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Midget Cyclone over Madras—20 November 1960

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ABSTRACT. Analysis of data of four observatories close to the track of the cyclonic storm of small extent over Madras on 20 November 1960 has been made and some features like extent, speed and central pressure are discussed. The observed winds are compared with computed gradient winds. The upper air flow pattern has been examined to find out causes for its rapid intensification.

1. Introduction

A depression formed in the southwest Bay of Bengal on 18 November 1960 with centre near Lat. 10·5°N and Long. 84·5°E. It moved initially northwestwards and later in a westerly direction. In the final stage, the depression intensified rapidly into a cyclonic storm of very small extent and passed over Madras city and neighbourhood at 1430 IST on 20 November. The track of the storm is shown in Fig. 1.

Preceding the movement of the storm inland, there was no evidence of the depression developing into a cyclonic storm. It was unfortunate that the Decca Radar at the Madras airport had gone out of order on 19 November due to a short circuit and was out of commission on the day of the storm. Available ships' observations did not indicate a system more intense than a depression. The nearest ship which was about 60 miles from the centre indicated only winds of 27 knots. The microseisms recorded by the Sprengnether instrument at Madras on the morning of 20 November did not indicate any large scale increase in their amplitudes which is normally observable when a cyclonic storm is formed.

2. Extent of the storm

During the survey of the storm damage, undertaken in the coastal district of Chenglepet, it was found that the total extent of the cyclone and the associated region of gale winds was limited to a north-south coastal belt of 20 to 25 miles. The area of damage as observed is shown in Fig. 2 by hatching. It will be seen that the severe damage due to winds was restricted only to a small sector of 6 miles around Meenambakkam. About 15 miles southeast of Meenambakkam it was noticed that trees had fallen in all directions. Evidently this was a region of 'confused' winds blowing in all directions and the centre of the storm passed over the area crossing coast at point 'P' to the north of Covelong. A photograph taken at this place is reproduced at Fig. 3. It shows that palm trees originally standing in a single row near this spot, have fallen in opposing directions.

To the north of this central region, the fall of trees have all been due to strong N/NE-ly winds. But further south of Covelong, although the number of tree falls is comparatively less, some huge trees have been uprooted by strong southerly winds (Figs 4a and 4b). The Superintendent of the salt factory at Covelong reported that the strong northerly winds blowing from the early morning veered in the afternoon and he definitely observed strong winds in all the directions for a short while at about 3 P.M. associated with torrential rain. The heaviest rainfall of 15 cm along the coast during the passage of the storm was recorded at Covelong.

At a distance of 100 miles north or south of Madras the coastal observatories of

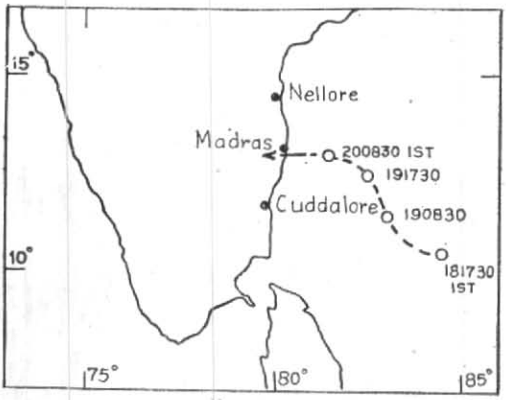

Fig. 1. Track of storm in the Bay of Bengal

Fig. 3. Photograph showing palm trees uprooted in opposing directions

A—Shows trees fallen towards the South with northerly strong winds

B—Shows trees fallen towards the North with southerly wind

Nellore and Cuddalore did not experience any strong winds. The wind speed throughout the day were of the order of 5/10 knots.

3. Speed of movement

It is of particular interest that four meteorological observing stations namely, Madras Harbour, Nungambakkam, Meenambakkam and Tambaram are located close to the track of this storm during its passage inland. Barograph records are available from first three of the above stations and also from Cuddalore which is about 100 miles south of the track. From the hourly values of pressure for the day available at the I.A.F. meteorological station, Tambaram, the pressure tendency curve has been drawn for this station also. The variation of pressure for all these five stations from 0930 to 1800 IST on 20th is shown in Fig. 5. It will be seen that the lowest pressure has been recorded successively at Harbour, Nungambakkam, Meenambakkam, Tambaram and Cuddalore. The minimum epochs at Harbour and Tambaram are at 1400 and 1515 IST respectively. Considering the longitudinal separation between the two stations which is about 12 miles, it can be inferred that the

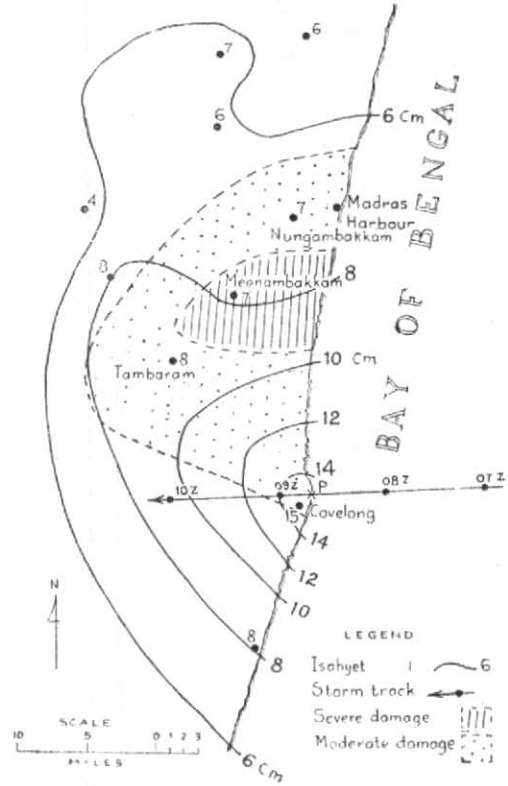

Fig. 2. Coastal belt of Madras showing extent of damage, rainfall and track of the storm

Fig. 4(a)

Fig. 4(b)

Huge trees uprooted by southerly winds

TABLE 1

Station	Mean sea level pressure (mb)	Time (IST)	Percentage deficit
Madras Harbour	1002·3	1400	—0·8
Nungambakkam	1002·0	1410	—0·8
Meenambakkam	998·5	1425	—1·1
Tambaram	998·0	1515	—1·2
Cuddalore	1007·0	1800	—0·3

storm moved inland in a westerly direction with a speed of 9 knots. The lowest pressure has occurred at Cuddalore four hours later than at Madras Harbour, since Cuddalore is to the southwest of Madras and their longitudinal separation is about 40 miles.

4. Central pressure

The lowest pressure at the five stations reduced to mean sea level with percentage departures from normal values are given in Table 1.

It will be seen that the lowest pressure with a maximum pressure departure has occurred at Tambaram located closest to the track of the storm at about 1515 IST.

At 1530 IST the pressure at Meenambakkam was 1·2 mb lower than at Nungambakkam and at Tambaram it was 3·6 mb lower than at Meenambakkam, the corresponding pressure difference being 0·2 and 1·2 mb/mile. Assuming the same rate of pressure fall over the inner storm area between Tambaram and the centre, the pressure at the centre 12 miles south of Tambaram can be estimated as 985 mb. Apparently the pressure fell by 20 mb in the inner storm area of 15 miles radius. Rapid fall of pressure with sudden increase in gradient on approaching the inner storm area from the outskirts has been observed in similar storms in the Bay of Bengal. It may be mentioned that in the case of False Point Cyclone 1885, steepest pressure gradient of 3 mb per mile was observed at a distance of 18 miles in front of the centre (Eliot 1893). An estimate of the central pressure before 1530 IST cannot be obtained since the storm centre was not close to the line joining three stations.

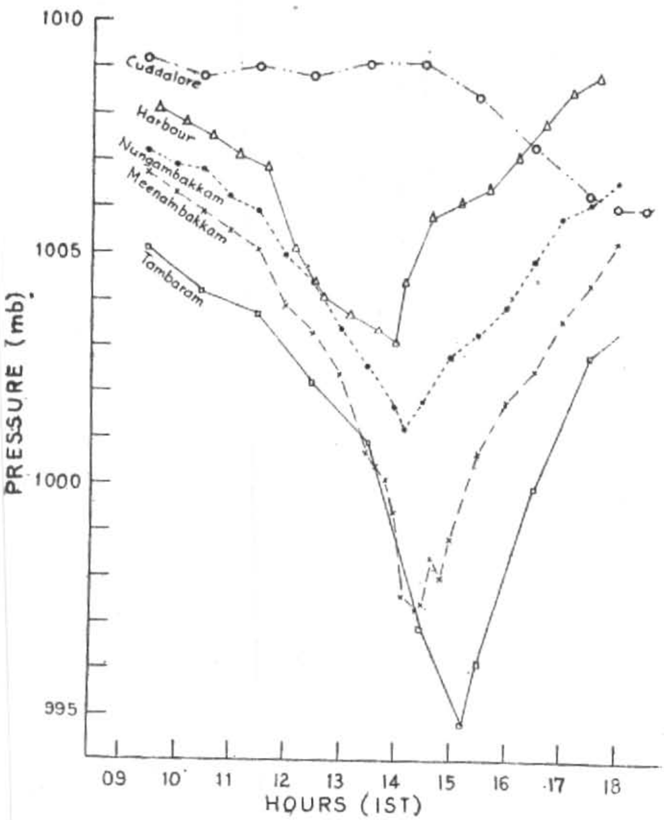

Fig. 5. Variations of pressure observed at the five stations on 20 November 1960

5. Winds and pressure gradient

Fig. 6 shows the mean sea level pressure tendency curves at the four stations together with the surface winds and at the Harbour, Meenambakkam and Tambaram. The inset figures A, B and C show the surface isobars in the central region at 1430, 1500 and 1530 IST when steep pressure gradient was set up and strong winds prevailed over the region. The anemograms of harbour and Meenambakkam for the relevant period are reproduced in Figs 7 and 8.

It will be observed that there was a horizontal pressure gradient of 0·59 mb/mile (distance measured normal to the isobars) between Meenambakkam and Nungambakkam during the period 1430 and 1500 IST when the storm centre was close to these stations. At 1530 IST pressure gradients of the order of 0·51 mb/mile prevailed between Meenambakkam and Tambaram.

6. Computation of gradient winds

The gradient wind equation for cyclonic curvature is

$$\frac{1}{\rho}\frac{dp}{dn} = 2\omega V \sin\phi + \frac{V^2}{r}$$

In the case of the central region of cyclonic storm in the tropical latitudes, values of both r, the radius of curvature and $\sin\phi$ are small compared to the high velocity of winds in the inner storm area. Hence the geostrophic term $2\omega V \sin\phi$ can be neglected and the pressure gradient force equated to the cyclostrophic component. For dp/dn, the radial component

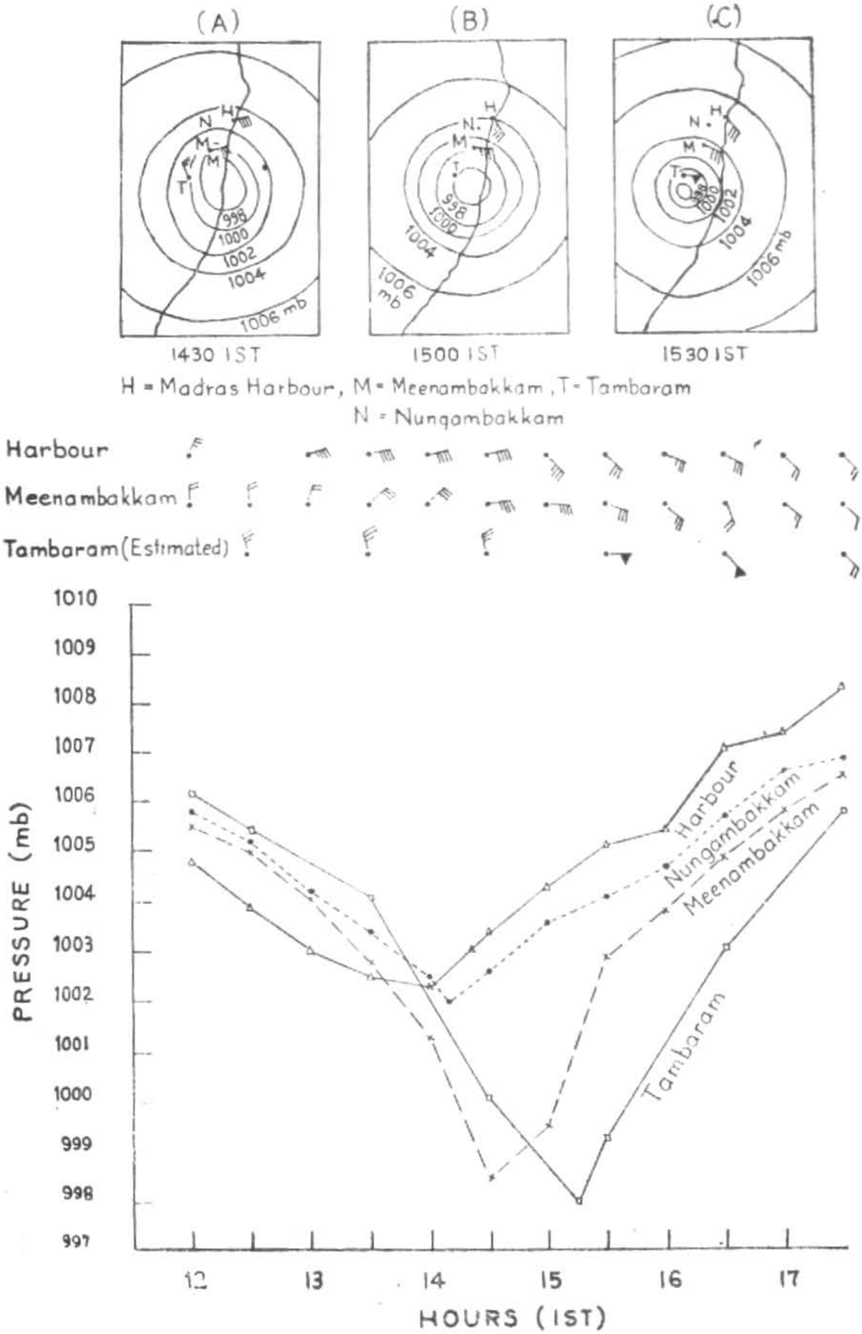

Fig. 6. Variations of pressure reduced to mean sea level and observed winds with insets showing isobars in the inner storm area on 20 November 1960

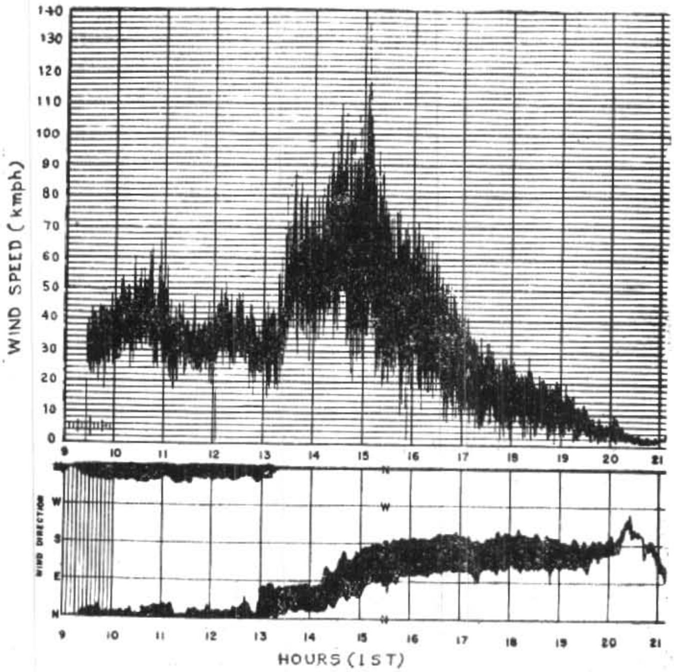

Fig. 7. Anemogram of Madras (Meenambakkam Observatory) on 20 November 1960

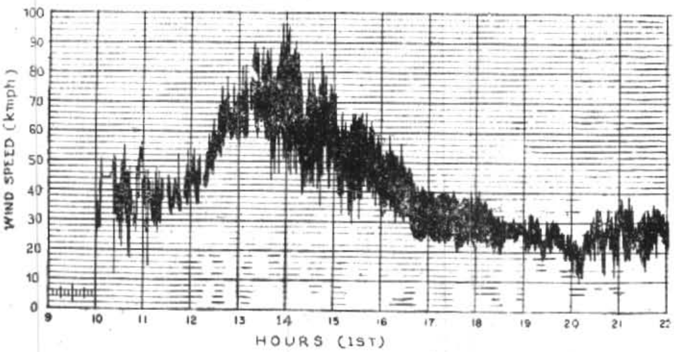

Fig. 8. Anemogram of Madras Harbour on 20 November 1960

of the pressure gradient between different pairs of observing stations is made use of. The isobars are assumed to be circular in the central region and the mean radii of curvature of isobars is taken as the distance of the storm centre from the midpoint of the line joining the two stations.

Table 2 gives the computed winds during period 1300-1530 IST between the following four pairs of stations—

1. Harbour and Nungambakkam
2. Harbour and Meenambakkam
3. Nungambakkam and Meenambakkam
4. Meenambakkam and Tambaram

TABLE 2

Time (IST)	Gradient winds (knots) computed with pressure gradient between				Observed winds (knots)				
	Harbour and Nungambakkam	Harbour and Meenambakkam	Nungambakkam and Meenambakkam	Meenambakkam and Tambaram	Harbour		Meenambakkam		Tambaram mean (estimated only)
					Mean	Gust	Mean	Gust	
1	2	3	4	5	6	7	8	9	10
1300	23	10	..	..	35	41	15	21	
1330	24	6	15	15	38	48	29	43	25
1400	29	18	26		39	52	31	43	
1430	22	46	52	20	32	43	37	57	25
1500	27	52	58		32	41	36	57*	
1530	37	39	34	45	28	36	32	49	50

* 73 knots at 1510 IST

The value of r ranged between 12 and 22 miles. The mean wind speeds observed together with the gust speeds are given in Cols. 6 to 10 of the table.

7. Comparison with observed winds

The observed wind speeds are in general agreement with computed values particularly so during 1430 to 1530 IST when the storm moved inland.

The observed winds at the Harbour are slightly higher than computed winds with pressure gradient values between Harbour and Nungambakkam, but this is not so in the case of observed winds at Meenambakkam. It is just possible that the surface frictional effects were more pronounced in the case of winds observed inland than that at the Harbour along the coast. In either case the gust wind speeds recorded were higher than the computed wind values.

The Harbour anemograph showed a significant minimum of wind speed at 1420 IST recording only 27 knots. This variation is also indicated with the gradient winds between Harbour and Nungambakkam, the minimum occurring at 1430 IST.

At 1510 IST Meenambakkm recorded the highest gust wind speed of 73 knots. This maximum epoch coincides with that of gradient wind speed at 1500 IST in both cases *viz.*, Harbour and Meenambakkam and also Nungambakkam and Meenambakkam.

It may be added that the computation of gradient winds is dependent on the accurate location of the centre of the storm at the various times. The track has been obtained by making use of all available surface wind data from the coastal stations and ships in the region and may be considered to be reasonably accurate.

8. Rainfall

In Fig. 2 the rainfall over Madras city and neighbourhood associated with the storm is indicated. Isohyets of rainfall for 24 hours ending 0830 IST on 21st are drawn. It will be noticed that along the coast, Covelong—the raingauge station situated close to the storm track recorded an exceptionally heavy rainfall of 15 cm. The rainfall was heaviest between 1400 and 1500 IST when the storm moved inland. The rainfall intensity recorded at Meenambakkam and Nungambakkam were 2·0 and 1·3 cm per hour respectively.

9. Upper air features

A plausible explanation for the sudden intensification during the final stages is obtained by a study of the upper flow pattern and the relevant time altitude cross-section. The upper air circulation over southwest Bay and neighbourhood associated with the depression on 18 and 19 November extended upto 3 km only. At Port Blair the winds at 4 km and above had become southeasterly at 1200 GMT of 18th and were so till 00 GMT of the next day after which they backed and became easterly. This shows that a trough had appeared over the south and central Bay of Bengal and was moving westwards. By 1200 GMT of 19th the trough had affected the upper winds over Madras. Weak northerlies prevailed between 5 and 7 km. During next 12 hrs as the trough came closer to Madras along longitude 81°E, the northerly flow became more marked being 35/45 knots between 4 and 7 km (Fig. 9).

During the same period, a deep upper level trough was moving in the higher latitudes. The winds at 5 km and aloft at Jodhpur veered to northwesterly at 00 GMT of 19th while the winds over Allahabad and Calcutta at these levels were predominantly westerly/southwesterly. The veering of the winds at Nagpur subsequently indicated that the trough was moving eastwards and was along longitude 81°E on 20th morning (Figs. 10-13). This juxtaposition of the troughs in the mid and upper troposphere also known as 'inphase superposition' must have been responsible for the rapid intensification of the depression on the afternoon of 20th. Similar cases of deepening of tropical perturbations in the lower levels under pronounced northerly flow in the upper troposphere resulting in large sacle upper air divergences have been studied by a number of workers in tropical meteorology (Rao and Hariharan 1957). In the present case the pronounced northerly flow in the upper levels over Madras on 20th morning can be associated with the axes of easterly trough over southwest Bay and also the westerly trough over Central India along longitude 81°E. The cyclonic circulations in the lower troposphere were more marked as a result of large scale upper air divergence and caused the depression to intensify into a small core cyclone before crossing coast.

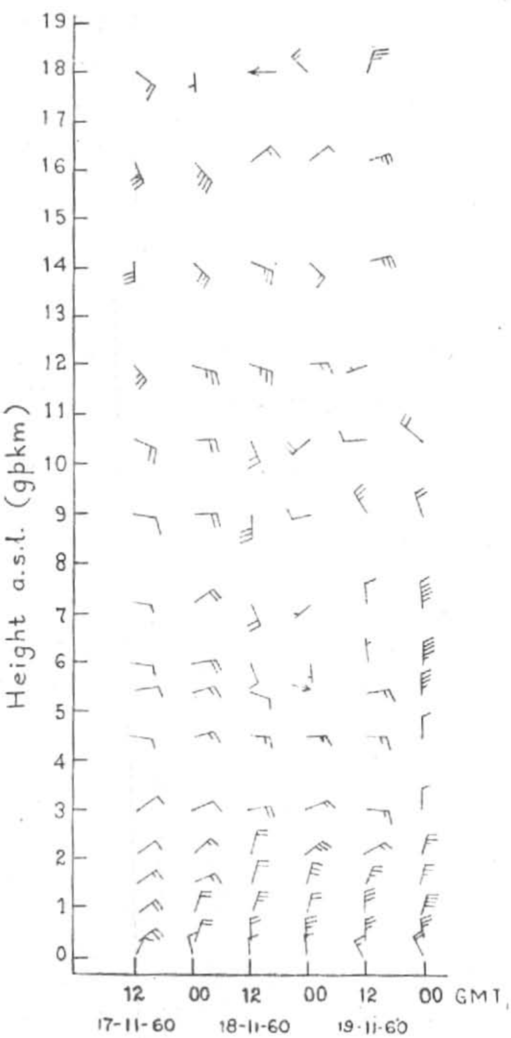

Fig. 9. Time-altitude cross-section over Madras

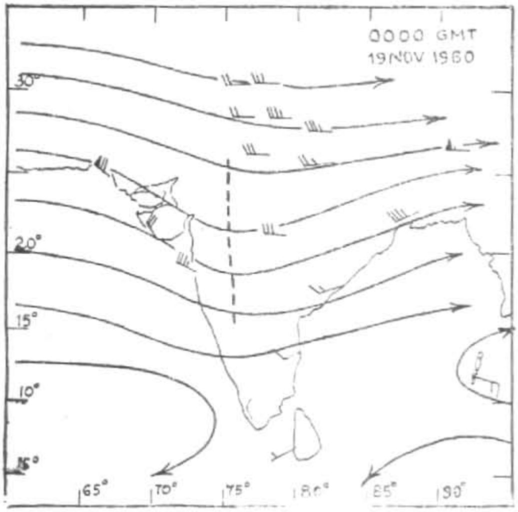

Fig. 10. Winds at 7·2 km

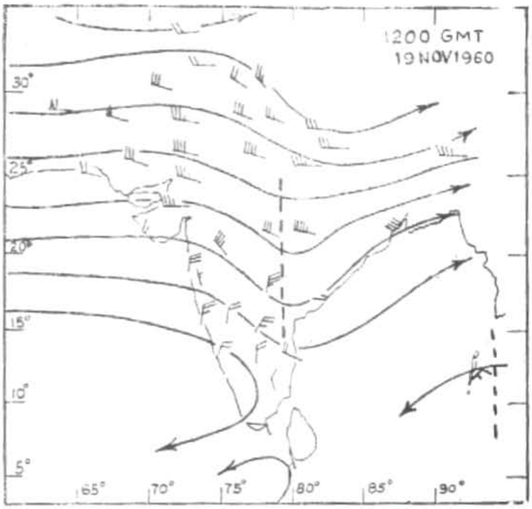

Fig . 11. Winds at 7·2 km

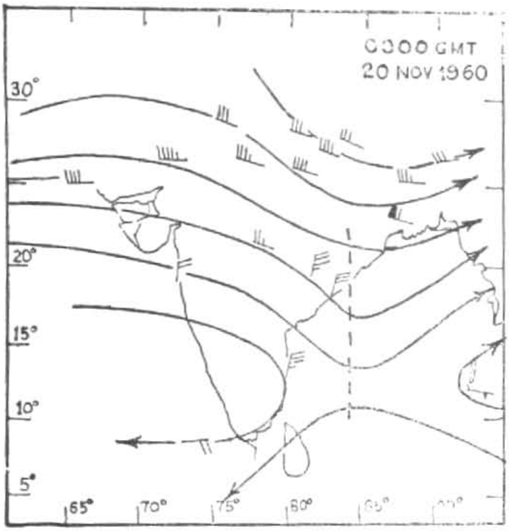

Fig. 12. Winds at 7·2 km at 1200 GMT

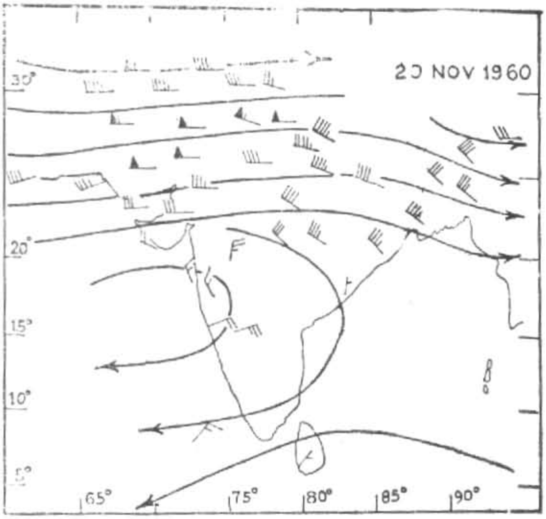

Fig. 13. Winds at 7·2 km

10. Acknowledgement

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REFERENCES

Eliot, J. 1893 *Cyclone Memoirs*, **5**, p. 81

Rao, Y. P. and Hariharan, P. S. 1957 *Indian J. Met. Geophys.*, **8**, 4. pp. 452-454.