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An analysis of the Masulipatam Cyclone of October 1949

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ABSTRACT. The paper gives the results of an analysis of a cyclone in the Bay of Bengal which struck Masulipatam on 28 October 1949. The available surface meteorological observations, upper winds and radiosonde data have been examined with a view to determine the air masses which took part in the formation and maintenance of the cyclone. Three air masses (*Tc*, *Tm* and *Em*) are found to have participated in the development of the cyclone, the interaction of the *Tc* and *Tm* air providing the active up-glide surface of a warm front type. The sequence of rainfall observed along the Orissa -Circars coast provides useful clue in support of the orientation of the warm front. The air masses involved and the frontal structure of this cyclone have been compared with those of a similar cyclone of 1945. In the latter case, two air masses (*Tm* and *Em*) only appear to have taken part at least during the formative stage of the cyclone and even for its maintenance for at least the first few days. Incursion of *Tc* air at a later stage, however, helped the development of a marked convergence zone.

1. Introduction

Although sufficient data have not yet been collected to enable one to have a complete idea of the mechanism of formation and of the structure of tropical cyclones in different regions, there is perhaps no doubt that their development, at least in the initial stages, is associated with convergence of two or more air masses. The facts that the regions of formation of the tropical cylones over most of the ocean areas coincide more or less with the zone where the two trade winds meet, *i.e.*, the intertropical front, and that with the shift of this zone of discontinuity from season to season, the regions of cyclone formation also shift correspondingly, have to be taken as a good evidence in support of such a conclusion. Among the earlier papers dealing with the structure of cyclones in the Bay of Bengal, reference may be made to those by Roy and Roy[1], Ramanathan and Iyer[2], Ramanathan[3], Mal and Desai[4], Basu and Desai[5] and Normand[6].

Experience has shown that most of the cyclones and depressions in the Bay of Bengal do not exhibit well defined warm or cold fronts. In fact, existence of such fronts in the revolving storms of the tropics is perhaps itself a controversial point. The cyclone of October 1949 in the Bay of Bengal, however, appears to be characterised by an active warm front and, as such, an analysis of this storm was undertaken with a view to determine its frontal structure and the air masses involved therein. It is known that the interaction between the intertropical front with another front, such as a quasi-stationary temperate front, produces a 'Triple point', which, in the presence of a wave disturbance along the intertropical front, would greatly stimulate frontogenesis resulting in the development of the disturbance into a violent cyclone (*vide* Chapter 8 of *Tropical and Equitorial Meteorology* by Garbell). Deppermann found in a study of 18 cyclones originating east of the Philippines that one third of them were linked up with such a Triple point, (*vide Dynamic Meteorology* by Haurwitz pp. 335). Frontogenesis of this type, by the interaction of three air masses, is noticed in the development of the October cyclone of 1949 under review.

Malurkar and Pisharoty[7] suggested that presence of three air masses is a necessary condition for the development of a tropical cyclone. Although the October cyclone of 1949 under review corroborates this suggestion, the existence of three air masses does not seem to be a necessary condition for the development of tropical cyclones. With favourable contrasts in the characteristics of the two air masses meeting at the intertropical front, a wave along the front can also develop into a depression under the same mechanism as in the case of extra-tropical depressions. The authors have come across instances where cyclones and depressions formed in the Bay of Bengal on the inter-tropical front by the interaction of two air masses only without the advent of any third air mass. The October cyclone of 1945 in the Bay of Bengal has been cited in this paper as an illustration of this. Comparison between these two cyclones reveal very interesting features. While the one in 1949 involved three air masses and was characterised by an active warm front, that in 1945 was formed by two air masses only, even though both the cyclones formed over the same region, in the same season, and moved along similar tracks.

Detailed studies of the structure of individual cyclones in the Indian areas with the help of upper air soundings now available have to be made before any generalised conclusions can be drawn in regard to the mechanism and structure of cyclones in this area. Before any theory of the formation of tropical storms is propounded, it would be necessary to make an extensive fact-finding study of the structures of a number of such storms in the early stage of their development.

The cyclones of the post-monsoon season in the Bay of Bengal are comparatively more violent and destructive in nature. A study of the structure of one such severe cyclone which struck the east coast of the Indian peninsula near Masulipatam on 28 October 1949, forms the subject of the present paper.

2. A short history of the Cyclone

For a few days prior to 22 October 1949, a shallow low pressure area which is a characteristic of the season, was noticed to persist over the Andaman Sea, at times becoming diffuse and also fluctuating in its day to day position. On the 22nd morning, conditions became unsettled over the South Andaman Sea and, by the same evening, the situation developed into a depression, which was centred about 200 miles southsoutheast of Port Blair. Moving northwestwards, the depression gradually intensified and, by the 26th morning, it concentrated into a cyclone about 450 miles southeast of Masulipatam. On the same morning, ships about 2 to 3 hundred miles away from the cyclone centre reported 45-50 knots wind, heavy rain squalls and very high seas. The cyclone was then declared to be severe. On the 27th morning, the severe cyclone was centred about 100 miles eastsoutheast of Masulipatam. Continuing to move slowly northwestwards, it struck the coast just north of Masulipatam at about 0130 IST of 28th, near about the high tide time. After moving inland, the cyclone weakened and recurved northeastwards through north. A track of the cyclone is given in Fig. 1.

The severity of the cyclone could be judged from the lowest pressure (976·9 mb) recorded by Masulipatam, which was about 30 mb below its normal value. The barogram of Masulipatam is reproduced in Fig. 2. Reports received from various sources from the regions over which the centre of the cyclone passed give definite indications of a pronounced calm centre—the 'eye' of the storm. The following extract from the report of observations made at Eluru (about 40 miles north-northwest of Masulipatam) by one of the officers of the India Meteorological Department is significant in this connection.

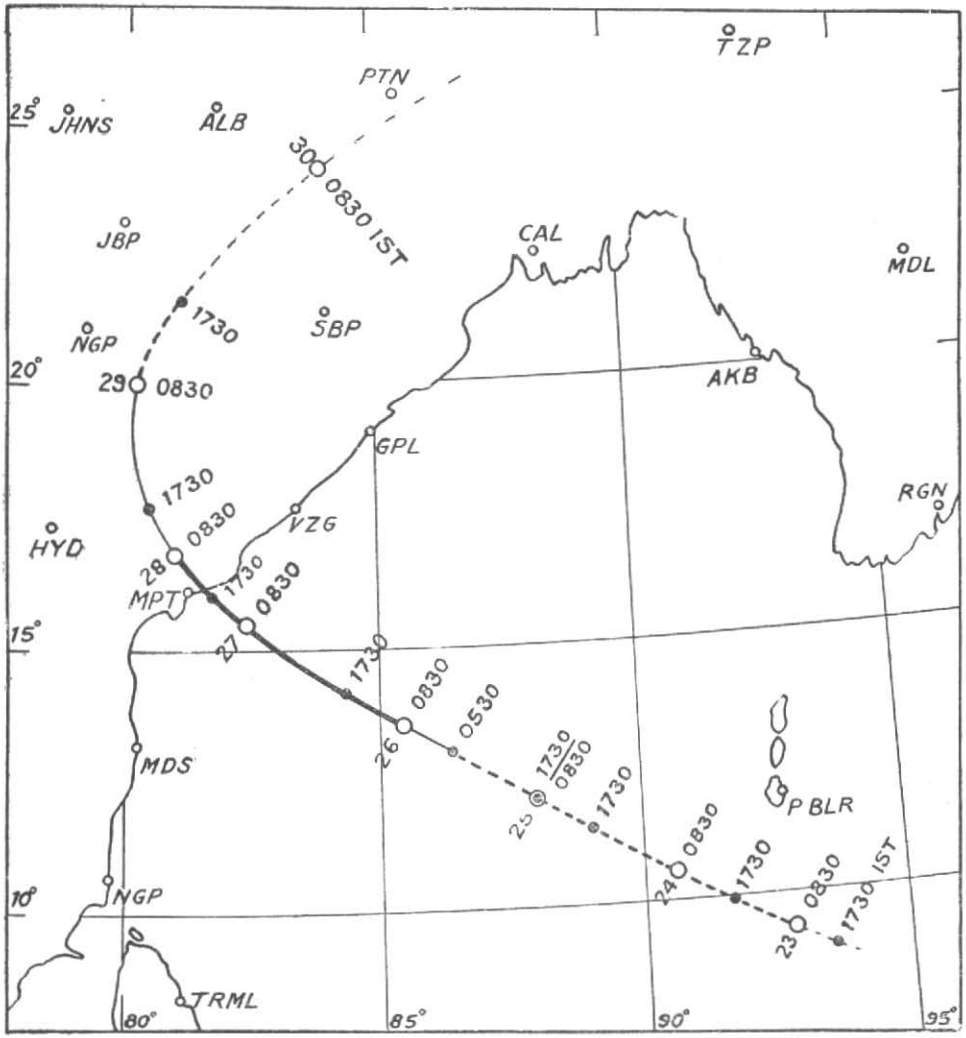
"....The direction of the wind continued northwest. The worst phase of the storm was experienced between midnight and 3 A.M. (28th). The wind speed during the period might have been easily of the order of 80 to 90 mph. The wind speed subsided after 4 A.M. and by 6 A.M. had considerably abated and was only a few mph. By 7 A.M. the winds had strengthened again, direction backing to WSW. By 8 A.M., it was again blowing gales and this continued with unabated fury till about 2 P.M. The maximum wind speed during this period might have been of the order of 50 to 60 mph. Winds subsided by 4 P.M....."

A very rough estimate of the dimension of 'calm' centre of the cyclone can be made from the above wind observations. It would appear that the duration of the calm condition at Eluru was of the order of one hour (from 6 A.M. to 7 A.M.). Judging from the rate of movement of the storm at this time (*i.e.*, from the time of the storm crossing the coast near Masulipatam at 0130 IST of 28th and its position at 0830 IST on the same day about 70 miles northwest of Masulipatam) the diameter of the calm region works out to be of the order of ten miles.

An important feature of the cyclone was a huge storm wave caused by the high on-shore winds which swept the coastal parts of East and West Godavari districts. Masulipatam and Kakinada experienced very high winds, reaching a maximum speed of about 85 mph. The tidal wave rose to a height of 10 to 15 ft and inundated the coastal area to a distance of 5 to 10 miles. The heavy downpour of rain caused by the cyclone (Masulipatam recording 20 inches of rain within a period of 12 hours) resulted in the flooding of rivers and irrigation channels. About 800 human lives perished and extensive damages to property and crops were caused in the East Godavari, West Godavari, Kistna and Guntur districts as a result of this cyclone.

3. Initial synoptic situation and air masses taking part in the cyclogenesis

One noticeable feature of the synoptic situation, as shown on the extended chart (Fig. 3), during the formative stage of the depression in the Bay of Bengal



---Depression ---Deep Depression —Cyclone —Severe Cyclone

O 0830 IST • Other hours

Fig. 1. Track of the Masulipatam Cyclone

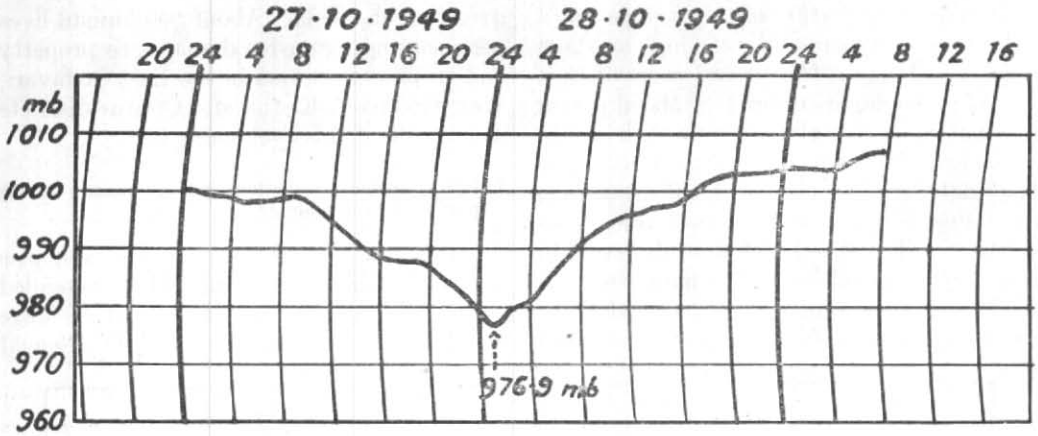


Fig. 2. Masulipatam barogram

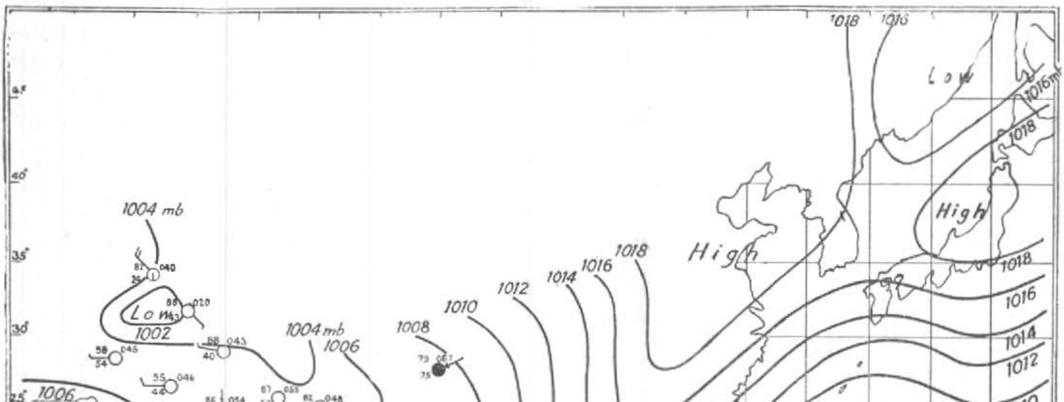


Fig. 3. Weather map at 1730 IST on 20 October 1949

was the simultaneous existence of two other storms in the southwestern North Pacific space, one to the northeast of the Philippines and the other near Guam. The synoptic chart covering these areas at 1730 IST on 20 October 1949, *i.e.*, two days prior to the formation of the depression in the Bay of Bengal, is reproduced under Fig. 3. The tracks of these tropical cyclones giving dates and their corresponding positions based on Bangkok and Singapore broadcasts, are shown in Fig. 4. It is significant that the depression in the Bay of Bengal began to form on 22 October 1949, after the storm to the northeast of the Philippines which moved into China Sea had weakened off Hongkong. In fact, the latter got filled up by the next morning. It seems that so long as the Typhoon to the northeast of Philippines was active, the cyclonic drift of the easterly maritime air in the field of the Typhoon was so strong that these maritime easterlies could not reach the Tenasserim coast in sufficient strength. With the weakening of the Typhoon, the incursion of these easterlies (*Tm*) into Andaman Sea considerably freshened and was followed by cyclogenesis. The other Typhoon near Guam moved westnorthwest towards northeast of the Philippines, recurved on the 25th and gradually moved away northeastwards.

On 18 October, the ITF extended from a trough in the east central Arabian Sea to near about Tavoy via Masulipatam. The wind systems upto 10,000 ft level over the Bay of Bengal were light, and the ITF was rather diffuse. On the 19th morning, the portion of the ITF over the Andaman Sea shifted southwards and was running from north of Port Blair to south of Victoria Point. This was indicated by the fresh incursion of easterlies (*Tm*) over Tenasserim, *vide*, 5000 ft upper wind chart in Figs. 5 (a) and (b). This resulted in the development of a shallow

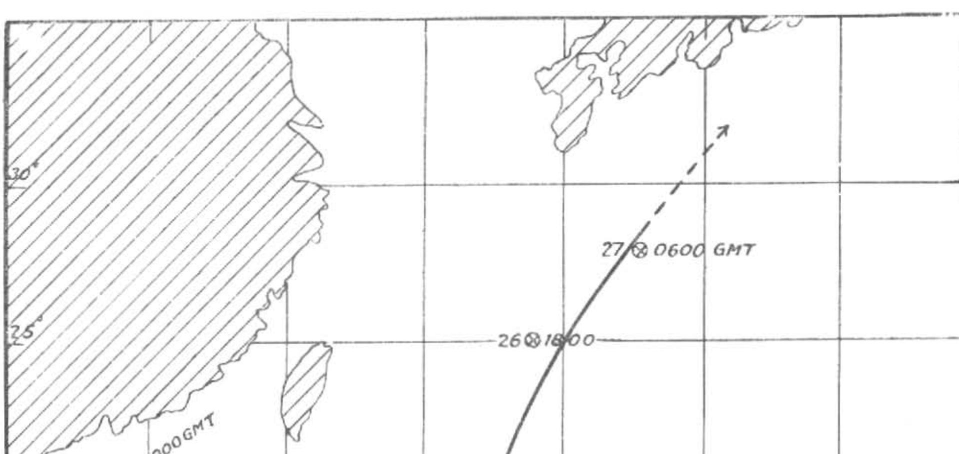


Fig. 4

trough over South Andaman Sea. A heavy rainfall of 4 inches at Victoria Point on the 19th, *i.e.*, following the incursion of the easterly current, is significant. By the evening of the 21st, easterly winds appeared over Port Blair indicating further shift of the ITF to south of Port Blair. Freshening of the easterlies (*Tm*) along the Tenasserim coast and also of the westerlies (*Em*) over Ceylon and Travancore-Cochin by the 21st evening indicated accentuation of the trough over South Andaman Sea. Port Blair started raining from 2230 IST of 21st, and by the next morning recorded a heavy fall of 4 inches.

With the approach of a western disturbance towards northwest India and its movement eastwards across East Punjab on the 21st and 22nd, the stagnant continental air (*Tc*) around the seasonal anti-cyclone was being pushed eastwards ahead of the western disturbance. The spreading of the *Tc* air eastwards is very clearly seen on the successive upper wind charts for the periods 18th to 23rd. Winds at 2000 and 5000 ft on those days are reproduced in Figs 5 (a) and (b). It will be seen on these charts for 19th and 20th that an anticyclone existed over North Bay and it presumably comprised mostly of the stagnant monsoon or 'old monsoon' air. There is no doubt that the western disturbance in this case did not draw any *Tc* air from northeast India. Later, as the disturbance moved away northeast to eastwards, a further spreading of *NPc* occurred in the rear of the disturbance which helped the spreading of the *Tc* air over the greater part of India and eventually over the Bay of Bengal. With the spreading of *Tc* air eastwards, the anti-cyclonic cell over the North Bay was also pushed eastwards and became less marked. By the 21st, the *Tc* air extended into North Bay. This is also supported by the fact that following several days of local thunder-rain over northeast India, a spell of dry weather commenced there on the 21st. By the 22nd, the *Tc* air apparently approached the area of unsettled conditions in the South Andaman Sea and participated in the cyclogenesis there. The radiosonde ascents at Allahabad and Calcutta during the period from 17th to 22nd show remarkably well the gradual eastward progress of the *Tc* air, *vide*, Fig. 6 showing isopleths of saturation potential temperatures over Allahabad and Calcutta during the period. The saturation potential temperatures in the lower levels fell sharply over Allahabad on the 19th and over Calcutta from 19th onwards reaching minimum on the 22nd. Incursion of cooler and drier air first over Allahabad and later over Calcutta and the actual upper wind pattern indicate that the *Tc* air from northwest India which was being pushed eastwards reached Calcutta on 20th or 21st. Northwesterly to northeasterly upper winds and appreciable fall of dew-points along the Arakan coast on the 21st suggest that the incursion of *Tc* air extended southwards towards Andaman Sea. It is possible that this *Tc* air might have eventually got mixed with the *Tc* air from over China round the Siberian anti-cyclone, but sufficient data are not available to confirm or disprove this.

Thus, the air masses taking part in the cyclogenesis on 22 October over the South Andaman Sea were (1) the equatorial maritime or the monsoon air (*Em*), (2) the tropical maritime (*Tm*), *i.e.*, the easterlies from the Pacific region and (3) tropical continental (*Tc*). Of these, the *Em* and *Tm* associated with the ITF existed from the beginning. The third air mass, namely *Tc* joined later and provided the 'Triple point' which appears to favour the development of cyclonic storms of typhoon intensity. It is, however, difficult to say with certainty whether *Tc* air had reached the area before the depression was formed, or the depression was initially formed by the interaction of the *Em* and *Tm* only, and the incursion of *Tc* air thereafter was responsible for quick intensification of the disturbance. The probable distribution of the air masses on the 22nd is indicated in Fig. 7. In any case, the incursion of the *Tc* air was responsible for the formation of the active warm front of the cyclone, details of which have been dealt with in the subsequent section.

4. The Frontal Structure

The characteristics of the air masses in India during different seasons have been discussed by Roy.[8] During the post-monsoon

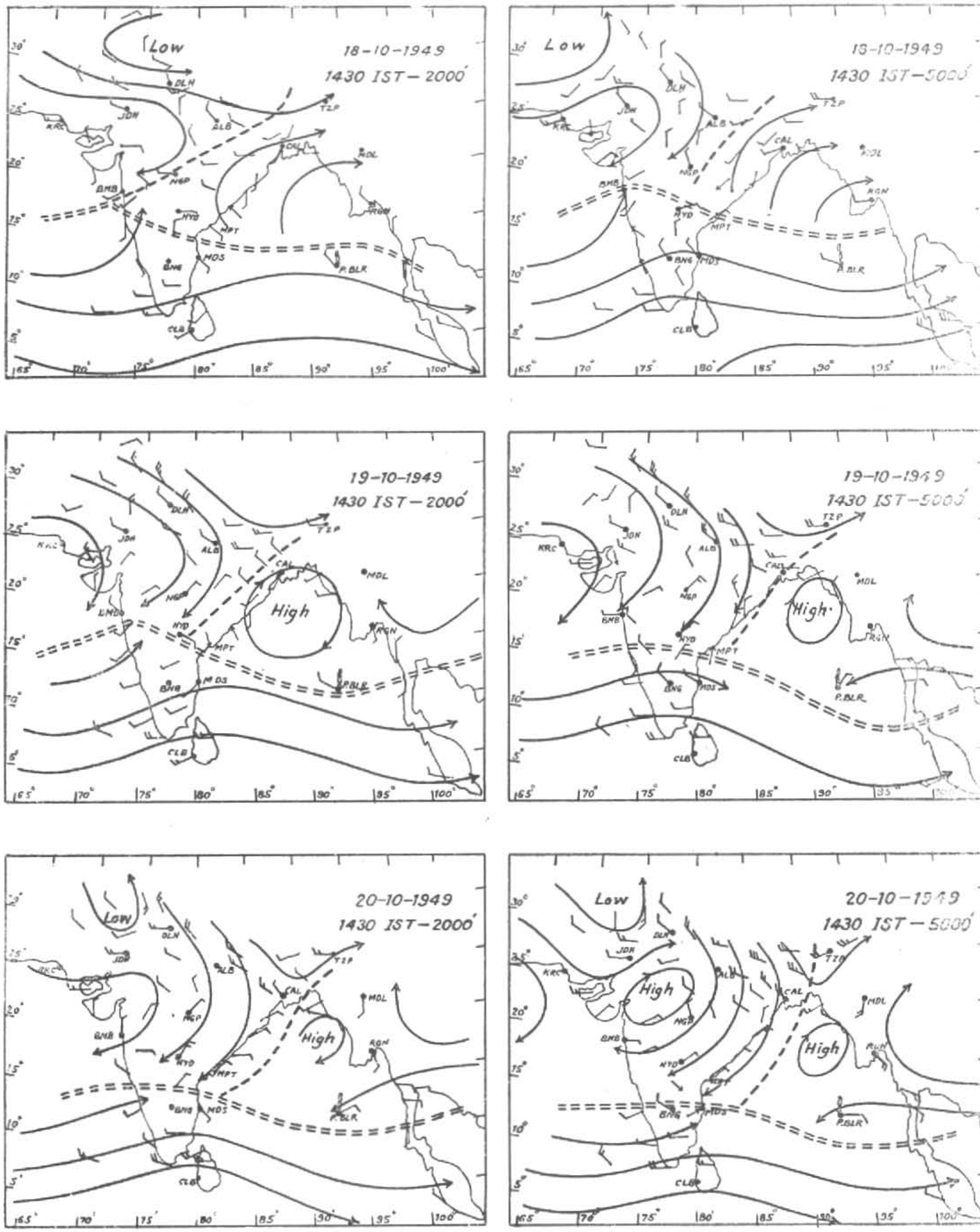


Fig. 5 (a)

season (October-November), *Tm* air is warmer than *Em* in the lower levels upto 2 km. When the depression formed in the South Andaman Sea, the ITF there, *i.e.*, the *Em-Tm* front eventually acted as a cold front, though the contrast in virtual temperatures might be small. In the absence of radiosonde data over Burma stations, it is not possible to get the actual temperature contrasts prevailing at the various levels over the region. The minimum temperatures were not reported by the observatories in

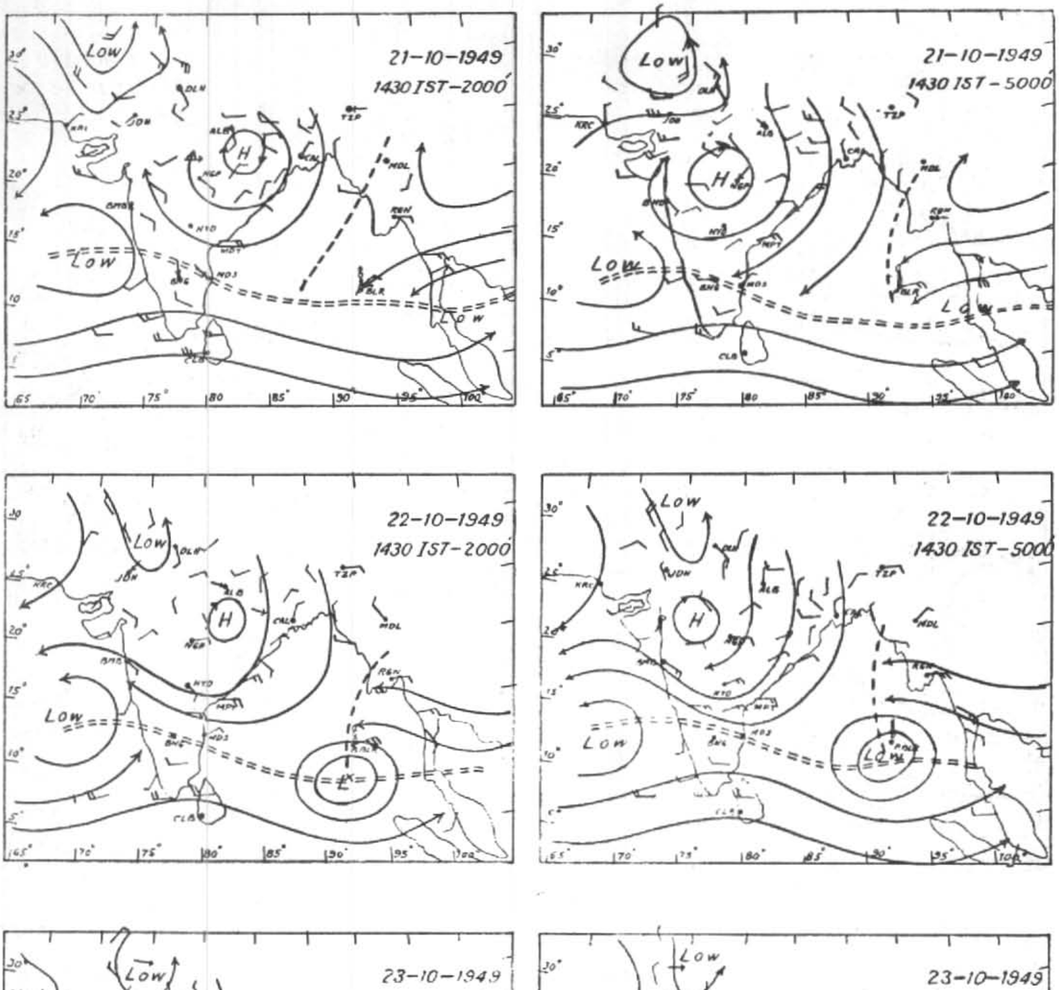


Fig. 5 (b)

Tenasserim during the period in question, and as such it has not been possible to see whether any appreciable rise in minimum temperatures corroborated the incursion of warm maritime (Tm) air. The following consideration, however, throws some light on this point—

The radiosonde ascents over Vizagapatam from 23rd to 25th (data not available for 26th and 27th) have been scrutinised. The rise

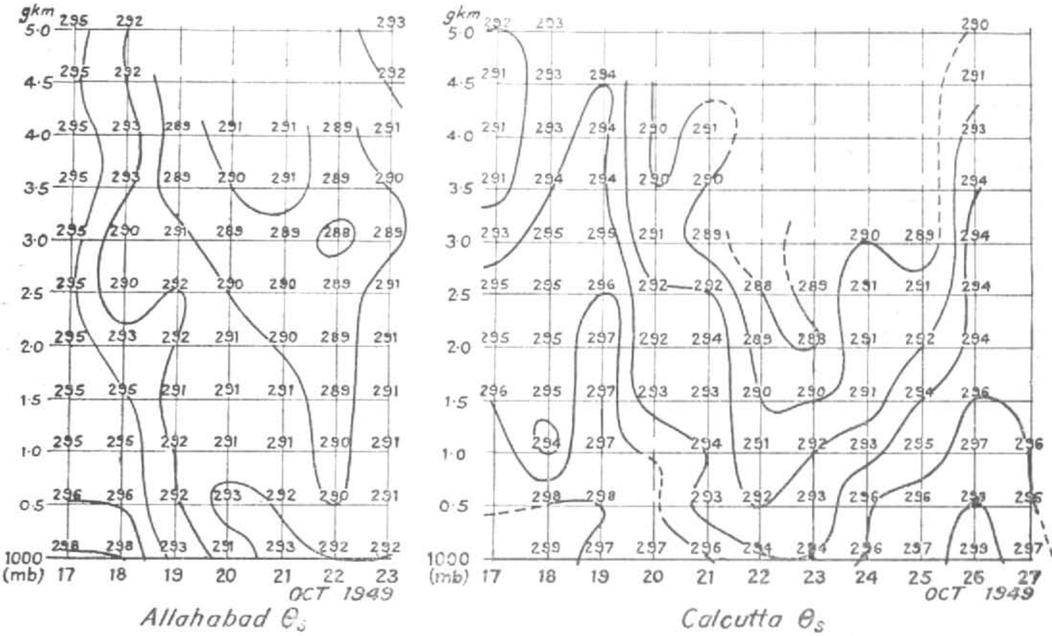


Fig 6

of saturation potential temperature and temperature above 1 km on the 25th compared to those on 24th (*vide* Figs. 8 a and 8 b) suggests incursion of *Tm* air over Vizagapatam on 25th at least above 1 km. Comparing the actual temperatures over Vizagapatam on 25th above 1 km (representing *Tm*) with those at corresponding levels over Trivandrum on the same day (representing *Em*), the former, *i.e.*, *Tm* is found to be 2 to 5 degrees warmer level for level than *Em*. The corresponding values of saturation potential temperatures are, however, nearly the same.

The active warm front of the cyclone developed between the *Tm* and *Tc* air. *Tm* is warmer and much more moist while *Tc* is cooler and drier. The contrast in virtual temperature between *Tm* and *Tc* should, therefore, be considerable. The sequence of cloud kinds and rain along the Orissa-Circars coast was characteristic of the approaching warm front.

The isobaric charts for the periods 22nd to 28th (0830 IST charts for all the days and 1730 IST for 26th and 27th) showing probable positions of the fronts and the distribution of clouds and rainfall are reproduced in Figs. 9 (a) and (b). The approximate locations of the fronts have been fixed by taking into consideration wind discontinuities at the lower levels upto 3000 ft and also the distribution of weather, specially at later stage, when the disturbance approached the coast. The position of the warm front (*Tm-Tc*) at the initial stage of the depression, *i.e.*, on the 22nd is noticeable on the lower level upper wind charts, the winds at 1000 ft on 22nd afternoon being particularly significant. The cloud sequence and the commencement of significant continuous rain along the Orissa-north Circars coast provide satisfactory clue for location of the active warm front at later stages, *viz.*, on 26th or 27th. In the absence of sufficient data over the Bay, the intermediate positions of the warm front cannot be precisely located but the positions have been roughly indicated with reference to the storm centre keeping in view the initial and later positions of the front as stated above, and also by taking into account few available observations from ships.

The only available ships' logs from *S. S. Chanda* and *Jalamatsya* were scrutinised. It is seen from the hourly observations recorded by *S.S. Jalamatsya* that throughout 26 October 1949, when the ship's position

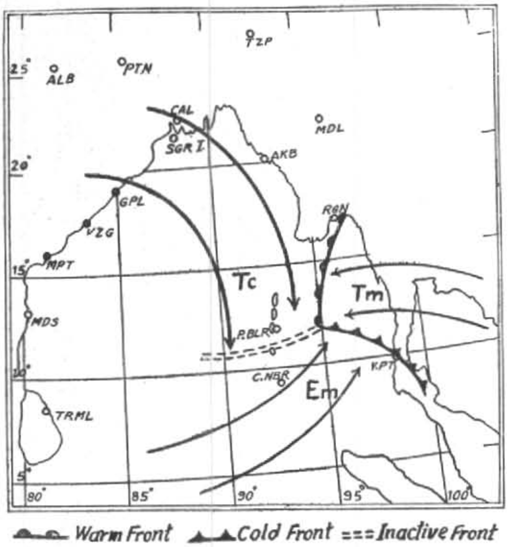


Fig. 7

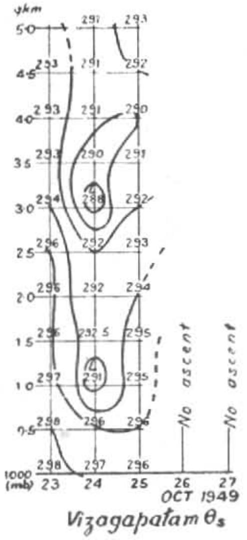


Fig. 8 (a)

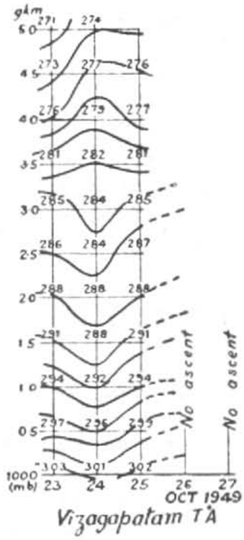


Fig 8 (b)

was about 200 to 300 miles south to southwest of the storm centre, the ship experienced continuous gales and *rough* to *high* seas. But both the ships being in the south sector of the storm throughout the period, they did not come in the path of the active warm front and as such logs of these ships do not throw any light on the frontal structure of the cyclone.

It is noteworthy that with the approach of the warm front, the first spell of heavy rain commenced earlier along the Orissa coast by the 26th evening, Puri and Gopalpur recording 6 inches and 4 inches of rain respectively by 0830 IST of 27th. Calingapatam recorded 3 inches on the same morning, whereas the rainfall amounts for the same period gradually decreased southwards from Vizagapatam to Masulipatam. Heavy rain occurred at Kakinada and Masulipatam after 1730 IST on 27th, rainfall recorded at these stations by 0830 IST on 28th being 4 and 20 inches respectively. Although the inner core of the cyclone would in all probability be a frontless eddy and the very heavy rain at Masulipatam may not be attributable purely to frontal effect, the observed belt of heavy rain along the coast, as stated above, provides justification for placing the active warm front in a more or less north-south orientation, with the northern end of the front than its southern end, nearer to the coast as shown on the charts for the 26th. Another important feature in the rainfall distribution was that a fresh spell of heavy rain occurred along Orissa-north Circars coast on the 27th night. This seems to be associated with the onset of the monsoon current (*Em*) on the coast after occlusion of the warm (*Tm*) sector.

The position of the cold front between *Em* and *Tm* air in the initial stages has been located as part of the ITF on the basis of the Port Blair and Tenasserim observations. The easterly winds at Port Blair on the 24th suggest the position of this front to the south of Port Blair, whereas southerly 40 knots winds at Port Blair at 0830 IST of 25th indicate shift of the front to the north of Port Blair by that day. The radiosonde ascents at Calcutta showed increase of temperature upto 10,000 ft from 24th to 26th, possibly due to incursion of *Tm* air. It is also noticed that from 26th to 27th, there was appreciable fall in temperatures upto 2 km over Calcutta which may be due to the approach of *Em* air or the cold front. In the absence of sufficient upper air data and ships' observations, the available data, together with the above considerations, have been utilised to indicate the approximate positions of the cold front.

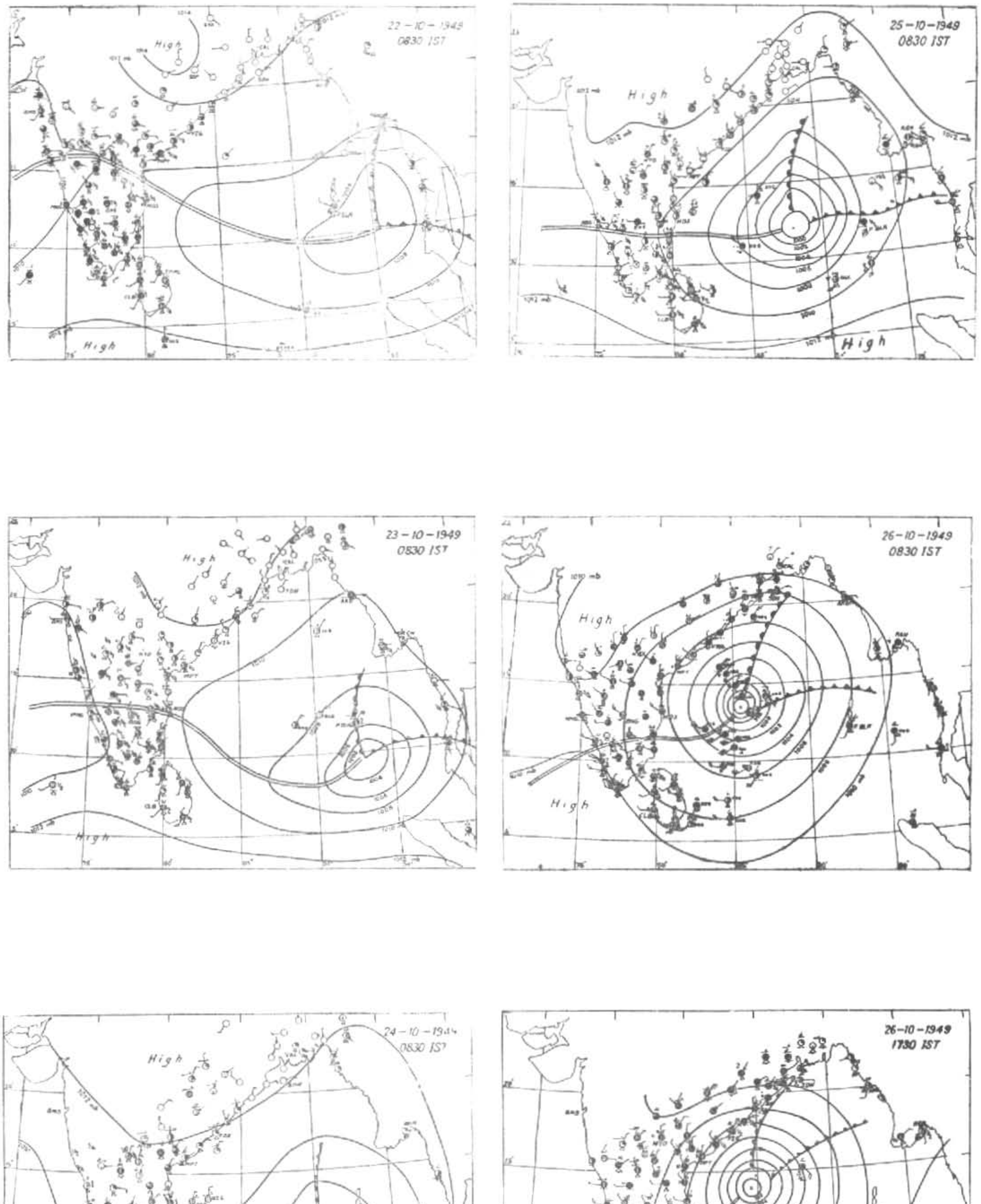


Fig. 9 (a) Isobaric Charts

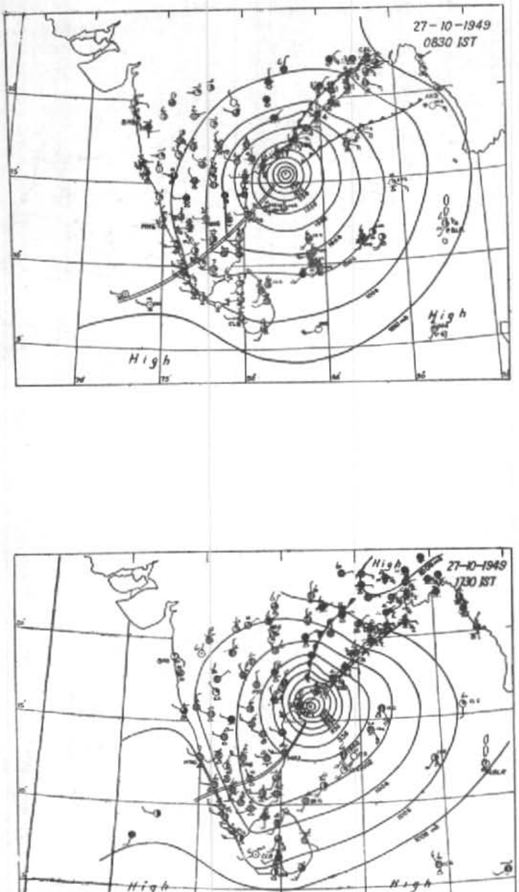


Fig. 9 (b) Isobaric Charts

The discontinuity between *Tc* and *Em* (ITF) across the peninsula and up to the storm centre could be located without difficulty on the basis of the surface data and upper wind discontinuities in the lower levels (1000 and 2000 ft). This discontinuity has been rather inactive over the peninsula, on account of insufficient thickness of the monsoon air.

5. Comparison with the structure of a similar cyclone of October, 1945

The structure of another similar cyclone which developed in the Southeast Bay of Bengal in October 1945 provides an interesting comparison with the structure of Masulipatam cyclone under review. It is noteworthy that both these cyclones of 1945 and 1949 formed in October in the same area, followed a similar path and struck the coast almost at the same place. But contrary to the structure of the Masulipatam cyclone of 1949 where incursion of *Tc* air took place right from the early depression stage providing active warm front with the *Tm* air, it is seen that in the case of the cyclone of October 1945, it not only formed initially by the interaction of only two air masses (*Tm* and *Em*), but that incursion of *Tc* air from the northwest into the Bay was conspicuously absent throughout the period of its development and movement. In fact, *Tc* air from west remained confined in an anticyclone over Gujarat and Kathiawar. The upper air charts clearly illustrate that the cyclone of 1945 formed and was maintained, at least for a few days, by two air masses only. To facilitate comparative study, the upper winds at 3000 ft corresponding to different stages of the disturbance, *viz.*, (*a*) initial depression, (*b*) cyclone and (*c*) crossing the coast, have been reproduced for both the cyclones of 1945 and 1949 side by side in Fig. 10. Although both the cyclones developed in the second half of October and moving northwestwards both struck the coast near about the same place, circulation of upper winds and distribution of weather are much different. The following contrasts are noteworthy—

(1) In the case of the October cyclone of 1945, deep easterlies (*Tm*) prevailed in the northern sector of the disturbance extending inland across Orissa-north Circars coast.

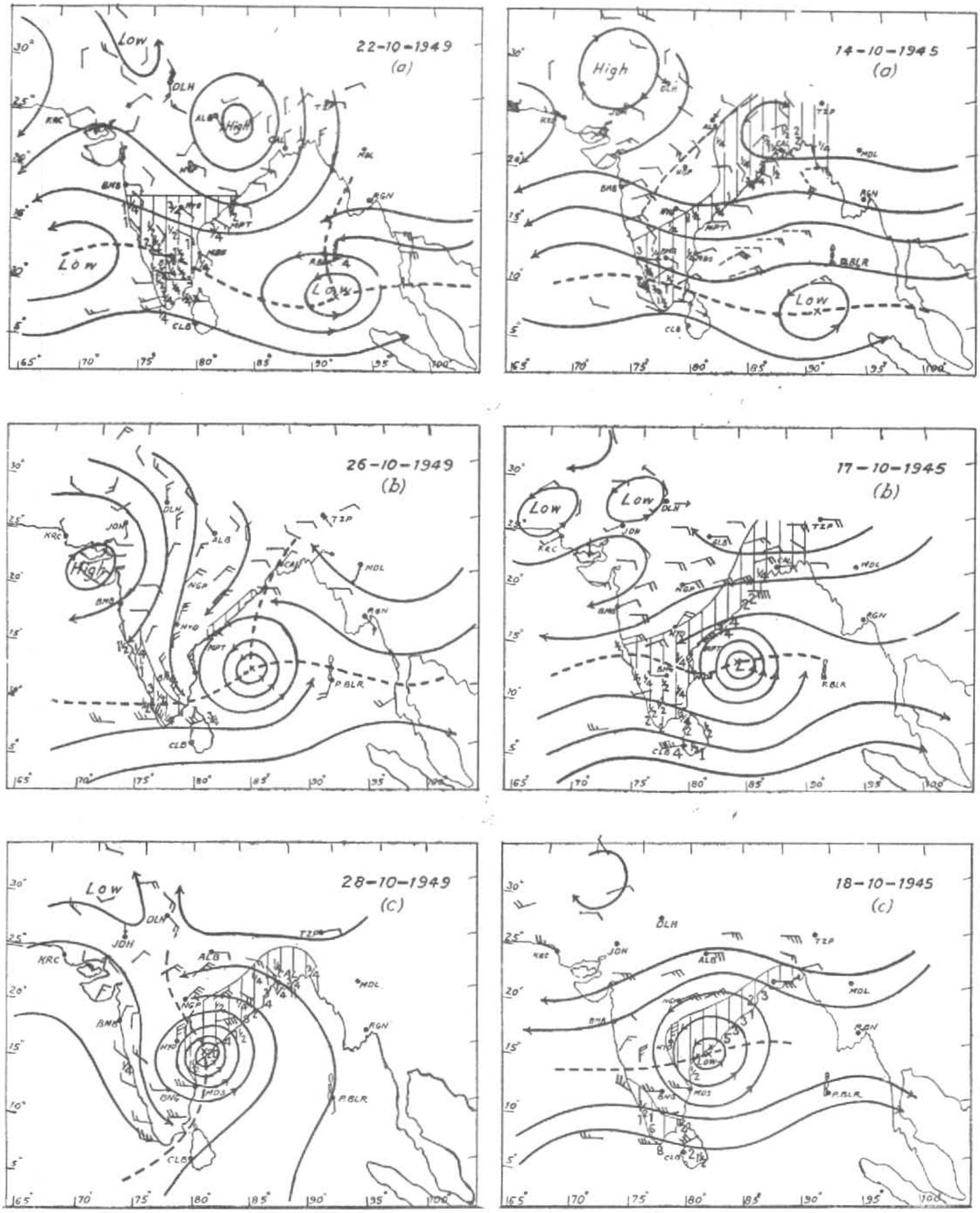


Fig. 10. Morning upper winds at 3000 ft during the Masulipatam cyclone of October 1949 and the Kakinada cyclone of October 1945

Notes—

1. (a) Depression stage (b) Cyclone stage (c) Crossing coast
2. Areas of precipitation are hatched by vertical lines and actual rainfall of ¼″ or more for past 24 hours are marked on the charts
3. In chart (a) on 14-10-1945 Recmets (1,000-2,000 ft) are plotted over Bay in broken lines
4. In chart (c) on 18-10-1945 rainfall amounts of Masulipatam and Kakinada have not been marked as the raingauges were submerged

This was responsible for the persistent local to widespread rain along the east coast from 12th, *i.e.*, prior to formation of the depression whereas in the case of 1949 cyclone, the incursion of *Tc* kept the weather dry until the cyclone came sufficiently near the coast.

(2) While the cyclone of October 1949 was characterised by the existence of an active warm front, causing corresponding sequence of clouds and weather along the coast, a regular sequence of weather as is normally associated with a typical warm front of temperate latitudes was absent in the case of the 1945 cyclone.

(3) The cyclone of 1945 caused very heavy rain in Travancore-Cochin (Trivandrum and Alleppy recording 8 and 6 inches of rain respectively on 18 October 1945) when the cyclone approached the east coast; but the cyclone of 1949 caused no heavy rain in Travancore-Cochin and in fact there was very little rain in Travancore-Cochin during 26th-28th. It is considered that in the case of the 1949 cyclone, the spreading of the *Tc* current southwards across the peninsula opposed incursion of monsoon air in thick layer and thus prevented heavy rain along the west coast; whereas in the case of 1945 cyclone the absence of the northerly current (*Tc*) across the peninsula permitted strengthening of the monsoon current (*Em*) over Travancore-Cochin when the cyclone came close to the east coast.

The cyclone of October 1945 caused widespread heavy rain and strong wind along north Circars-Orissa coast on the 17th and 18th when the cyclone was within 300 miles of the coast. These concentrated falls of rain and the corresponding upper winds over the region give indication of the existence of a marked convergence zone. The upper winds over northeast India and Burma and the decrease of weather over northeast India suggests possibility of incursion of *Tc* air from China round the Siberian anti-cyclone, which apparently provided the convergence zone along the coast with the *Em* and *Tm* air around the Bay cyclone. In this connection the radiosonde ascents at Lalmanirhat, Chittagong, Barrackpore (Calcutta) and Cuttack during the period 11 to 16 October 1945 have been examined and it is found that in each case θ_s falls appreciably from 14th onwards at all levels except the lower levels over Cuttack. This supports the incursion of drier northeast to easterly air (*Tc*) across northeast India which perhaps accounts for the pronounced convergence zone noticed on the 17th along Orissa-north Circars coast.

6. Conclusion

It is found that three air masses (*Tc*, *Tm* and *Em*) were involved in the formation and maintenance of the Bay cyclone of October 1949 and that the cyclone was characterised by a well marked warm front formed by the interaction of *Tc* and *Tm* air. The existence of all the three air masses is, however, not considered to be a necessary condition for development of all tropical cyclones because interaction of only two air masses of different characteristics is quite sufficient for cyclogenesis as in the case of extra-tropical depressions. The cyclone of October 1945 discussed in the paper shows an illustration where a cyclone was formed and maintained at least for the first few days by only two air masses.

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