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INDIA METEOROLOGICAL DEPARTMENT

FORECASTING MANUAL

PART I

CLIMATOLOGY OF INDIA AND NEIGHBOURHOOD

I. MONTHLY MEAN SEA LEVEL ISOBARIC CHARTS

BY

R. ANANTHAKRISHNAN, V. SRINIVASAN AND A. R. RAMAKRISHNAN

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1. Monthly Mean Sea Level Isobaric Charts

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R. Ananthakrishnan, V. Srinivasan and A.R. Ramakrishnan

Contents:

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CLIMATOLOGY OF INDIA AND NEIGHBOURHOOD

General Introduction

1. Scientific Basis of Weather Forecasting

1.1 Weather forecasting consists essentially in predicting the future state of the atmosphere from a knowledge of its current state. Given the state of a dynamical system at a certain time, it is in principle possible to predict its state at a future time provided the parameters required to define the initial state are known in sufficient detail and the physical laws governing the behaviour of the system are well understood. This is what is being attempted in "Numerical Weather Prediction". Since the parameters required to define the initial state of the atmosphere over an extended area are very large in number and the equations governing atmospheric motion are complex, high speed electronic computers have to be employed for predicting the future state of the system. The synoptic observations that define the current state of the atmosphere are fed into programmed computers that print out charts depicting the current state as well as the future states of the atmosphere after specified intervals of time. The prognostic charts are essentially dependent on the mathematical equations pertaining to the prediction model on the basis of which the computer is programmed. To simulate the conditions in the real atmosphere very sophisticated atmospheric models are required. The solution of the corresponding prediction equations necessitates the use of the most advanced type of electronic computers.

1.2 The conventional method of weather forecasting that has been practised over the years and which is still in vogue, has also as its starting point the current state of the atmosphere as defined by synoptic observations over an extensive area much larger than the area for which forecasts are required. The synoptic observations such as pressure, temperature, humidity, winds, clouds, visibility, past and present weather etc., are plotted on a series of weather maps which are then analysed following standard procedures.

These analysed charts give the forecaster a synopsis of the current state of the atmosphere. Such charts generally reveal characteristic weather systems such as areas of high and low pressure, regions of convergence and divergence, troughs and ridges, jet streams, etc. It is found that these weather systems undergo displacements in space and evolution in time from one synoptic chart to another. These changes are not random but show a certain degree or orderliness when a series of successive synoptic charts are examined. The observed behaviour of the weather systems can be broadly explained on the basis of atmospheric dynamics. Conventional weather forecasting consists in the identification of the more important weather systems from the analysed synoptic charts and prognosticating their movement and evolution during the period covered by the forecast. Clouds and precipitation result from the vertical ascent of moist air. Vertical motion is generally associated with convergence in the lower levels and divergence at the upper levels of the atmosphere. Dynamical meteorology furnishes the broad guide lines for inferring the convergence/divergence associated with different types of synoptic flow patterns and hence to draw conclusions about the probable areas of weather development. The scientific background of the forecaster, in particular his knowledge of the basic principles of the physics and dynamics of the atmosphere is, therefore, extremely important for his being able to make a correct assessment of the important weather systems on the synoptic charts, their probable displacements during the next 24 or 36 hours and the weather features associated with them. The experience of the forecaster, in particular his familiarity with the past weather charts for the area for which he is forecasting is also equally important, especially on occasions when two or more possibilities of future developments are indicated by the synoptic weather charts. Conventional weather forecasting is thus at once a science as well as an art.

1.3 In operational weather forecasting, time is a very important factor. Since the atmosphere is always in a state of flux, the interval between the time of synoptic observations and the time at which forecasts based on them are issued should be as short as possible. Indeed, the value of synoptic observations for weather forecasting rapidly decreases with time. Hence the preparation and analysis of the weather charts should be completed expeditiously and thereafter the forecasts should be issued with the minimum possible delay. It is in this context that the experience and background of the forecaster are of particular help in enabling him to take quick decisions about the salient features revealed by the weather charts and the probable future developments.

2. Use of Climatological Charts in Weather Forecasting

2.1 Any one who has examined the synoptic weather charts for India and adjoining areas day after day for a period of one year will notice the progressive seasonal changes in the weather systems and patterns. If we take the synoptic weather charts for any two days at random in the months of January and July, the pressure and wind patterns are entirely different. This arises from the fact that, by far the most important control on weather is exercised by the sun. The distribution of solar radiation reaching the earth at various latitudes determines the over-all features of atmospheric dirculation and the large-scale weather patterns, which, therefore, are broadly repetitive from year to year. It is important for the weather forecaster to know what these large-scale pressure systems and wind circulations are and how they vary from month to month and season to season.

2.2 The average of the daily synoptic values of meteorological elements such as pressure, temperature, wind etc. recorded at a station during a month gives a representative value from which the daily variations have been largely filtered out. A further smoothing is effected by taking the mean monthly values over a period of several years. Such values are known as the climatological mean values for the month. Weather maps prepared utilising the climatological mean values of the stations in the synoptic network are known as climatological maps. Comparison of the synoptic charts for the day with the climatological charts for the month brings out the departures from normal of the day's weather maps. The location of such abnormalities gives important clues to the forecaster about synoptic weather systems and their probable course of movement and evolution. Hence monthly mean climatological maps for various elements are extremely helpful in conventional weather forecasting where careful diagnosis of the current weather forms the essential basis for prognosis of future weather. It has, therefore, been considered appropriate to begin the Forecasting Manual with a series of climatological weather maps for selected elements relating to the surface as well as the upper air.

3. Area Coverage of the Climatological Maps

3.1 Part I of the Manual bears the title "Climatological Charts for India and Neighbourhood". The climatological maps (Mercator projection) comprise the geographical area from 70°N to 70°S and from 30°W to 170°W through 90°E. This covers nearly 58% of the total area of the globe. The surface area of India is 3,274,600 sq. km. This is a little less than 0.7% of the area of the globe and about 1.2% of the area covered by the climatological charts. In this context, the use of the expression "India and Neighbourhood" to describe the area covered by the climatological charts may appear rather inappropriate. However, the fact that a modern jet airliner taking off from Bombay or Calcutta and flying non-stop can reach places such as London, Moscow, Nairobi, Tokyo, Sydney etc. in about 12 hours and that the supersonic aircraft of the near future will reduce the time to less than half, provides some justification for the use of the expression. In any case, it is important that the forecaster in India should be familiar with the general climatology of the area covered by these charts to appreciate the weather and climate of India in their proper perspective. A knowledge of the climatological features of this area is also required for rendering efficient weather service to long-distance flights originating from India.

3.2 Since conventional weather forecasting depends upon the identification of weather-producing systems and following their movement and evolution, it is obvious that as the period for which the forecast is required for a region increases, one has to deal with synoptic weather charts covering larger and larger areas since the more distant weather systems are likely to influence the region in question during the extended period. Thus, to forecast if Calcutta will have a thunderstorm this afternoon the forecaster will naturally concentrate his attention on the synoptic features over northeast India. However, if he has to forecast the weather on Republic Day at Delhi three or four days in advance, he has to look at synoptic weather systems as far west as the Mediterranean. Hence synoptic weather charts of large area coverage are required not only for giving comparatively short-range forecasts for long-distance aviation but also for issue of forecasts and warnings for the Indian area for 2 to 3 days. Synoptic charts covering the major part of the area covered by the climatological charts are now prepared and analysed in a number of Forecasting Offices of the Department. In the analysis of the daily charts, particularly over areas of sparse data coverage, the climatological charts provide useful guide lines to the meteorologist.

3.3 The most important geographical feature of the area covered by the climatological charts is the great contrast in the distribution of land and Sea on either side of the equator. In the northern half where India is situated, 53% of the area is land and 47% is sea. In the southern half 88% is covered by the oceans. This great land-sea contrast between the northern and southern halves of the area has a profound influence on the meteorology of India and the adjoining areas.

3.4 The following climatic charts covering the Indian Monsoon area have been published by the India Met. Department:-

i) Climatological Atlas of India : 1906

ii) Climatic Charts of India and Neighbourhood for Meteorologists and Airmen : 1943

iii) Climatological Charts for Airmen : 1943

iv) Climatological Charts of the Indian Monsoon area : 1945

The area covered in all these charts is less than what is comprised in the present set of climatological charts included in the Forecasting Manual. Since the publication of these atlases a large volume of data, particularly for the upper air, has become available; these have also been utilised for the present set of climatic charts.

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FORECASTING MANUAL

Part I. Climatology of India and Neighbourhood

1. Monthly Mean Sea Level Isobaric Charts

by

R. Ananthakrishnan, V. Srinivasan and A.R. Ramakrishnan

1. Atmospheric Pressure at Sea Level

1.1 The atmospheric pressure at a station is a measure of the mass of air in a vertical column of unit cross-section over the station. Near the surface of the earth pressure decreases in the vertical at the rate of approximately 1 mb per 10 metres. This rate varies with elevation as well as with the temperature of the air column. The horizontal variation of pressure is thousands of times smaller than the vertical variation. For instance, a surface pressure gradient of 10 millibars over a latitude interval of 10 degrees can occur over the Indian area in the southwest monsoon months. This gives a horizontal variation of about 0.01 mb/km as against a vertical variation of 100 mb/km. Despite its small magnitude, the horizontal pressure gradient is of fundamental importance in determining atmospheric motions.

1.2 To compare the atmospheric pressure at any two stations it is necessary to reduce the surface pressure values to a common reference level which can be any level close to the surface of the earth. The reference level normally chosen for this purpose is the mean sea level. The reduction of pressure to sea level consists in adding to the station level pressure the weight of a fictitious column of air of unit cross-section whose top is at the level of the station and whose base is at sea level. The weight of this column depends upon its mean virtual temperature. In general it is difficult to estimate this temperature accurately for each of the stations in the synoptic network. The methods followed by different Meteorological services for the reduction of station level pressure to mean sea level are not the same. As a matter of fact, it is not possible to devise a method which is suitable in all respects. For a detailed discussion on this subject reference may be made to WMO Technical Notes Nos. 7 and 61.

1.3 The error introduced in the reduction of pressure to sea level increases with the elevation of the station. Hence the surface pressures of high level stations are not reduced to sea level. In the India Meteorological Department the surface pressures of those stations in the synoptic network whose elevations are less than 800 gpm are reduced to sea level.

1.4 From the early days of synoptic meteorology the sea level isobaric chart has been an important aid to the forecaster in the diagnosis of the current weather situation and for prognosticating the future developments of weather. For this purpose the analysed surface isobaric chart is studied in conjunction with other synoptic charts such as the upper air charts. The monthly mean sea level isobaric charts highlight the semi-permanent pressure systems which control the air circulation in the lower levels of the atmosphere. These undergo progressive variations in location and intensity from month to month. Familiarity with the climatological charts and their salient features is indispensable in the analysis of the daily synoptic charts. Mean monthly surface isobaric charts for the area 70°N to 70°S and 30°W to 170°W through 90°E are presented in this report.

2. Source of Data

The bulk of the data for the sea level isobaric charts have been taken from WMO publication No. 117 - T.P. 52 "Climatological Normals (CLINO) for climat and climat ship stations for the period 1931-1960". This was supplemented by data from the "World Weather Records (1941-50 and 1951-60)"(U.S.A.), "Five Day Normals" (I.M.D., 1965) and a few other publications. All the relevant publications are listed in Appendix I. The total number of stations whose data have been used is 720. Areawise split up of this figure is given in Appendix II.

3. Method of Analysis

3.1 The charts cover large continental as well as vast oceanic areas. The network of stations over the continental areas was satisfactory for a reliable analysis. Over the oceanic areas the analysis was largely based on the climatological charts published by some of the Meteorological Services and Agencies supplemented by data from island, coastal and ocean weather stations. A list of such publications is given in Appendix III. The analysis over the oceanic area south of 50°S was especially difficult due to paucity of data and had to be based on Vowinckel's work (NOTOS, Vol.4, 1955) and the information available in M.P. van Rooy's "Meteorology of the Antarctic" (1957).

3.2 Isobars have been drawn generally at intervals of 4 mb in the higher latitudes. Equatorward of latitude 30°, the interval has been reduced to 2 mb except in areas of steep pressure gradient. In the near equatorial region a few isobars have been drawn even at 1 mb interval to bring out some significant patterns which would otherwise be lost. For the sake of clarity of presentation, a few isobars drawn in areas of weak pressure gradient have not been continued into the region of steep pressure gradient, e.g., the 1011 mb isobar in the Indian Ocean area running from East Africa to Malaysia in the chart for February. In cases where the centre of the pressure system lies within the chart, the letter H or L is printed over the point corresponding to the location of the centre of the system and the central pressure in whole millibars is indicated in two figures (tens and units) within square brackets close to the letter H or L. However, this procedure has not been followed in marking the centres of the lows in the sub-polar trough of the southern hemisphere where the analysis is tentative due to paucity of data.

3.3 Taking into account the scale of the charts, delineation of only the broad features of the isobaric pattern has been attempted. Analysis was checked and adjusted for continuity from month to month. Reference to literature shows differences in the locations and intensifies of centres of the pressure systems in the analyses published by different Meteorological Services.

4. Pressure Distribution over the Globe

4.1 The two basic factors that determine the pattern of global pressure distribution are the geographical variation of solar radiation and the rotation of the earth. The arrangement of continents and oceans brings about profound modifications. The pressure distribution over the globe can be divided into four broad belts. The equatorial region is one of low pressure. It is flanked on both sides by zones of high pressure, the "Sub-tropical Highs". These high pressure belts particularly in the summer hemisphere do not extend continuously around the earth but are broken up into cells due to differences in the heating baused by land-sea distribution. Poleward of the sub-tropical ridges, the mean pressure distribution is rather irregular owing to the migrating extratropical cyclones. However, on the whole, the pressure decreases polewards. The very cold air over the surface layers of the Arctic and the Antarctic zones, at least over the glaciated continental areas of Greenland and Antarctica, gives rise to high pressure areas over these regions. Consequently, the region between latitudes 60° and 70° in both the hemispheres is ore of low pressure.

4.2 The salient features of the mean sea level pressure distribution as seen from the monthly mean isobaric charts are described seasonwise in the following paragraphs.

5. December - January - February

5.1 In these months the intense anticyclone over Central Asia dominates the flow pattern over the whole of Asia. It is centred near 49°N 100°E to the southwest of Lake Baikal with tha mean central pressure of about 1035 mb and extends westwards as a ridge into eastern Europe. This Asiatic anticyclone of the winter months is the most intense seasonal high pressure system over the whole globe, The location and intensity fluctuate from day to day; on individual charts the central pressure may reach as high a value as 1075 mb.

5.2 The other major anticyclone over the area in northern hemisphere is the one over north Atlantic called the "Azores High". It is centred near about 30°N over the western border of the chart with a central pressure of about 1025 mb. This anticylone extends as a narrow ridge eastwards over northwest Africa extending as far east as U.A.R. in January. Only the western extension of the anticyclone over the Pacific is seen on the charts as a narrow ridge, roughly along 25°N, to the southeast of Japan.

5.3 The main low pressure systems of the northern hemisphere during the winter are the 'Icelandic Low' over north Atlantic and the 'Aleutian Low' over north Pacific. Only the eastern end of the Icelandic low is seen over the extreme northwest portion of the chart, the main low being further to the west. A trough extends northeastwards from the Icelandic low to the north of Scandinavia over the warm waters between Scandinavia and Spitsbergen.

5.4 The intense Aleutian low is well within the area of the chart during winter. Its central region is near about 50°N 175°E, with central pressure of 998 mb in January. Note the steep pressure gradient between the Asiatic anticylone and the Aleutian low.

5.5 There is another low pressure system over the Mediterranean centred over Italy, with a pressure of about 1013 mb. This low is primarily due to the warm and moist air over the Mediterranean Sea in contrast to the air over the surrounding continental areas. For the same region the Black Sea and the Caspian Sea are also regions of relalatively low pressure.

5.6 The equatorial trough extends from Guinea coast of Africa through central Africa to northern Australia and further eastnortheastwards towards

10°S 170°W. Over east Atlantic and Africa the trough line is near about the equator. Over east Africa there is an abrupt shift of the trough southward to near 15°S. Over the oceanic area between 50°E and 170°W, the trough line is generally 10° to 15° south of the equator. Because of land heating over north Australia the trough intensifies locally with the central pressure reaching about 1005 mb. This forms the monsoonal low of Australia. A minor trough is also noticed over the extreme south Bay of Bengal and Maldives area.

5.7 The subtropical ridgeline of the southern hemisphere runs roughly between 30°S and 35°S. It is split into two well-marked anticyclones over the oceanic areas, one over south Atlantic and the other over the south Indian Ocean. A third weaker anticyclone is seen over New Zealand. In January, the anticyclones are centred near 30°S 10°W in the south Atlantic, 32°S 85°E in south Indian Ocean and 35°S 170°E over New Zealand. The central pressure of the south Atlantic and Indian Ocean anticyclones is about 1020 mb whereas the central pressure of the New Zealand anticyclone is only about 1015 mb. The locations and intensities of these cells remain more or less the same in all the three months.

5.8 The sub-tropical high pressure cells over the Oceans in the two hemispheres are the most permanent features of the general circulation. Over these systems there is subsidence of air which is a maximum in their eastern parts. They are rarely absent on individual synoptic charts.

5.9 The sub-polar low in the southern hemisphere is located between 55°S and Antarctica. The axis of the low pressure system is along 63°S. Well developed low pressure cells are seen in this trough system. The lowest pressure in the trough system is of the order of 985 mb in all the three months.

6. March - April - May

6.1 The weakening of the intense winter Asiatic anticyclone commences in March and continues progressively throughout the season. By April, a low appears over Sakhalin area which shifts westwards and intensifies in May. The Icelandic low weakens and by May shifts westwards from its winter position. As a result, the Azores high over north Atlantic extends northeastwards as a ridge towards western Europe in April-May. The centre of the high is located near 30°N 37°W during these three months, with central pressure of 1023 mb. Similarly, the Aleutian low also gradually becomes less marked and the Pacific high becomes the dominant system. The western portion of the Pacific high is seen in the charts, extending as a ridge upto longitude 130°E in May.

6.2 With the progressive northward march of the Sun, the equatorial trough rapidly shifts northwards from its winter location. By April-May it becomes the dominant feature over north Africa. Similar changes also take place over India and over southern China and adjoining areas. Over the Pacific the the trough line shifts from 10°S in March to close to equator in April-May. A secondary trough is also seen between equator and 10°S over the Indian Ocean. This configuration of a trough in each hemisphere, on either side of the equator can be seen in the isobaric analysis only in certain months. As already mentioned in the introductory paragraphs, over the sea areas the isobars have been mostly copied from earlier publications and no revised analysis was attempted.

6.3 With the northward shift of the monsoonal trough over north Australia, the anticyclonic circulation of the subtropical high pervades the Australian continent. The southern hemispheric subtropical ridge line is between 25°S and 35°S over the entire stretch of the chart. There are four prominent cells in April and May as against three in the winter months; the additional. cell is the one that develops over Australia. Another significant feature during these months is the westward shift of the centre of the Indian Ocean cell from the east to the west (from 90°E to 55°E).

7. June - July - August

7.1 The significant feature in these months in the northern hemisphere is the intense monsoon low over north Africa and south Asia. The monsoon trough system covers a large area extending from western Sahara to China across Arabian Peninsula, Iran, West Pakistan and north India. The most intense portion of the trough is over West Pakistan and northwest India with the lowest pressure of 995 mb. The summer monsoon low and the winter Icelandic low are the deepest seasonal low pressure systems of the northern hemisphere. On individual charts the lowest pressure in the monsoon trough over northwest India and West Pakistan can be as low as 985 mb. In July the vast land mass of Asia is covered by the low pressure system, in marked contrast to January when the Asiatic high is the dominant feature. No continent other than Asia shows monsoonal effects of such a magnitude. Although the equatorial trough has shifted to a location of 25° to 35°N (its northernmost position) over Africa and South Asia it continues to be near about the equator over the western Pacific. There are signs of a secondary trough in the eastern Indian Ocean between equator and 5°S.

7.2 The oceanic anticyclone dominates the whole of the Pacific in July and August. The Azores high reaches its maximum intensity (1026 mb) in July. It is centred near about 35°N 36°W during this period with a ridge extending northeastwards across Europe.

7.3 The Icelandic low continues to be weak; the Aleutian low disappears by July.

7.4 In southern hemisphere, the sub-tropical ridge line is well-marked during this period, with its axis between 25°S and 35°S. The four anticyclonic cells attain their maximum intensity during the period June-September, the cells over the south Atlantic and the Indian Ocean having central pressure of about 1025 mb. On individual days the central pressure of the Indian

Ocean anticyclone can be as high as 1040 mb.

7.5 The southern hemisphere sub-polar trough is between 55°S and Antarctica and shows a tendency for southward shift and progressive intensification. The main low in the trough is apparently between 80°E to 120°E.

8. September - October - November

8.1 This period is one of transition from the summer conditions to the winter conditions. In the northern hemisphere, the transition sets in, in the middle latitudes, by September. The Asiatic anticyclone covers the whole of Siberia and China by October and intensifies appreciably by November.

8.2 The Aleutian low begins to show itself in September and deepens progressively. The Icelandic low also becomes well-marked. Simultaneously the Azores anticyclone and the Pacific high shrink in size and are noticed as narrow ridges. The Mediterranean low makes its appearance over Italy in October and persists.

8.3 The monsoon trough over north Africa and south Asia weakens and rapidly moves towards the equator. The shift is over 10° latitude between September and November over Africa and 20° over India. The monsoon low over northwest Australia appears by November and intensifies progressively. To the northeast of Australia there is a southward migration of the equatorial trough; the trough line reaches to the south of the equator by November.

8.4 The southern hemisphere subtropical ridge line is located roughly along 30°S. With the formation of heat low over Australia, the anticyclonic cell over Australia weakens. The centre of the anticyclonic cell over Indian Ocean shifts from western Indian Ocean to eastern Indian Ocean and weakens.

8.5 The sub-polar trough of the southern hemisphere appears to be closest to Antarctica in October and is probably most intense with central pressure of the order of 980 mb. It shifts slightly northwards in November. The southern hemisphere sub-polar trough is more intense than the monsoonal low over northwest India and West Pakistan in June - July. The October value of 980 mb in this sub-polar trough is the lowest for any mean seasonal low pressure system.

9. Contrast between the Seasonal Variations in the Pressure Patterns in the two Hemispheres

9.1 While the Atlantic and Pacific Oceans stretch across the equator in both the hemispheres, the Indian Ocean is land-bound in the north. The chief geographic difference between the northern and southern halves of the area covered by the climatological charts is in respect of the proportion of land to sea. In the northern half a little over 50% of the area is occupied by the continents while in the southern half 7/8 of the area is oceanic. This difference has a profound influence on the meteorology of the two different areas.

9.2 The following facts relating to the distribution of land and sea over the globe are also of interest and meteorologically significant:-

Area	Relative proportion of Land and Sea	
	Land (%)	Sea (%)
i) Entire globe	29	71
ii) Northern Hemisphere	39	61
iii) Southern Hemisphere	19	81
iv) Eastern half of Northern hemisphere	52	48
v) Western half of Northern hemisphere	26	74
vi) Eastern half of southern hemisphere	20	80
vii) Western half of southern hemisphere	18	82

9.3 The pronounced land-sea contrast between the two halves of the area comprised by the climatological charts accounts for the striking differences in the seasonal variation of pressure distribution over the two areas. The strongly oceanic character of the southern half inhibits large seasonal changes. Hence the subtropical ridge and the sub-polar low remain as prominent features in the southern hemisphere in all the months, with comparatively small seasonal variations in their location and intensity. The central pressure in the subtropical anticyclonic cells over the oceanic area in the south Atlantic and the south Indian Ocean is about 1025 mb in July (southern winter) and 1020 mb in January (southern summer). The corresponding pressure values for the sub-polar low are 988 mb and 984 mb. The continental area of Australia gives rise to a monsoonal effect in the summer months. Notice the low pressure area over north Australia in the months November to March. The lowest pressure of 1005 mb occurs over the Australian monsoon low in the months of January and February. In July the subtropical anticyclone with a maximum central pressure of 1021 mb is located over Australian mainland.

9.4 In the northern half where continentality is very pronounced, the [illegible] intense anticyclone over Asia with a central pressure of 1035 mb in the winter month of January gives place to an equally pronounced monsoon low over northwest India and West Pakistan with a lowest pressure of 995 mb. As against a total seasonal pressure variation of 16 mb over Australia a winter to summer pressure variation of 40 mb occurs over Asia. It should be noted that these are based on mean monthly values from which the day-to-day fluctuations caused by by synoptic weather systems have been eliminated by averaging. The Aleutian low off Kamchatka in the winter months is no longer present in summer. The Pacific anticyclone which was largely outside the area of the chart in the winter months moves westward and is the most dominant pressure system over the western Pacific off Japan in the summer monsoon months. In the northern hemisphere the oceanic anticyclones (the Azores high and the Pacific high) are stronger in summer than in winter while the reverse is the case in the southern hemisphere.

9.5 The pronounced seasonal pressure variations give rise to a reversal of circulation from winter to summer over South Asia. The Asiatic summer monsoon is the most pronounced monsoon circulation over the globe. The economy of India is vitally linked with the monsoon rainfall. As can be seen from the sea level isobaric charts, the conspicuous feature over India and adjoining areas is the north-south progression of the equatorial trough between summer and winter. The trough over India attains its northernmost location of about 30°N in July-August. In January-February the trough is near the equator. There is no other part of the world where the equatorial trough has as much seasonal amplitude of oscillation as over the Indian area. The march of the equatorial trough across India and its location and intensity day after day are matters of profound interest and concern to the forecaster in India. Synoptic weather systems over India and neighbourhood, should, however be viewed in relation to the other semi-permanent pressure systems in the neighbouring areas to understand the current weather situation and for prognosticating future development. These aspects will be dealt with in detail elsewhere in the Manual.

Acknowledgement:

Grateful acknowledgement is made to the various Meteorological Services and Agencies (listed in Appendices I and III) whose published data and analyses have been utilised in the preparation of this report. Our thanks are due to the members of the Forecasting Manual Unit and of the Investigation and Development Section of the DDGF's Office for assistance in the compilation of data, preparation of the diagrams and typing of manuscript.

* * *

APPENDIX - I

Sources of Data

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7. M.P. Van Rooy (Editor). 1957: Meteorology of the Antarctic, Weather Bureau, South Africa.
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APPENDIX - II

Station Network for Mean Sea Level Isobaric Charts

Area	No. of Stations from	
	WMO. No.117-T.P. 52	Other Sources
Europe (including east Atlantic)	169	59
Asia	184	58
Africa (including south Atlantic)	134	10
Madagascar and Indian Ocean	18	3
Australia, New Zealand, Indonesia and southwest Pacific	72	8
Antarctica	..	5

APPENDIX - III

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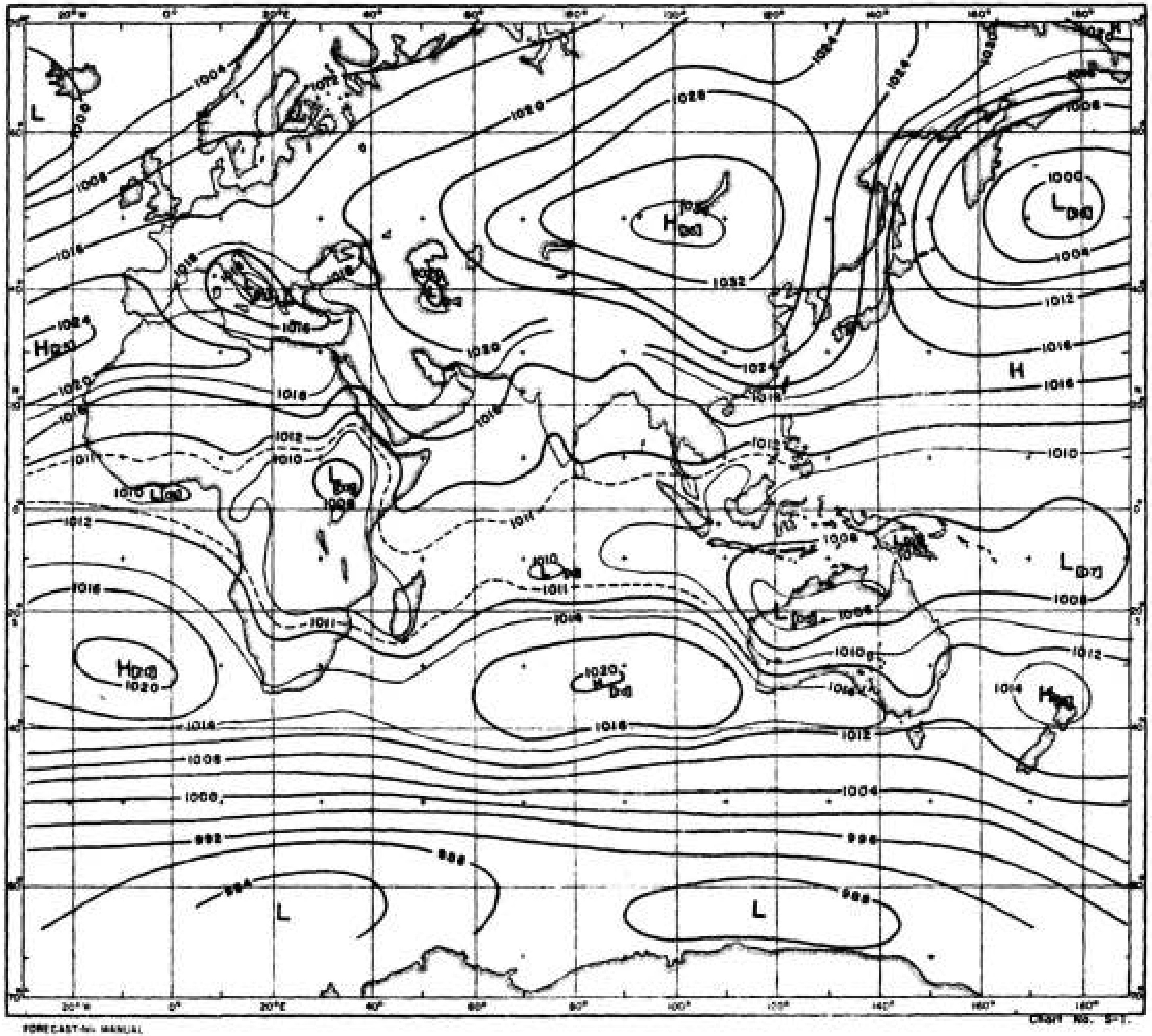


FORECASTING MANUAL

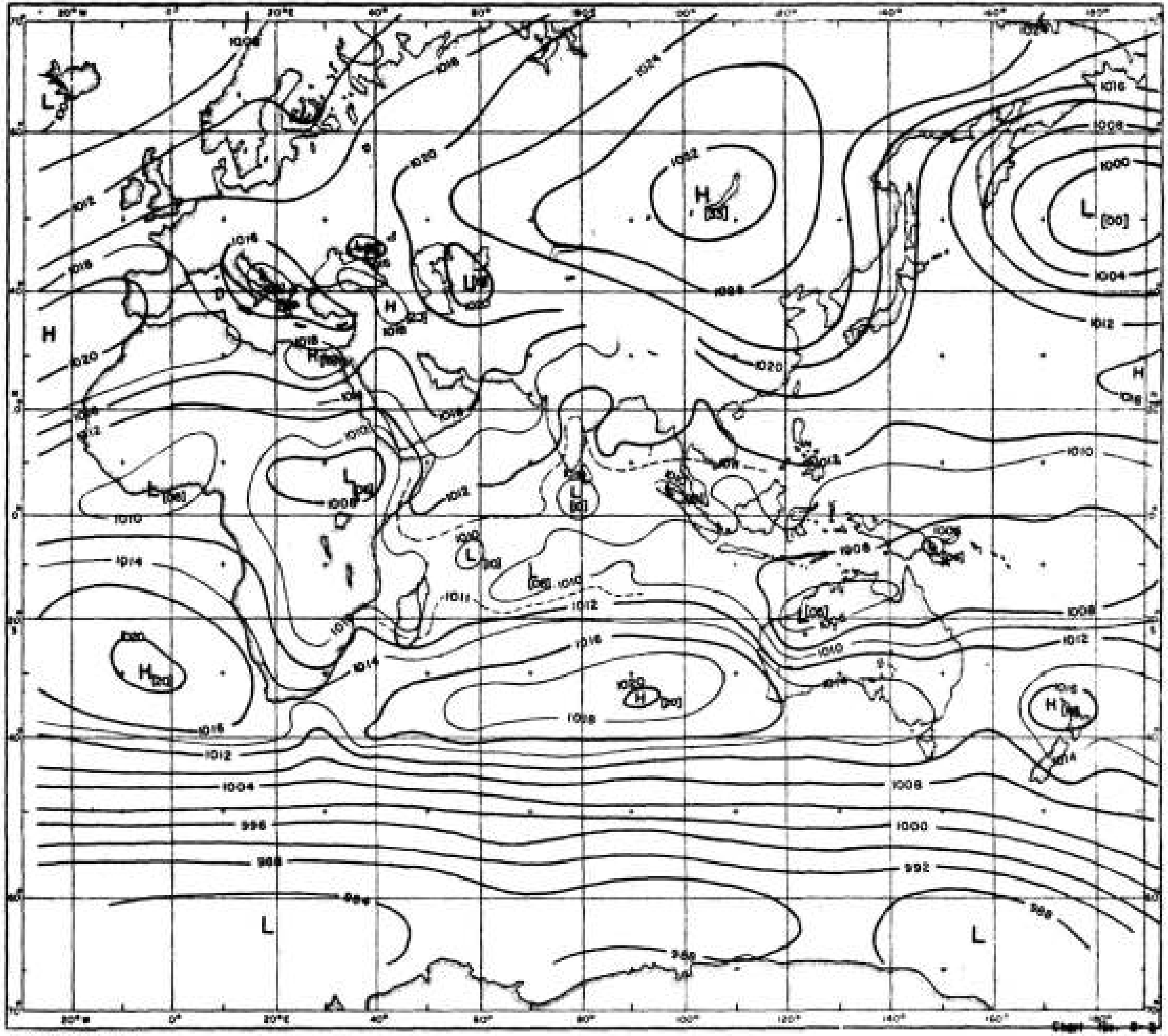
Chart No. S-1.

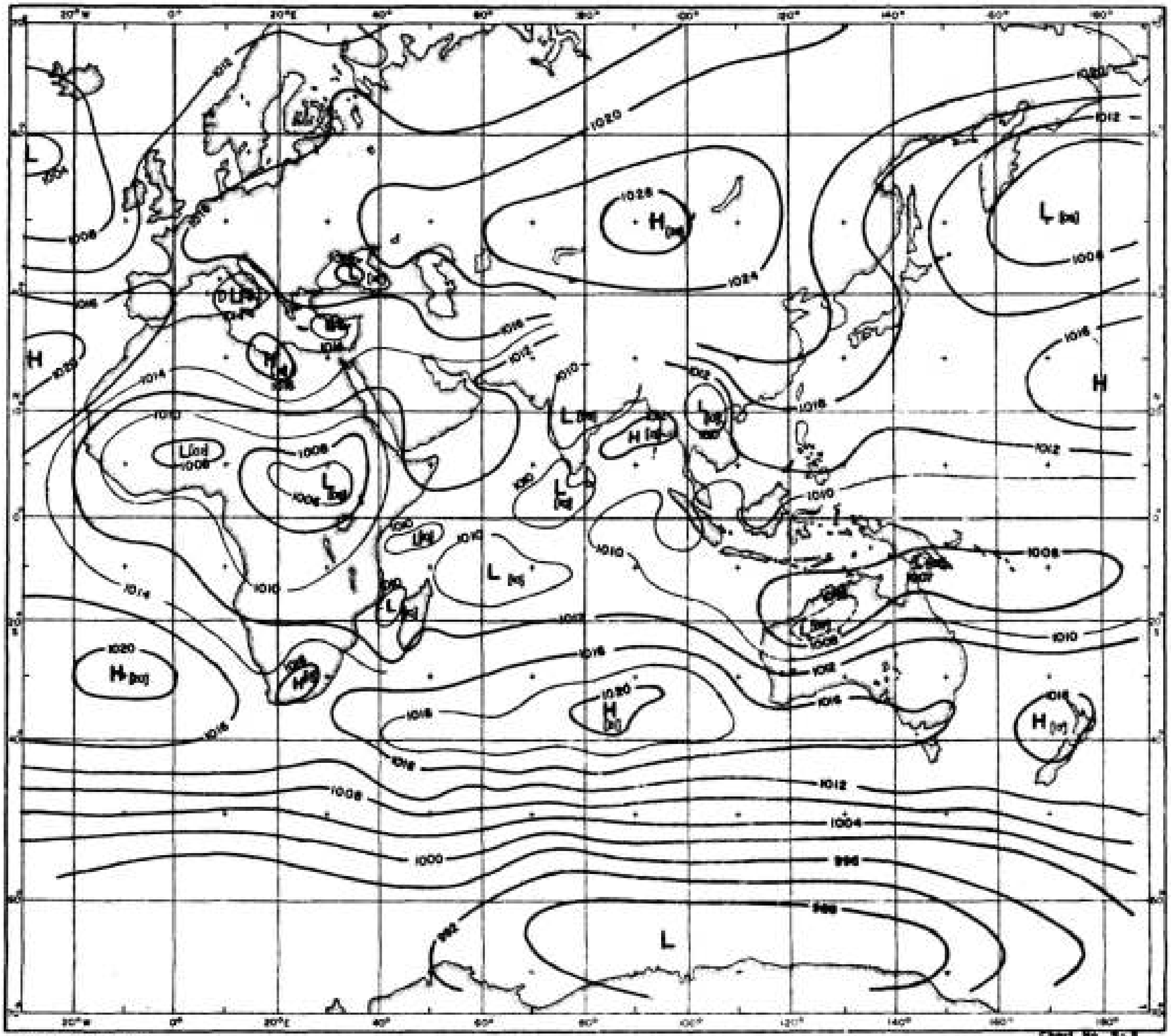
SEA LEVEL PRESSURE (mb)

JANUARY

SEA LEVEL PRESSURE (mb)

FEBRUARY



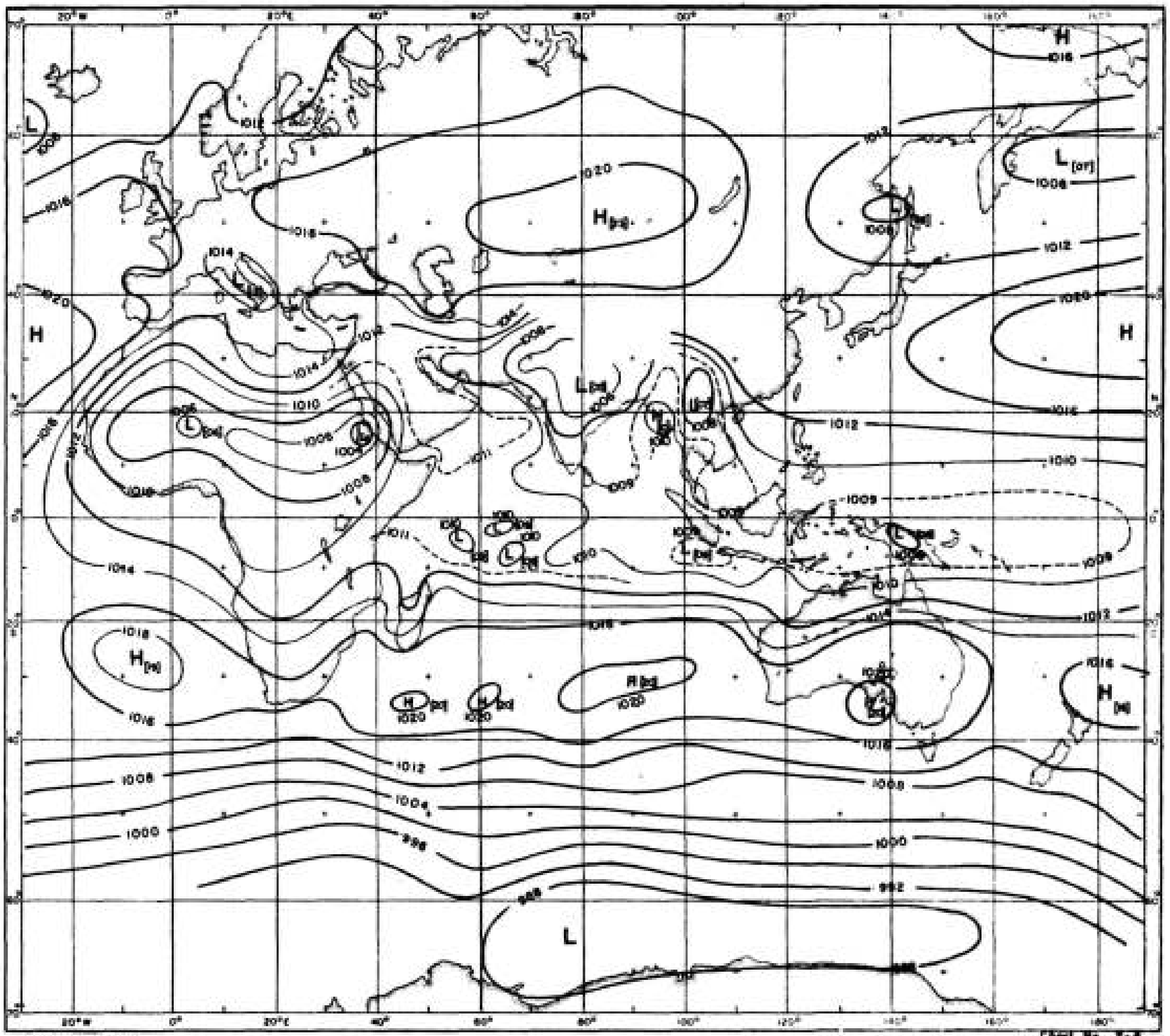


FORECASTING MANUAL

Chart No. S-3

SEA LEVEL PRESSURE (mb)

MARCH

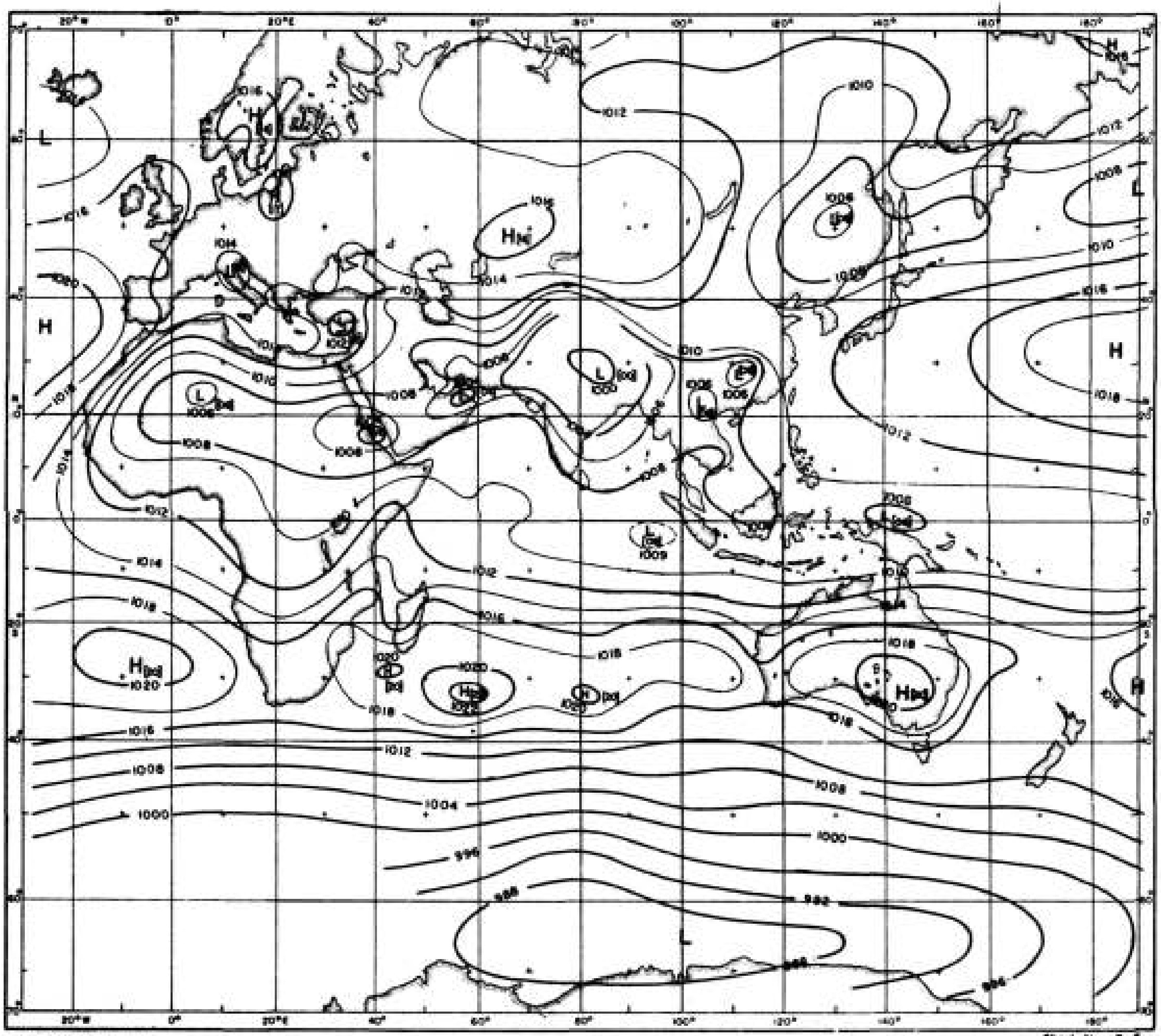


SEA LEVEL PRESSURE (mb)

APRIL

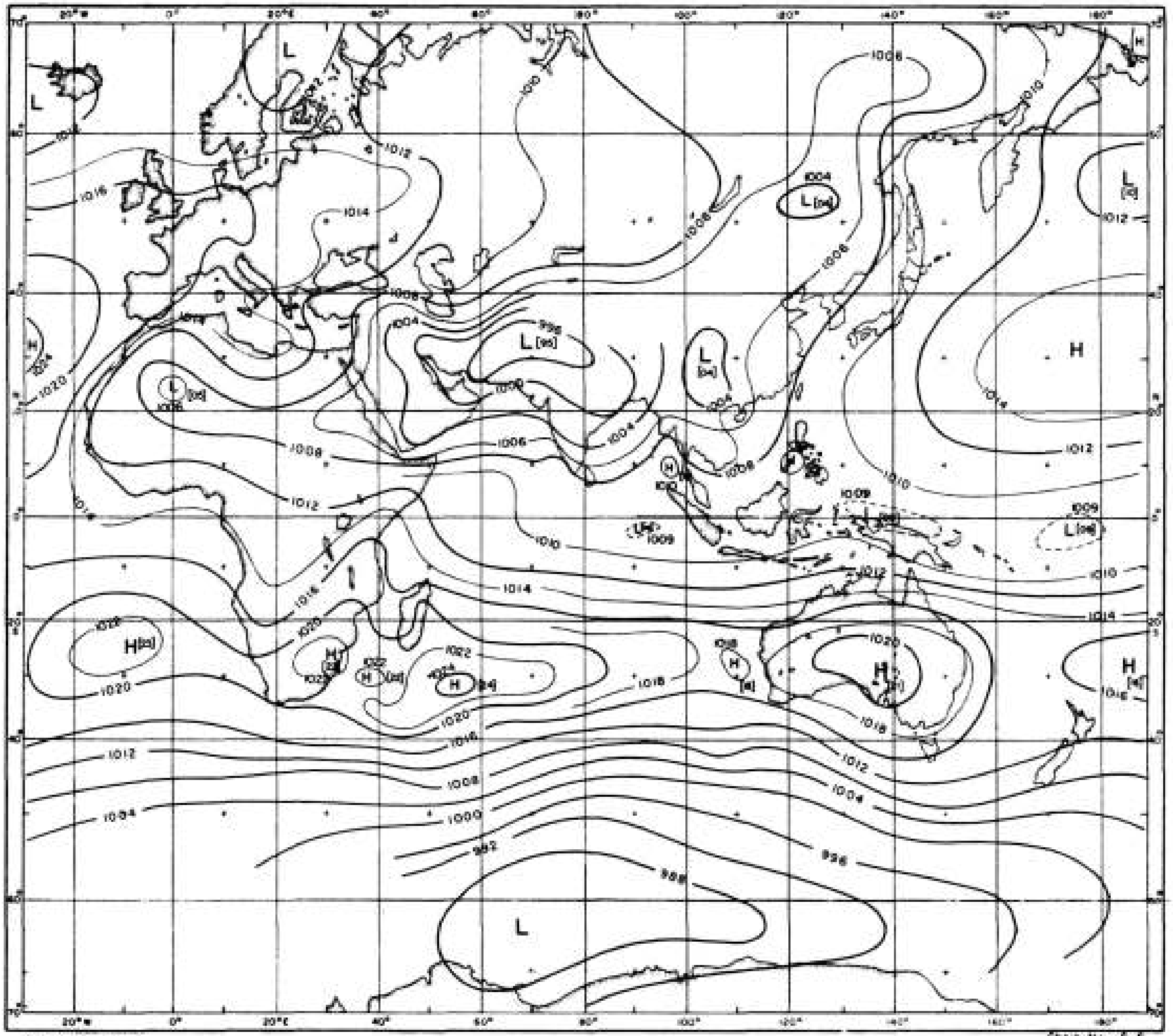
FORECASTING MANUAL

Chart No. 5-4



SEA LEVEL PRESSURE (mb)

MAY

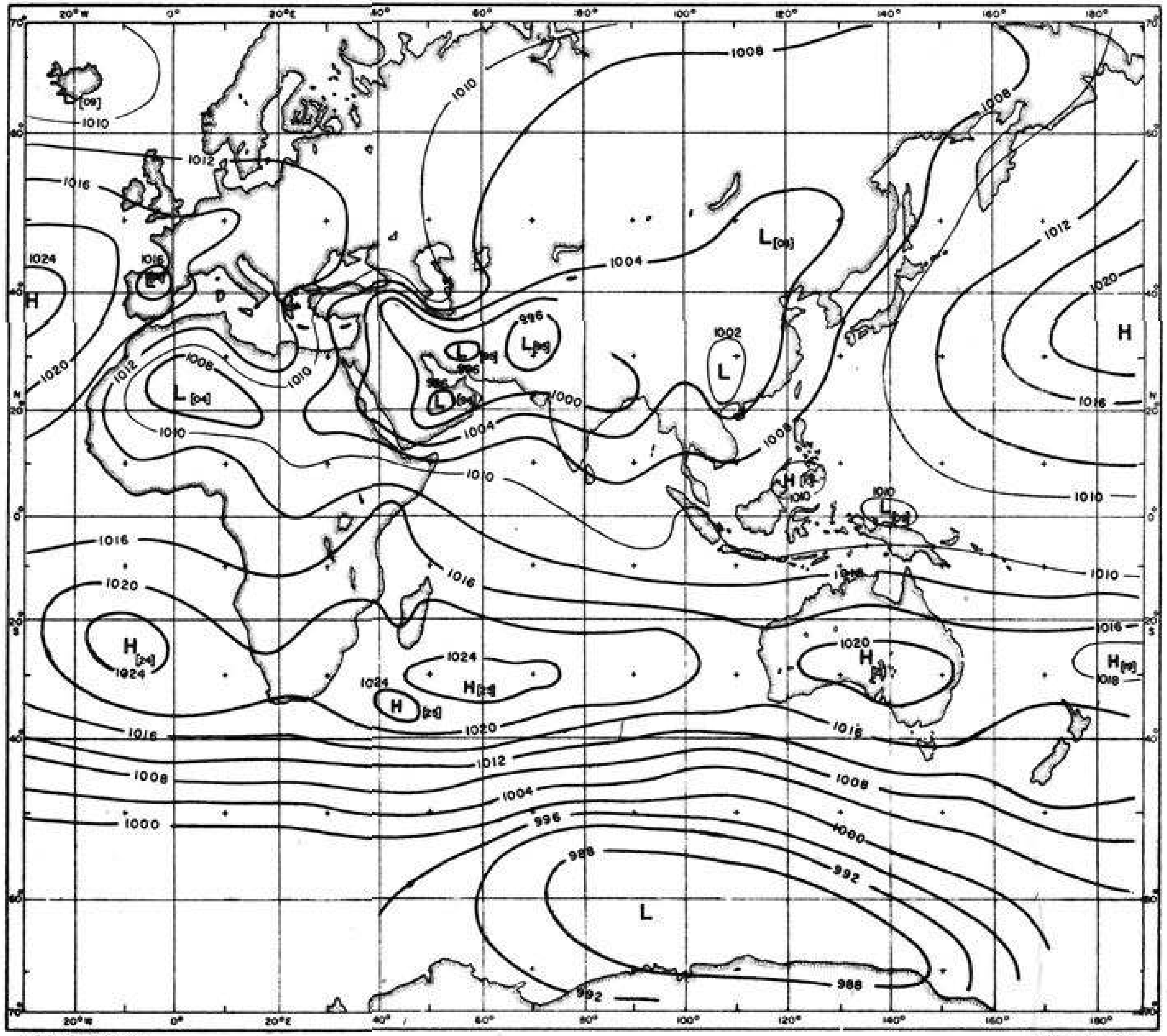


FORECASTING MANUAL

Chart No. S-6

SEA LEVEL PRESSURE (mb)

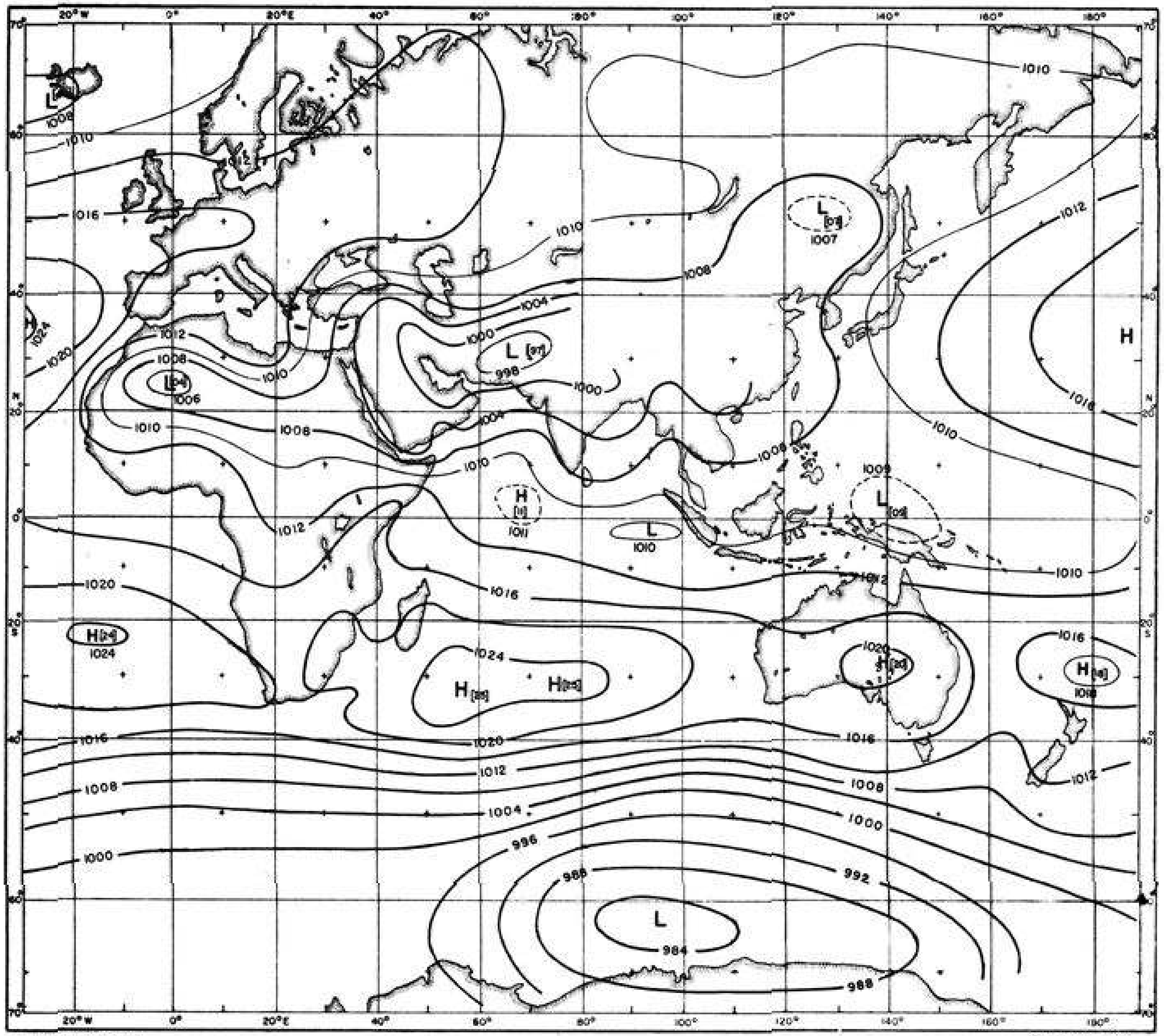
JUNE



SEA LEVEL PRESSURE (mb)

JULY

Chart No. S-7



FORECASTING MANUAL

Chart No. S-8

SEA LEVEL PRESSURE (mb)

AUGUST

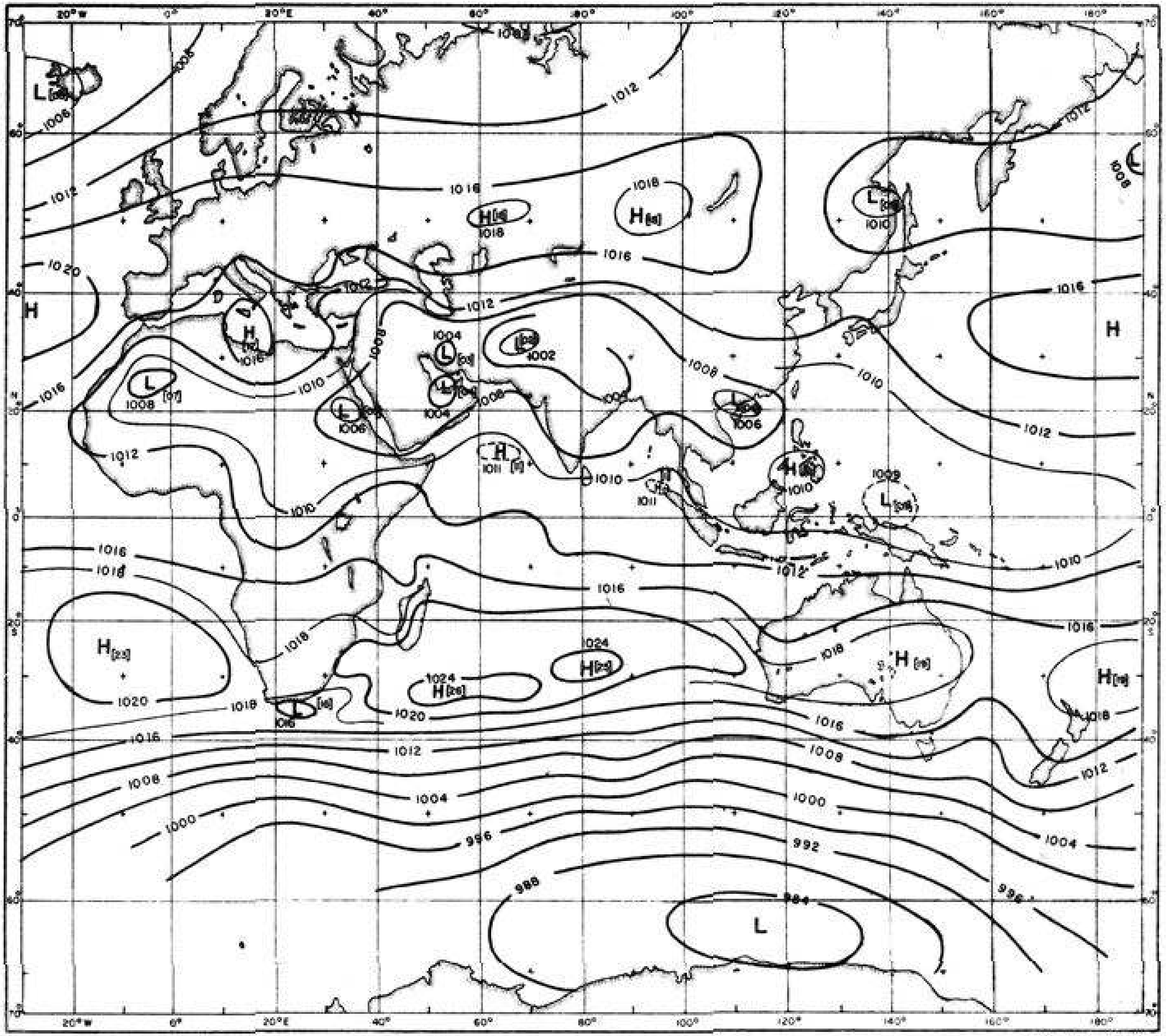


Chart No. S-9

SEA LEVEL PRESSURE (mb)

SEPTEMBER

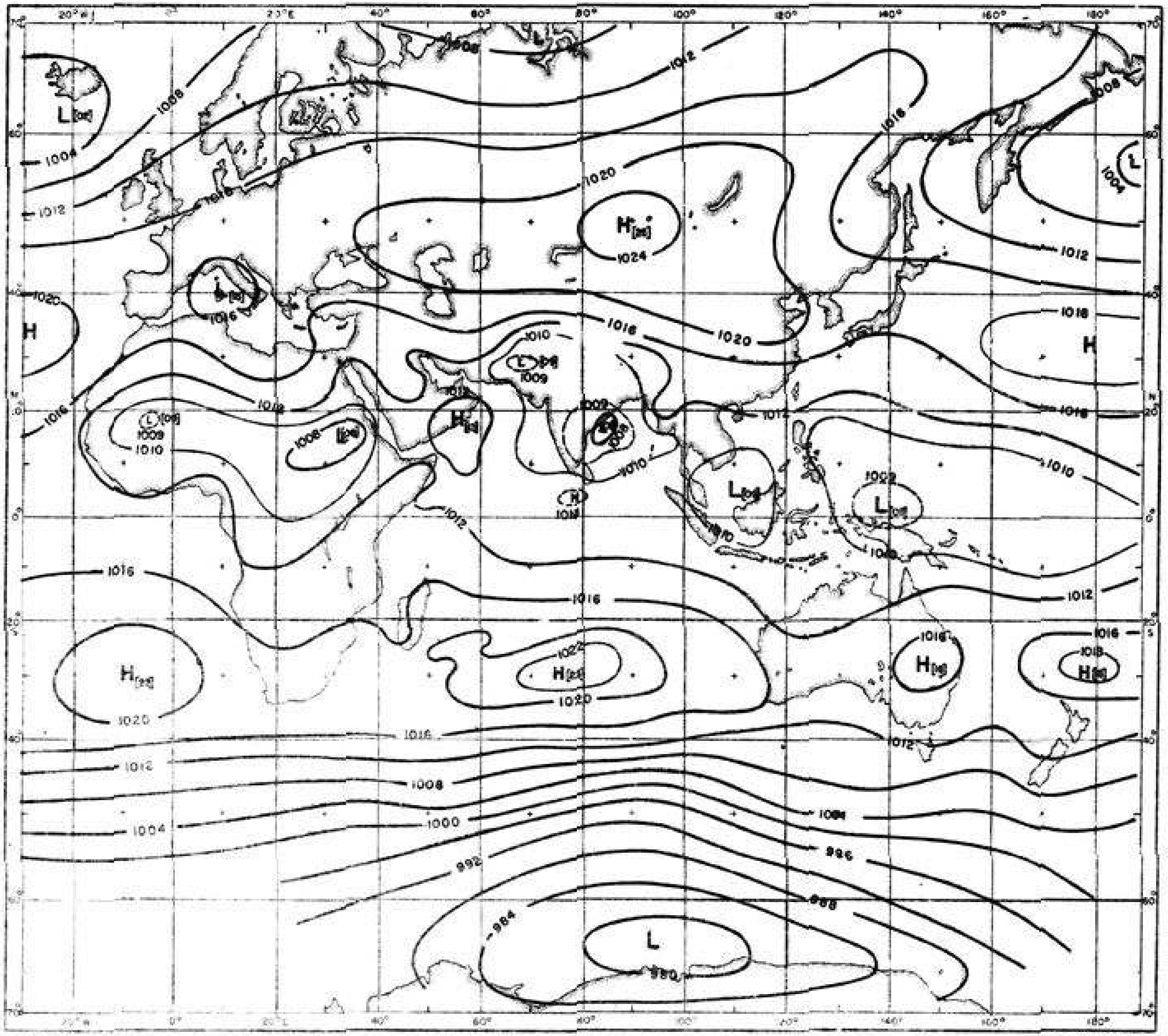
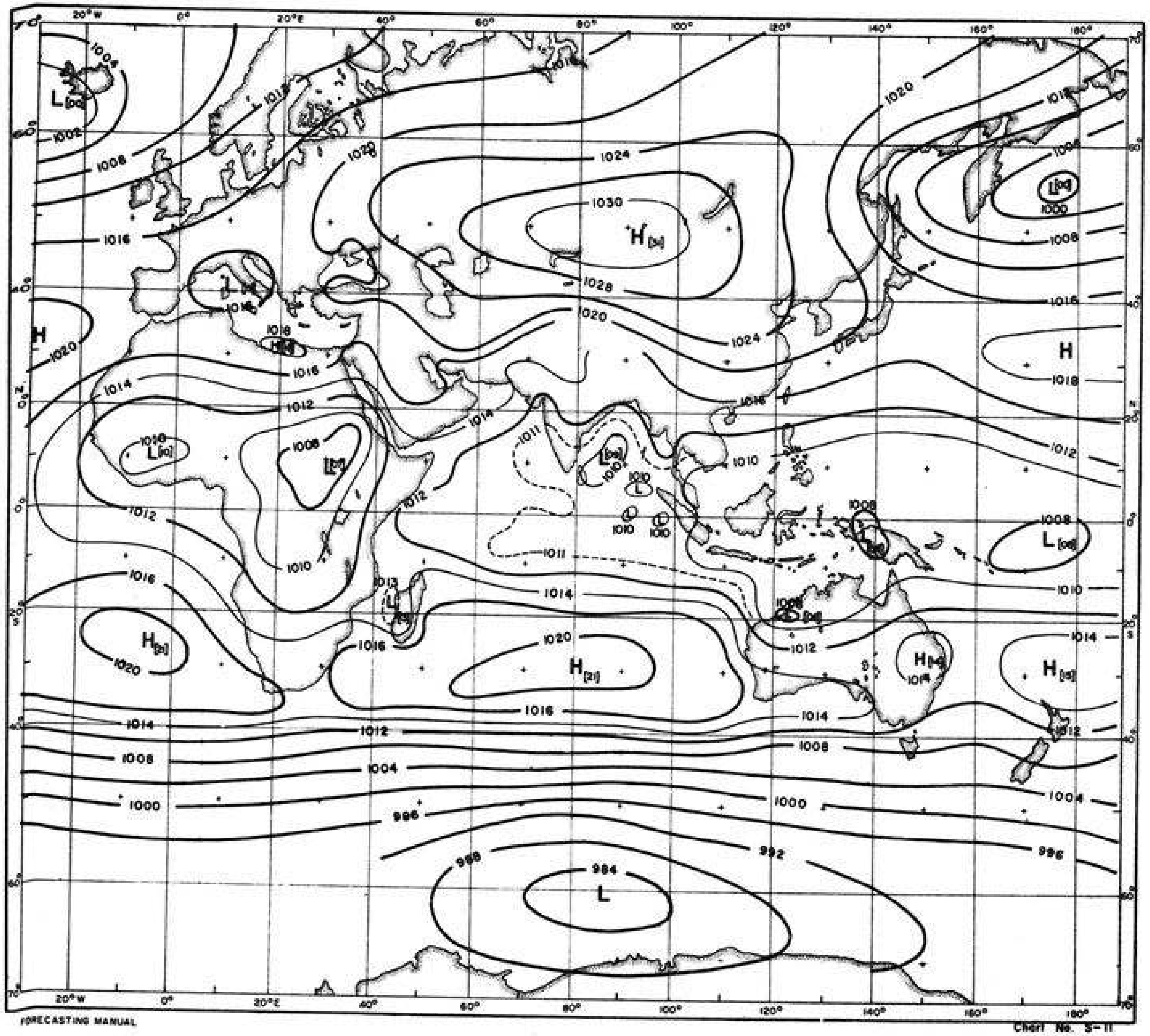


Chart No. S-10

SEA LEVEL PRESSURE (mb)

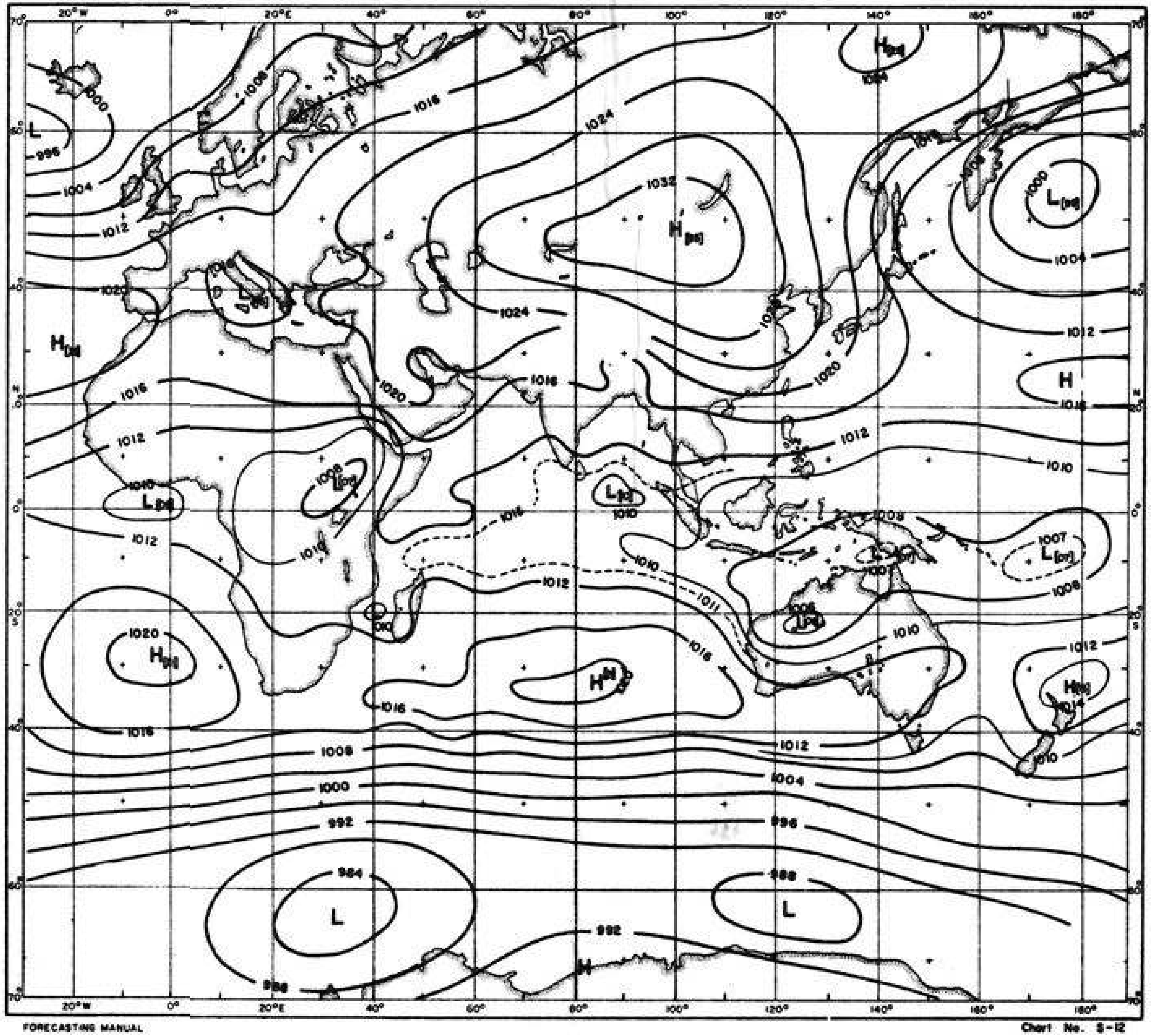
OCTOBER



SEA LEVEL PRESSURE (mb)

NOVEMBER

Chart No. S-11



FORECASTING MANUAL

Chart No. S-12

SEA LEVEL PRESSURE (mb)

DECEMBER