WINDS AT 10 KMS. AND ABOVE OVER INDIA AND ITS NEIGHBOURHOOD.

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ABSTRACT.

Upper winds from the surface to 8 kms. over India have been analyzed by Dr. Ramanathan and Mr. Ramakrishnan. The present paper summarizes all data available during the period 1920 to 1941 for the levels above 8 kms. Charts showing the general circulation of winds for every 2 kms. level from 10 to 20 kms. are drawn. These Charts show the strength and direction of the Westerlies during the winter months and the Easterlies during the monsoon months. The charts for the transitional months indicate the replacement of one set of general circulation by the other. The zonal components of the winds over India at all levels from 5°N. to 25°N. drawn for the two representative months February and August compared with those drawn by Bjerknes from an analysis of the upper air pressure distribution show similarity. The paper also illustrates the variation of wind with height over different regions in different seasons.

Upper wind circulation over India and its neighbourhood up to 8 kms. has been analyzed and discussed by K. R. Ramanathan and K. P. Ramakrishnan (1939). Recently, during the war, more up-to-date charts analyzing all available data over India and its neighbouring countries, viz. Russia, Iraq, Arabia, Malaya, Siam, Indo-China and China have been published (1943). These also give the upper air circulation up to 8 kms. only. Demand for information regarding the upper air circulation at much higher levels has, however, increased recently due to the increase in the levels of flying that can be usually attained by aeroplanes and due to attempts at stratospheric and rocket flying. There is no analysis on this subject for India except that by N. K. Sur (1930) over a single station, viz. Agra. The present paper summarizes briefly all the available data above 8 kms. over India and its neighbourhood.

The resultant monthly direction and velocities and the average speeds irrespective of direction together with a number of observations at each km. level up to the maximum height for which it is available for all Pilot Balloon Observatories under the India Meteorological Department are published annually. All such data for the period 1920 to 1941 were tabulated and analyzed.

In summarizing the data, the observations made during the different parts of the day have not been separated out, and all available data have been taken into account. There seems to be no objection to this as the diurnal variation at such high levels will be negligible; the number of occasions with two high flights on the same day at one station will also be negligible, because for most of the period for which the data have been analyzed, either the morning or the afternoon flight was restricted to expedite supply of data to different customers, particularly the aviators. There was also the limitations imposed by the diurnal variation of cloud and visibility.

Different types of balloons have been used for Pilot Balloon Observations in India, e.g., balloon made of gutta percha tissue made at the Upper Air Observatory at Agra/Delhi, balloons from rubber tissues obtained from Germany, and rubber balloons obtained from England, Germany or America. The size of the balloon used varied with the season, bigger ones being invariably used for unrestricted ascents in clear weather.

The method of observation and computation throughout was the single station 'tail method'. The length of tail used depended upon the weather and the size of the balloon, 100 metre tails with flags at 12½, 25, 50 and 100 metres being normally used with the bigger size balloons in clear weather.

Most of the flights were checked by the Central Observatory at Agra/Delhi before accepting them. In deciding the height up to which a particular flight is accepted, the shape and character of the 'height line' is particularly examined along with the other factors.

It can be remarked that these high level winds obtained from Pilot Balloon Observations depict the conditions during clear weather only. However, with the design of instruments for determining the upper winds by Radio, it will be possible to obtain high level data in larger numbers in all seasons. Though the present analysis may not represent the circulation over disturbed areas, it will be a fair representation of the general circulation over the country. The upper winds over a particular area during cloudy season can be inferred by extrapolation, e.g., even if no ascents are possible on the western half of the Peninsula during the monsoon, high ascents are possible on the eastern half, and the winds at these high levels can be fairly representative of that over the West Coast.

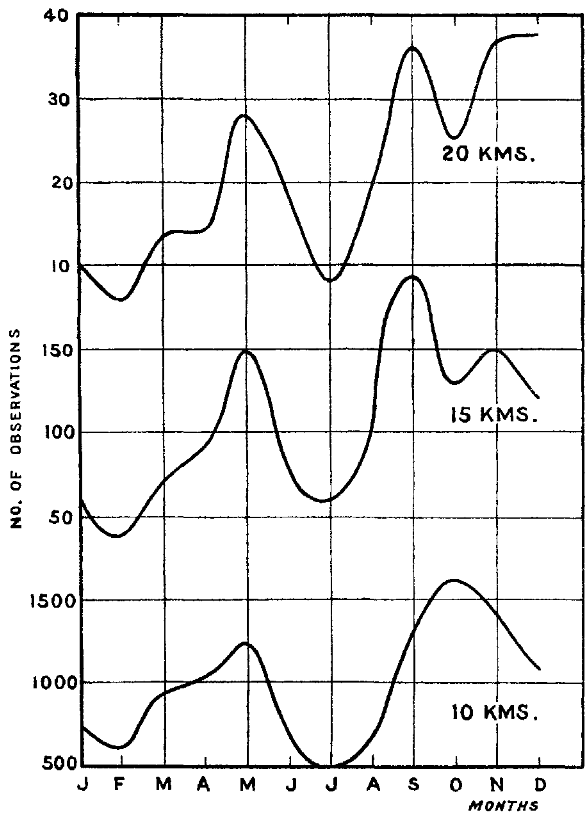

FIG. 1. TOTAL NO. OF OBSERVATIONS AT 10, 15 & 20 KMS OVER INDIA IN DIFFERENT MONTHS.

Fig. 1 gives the total number of observations over the whole of India and its neighbourhood during each month for the 10, 15 and 20 km. level. The number of

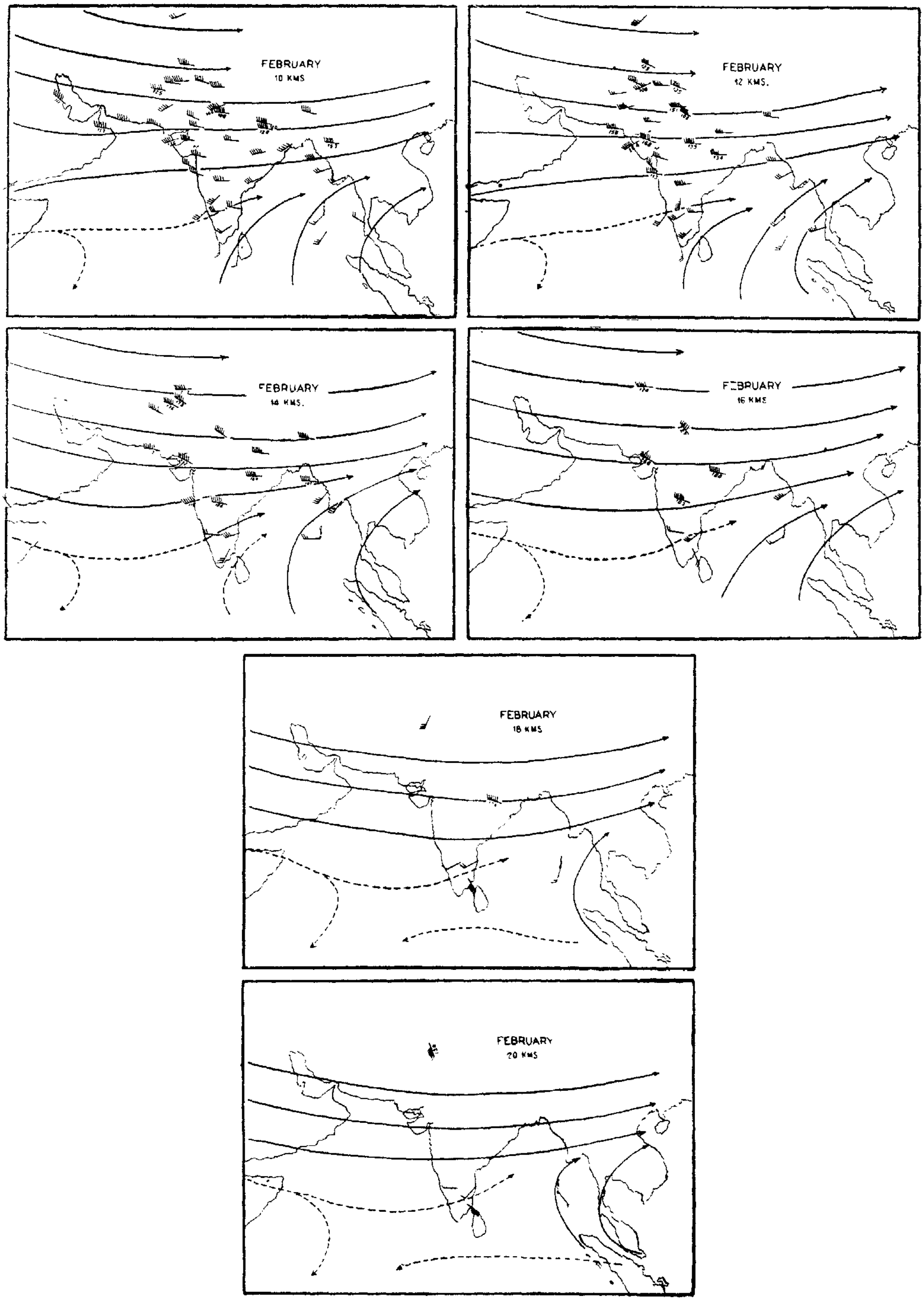
FEBRUARY
10 KMS
FEBRUARY
12 KMS.
FEBRUARY
14 KMS.
16 KMS
FEBRUARY
18 KMS
FEBRUARY
20 KMS

FIG. 2.

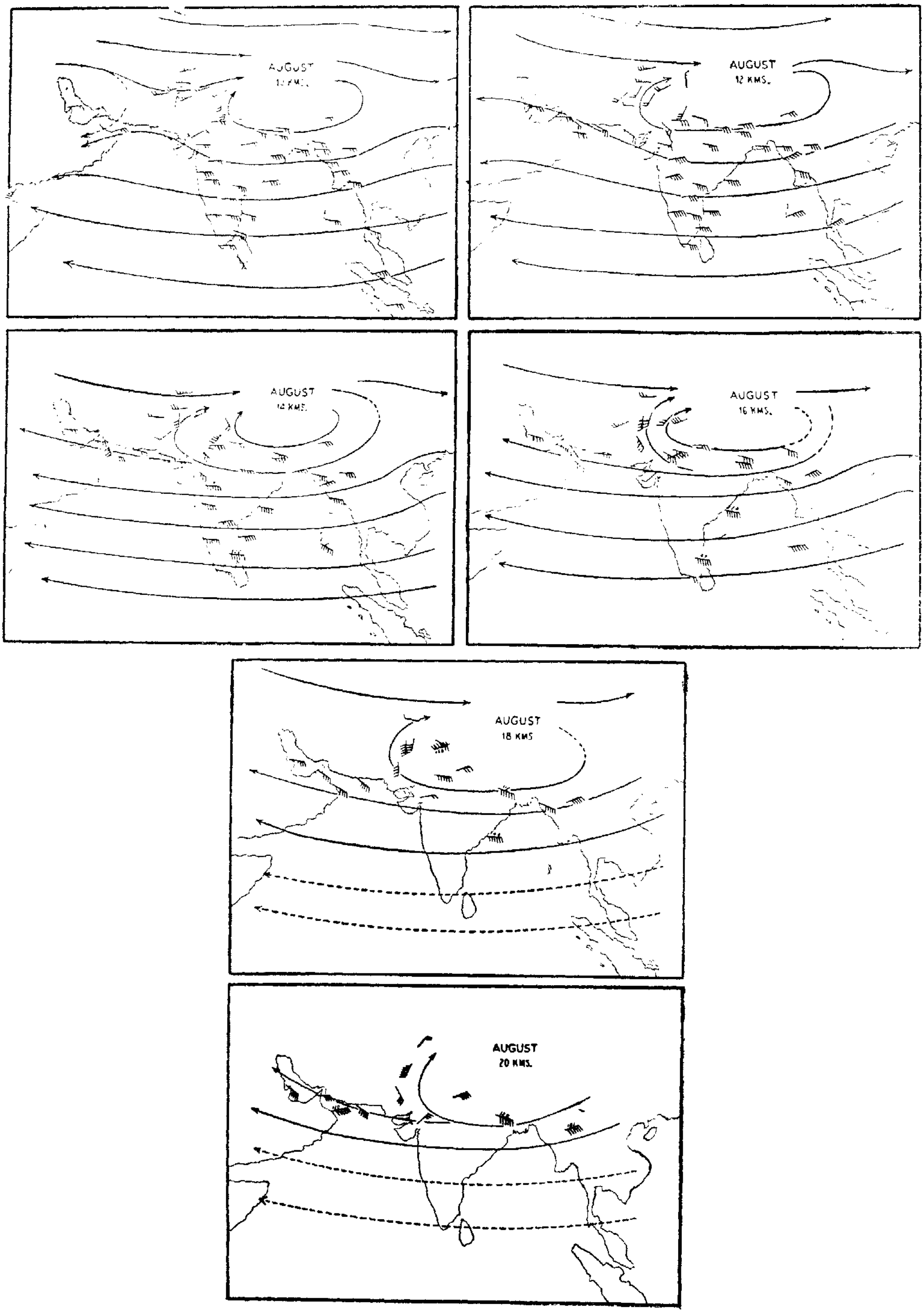
AUGUST
AUGUST
12 KMS.
AUGUST
14 KMS.
AUGUST
16 KMS.
AUGUST
18 KMS.
AUGUST
20 KMS.

FIG. 3

observations shows minima in the two months February and July. The comparatively small number of observations during February can be explained as being due to the winds being strong and from the west over the country at most of the levels with the result that the balloons are lost at low angles to the east before long.

The comparatively fewer observations during the month of July can be easily explained as due to the south-west monsoon when most of the country is cloudy.

During the months, February to May, though there is no large change in the direction of winds, the wind speeds decrease from month to month, particularly over northern India below the 10 km. level. Therefore the balloons do not drift horizontally to low angles so quickly in May as in February, and the number of high observations are also larger. There is a sudden drop in the number of observations after this month due to the onset of the monsoon.

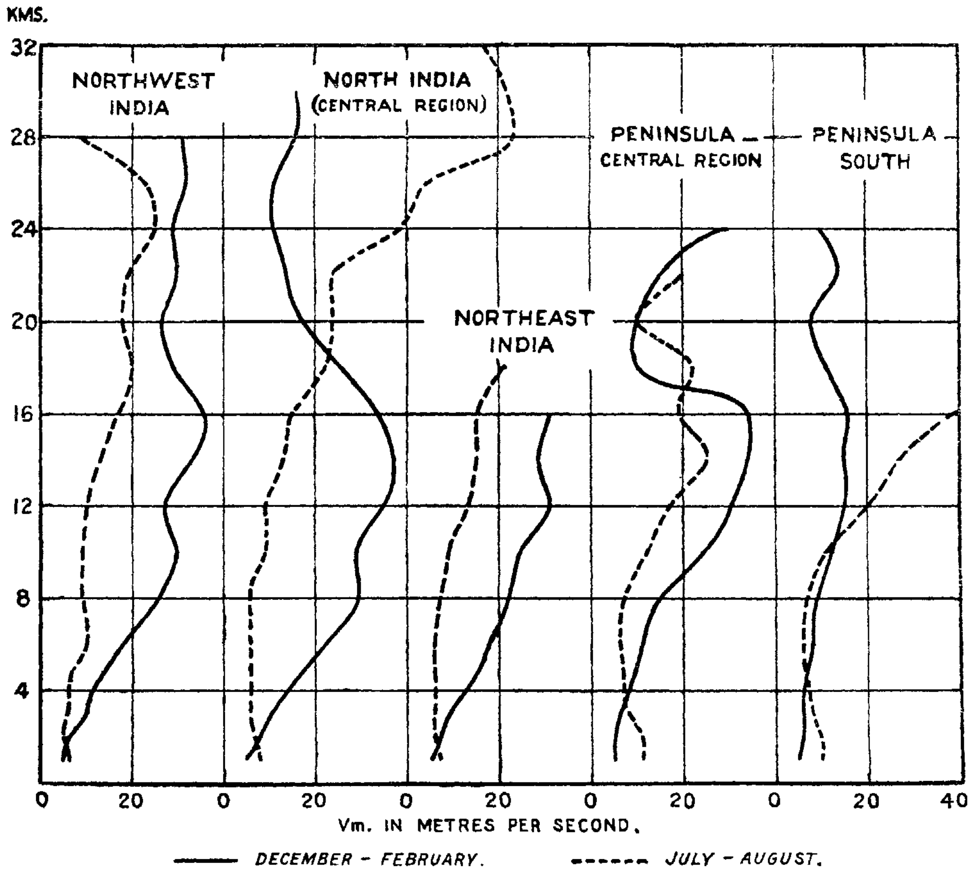

FIG. 4. MEAN WIND OVER DIFFERENT REGIONS IN INDIA.

The second maximum during September and October is also due to the clearing of the skies after the monsoon; the number of observations are greater in September at the 15 and 20 km. levels, as the winds are weaker during this month than during October at most levels over northern India.

All available data were analysed and the resultant direction and velocity of winds were charted for the levels 10, 12, 14, 16, 18 and 20 kms. for different months. Lines showing the general direction of flow of winds were also drawn.

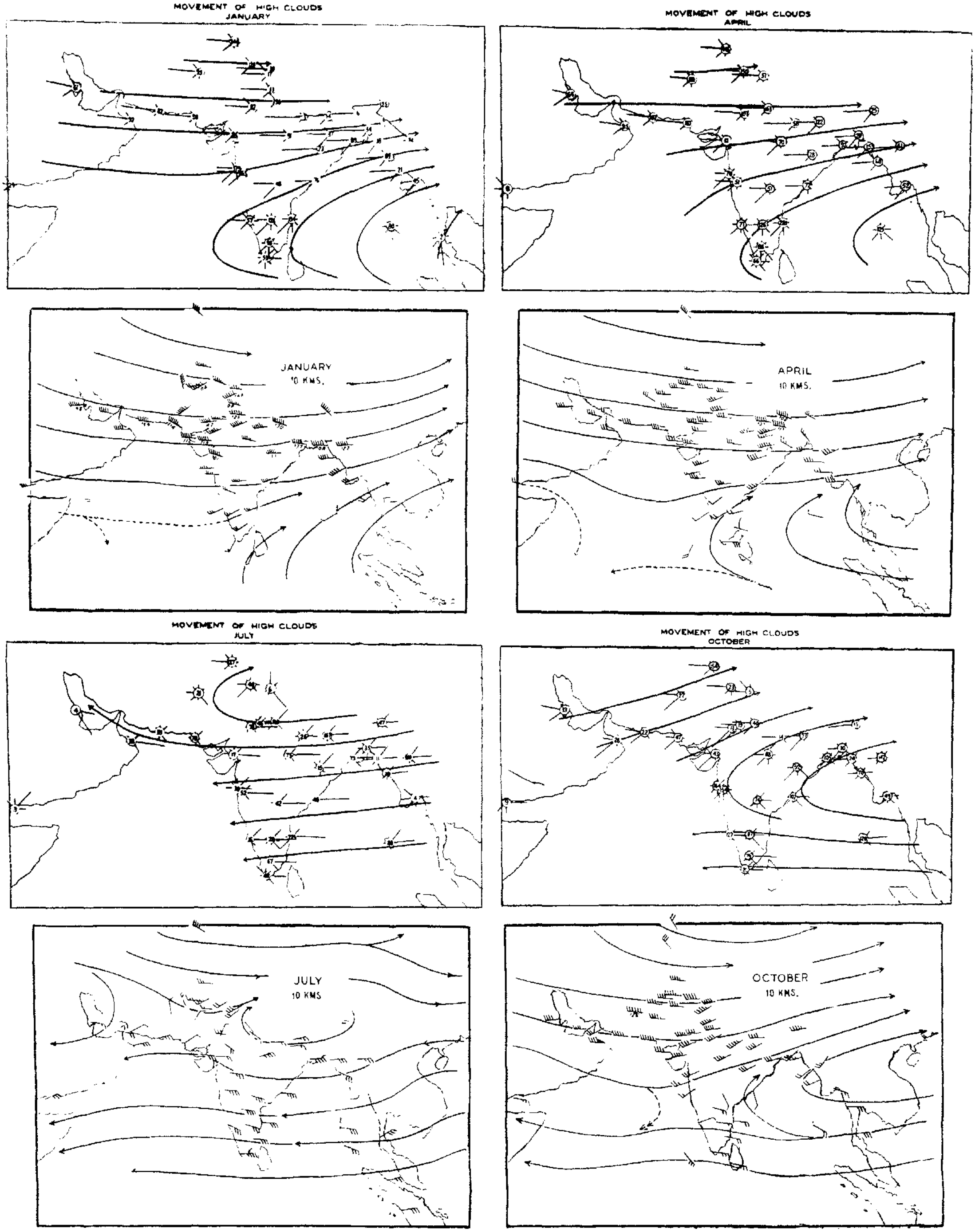
MOVEMENT OF HIGH CLOUDS
JANUARY
MOVEMENT OF HIGH CLOUDS
APRIL
JANUARY
10 KMS.
APRIL
10 KMS.
MOVEMENT OF HIGH CLOUDS
JULY
MOVEMENT OF HIGH CLOUDS
OCTOBER
JULY
10 KMS
OCTOBER
10 KMS.

FIG.5

Figs. (2) and (3) are the charts for the two months February and August. The 'High' circulation over south China Seas observed during the winter month of February moves to the north from month to month till August when it is situated over the Himalayas. It gradually moves back to the South China Seas from September onwards. The winds at all levels are, therefore, westerly over India and its neighbourhood during winter. But during the monsoon up to 20 kms. they are mostly easterly except at the extreme north as indicated by the winds at Peshawar. At Peshawar, the winds are westerly in all the months from 10 to 20 kms. However, the single available observation for August shows that the wind at 20 kms. and above is easterly up to the 29 km. level and has an average speed of about 45 km. per hour.

The variation of the mean speed of wind at different heights over the different regions of India during the winter and monsoon is shown in Fig. 4. During winter, the winds are stronger over the northern half of the country, and attain their largest speed between the levels 12 and 16 kms. Over this area, velocities of the order of 150 to 200 km. per hour are common during this season. Above the 16 km. level, there is an appreciable decrease of speed with height. In the southern half of the Peninsula, the speed between the 10 and 20 km. level averages about 45 kms. per hour.

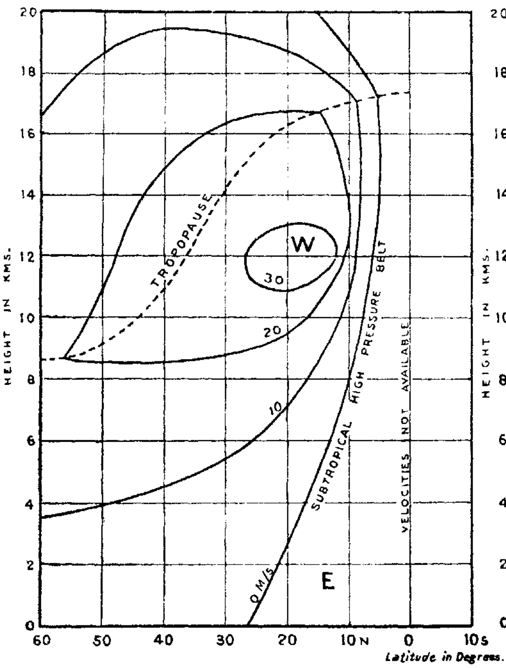

FIG. 6 (a). ZONAL COMPONENTS OF GRADIENT WINDS. FEBRUARY. (BJERKNES)

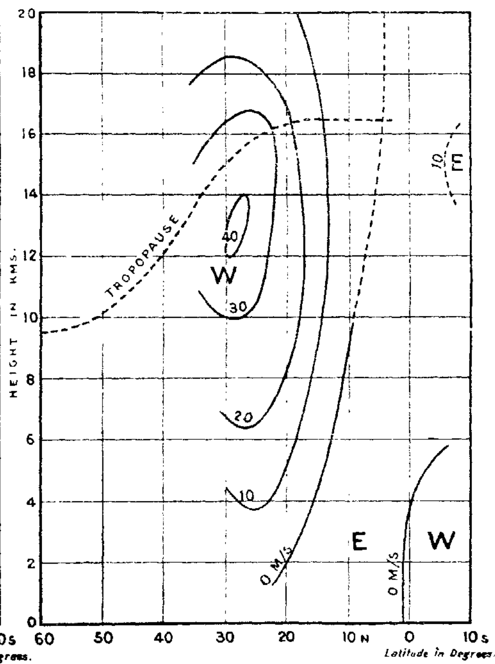

FIG. 6 (b). E-W COMPONENTS OF WINDS ALONG 78°E (DEC.-FEB.)

During the monsoon, winds over northern India are weaker than those during winter; in the southern half of the Peninsula, they are stronger than those during December–February; but information is not available above the 16 km. level over this area. However, even in these levels, easterly winds of the order of 100 to 150 kms. per hour appear to be common.

Ramanathan and Ramakrishnan (1939) have summarized and published charts showing the direction of movement of high clouds over India and neighbourhood in

January, April, July and October. The wind circulation at the 10 and 12 km. level agrees fairly accurately with the movement of the high clouds. (Fig. 5.) One can, therefore, infer that the high cloud level over India is of the order of 10–12 kms. where the temperature is about 220°A.

From the upper air pressure and temperature distribution, Bjerknes (1933) has calculated the zonal strength of the gradient winds for different heights during the two months February and August—Fig. 6(*a*) and Fig. 7(*a*). In these diagrams Bjerknes has drawn the boundary between the westerly and easterly components below the 10 km. level in the tropics from the observations of Banerji and Ramanathan (1930).

The mean west-east components of winds up to 20 kms. over the 78°E. longitude were calculated and charted for the two seasons, December–February and July–August, Figs. 6(*b*) and 7(*b*). The diagrams represent the zonal circulation over the region from the equator to about 35°N. as upper wind data are available only for this region. The data up to 8 kms. have been taken from Ramanathan and Ramakrishnan's paper. The upper wind observations of Batavia (1943) have also been incorporated and the curves for regions to the south of 5°N. latitude are therefore approximate to this extent. The height of the tropopause is from Ramanathan's diagram. The zonal circulation calculated by Bjerknes agrees fairly accurately over the region for which the observations are available.

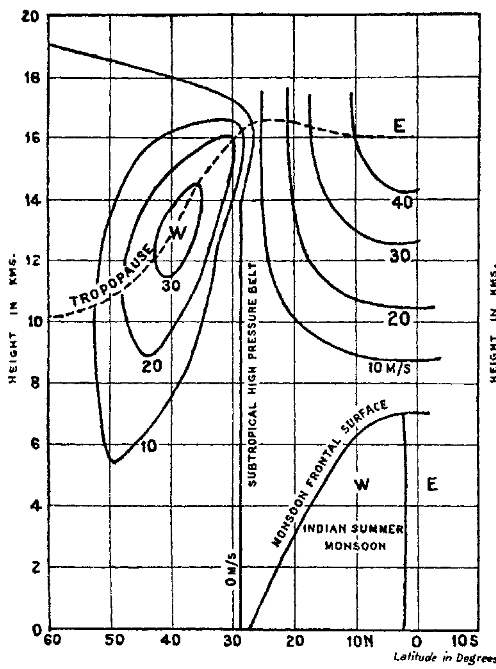

FIG.7(a) ZONAL COMPONENTS OF GRADIENT WINDS AUGUST (BJERKNES)

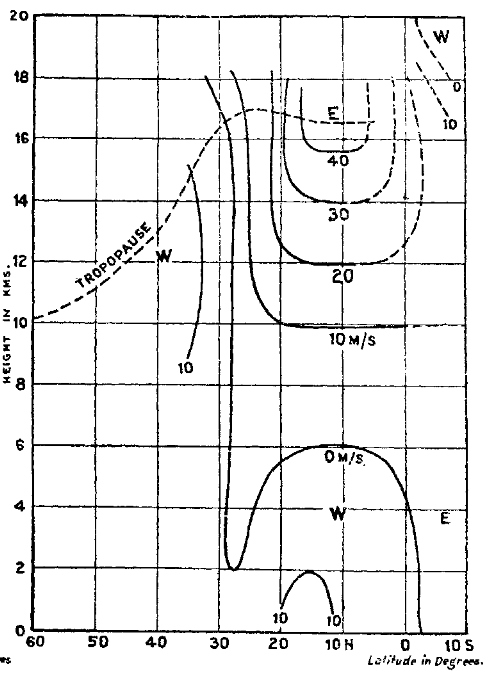

FIG.7(b). E-W COMPONENTS OF WINDS ALONG 78°E (JULY-AUGUST)

This is in brief the general circulation of winds at high levels over India and its neighbourhood. A more detailed paper on the subject is under preparation.

Reference.

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