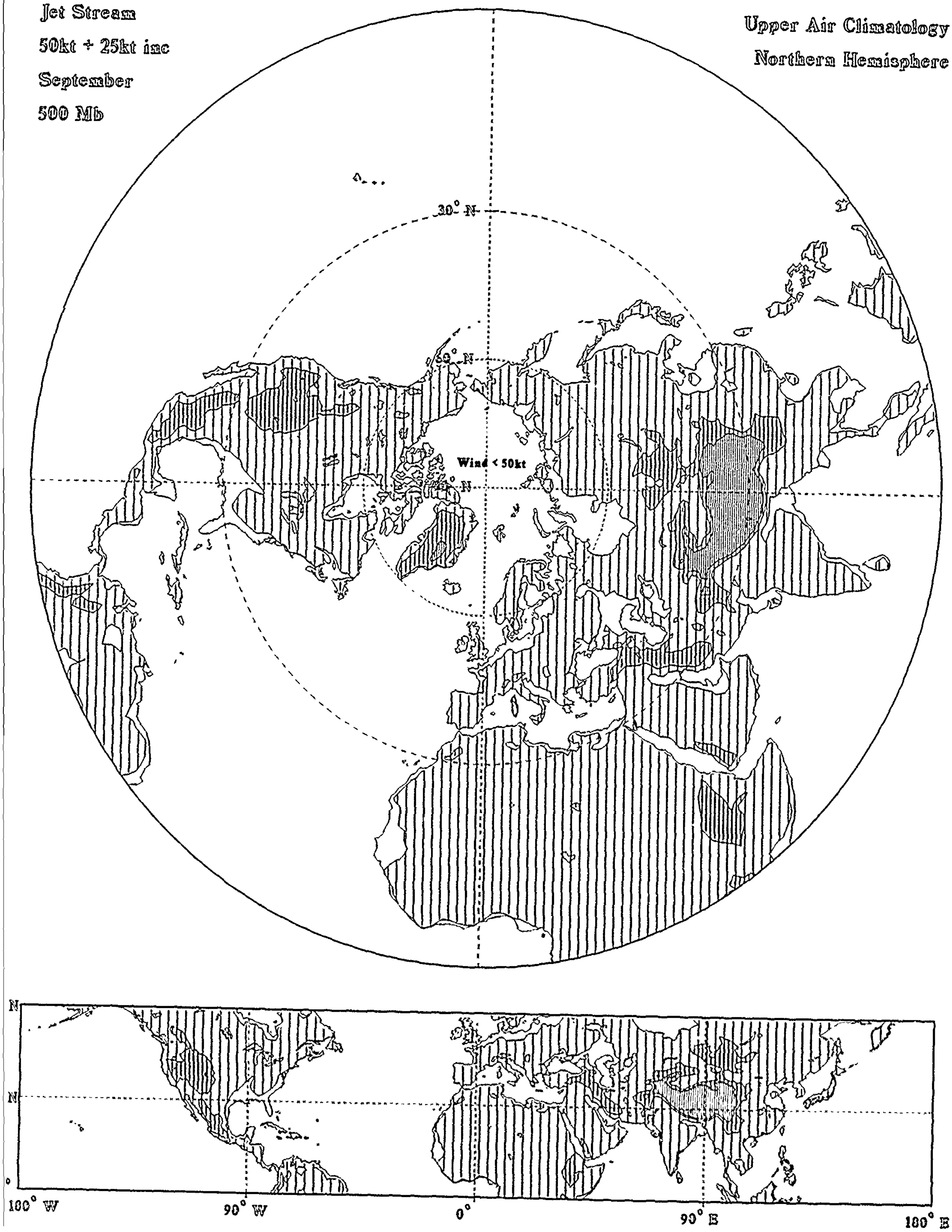
- Contours of mean scalar wind speed in knots
- Minimum mean scalar speed: 50 knots
- Contour interval of mean scalar speed: 25 knots

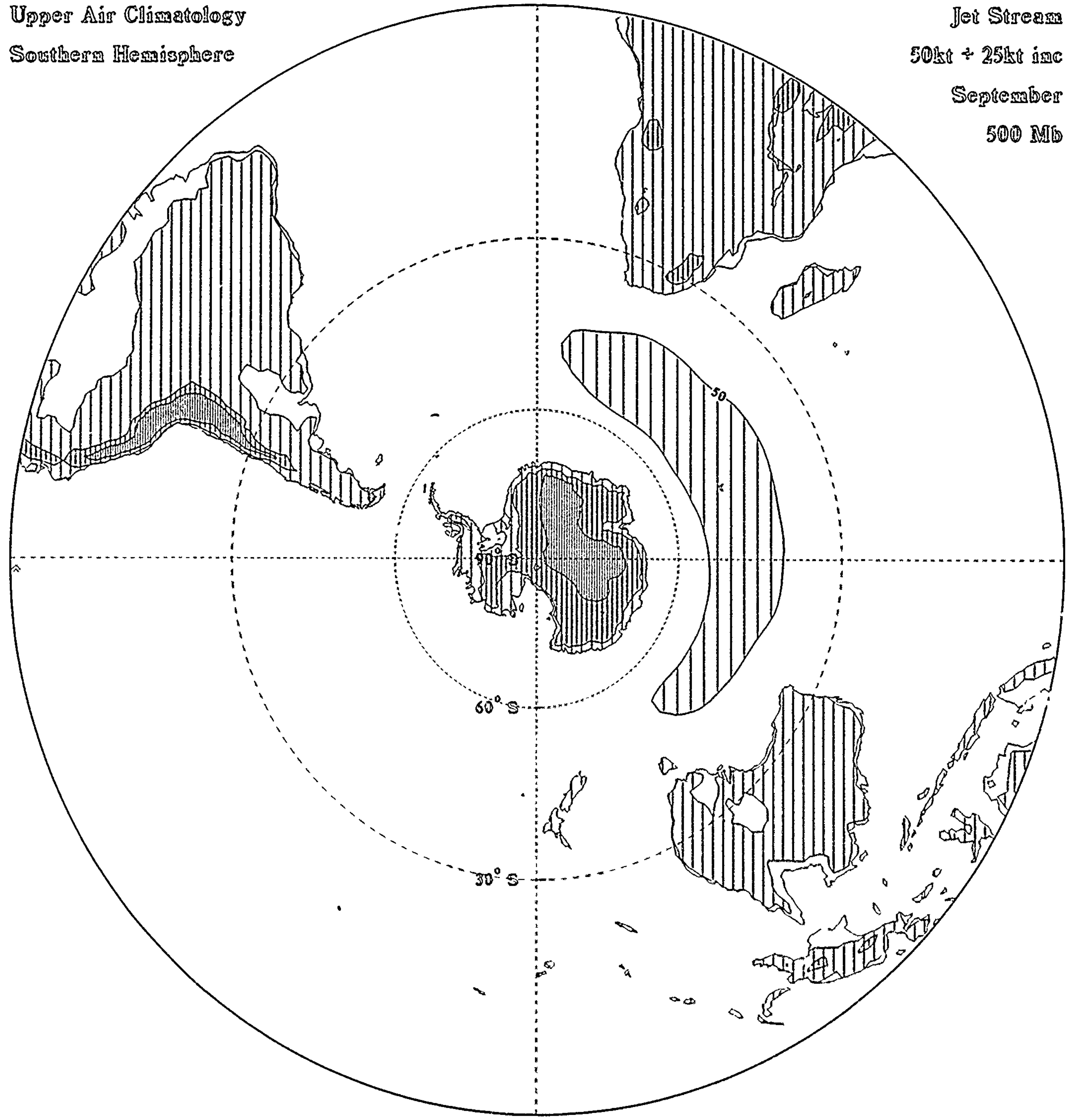
ELEVATION SCALE

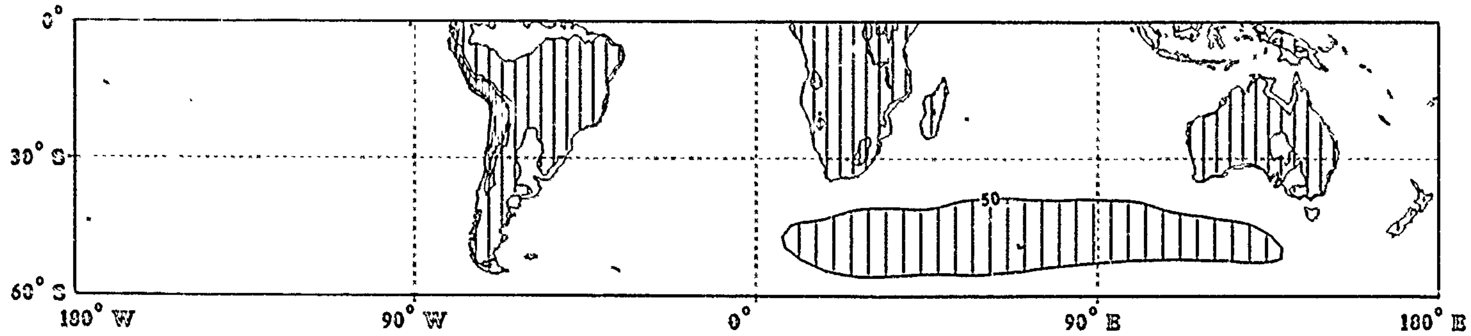


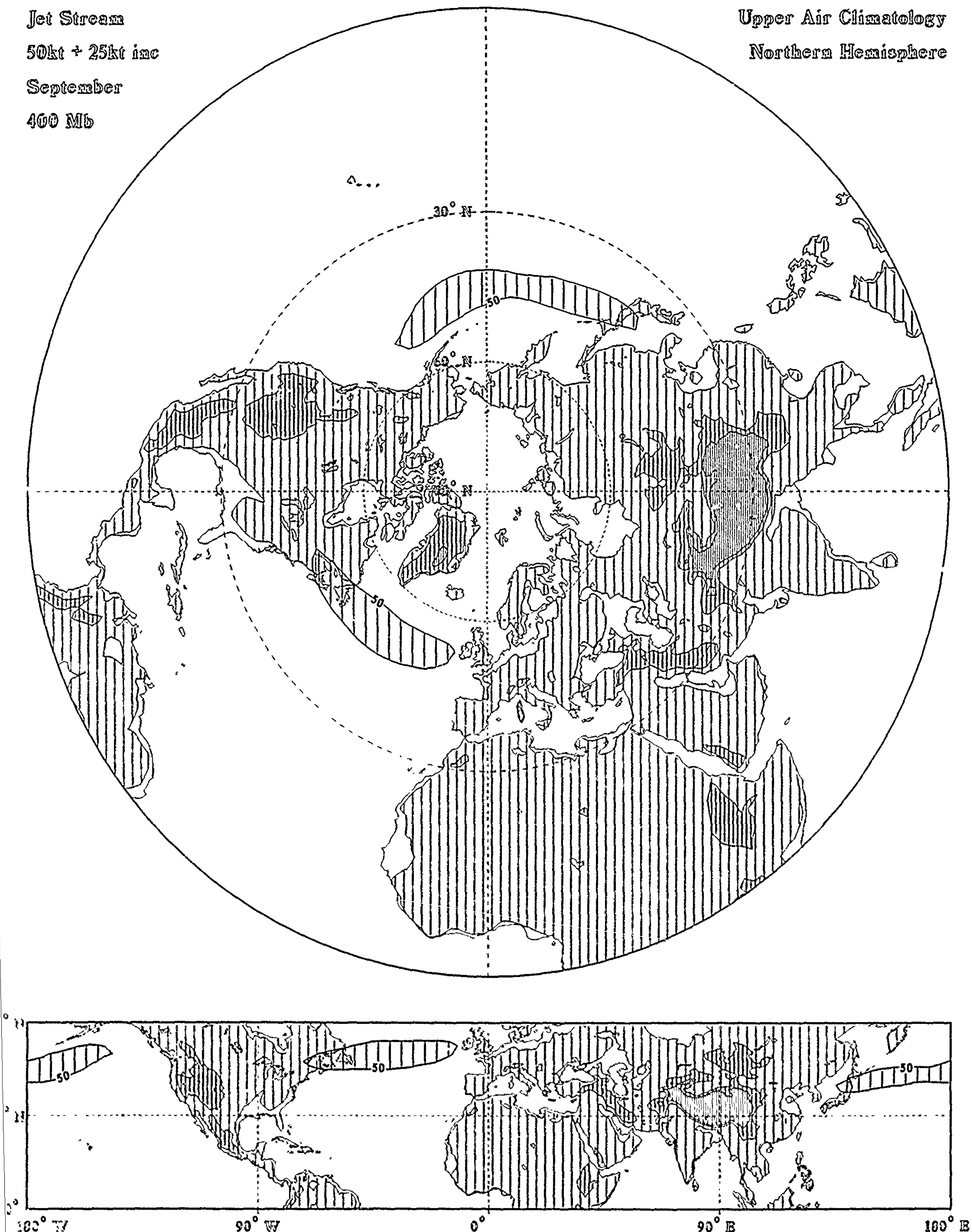
Jet Stream
50kt + 25kt inc
September
500 Mb

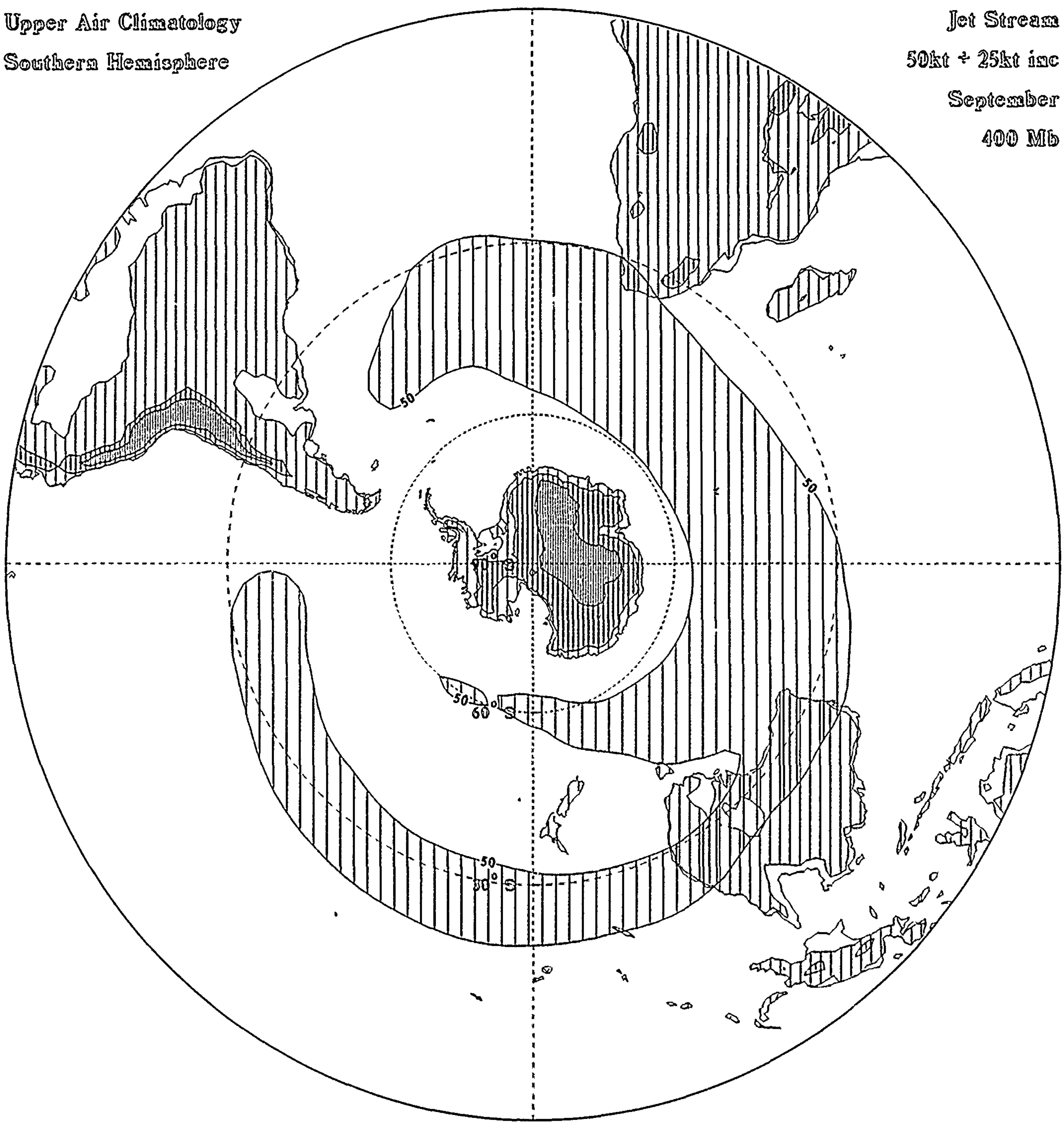
Upper Air Climatology
Northern Hemisphere

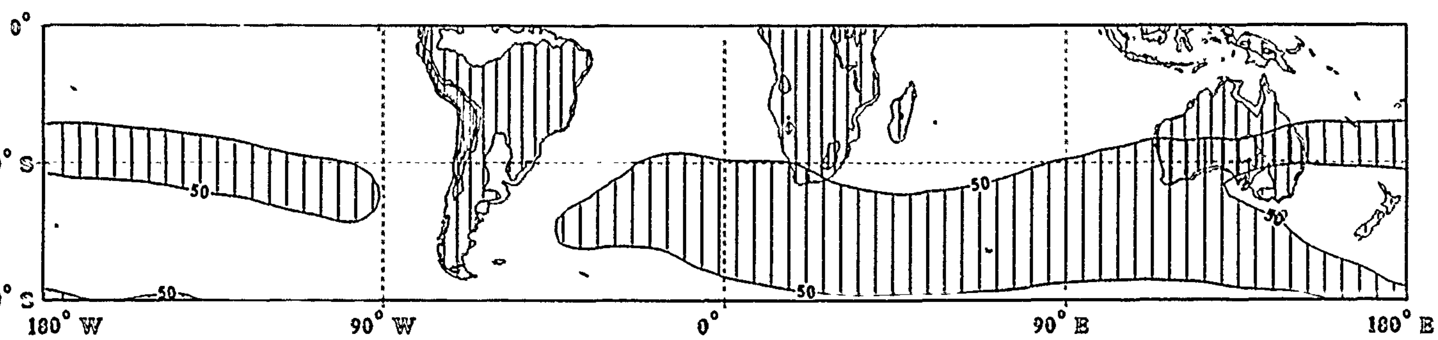



Upper Air Climatology
Southern Hemisphere
Jet Stream
50kt + 25kt inc
September
500 Mb
50
60° S
30° S


0°
30° S
60° S
180° W
90° W
0°
90° E
180° E
50


Jet Stream
50kt + 25kt inc
September
400 Mb
Upper Air Climatology
Northern Hemisphere
30° N
60° N
N
50
50
50
50
50
50
180° W
90° W
0°
90° E
180° E


Upper Air Climatology
Southern Hemisphere
Jet Stream
50kt + 25kt inc
September
400 Mb
50
50
50
60° S
50
30° S


0°
30° S
60° S
50
50
50
50
50
180° W
90° W
0°
90° E
180° E

Jet Stream

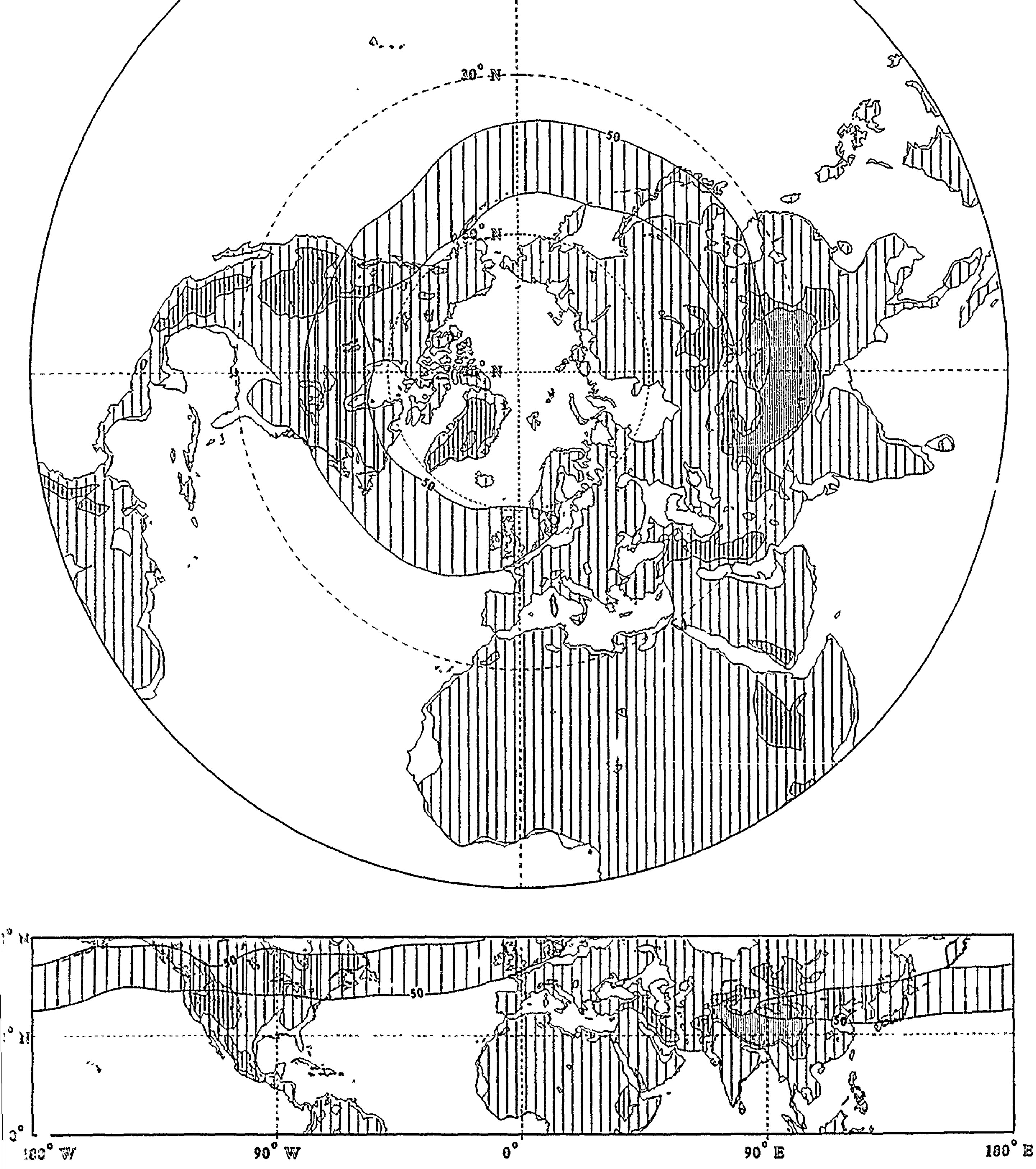
50kt + 25kt inc

September

300 Mb

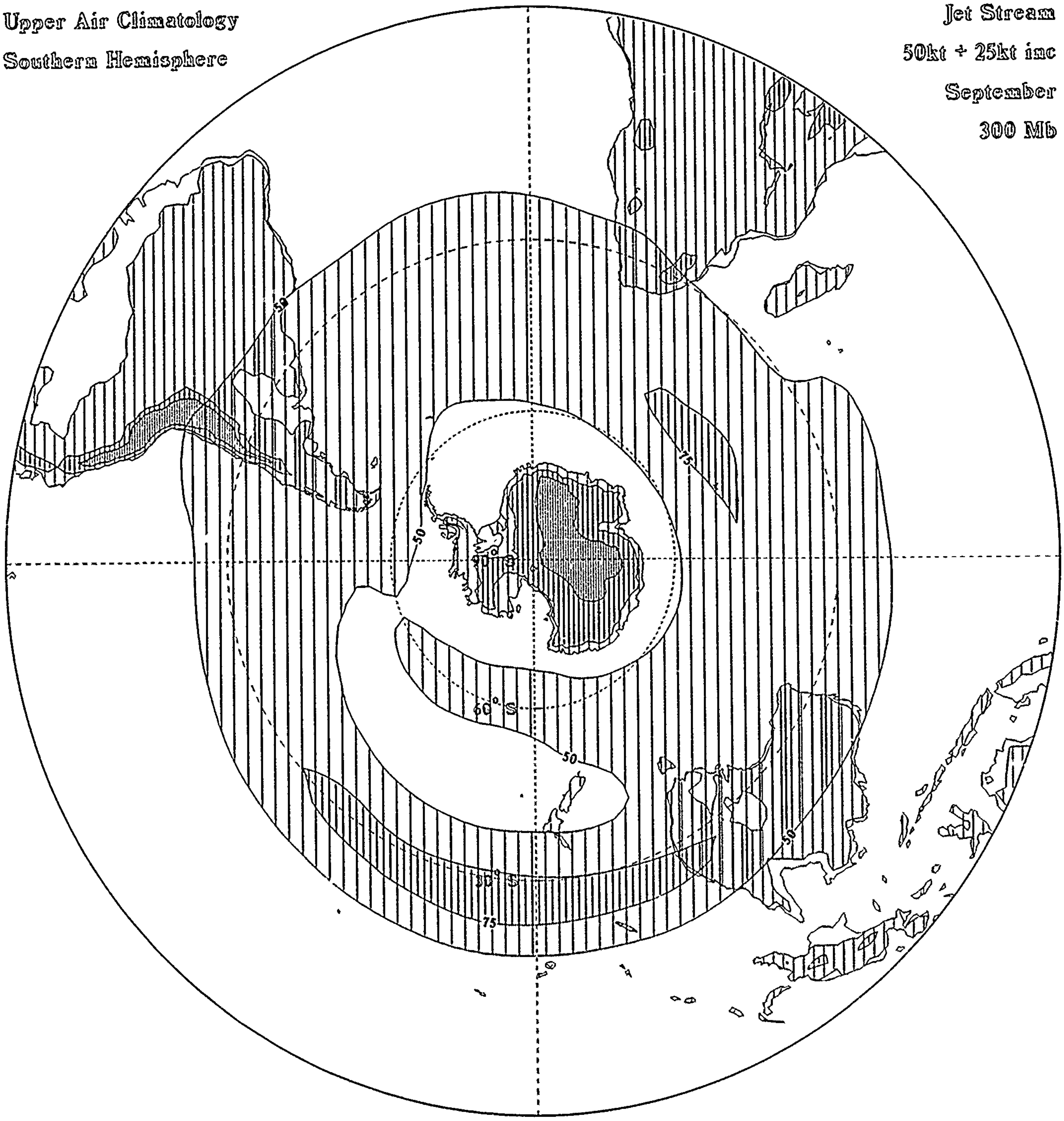
Upper Air Climatology

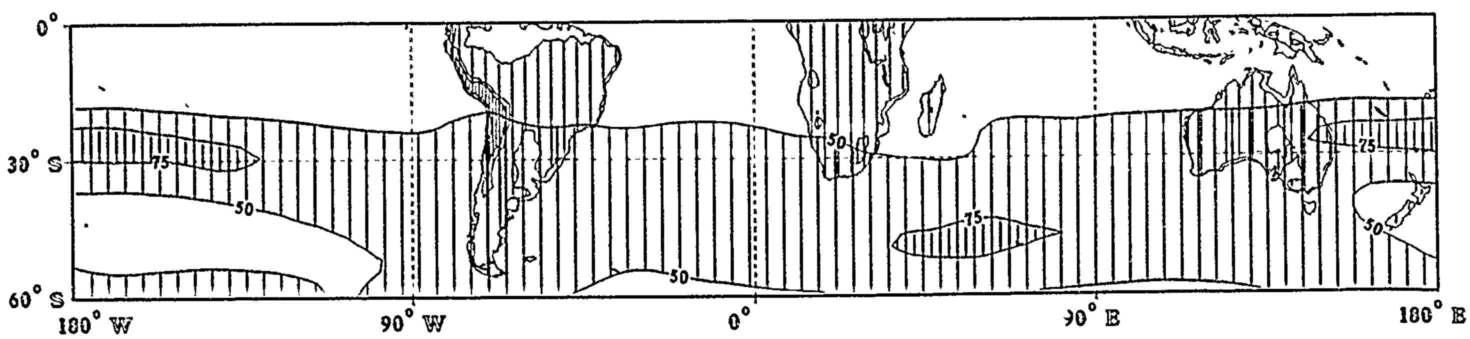
Northern Hemisphere

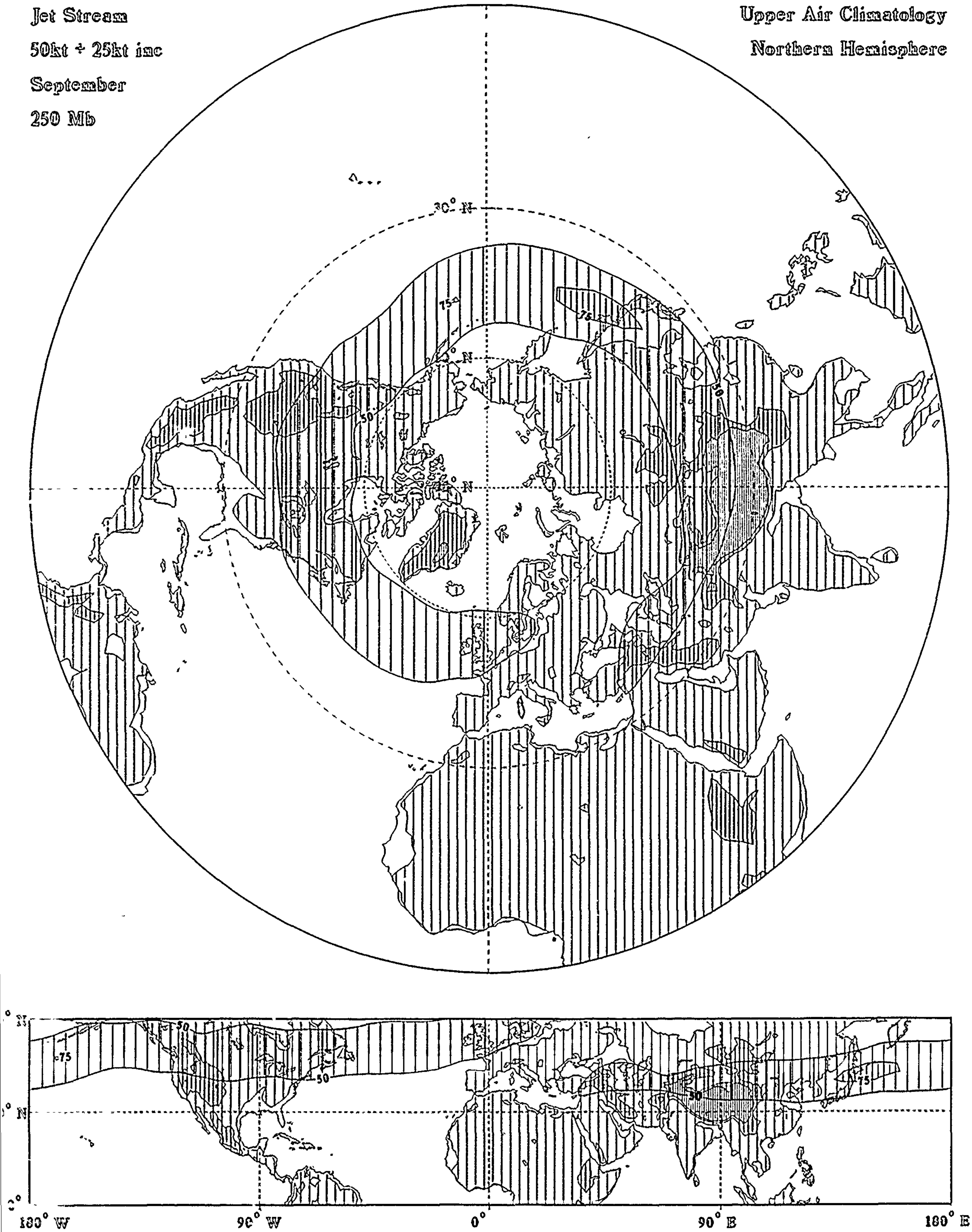


Upper Air Climatology
Southern Hemisphere

Jet Stream
50kt + 25kt inc
September
300 Mb

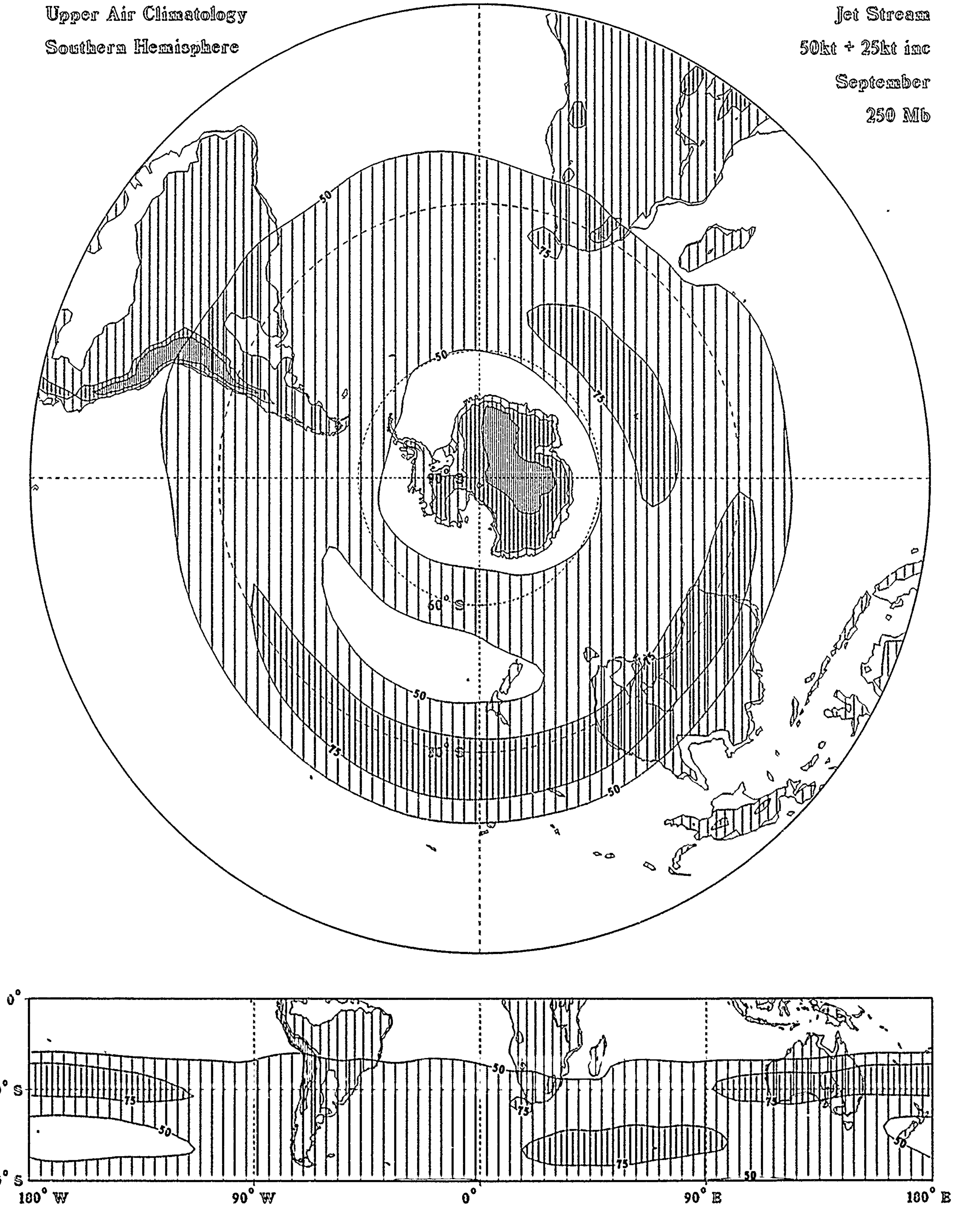





Jet Stream
50kt ÷ 25kt inc
September
250 Mb
Upper Air Climatology
Northern Hemisphere
30° N
N
75
50
180° W
90° W
0°
90° E
180° E

Upper Air Climatology
Southern Hemisphere

Jet Stream
50kt + 25kt inc
September
250 Mb



Jet Stream

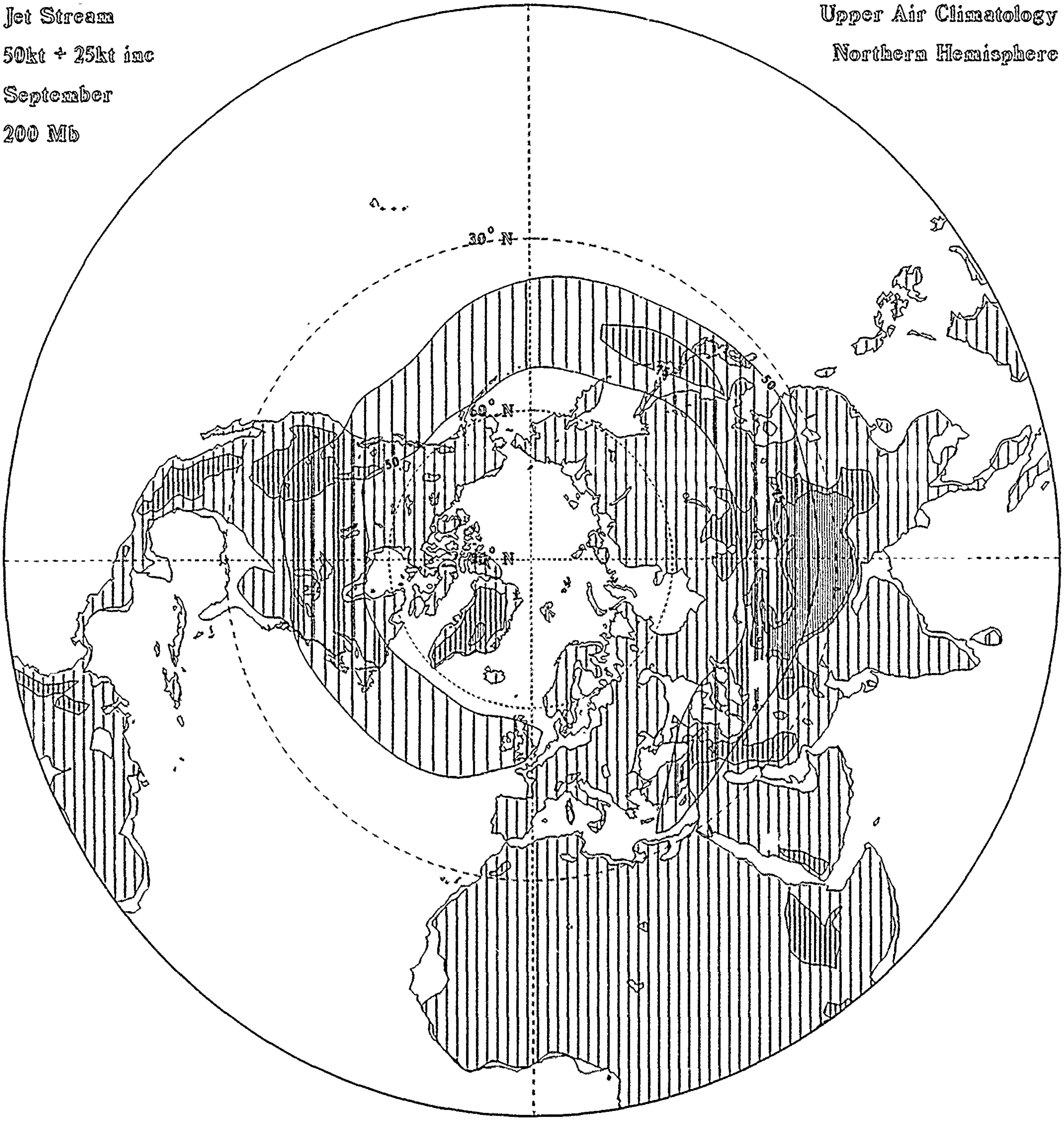
50kt + 25kt inc

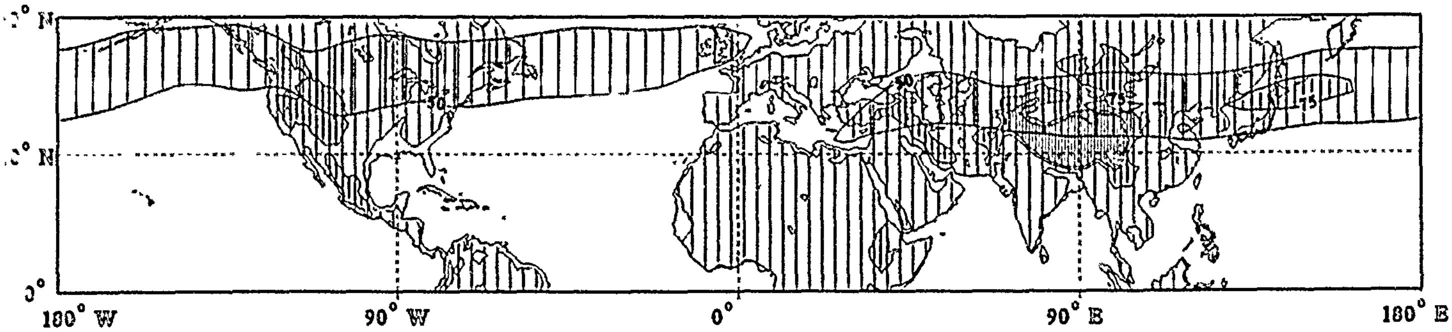
September

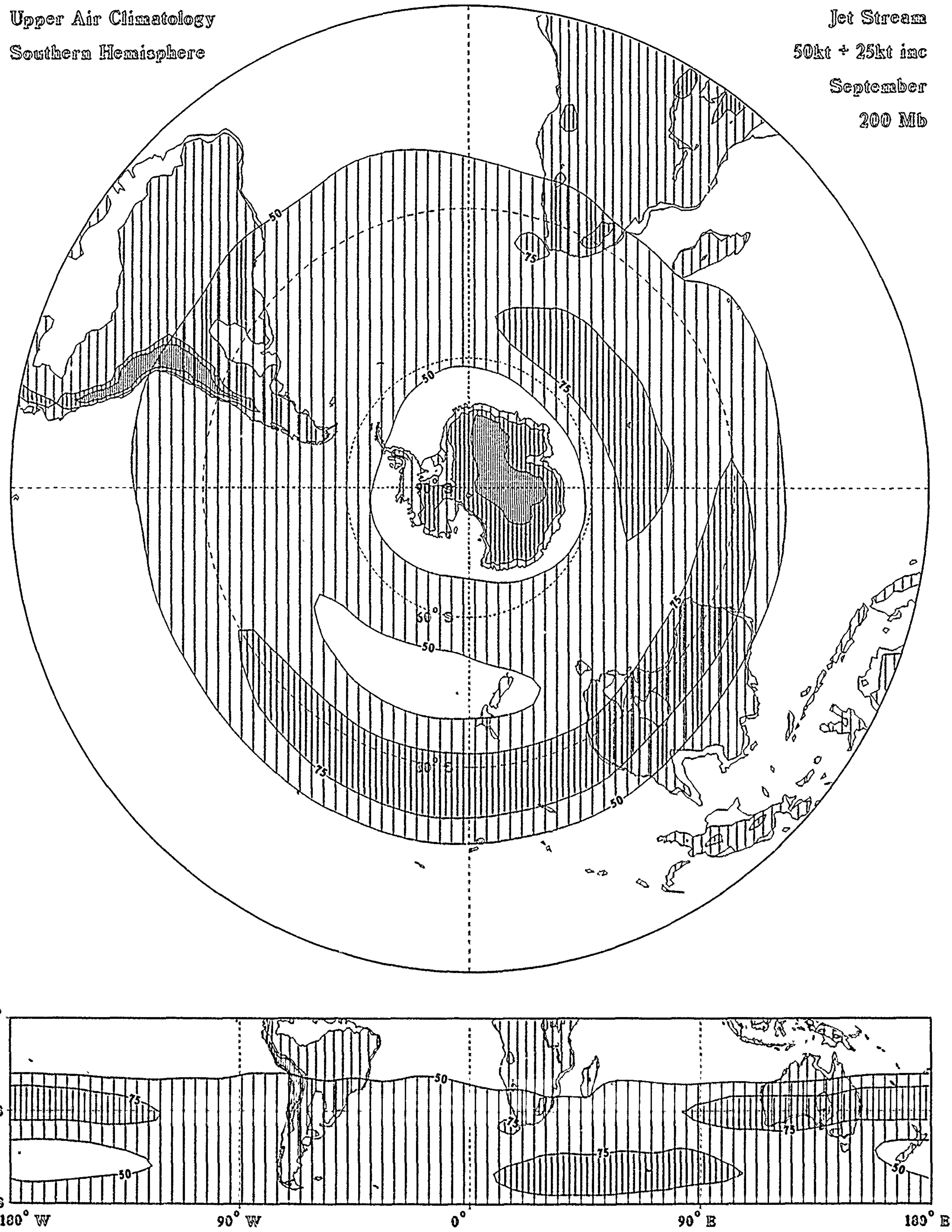
200 Mb

Upper Air Climatology

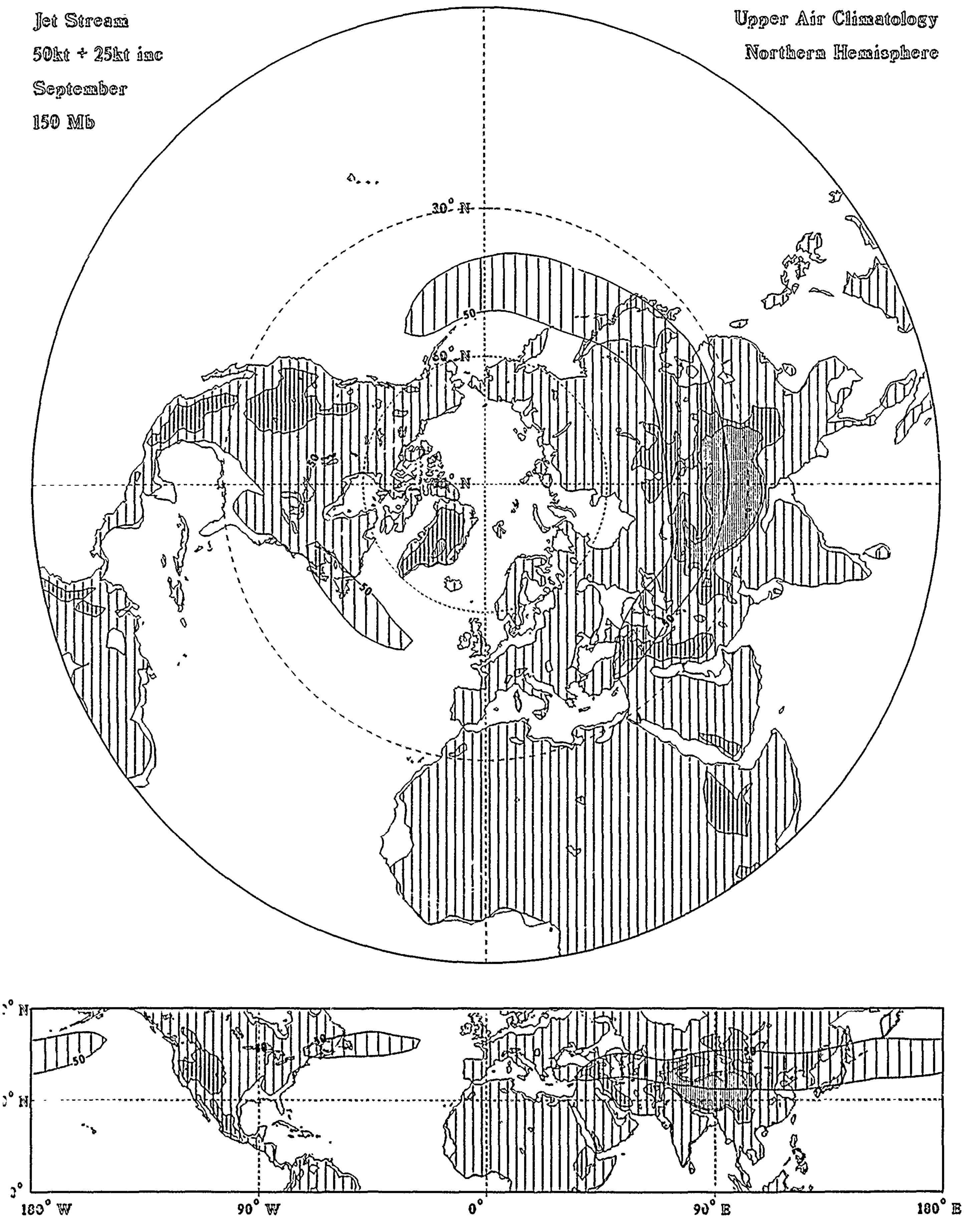
Northern Hemisphere



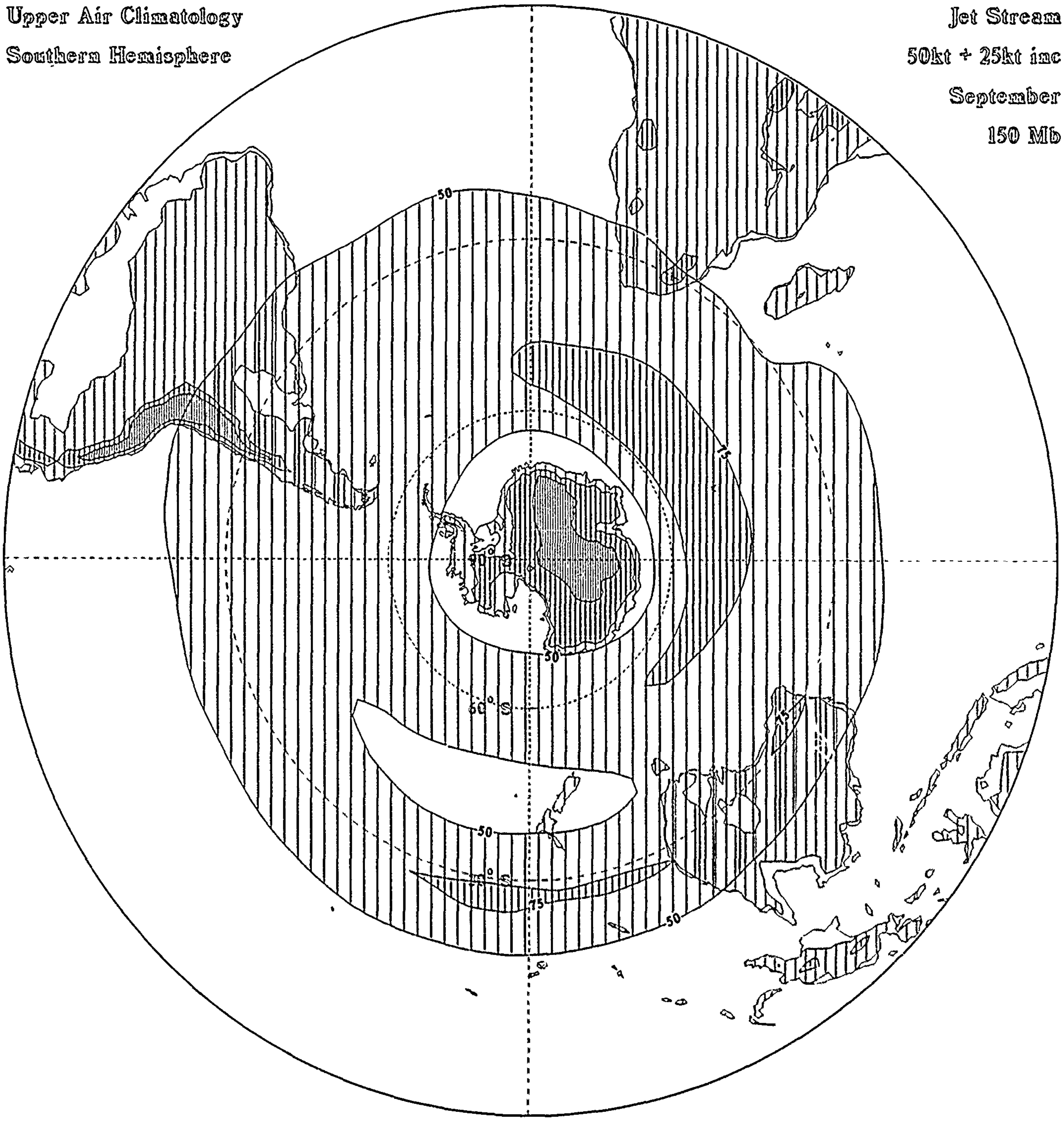


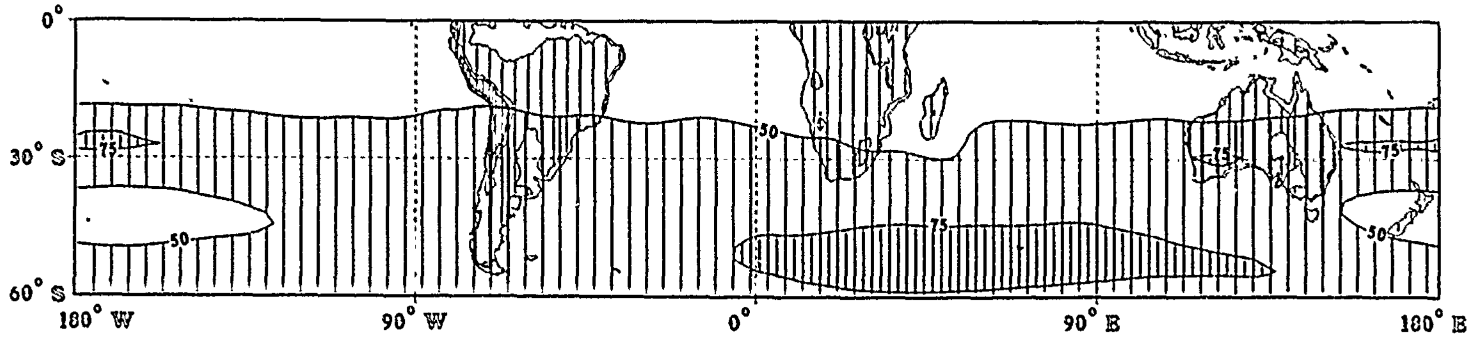


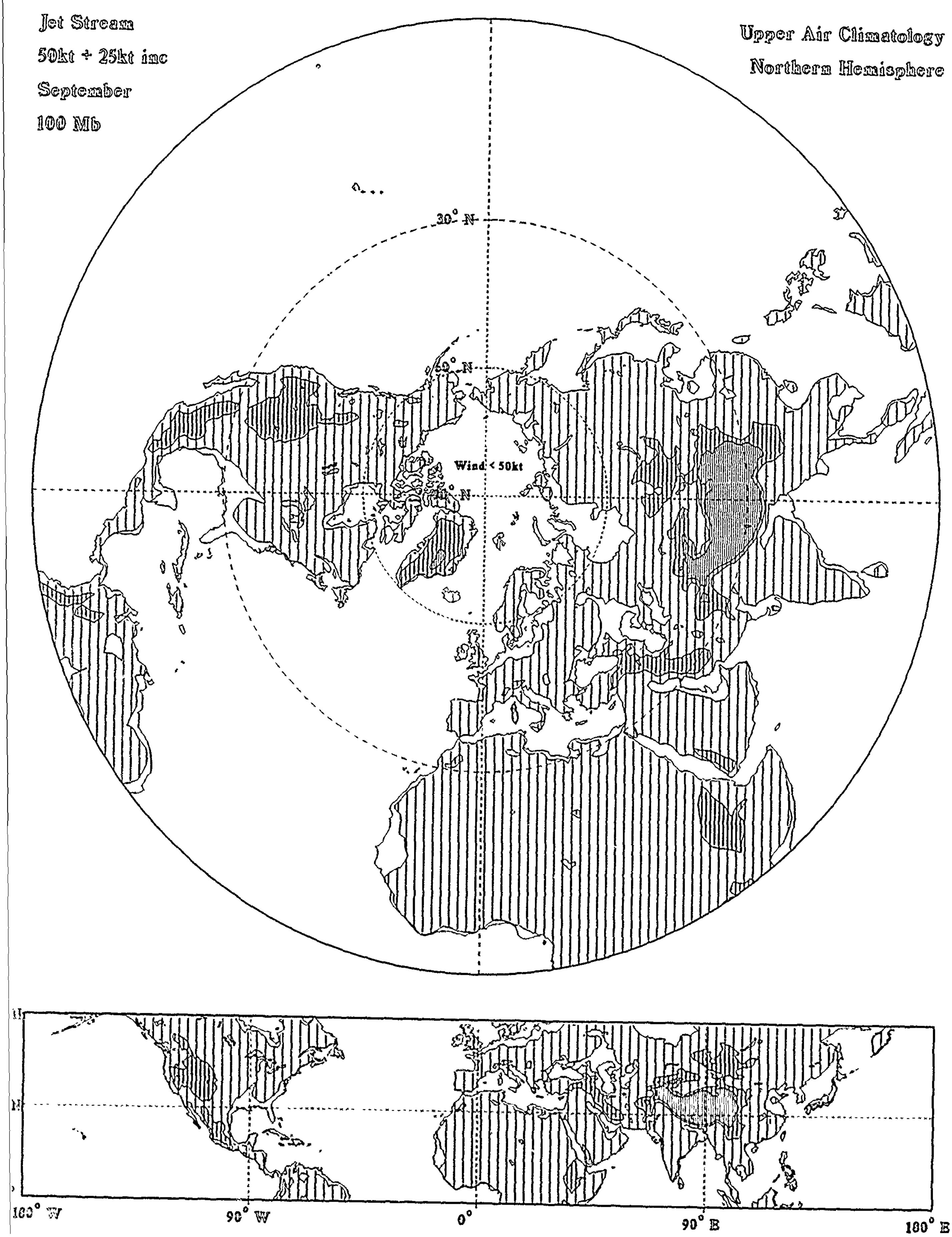
Upper Air Climatology
Southern Hemisphere
Jet Stream
50kt + 25kt inc
September
200 Mb
50
75
90° S
60° S
30° S
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E



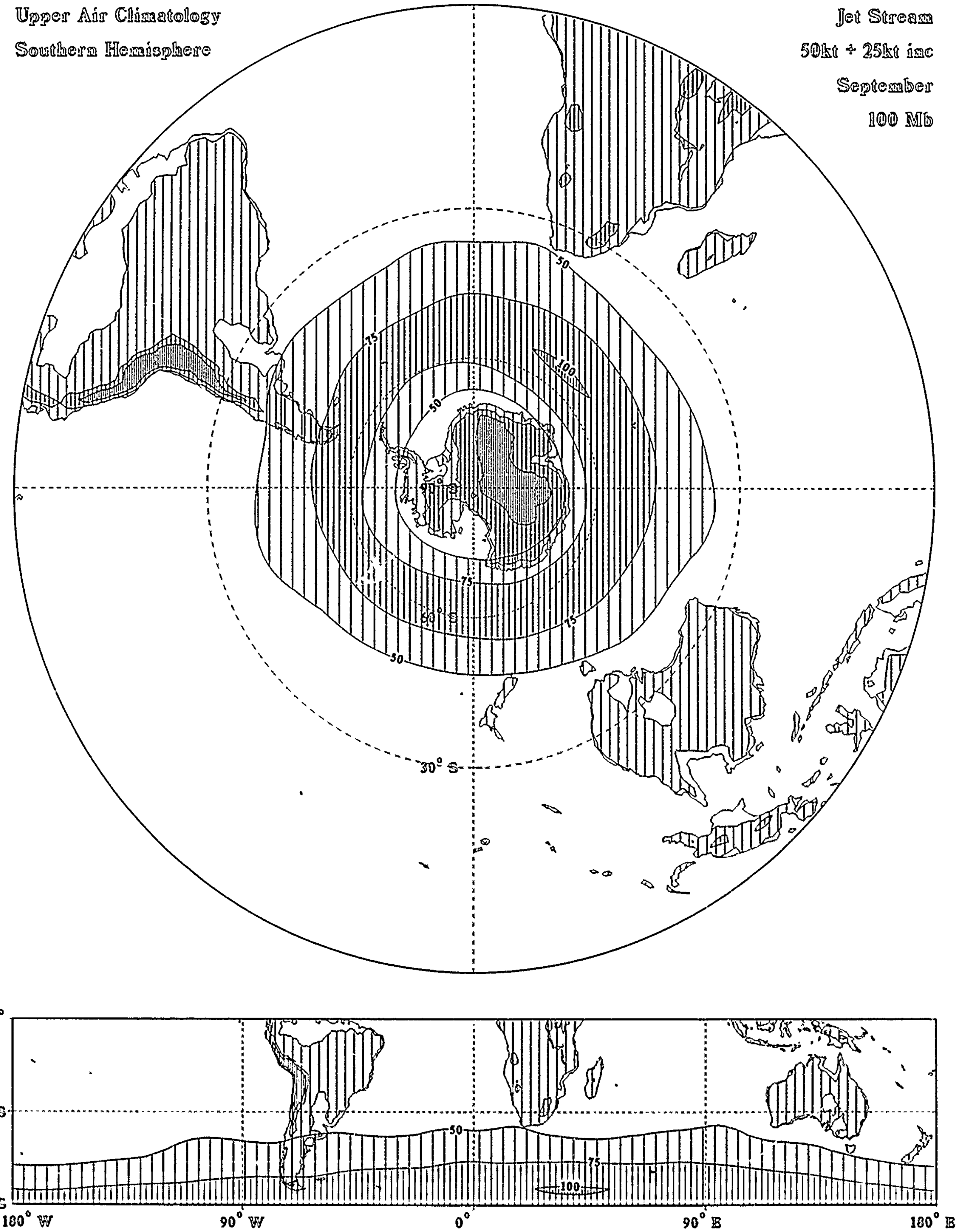
Jet Stream
50kt + 25kt inc
September
150 Mb
Upper Air Climatology
Northern Hemisphere
30° N
60° N
N
50
180° W
90° W
0°
90° E
180° E


Upper Air Climatology
Southern Hemisphere
Jet Stream
50kt + 25kt inc
September
150 Mb
50
75
60° S


0°
30° S
60° S
180° W
90° W
0°
90° E
180° E
50
75



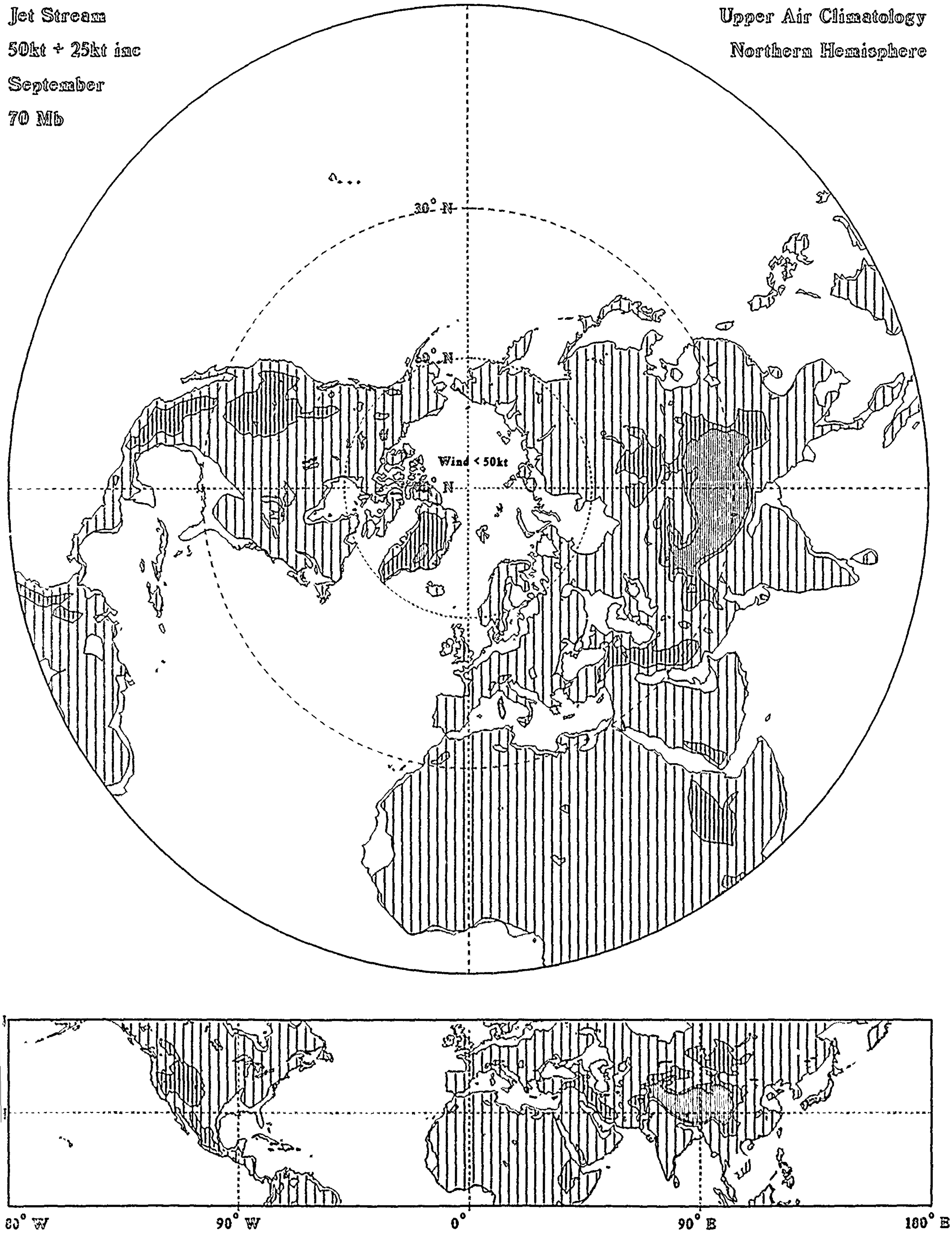
Jet Stream
50kt + 25kt inc
September
100 Mb
Upper Air Climatology
Northern Hemisphere
30° N
60° N
Wind < 50kt
180° W
90° W
0°
90° E
180° E

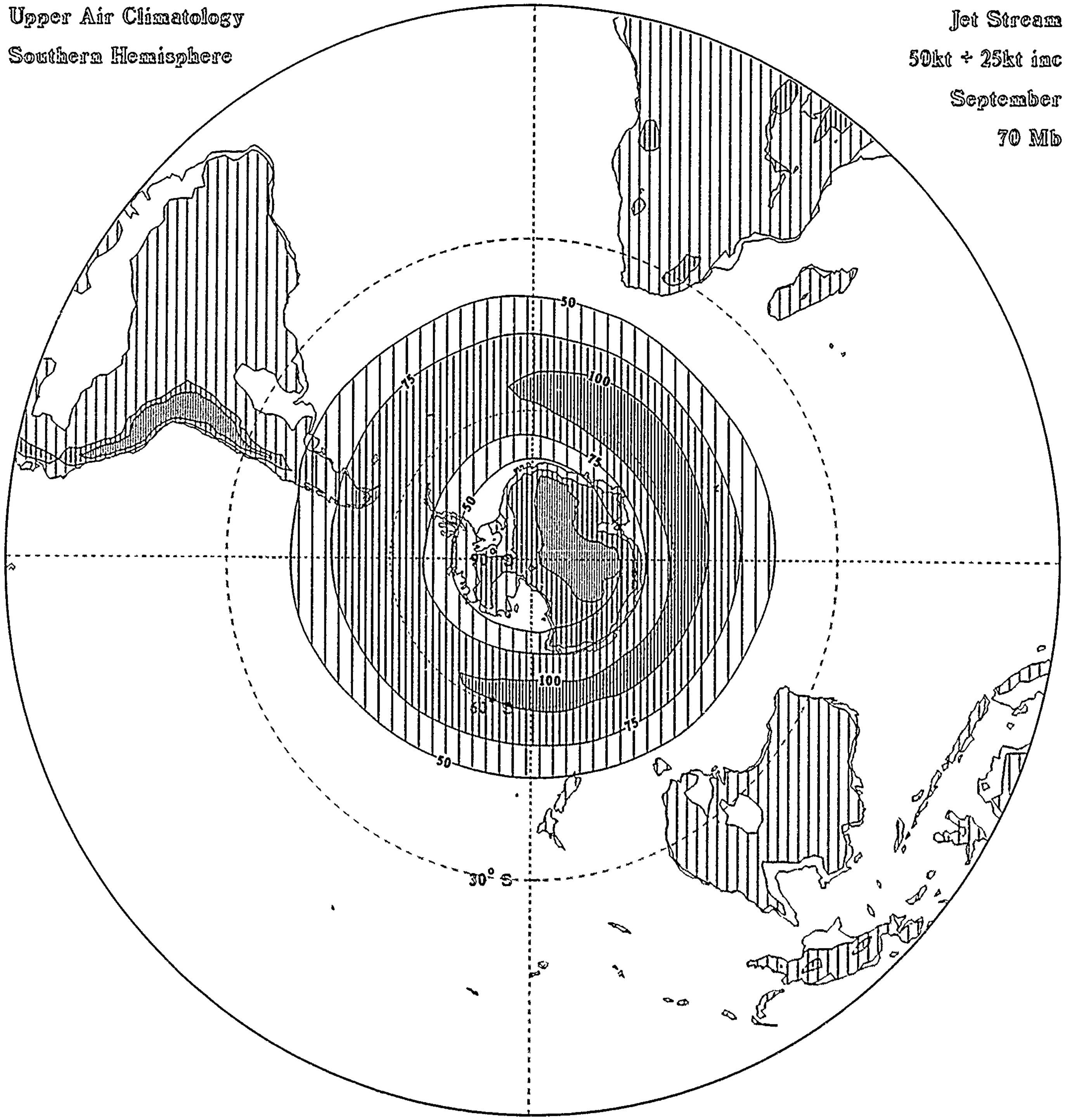


Upper Air Climatology
Southern Hemisphere
Jet Stream
50kt + 25kt inc
September
100 Mb
50
75
100
60° S
30° S
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

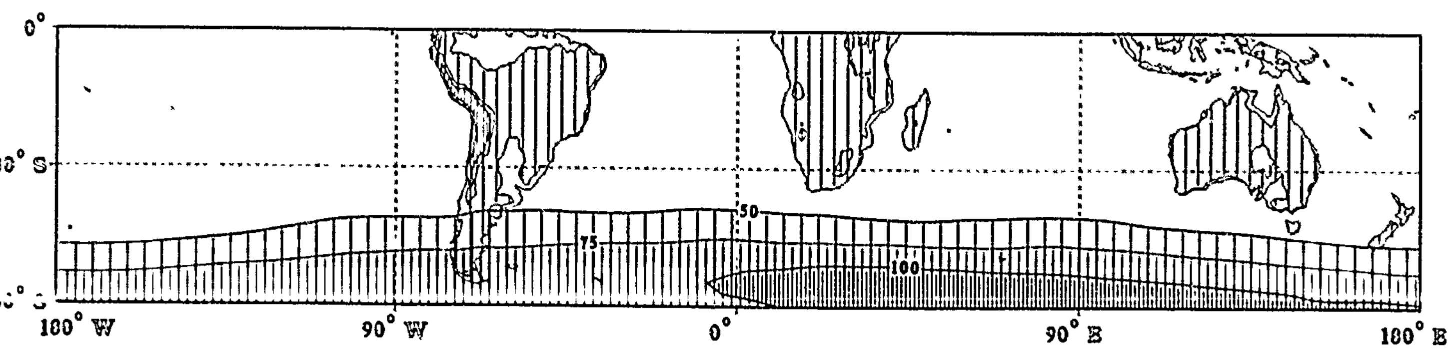
Jet Stream
50kt + 25kt inc
September
70 Mb

Upper Air Climatology
Northern Hemisphere





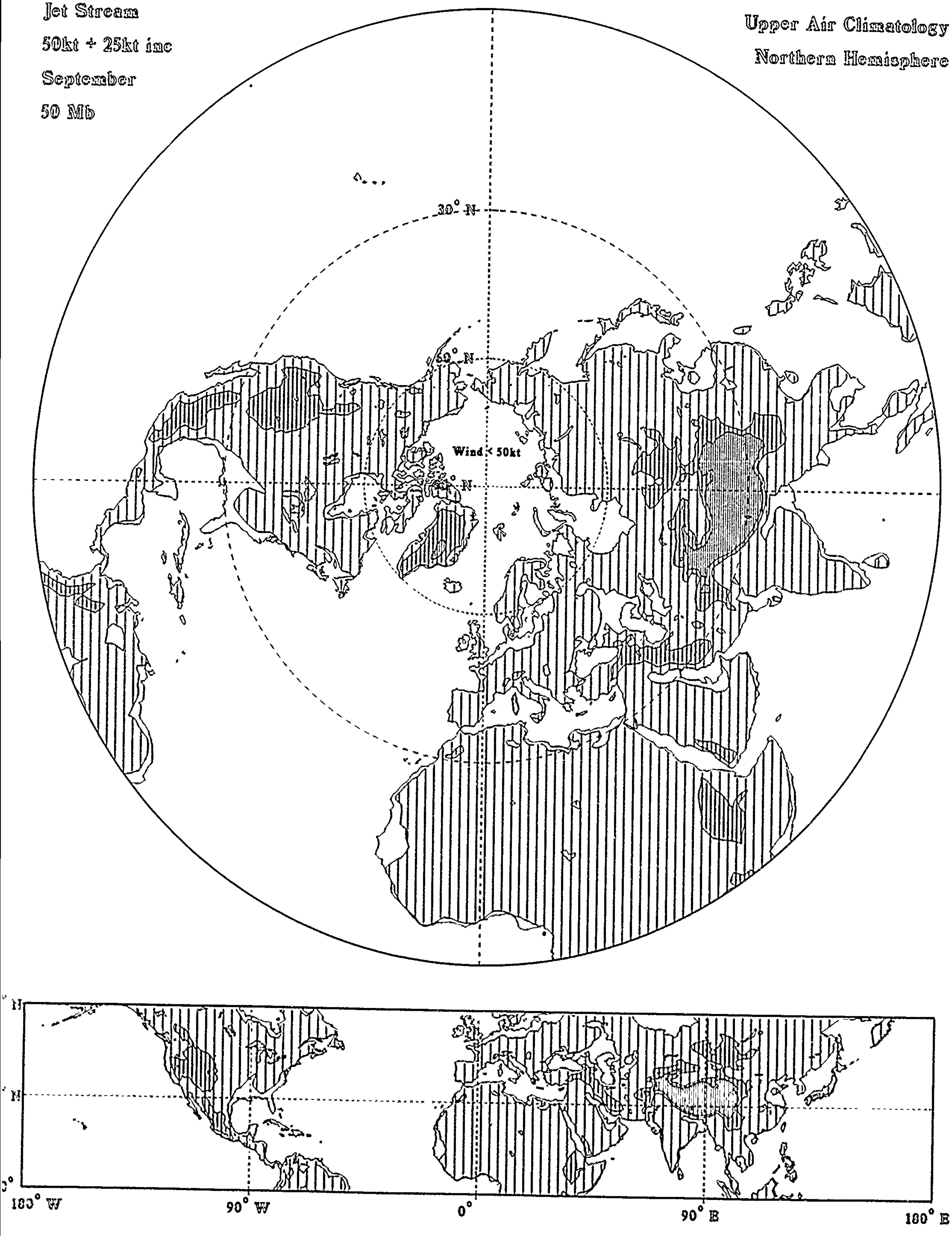
Upper Air Climatology
Southern Hemisphere
Jet Stream
50kt + 25kt inc
September
70 Mb
50
75
100
30° S



0°
30° S
50
75
100
180° W
90° W
0°
90° E
180° E

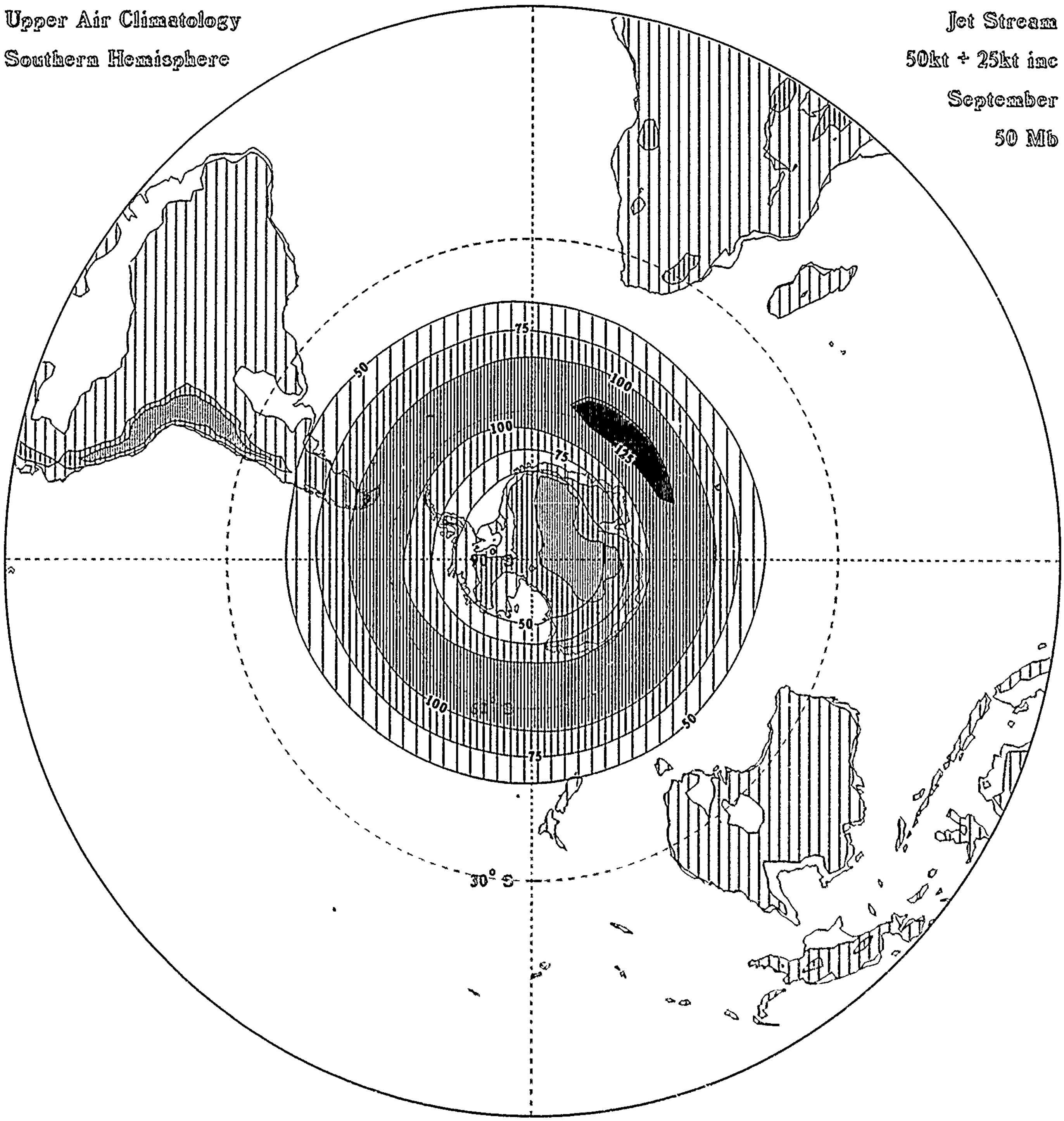
Jet Stream
50kt + 25kt inc
September
50 Mb

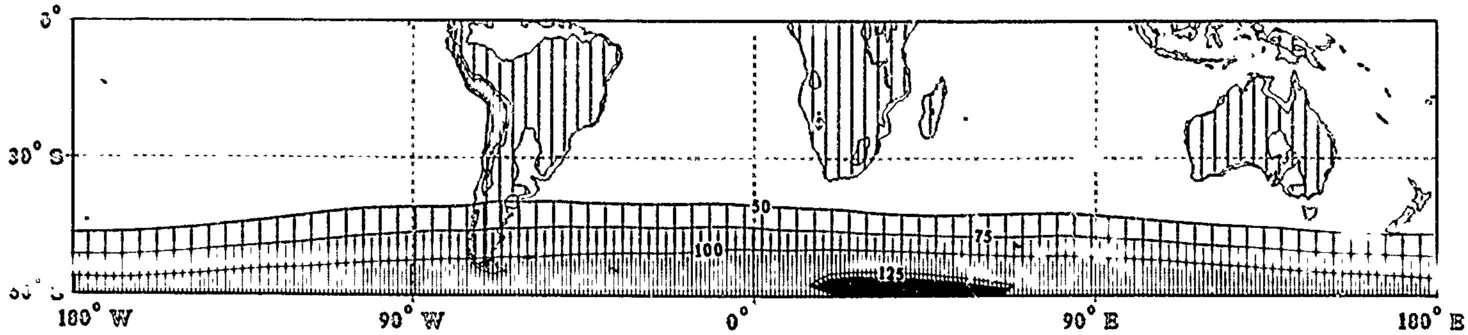
Upper Air Climatology
Northern Hemisphere



Upper Air Climatology
Southern Hemisphere

Jet Stream
50kt + 25kt inc
September
50 Mb





Jet Stream

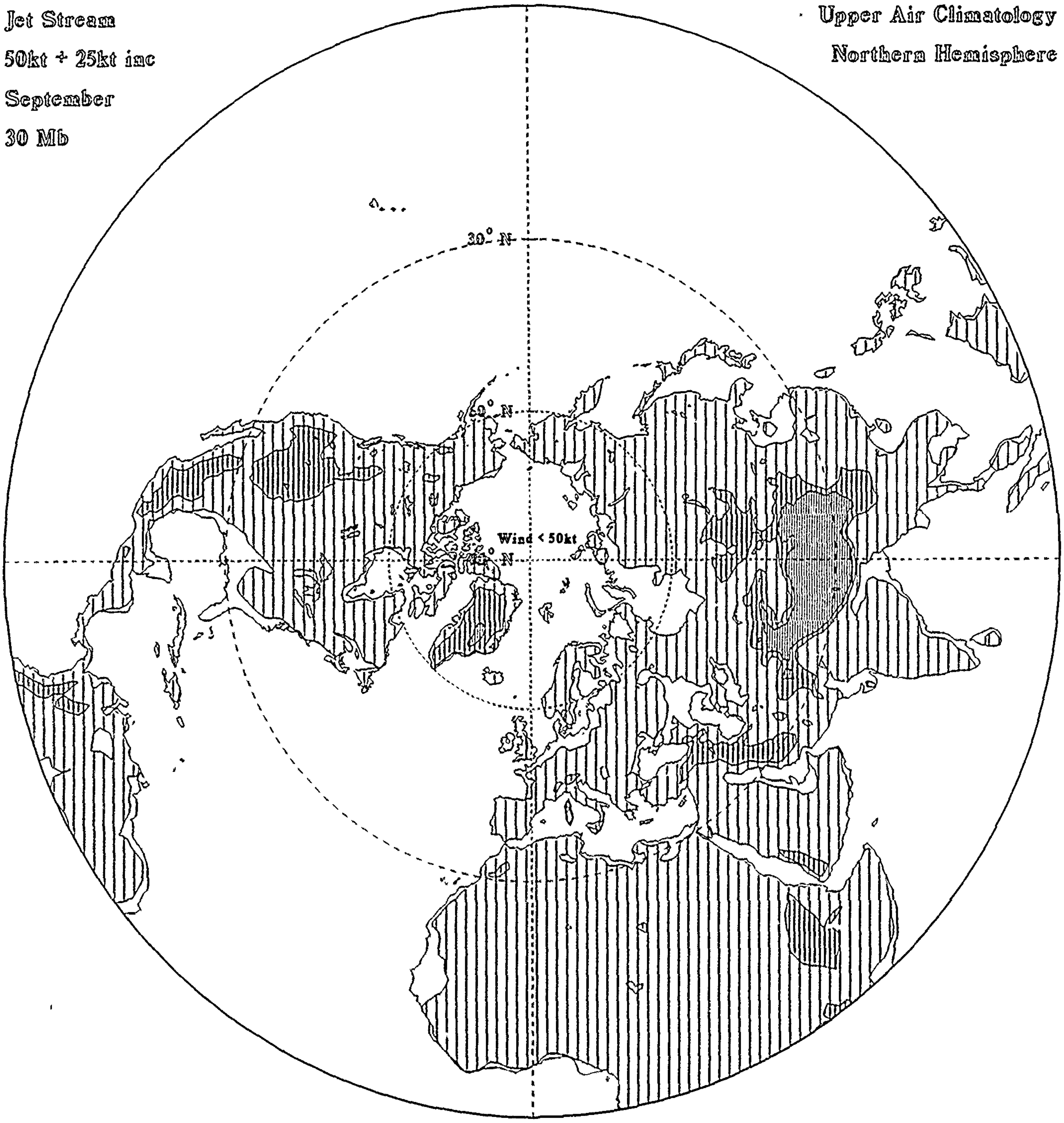
50kt + 25kt inc

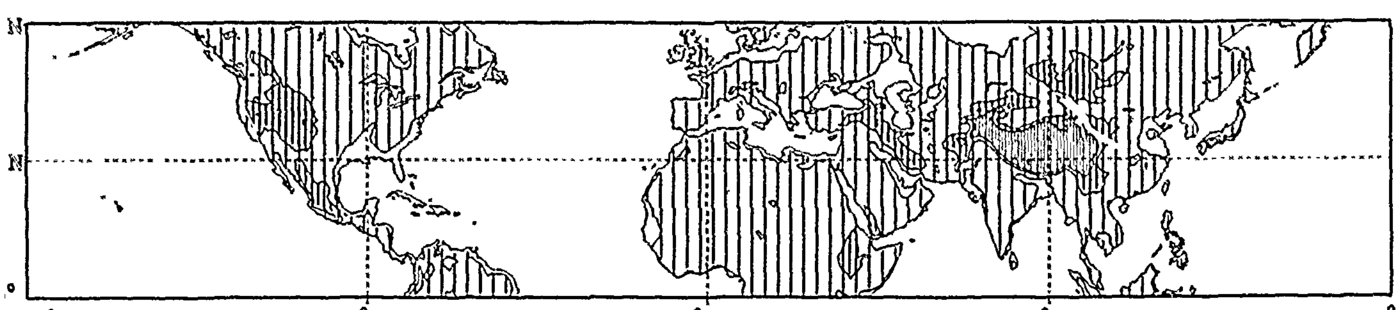
September

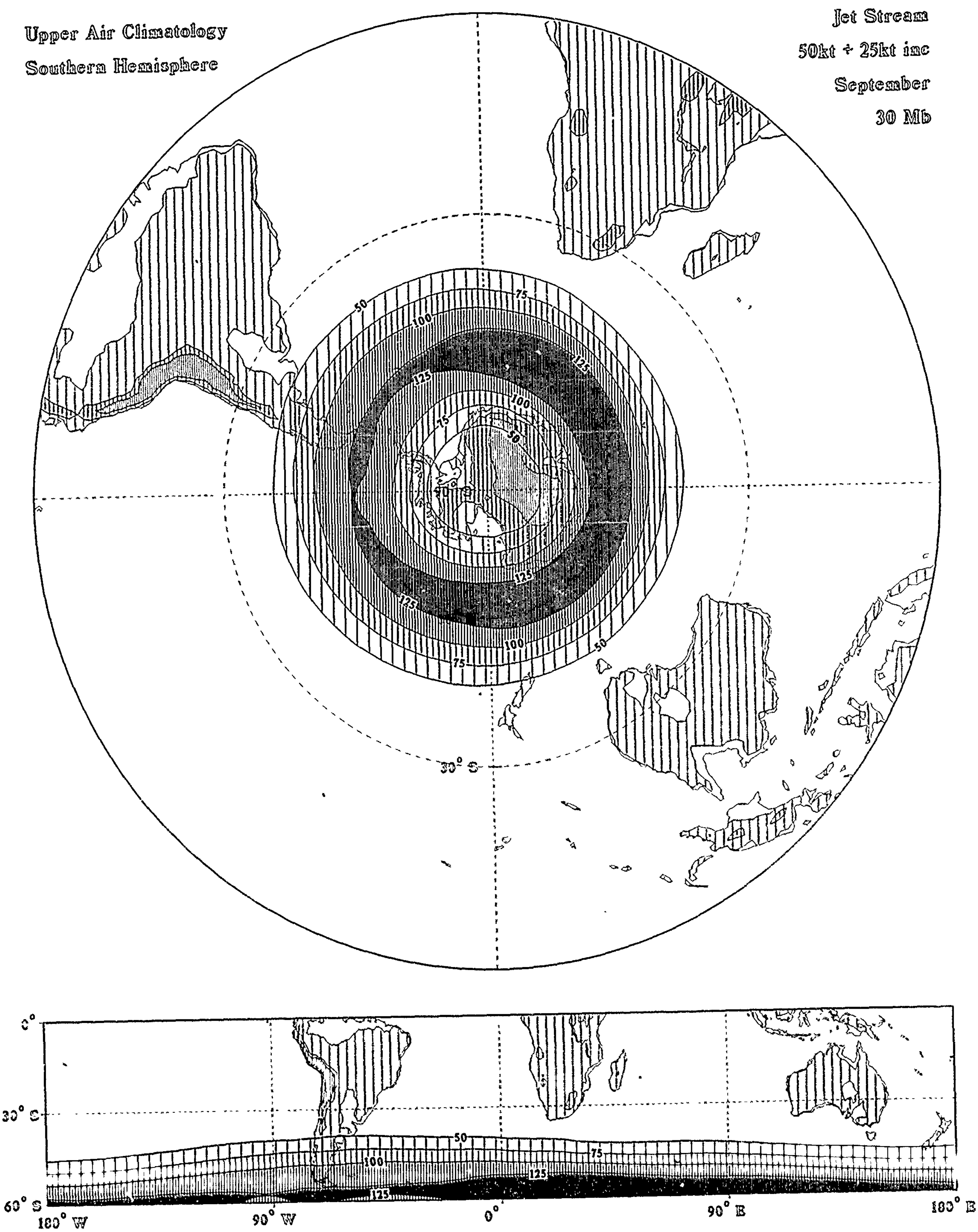
30 Mb

Upper Air Climatology

Northern Hemisphere





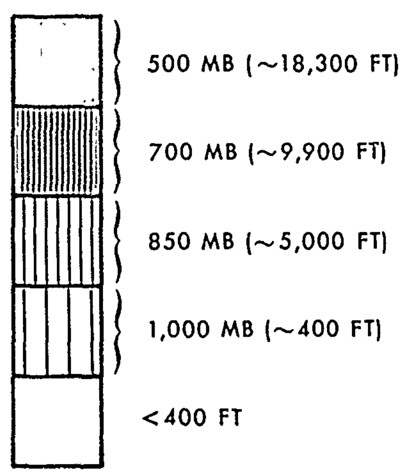


Upper Air Climatology
Southern Hemisphere
Jet Stream
50kt + 25kt inc
September
30 Mb
50
75
100
125
30° S
0°
60° S
180° W
90° W
90° E
180° E

TEMPERATURE
(13 LEVELS, 1000 TO 30 MB)

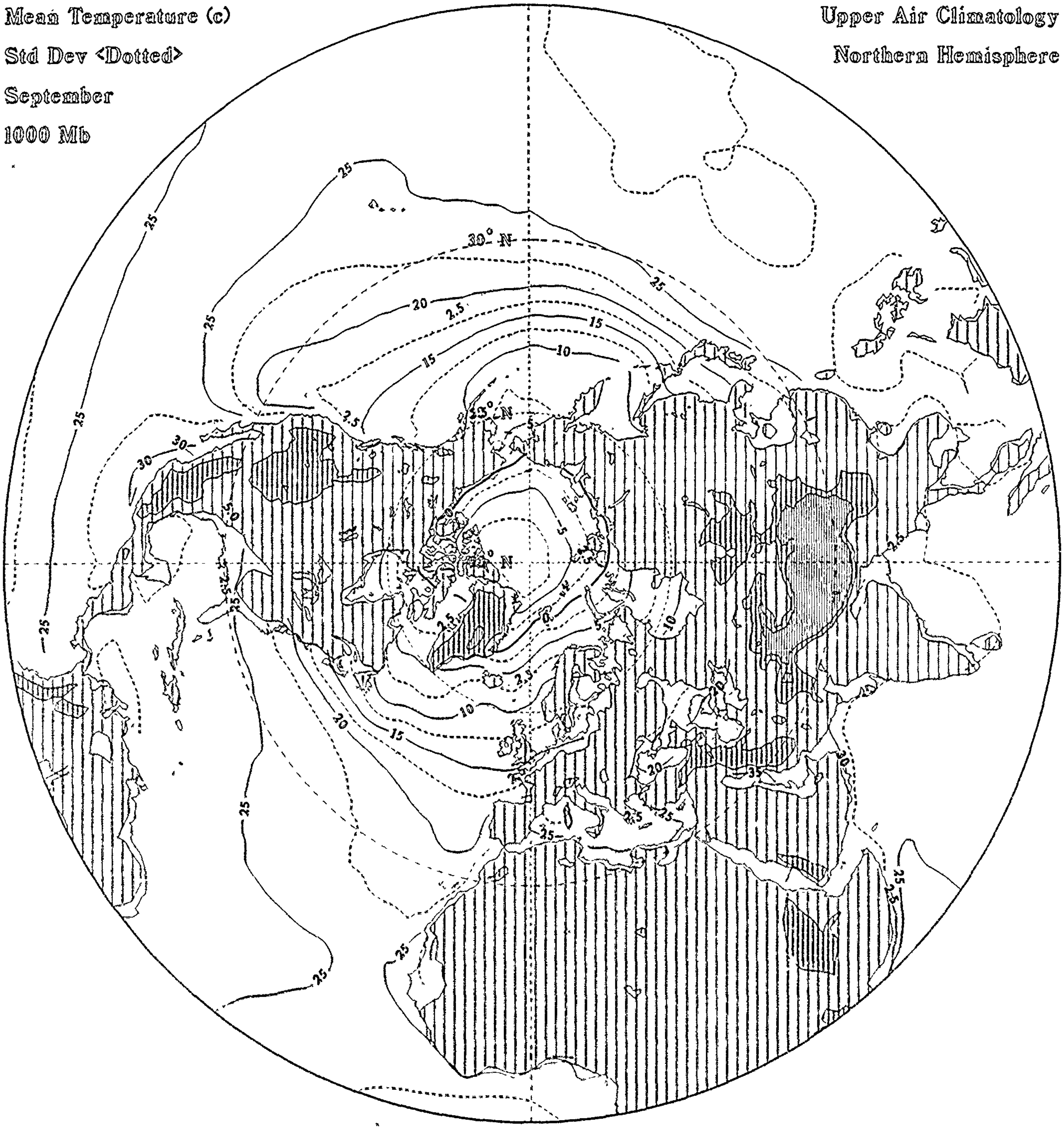
- Contours of mean temperature (solid and dashed lines) in °C; solids labeled, dashed intermediates unlabeled
- Temperature labeled interval: 5°C
- Contours of standard deviation of temperature (dotted lines) in °C
- Standard deviation of temperature labeled interval: 2.5°C
- Contours blanked for geographic areas with elevations exceeding specified geopotential heights

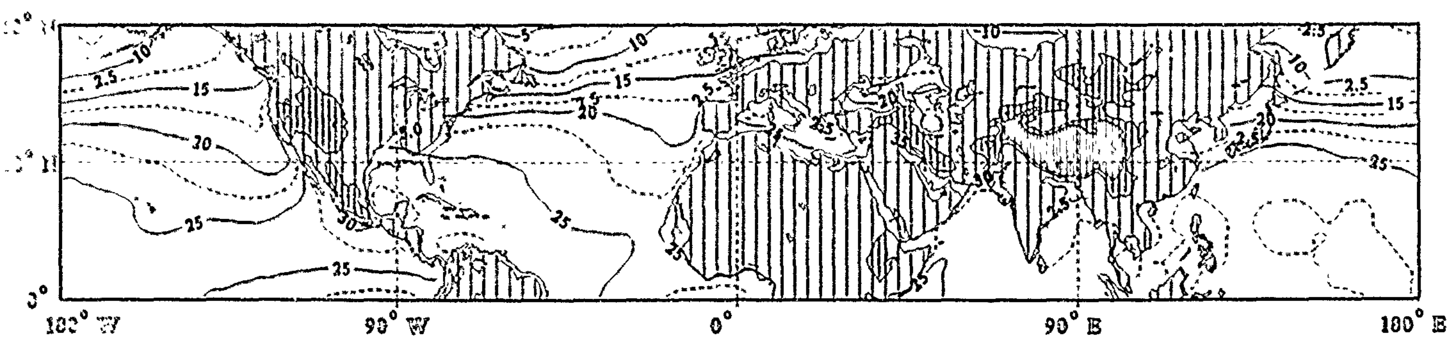
ELEVATION SCALE

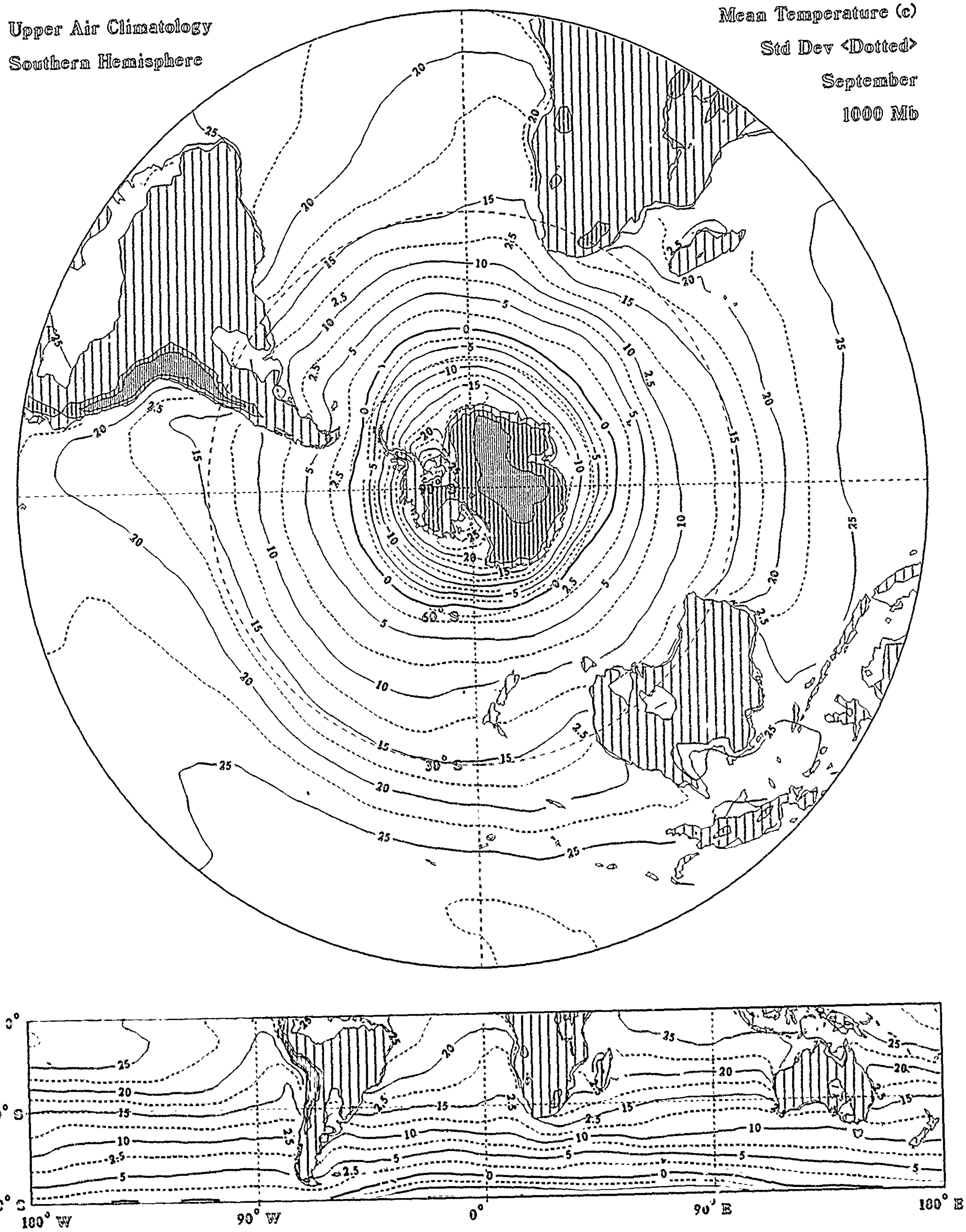


Mean Temperature (c)
Std Dev <Dotted>
September
1000 Mb

Upper Air Climatology
Northern Hemisphere

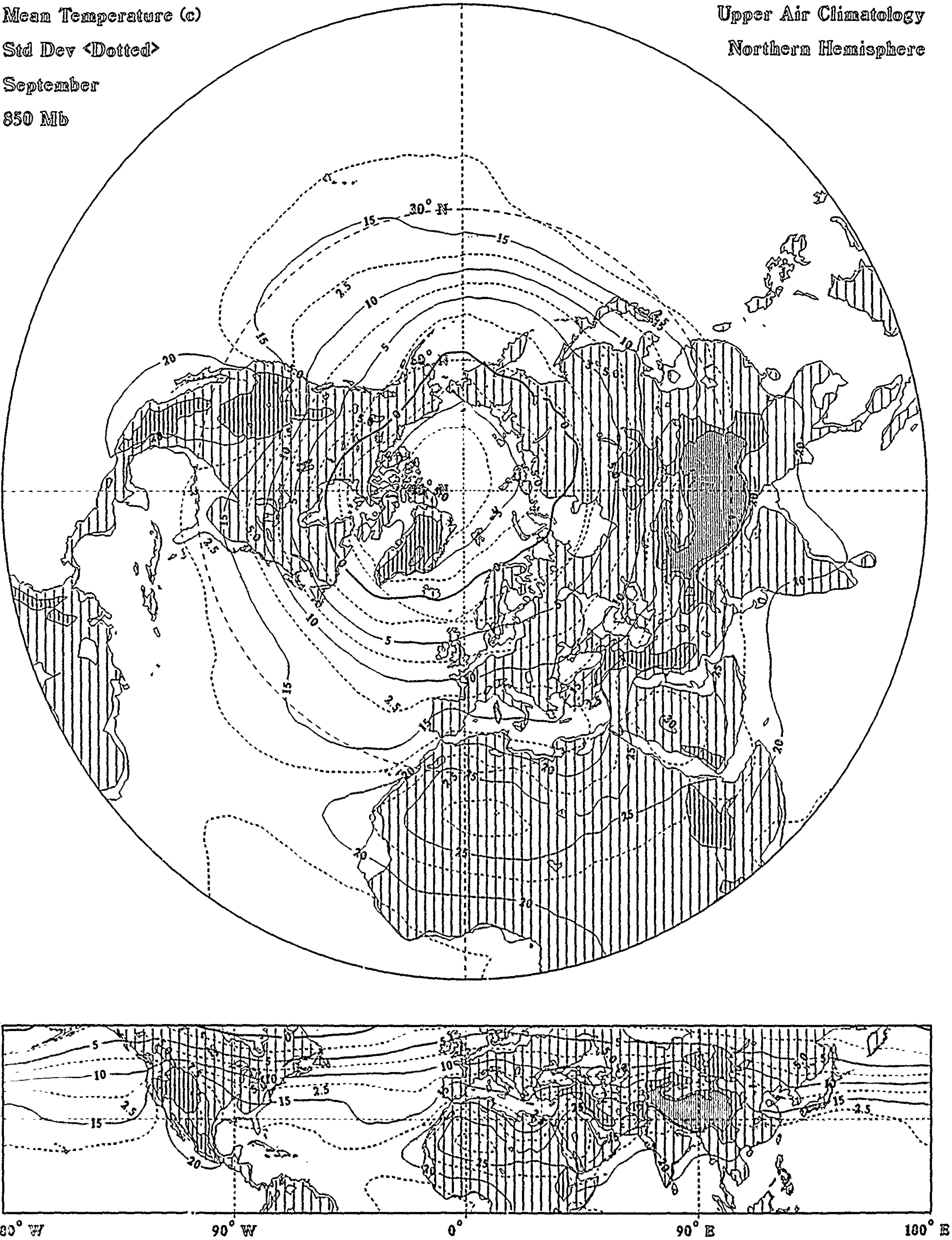


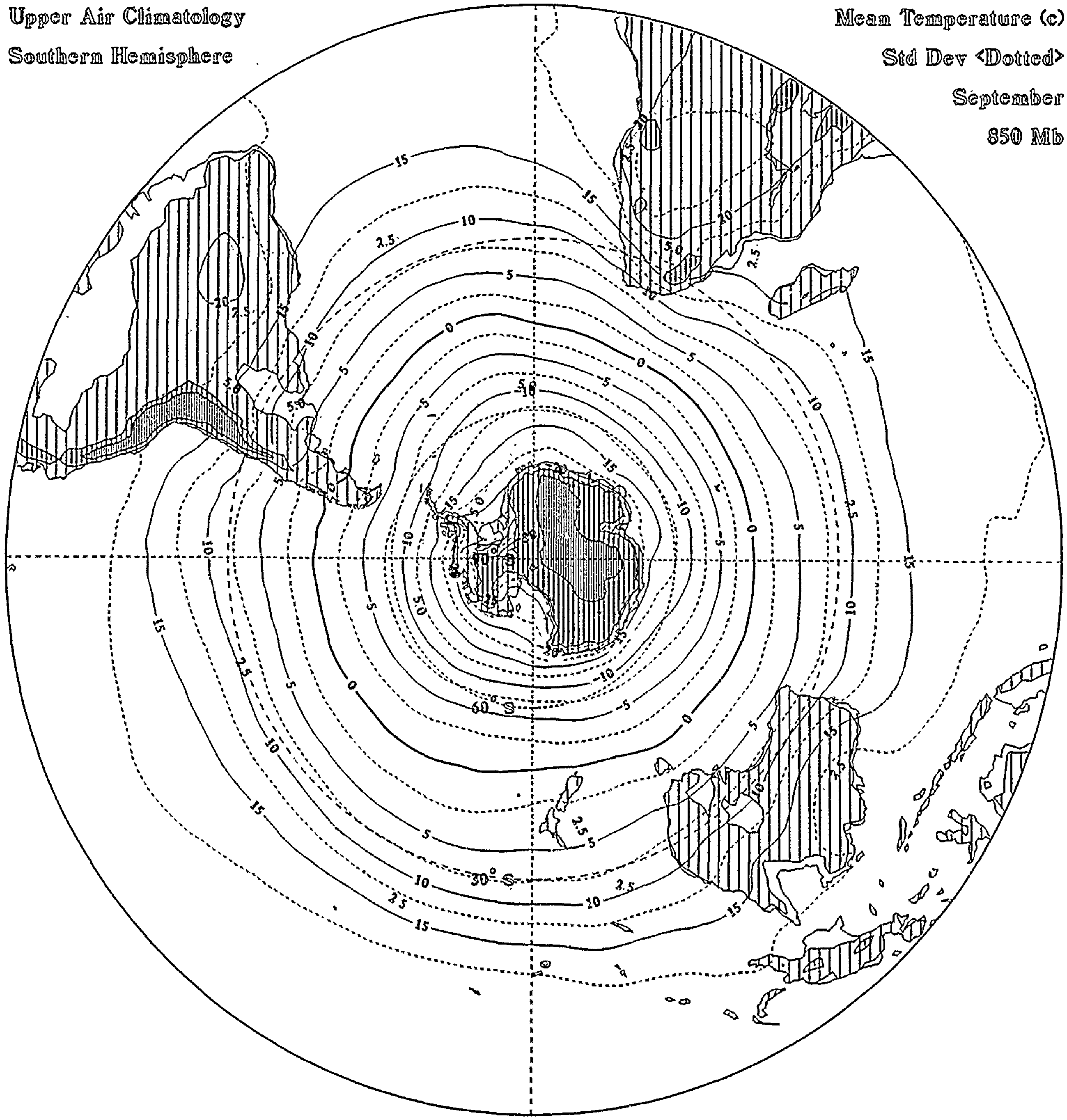


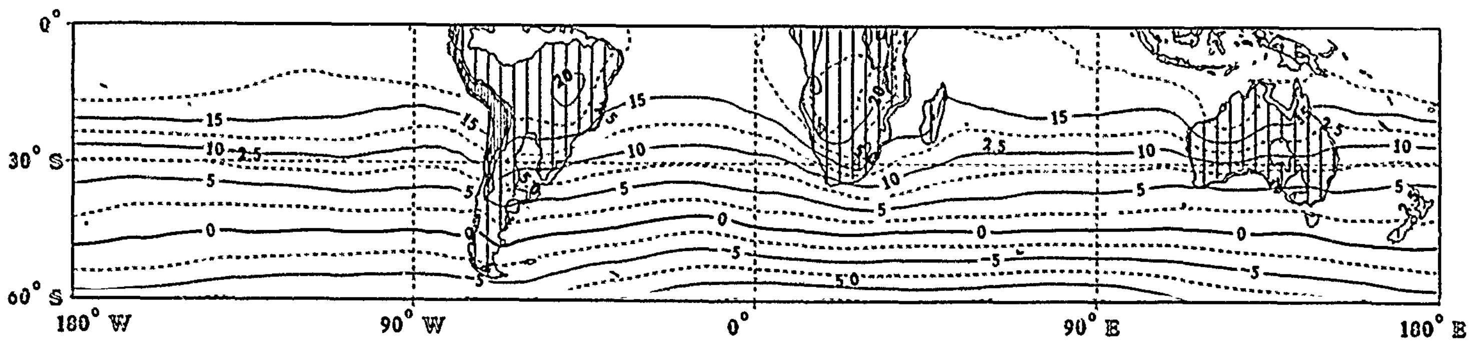

Upper Air Climatology
Southern Hemisphere
Mean Temperature (c)
Std Dev <Dotted>
September
1000 Mb
60° S
30° S
0°
180° W
90° W
90° E
180° E

Mean Temperature (c)
Std Dev <Dotted>
September
850 Mb

Upper Air Climatology
Northern Hemisphere

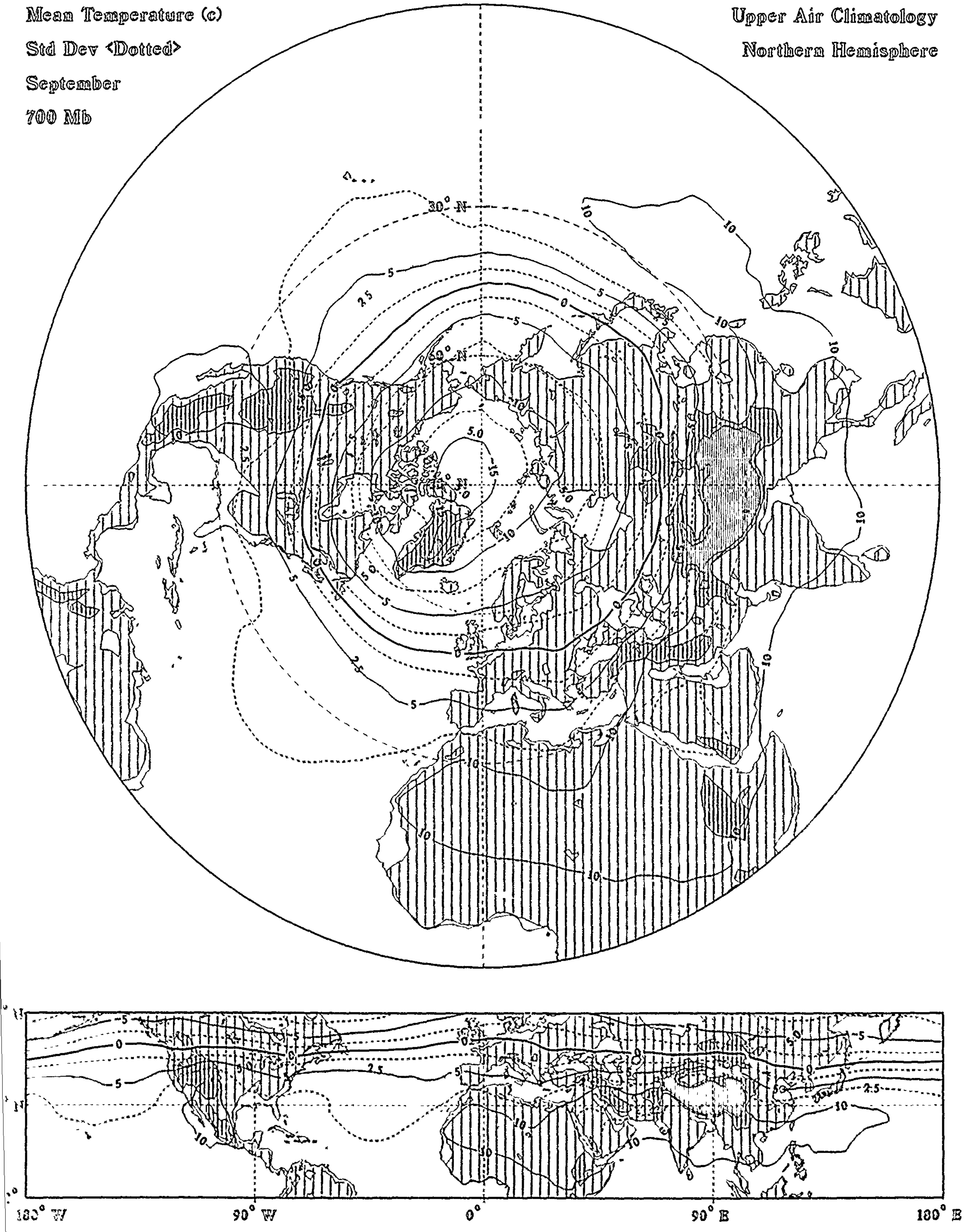



Upper Air Climatology
Southern Hemisphere
Mean Temperature (c)
Std Dev <Dotted>
September
850 Mb
60° S
30° S


0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

Mean Temperature (c)
Std Dev <Dotted>
September
700 Mb

Upper Air Climatology
Northern Hemisphere



Upper Air Climatology

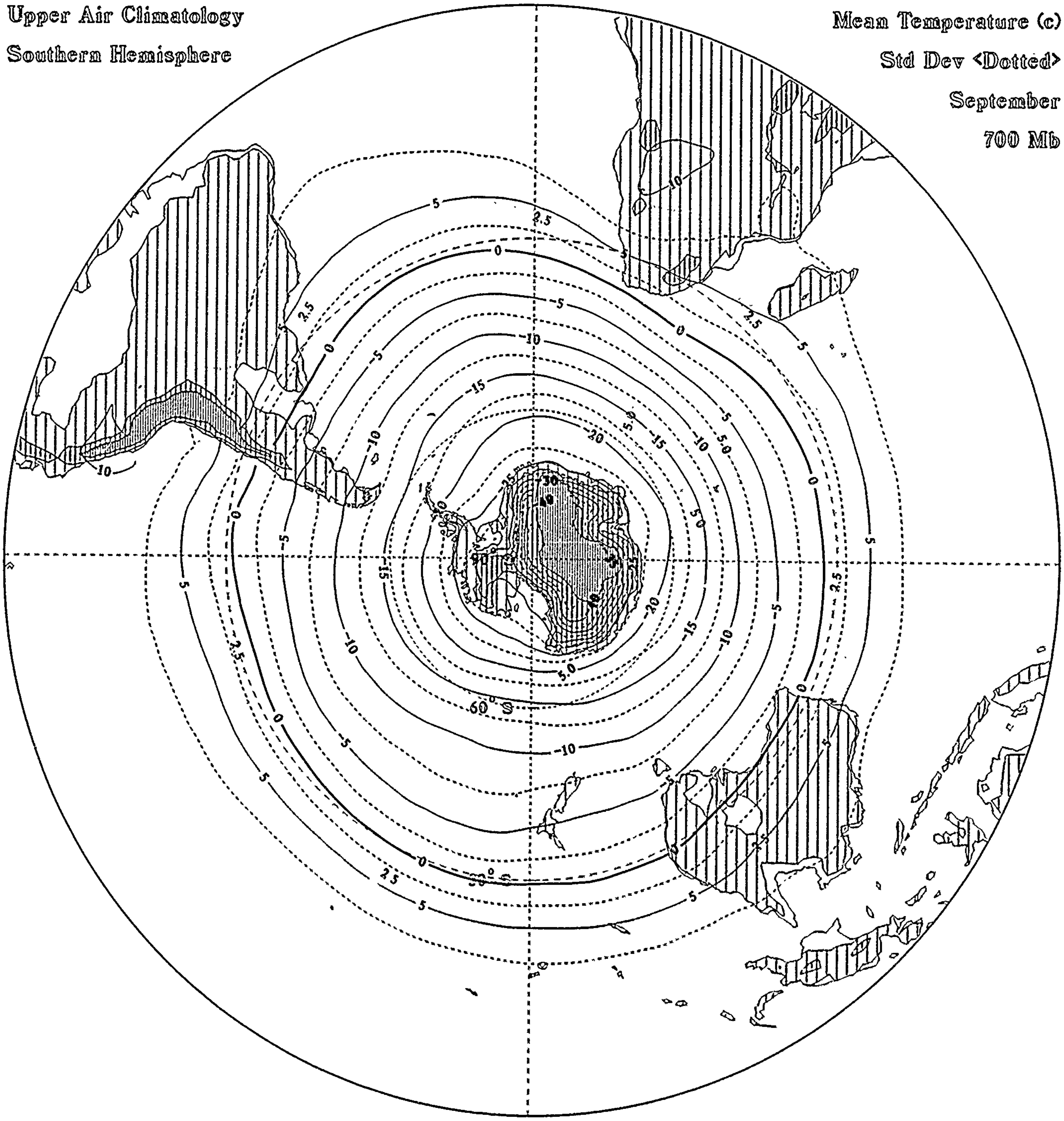
Southern Hemisphere

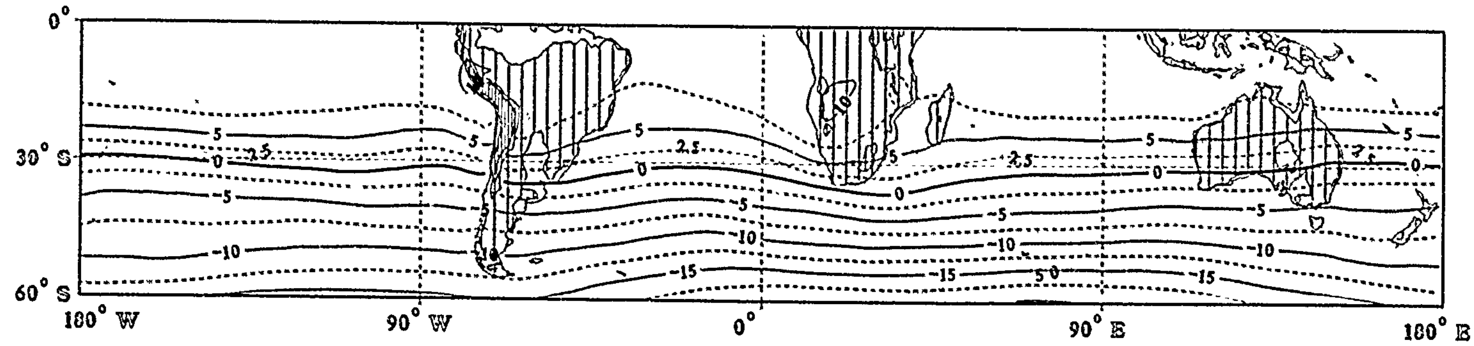
Mean Temperature (c)

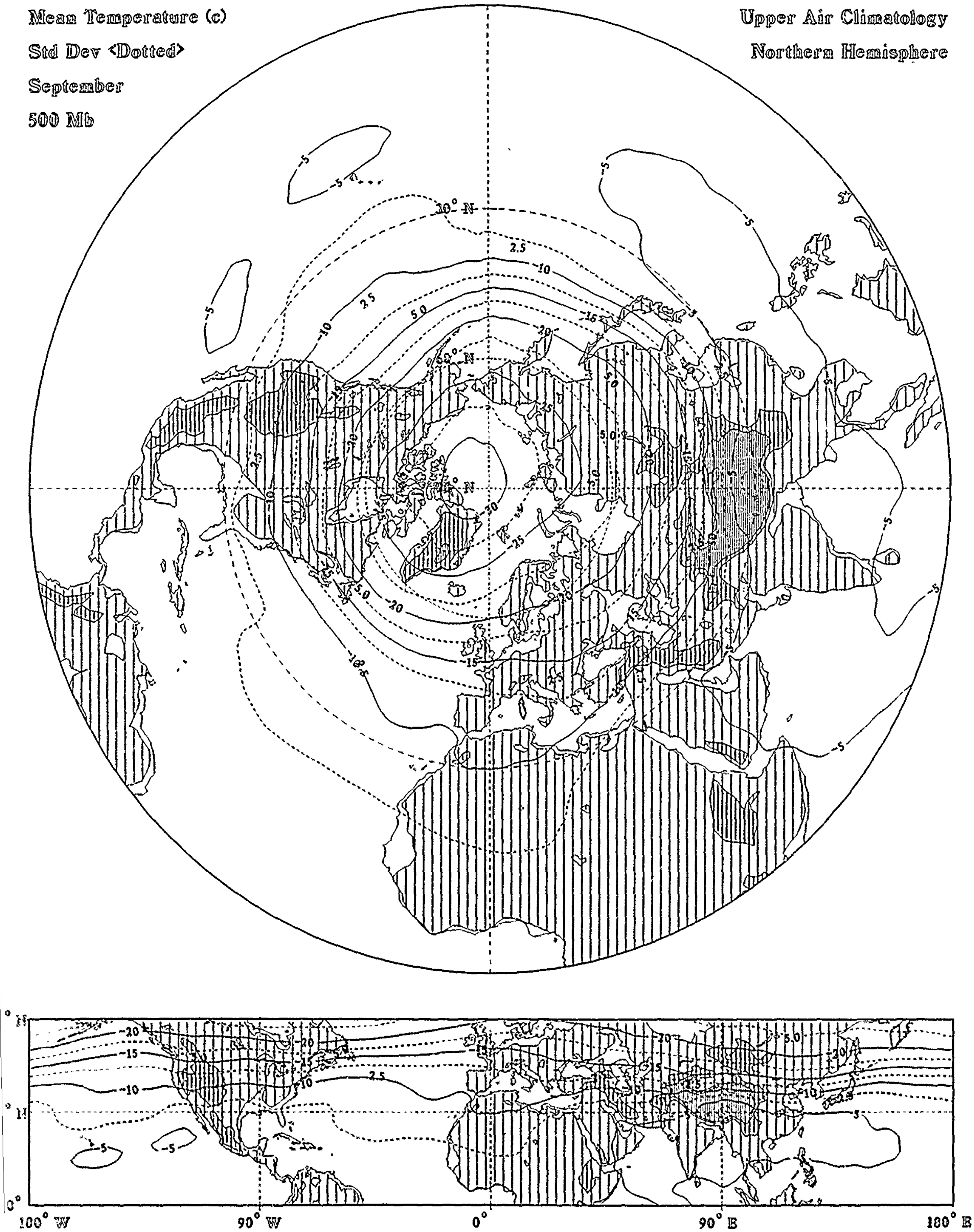
Std Dev <Dotted>

September

700 Mb






Mean Temperature (c)
Std Dev <Dotted>
September
500 Mb
Upper Air Climatology
Northern Hemisphere
90° W
0°
90° E
180° E

Upper Air Climatology

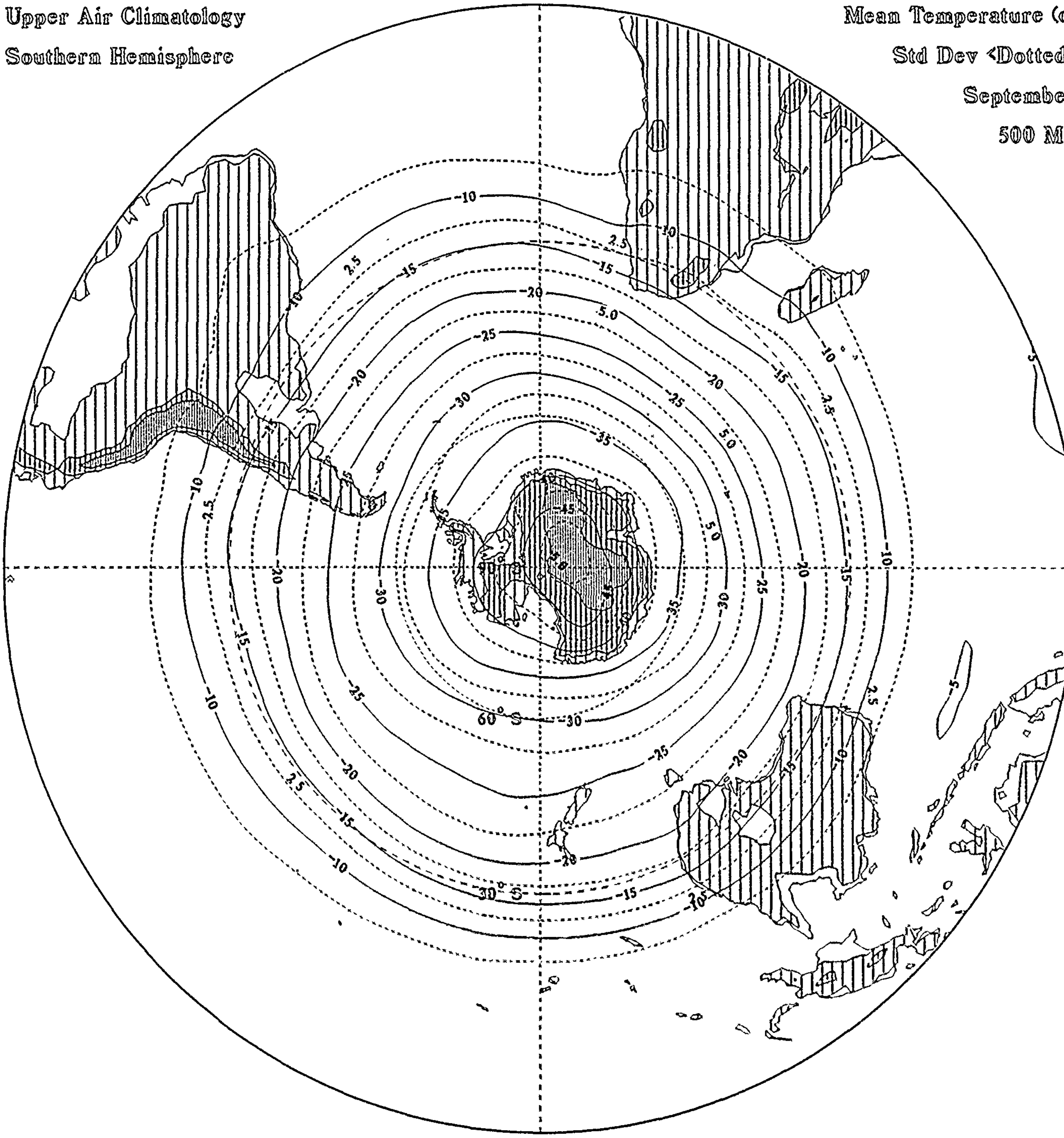
Southern Hemisphere

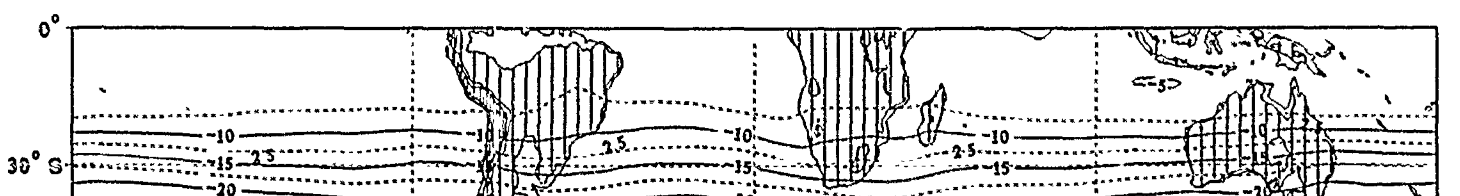
Mean Temperature (c)

Std Dev <Dotted>

September

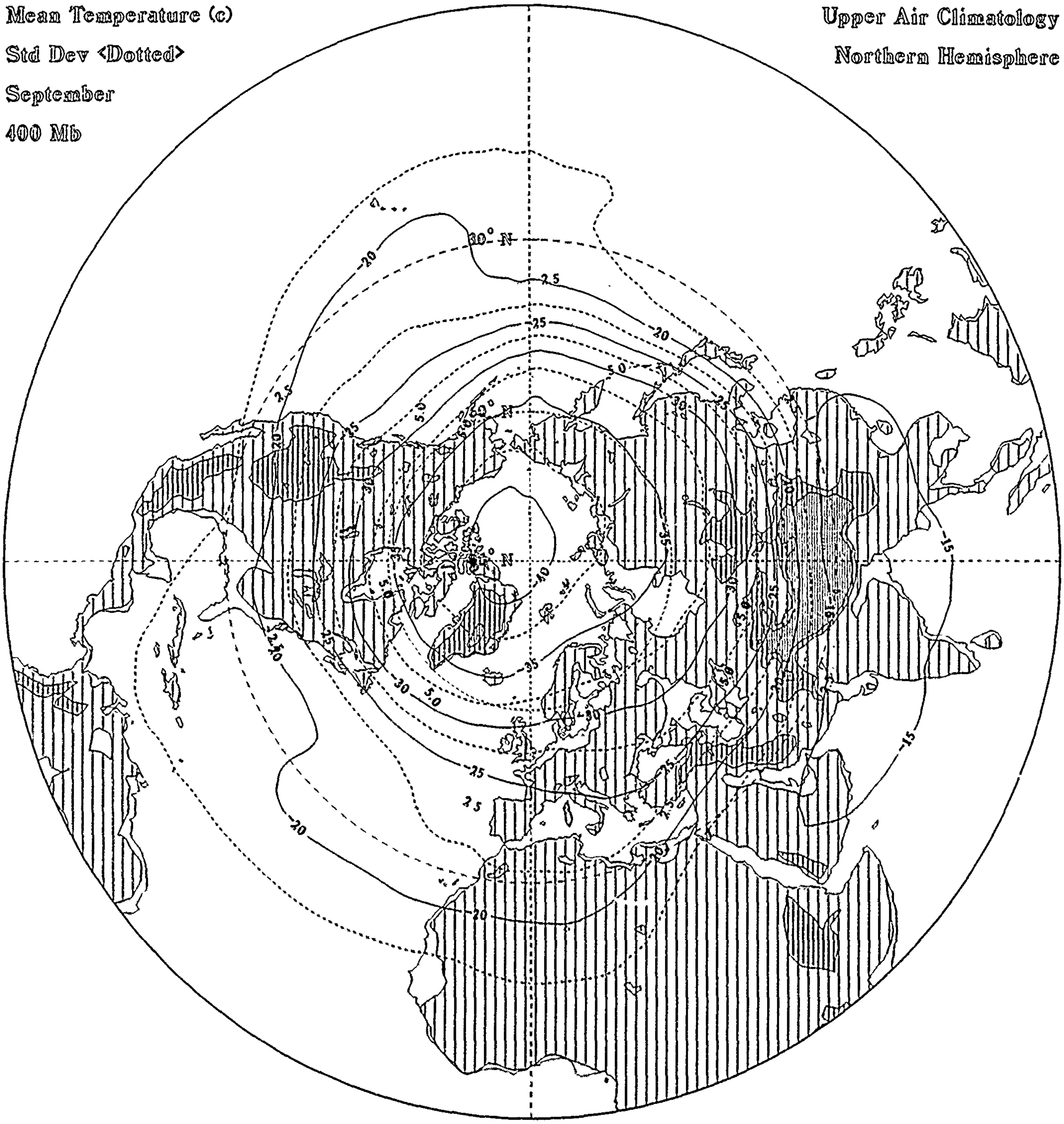
500 Mb

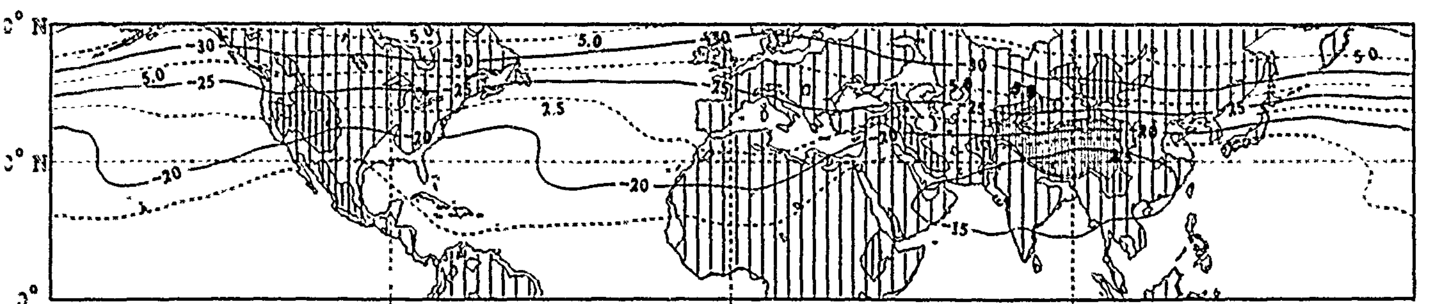




Mean Temperature (c)
Std Dev <Dotted>
September
400 Mb

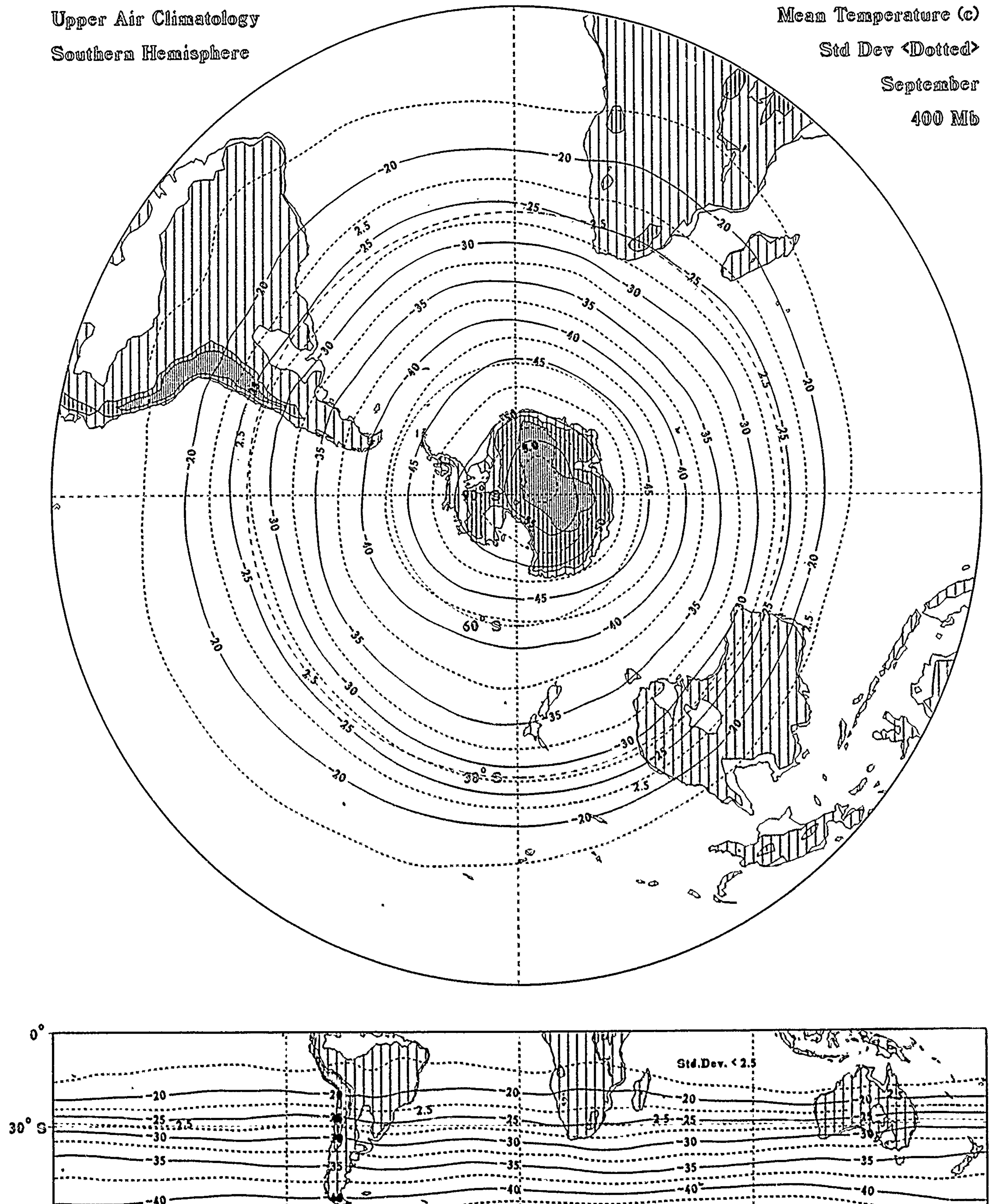
Upper Air Climatology
Northern Hemisphere





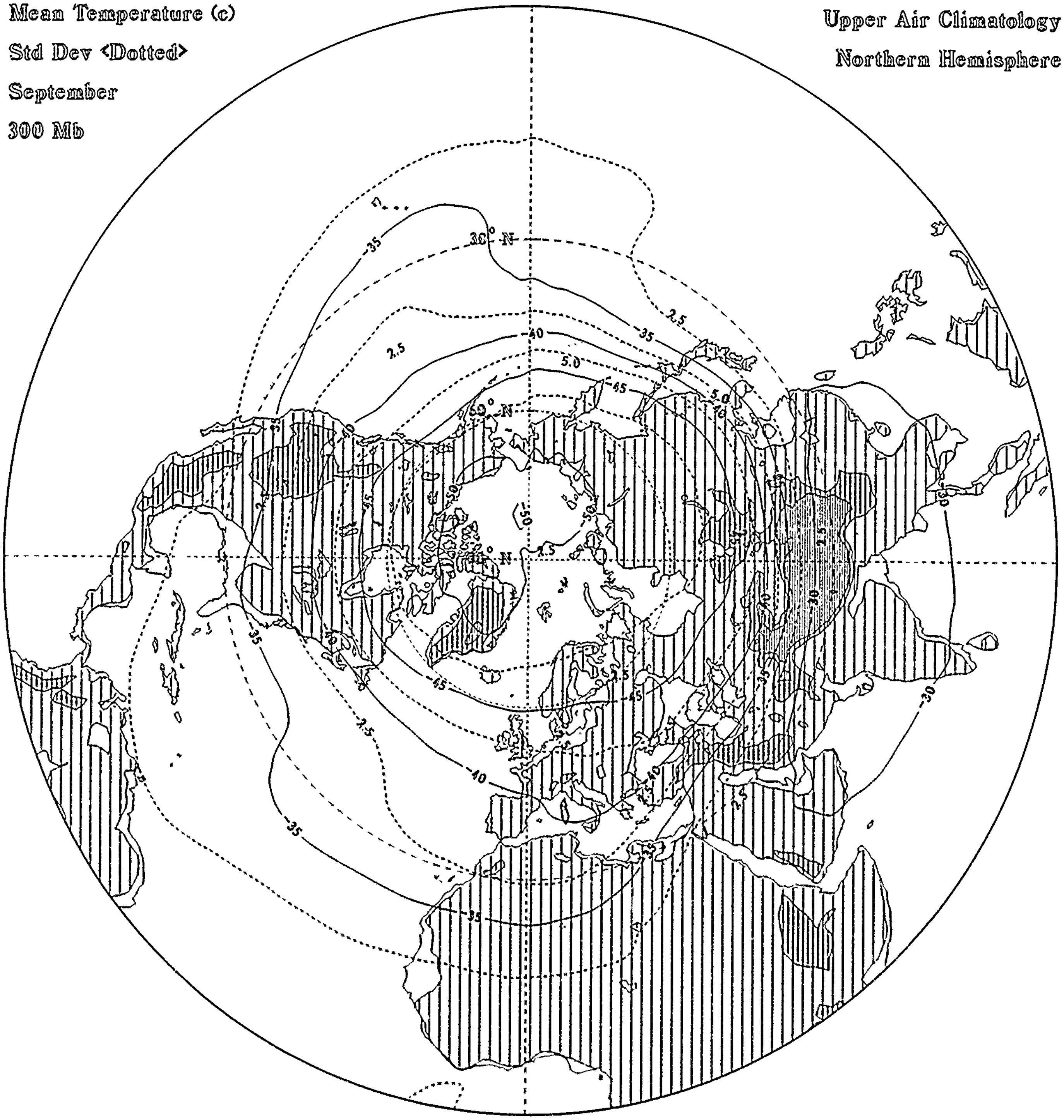
Upper Air Climatology
Southern Hemisphere

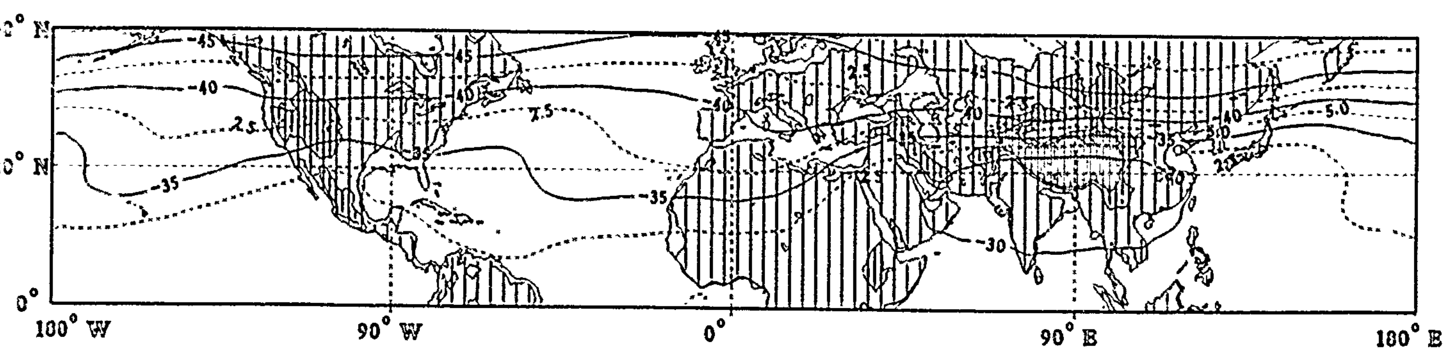
Mean Temperature (c)
Std Dev <Dotted>
September
400 Mb



Mean Temperature (c)
Std Dev <Dotted>
September
300 Mb

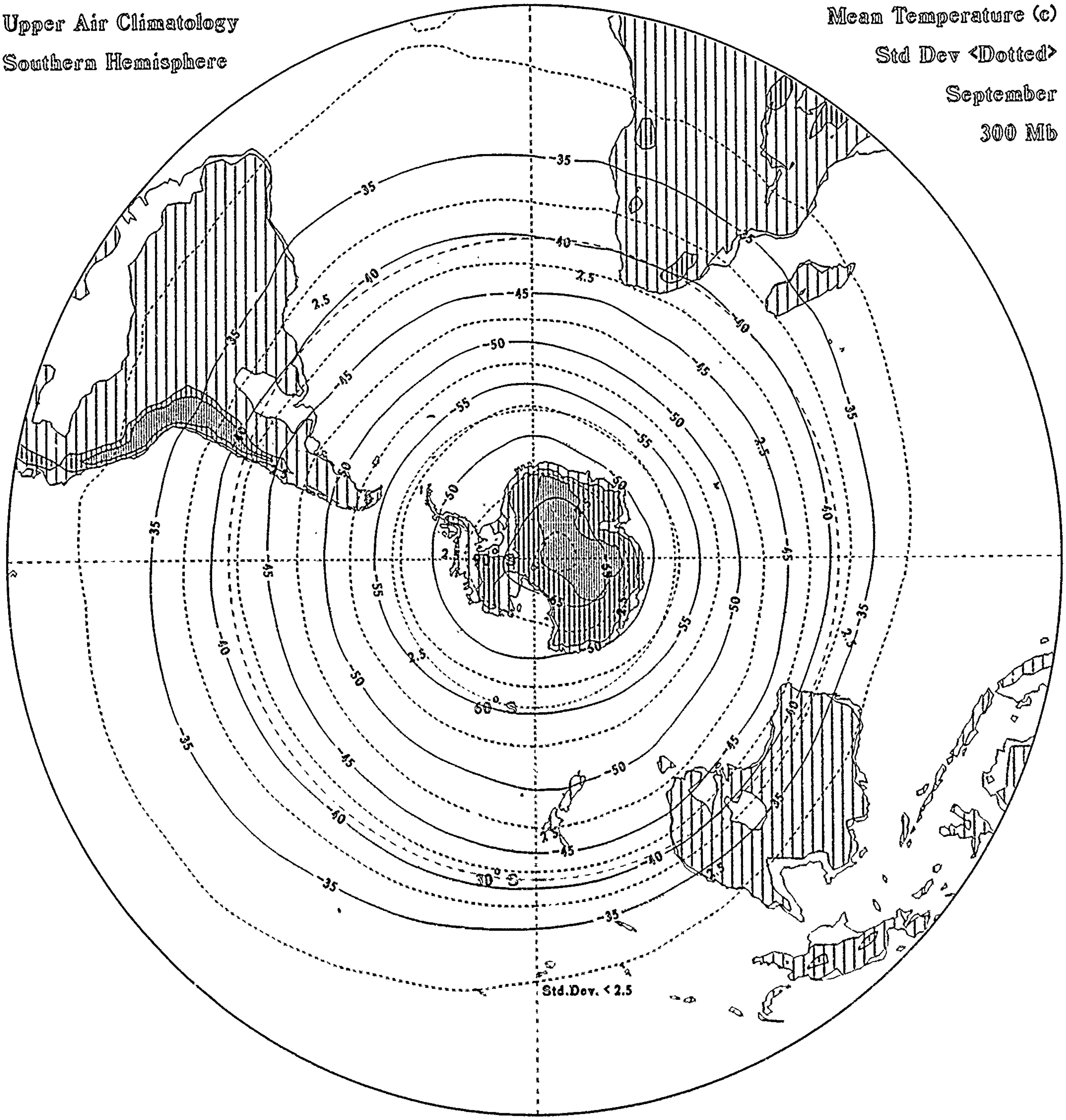
Upper Air Climatology
Northern Hemisphere

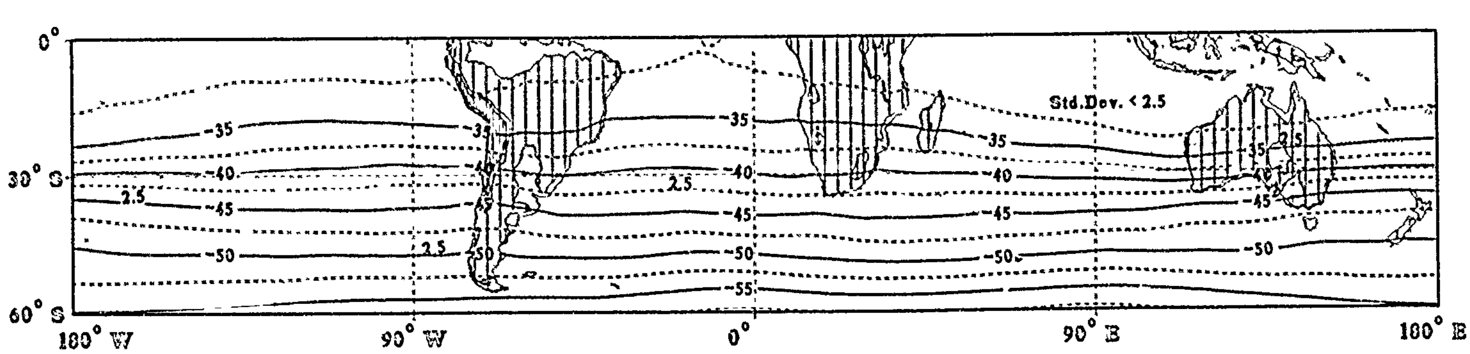




Upper Air Climatology
Southern Hemisphere

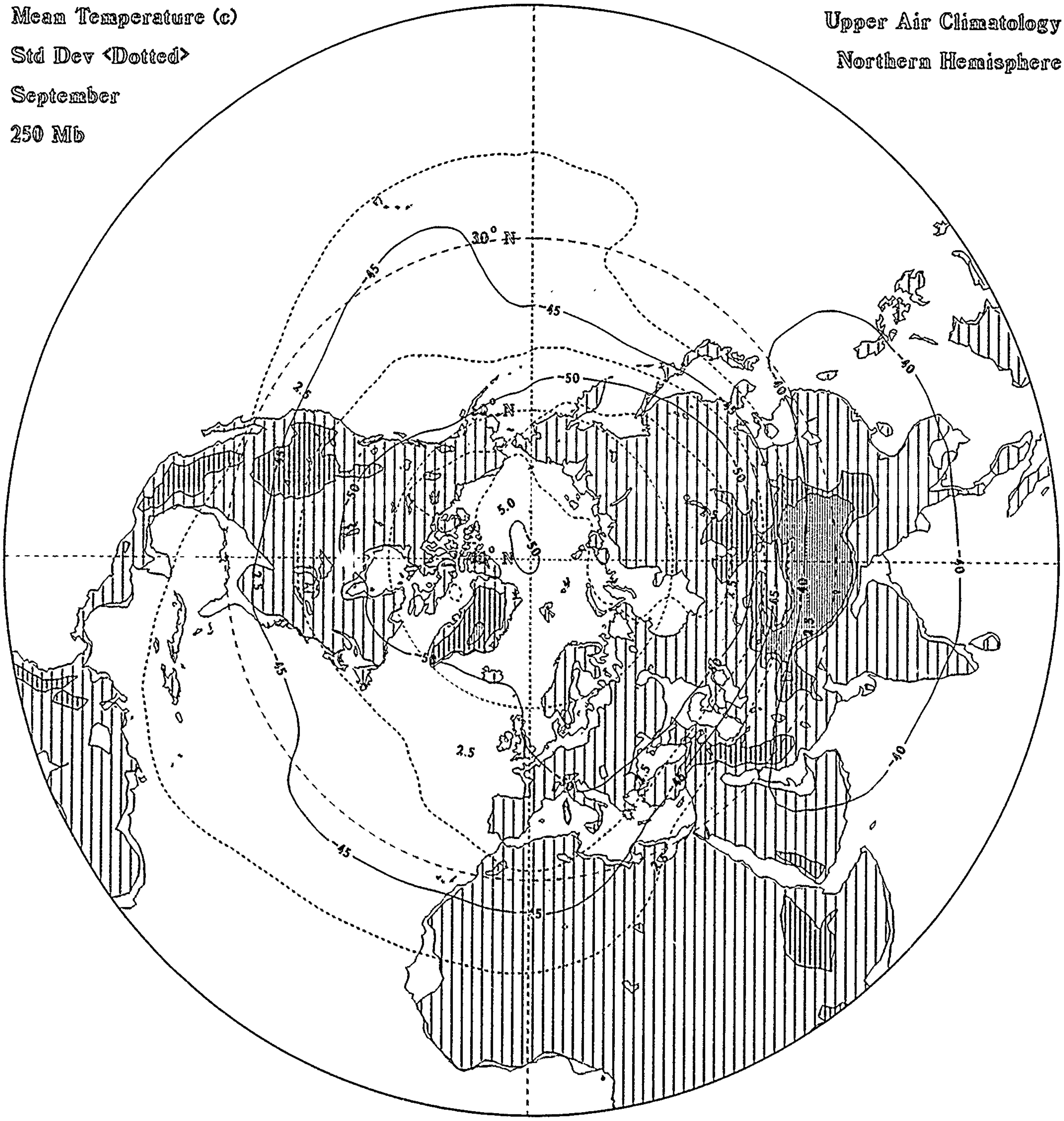
Mean Temperature (c)
Std Dev <Dotted>
September
300 Mb

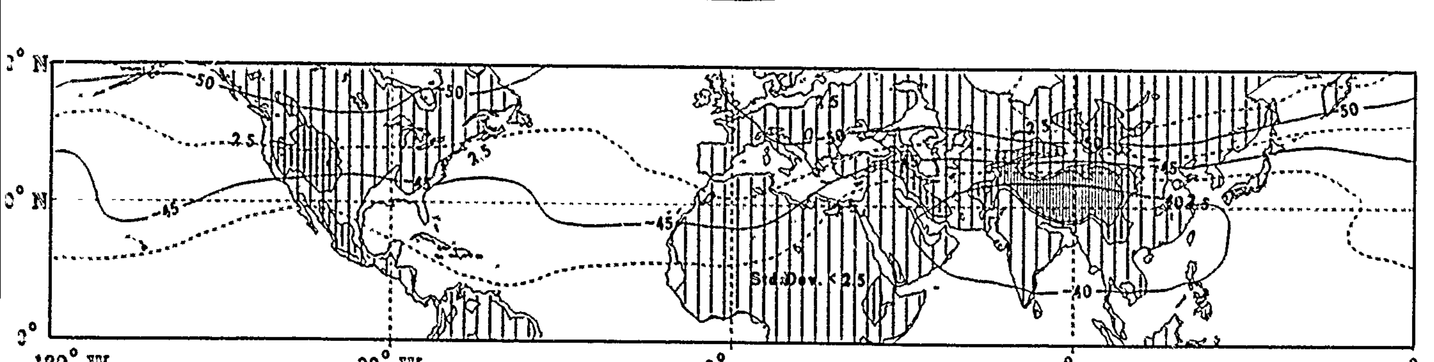


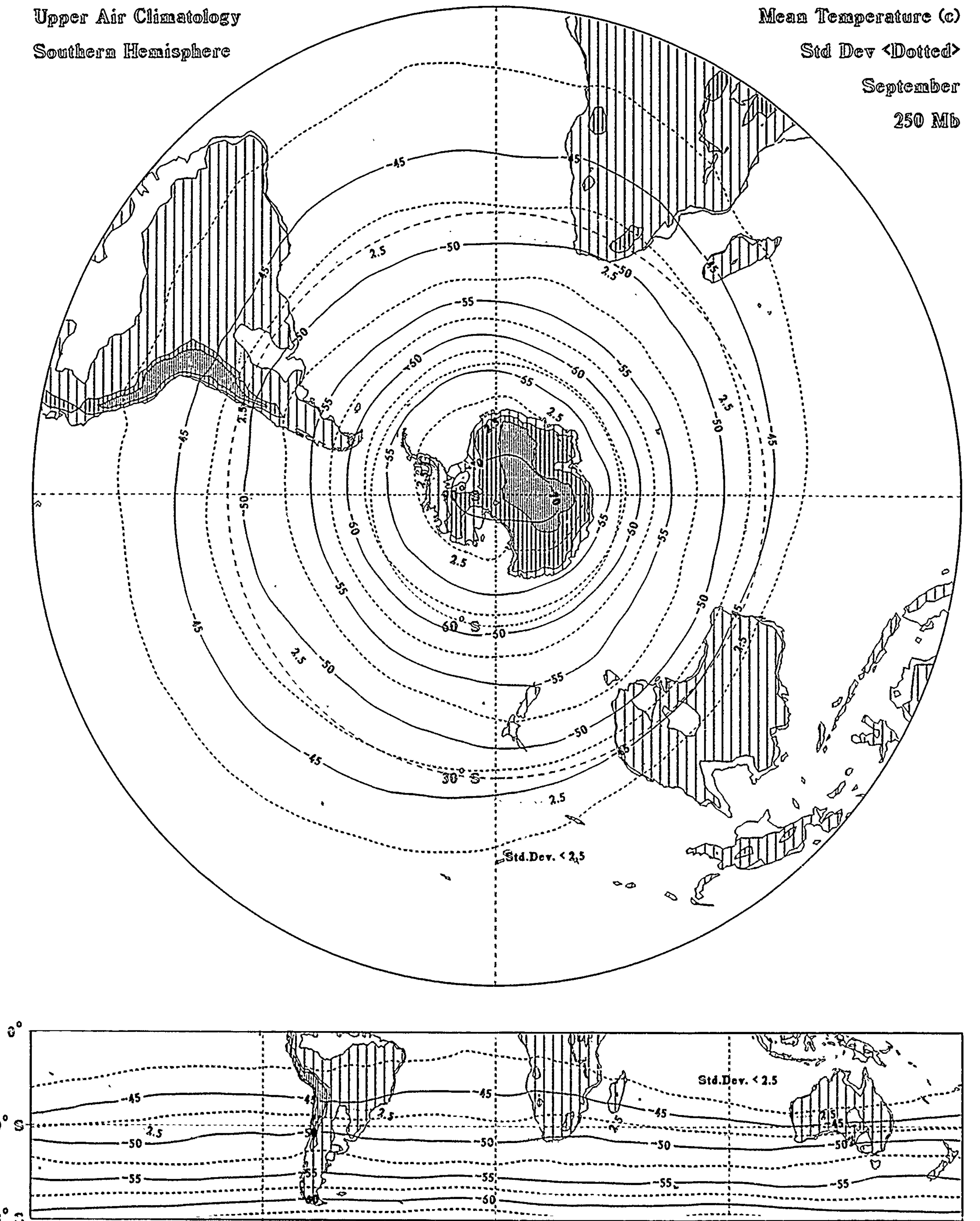


Mean Temperature (c)
Std Dev <Dotted>
September
250 Mb

Upper Air Climatology
Northern Hemisphere






Upper Air Climatology
Southern Hemisphere
Mean Temperature (c)
Std Dev <Dotted>
September
250 Mb
60° S
30° S
Std.Dev. < 2.5
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

Mean Temperature (c)

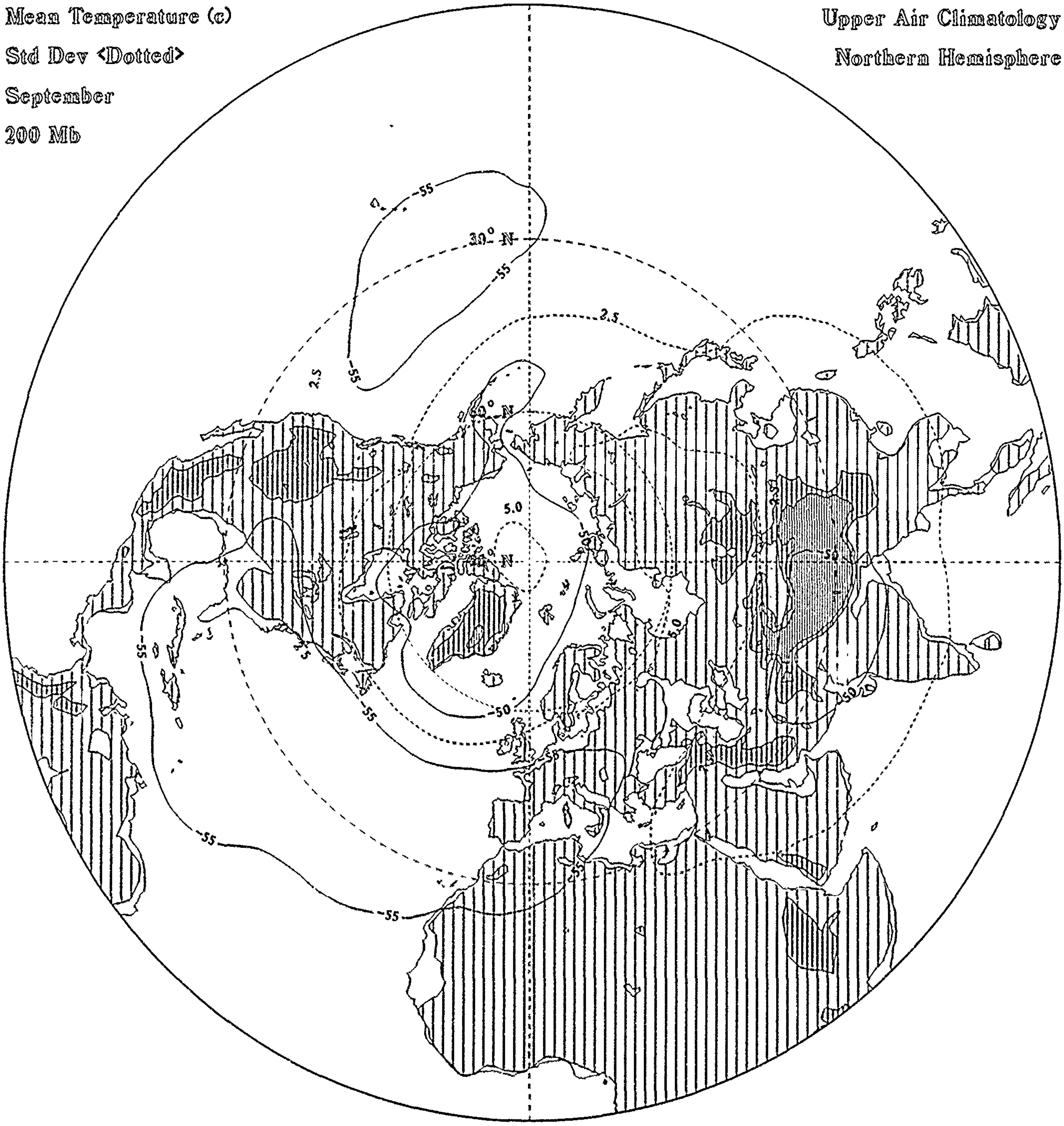
Std Dev <Dotted>

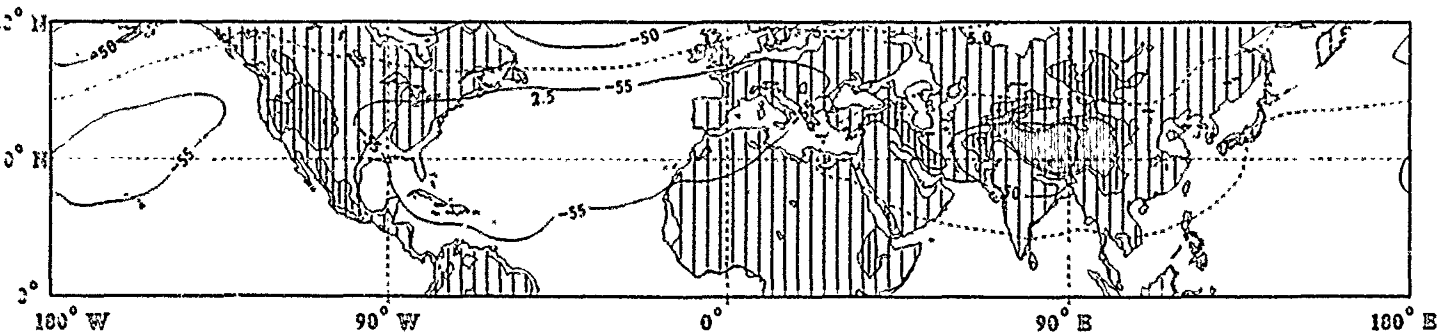
September

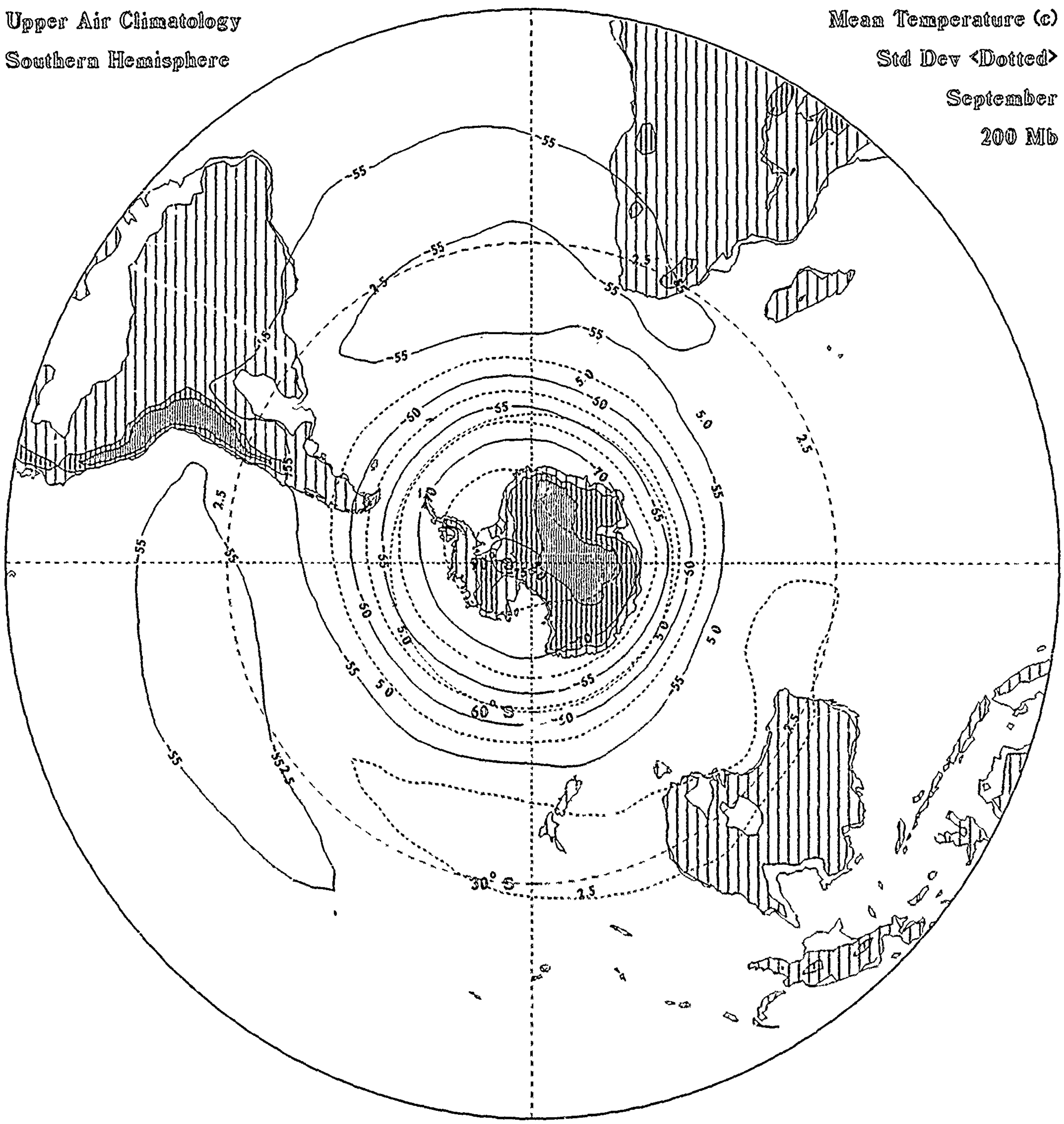
200 Mb

Upper Air Climatology

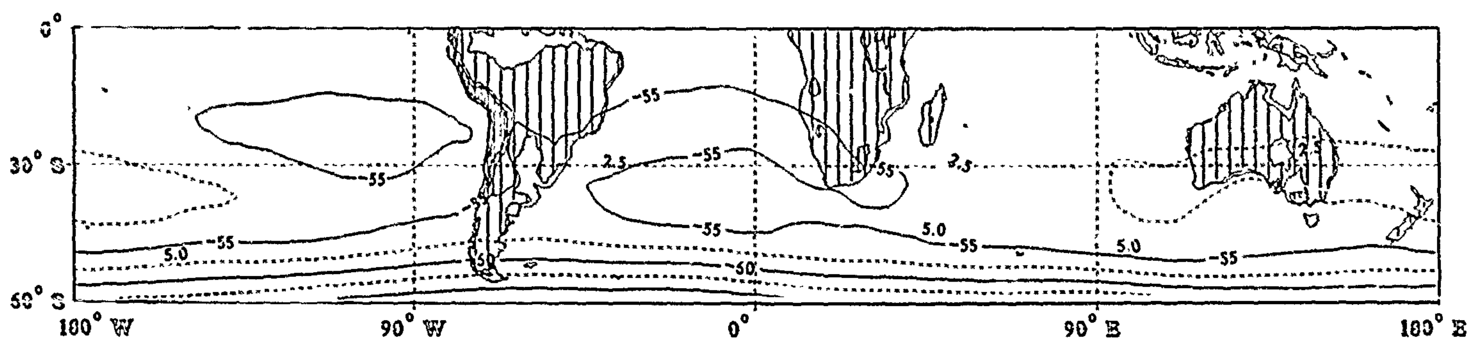
Northern Hemisphere







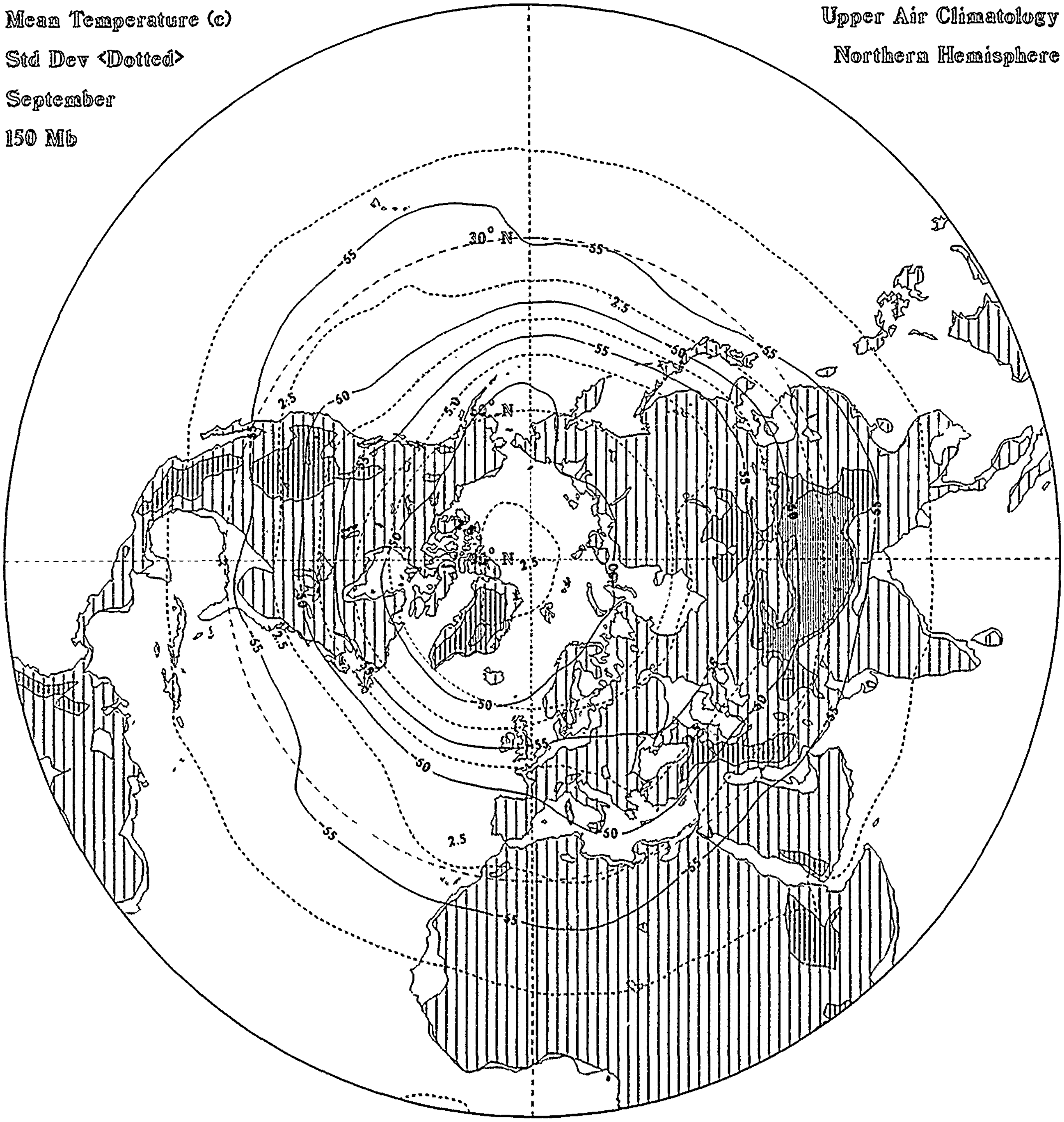
Upper Air Climatology
Southern Hemisphere
Mean Temperature (c)
Std Dev <Dotted>
September
200 Mb
60° S
30° S

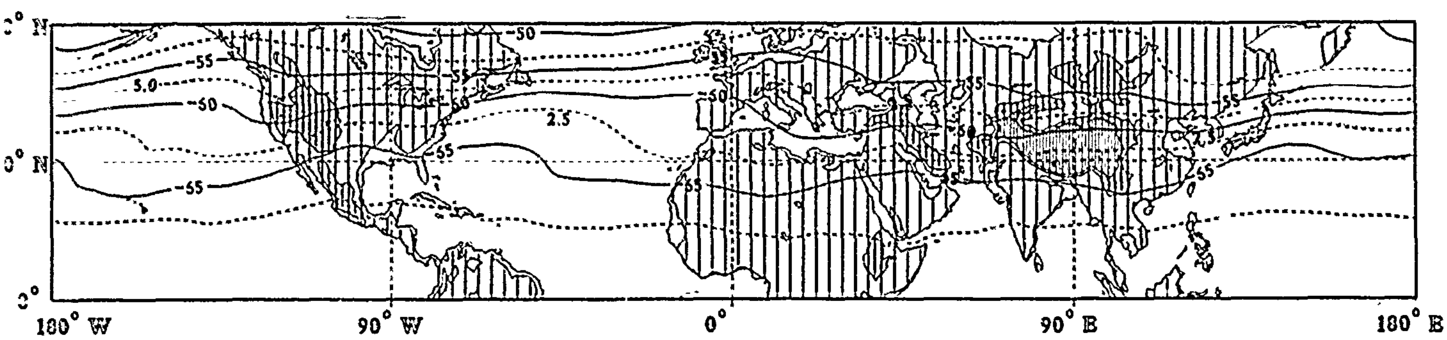


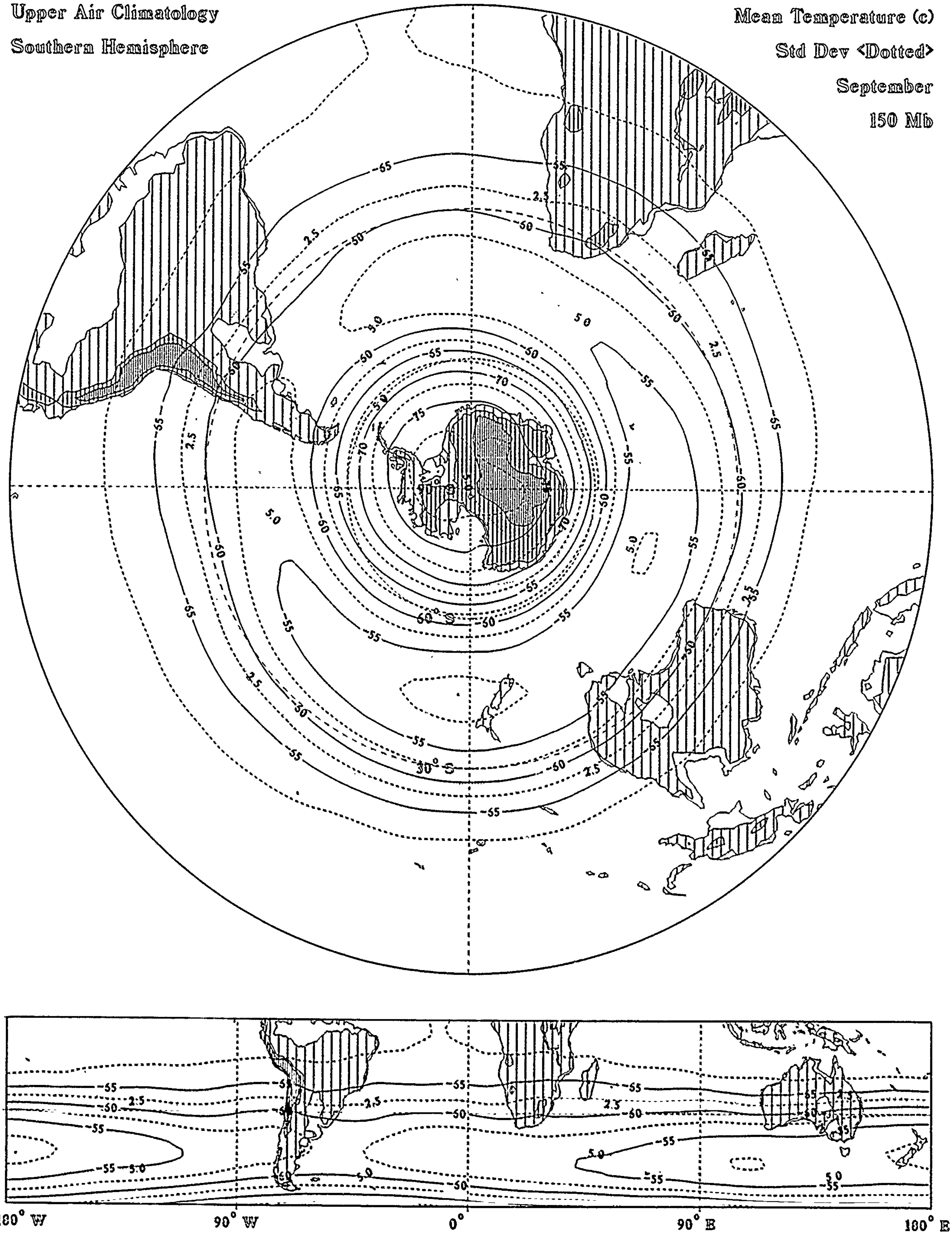
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

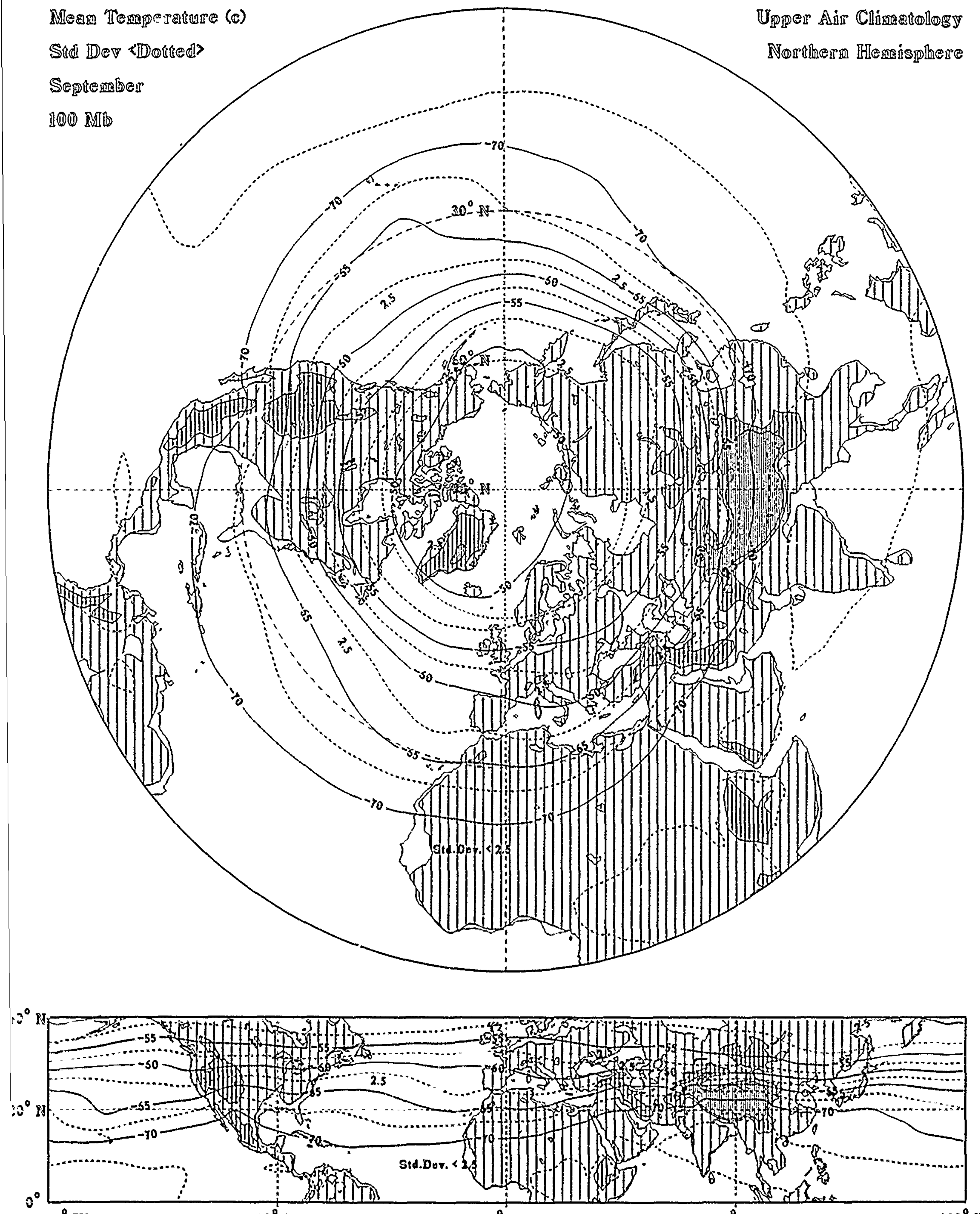
Mean Temperature (c)
Std Dev <Dotted>
September
150 Mb

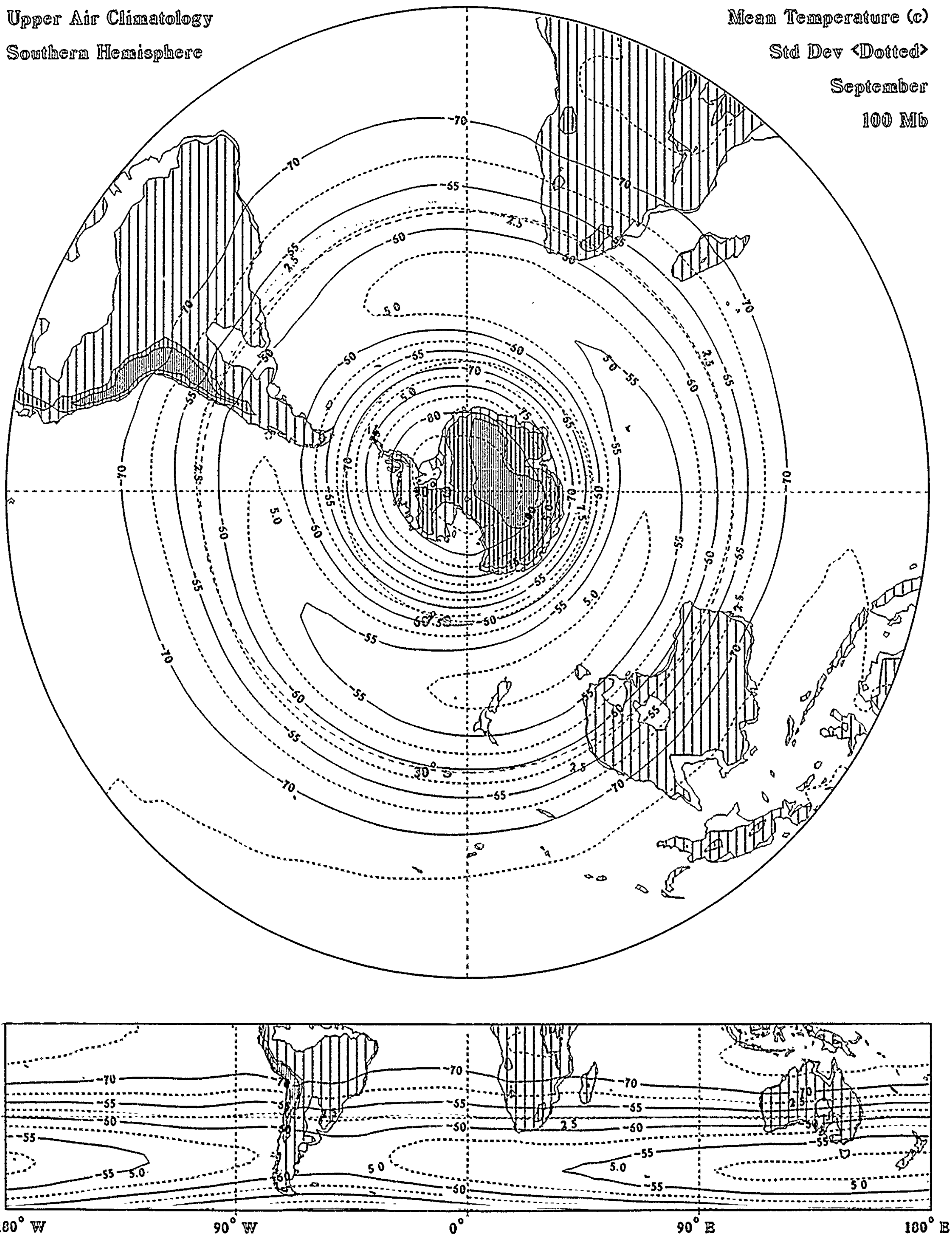
Upper Air Climatology
Northern Hemisphere





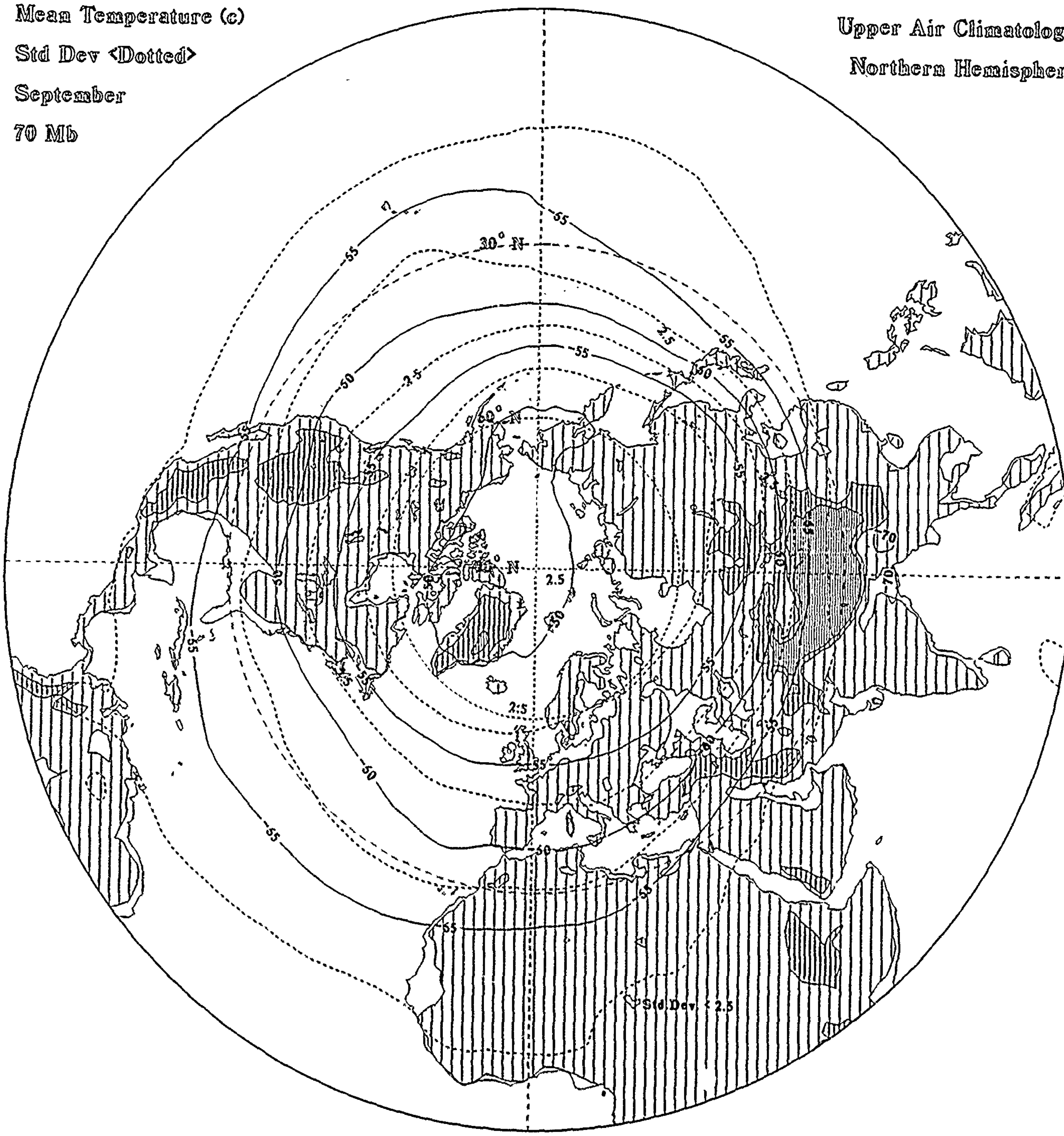

Upper Air Climatology
Southern Hemisphere
Mean Temperature (c)
Std Dev <Dotted>
September
150 Mb
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

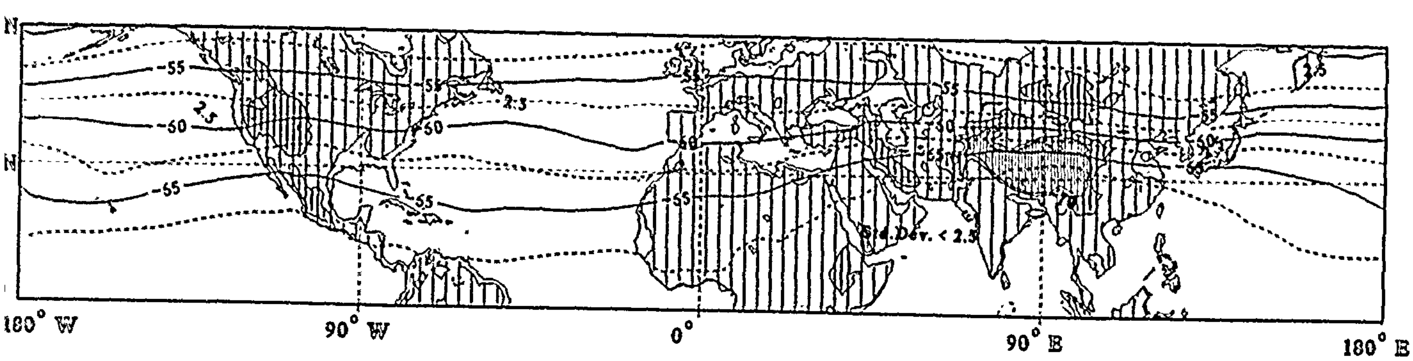

Mean Temperature (c)
Std Dev <Dotted>
September
100 Mb
Upper Air Climatology
Northern Hemisphere
30° N
Std.Dev. < 2.5
180° W
90° W
0°
90° E
180° E

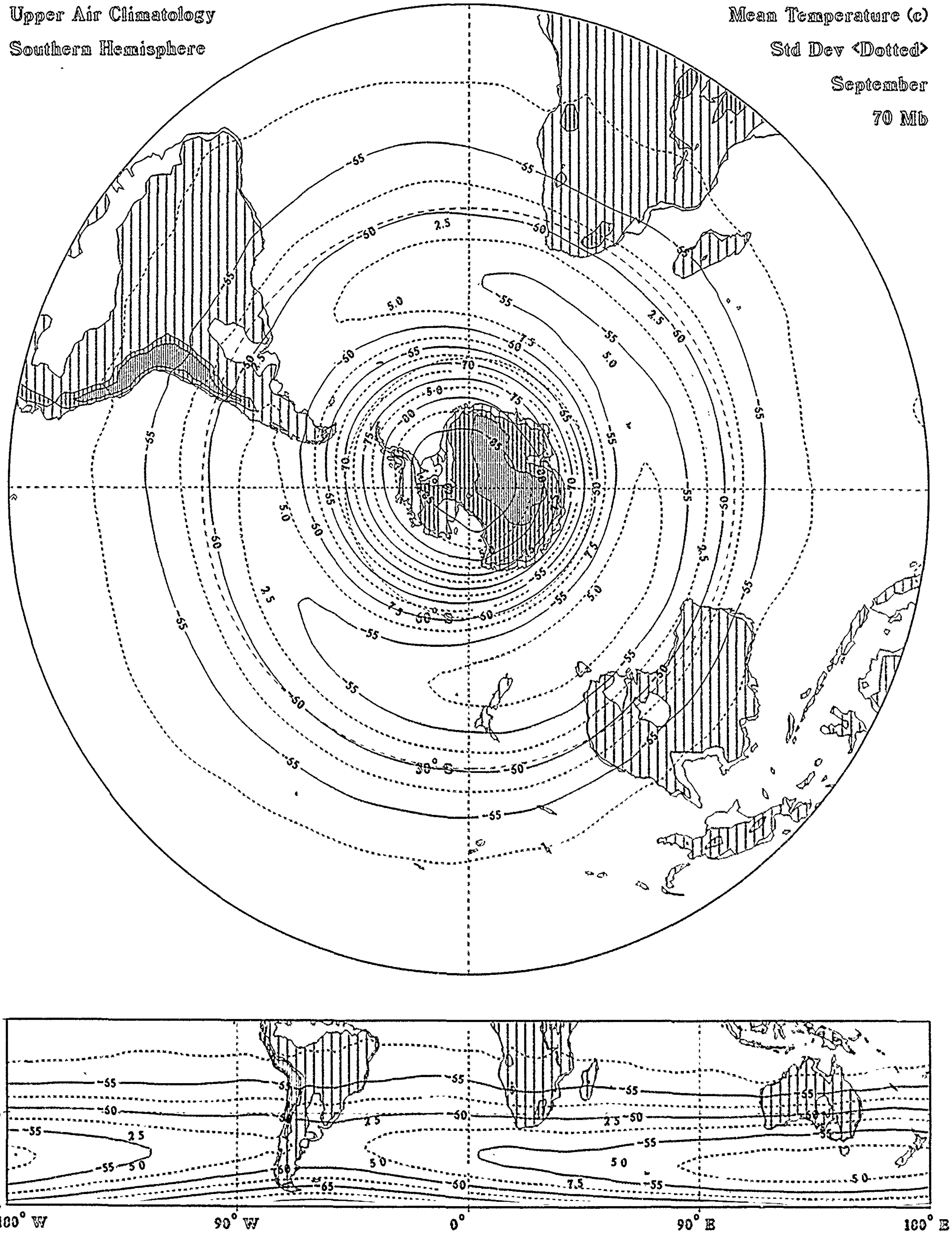

Upper Air Climatology
Southern Hemisphere
Mean Temperature (c)
Std Dev <Dotted>
September
100 Mb
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

Mean Temperature (c)
Std Dev <Dotted>
September
70 Mb

Upper Air Climatology
Northern Hemisphere







Upper Air Climatology
Southern Hemisphere
Mean Temperature (c)
Std Dev <Dotted>
September
70 Mb
30° S
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

Mean Temperature (c)

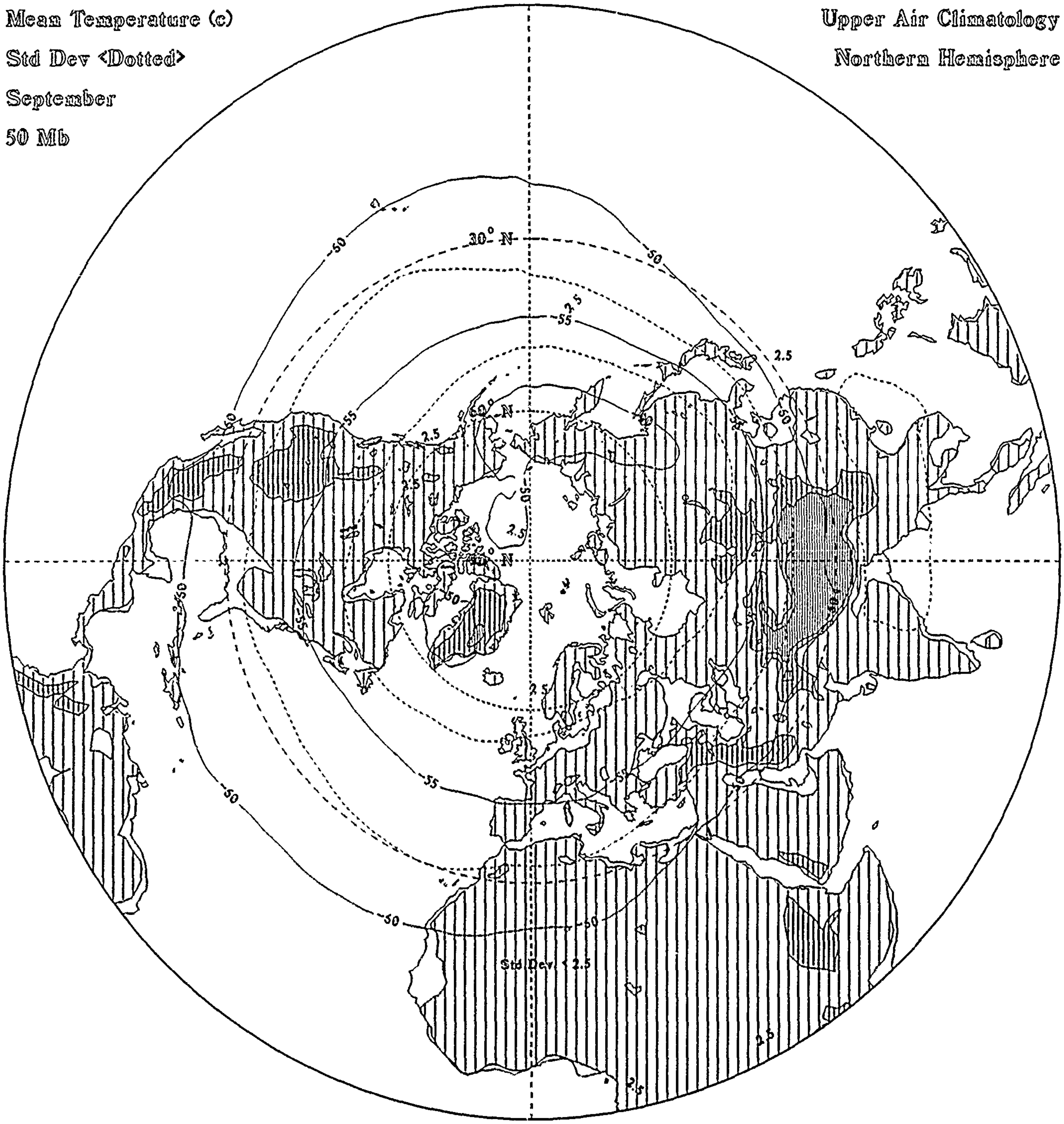
Std Dev <Dotted>

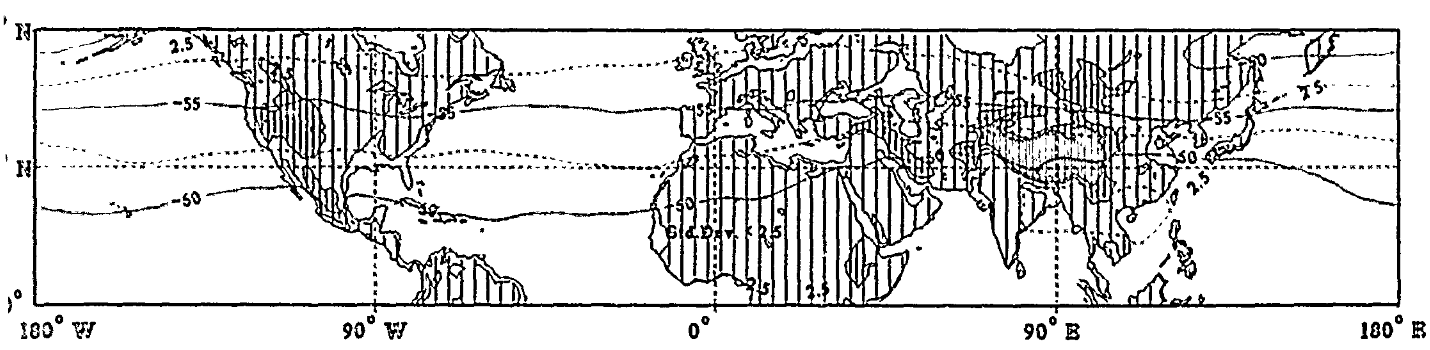
September

50 Mb

Upper Air Climatology

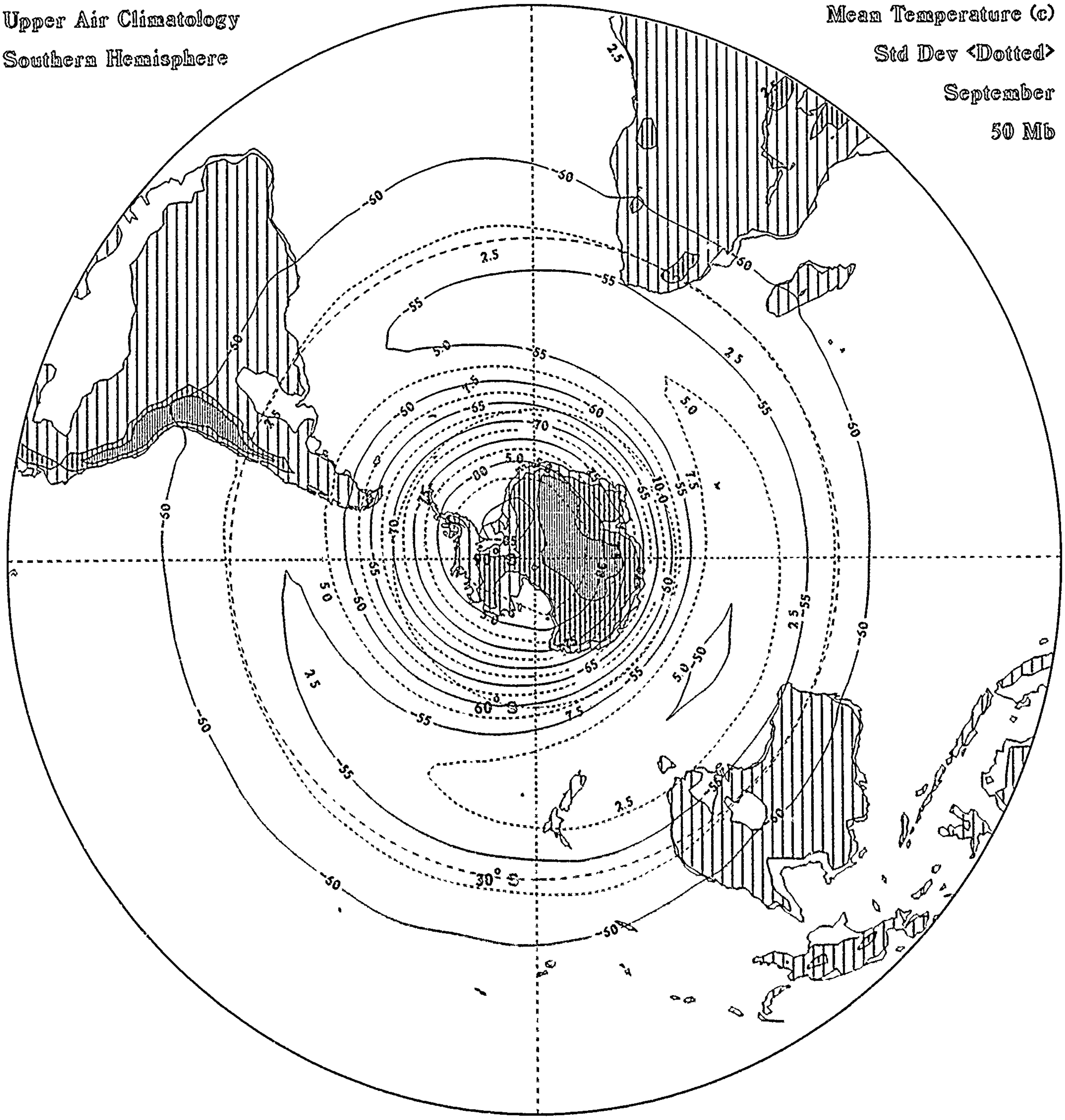
Northern Hemisphere

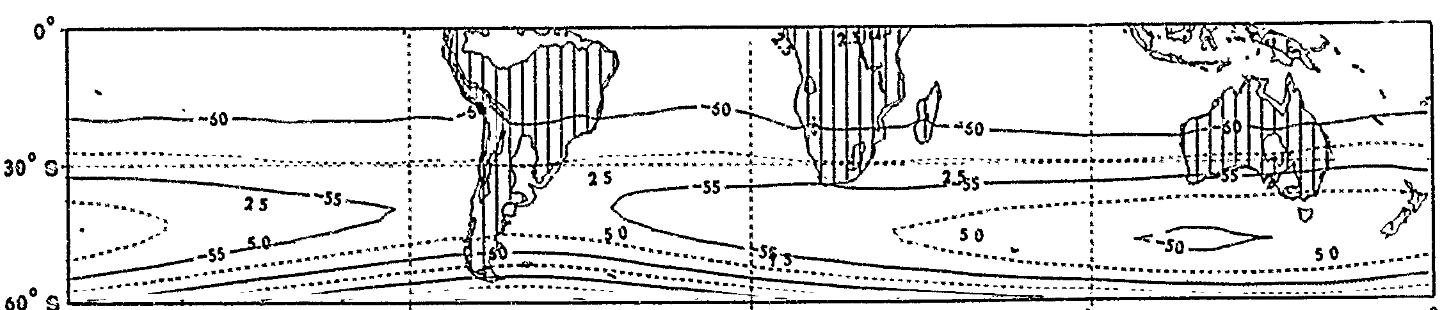




Upper Air Climatology
Southern Hemisphere

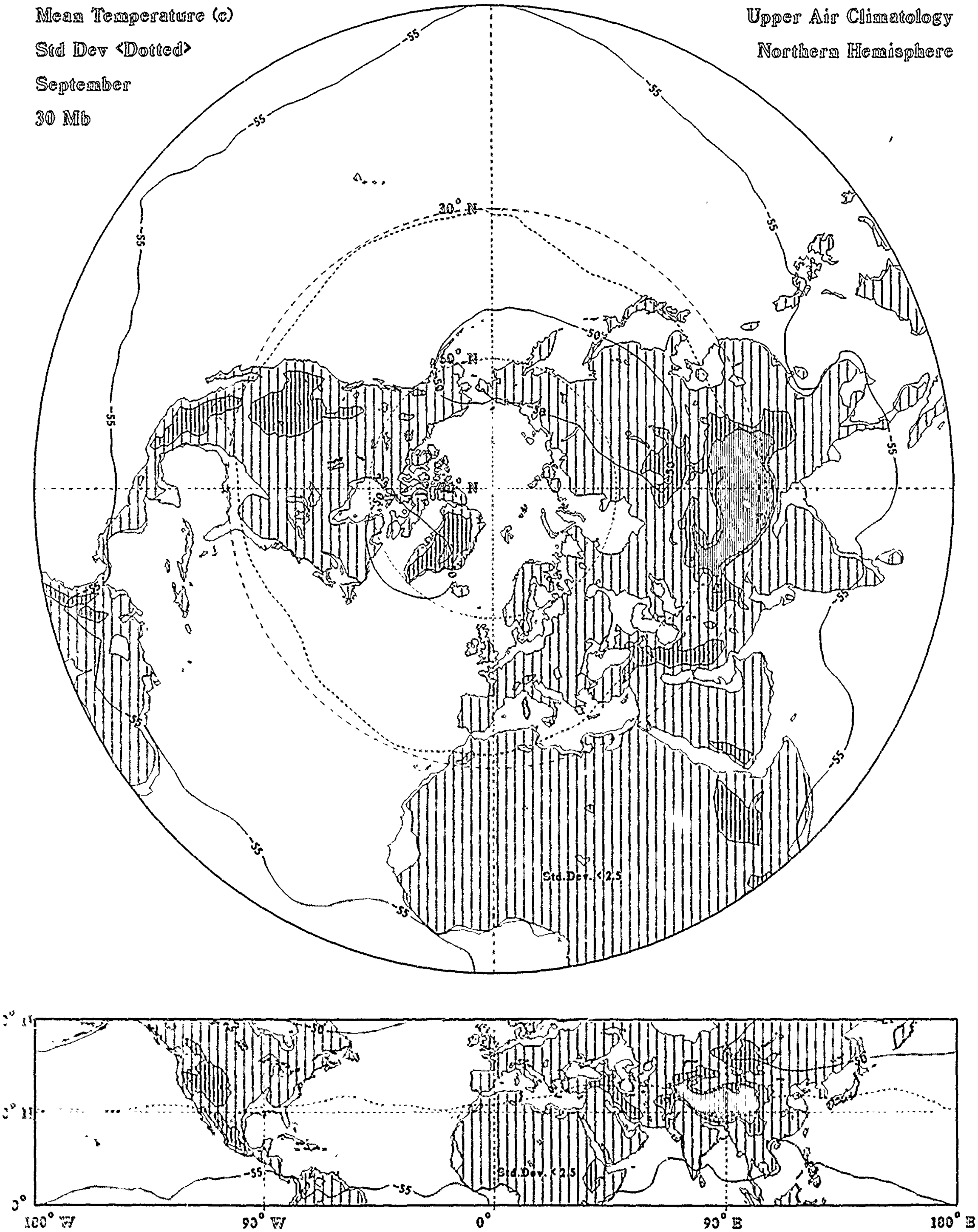
Mean Temperature (c)
Std Dev <Dotted>
September
50 Mb





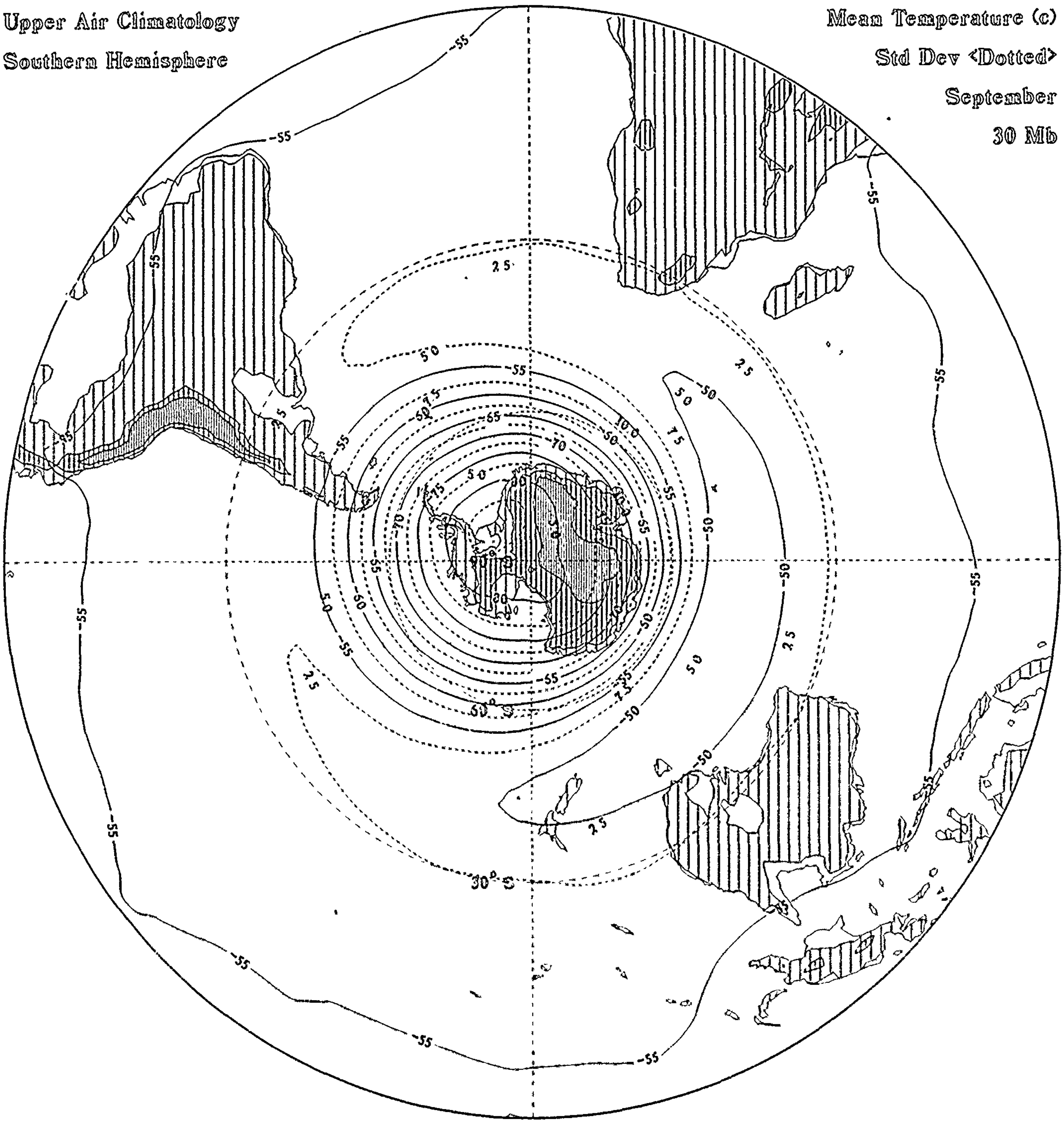
Mean Temperature (c)
Std Dev <Dotted>
September
30 Mb

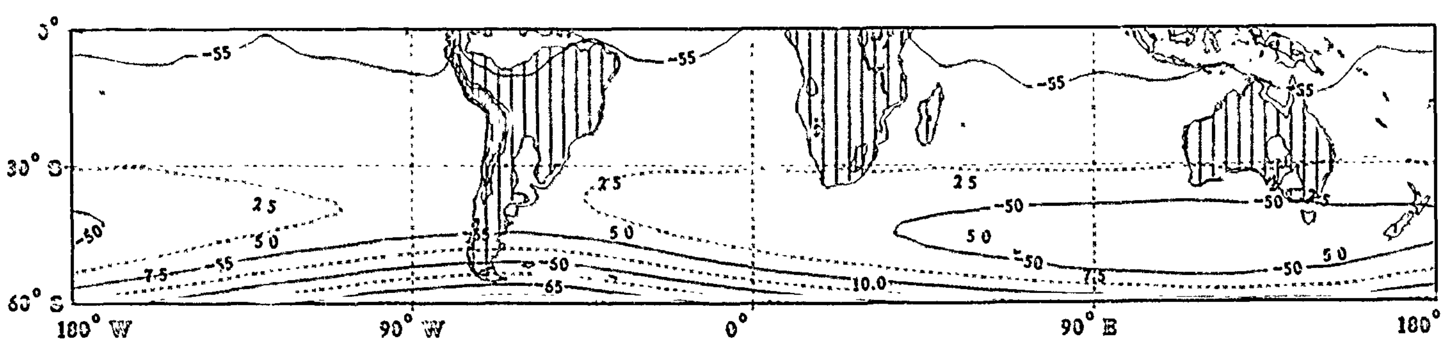
Upper Air Climatology
Northern Hemisphere



Upper Air Climatology
Southern Hemisphere

Mean Temperature (c)
Std Dev <Dotted>
September
30 Mb





DEW POINT
(6 LEVELS, 1000 TO 300 MB)

- Contours of mean dew point (solid and dashed lines) in °C; solids labeled, dashed intermediates unlabeled.

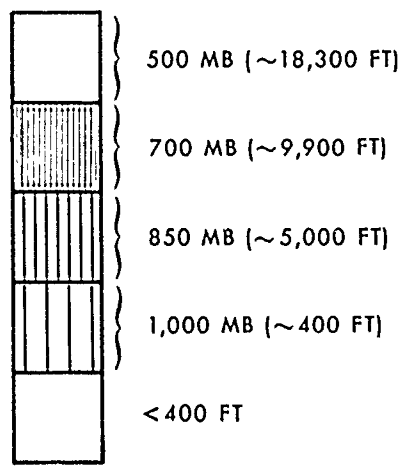
- Dew point labeled interval: 5°C

- Contours of standard deviation of dew point (dotted lines) in °C

- Standard deviation of dew point labeled interval: 2.5°C

- Contours blanked for geographic areas with elevations exceeding specified geopotential heights

ELEVATION SCALE



Mean Dew Point (c)

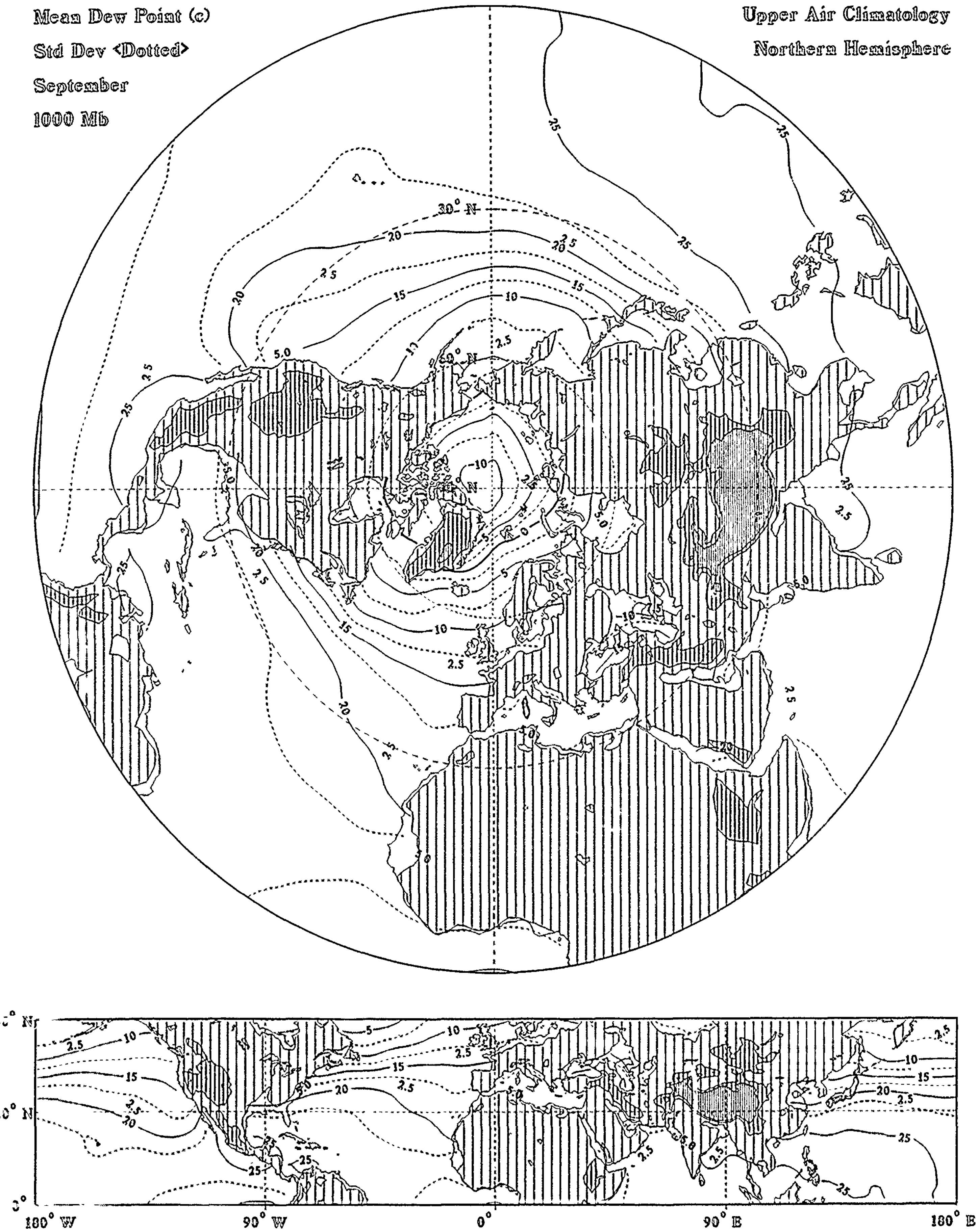
Std Dev <Dotted>

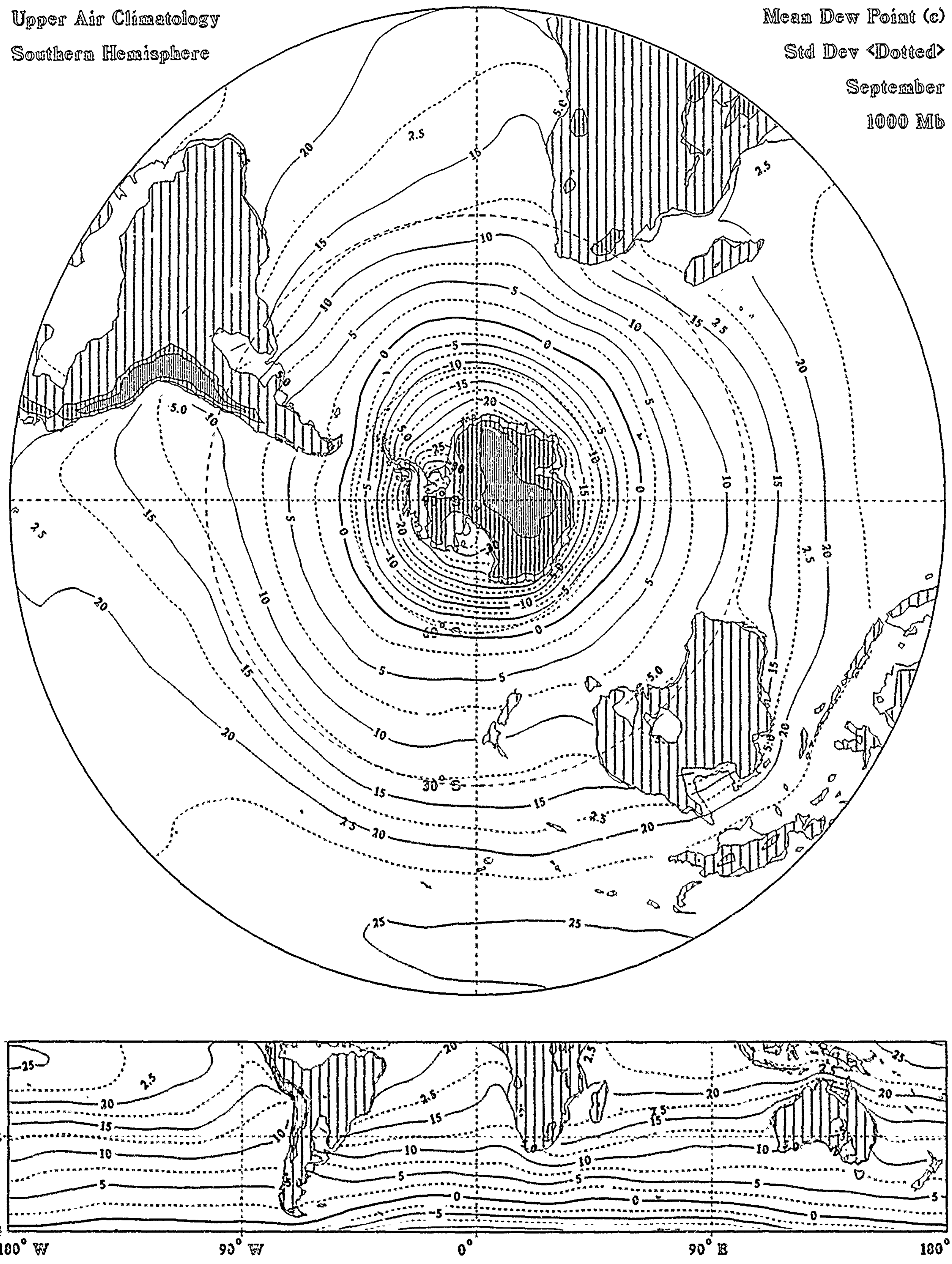
September

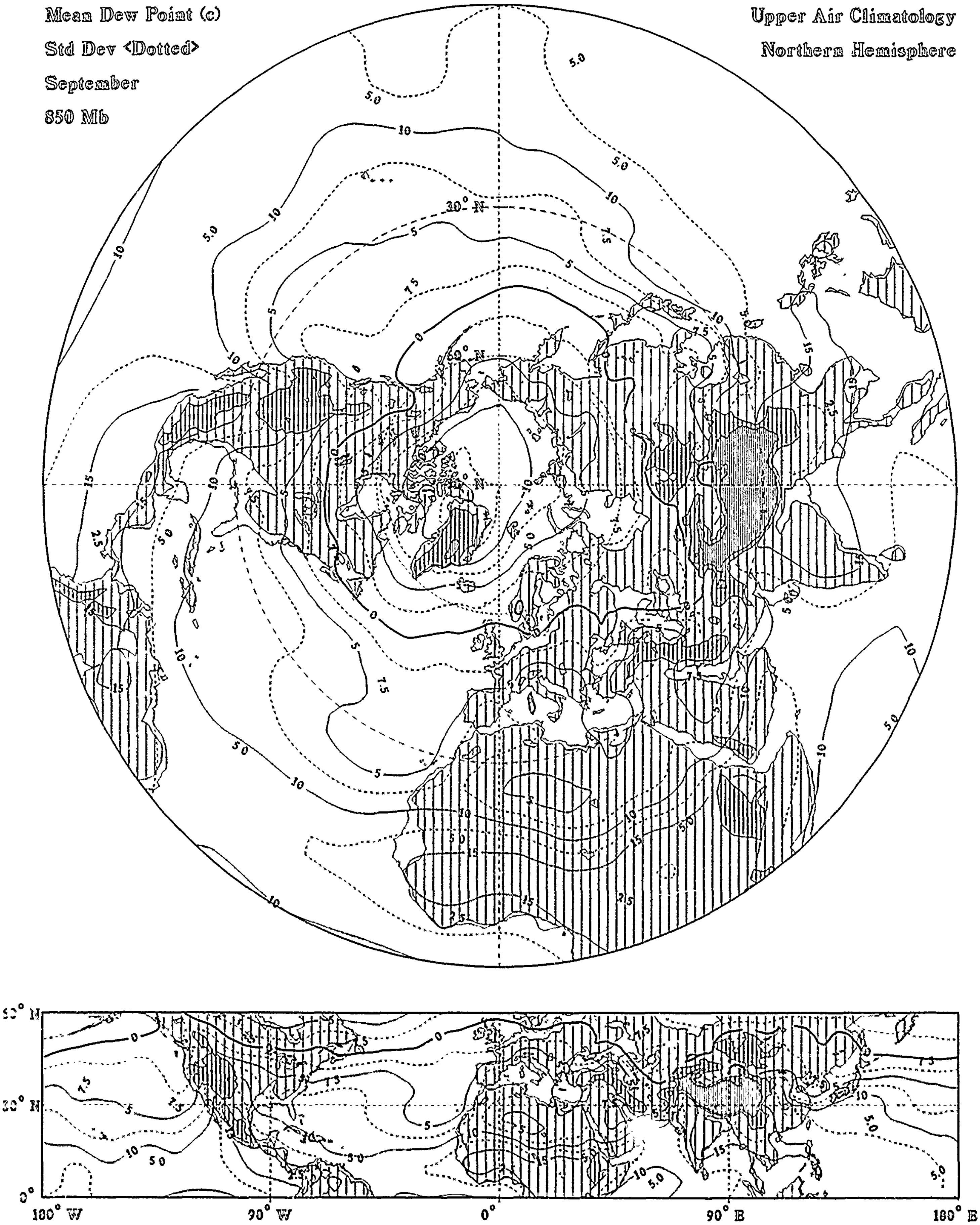
1000 Mb

Upper Air Climatology

Northern Hemisphere

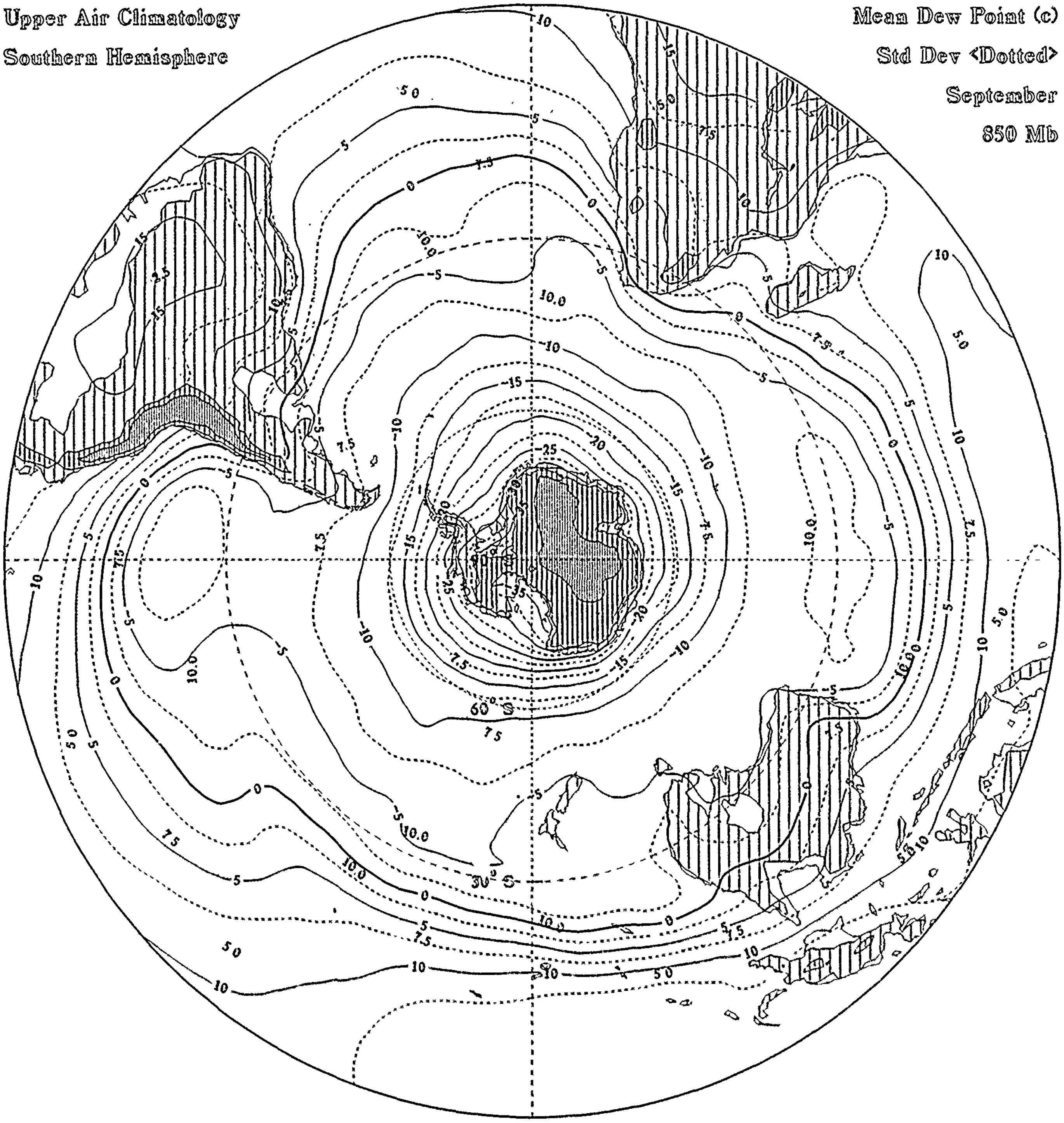


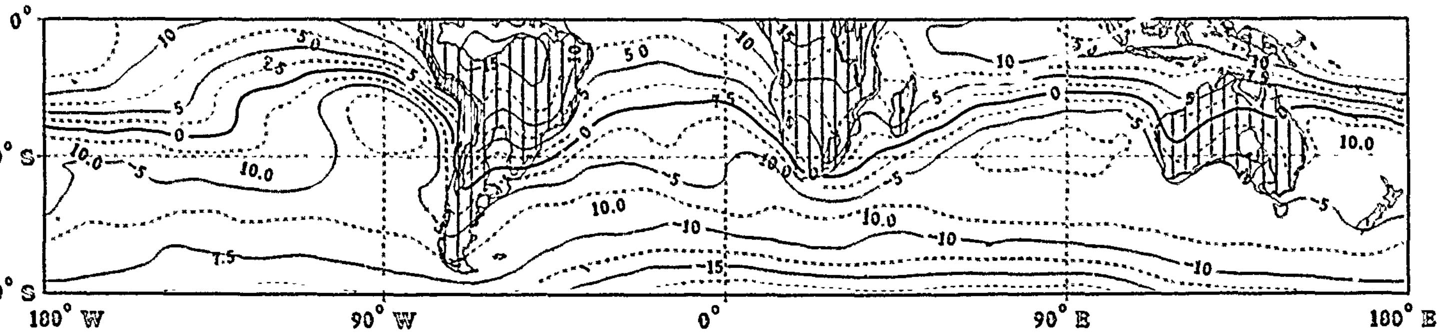

Upper Air Climatology
Southern Hemisphere
Mean Dew Point (c)
Std Dev <Dotted>
September
1000 Mb
30° S
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E


Mean Dew Point (c)
Std Dev <Dotted>
September
850 Mb
Upper Air Climatology
Northern Hemisphere
30° N
60° N
180° W
90° W
0°
90° E
180° E

Upper Air Climatology
Southern Hemisphere

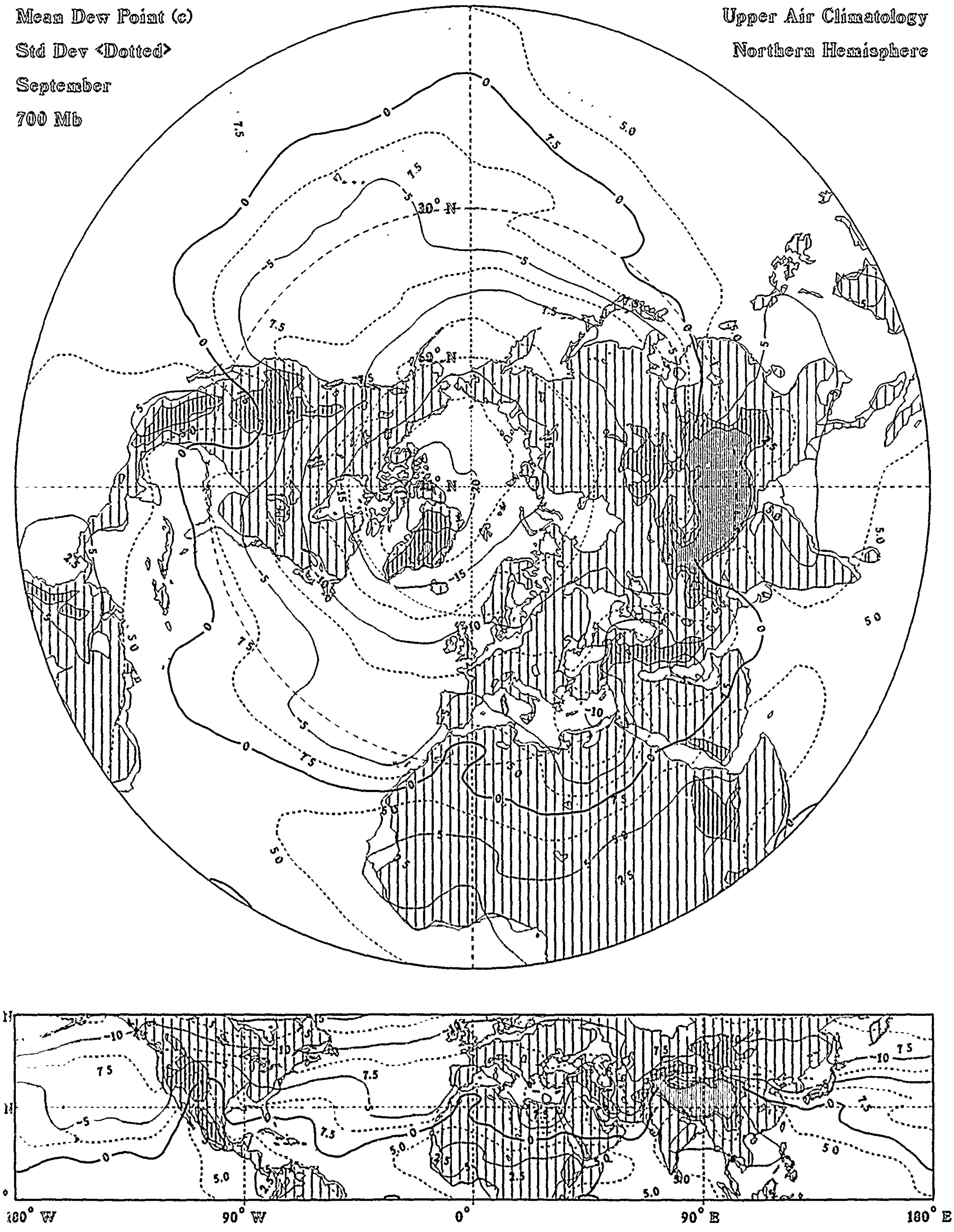
Mean Dew Point (c)
Std Dev <Dotted>
September
850 Mb





Mean Dew Point (c)
Std Dev <Dotted>
September
700 Mb

Upper Air Climatology
Northern Hemisphere



Upper Air Climatology

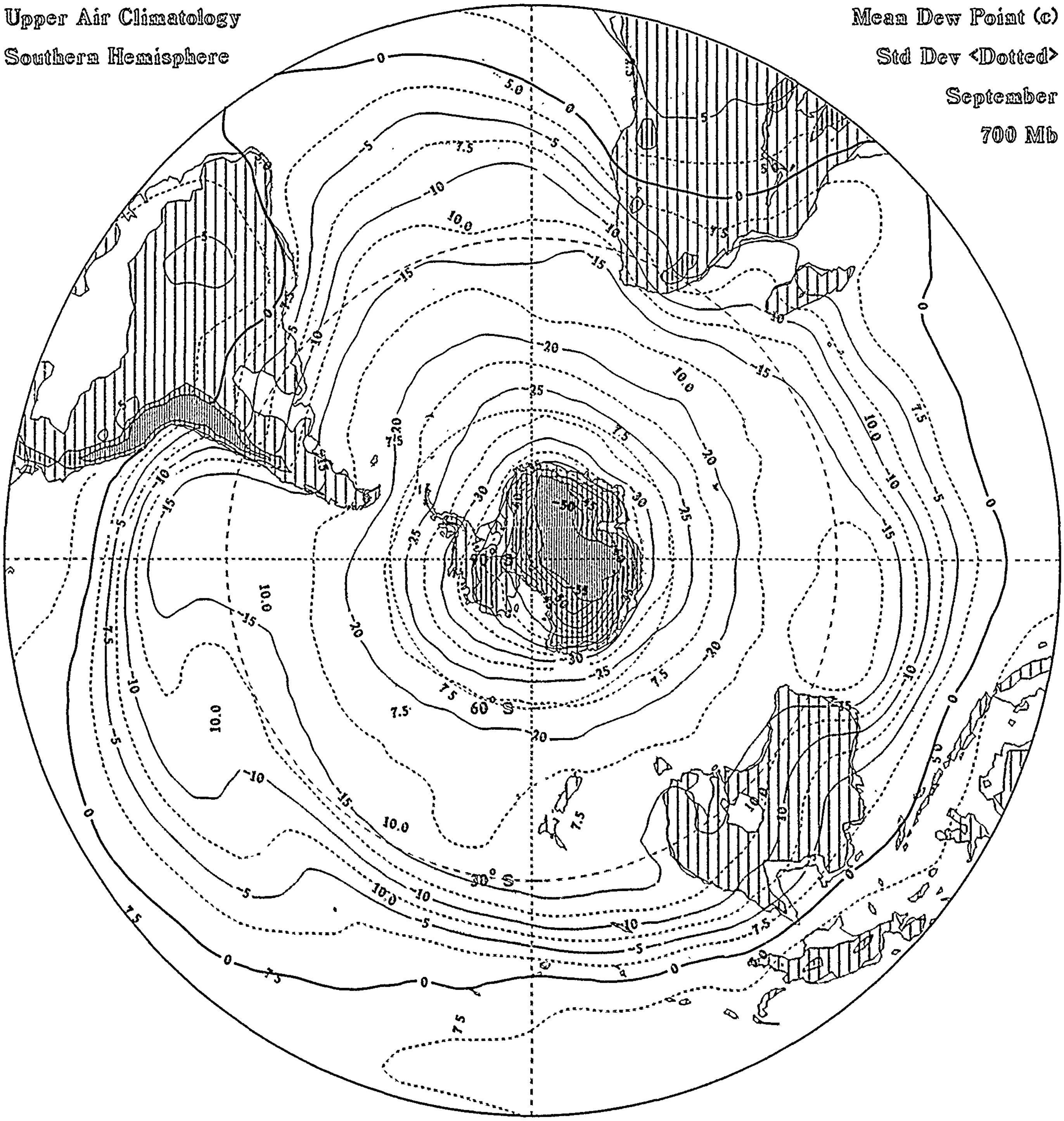
Southern Hemisphere

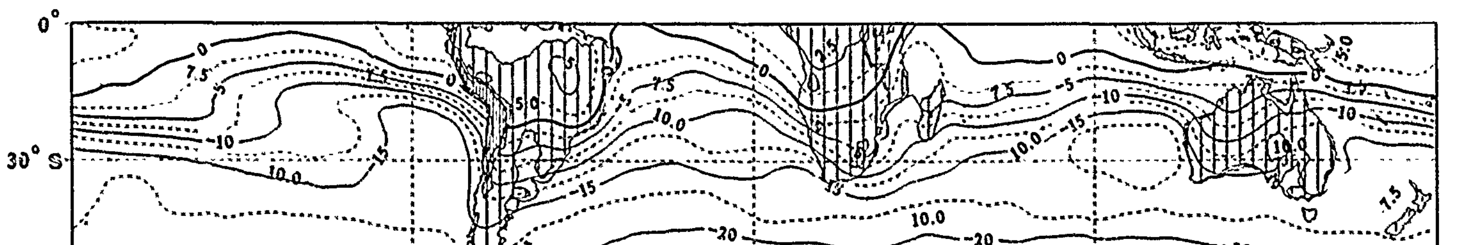
Mean Dew Point (c)

Std Dev <Dotted>

September

700 Mb





Mean Dew Point (c)

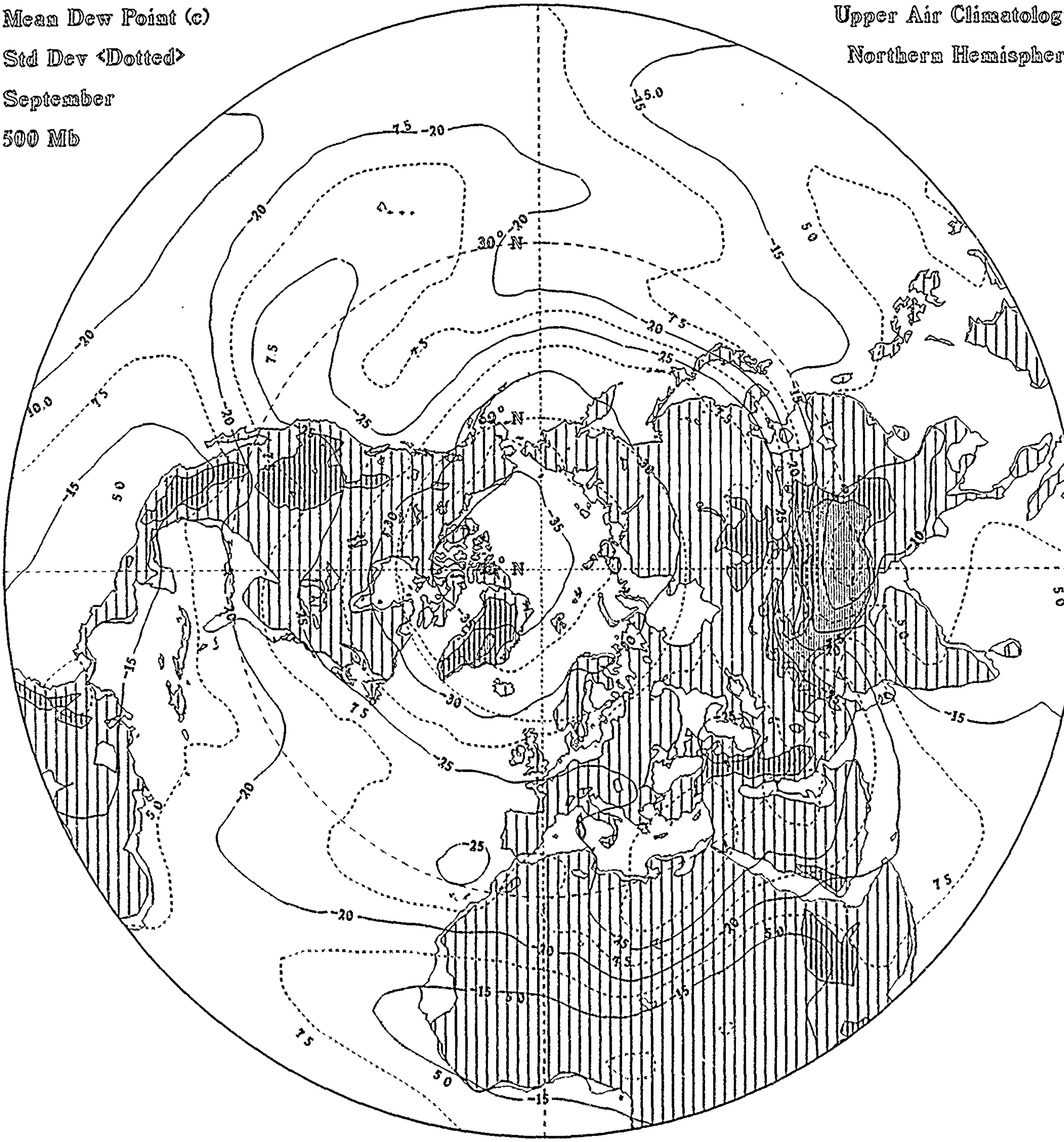
Std Dev <Dotted>

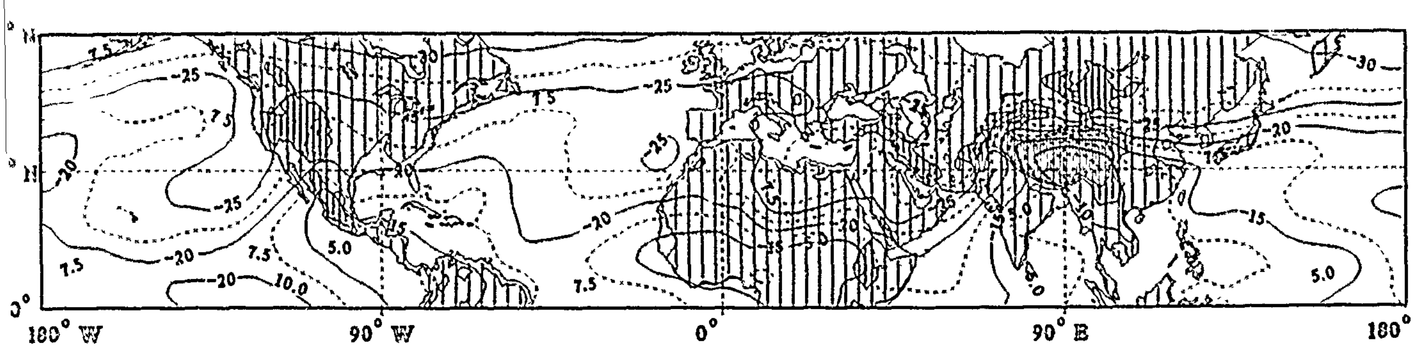
September

500 Mb

Upper Air Climatology

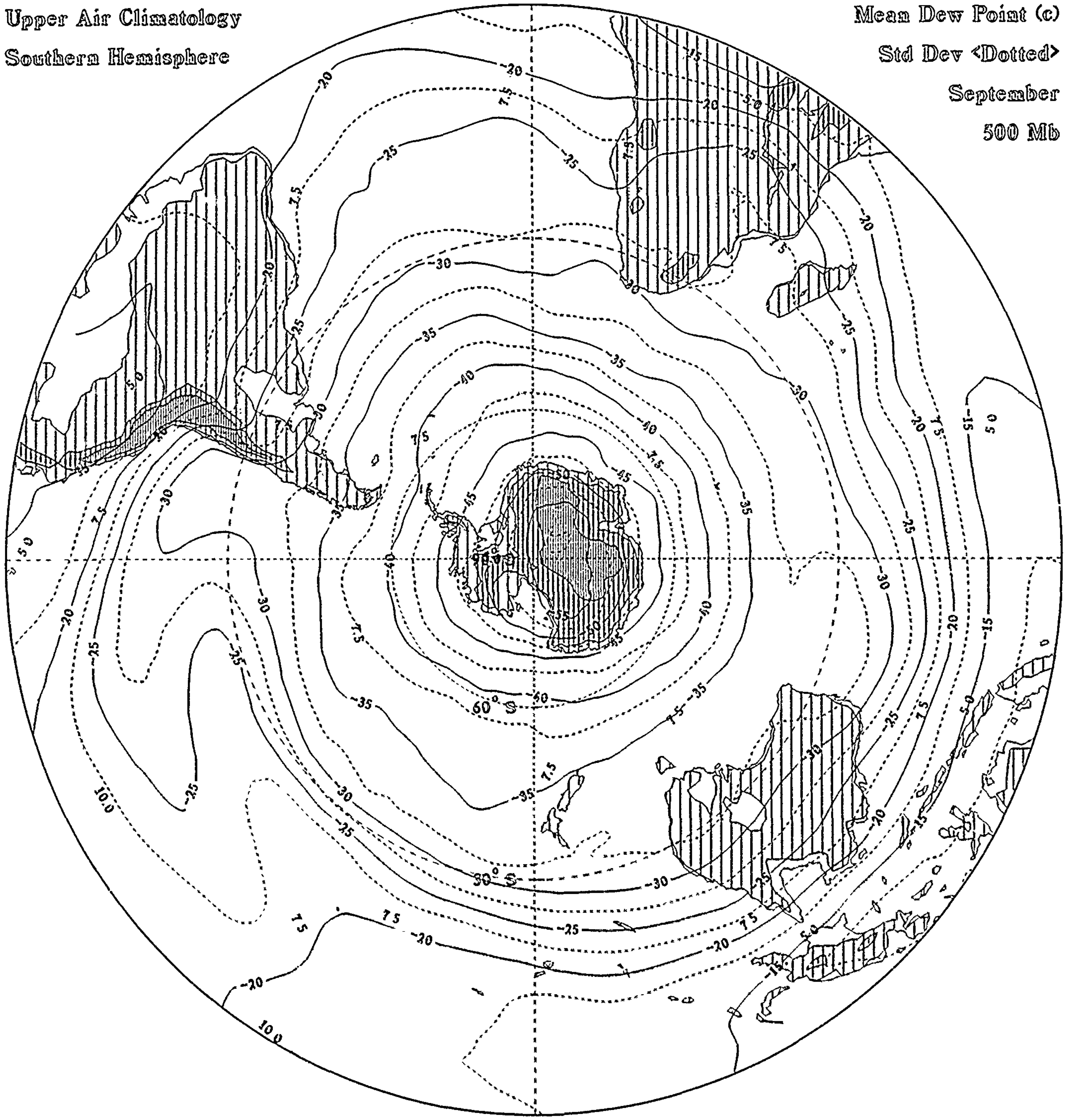
Northern Hemisphere

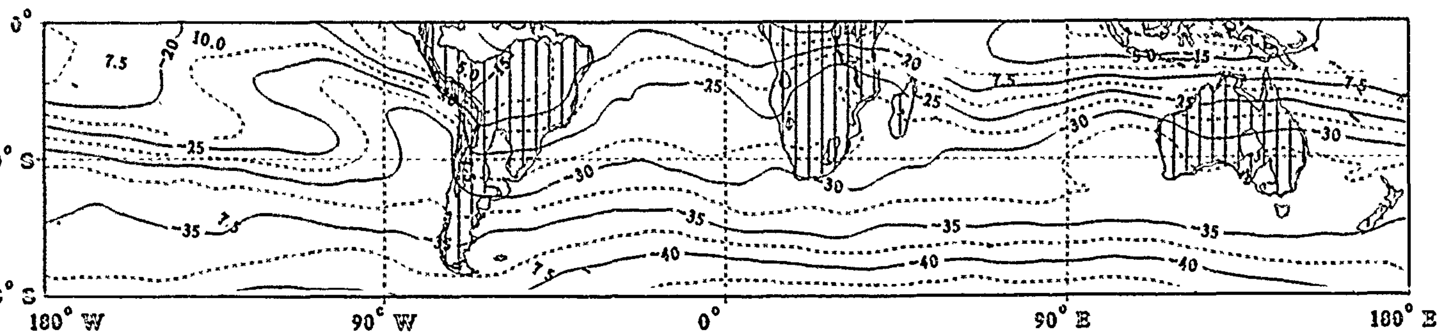




Upper Air Climatology
Southern Hemisphere

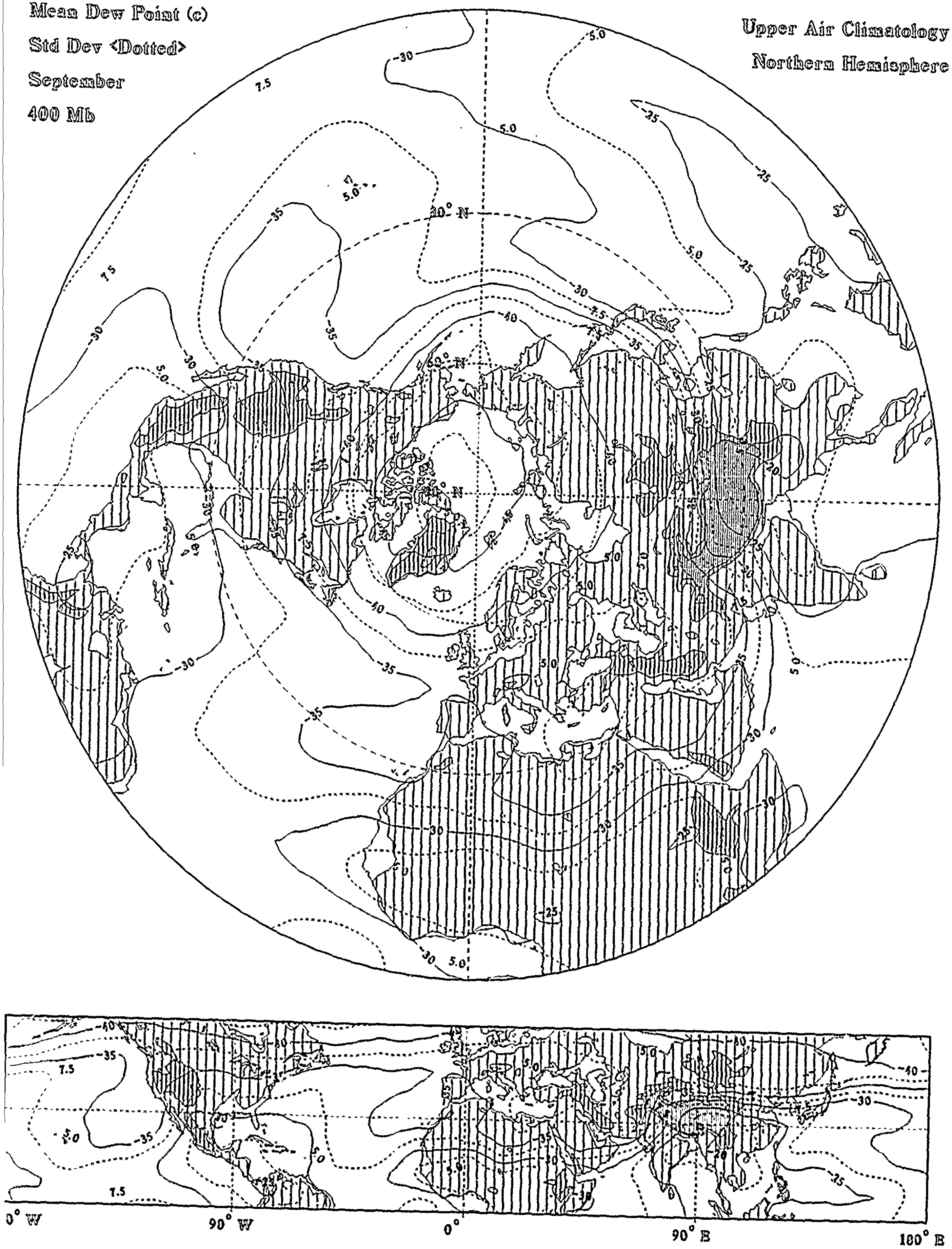
Mean Dew Point (c)
Std Dev <Dotted>
September
500 Mb





Mean Dew Point (c)
Std Dev <Dotted>
September
400 Mb

Upper Air Climatology
Northern Hemisphere



Upper Air Climatology

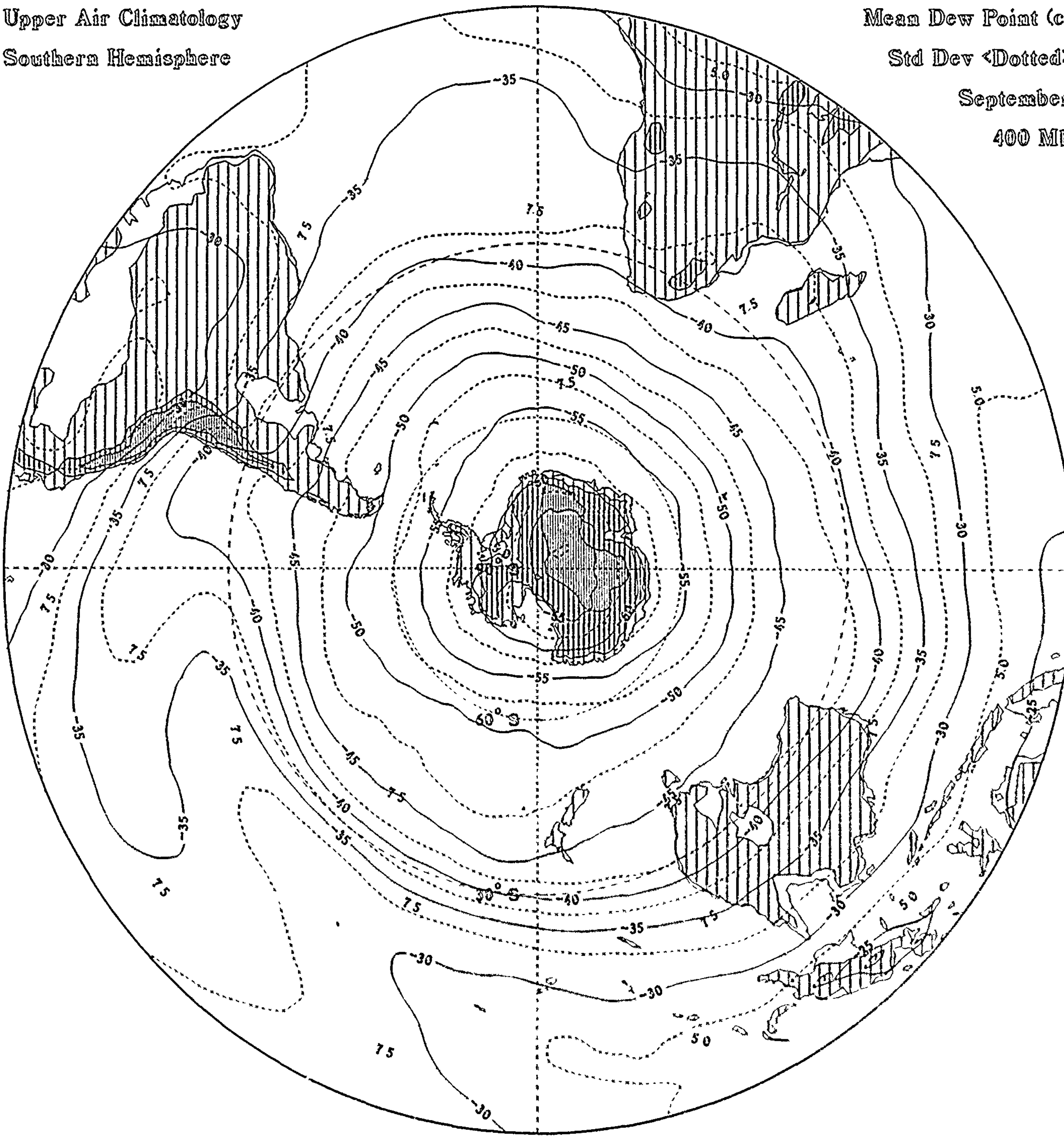
Southern Hemisphere

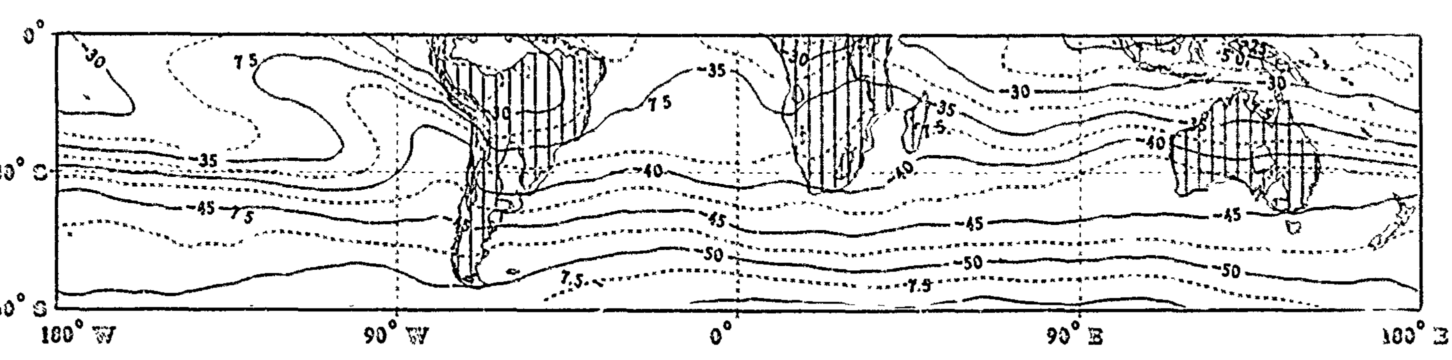
Mean Dew Point (c)

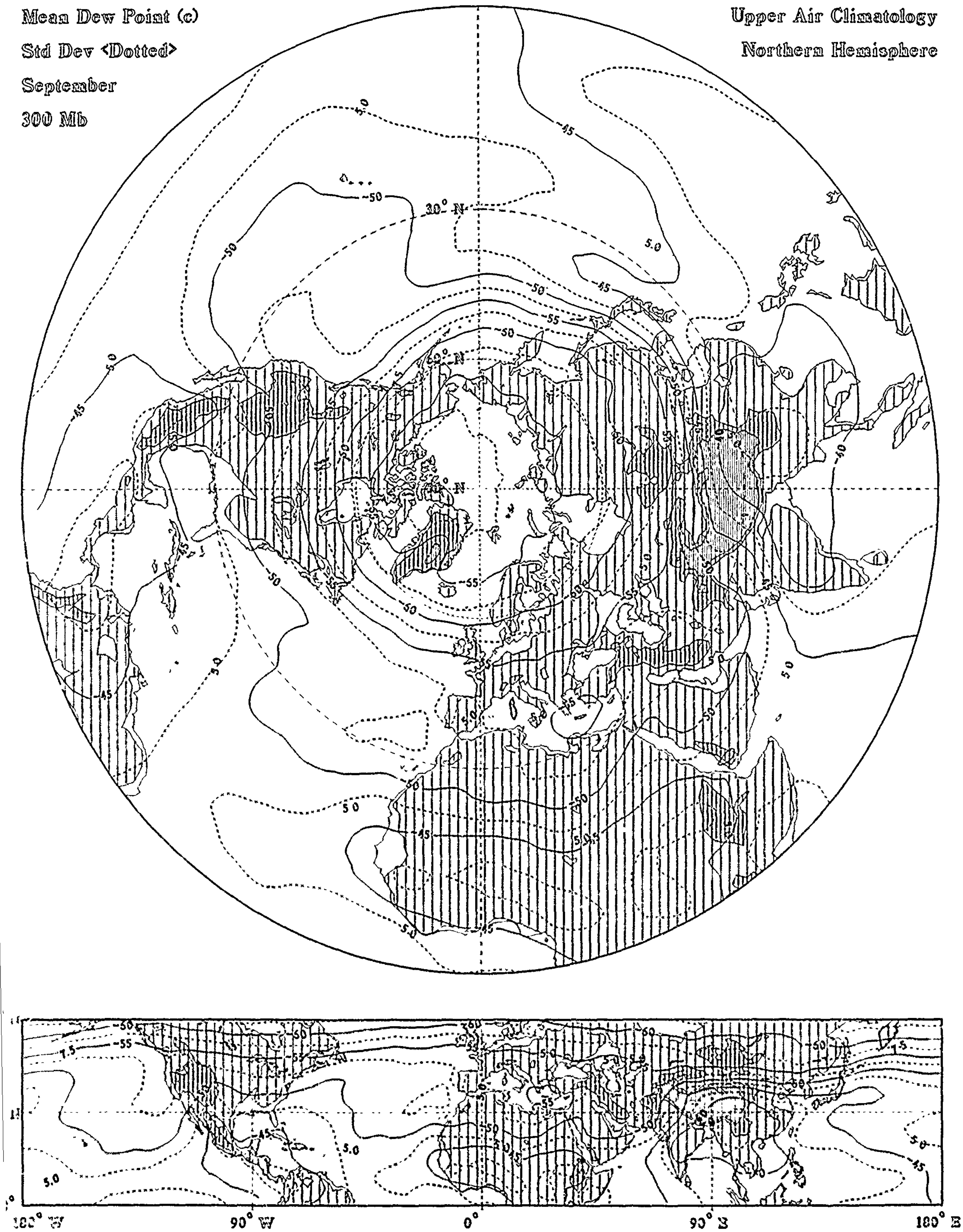
Std Dev <Dotted>

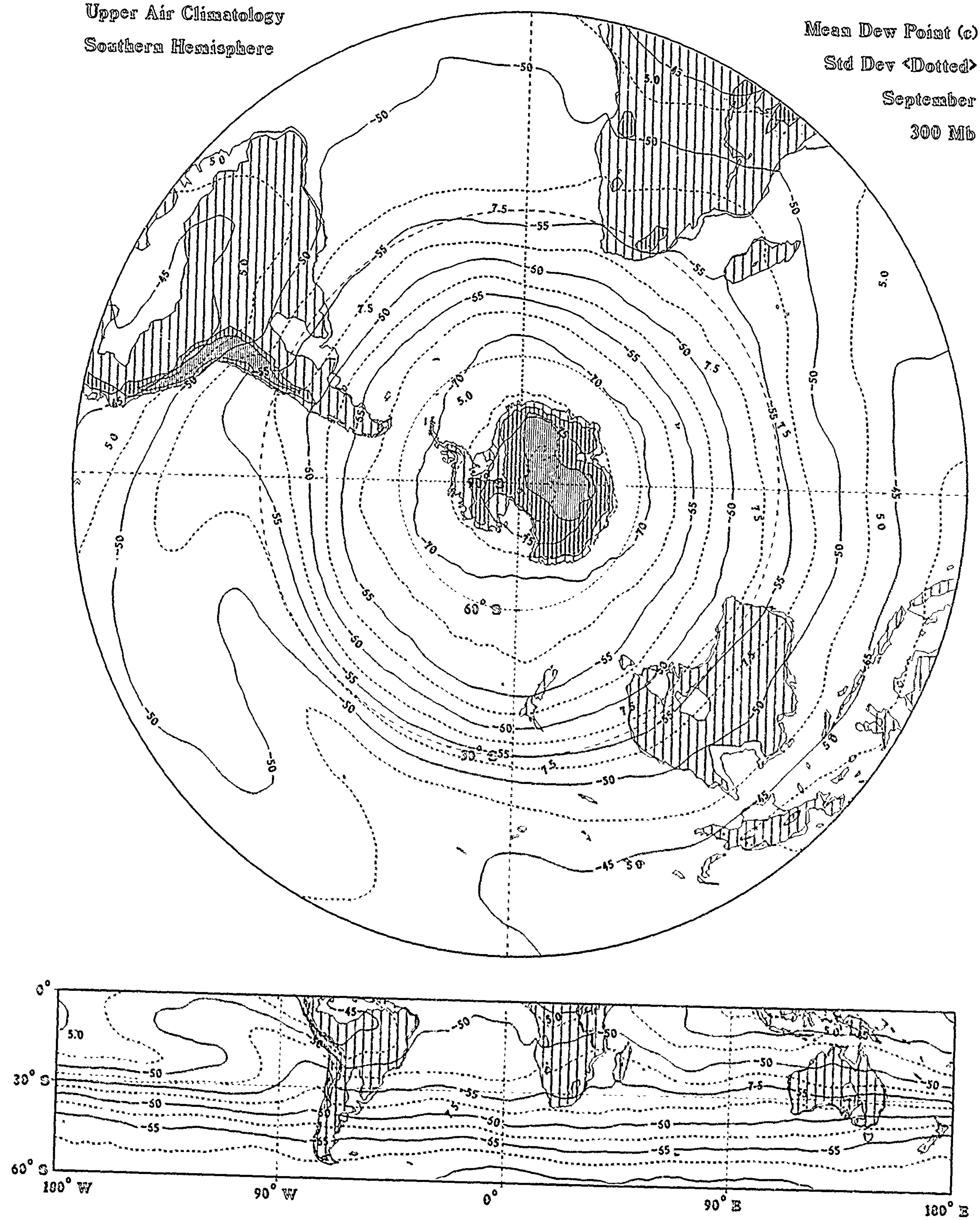
September

400 Mb






Mean Dew Point (c)
Std Dev <Dotted>
September
300 Mb
Upper Air Climatology
Northern Hemisphere
30° N
60° N
90° N
180° W
90° W
0°
90° E
180° E



Upper Air Climatology
Southern Hemisphere
Mean Dew Point (c)
Std Dev <Dotted>
September
300 Mb
60° S
30° S
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

DENSITY
(13 LEVELS, 1000 TO 30 MB)

- Contours of mean density (solid and dashed lines) in kilograms/cubic meter; solids labeled, dashed intermediates unlabeled

- Density labeled interval:

  .02 kilograms/cubic meter - 1000 MB to 400 MB
  .01 kilograms/cubic meter - 300 MB to 200 MB
  .006 kilograms/cubic meter - 150 MB to 30 MB

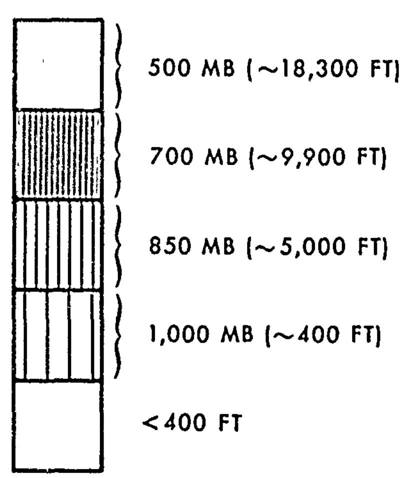
- Contours of standard deviation of density (dotted lines) in kilograms/cubic meter

- Standard deviation of density labeled interval:

  .01 kilograms/cubic meter - 1000 MB to 400 MB
  .005 kilograms/cubic meter - 300 MB to 200 MB
  .003 kilograms/cubic meter - 150 MB to 30 MB

- Contours blanked for geographic areas with elevations exceeding specified geopotential heights

ELEVATION SCALE



Mean Density (kg/m3)

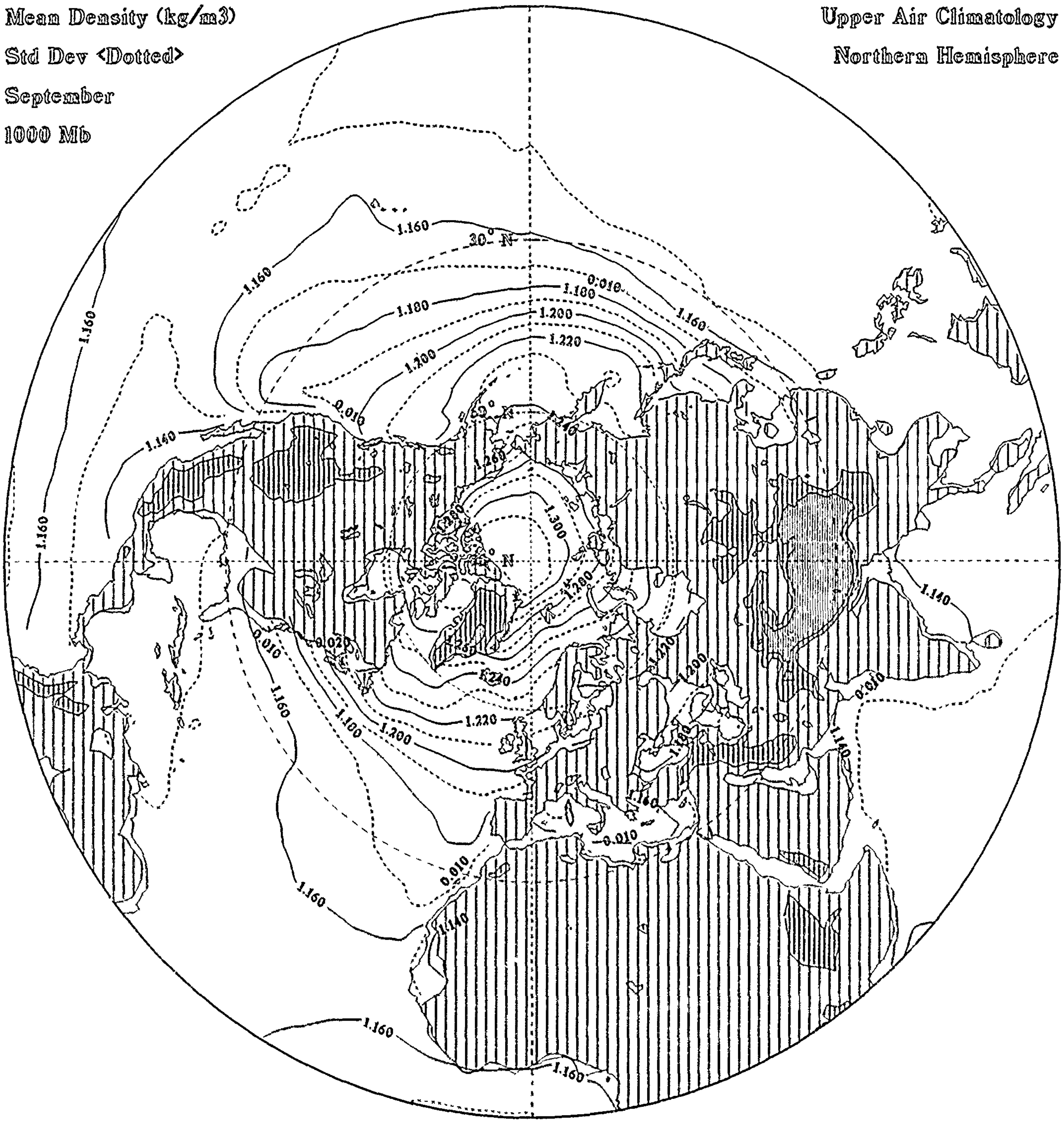
Std Dev <Dotted>

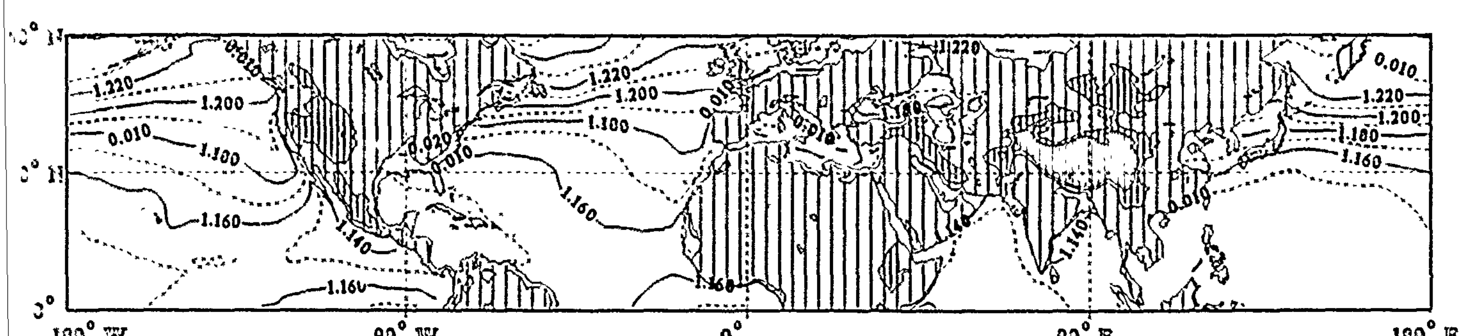
September

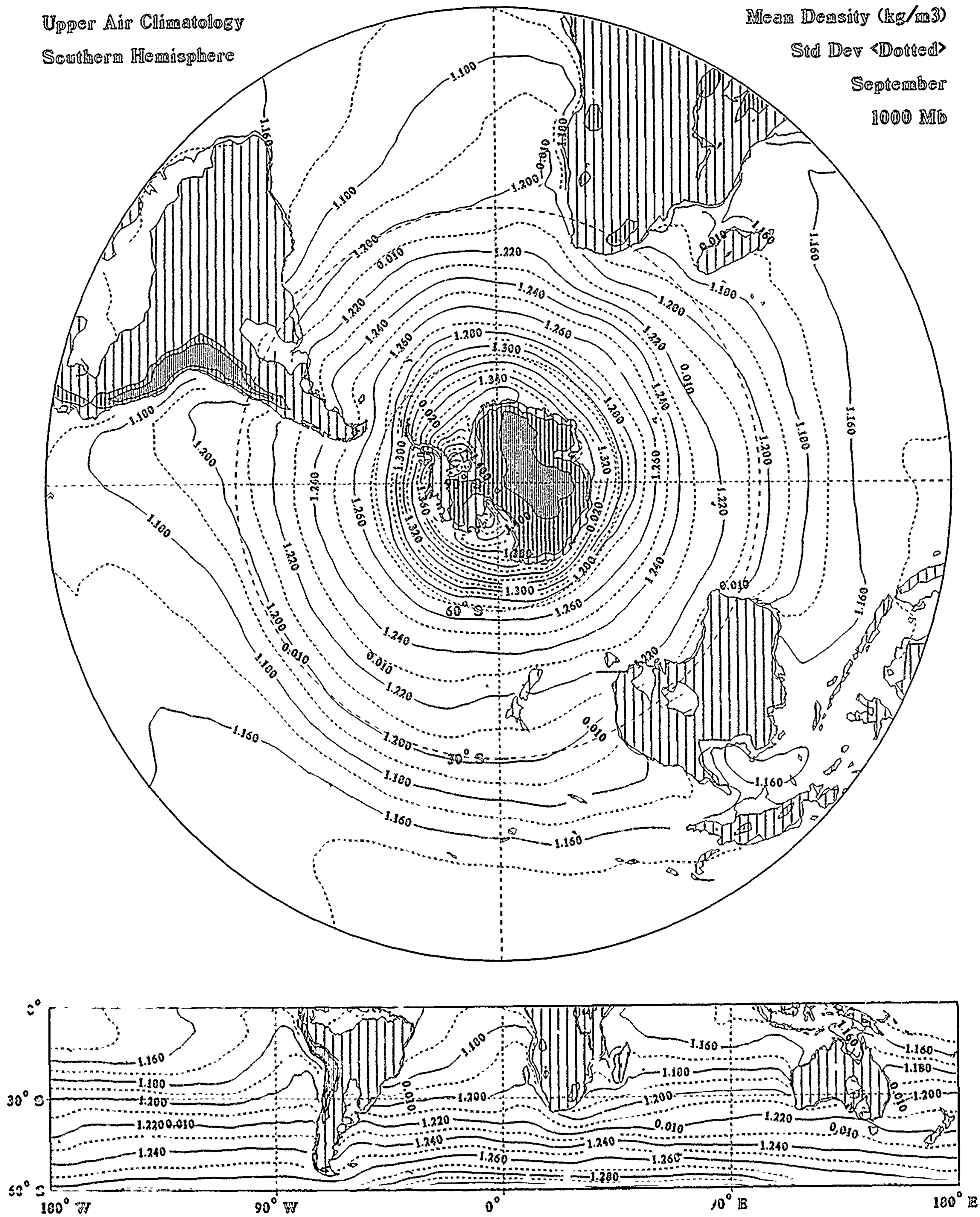
1000 Mb

Upper Air Climatology

Northern Hemisphere

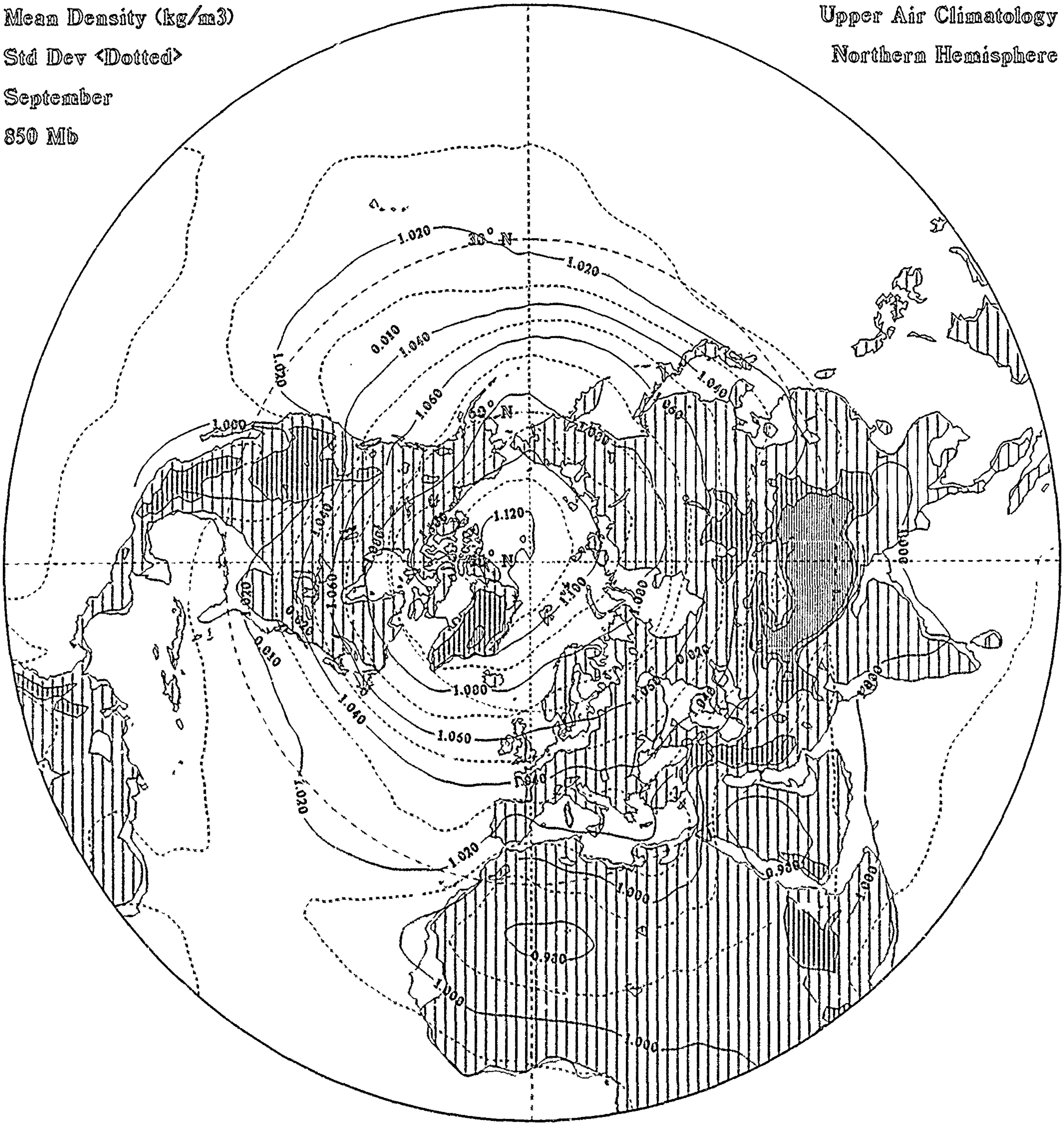


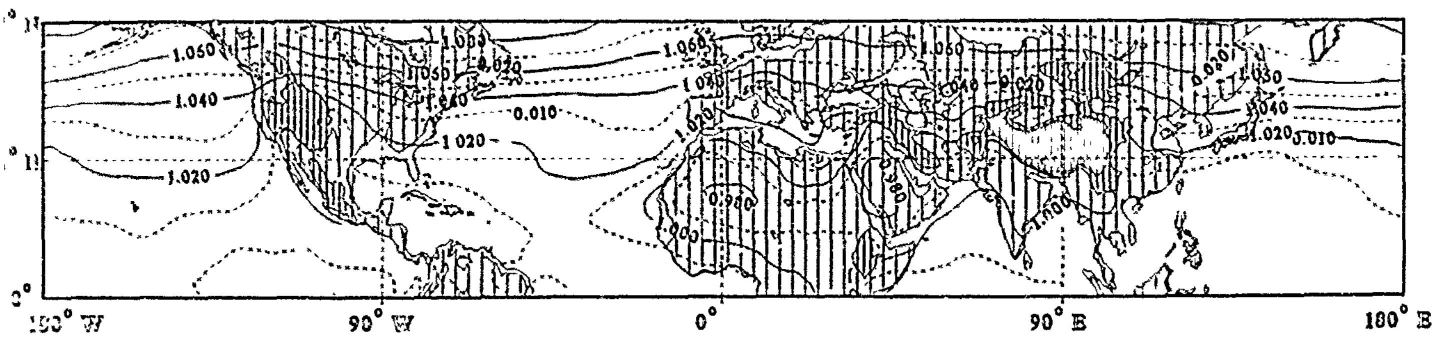



Upper Air Climatology
Southern Hemisphere
Mean Density (kg/m3)
Std Dev <Dotted>
September
1000 Mb
60° S
30° S
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

Mean Density (kg/m3)
Std Dev <Dotted>
September
850 Mb

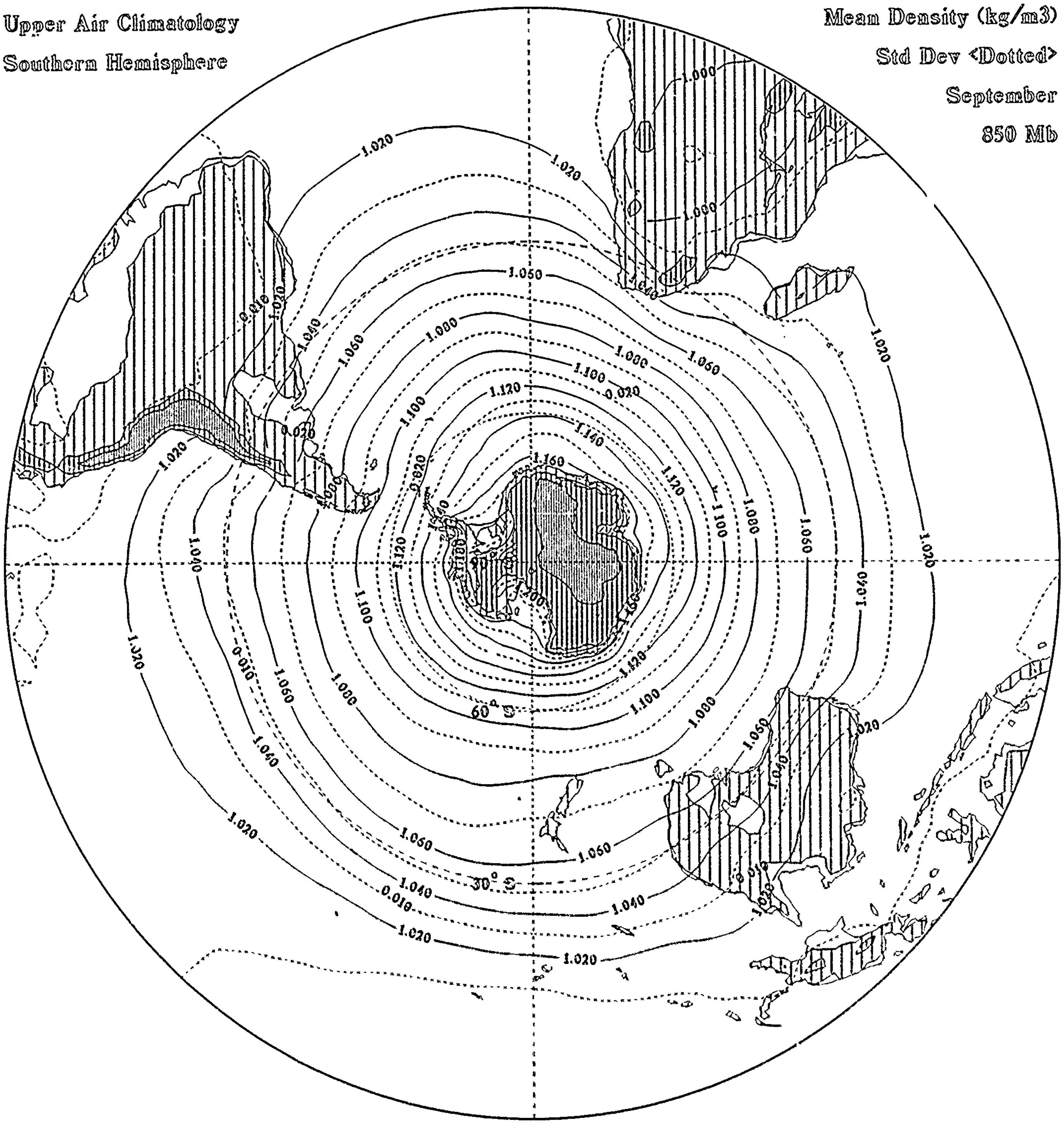
Upper Air Climatology
Northern Hemisphere

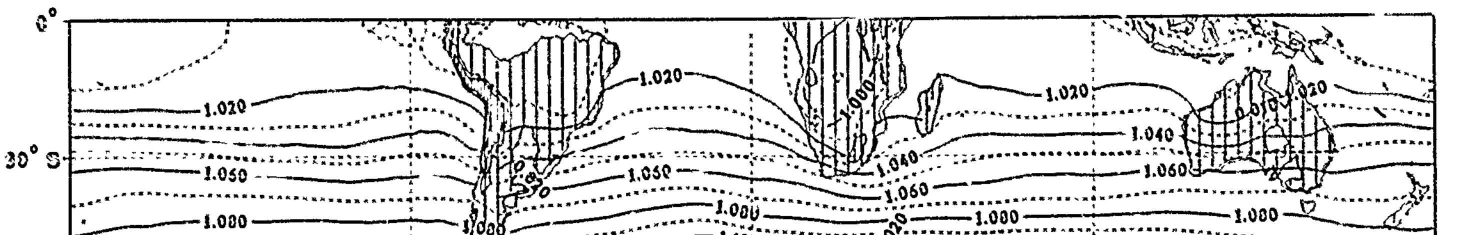




Upper Air Climatology
Southern Hemisphere

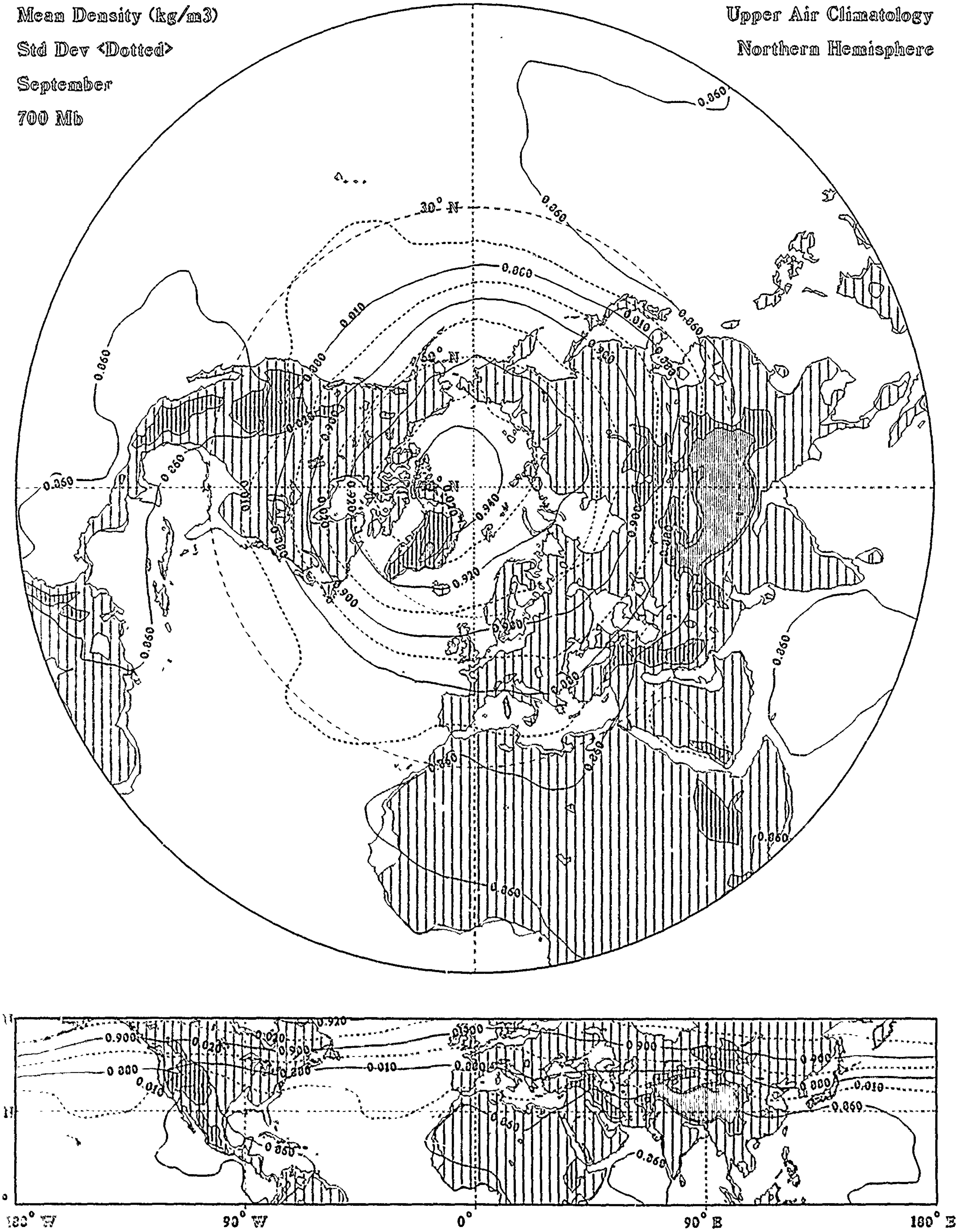
Mean Density (kg/m3)
Std Dev <Dotted>
September
850 Mb

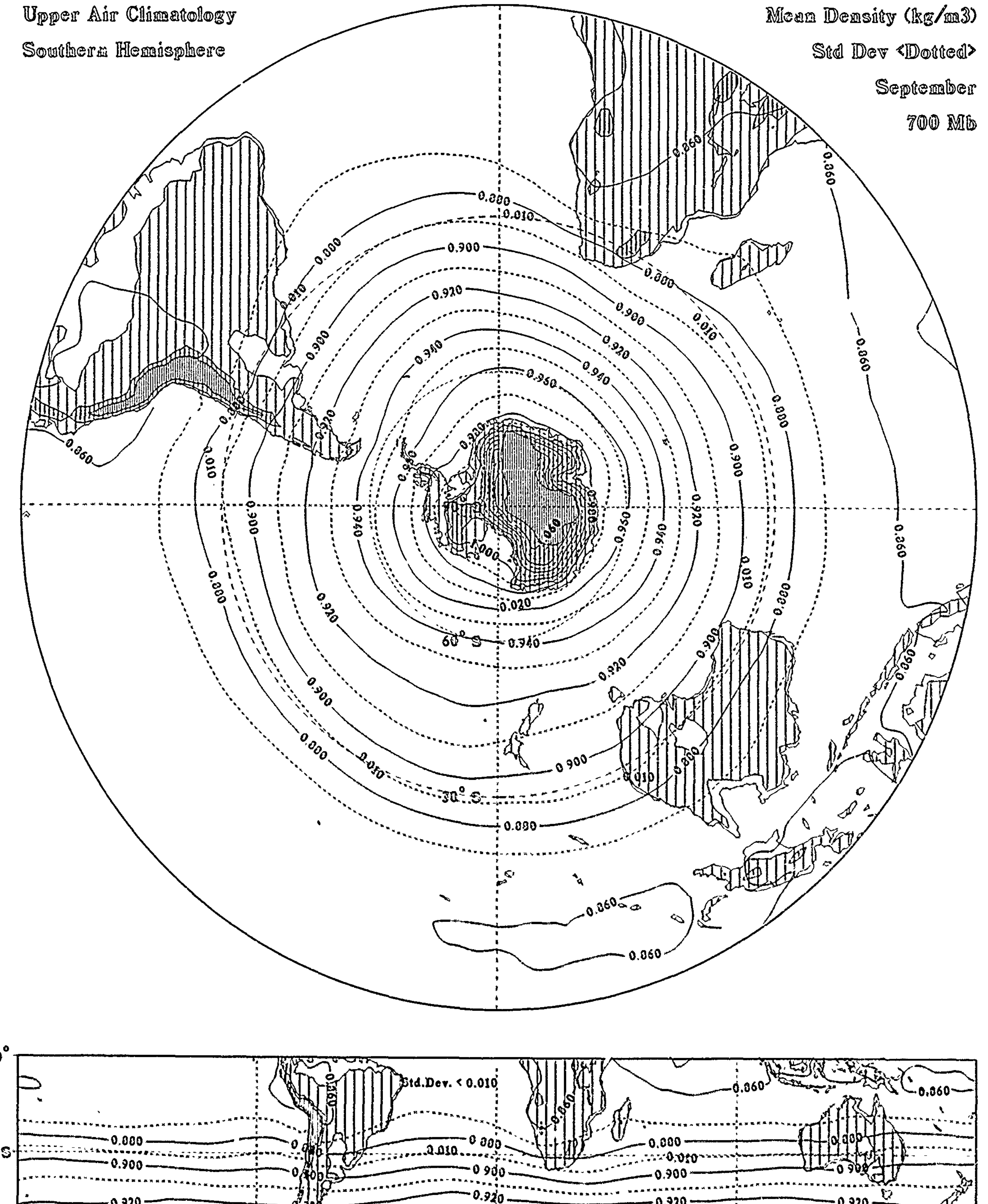




Mean Density (kg/m3)
Std Dev <Dotted>
September
700 Mb

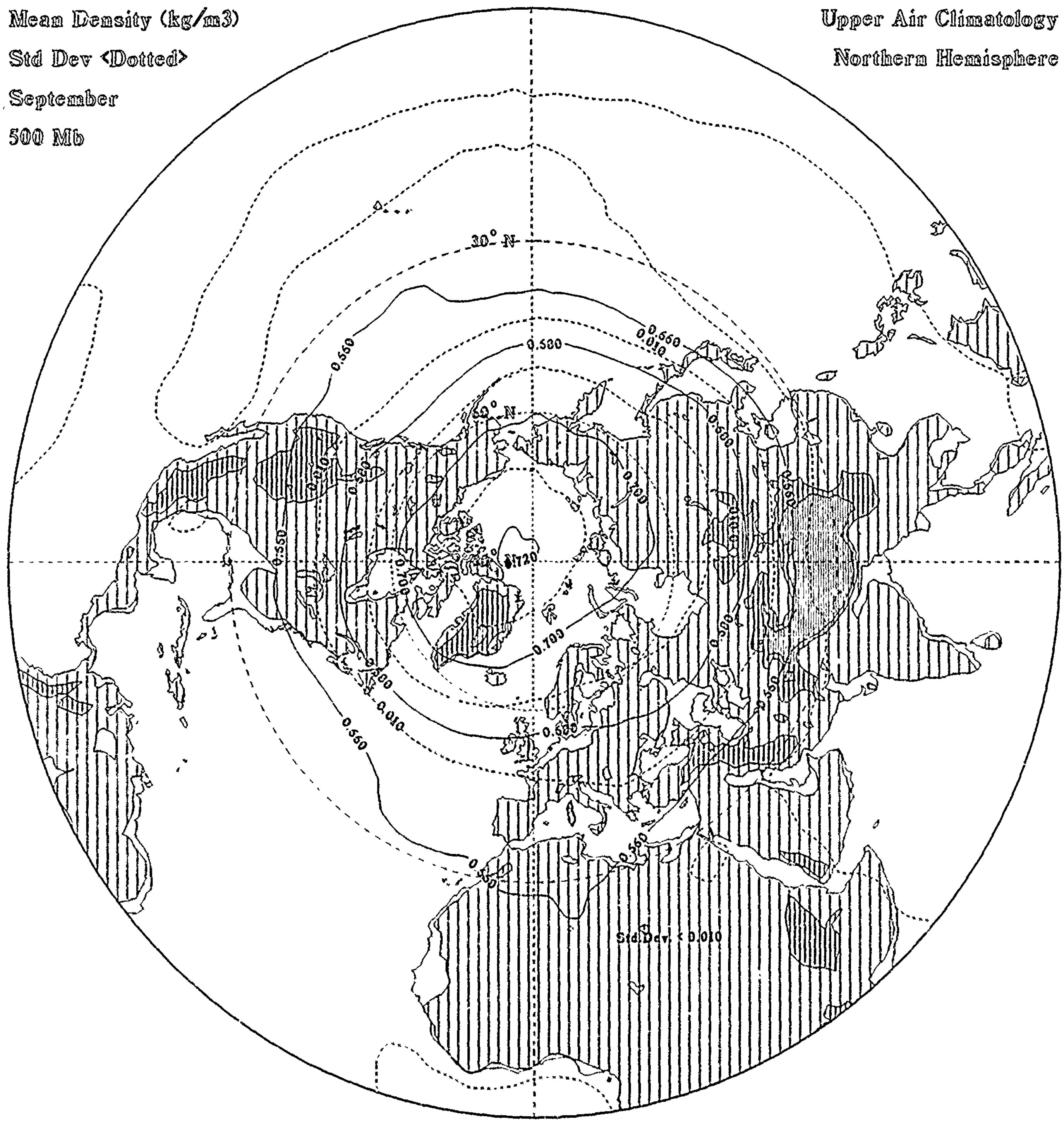
Upper Air Climatology
Northern Hemisphere

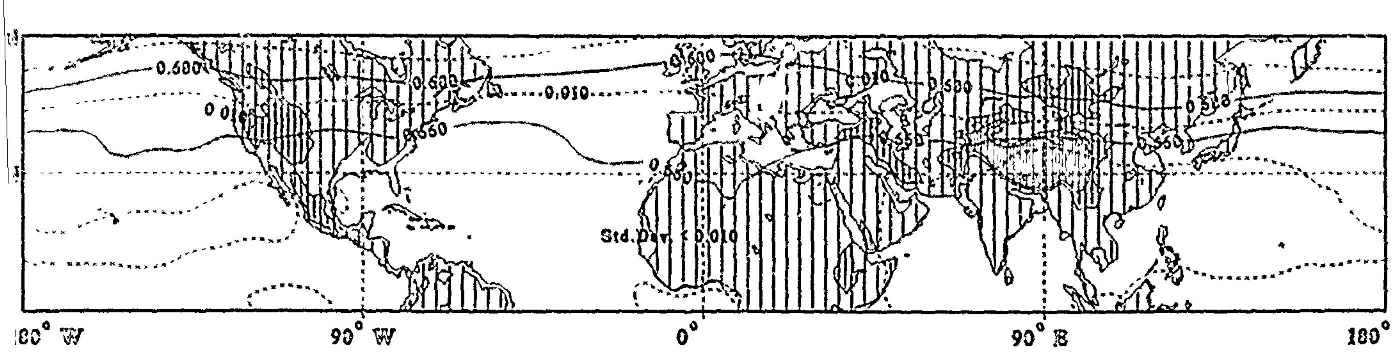


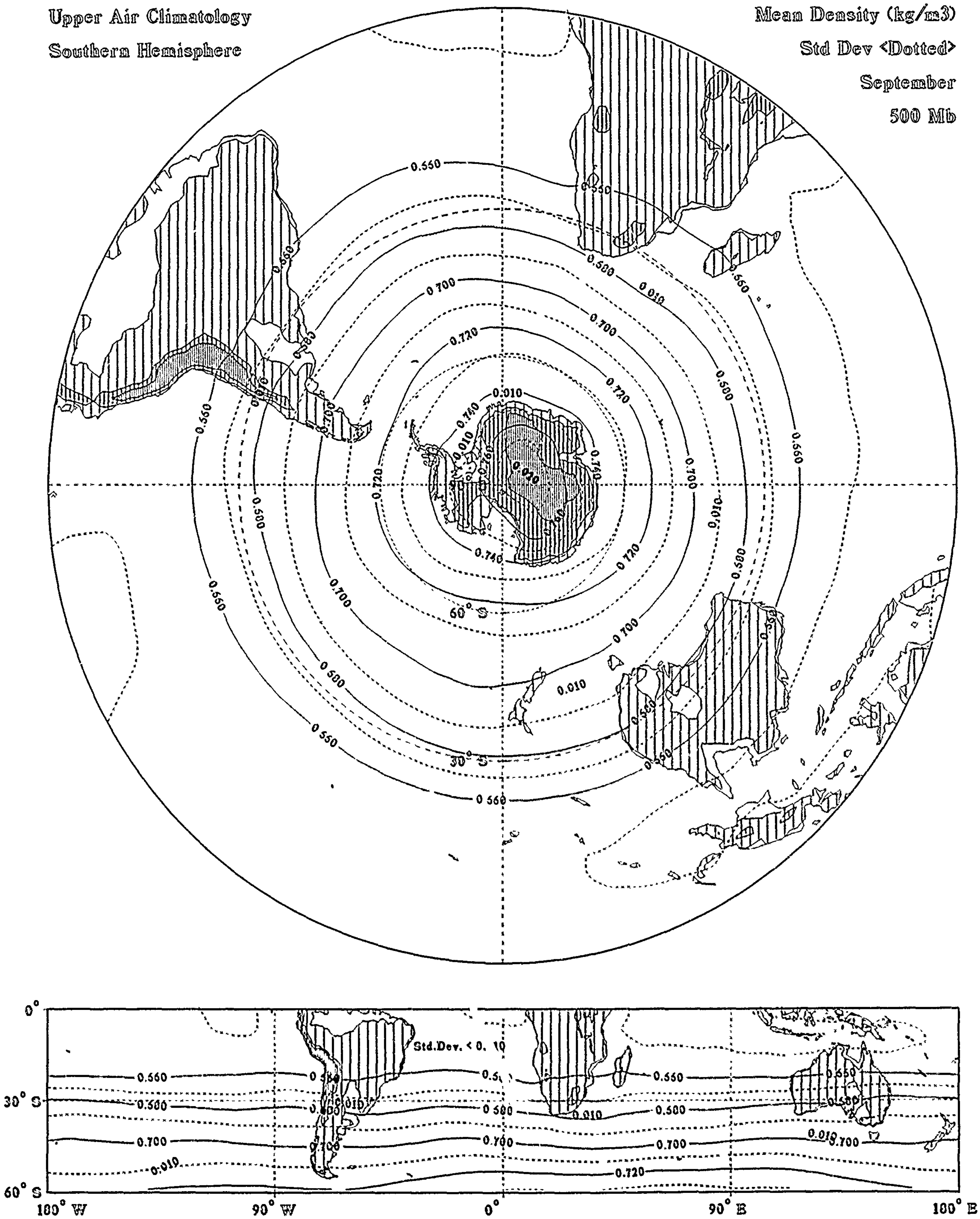

Upper Air Climatology
Southern Hemisphere
Mean Density (kg/m3)
Std Dev <Dotted>
September
700 Mb
60° S
30° S
Std.Dev. < 0.010
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

Mean Density (kg/m3)
Std Dev <Dotted>
September
500 Mb

Upper Air Climatology
Northern Hemisphere

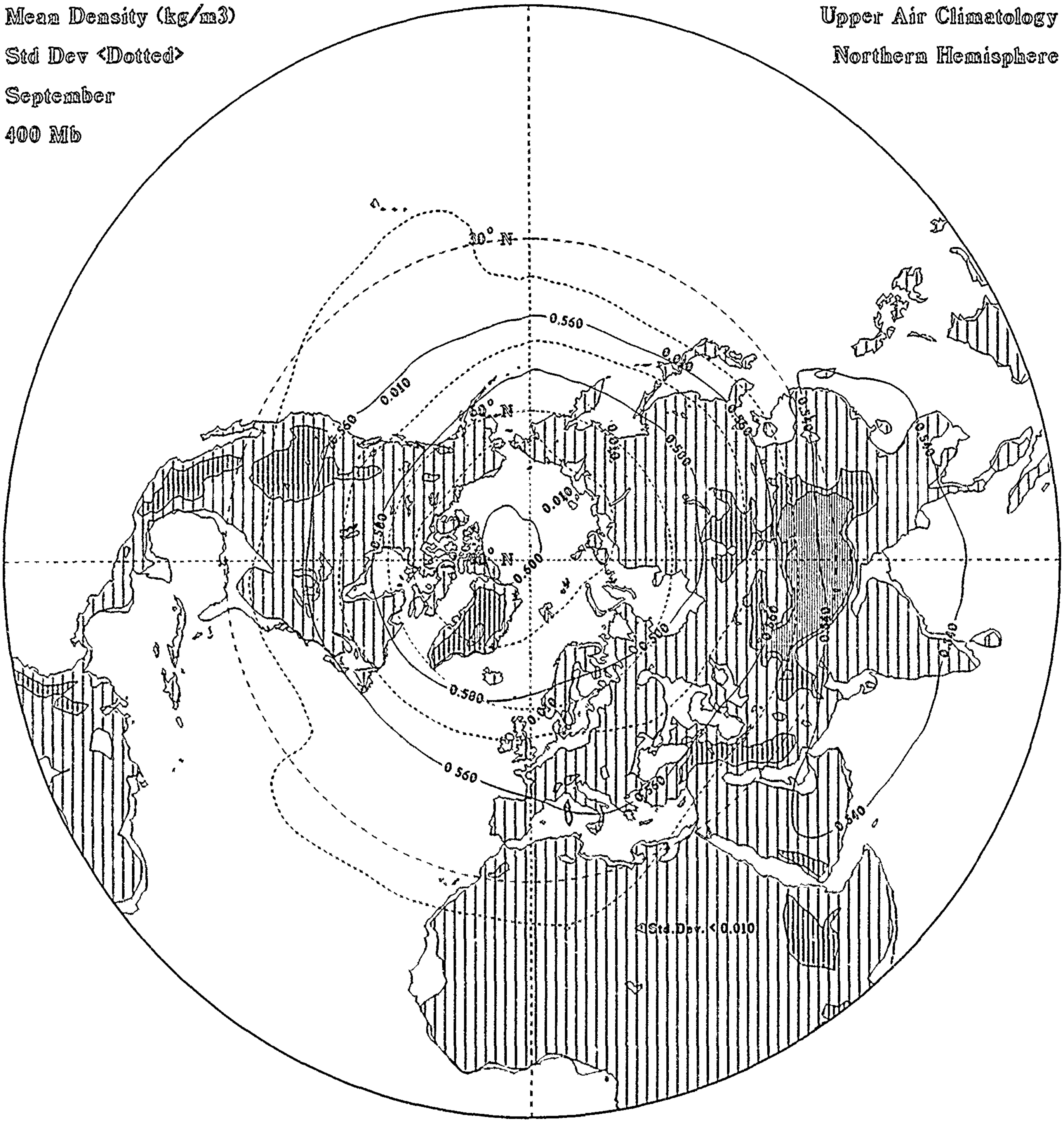


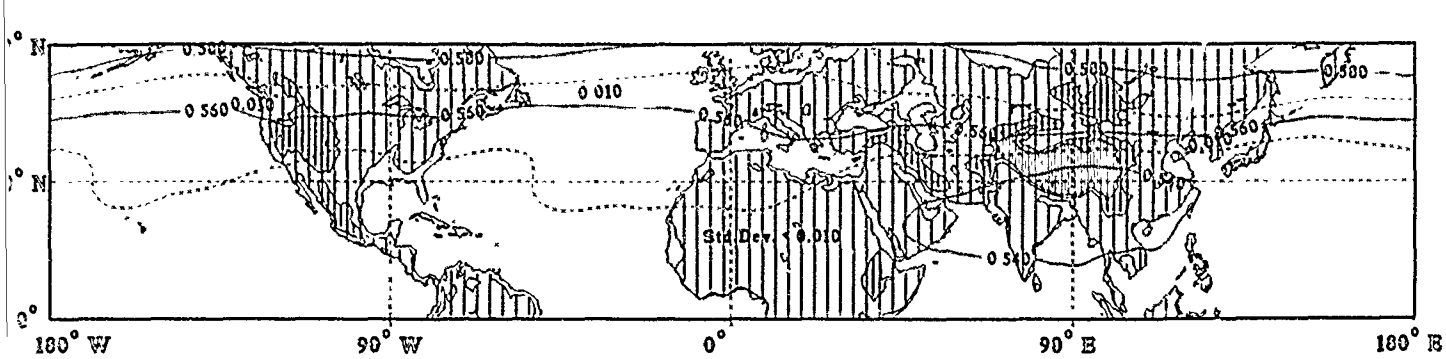


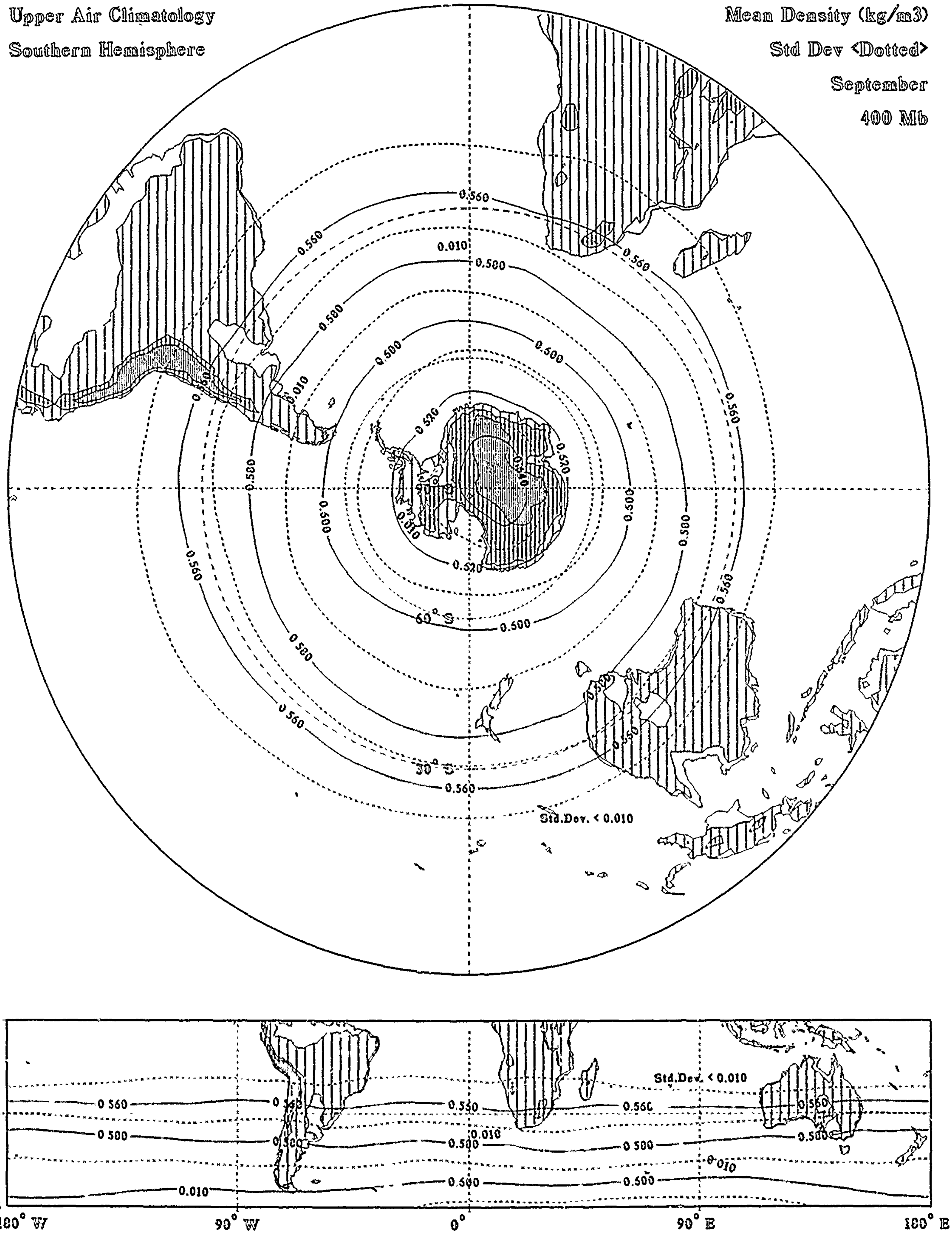

Upper Air Climatology
Southern Hemisphere
Mean Density (kg/m3)
Std Dev <Dotted>
September
500 Mb
0.560
0.580
0.700
0.720
0.740
0.010
60° S
30° S
Std.Dev. < 0. 10
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

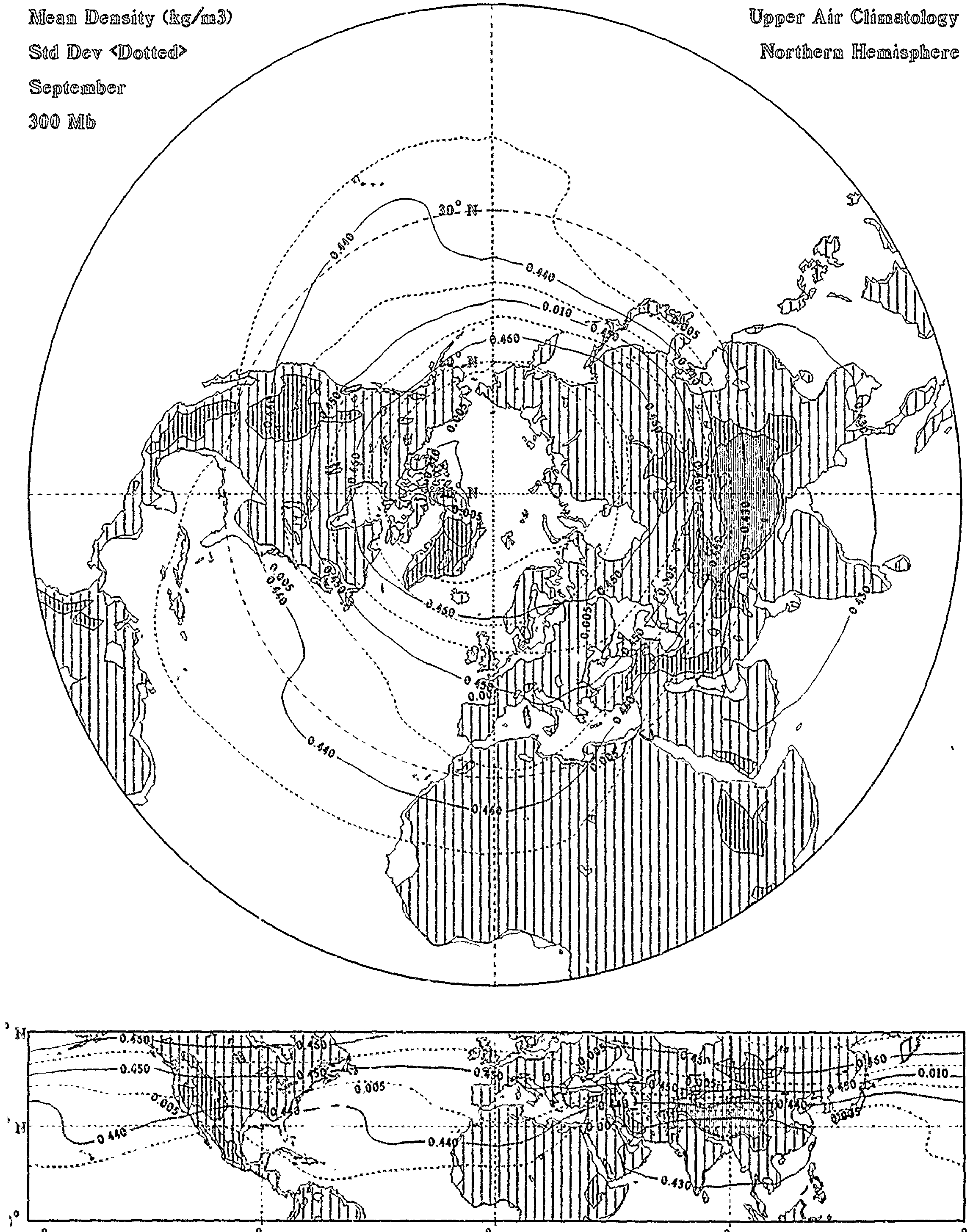
Mean Density (kg/m3)
Std Dev <Dotted>
September
400 Mb

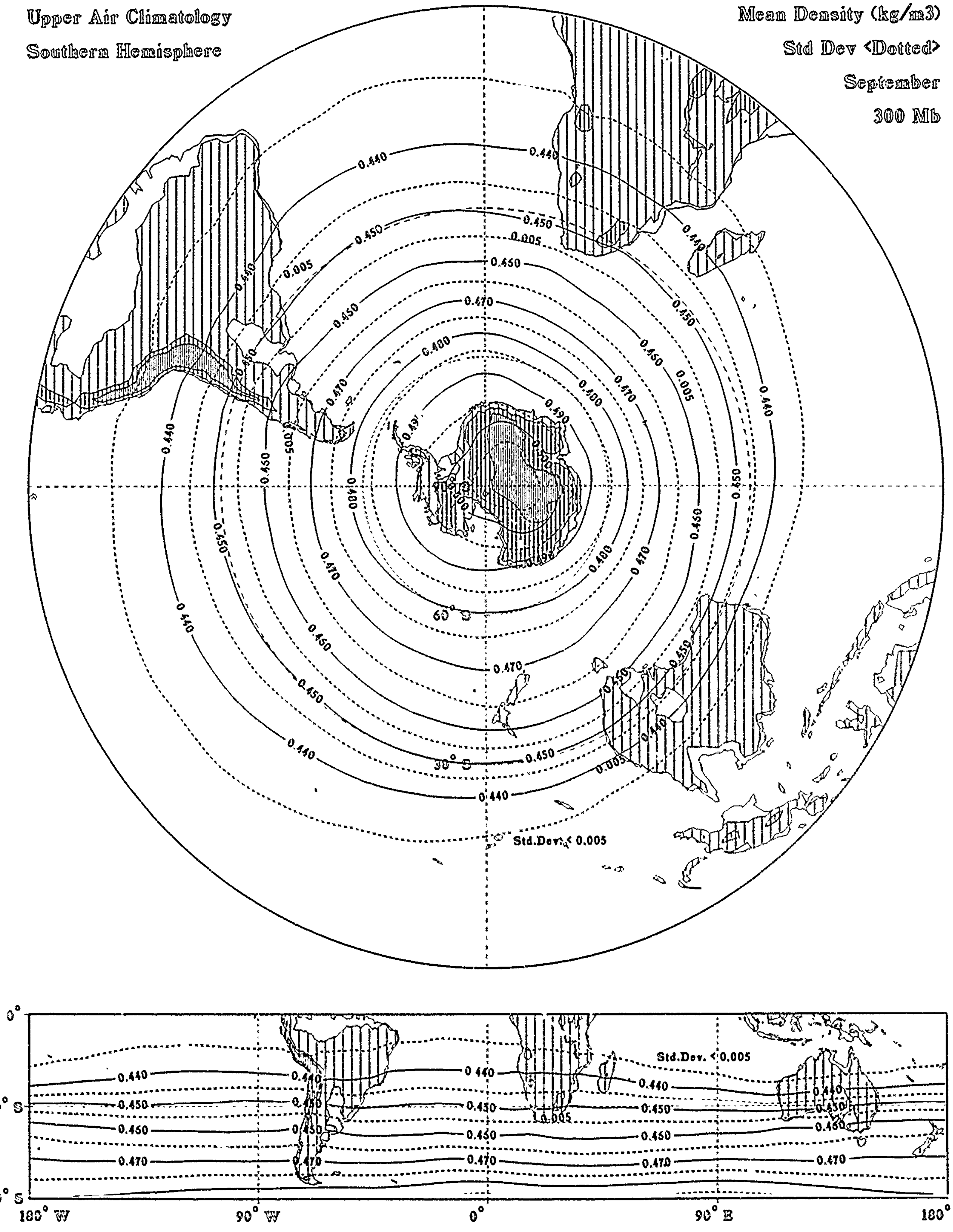
Upper Air Climatology
Northern Hemisphere





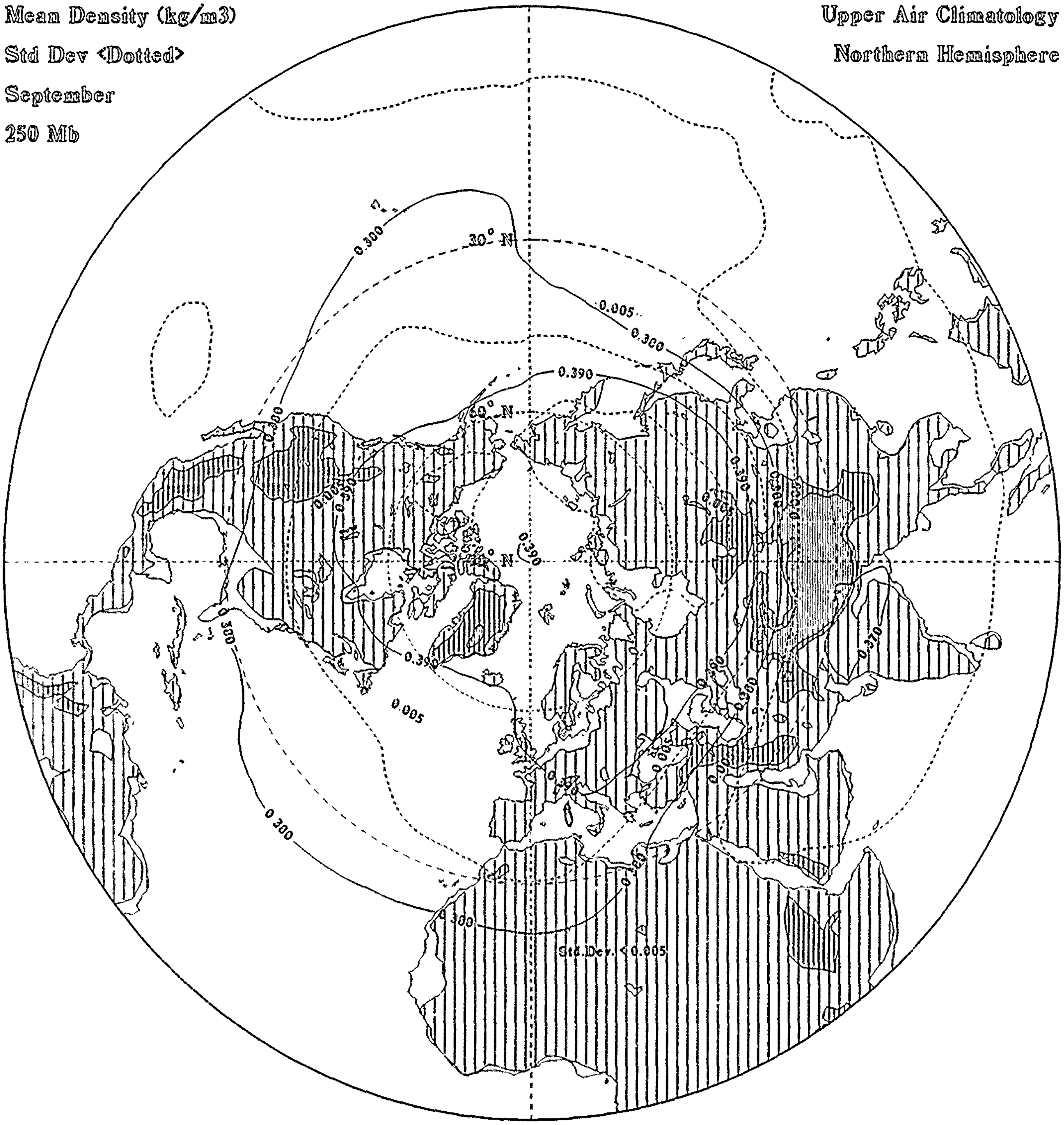

Upper Air Climatology
Southern Hemisphere
Mean Density (kg/m3)
Std Dev <Dotted>
September
400 Mb
0.560
0.010
0.500
0.580
0.600
0.520
0.540
60° S
30° S
Std.Dev. < 0.010
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

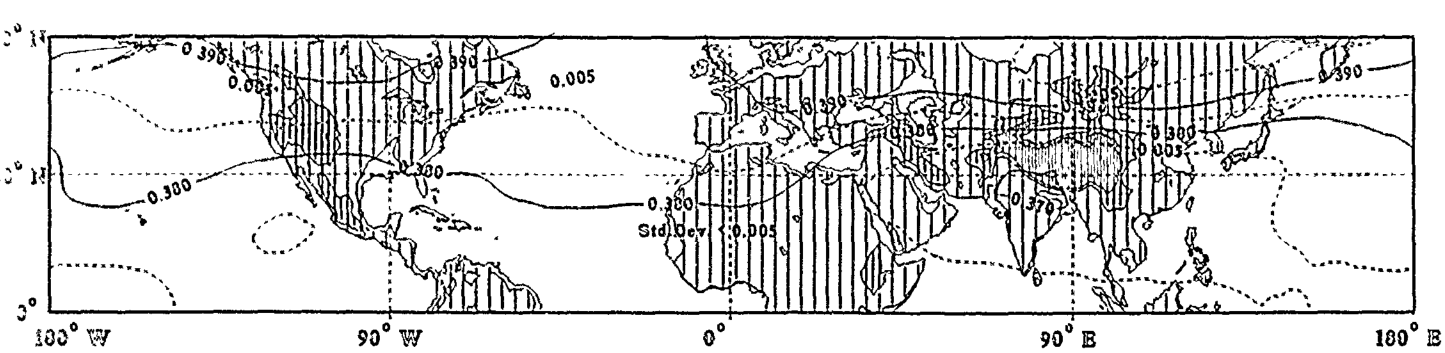

Mean Density (kg/m3)
Std Dev <Dotted>
September
300 Mb
Upper Air Climatology
Northern Hemisphere
30° N
0.440
0.010
0.460
0.005
0.450
0.430
180° W
90° W
0°
90° E
180° E

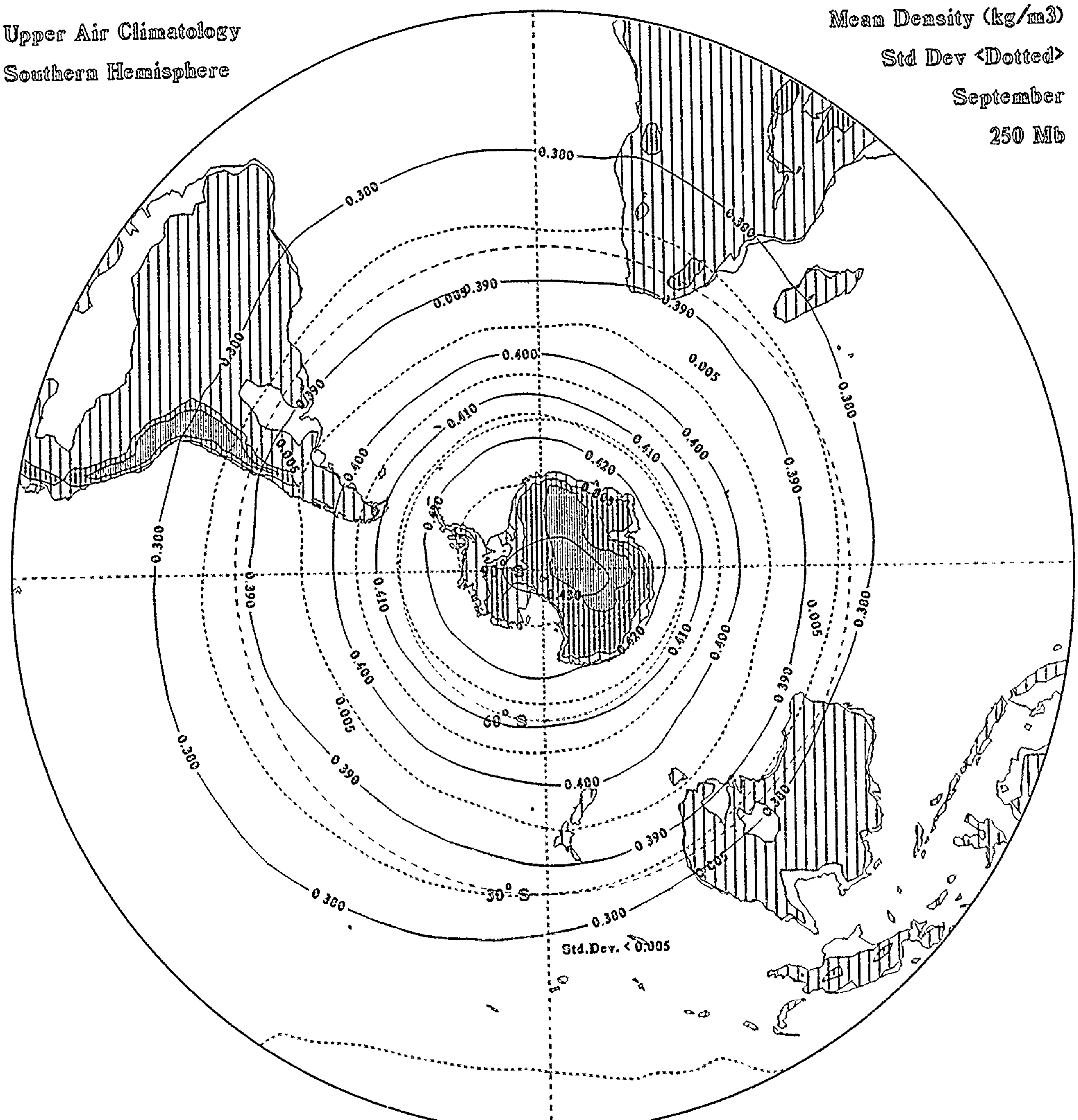

Upper Air Climatology
Southern Hemisphere
Mean Density (kg/m3)
Std Dev <Dotted>
September
300 Mb
0.440
0.450
0.460
0.470
0.480
0.490
0.005
60° S
30° S
Std.Dev. < 0.005
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

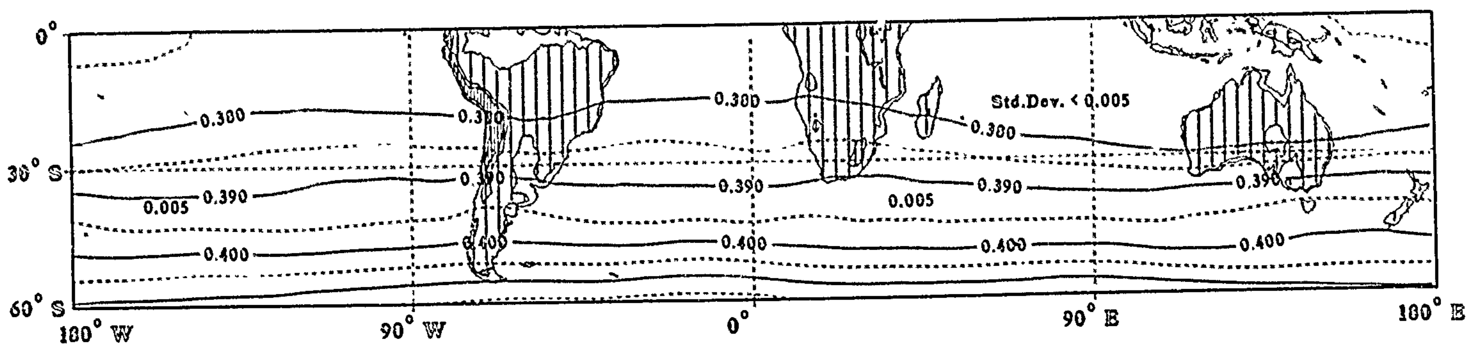
Mean Density (kg/m3)
Std Dev <Dotted>
September
250 Mb

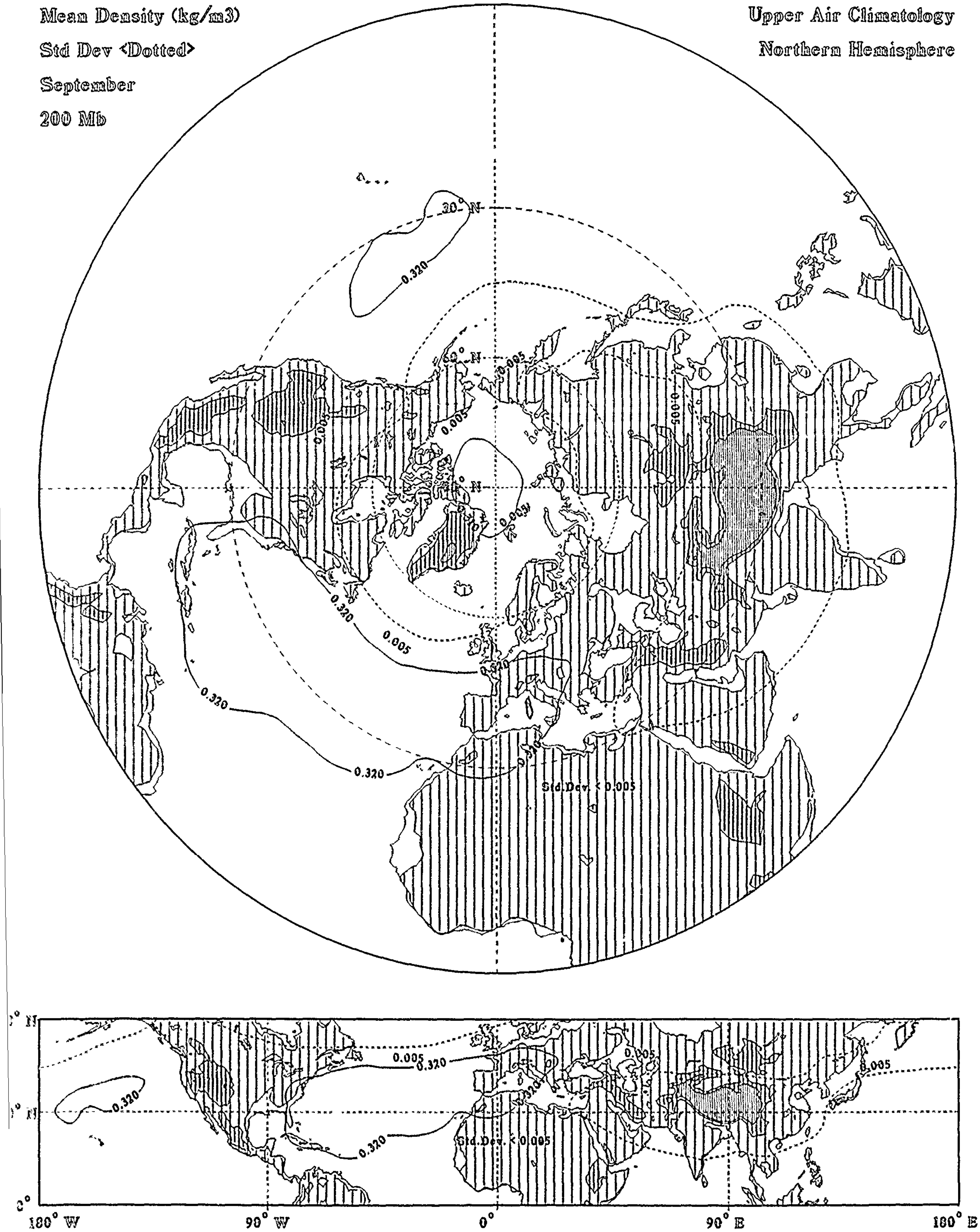
Upper Air Climatology
Northern Hemisphere





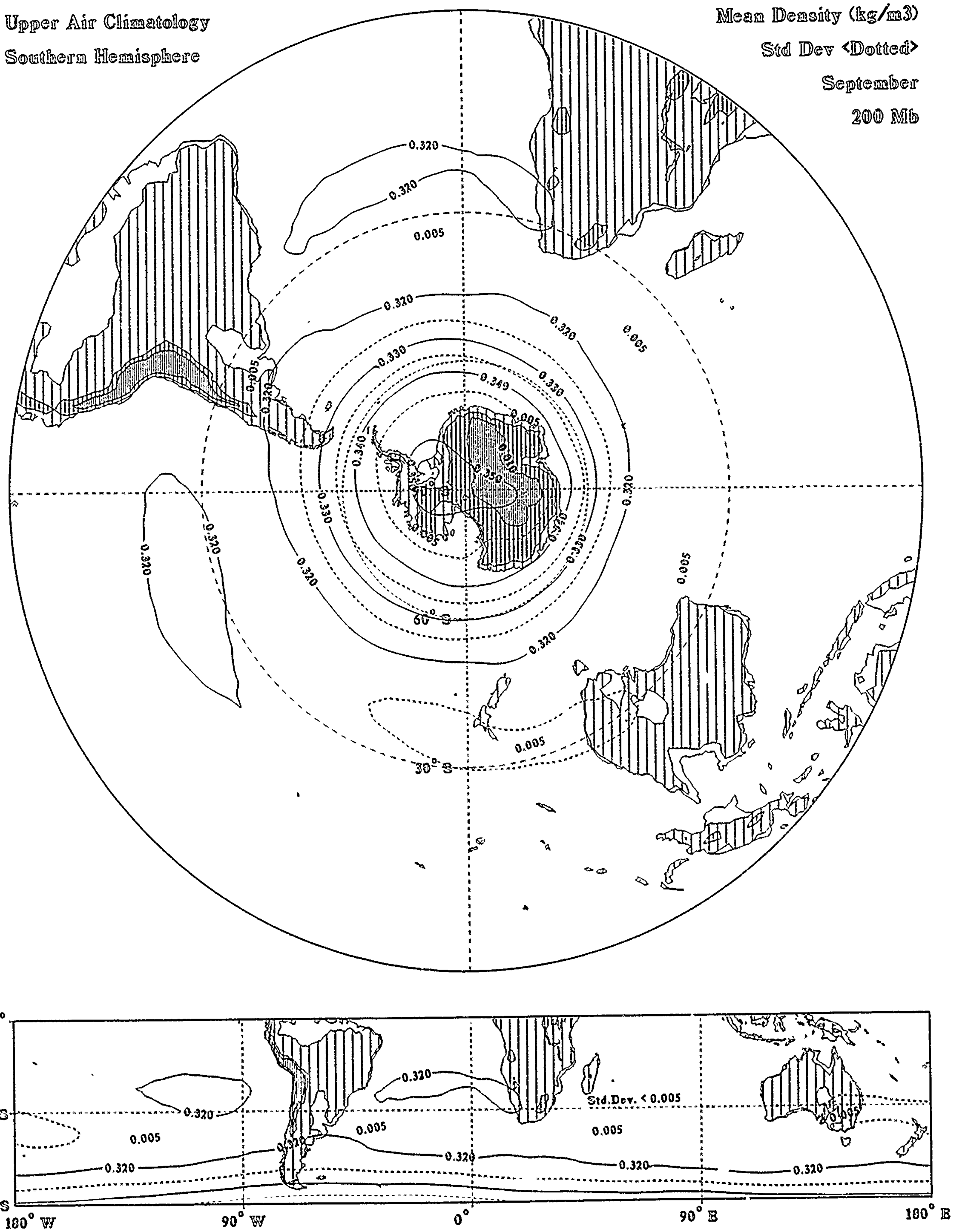

Upper Air Climatology
Southern Hemisphere
Mean Density (kg/m3)
Std Dev <Dotted>
September
250 Mb
0.380
0.390
0.400
0.410
0.420
0.430
0.005
60° S
30° S
Std.Dev. < 0.005


0°
30° S
60° S
180° W
90° W
0°
90° E
180° E
0.380
0.390
0.400
0.005
Std.Dev. < 0.005


Mean Density (kg/m3)
Std Dev <Dotted>
September
200 Mb
Upper Air Climatology
Northern Hemisphere
30° N
60° N
0.320
0.005
Std.Dev. < 0.005
180° W
90° W
0°
90° E
180° E

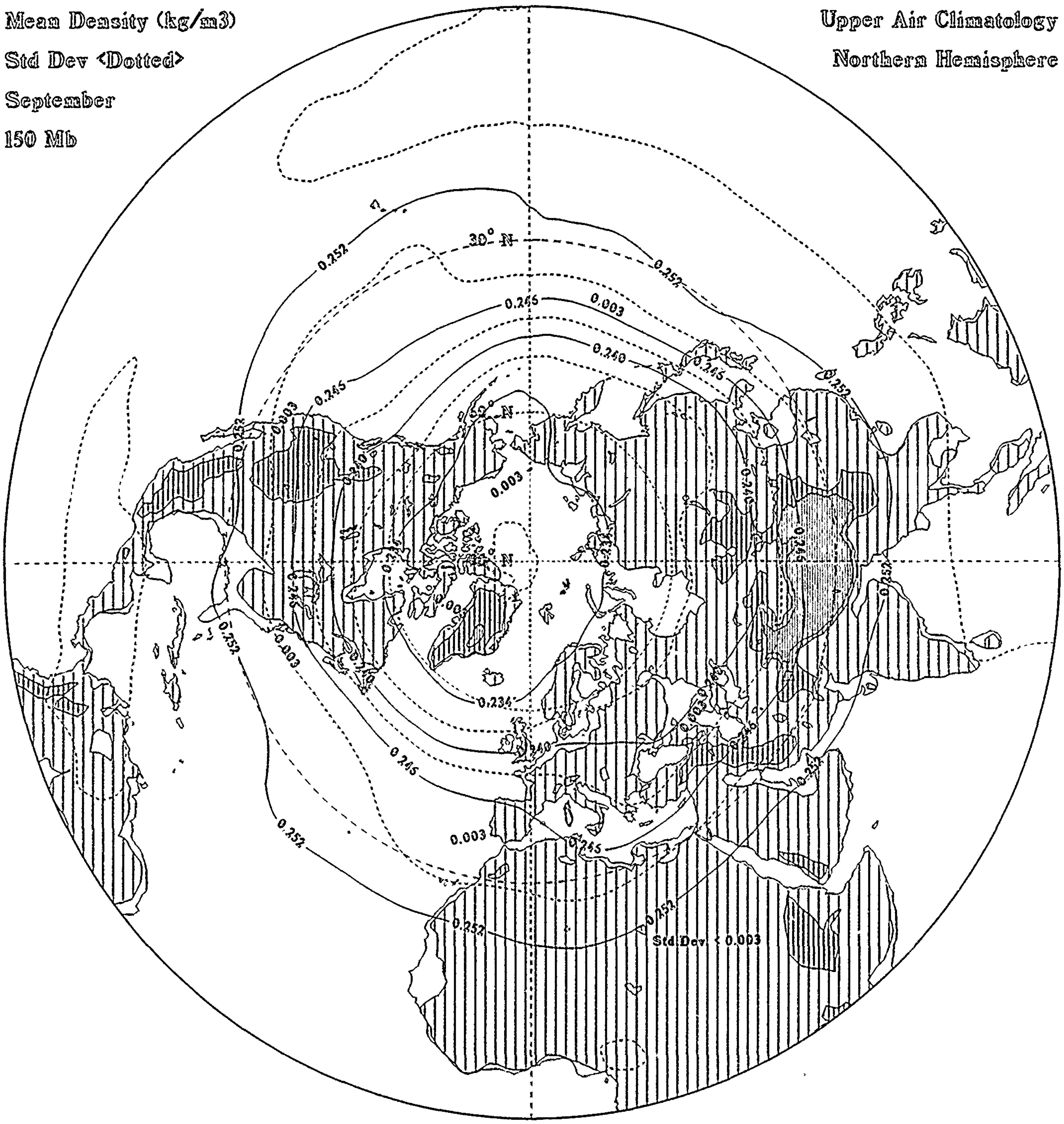
Upper Air Climatology
Southern Hemisphere

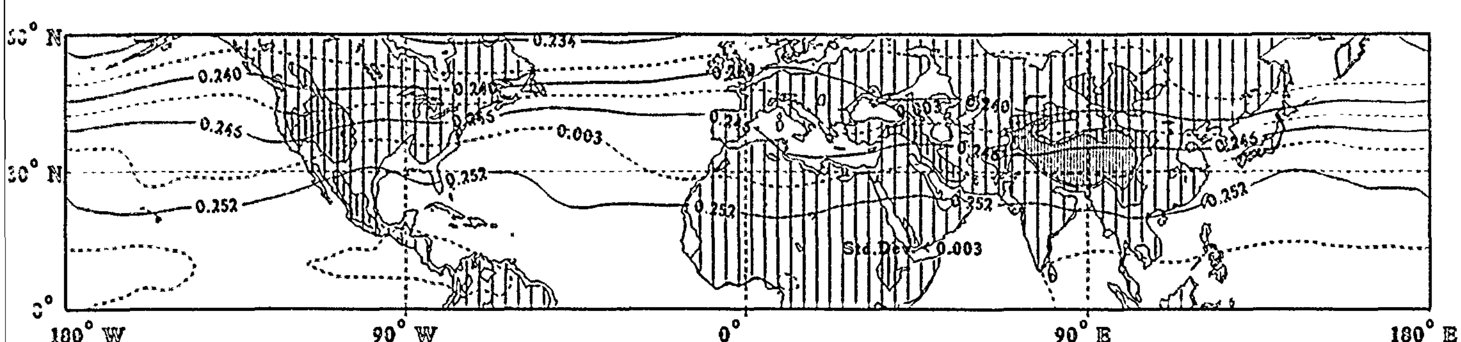
Mean Density (kg/m3)
Std Dev <Dotted>
September
200 Mb

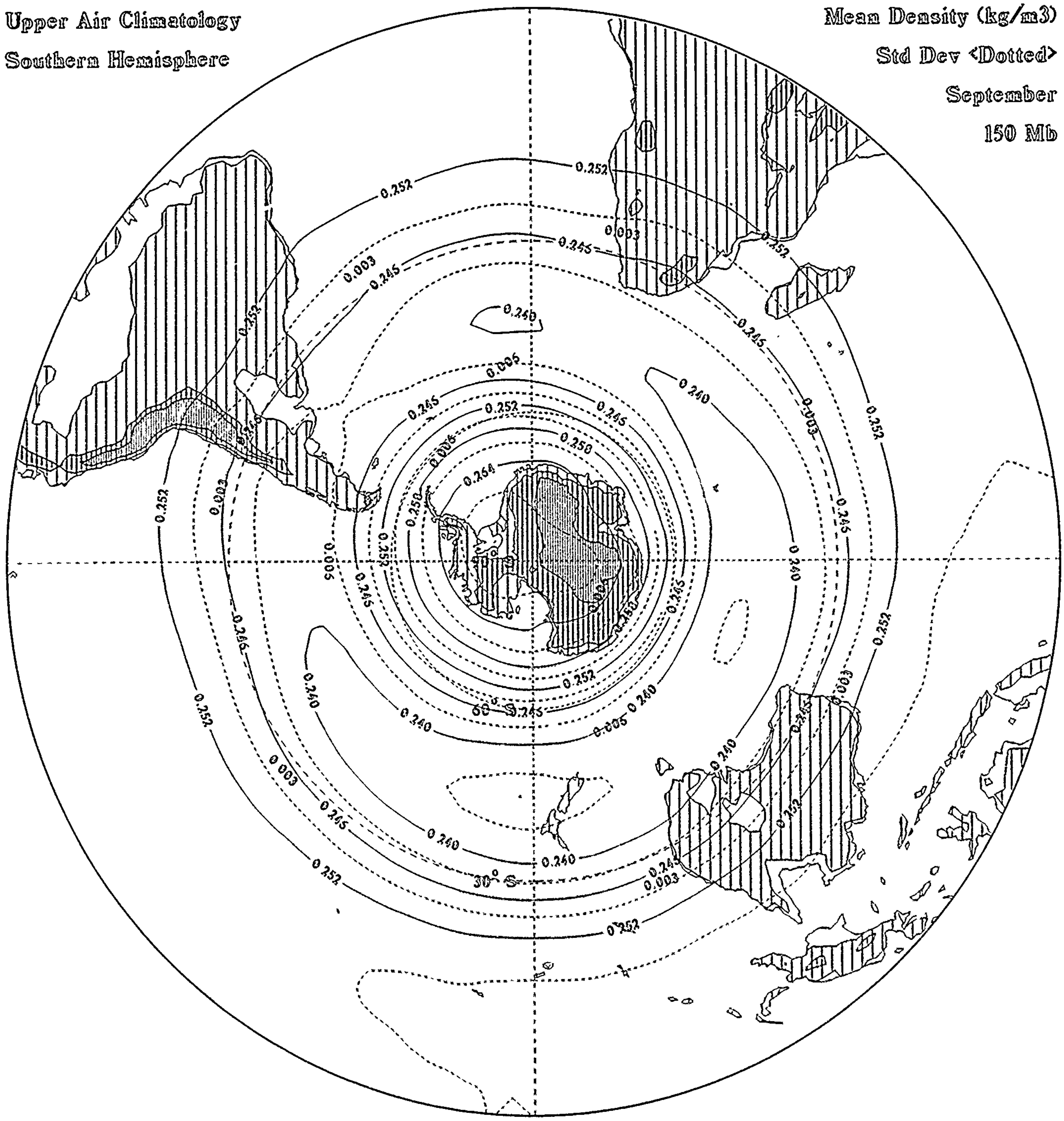


Mean Density (kg/m3)
Std Dev <Dotted>
September
150 Mb

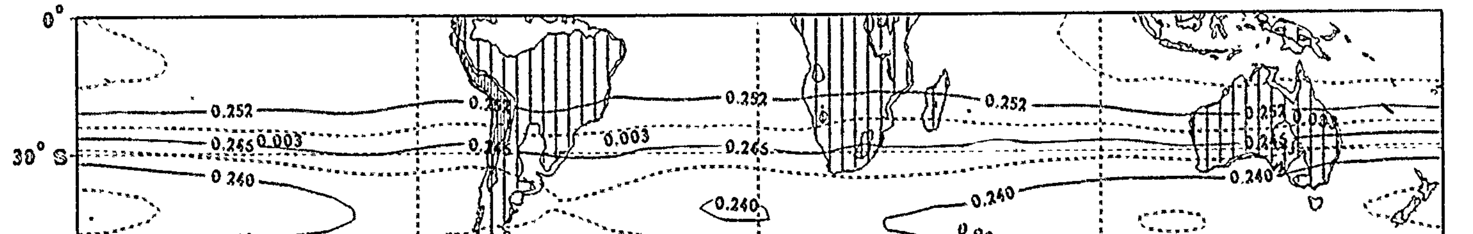
Upper Air Climatology
Northern Hemisphere







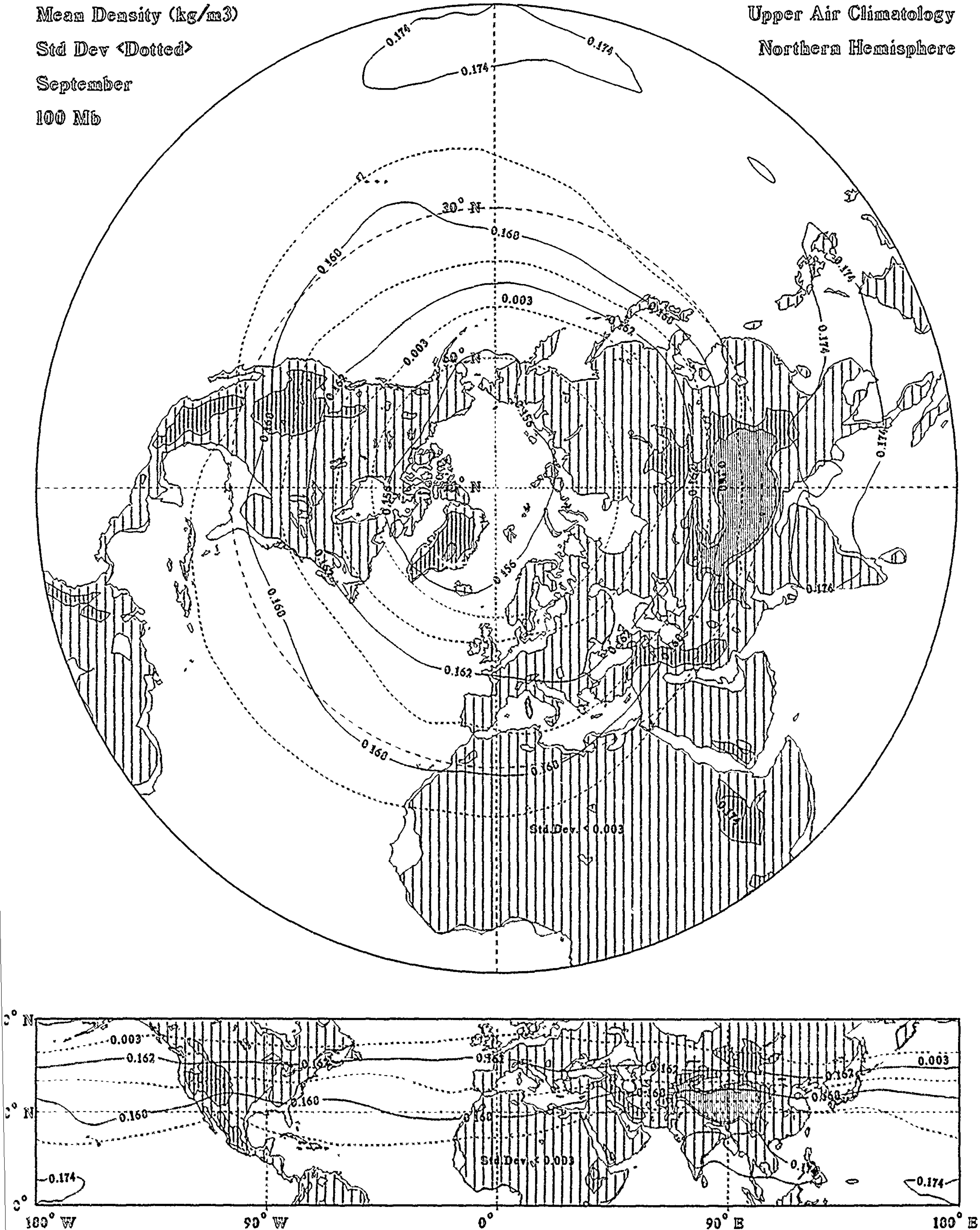
Upper Air Climatology
Southern Hemisphere
Mean Density (kg/m3)
Std Dev <Dotted>
September
150 Mb
0.252
0.245
0.240
0.003
0.006
0.264
0.258
60° S
30° S

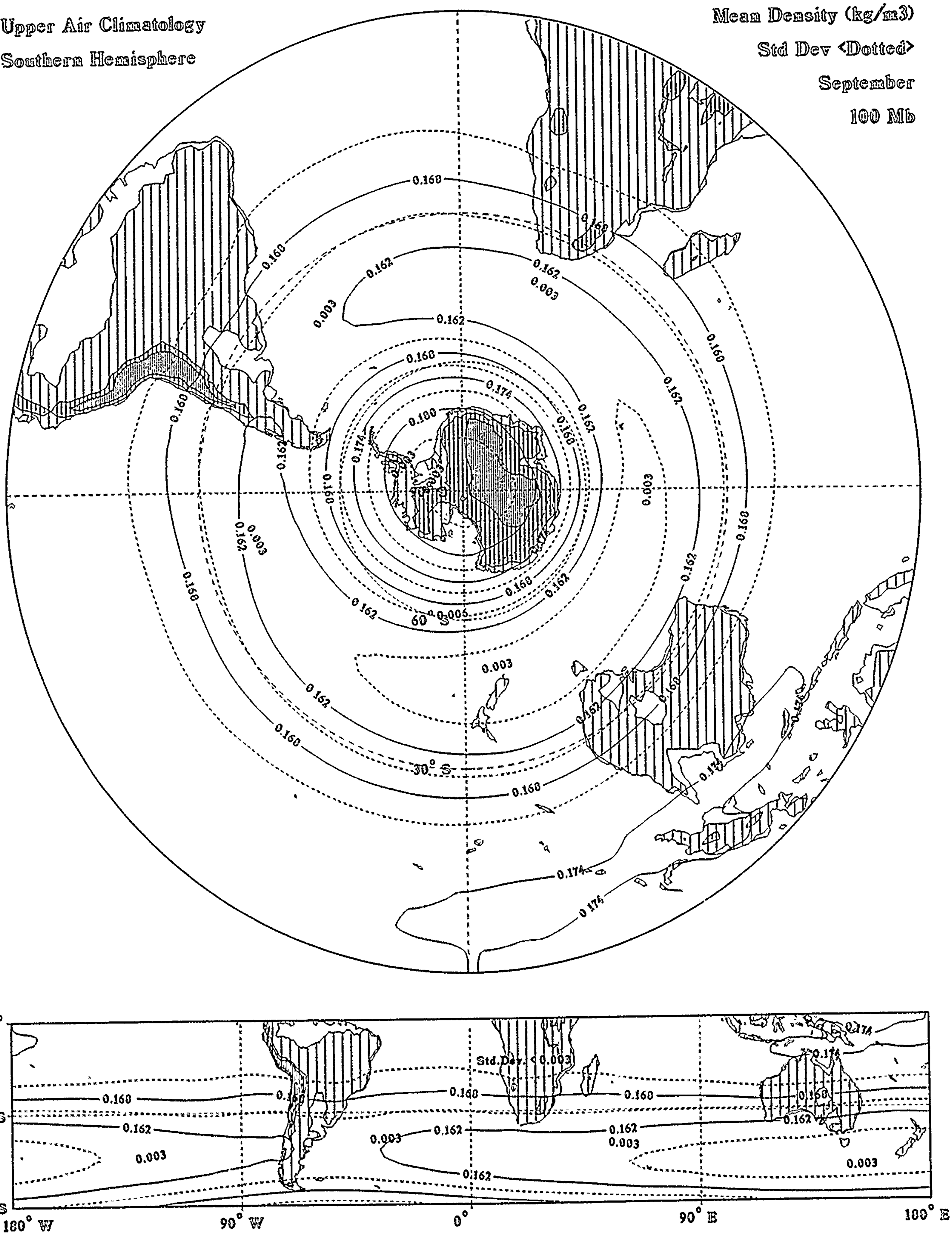


0°
30° S
60° S
180° W
90° W
0°
90° E
180° E
0.252
0.245
0.003
0.240
0.006

Mean Density (kg/m3)
Std Dev <Dotted>
September
100 Mb

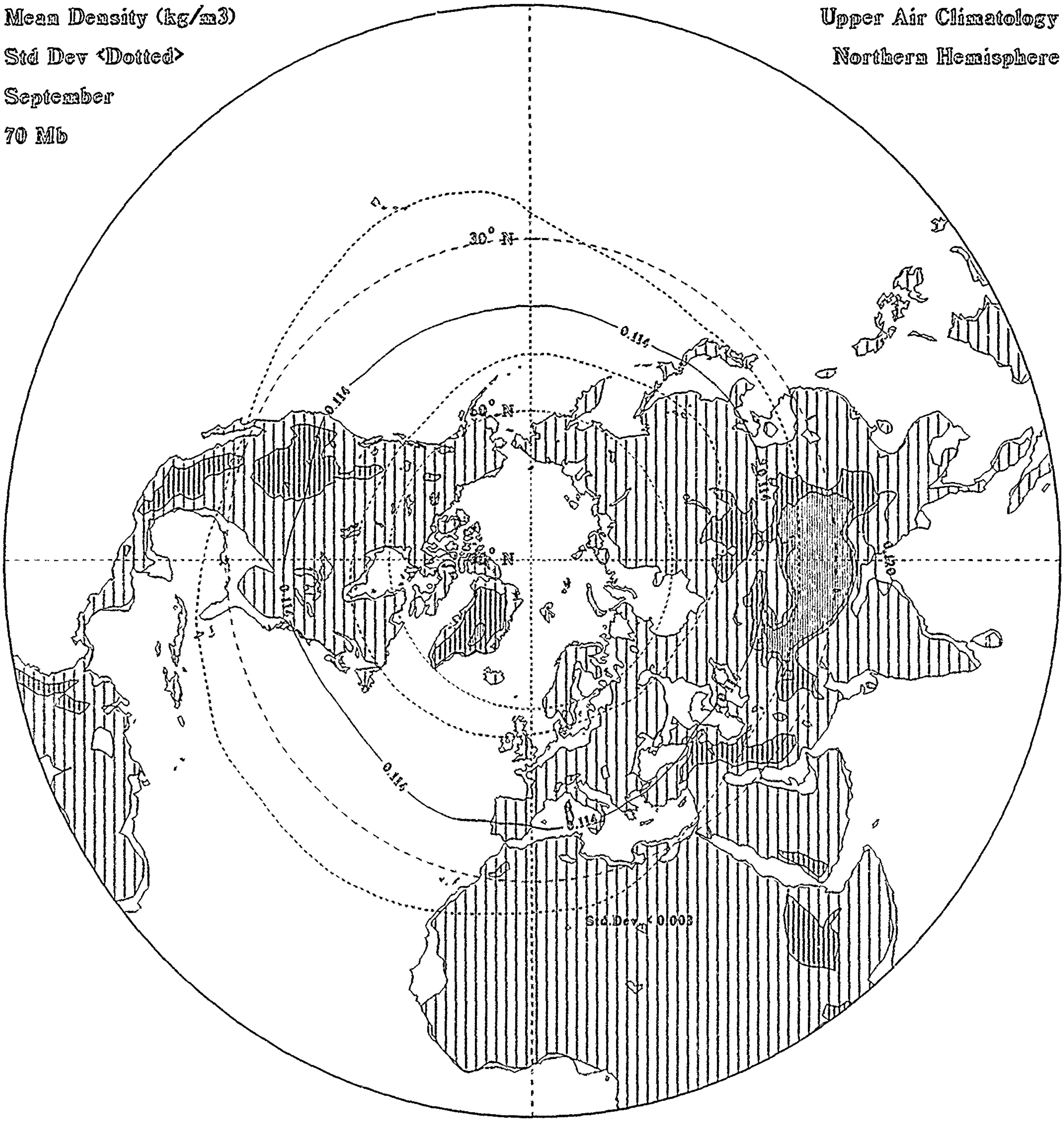
Upper Air Climatology
Northern Hemisphere

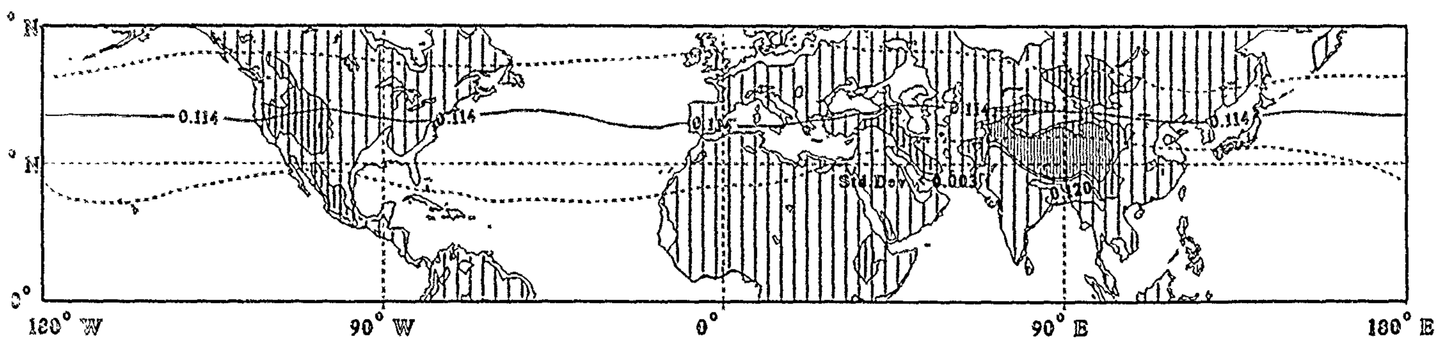



Upper Air Climatology
Southern Hemisphere
Mean Density (kg/m3)
Std Dev <Dotted>
September
100 Mb
0.168
0.162
0.160
0.003
0.174
0.180
60° S
30° S
Std.Dev. < 0.003
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

Mean Density (kg/m3)
Std Dev <Dotted>
September
70 Mb

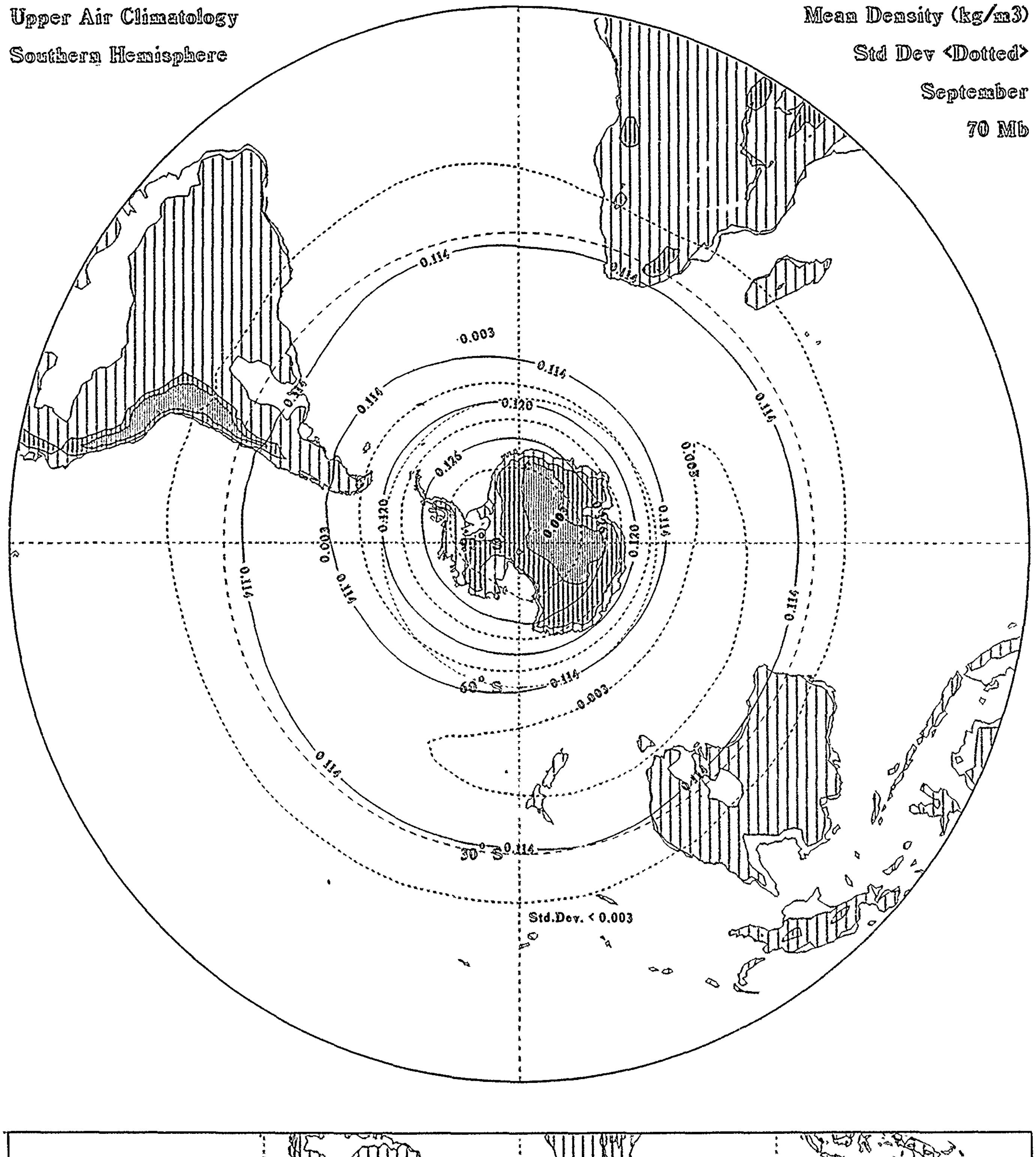
Upper Air Climatology
Northern Hemisphere

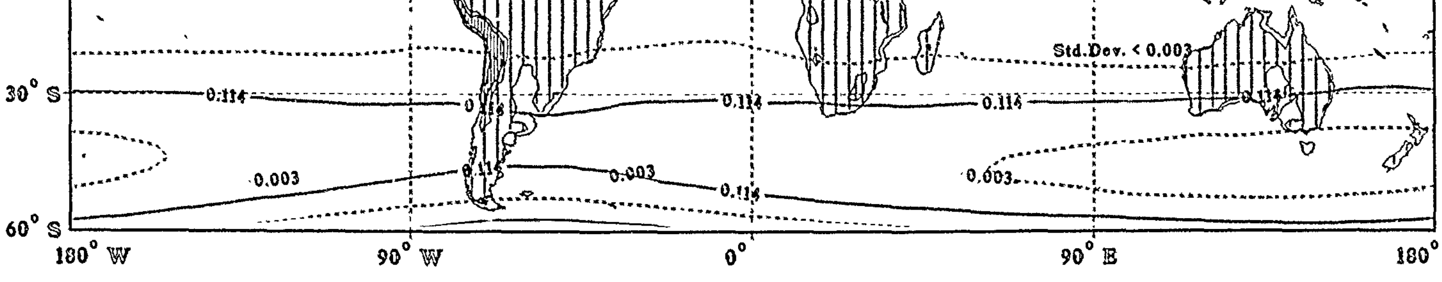




Upper Air Climatology
Southern Hemisphere

Mean Density (kg/m3)
Std Dev <Dotted>
September
70 Mb





Mean Density (kg/m3)

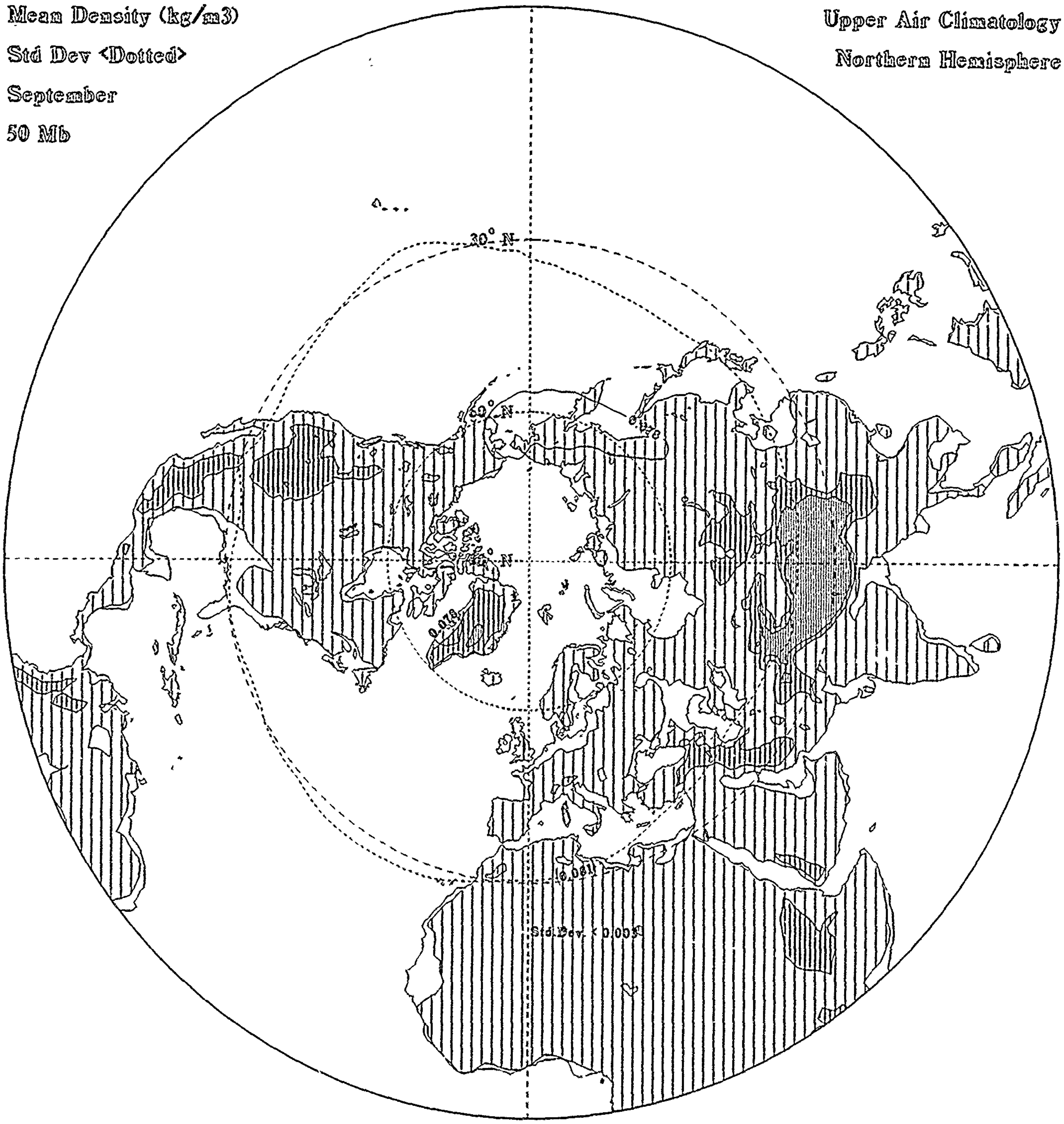
Std Dev <Dotted>

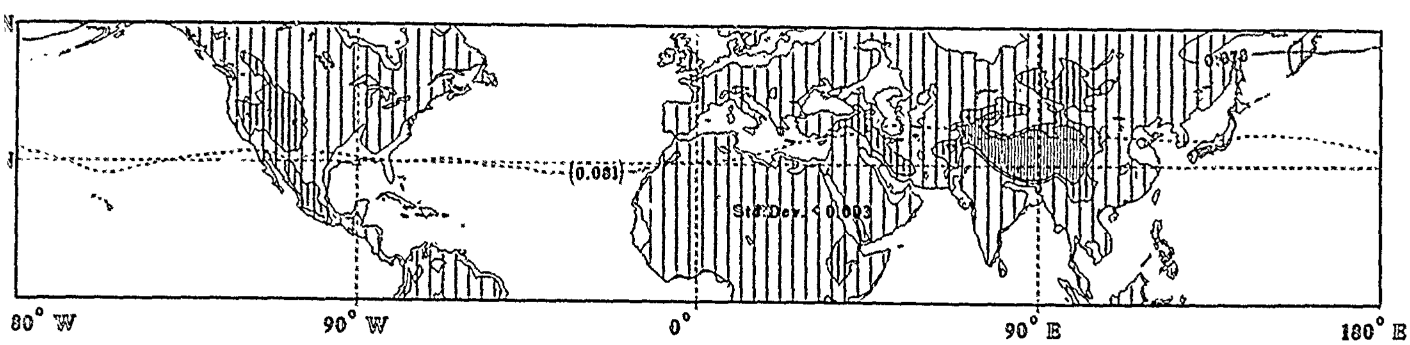
September

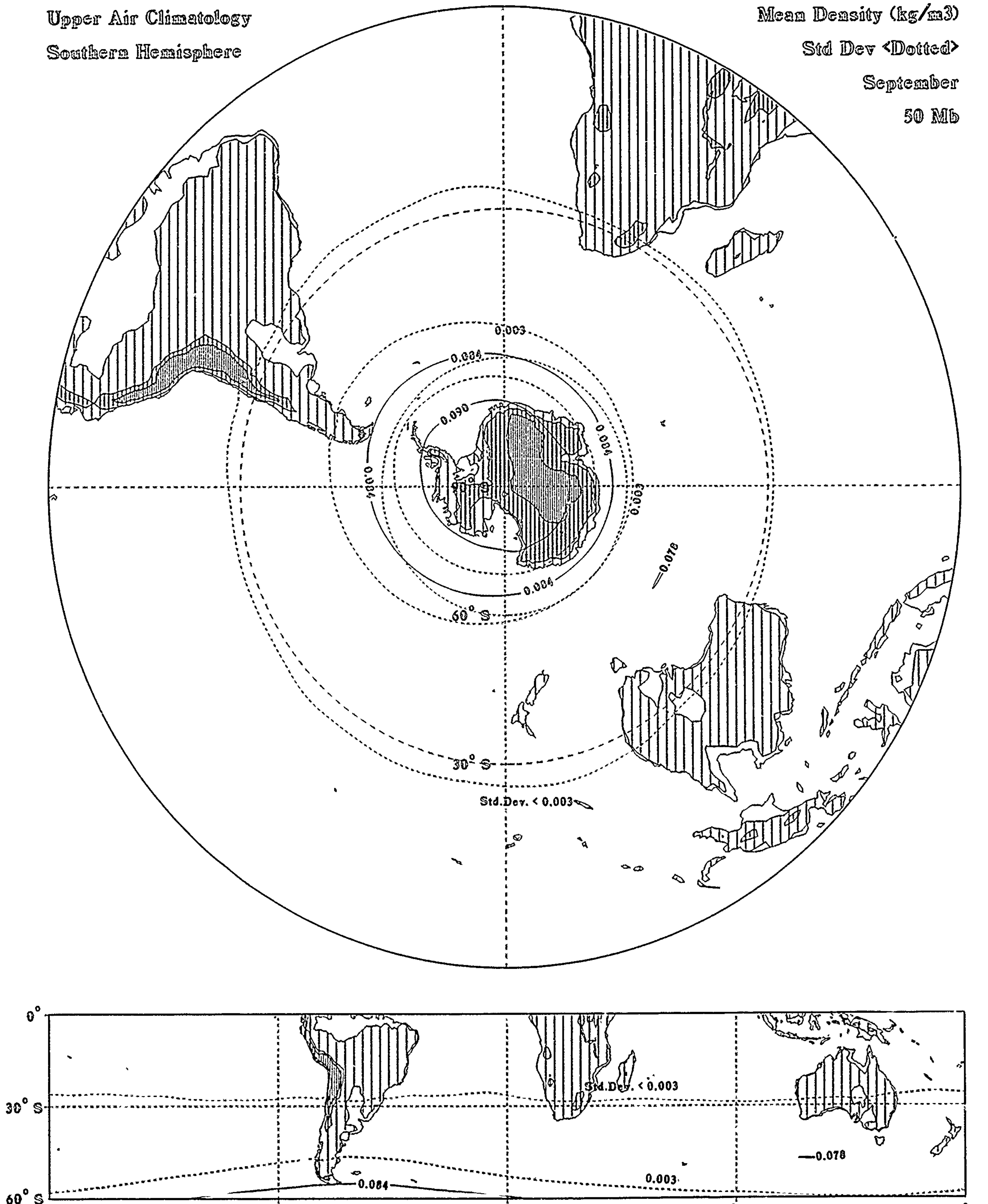
50 Mb

Upper Air Climatology

Northern Hemisphere

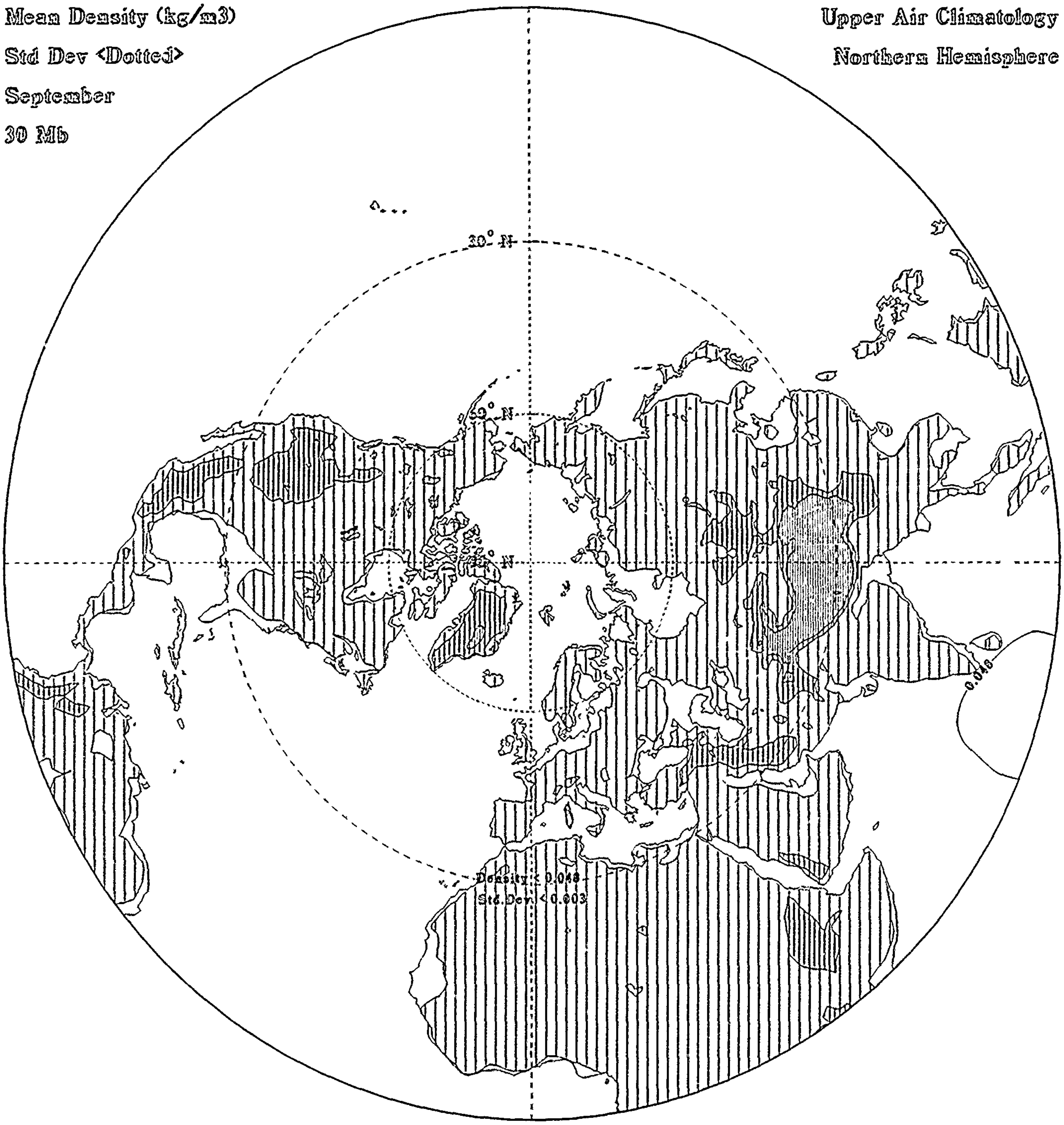


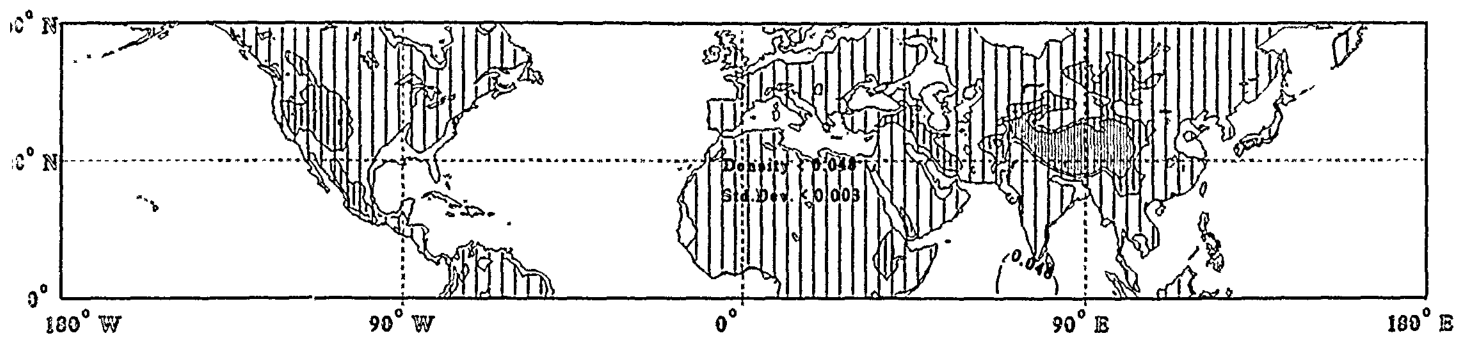


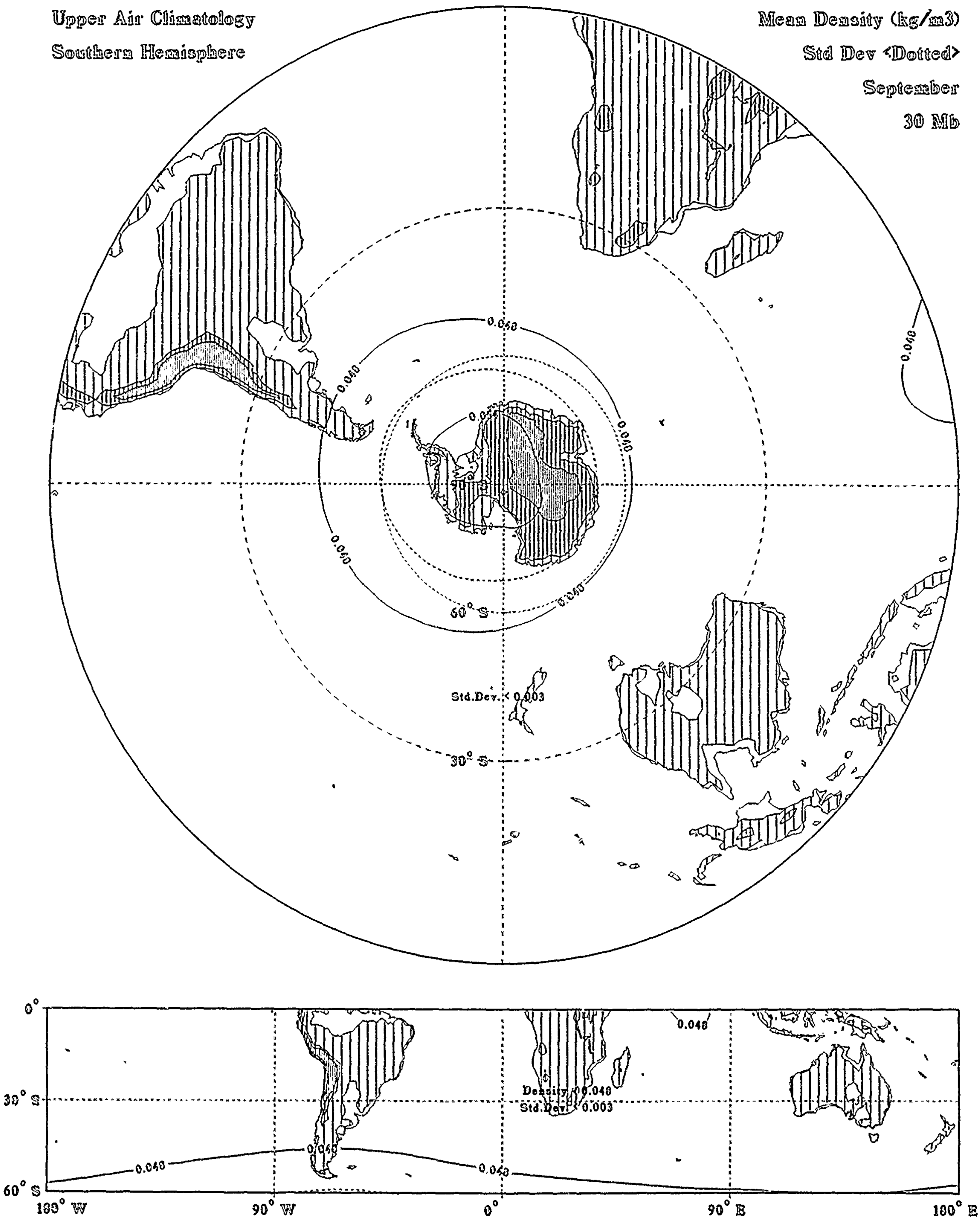

Upper Air Climatology
Southern Hemisphere
Mean Density (kg/m3)
Std Dev <Dotted>
September
50 Mb
0.003
0.084
0.090
0.078
60° S
30° S
Std.Dev. < 0.003
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E
0.084
0.003
0.078

Mean Density (kg/m3)
Std Dev <Dotted>
September
30 Mb

Upper Air Climatology
Northern Hemisphere







Upper Air Climatology
Southern Hemisphere
Mean Density (kg/m3)
Std Dev <Dotted>
September
30 Mb
0.048
60° S
30° S
Std.Dev. < 0.003
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E
Density 0.048
Std.Dev. 0.003

STANDARD DEVIATION OF HEIGHT
STANDARD DEVIATION OF VECTOR MEAN WIND
(13 LEVELS, 1000 TO 30 MB)

- Contours of standard deviation of height (solid lines) in geopotential dekameters

- Standard deviation of height labeled interval:

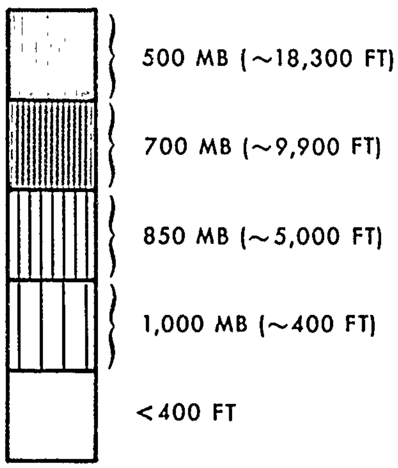
  3 dekameters (30 meters) - 1000 MB to 400 MB
  6 dekameters (60 meters) - 300 MB to 200 MB
  4 dekameters (40 meters) - 150 MB to 30 MB

- Contours of standard deviation of vector mean wind (dashed lines) in knots

- Standard deviation of vector mean wind labeled interval: 5 knots

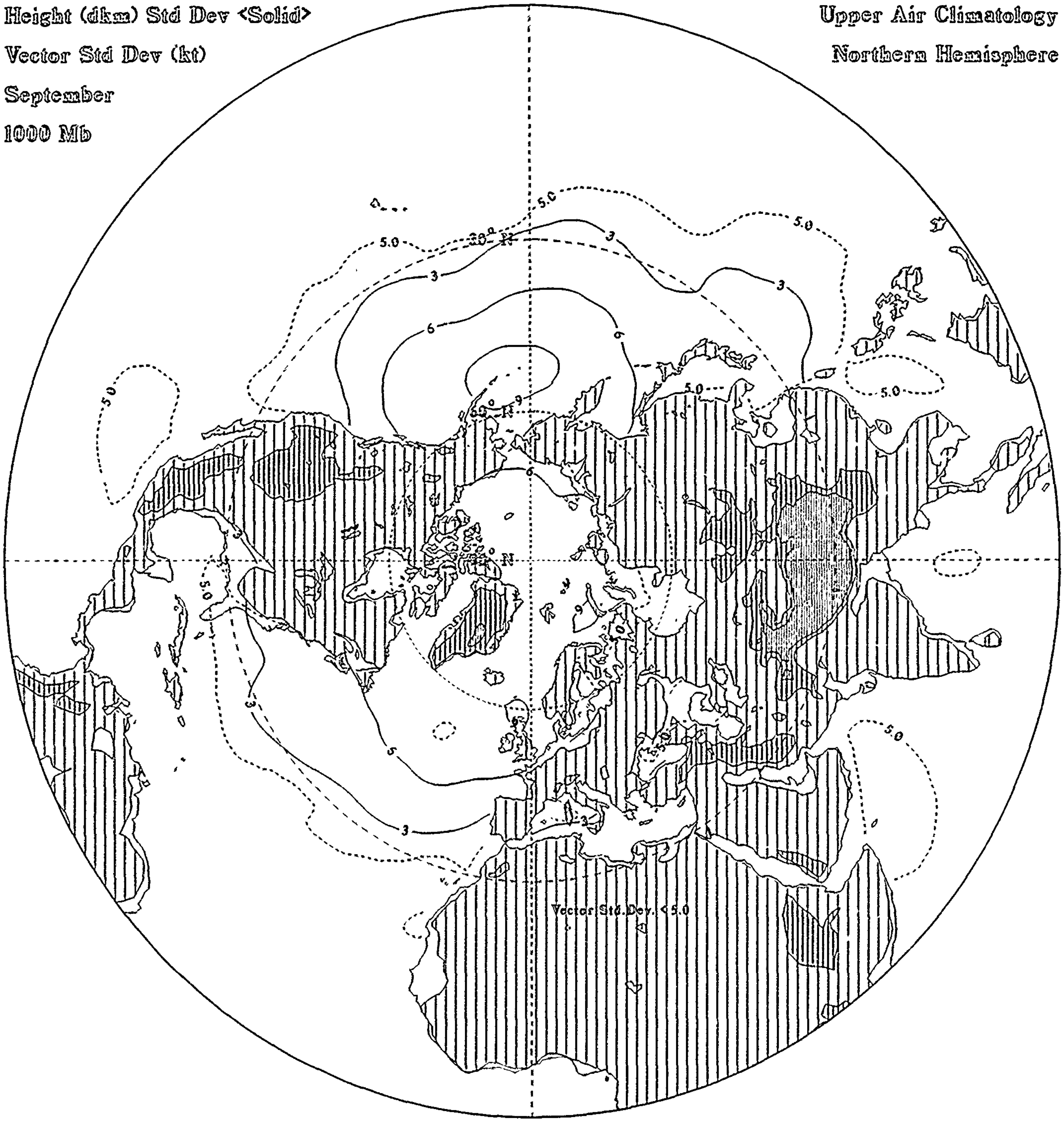
- Contours blanked for geographic areas with elevations exceeding specified geopotential heights

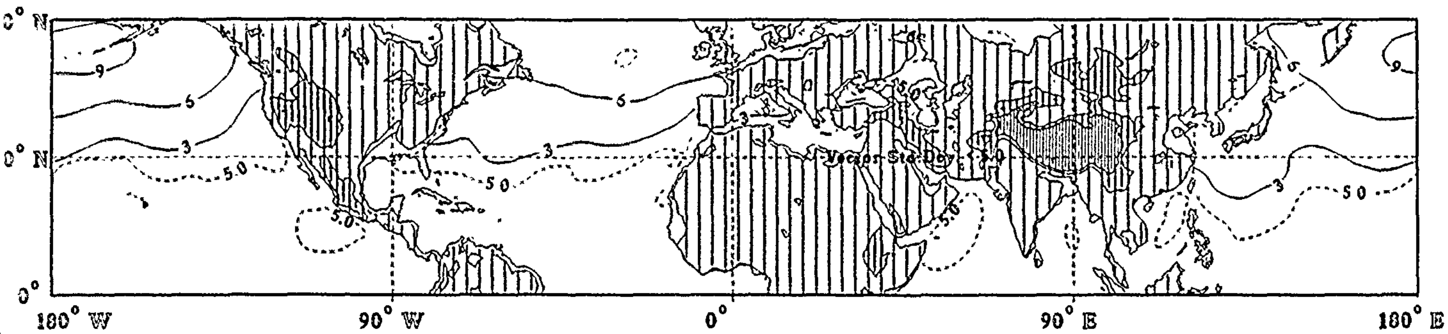
ELEVATION SCALE



Height (dkm) Std Dev <Solid>
Vector Std Dev (kt)
September
1000 Mb

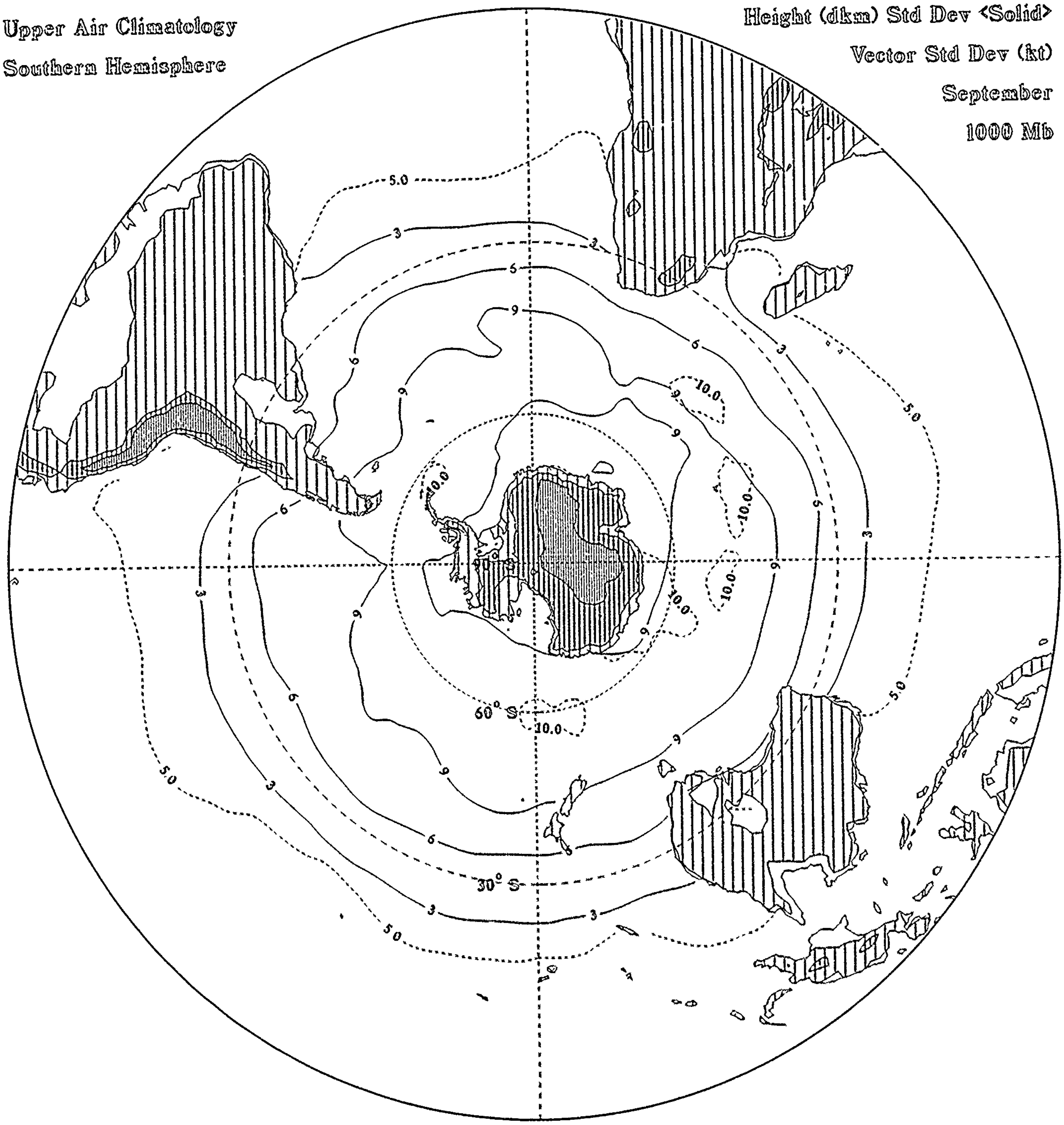
Upper Air Climatology
Northern Hemisphere

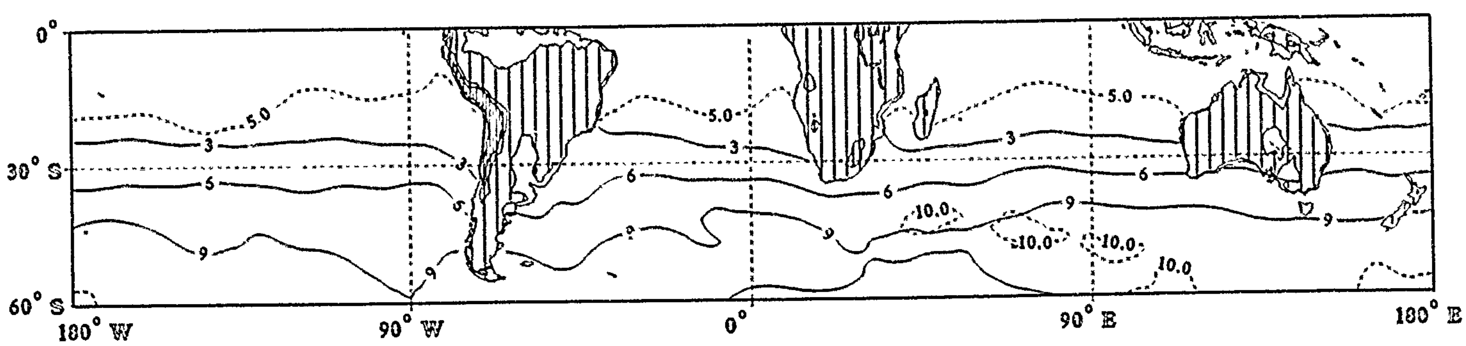




Upper Air Climatology
Southern Hemisphere

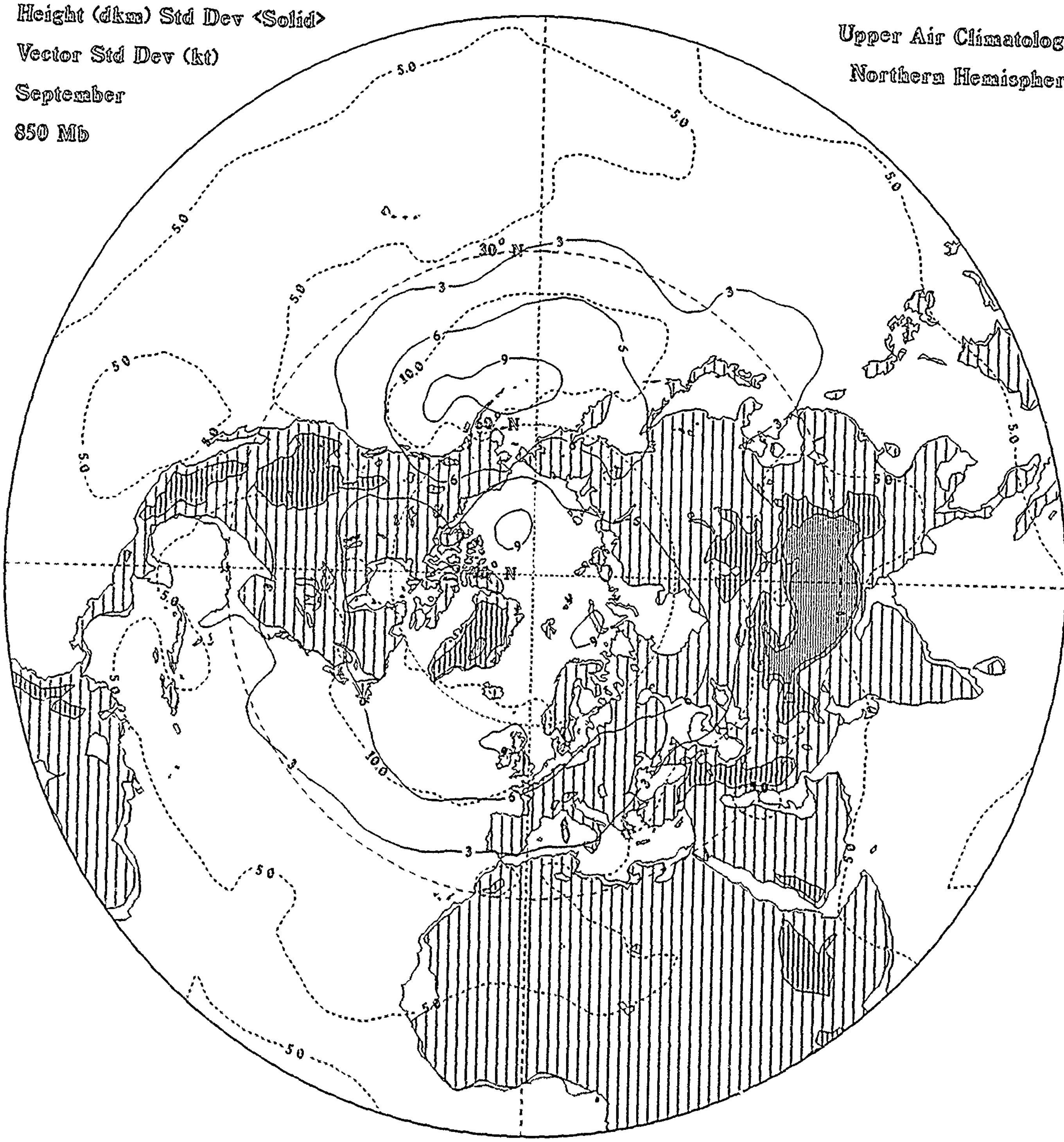
Height (dkm) Std Dev <Solid>
Vector Std Dev (kt)
September
1000 Mb

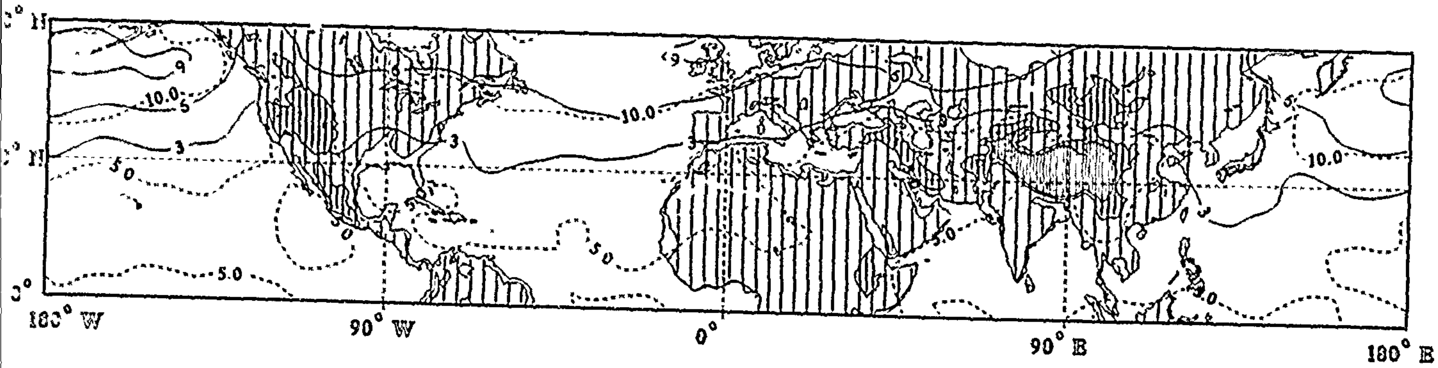


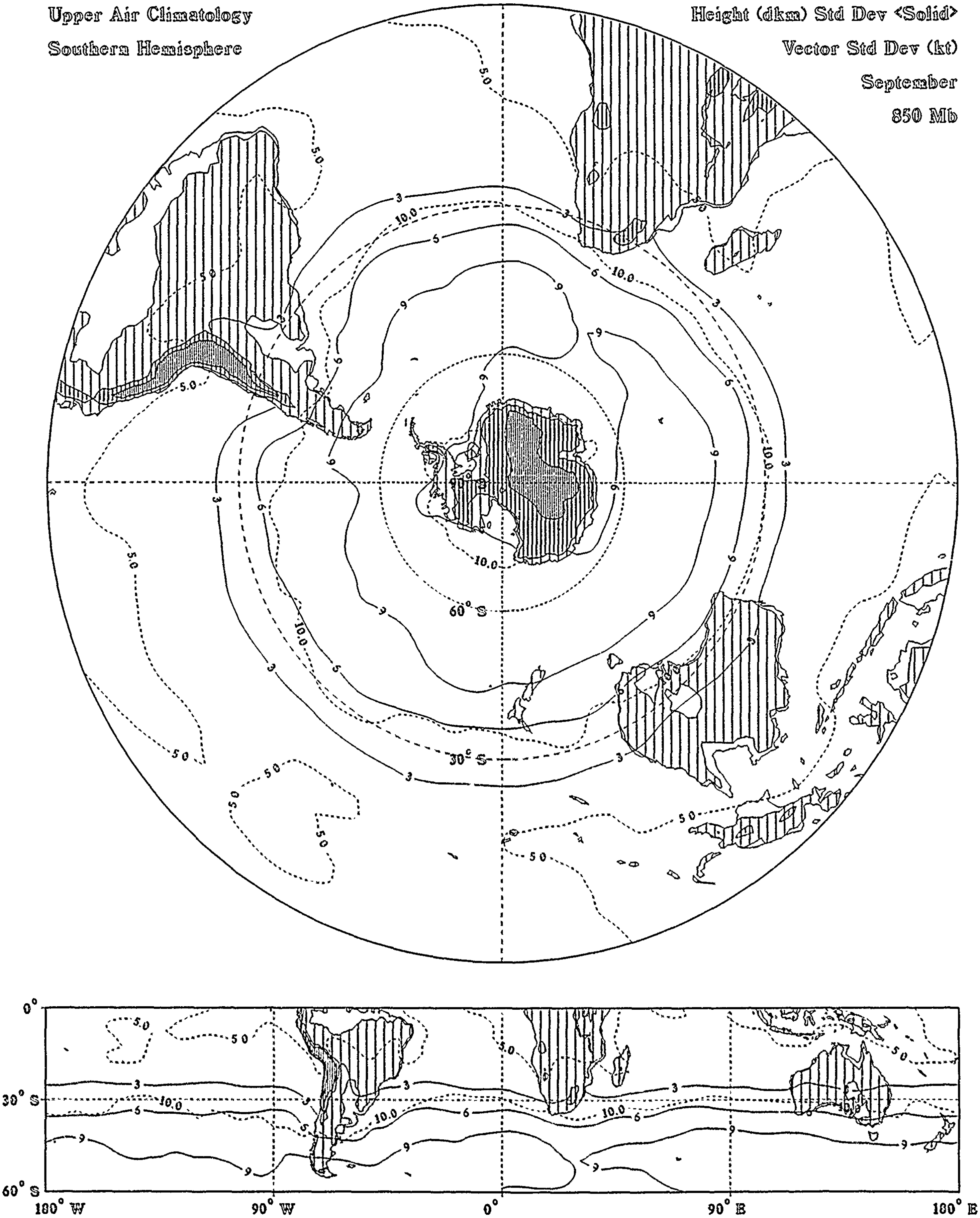


Height (dkm) Std Dev <Solid>
Vector Std Dev (kt)
September
850 Mb

Upper Air Climatology
Northern Hemisphere






Upper Air Climatology
Southern Hemisphere
Height (dkm) Std Dev <Solid>
Vector Std Dev (kt)
September
850 Mb
60° S
30° S
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

Height (dkm) Std Dev <Solid>

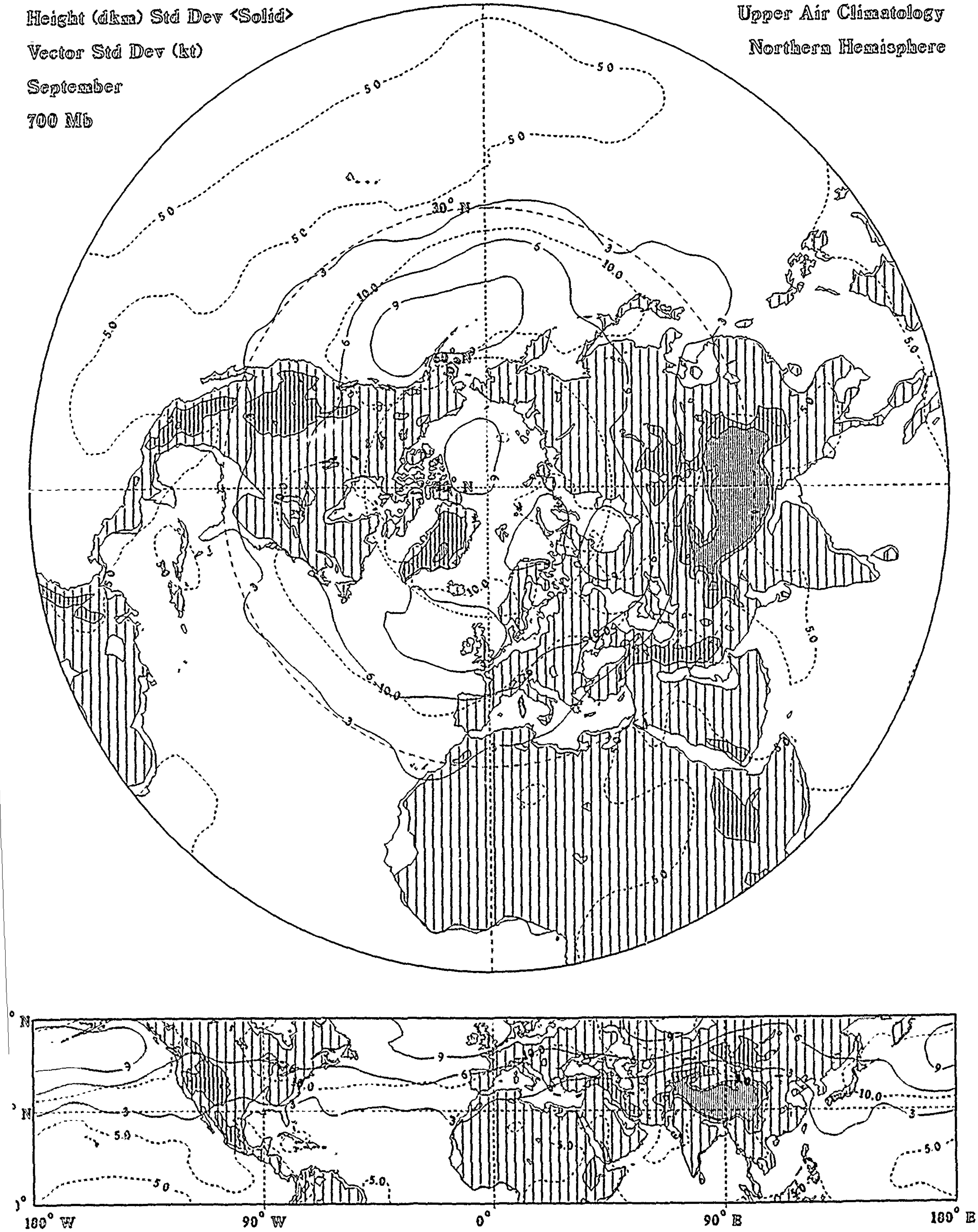
Vector Std Dev (kt)

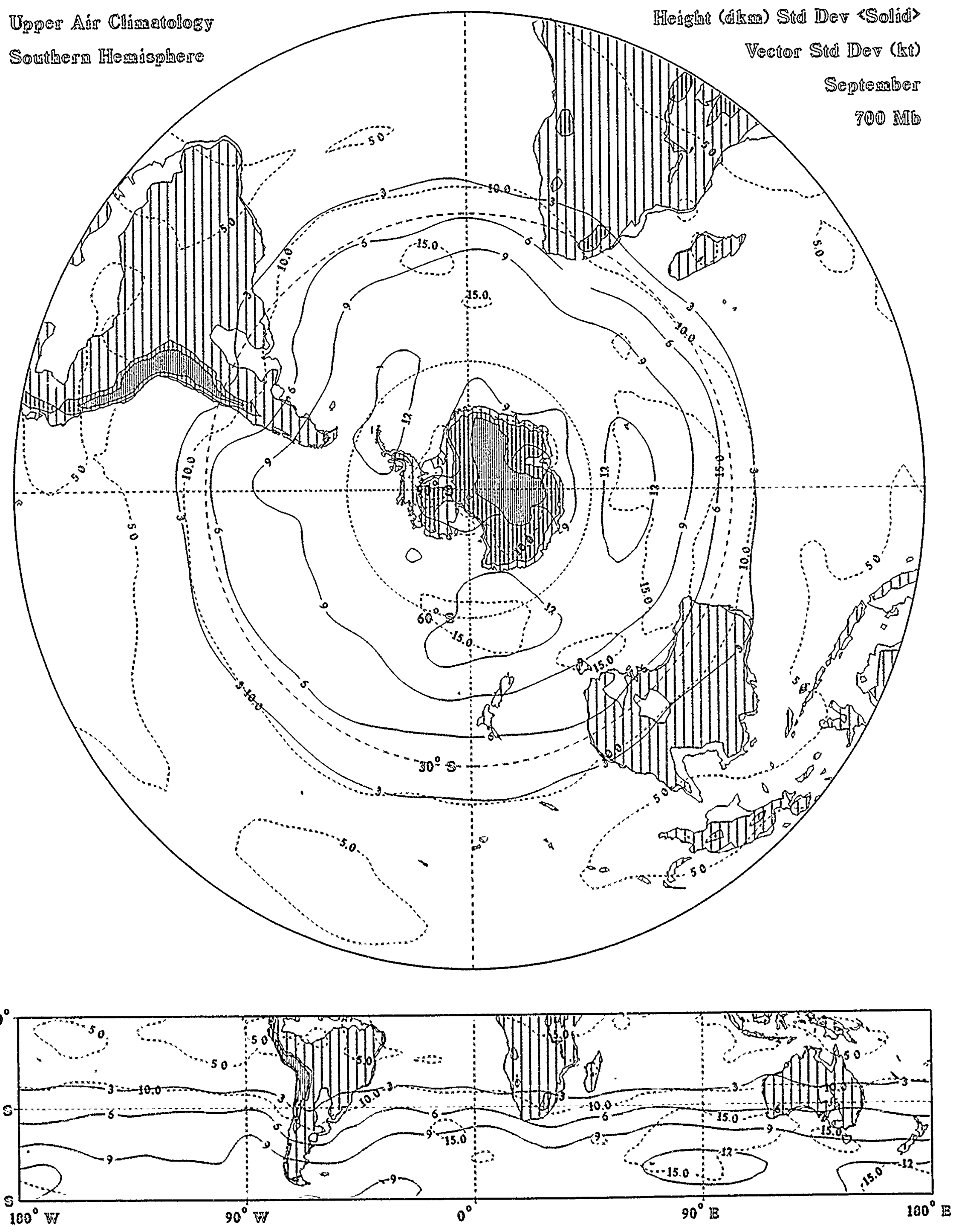
September

700 Mb

Upper Air Climatology

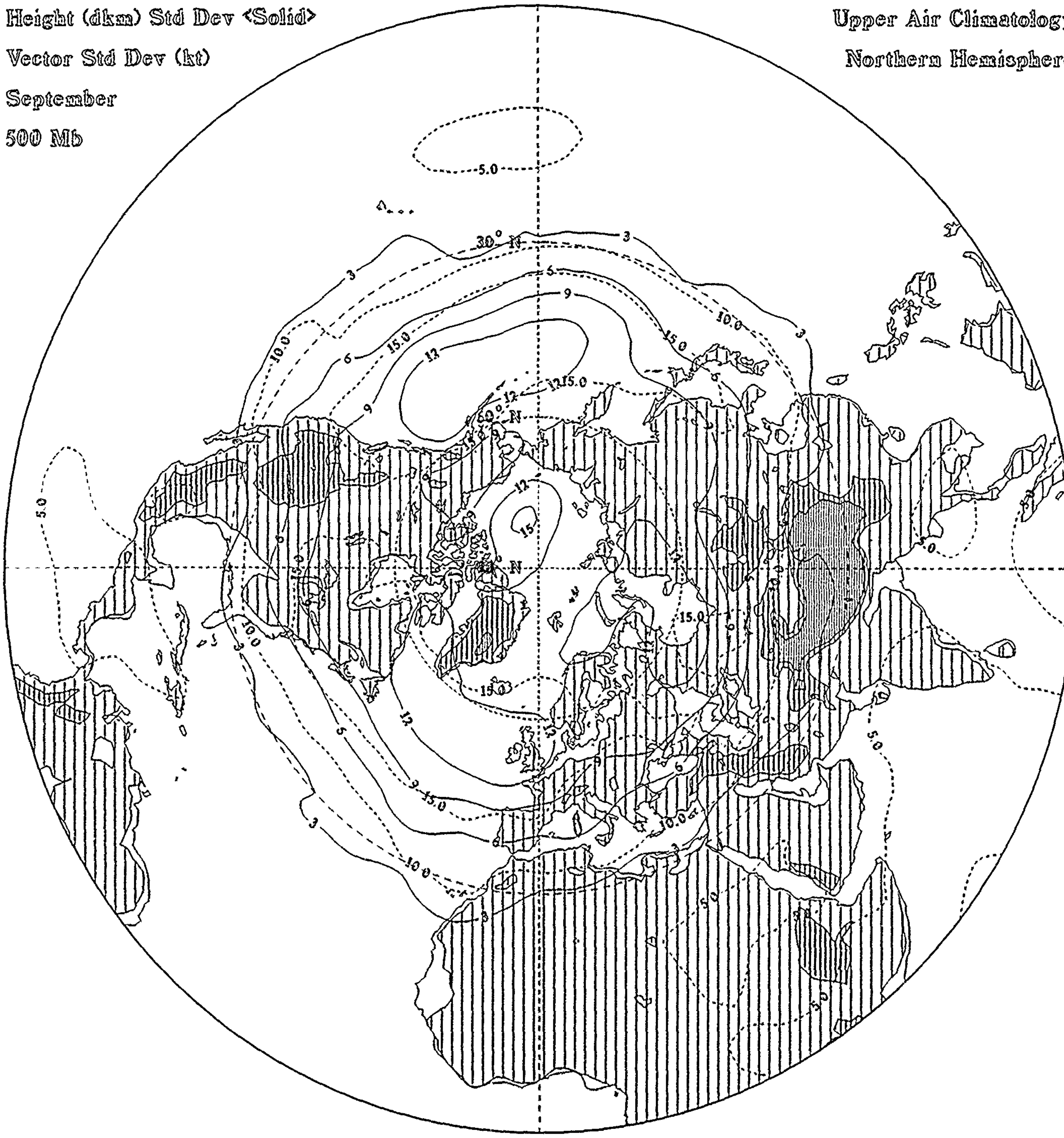
Northern Hemisphere

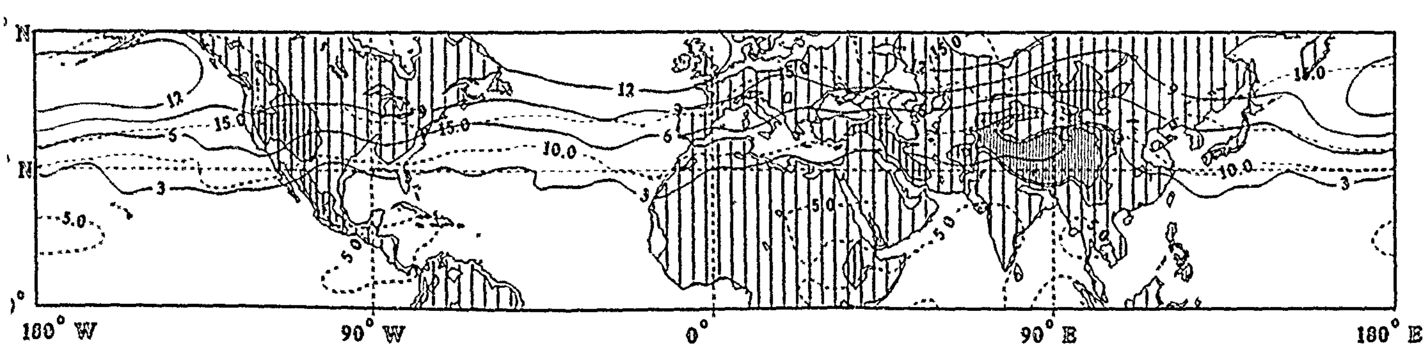



Upper Air Climatology
Southern Hemisphere
Height (dkm) Std Dev <Solid>
Vector Std Dev (kt)
September
700 Mb
30° S
60° S
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

Height (dkm) Std Dev <Solid>
Vector Std Dev (kt)
September
500 Mb

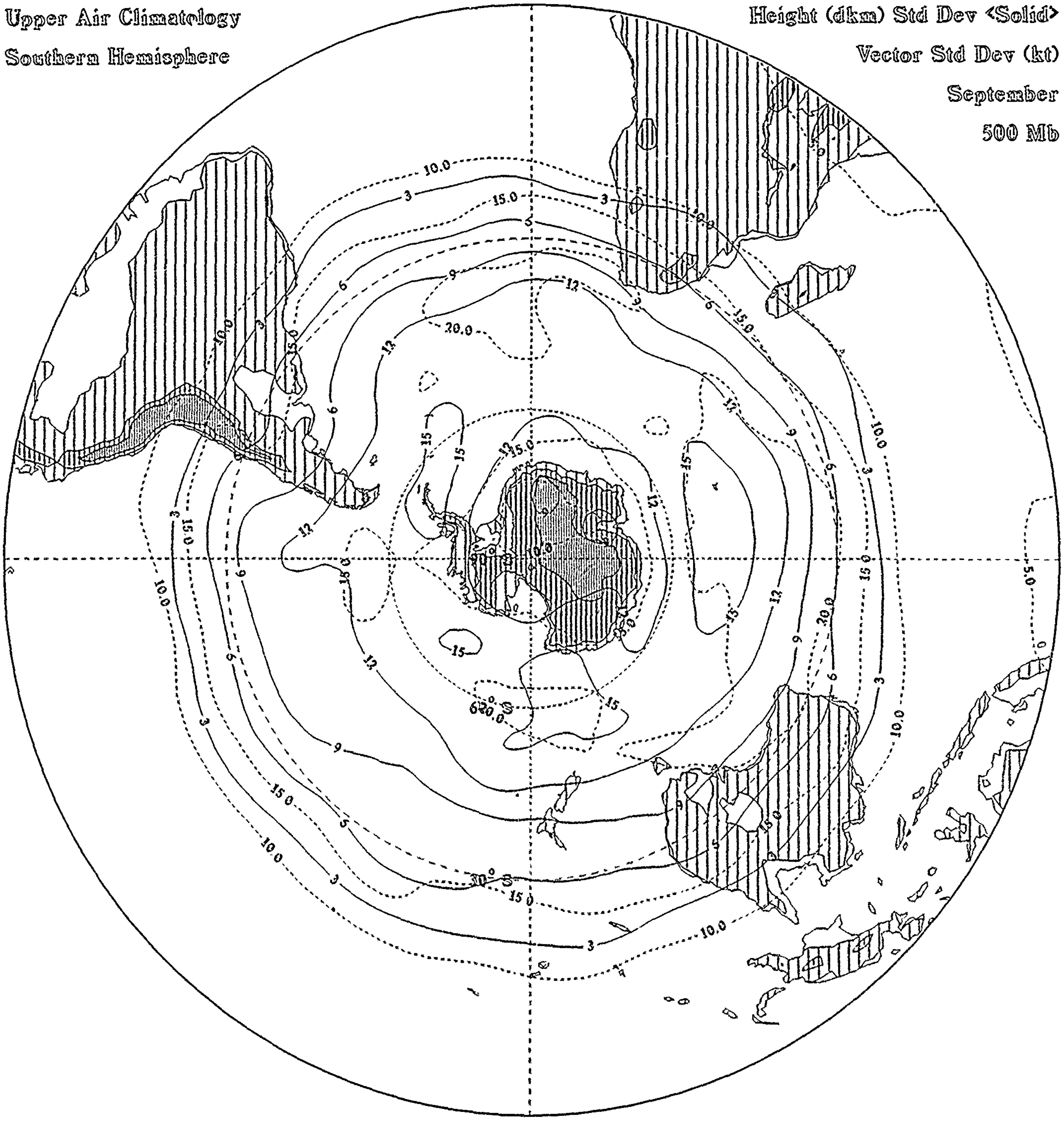
Upper Air Climatology
Northern Hemisphere

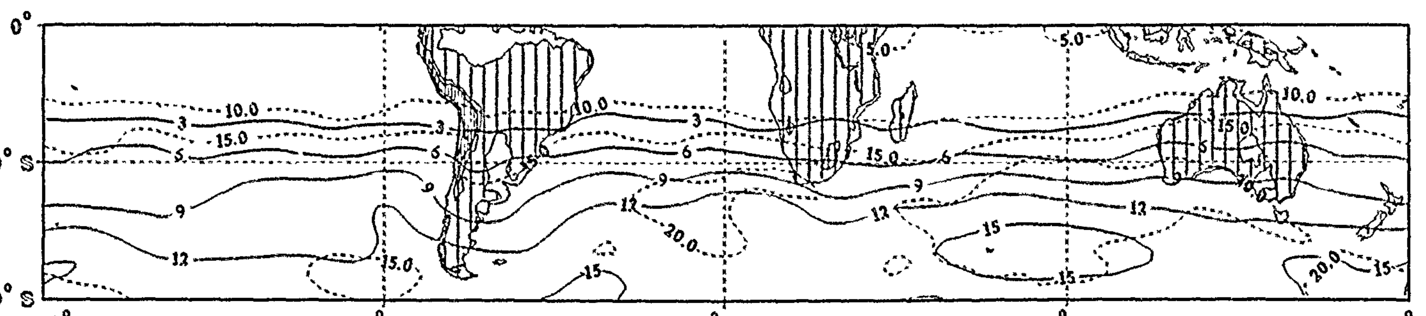




Upper Air Climatology
Southern Hemisphere

Height (dkm) Std Dev <Solid>
Vector Std Dev (kt)
September
500 Mb





Height (dkm) Std Dev <Solid>

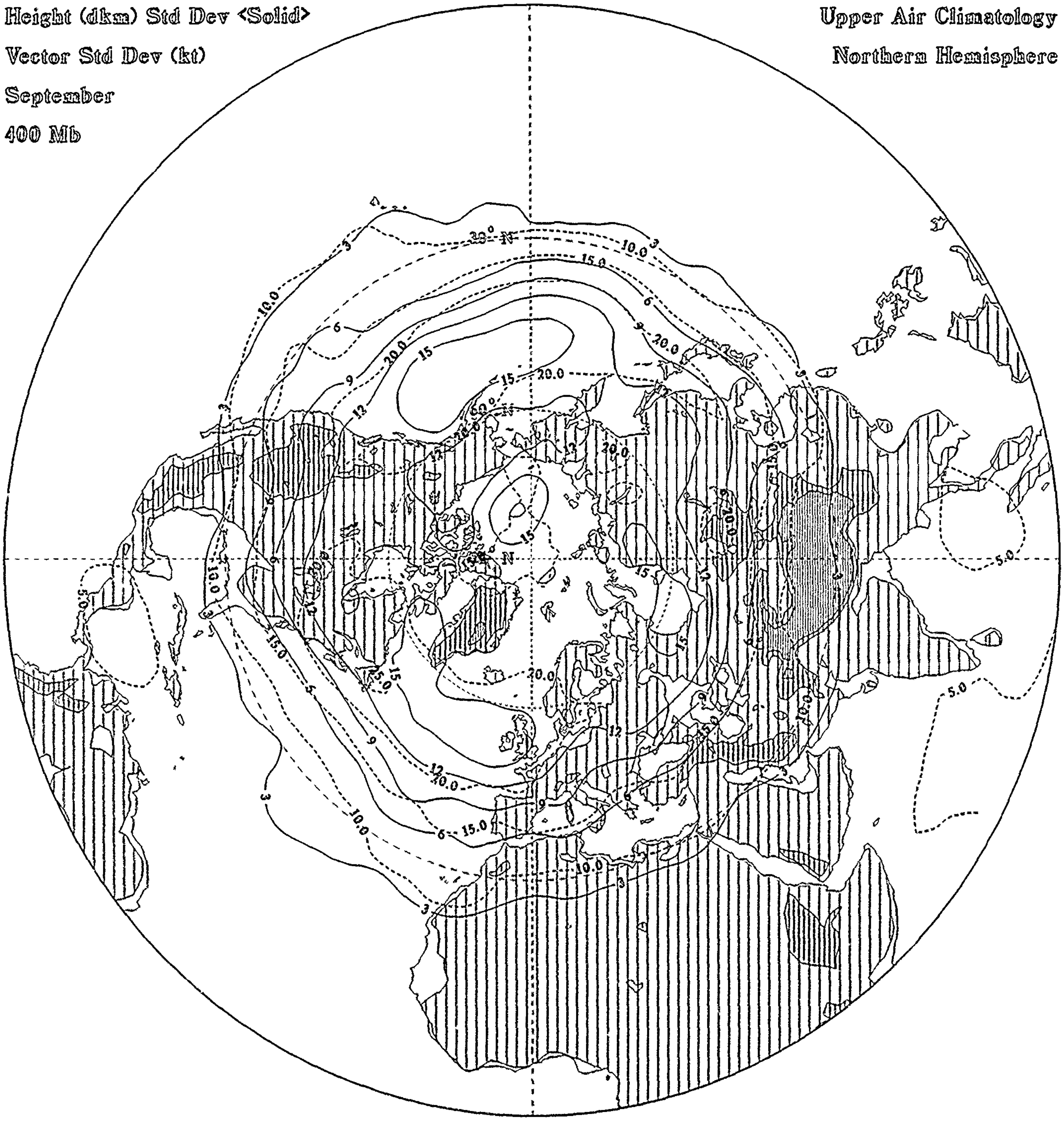
Vector Std Dev (kt)

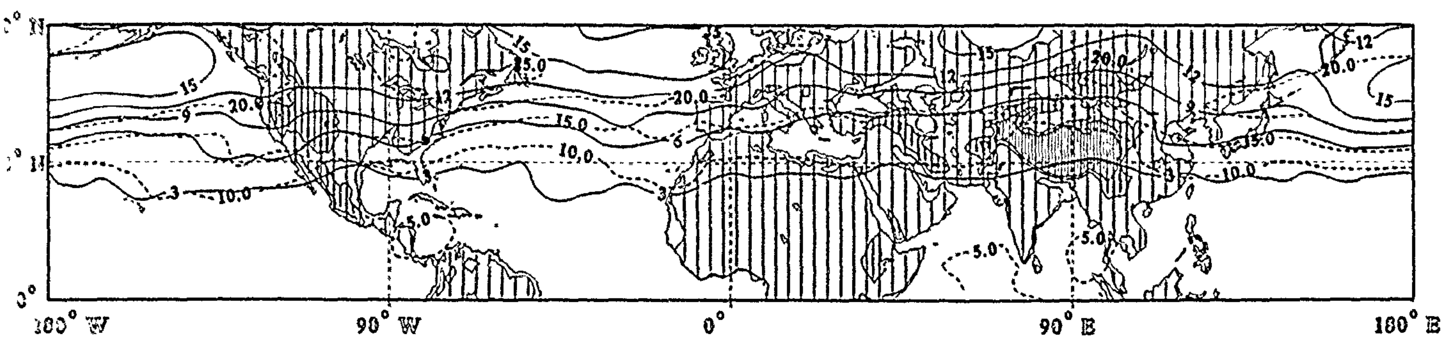
September

400 Mb

Upper Air Climatology

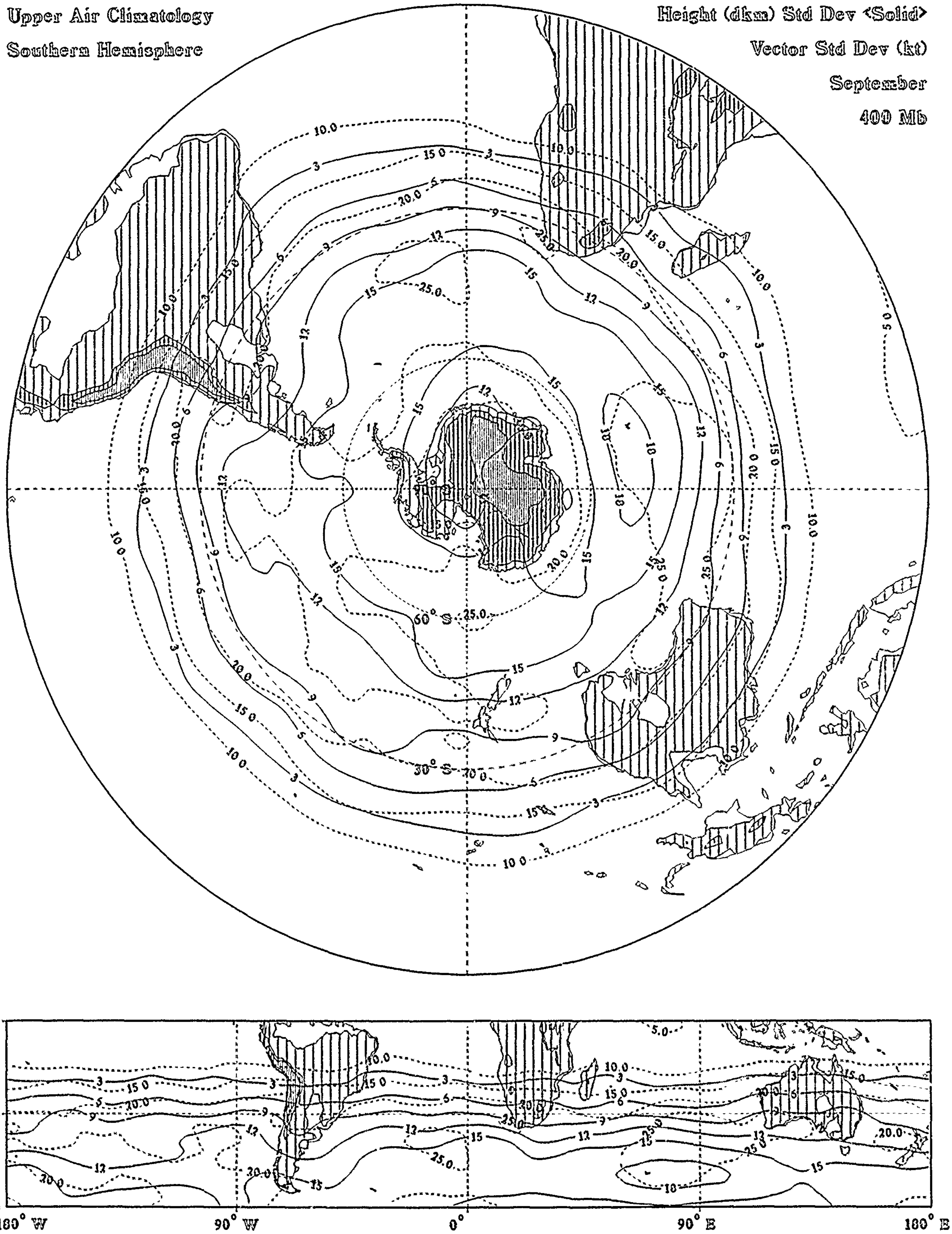
Northern Hemisphere

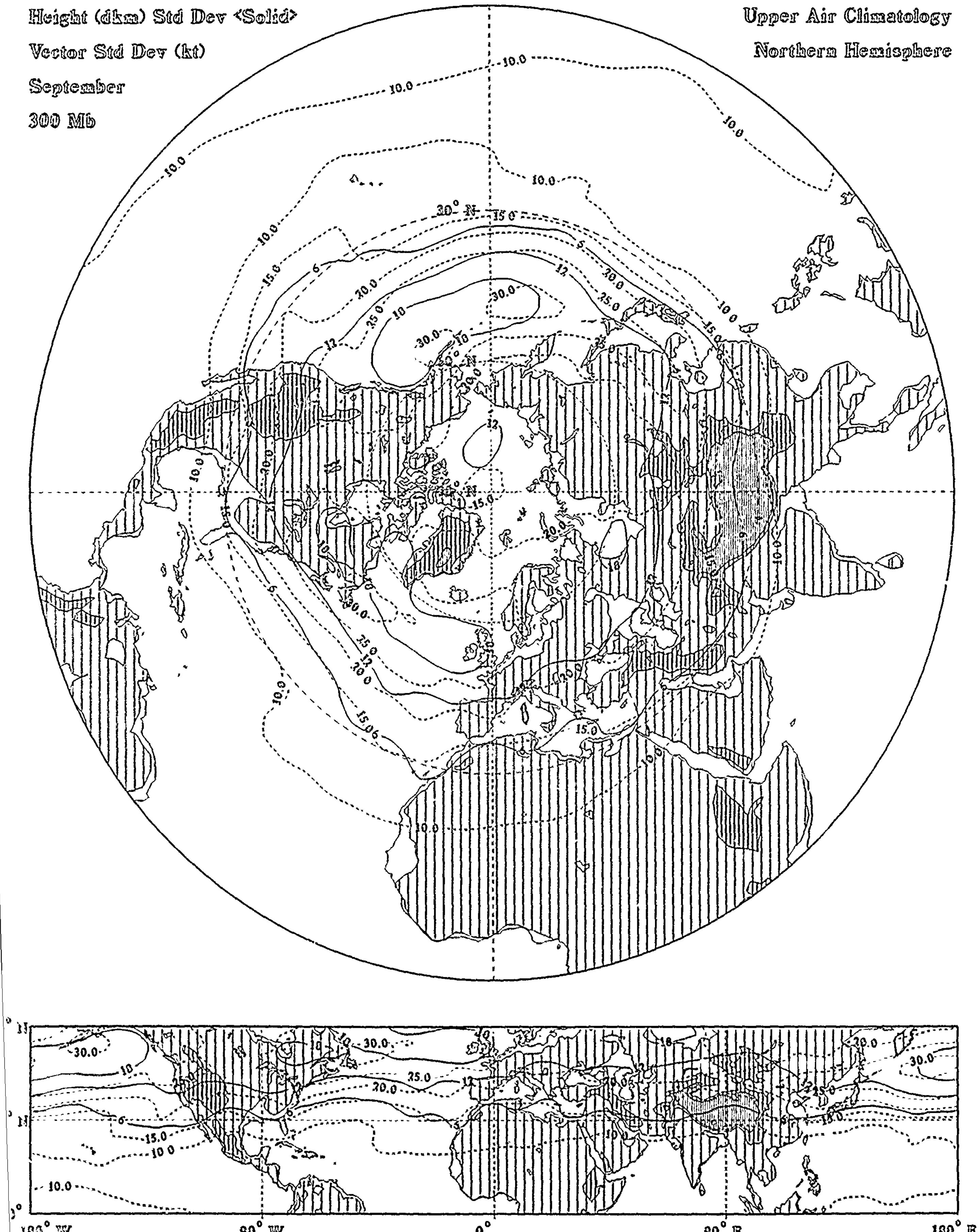




Upper Air Climatology
Southern Hemisphere

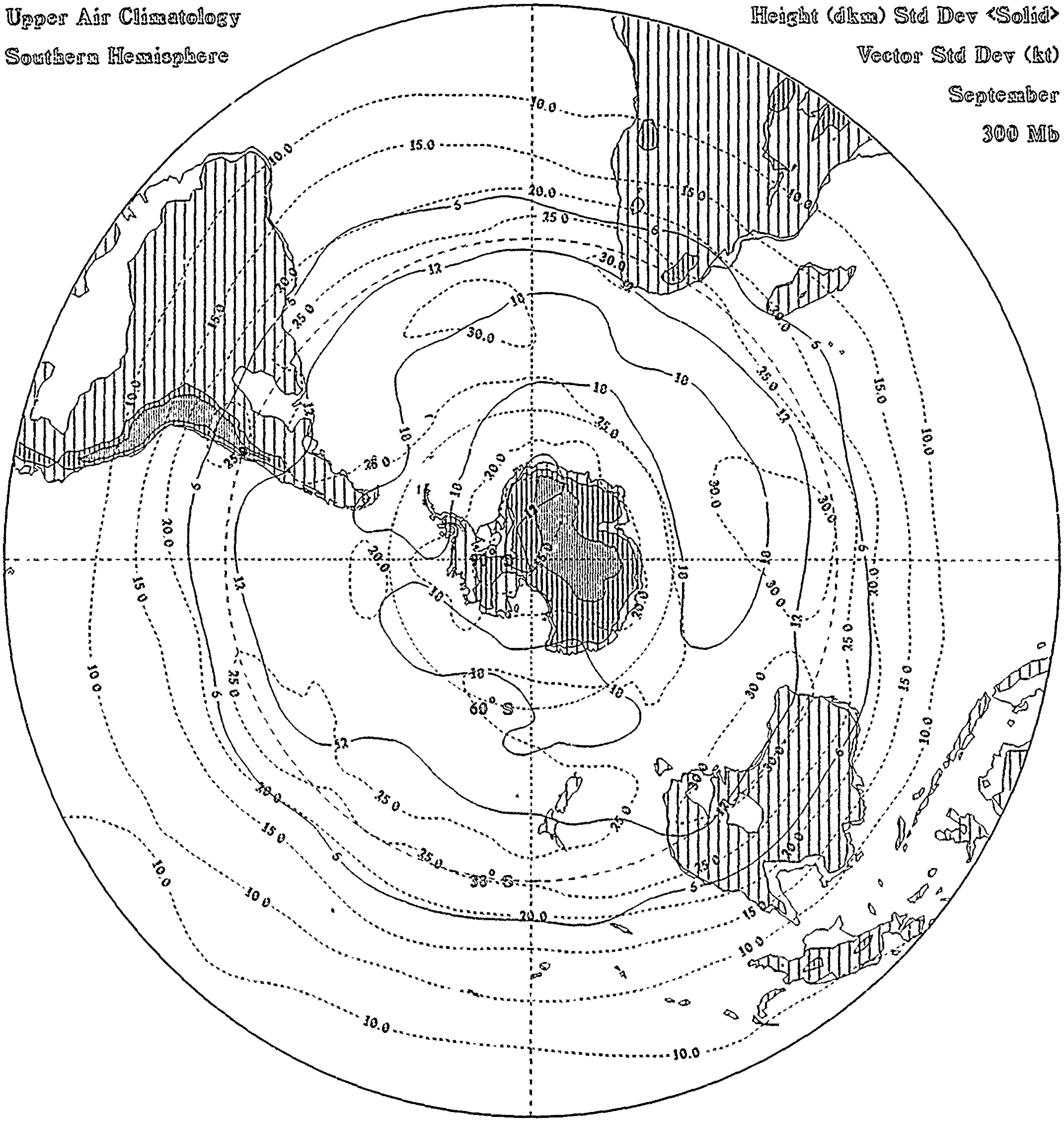
Height (dkm) Std Dev <Solid>
Vector Std Dev (kt)
September
400 Mb

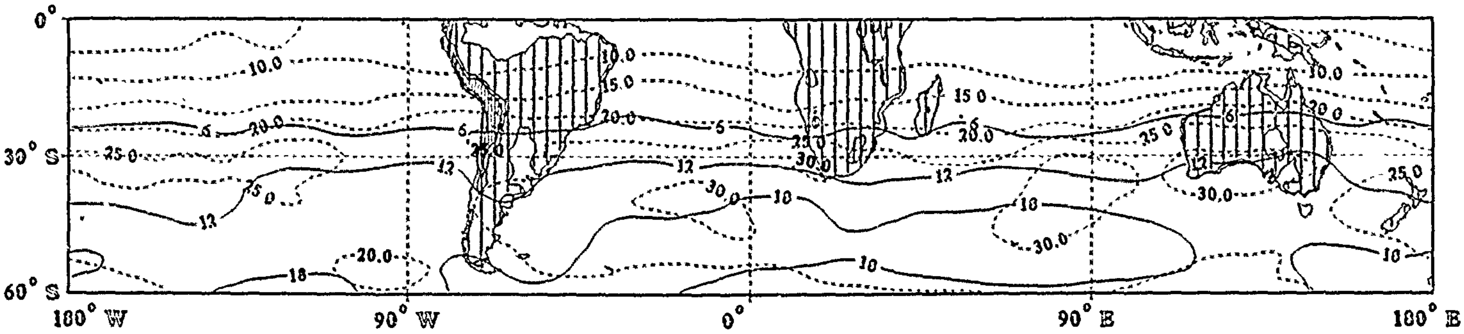



Height (dkm) Std Dev <Solid>
Vector Std Dev (kt)
September
300 Mb
Upper Air Climatology
Northern Hemisphere
180° W
90° W
0°
90° E
180° E

Upper Air Climatology
Southern Hemisphere

Height (dkm) Std Dev <Solid>
Vector Std Dev (kt)
September
300 Mb





Height (dkm) Std Dev <Solid>

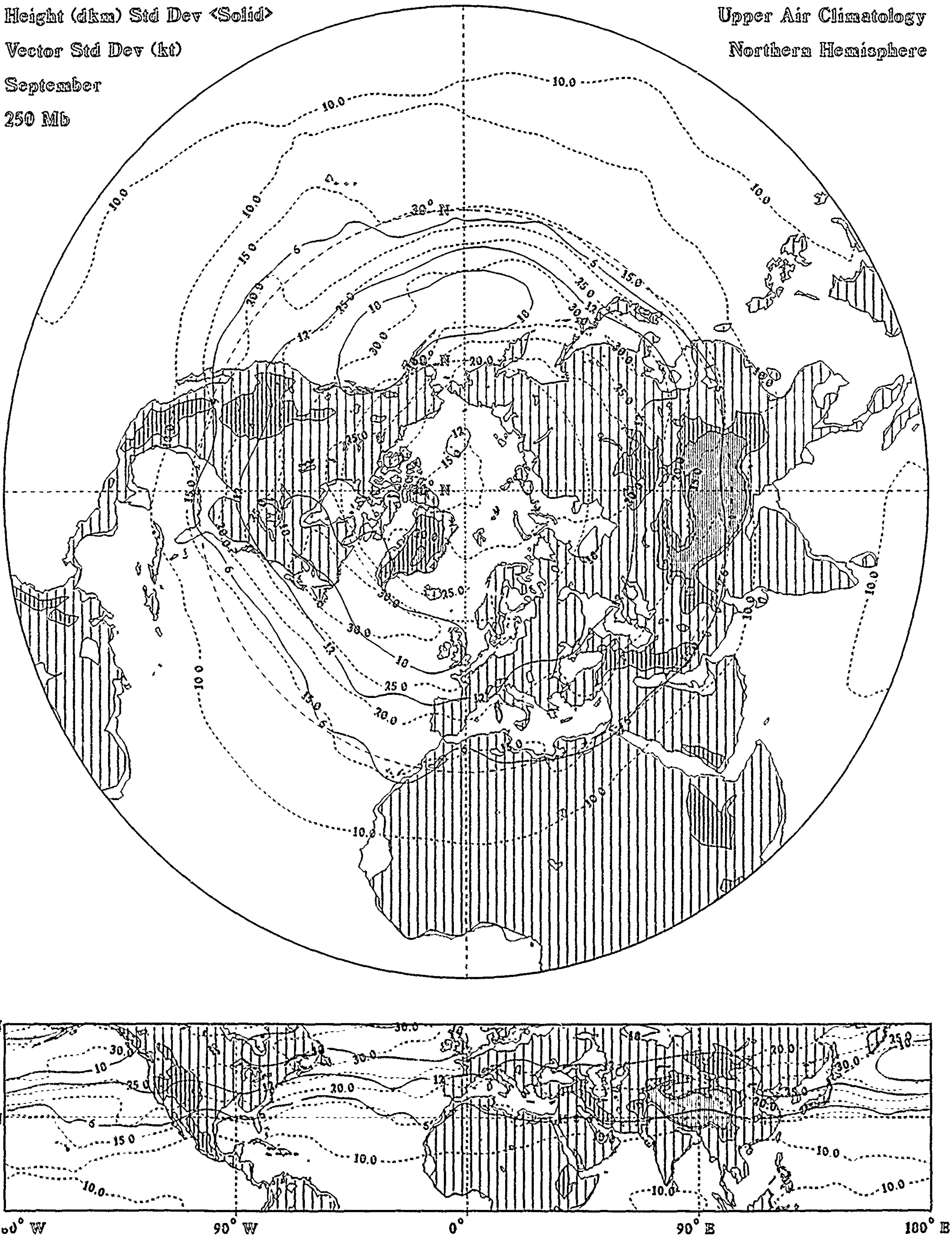
Vector Std Dev (kt)

September

250 Mb

Upper Air Climatology

Northern Hemisphere



Upper Air Climatology

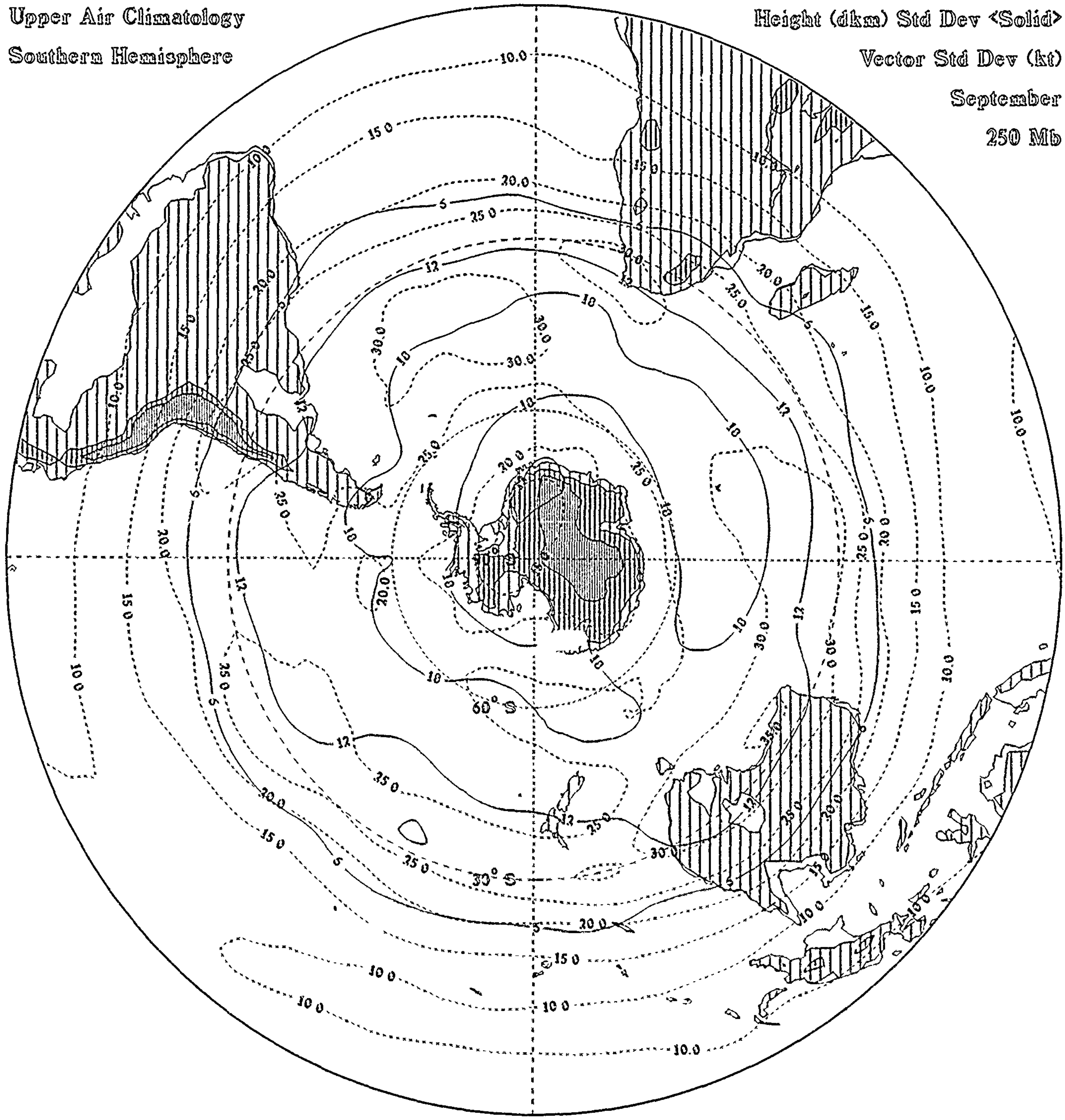
Southern Hemisphere

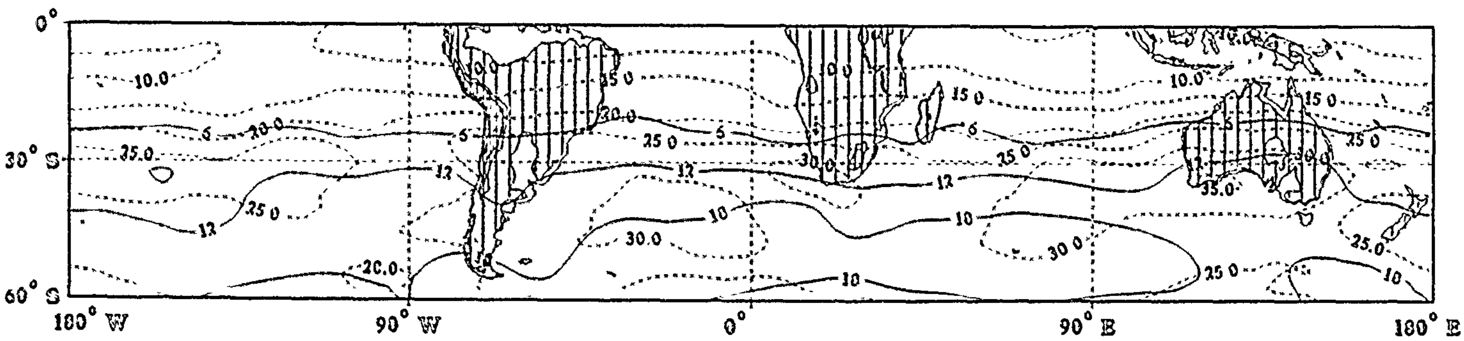
Height (dkm) Std Dev <Solid>

Vector Std Dev (kt)

September

250 Mb





Height (dkm) Std Dev <Solid>

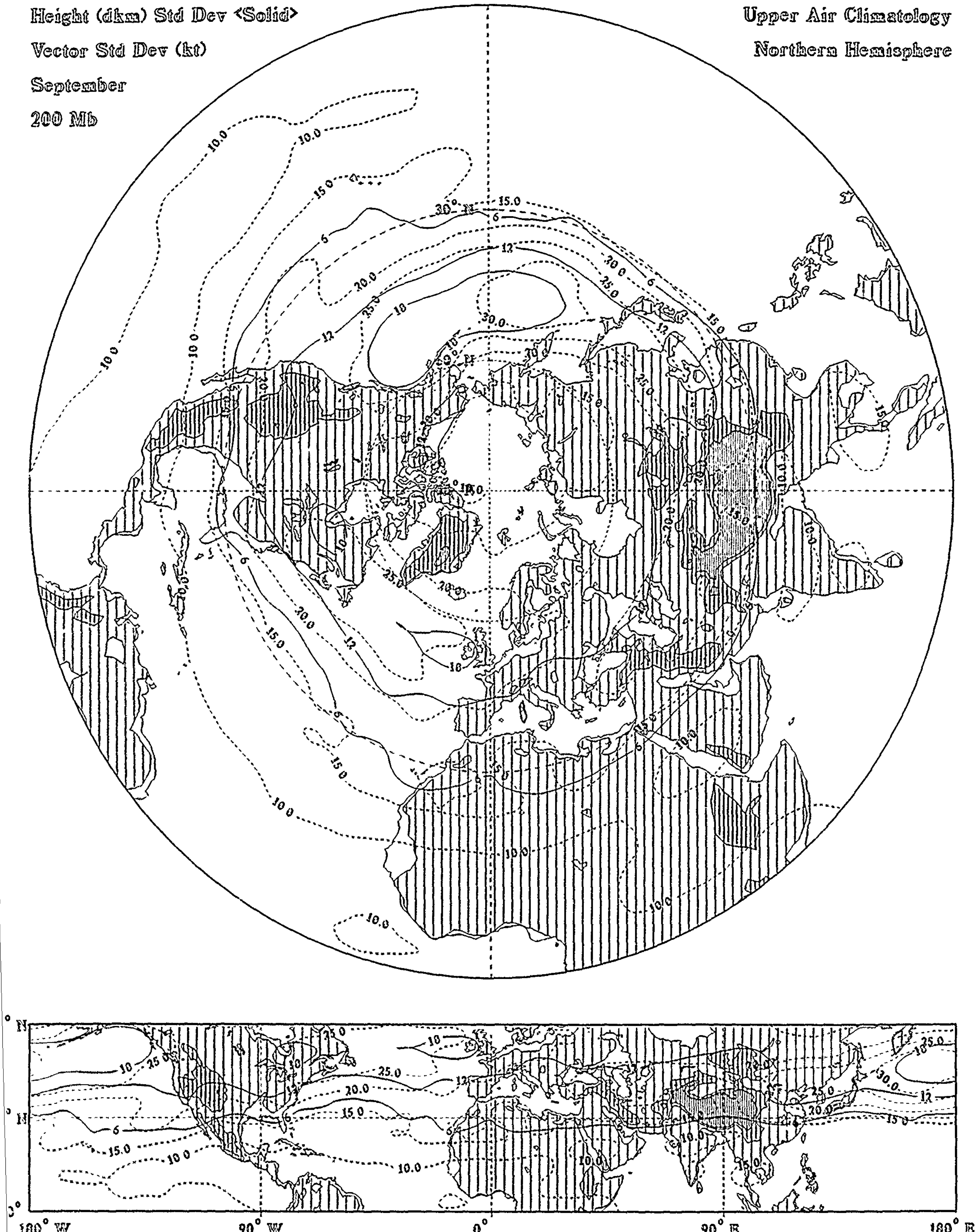
Vector Std Dev (kt)

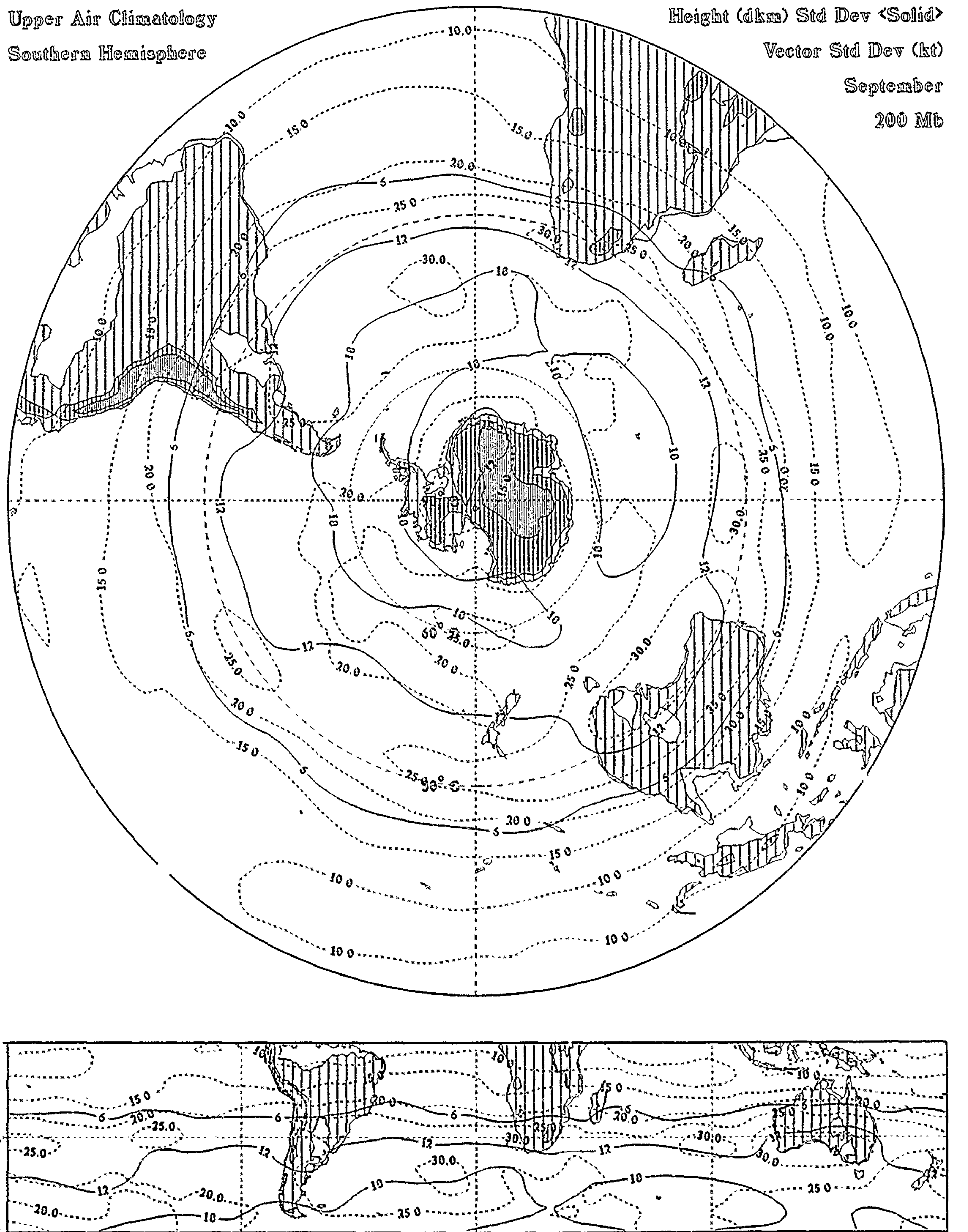
September

200 Mb

Upper Air Climatology

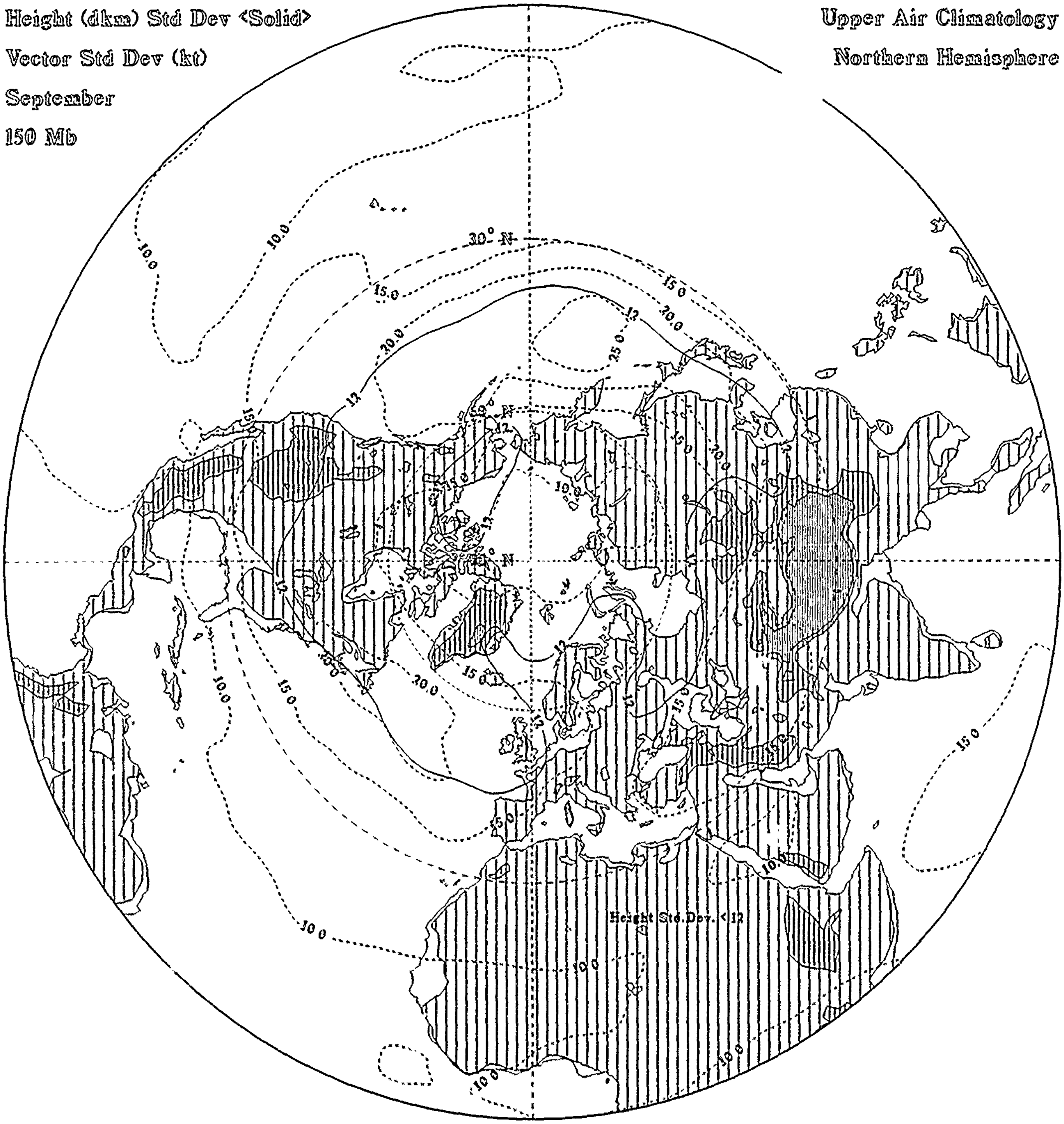
Northern Hemisphere

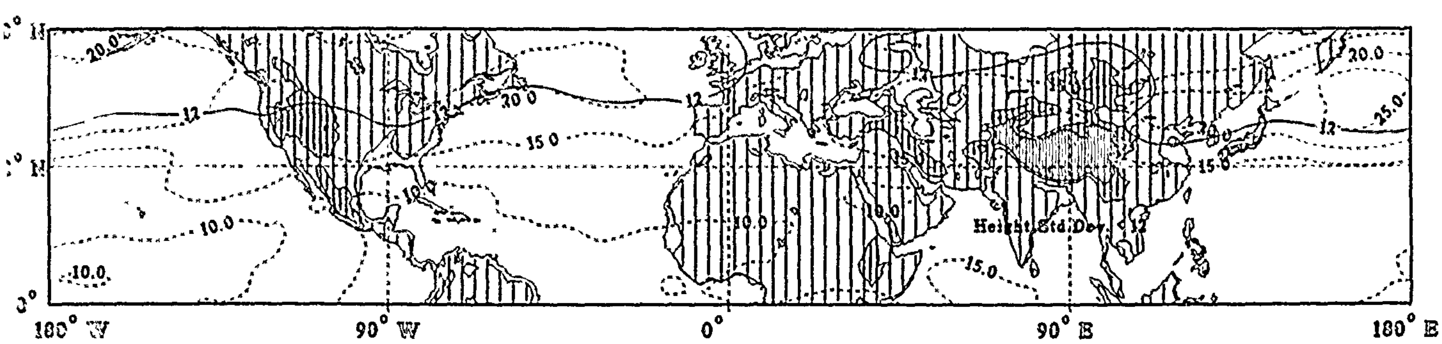


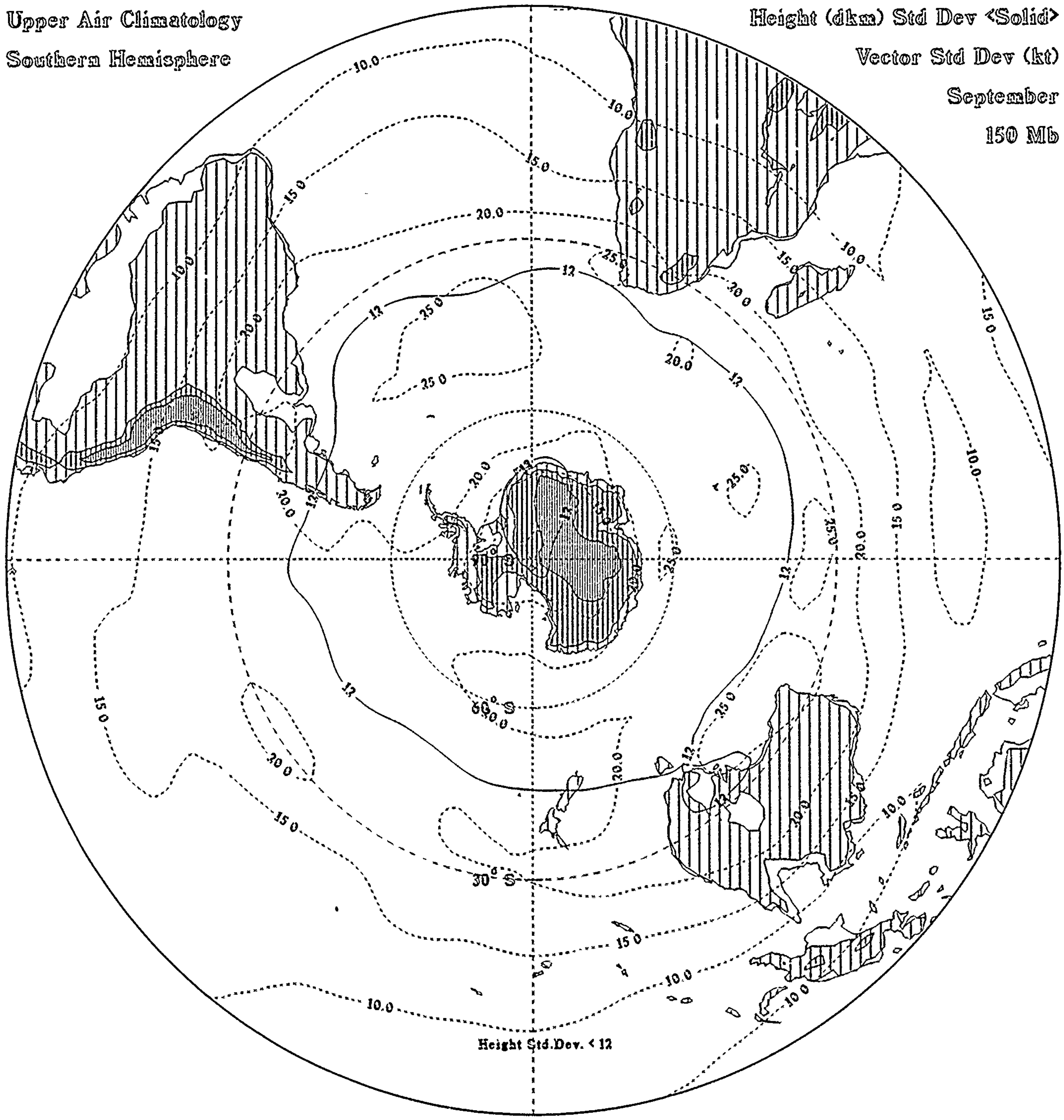

Upper Air Climatology
Southern Hemisphere
Height (dkm) Std Dev <Solid>
Vector Std Dev (kt)
September
200 Mb
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

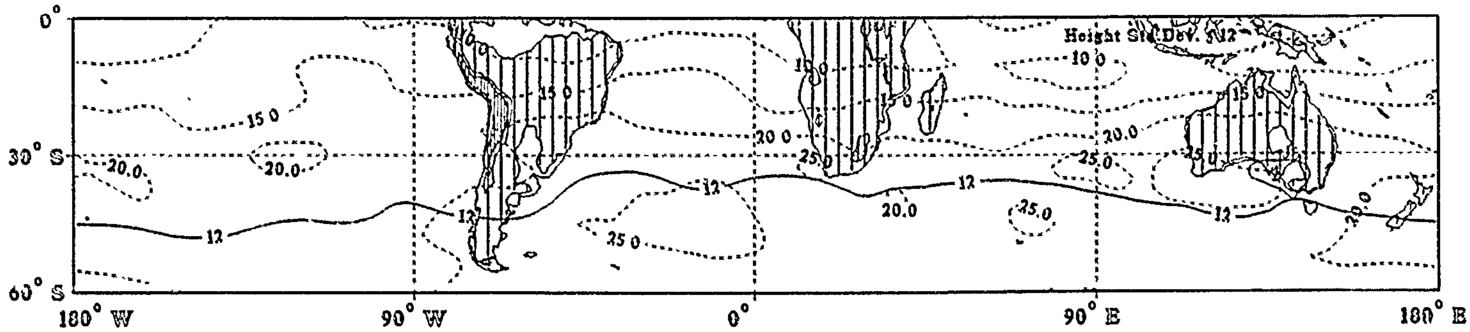
Height (dkm) Std Dev <Solid>
Vector Std Dev (kt)
September
150 Mb

Upper Air Climatology
Northern Hemisphere






Upper Air Climatology
Southern Hemisphere
Height (dkm) Std Dev <Solid>
Vector Std Dev (kt)
September
150 Mb
60° S
30° S
Height Std.Dev. < 12


0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

Height (dkm) Std Dev <Solid>

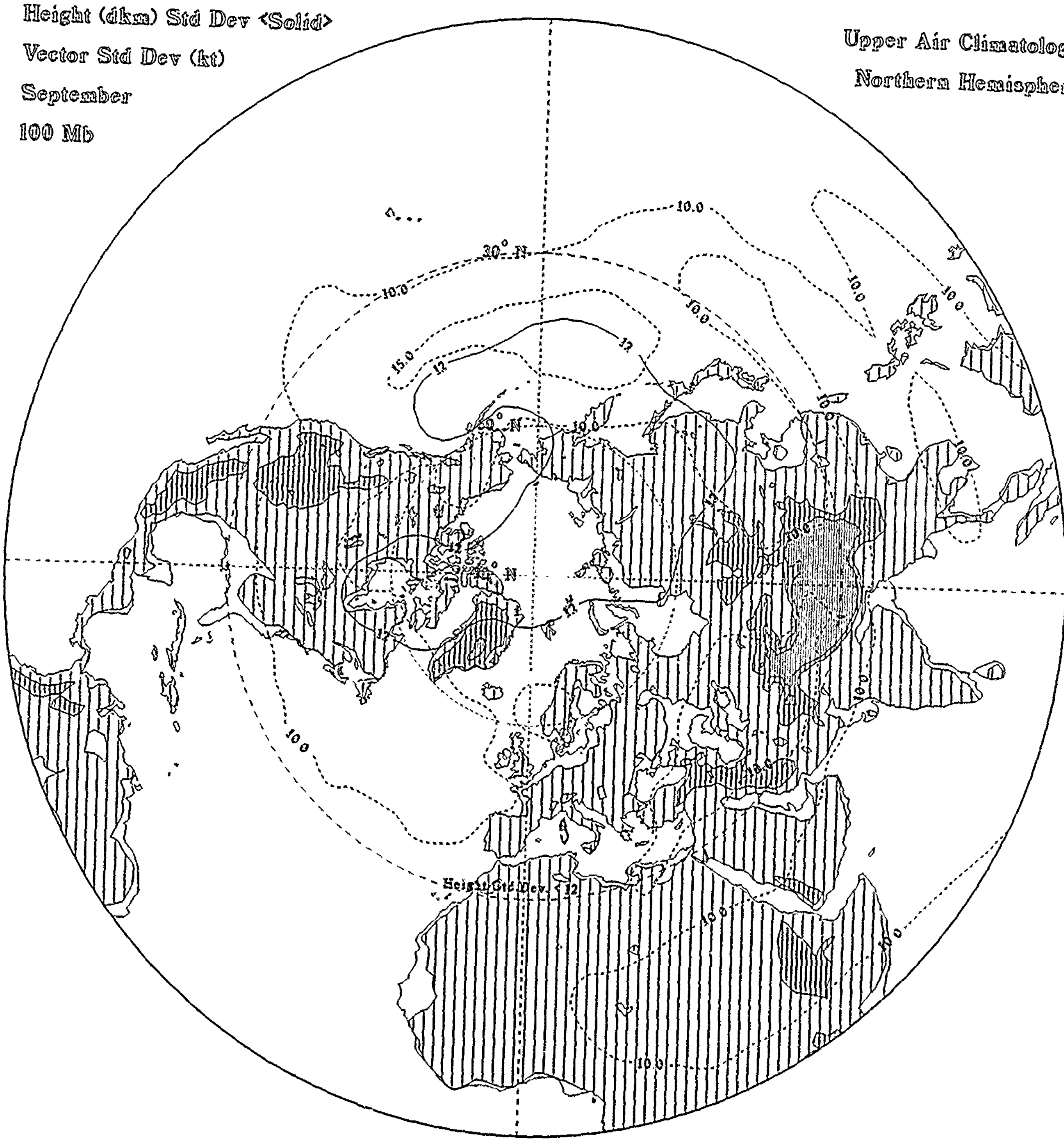
Vector Std Dev (kt)

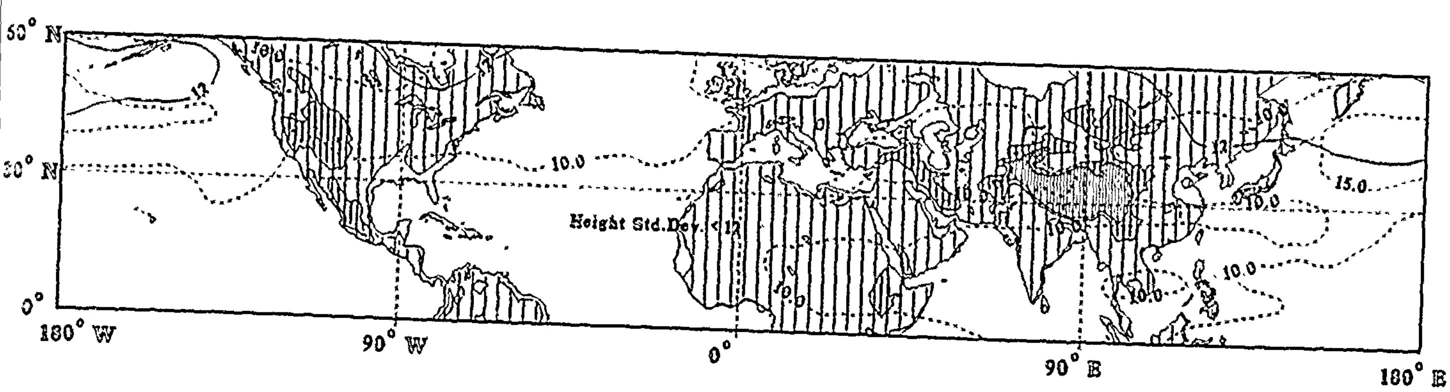
September

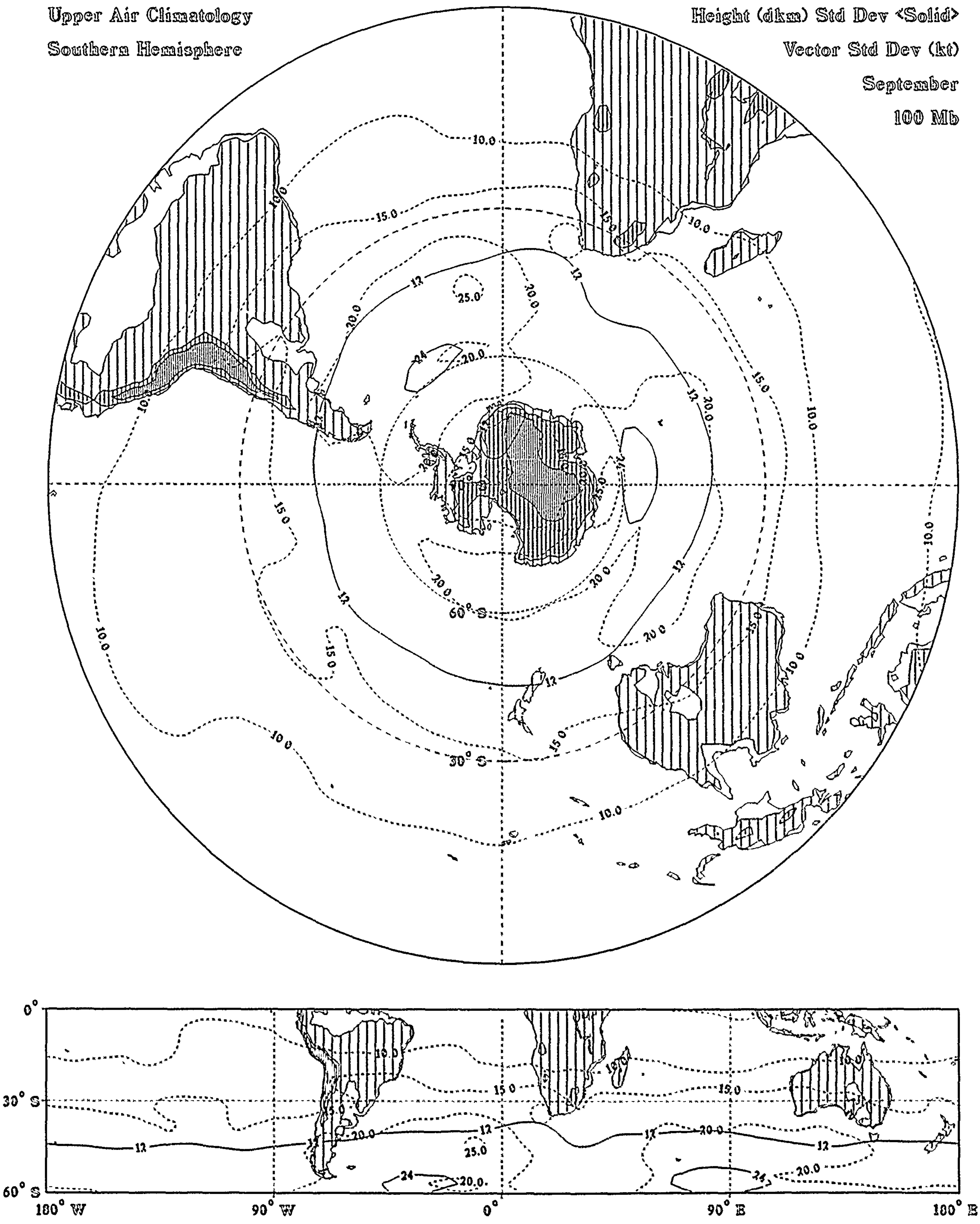
100 Mb

Upper Air Climatology

Northern Hemisphere







Upper Air Climatology
Southern Hemisphere
Height (dkm) Std Dev <Solid>
Vector Std Dev (kt)
September
100 Mb
10.0
15.0
12
20.0
25.0
24
60° S
30° S
0°
30° S
60° S
180° W
90° W
0°
90° E
180° E

Height (dkm) Std Dev <Solid>

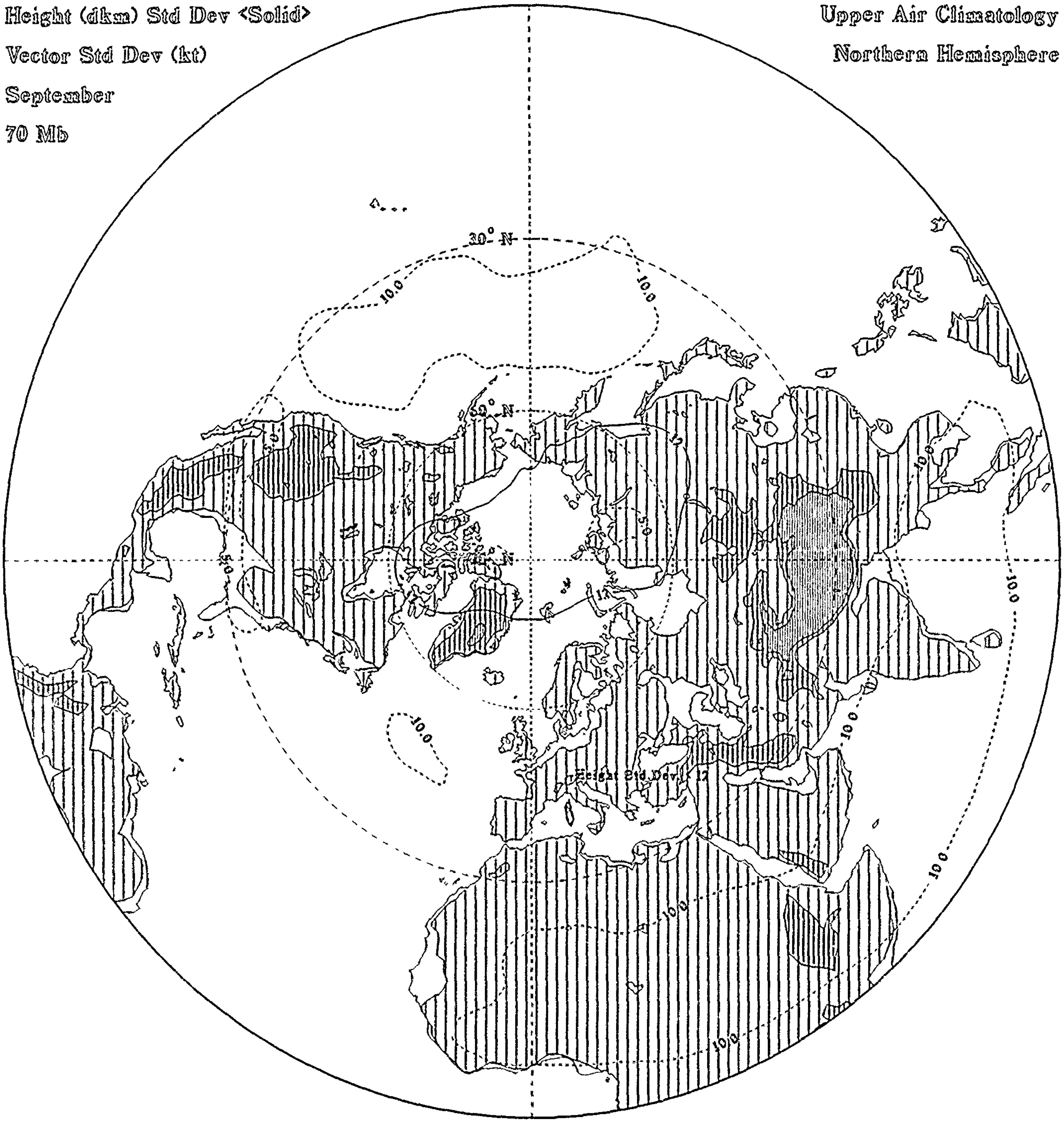
Vector Std Dev (kt)

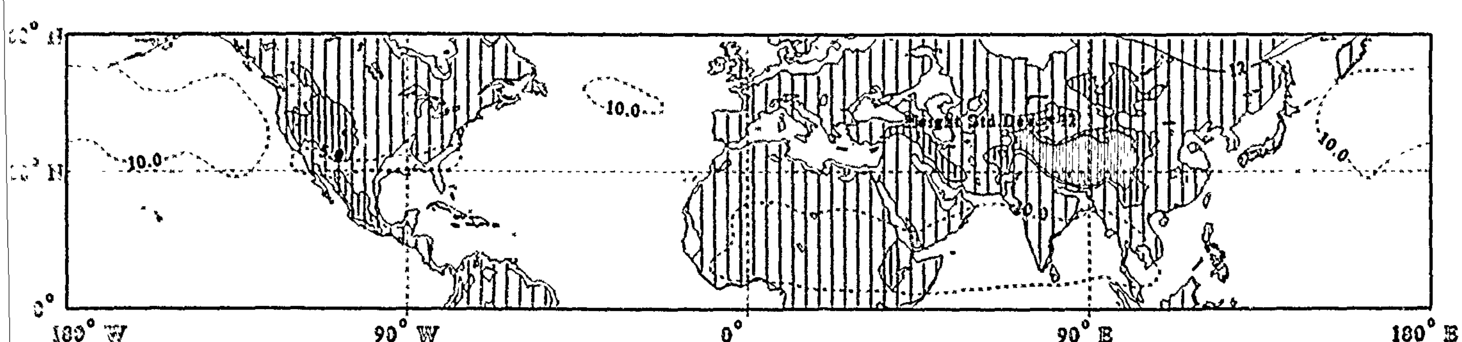
September

70 Mb

Upper Air Climatology

Northern Hemisphere





Upper Air Climatology

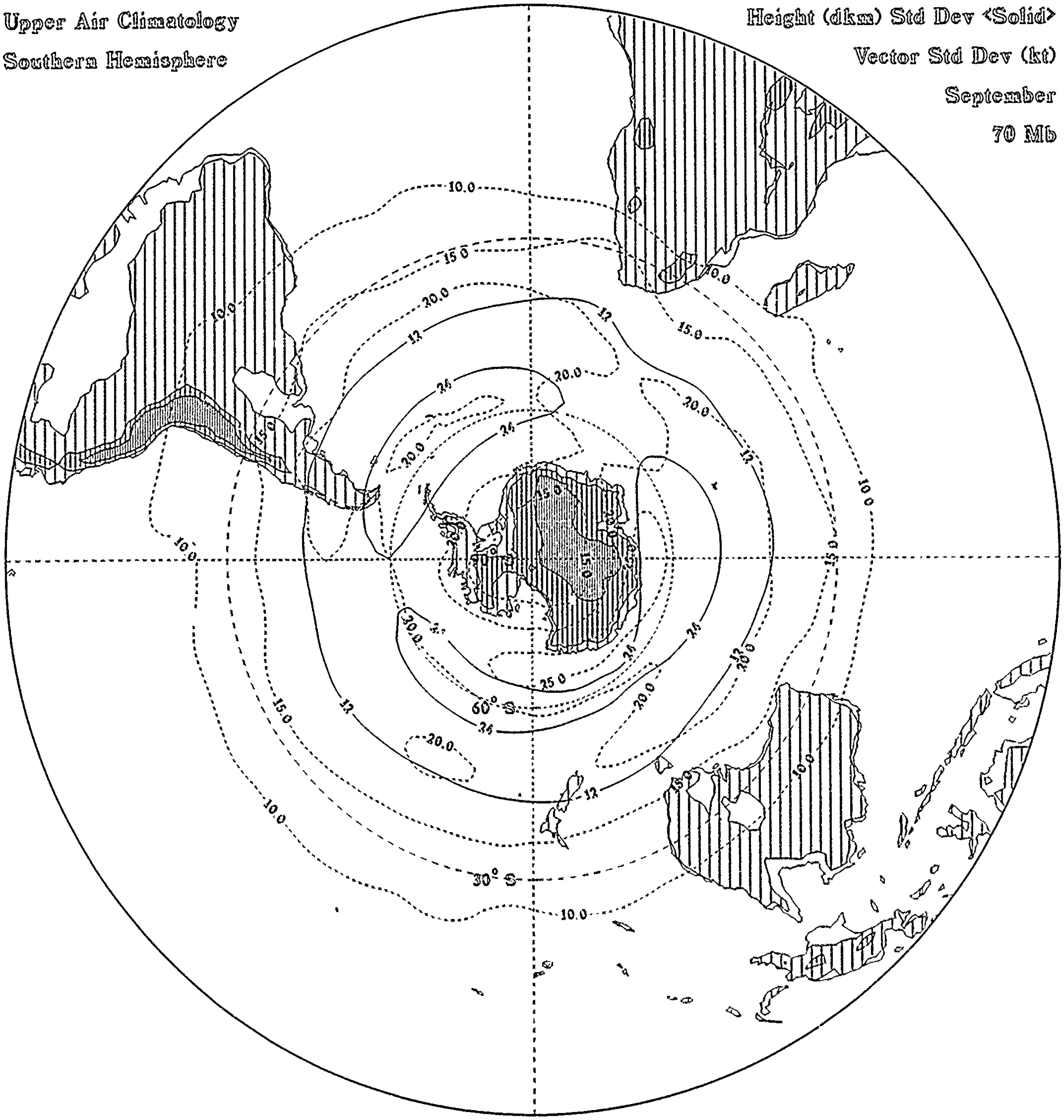
Southern Hemisphere

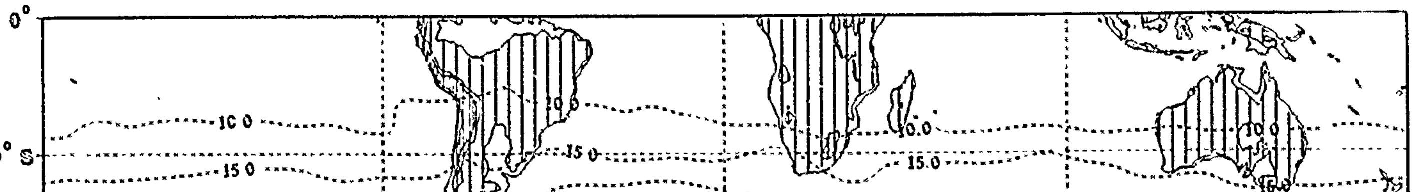
Height (dkm) Std Dev <Solid>

Vector Std Dev (kt)

September

70 Mb





Height (dkm) Std Dev <Solid>

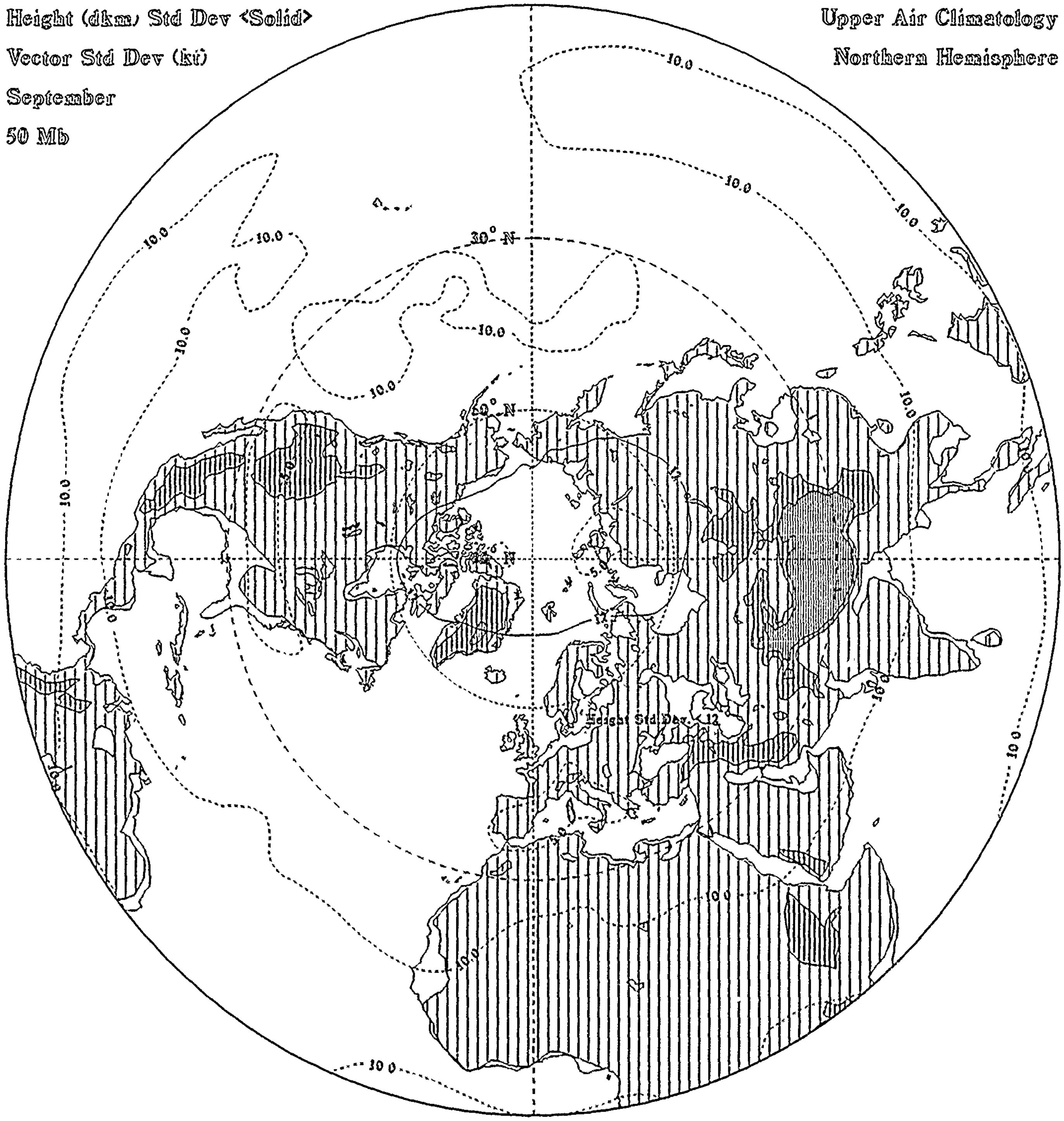
Vector Std Dev (kt)

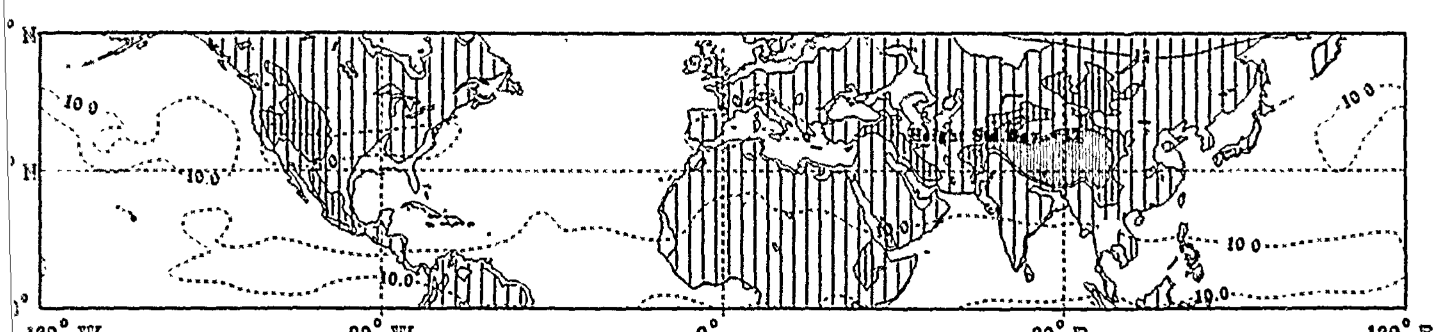
September

50 Mb

Upper Air Climatology

Northern Hemisphere





Upper Air Climatology

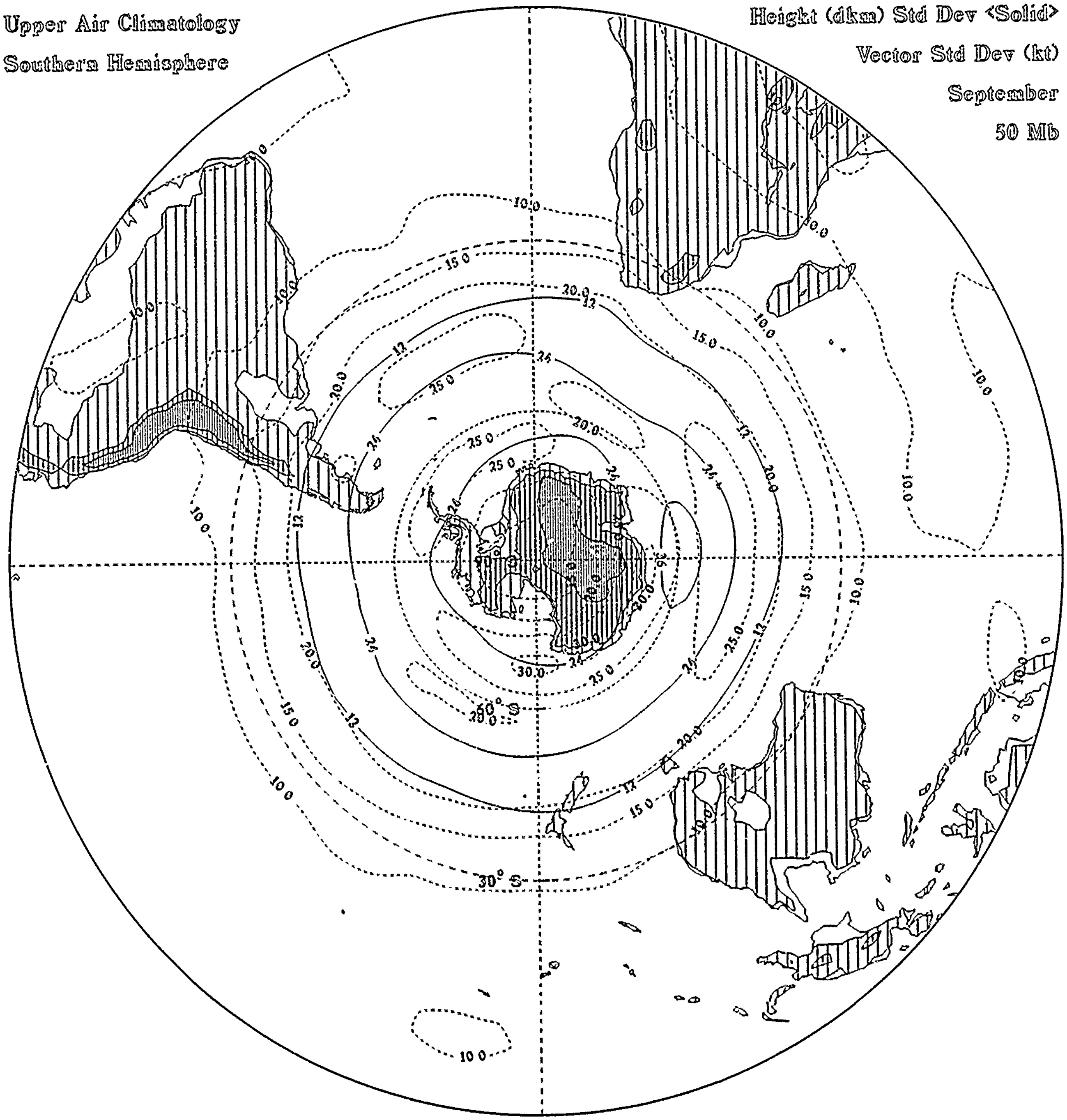
Southern Hemisphere

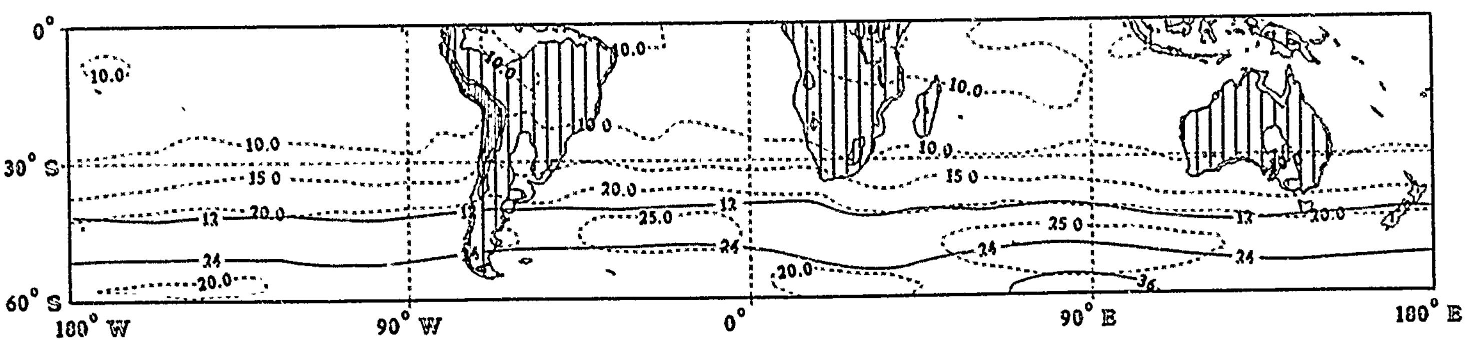
Height (dkm) Std Dev <Solid>

Vector Std Dev (kt)

September

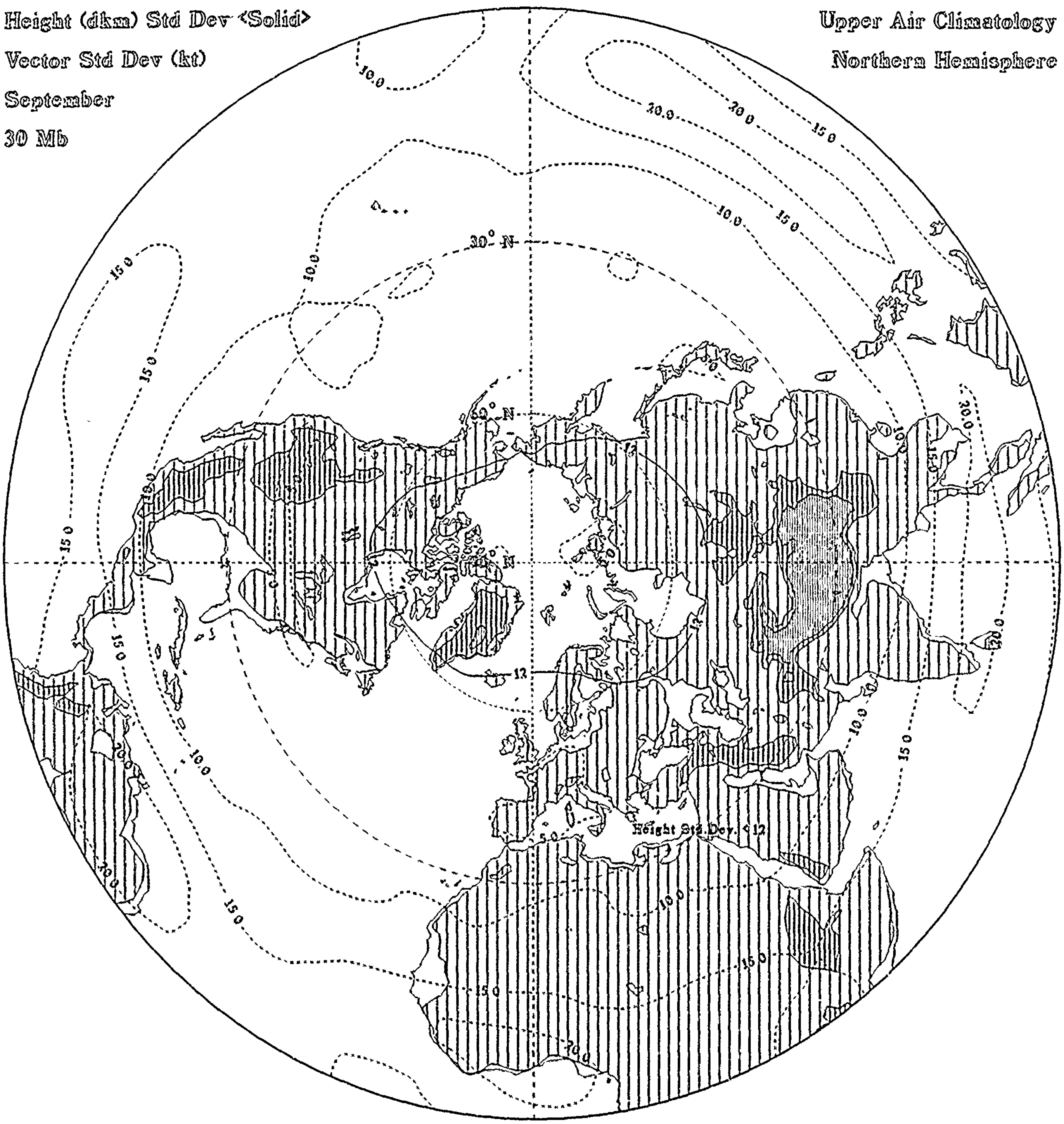
50 Mb

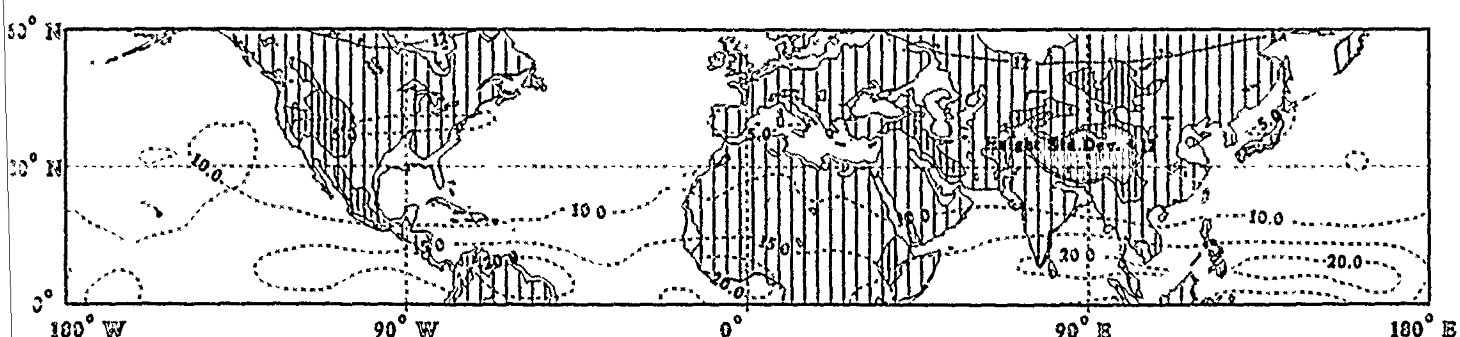




Height (dkm) Std Dev <Solid>
Vector Std Dev (kt)
September
30 Mb

Upper Air Climatology
Northern Hemisphere





Upper Air Climatology

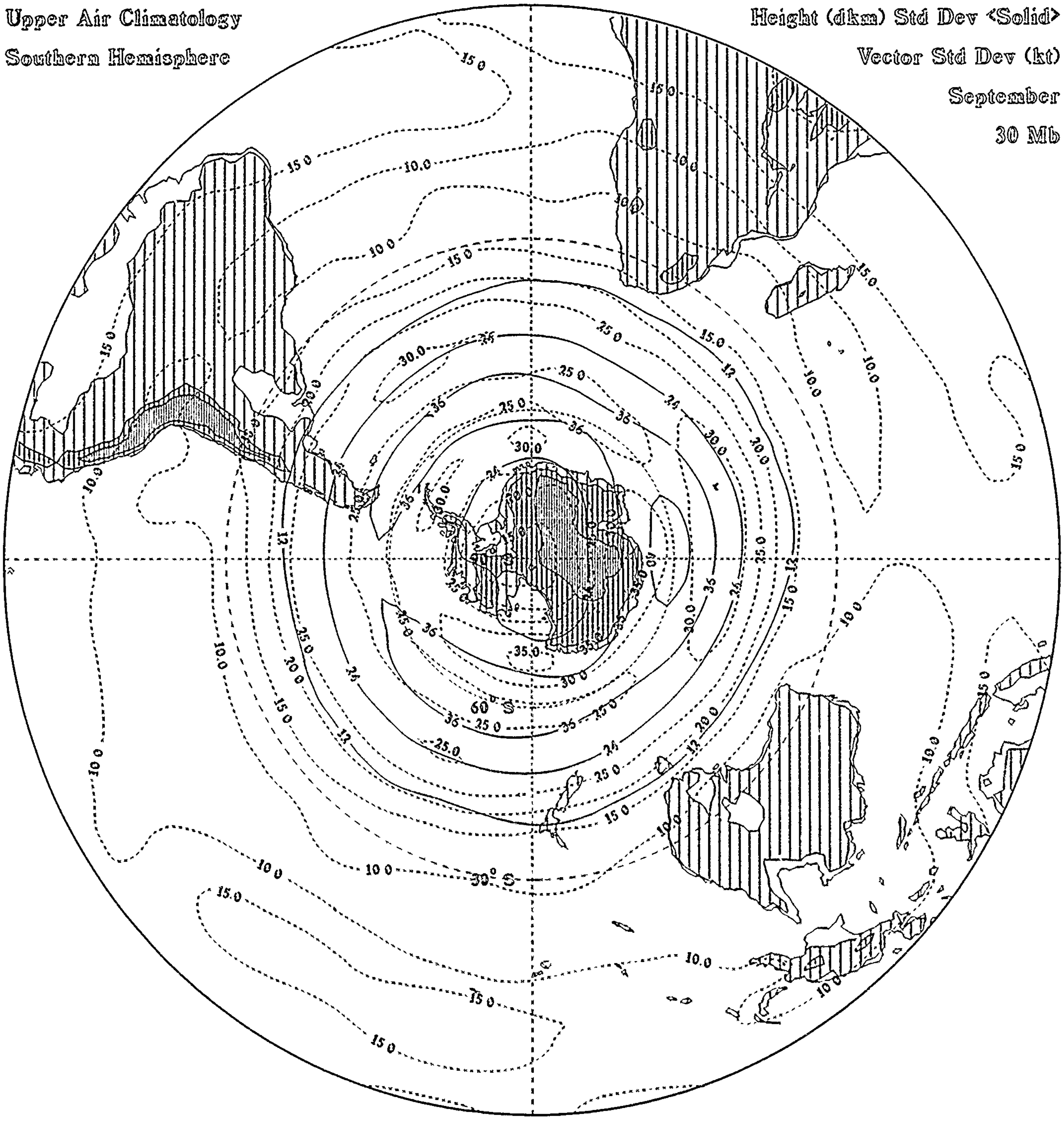
Southern Hemisphere

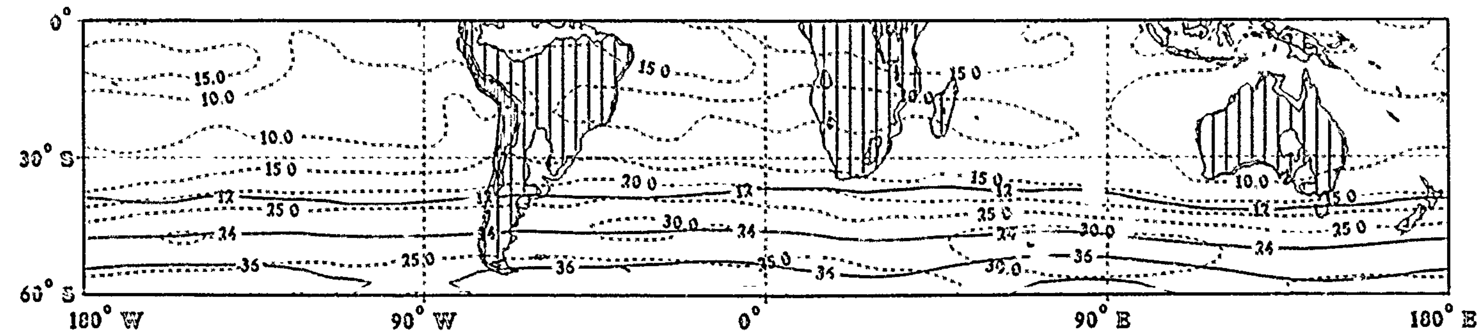
Height (dkm) Std Dev <Solid>

Vector Std Dev (kt)

September

30 Mb





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