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Winds at Tiruchirapalli airfield and neighbourhood

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ABSTRACT. An examination of the hourly observations made at the Tiruchirapalli airfield during the years 1945-46 and those made at the Tiruchirapalli cantonment during May 1943 to November 1944 has been made and discussed in this note. It has been found that the variation of wind during the course of the day as well as during the different seasons are well marked. The diurnal variation has been subjected to harmonic analysis and the characteristic features in the different seasons have been discussed. The predominant directions of wind during the different seasons, as well as the frequency of winds from different directions have also been given. A preliminary examination in regard to the incursion of sea breeze at Tiruchirapalli has also been made.

1. Introduction

Local variation of wind in the neighbourhood of Tiruchirapalli town had received notice as early as the second half of the last century as is evident from the following extracts (Nicholson 1899, King and Foote 1865):

> "In the month of June, July and August, the effects of the Palghat Gap are conspicuous; through the funnel shaped opening some 16 miles broad, the cool southwest wind rushes with great violence, its course being visible from Coimbatore by a column of clouds and vapour... Its violence is such as to overturn laden carts and entirely to prevent the pitching of tents in the tract opposite the Gap."

> Further to the east, King and Foote observe, "....the southwest wind meets with little or nothing in the Coimbatore district to oppose it till east of Cauvery, the Shevroys and Kollumalais break its force and receive in heavy showers a large share of its moisture then remaining. Southwards of Kollumalais no obstruction is offered to the westerly wind owing to the absence of mountains, the nearest being the Dindigal mountains at a distance of some 40 miles and in consequence it blows very strongly across the Delta of Cauvery to the East Coast."

The author of this paper had also drawn the attention of readers to the peculiar character of surface wind at this station in an earlier scientific note (1949) on the climatology of Tiruchirapalli airfield (10° 46′ N, 78° 43′ E). A more detailed picture of the local variation of wind at the station and its neighbourhood is attempted in this note.

Prior to July 1944 the current weather observations made at the Tiruchirapalli observatory in the cantonment which was situated at a distance of 6 miles to the north of the airfield were used for supplying weather information to the aircraft. It was noticed that especially during the southwest monsoon season the observatory at the cantonment was reporting no more than a fresh breeze when the airfield was experiencing wind of gale force. This difference in wind condition led to the establishment of a meteorological station at the airfield itself.

The records of regular current weather observations at a number of hours of the day taken at the Tiruchirapalli cantonment observatory during the period May 1943 to November 1944 were examined together with the data of hourly observations made at the Tiruchirapalli airfield with a view to study the local variation of wind at the station. The wind instruments at the airfield observatory were installed on suitable pedestals on the terrace of the Flying Control tower at a height of 34 ft above ground and those at the cantonment observatory were on a specially constructed tower at a height of 37 ft above ground* in the compound of the office of the Superintending Engineer, P.W.D., Tiruchirapalli. Being in open surroundings near the aerodrome the exposure of wind instruments at the airfield was reported to be very good while the exposure of the instruments at the cantonment observatory surrounded by high buildings and trees was reported as not satisfactory in spite of the wind tower on which the wind instruments were mounted.

*The heights indicated refer to the heights of the anemometer cups

It is also realised that the data presented here is not sufficient to give the exact picture of the wind regime at this station but in the absence of such systematic observations throughout the day and night for a longer period the discussion which is made, mainly in corroboration of the author's own experience and impressions gained during his stay at this place, will, it is hoped, be of some value to pilots using this aerodrome.

2. Comparison of mean wind

The mean daily wind speeds irrespective of direction for all the hours for which observations are available for the airfield and the cantonment sites are given in Figs. 1 and 2. The mean daily wind speeds (*mph*) for the day as a whole during the periods January to May, June to September, October to December and for the year with their standard deviations at the two sites are given below—

Period	Airfield		Cantonment		Difference	t
	Mean	S. D.	Mean	S.D.		
Jan—May	6·2	2·3	5·6	1·8	0·64	2·11
Jun—Sep	16·5	4·7	9·4	2·2	7·09	15·41
Oct—Dec	6·5	1·9	5·3	1·9	1·24	5·75
Year	9·7	5·8	7·1	2·8	2·69	5·83

It may be seen from the above that the average wind speeds at the airfield are generally stronger than those at the cantonment, and during the southwest monsoon season they are nearly twice as strong. The difference between the wind speeds at the two sites have been tested by the 't-test' and found to be significant at the 5 per cent level during the different periods. Thus we see that the wind speeds at the airfield are significantly stronger than those at the cantonment*. It would be desirable to examine at this stage if the distribution of the mean daily wind speeds are ' normal '. For this purpose Fisher's g statistics were calculated for the sample of mean daily wind speeds obtained for the different hours for the airfield observatory and they are given below with their standard errors.

Period	g_1	S.E.(g_1)	g_2	S.E.(g_2)
Jan—May	*+0·7364*	0·1863	*+2·0470*	0·3703
Jun—Sep	—0·1147	0·2086	—0·6980	0·4141
Oct—Dec	—0·0457	0·2402	—0·6050	0·4760
Year	*+0·9790*	0·1210	—0·0268	0·2417

The distribution is positively skewed in the case of the year, indicating that sub-normal winds are more frequent than it would be if the distribution were normal and this is mainly due to positive skewness as well as a positive ' kurtosis ' in the case of January-May.

A comparison of the wind speeds (*mph*) with those of the neighbouring observatories is shown below—

Station	May	Jun	Jul	Aug	Sep
Tiruchirapalli cantonment	4·6	7·2	7·7	6·2	4·6
Nagapattinam	6·4	6·5	6·0	5·2	4·8
Cuddalore	5·3	5·3	4·6	4·2	3·9
Madurai	4·3	4·9	4·9	3·8	3·2
Salem	3·6	4·4	4·2	3·7	3·1
Palghat (1943-1945)	7·1	6·9	7·1	6·7	6·6
Coimbatore	3·8	6·2	6·6	5·4	4·7

It indicates that during the months June to September even the winds at the Tiruchirapalli cantonment are stronger than those at the other stations. They are about 50 per cent stronger than those at Madurai, Salem and Cuddalore, which are not directly on

*As a result of comparative observations made for 2 years from March 1945 to February 1947 between the two sites, examined by the Climatology Branch of the Meteorological Office, Poona (I am indebted to Mr. K. Nagabhushana Rao for drawing my attention to this), the following corrections have been accepted for the normal daily wind speeds for Tiruchirapalli due to the change of site.

January	+	2 mph
February	+	1 mph
March	+	2 mph
April	+	2 mph
May	+	5 mph
June	+	9 mph
July	+	11 mph
August	+	9 mph
September	+	6 mph
October	+	3 mph
November	+	1 mph
December	+	2 mph

It may be mentioned here that the corrections have been worked out from a comparison of 0830 and 1730 IST observations only while the differences indicated in this paper are based on all the hourly observations

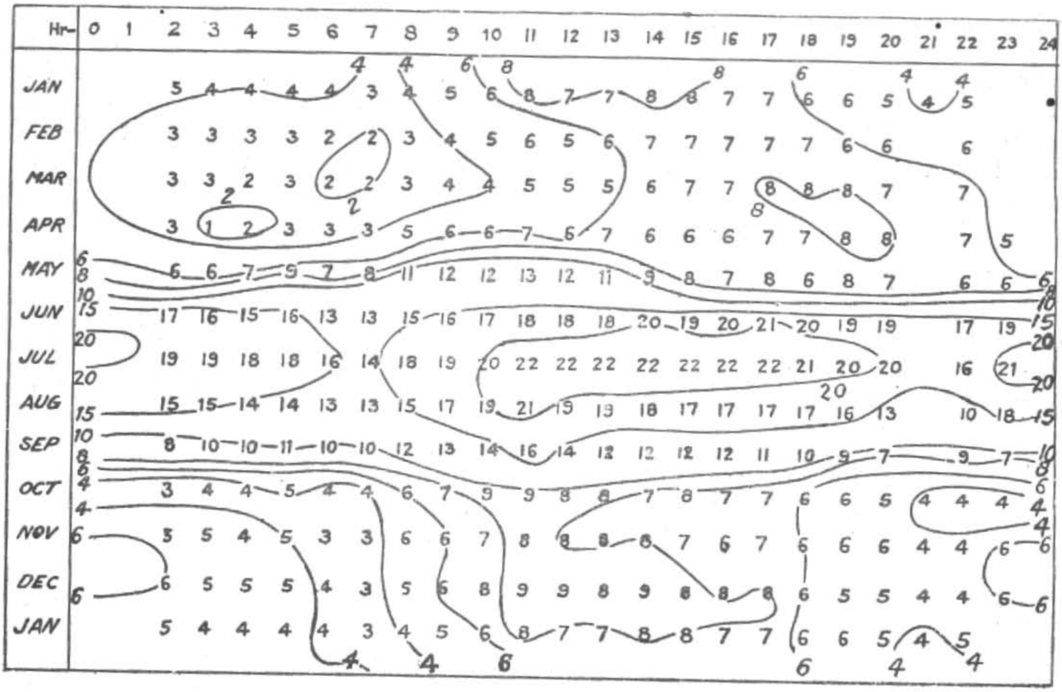

Fig. 1. Mean wind speed at Tiruchirapalli airfield (1945-1946)

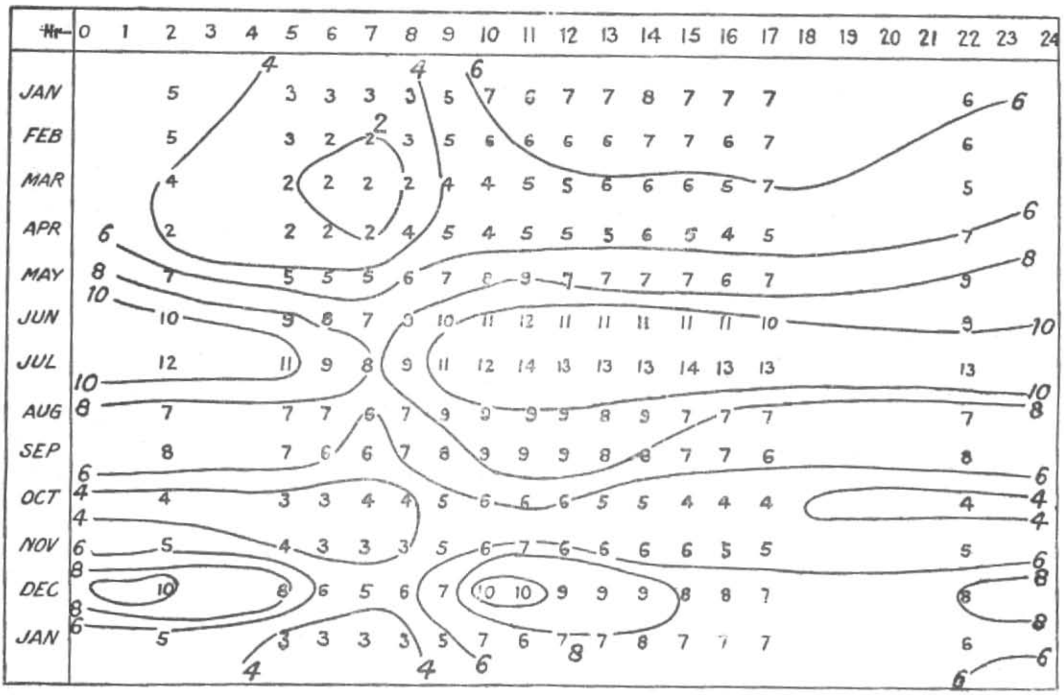

Fig. 2. Mean wind speed at Tiruchirapalli cantonment (May 1943-November 1944)

NOTE: In Figs. 1 and 2 the digits indicate average wind speed in mph *irrespective of direction* correct to the nearest integer.

The iso-lines have, however, been drawn on the basis of the figures correct to first decimal place the track of the westerly stream produced by the Palghat Gap. It may be mentioned that the wind speeds at Nagapattinam, which is also against the Palghat Gap, though farther away, are stronger than those at the other stations mentioned, except for Palghat and Coimbatore where the effect of the Palghat Gap is perceptible, while they are lighter than those at Tiruchy.

As regards wind measurements it is hardly an exaggeration to say that the exposure is more important than the actual instrument itself. The site selected should be such that the instrument is not sheltered by trees or buildings as the eddies caused by such obstacles extend both vertically and horizontally to great distances. In perfectly open and flat situations a tower or mast 30-40 ft high will provide an excellent exposure, but where such sites are not available the instrument should be raised sufficiently to be free from the effect of eddies caused by the obstructions. It may be recognized that the airfield observatory is at a more open site than the cantonment observatory, which is in a built-in-locality with large number of big buildings and trees all round practically rising to the level of the instrument. While this better exposure for the airfield observatory is responsible to a large extent for the higher wind speed at the airfield than at the cantonment, the higher speeds during the southwest monsoon at the cantonment observatory over those at the neighbouring stations indicates that it is the presence of Tiruchirapalli against the Palghat Gap which is the prime cause.

3. Analysis of variance

Observations of wind have been made daily at practically all hours from 0200 to 2300 IST during the two years 1945 and 1946 and in all 14022 observations are available. The speeds measured on two different occasions differ between themselves due to a variety of causes, the chief amongst them being the time of the day and the season to which the observations relate. In addition one can enumerate several other causes, *e.g.*, variation due to different years, variation due to observational errors etc. The extent of the variations due to the different contributory causes in the above set of observations made at the Tiruchirapalli airfield, can be seen from the analysis of variance given below—

Source of variation	Degrees of Freedom	Sums of squares	Mean square	F
Diurnal (Between hours)	21	39083	1861	52
Seasonal (Between months)	11	381682	34698	976
Between years	1	1980	1980	56
Residual	13988	497052	35	
Total	14021	919797		

It will be seen from column 3 of the above that much of the random variations have been included in those ascribed to months and probably accounts for the high variation from month to month. The variation between hours is also quite high indicating that the diurnal character has been on the whole similar in the different months. The variation between years is also quite high and significant compared with the residual variation.

4. Diurnal variation

The variation in the strength of the wind during the course of the day in the different months has been represented in Figs (3) (*a*) and (*b*). The systematic periodic oscillation of wind speed has been subjected to harmonic analysis. The speed of wind at any time of the day can be represented as a function of time as follows—

$$S(m,t)=S(m)+a_{m_1}\text{ Sin }(\epsilon_{m_1}+2t\pi/T) +a_{m_2}\text{ Sin }(\epsilon_{m_2}+4t\pi/T)+\ldots \quad (1)$$

where $S\ (m,t)$ is the speed of wind at any time t in the m^{th} month, $S(m)$ is the mean speed of wind during the day in the m^{th} month, a_{m_1}, ϵ_{m_1}, a_{m_2}, ϵ_{m_2} etc, are all constants, t, the time of the day measured in IST from midnight to midnight and $T=24$. The first harmonic, *i.e.*, the second term on the right hand side indicates the oscillation taking place during the course of 24 hours due, probably, to the alternating effect of the day associated with the heating of the air by the Sun, and night with cooling of the

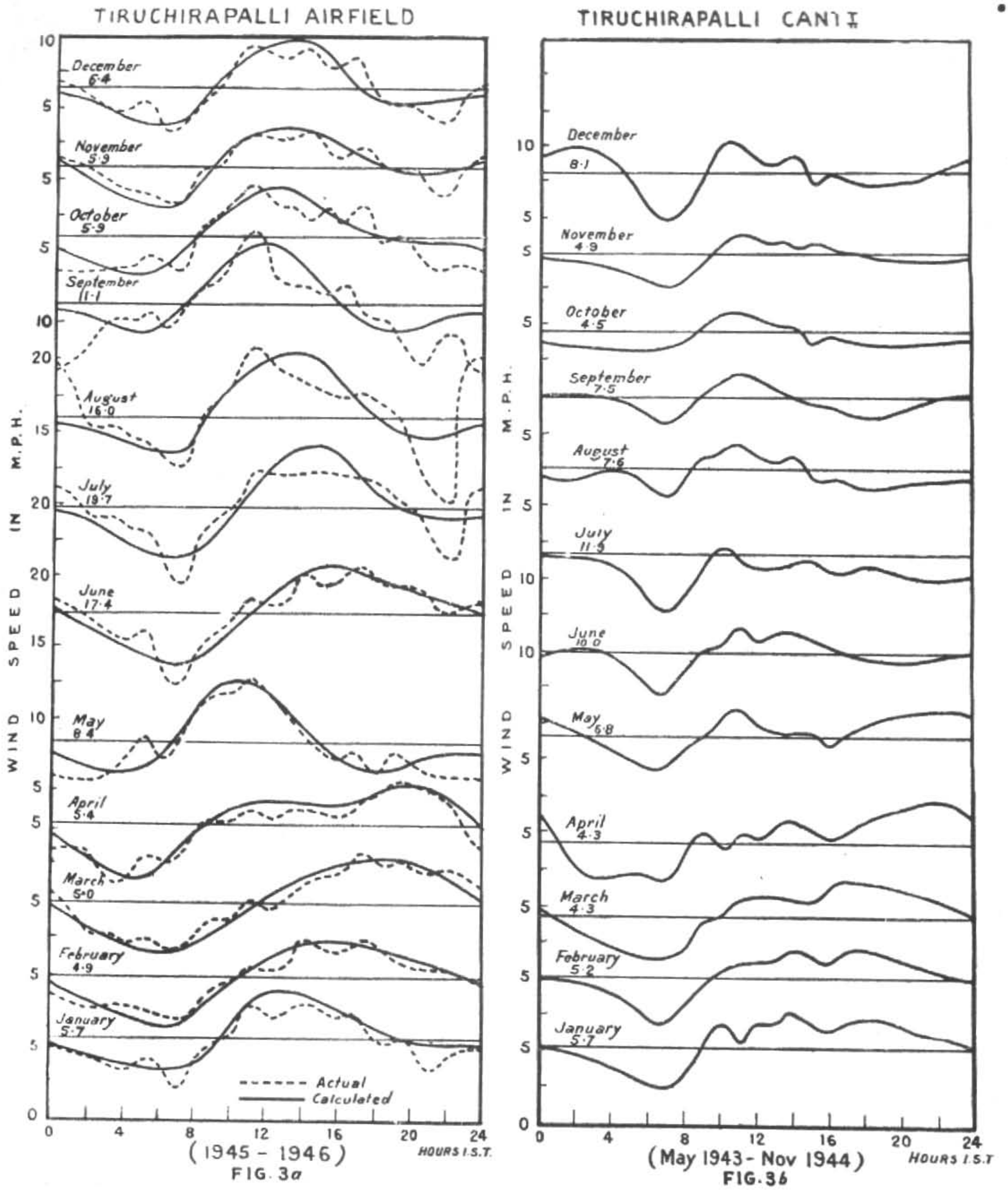

Fig. 3. Diurnal variation of wind

air due to nocturnal radiation. This is called the diurnal oscillation. The second indicates the oscillation taking place during the 12 hour periods corresponding to the day and night and may be called the semi-diurnal oscillation. The third may be called the ter-diurnal oscillation and so on.

The constants appearing in the first three terms of the right hand side of equation (1) have been calculated in respect of the airfield observations and given in Table 1. The residual error, *i.e.*, the excess of the observed speed over the calculated one have also been calculated and given in the same table as percentage of the mean wind speed of the day. As the maximum error is only of the order of 7 per cent (in March), the first two harmonics can be considered to be representing the diurnal variation fairly accurately*. For example, the wind speed at any time of the day in January can be calculated from the following equation—

$$S\,(1, t) = 5{\cdot}7 + 2{\cdot}0\ \mathrm{Sin}\,(221°5' + t\pi/12) + 1{\cdot}2\ \mathrm{Sin}\,(65°50' + t\pi/6)$$

with a mean error of 1 per cent. The times at which the wind speed attains a maximum and minimum can be calculated by solving $dS/dt=0$. As a quartic in Tan $t\pi/T$, the equation yields four solutions, 2 relating to the time of maximum and 2 for minimum. The maximum and minimum speeds and the times at which they occur, as calculated from the harmonics fitted have also been given in this table. The calculated values of the wind speed at the airfield have been indicated by continuous curves in Fig. 3 (*a*).

The chief features of the diurnal variation are summarised below—

At the airfield

January—Winds are weakest at dawn with a speed of about 3 mph but strengthen sharply after sunrise. The speed increases at a more or less steady rate upto the time of attainment of maximum of about 9 mph in the afternoon. The speed then falls off gradually till about 2100 IST. There is a slight strengthening of wind towards midnight.

February and March—Winds are weakest during these months. The speed increases gradually from a value of 1·5 to 2 mph at dawn to a value of 8 mph in the late afternoon. It may be seen that the time of maximum occurs later than in January by about 2 hours in February and about 5 hours in March. There is no secondary maximum in these months.

April—The variation during April resembles that of March with the maximum which was progressively receding during the previous months occurring at about 2000 IST. However, the development of a fresh characteristic is noticeable in that the wind speed strengthens rapidly in the mornings and attains a secondary maximum at about noon. A further strengthening occurs after about 1600 IST with the main maximum at about 2000 IST.

May—The tendency for strengthening in the morning is more marked during this month. The speed increases vigorously from a value of 6 mph at dawn to about 13 mph at about 1030 IST. The speed falls off at a lower rate till about 1700 IST after which winds strengthen slightly attaining a subsidiary maximum at about 2245 IST.

June—The characteristic variation during this month has completely changed from those of the previous months. The early morning minimum of 13½ mph occurs at about 0630 IST, two hours later than in the previous months. The strengthening is fairly rapid and the maximum of 20½ mph occurs at about 1530 IST. Thereafter the speed falls off gradually with no subsidiary maximum at night.

July—Winds are strongest during this month. The speed increases from a value of 16 mph at dawn to a value of 24 mph at about 1400 IST. The speed falls off more or less at the same rate till about 2000 IST after which there is some slight strengthening

*The harmonics of higher order will no doubt give slightly better fit to the observed values but in view of the fact that the observations relate only to two years, greater accuracy has not been aimed at. Further, the completeness criterion of Brunt (1937) indicates that higher terms of the series are not significant towards midnight.

August—The variation during this month resembles mainly that taking place in July but the general strength of the wind is lower than in July.

September—The wind increases from a value of 9 mph at dawn to about 15 mph at noon. The weakening of the winds in afternoon takes place at the same rate as the rise was in the forenoon. The speed again attains another minimum at 1900 IST practically of the same strength as at dawn. Wind strengthens afterwards attaining a subsidiary maximum at about midnight.

October to December—Winds are weakest at dawn but strengthens a bit more sharply than in the previous month. The maximum of 9-10 mph is attained just afternoon after which the speed falls off gradually till about 2000 IST. There is again a slight strengthening in the night with a secondary maximum at 2200 IST in October and about midnight in November and December.

At the Cantonment

The general character of the diurnal variation of wind speed at the cantonment site is to a large extent identical in all the months with those experienced at the airfield. The strengthening occurs at about dawn and continues till about noon after which the speed generally falls off. However, there is a striking contrast between the characteristic curves for the different seasons at the airfield, while such a contrast is absent in the case of the cantonment. The main reason for this appears to be the better exposure of the wind instruments at the airfield than those at the cantonment.

Seasonal variation of diurnal and semi-diurnal waves

The maximum of the oscillation of a particular period (24 hour or 12 hour) will occur when Sin $(\epsilon_{mi} + 2it\pi/T) = 1, (i = 1 \text{ or } 2)$, *i.e.*, when the angle $\epsilon_{mi} + 2it\pi/T$ is of the form $(4n+1)\pi/2$. Thus the time of maximum

TABLE 1

Harmonic analysis of diurnal variation of wind speed at Tiruchirapalli

Month	$S(m)$	a_{m_1}	ϵ_{m_1}	a_{m_2}	ϵ_{m_2}	Ratio a_{m_1}/a_{m_2}	$100\Sigma(S_{obs}-S_{cal})/S(m)$	As calculated: Maximum* I	Maximum* II	Minimum* I	Minimum* II
Jan	5·7	2·0	221° 5′	1·2	65° 50′	1·67	1·1	9·0 (1315)	5·4 (0030)	3·5(0600)	5·2 (2100)
Feb	4·9	2·6	198° 0′	0·6	59° 30′	4·33	—2·0	7·5 (1515)	—	1·7(0600)	—
Mar	5·0	3·1	184° 25′	0·1	183° 0′	31·00	—6·7	8·0(1810)	—	1·5(0515)	—
Apr	5·4	2·5	199° 20′	1·2	162° 30′	2·09	—4·4	6·9(1300)	8·5(2000)	1·5(0430) 6·5(1430)	—
May	8·5	2·4	289° 20′	1·9	133° 35′	1·26	—1·1	12·8(1030)	8·0(2245)	6·2(0345)	6·4(1715)
Jun	17·4	3·0	190° 20′	0·9	39° 50′	3·33	—2·1	20·5(1530)	—	13·5(0630)	—
Jul	19·7	2·7	214° 10′	1·7	46° 45′	1·59	0·3	23·8(1405)	19·5(0045)	16·0(0630)	19·0(2030)
Aug	16·0	2·7	250° 0′	1·7	66° 50′	1·59	3·1	20·2(1310)	15·2(0100)	13·2(0530)	14·1(2030)
Sep	11·1	2·5	276° 0′	1·7	73° 45′	1·49	3·1	15·5(1130)	10·5(2345)	8·8(0410)	9·0(1900)
Oct	6·0	2·3	246° 10′	1·2	74° 30′	1·92	1·3	9·5(1210)	5·5(2200)	3·3(0415)	5·4(2000)
Nov	5·9	1·9	232° 0′	1·3	81° 25′	1·47	—2·7	8·6(1245)	6·3(2330)	3·0(0530)	5·3(1945)
Dec	6·4	2·1	235° 30′	1·6	63° 50′	1·31	—4·3	9·8(1315)	6·0(0030)	3·7(0545)	5·4(2015)

* The times (IST) at which the maximum and minimum occur are given in brackets

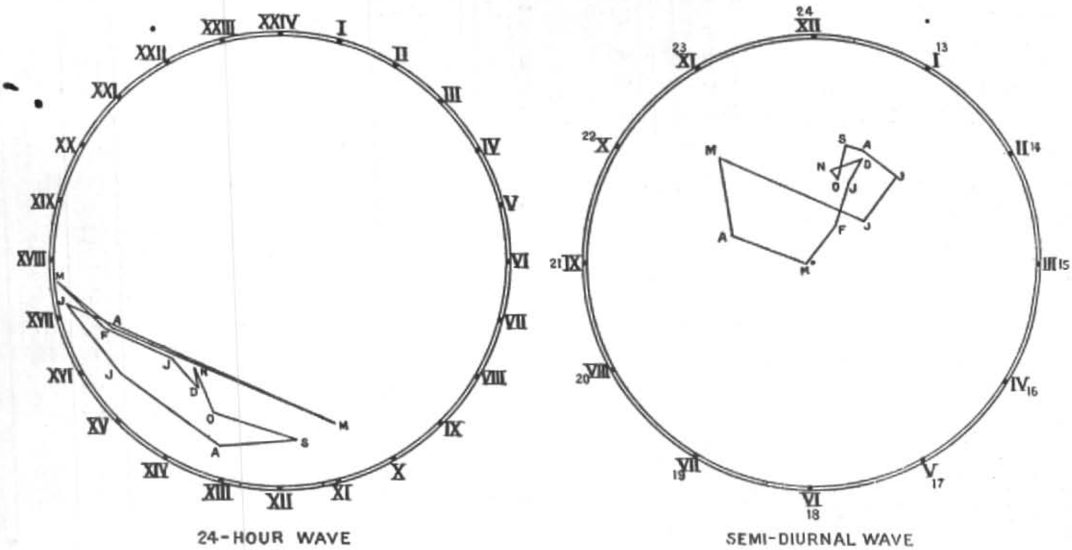

Fig. 4. Harmonic dial for average diurnal variation of wind speed at Tiruchirapalli airfield

due to the oscillation of a particular period is determined by its phase angle. The oscillation of a particular period (24 hour or 12 hour) in the different months, differs in the values of the amplitude a and those of the phase angle ε. With a view to compare the nature of the oscillation in the different months, the vectors represented by the amplitude and the phase angle have been plotted on a diagram called the 'Harmonic Dial' following Chapman (1928). Harmonic dials in respect of the 24-hour and the semi-diurnal waves have been plotted in Fig. 4.

The diagrams show in an interesting manner the march of the time of maximum oscillation for the 24-hour and 12-hour periods. During January to April, the maximum for the 24-hour wave oscillates between 3-15 PM (in January) and 5-45 PM (in March). In May the maximum advances by 6 hours, but in June it comes back to the April level. Afterwards as the season advances, the maximum gradually advances, the maximum in September occurring at about 1130. During October to December the time of maximum generally oscillates between 1-30 and 2-30 PM.

The semi-diurnal wave has likewise an interesting seasonal variation. The first maximum during the period June to February oscillates between 0015 IST in November to 0145 IST in June, the second maximum occurring exactly 12 hours ahead. During March to May, the first maximum occurs between 0900 and 1030 IST and the second maximum between 2100 and 2230 IST.

The ratios of the amplitudes of the two periodic terms are given in column 7 of Table 1. These indicate that in the months of February, March and June, the 24-hour wave is more predominant than the semi-diurnal wave, while in the rest of the months, the semi-diurnal wave, though still smaller in amplitude than the diurnal wave is still appreciable. This accounts for the perceptible secondary maximum noticed in the curves for these months in Fig. 3 (*a*).

It is seen that the variation of wind speed at Tiruchirapalli is a well marked phenomenon, the characteristic features of the diurnal variation varies with the seasons. An examination of the different factors responsible for the peculiar type of daily variation is being made and will be discussed separately.

5. Variation in wind direction

The variation in wind direction has likewise a significant seasonal and diurnal aspect.

These have been examined in the following sections in respect of the mean resultant winds at the airfield.

In Table 2 is given the mean monthly directions and speed of wind measured at Tiruchirapalli airfield with instruments at a height of 34 ft above ground level. The mean value of the wind direction and speed are given for all hours for which observations are available and worked out from the actual reported winds by compounding them vectorially. The directions are given correct to 5° and speeds correct to 0·1 mph. The nature of the air movements can be better appreciated from the trajectories (Fig. 5), which indicate the paths of a balloon floating in the air at a height of 34 ft above ground over Tiruchy and being drifted by winds from midnight to midnight. It will be seen that during the months May to September, winds are mainly westerly. In the afternoons of May and September, there is a tendency for the winds to veer and weaken till about 1800 IST after which there is a sudden backing to nearly south in May and west to southwest in September*. During the period November to March, the winds are northeasterly at first and veer to ENE-E with the advance of the day. With the advance of the season, the diurnal veering is more pronounced and in March, the afternoon winds are practically E-SE.

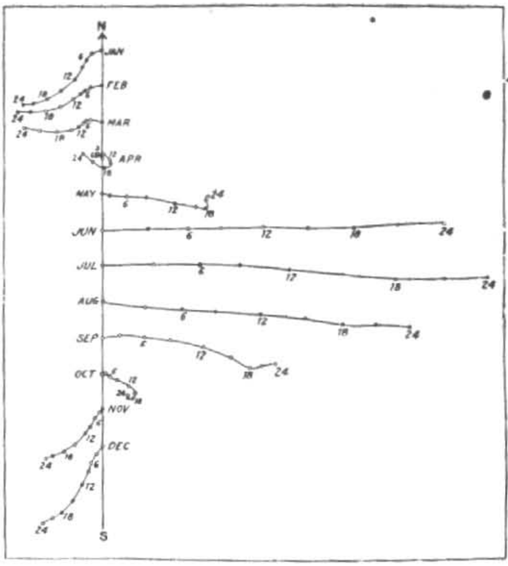

Fig. 5. Mean trajectories of winds at Tiruchirapalli airfield at 34 ft above ground level

April and October are the transition months when the winds are variable and generally light. In April winds are very light in the early morning but strengthen and veer during the day becoming east to southeast after 1700 or 1800 IST. In October winds are light and northwesterly till afternoon after which they veer through NE-E-S till they are masked by the W-NWly flow.

6. Predominant winds

In Table 3 are given the predominant winds at Tiruchirapalli airfield. For this purpose, percentage frequencies of winds from different directions with different speeds were worked out for the different hours and the most frequent direction or directions were shown in the table and also represented diagrammatically in Fig. 6. The nature of the variations are generally as detailed for the mean resultant winds in the previous section. It will be seen that the predominant winds during May to September are westerly practically throughout the day except that in the evenings of May and September changes in the direction are perceptible, due probably to the overcoming of the normal wind-field by the advancing sea breeze (see also Section 7). In October the winds are generally light variable and during the period November to March the predominant winds particularly during the daytime are northeasterly, while in the nights the cooler south to southeasterly flow from the sea side tends to weaken it during the early part of the season and give a predominantly easterly direction during the period January to March. In April the winds are light and variable with frequent ' Calms '. In the evenings after about 1700 IST east to southeasterly winds, probably the sea-breeze† prevail generally.

* This is obviously due to sea-breeze. This aspect has been discussed separately.

† It is likely that on some occasions the easterly wind is due to squall from some thunderstorm to the east or southeast

TABLE 2

Resultant winds at 34 ft above ground at Tiruchirapalli airfield

Hours (IST)	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
02	040 3·7	065 2·6	070 2·4	165 0·8	270 4·6	270 16·5	270 19·0	275 14·8	270 8·0	295 1·4	040 3·5	040 4·8
03	040 3·8	055 2·9	095 2·0	110 0·4	280 5·5	270 15·9	270 18·5	270 15·0	270 9·7	295 1·5	040 3·1	030 3·9
04	045 3·1	050 2·9	090 1·8	075 0·7	280 6·5	270 15·3	270 18·1	275 14·2	275 9·6	295 2·1	030 2·6	030 4·1
05	035 4·0	050 2·4	055 1·9	305 1·0	270 8·2	270 16·1	270 17·8	275 14·0	275 9·7	305 3·0	035 3·5	025 4·5
06	040 3·2	045 2·0	035 1·1	280 1·1	275 6·9	270 13·2	270 15·8	275 13·0	275 9·2	300 2·9	030 2·1	020 3·0
07	030 2·3	045 1·4	045 1·2	275 1·7	270 7·8	270 12·1	270 14·2	275 12·4	275 10·3	285 2·5	015 2·2	020 3·0
08	025 3·5	040 2·8	040 1·6	290 2·3	275 10·2	270 14·4	275 17·3	275 14·8	280 11·7	290 4·4	035 3·5	015 4·2
09	030 4·0	045 3·7	050 2·0	290 2·7	280 11·3	270 15·7	275 18·7	270 16·7	280 12·2	295 4·6	035 3·9	015 4·9
10	030 5·6	045 4·2	045 2·4	305 3·1	280 11·1	270 16·9	275 19·5	275 18·1	280 13·7	300 4·9	035 4·9	025 6·4
11	040 7·8	055 4·9	055 3·3	295 2·7	285 11·7	275 17·8	275 21·9	275 19·8	285 15·4	300 5·4	035 5·3	025 7·6
12	045 6·9	055 4·6	060 2·4	305 2·3	280 10·3	275 17·5	275 21·5	275 19·0	285 13·2	305 4·7	035 5·1	025 7·1
13	050 7·1	055 5·2	060 4·0	330 1·7	275 8·7	270 17·7	275 21·2	275 17·4	290 11·4	310 4·6	045 5·9	025 6·8
14	055 7·5	065 7·0	065 3·7	010 2·3	280 6·9	270 19·3	275 20·8	280 17·2	300 10·8	350 2·5	050 6·9	035 7·6
15	060 7·2	065 6·7	075 5·4	030 2·6	280 5·4	270 18·0	275 21·3	280 16·3	305 9·7	005 2·5	055 5·1	040 6·6
16	060 6·8	070 6·2	080 6·1	055 3·7	285 3·7	270 18·5	275 20·5	280 15·3	300 8·7	010 1·9	060 4·9	045 6·5
17	065 6·6	080 6·9	085 7·5	070 3·4	290 3·0	270 18·4	270 20·5	280 13·7	295 7·3	040 2·7	055 5·9	045 6·9
18	070 5·5	085 6·9	090 6·7	110 4·2	225 2·7	270 18·3	270 20·1	275 15·3	265 5·0	075 2·0	060 5·2	055 5·1
19	070 5·3	085 5·8	095 6·9	125 5·7	190 4·4	265 17·5	270 19·2	270 14·4	250 4·1	085 2·3	070 4·1	055 4·4
20	075 5·1	085 5·5	100 6·8	115 5·8	165 3·8	270 18·0	270 18·0	270 11·7	255 4·7	130 1·6	075 5·1	055 4·2
21	080 3·6									090 2·6	070 3·7	075 3·9
22	080 4·6	090 5·1	100 6·4	130 3·1	200 3·2	270 17·3	270 14·6	270 9·6	270 7·1	190 0·6	065 3·8	075 4·4
23				135 3·2	290 2·0	270 18·1	270 20·4	280 18·5	265 6·3	215 1·3	015 0·6	035 4·9

NOTE—Figures in the first line against each hour indicate direction in degrees from north and those in the second line, speed in mph

TABLE 3

Predominant wind at 34 ft above ground at Tiruchirapalli airfield

Hours (IST)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
02	C NE7	C NE5	C E6	C Var4	C W10	W20	W22	W17	W14	C Var3	C NE8	NE8
03	C NE8	C NE5	C E6	C Var1	C W12	W17	W21	W17	W14	C Var4	C NE10	NE7
04	C NE7	C NE6	C E6	C Var2	W10	W17	W21	W16	W13	C WNW8	C NE6	C NE6
05	C NE7	C NE6	C NE7	C Var3	W12	W19	W19	W16	W13	C W6	C NE8	NE7
06	C NE5	C NE5	C NNE5	C Var3	W10	W16	W18	W14	W11	C W7	C NE7	C NE5
07	C NE5	C NE5	C NNE5	C Var3	W11	W14	W17	W14	W13	C W7	C NNE5	C NE6
08	C NE7	C NE5	C NE6	C Var5	W12	W15	W21	W16	W13	C W7	C NE7	C NNE7
09	C NNE8	C NE5	C NE7	C Var6	W12	W17	W21	W18	W14	W12	NE7	NE7
10	NE7	NE6	C NE6	C NW12	W12	W19	W22	W19	W16	W11	NE7	NE9
11	NE9	NE6	NE5	C Var7	W14	W19	W23	W22	W18	W13	NE7	NE11
12	NE8	NE6	NE5	C Var6	W14	W20	W23	E21	W16	W13	NE9	NE10
13	NE9	NE6	NE6	C Var7	W12	W20	W23	E23	W17	NW6	NE9	NE9
14	NE10	NE8	NE6	C Var6	W11	W22	W25	W21	W17	Var7	NE8	NE11
15	NE8	ENE8	NE7	NE6	W10	W23	W25	W21	NW14	C Var8	NE10	NE10
16	NE7	ENE8	E8	C E7	W9	W24	W26	W22	NW13	Var7	ENE8	NE10
17	E7	E9	E10	C E10	W8	W24	W26	W20	WNW16	Var7	NE8	NE8
18	E7	E9	E8	C E8	SW6	W23	W25	W22	W19 Var10	C Var6	ENE7	NE6
19	E6	E8	E9	SE9	C S12	W22	W23	W22	W18 Var9	Var6	C ENE8	NE6
20	E6	E7	E8	ESE9	S10	W24	W22	W18	W12	C Var5	C ENE8	C NE6
21	C E5	—	—	—	—	—	—	—	—	C Var4	C ENE6	C NE7
22	E6	E7	E8	E9 S7	SE7 W7	W22	W20	W14	W14	C Var4	C E5	C NE7
23 Mdt	—	—	—	C SE6	C W10	W21	W23	W23	C W14	C Var4	C Var6	NE6

(*i*) The most frequent wind direction with the average speed in that direction is indicated as the predominant wind.

(*ii*) When 'Calm' is most frequent, the direction with the next predominant frequency is indicated.

(*iii*) When two neighbouring directions like N and NE are equally frequent, the direction is given as NNE

(*iv*) When winds are variable with no frequency equal or greater than 20% and with variability $v/V > 0 \cdot 5$, it is indicated as variable (Var) with mean wind speed.

(*v*) When there are two or more markedly different directions, the directions with the speeds in the respective directions are marked 1, 2, 3 etc.

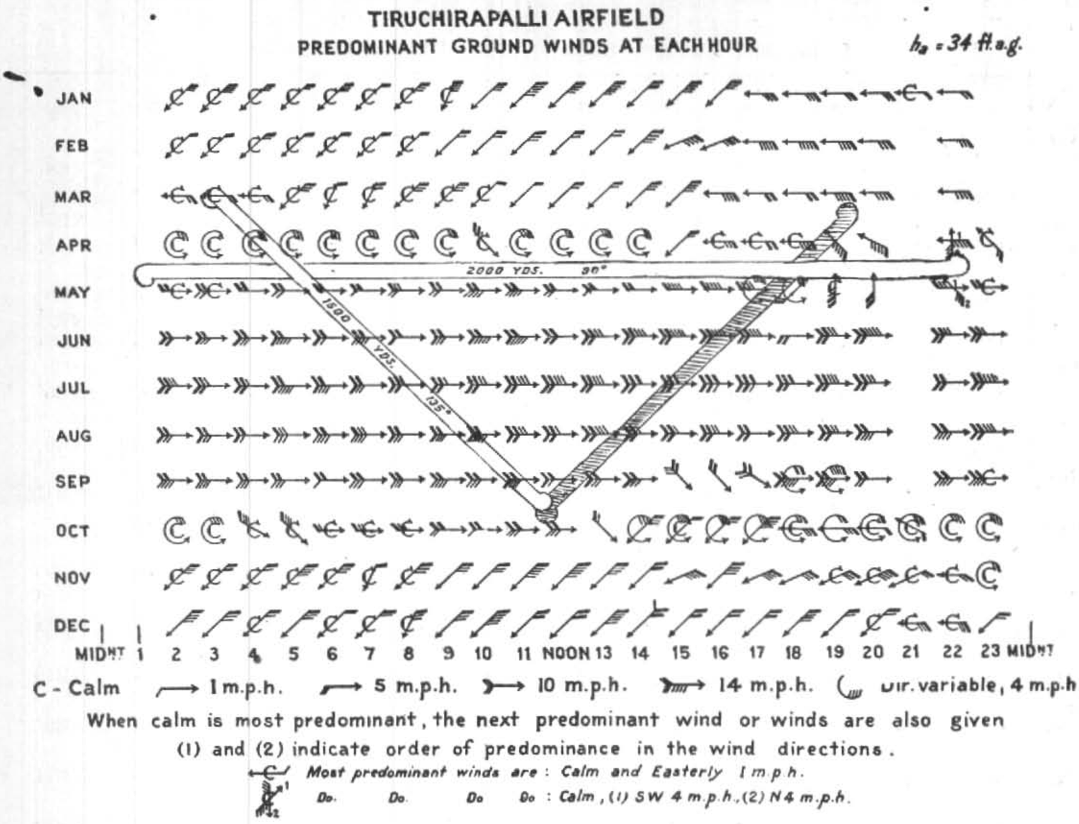

Fig. 6

The orientation of the existing runways are indicated in Fig. 6. It will be seen that while the present East-West runway is useful in the months of May to September and the late evening of January to March, the NW-SE runway is not of much service because both NW and SE winds are rare. A runway NE-SW direction would be useful during the period November to March when NE winds prevail.

For the sake of completeness, to indicate the frequency of winds of different strengths from different directions, ' Wind Roses ' for seven representative hours 0200, 0500, 0800, 1100, 1400, 1700 and 2200 IST have been prepared and given in Fig. 7.

7. Sea breeze

Tiruchirapalli is about 75 miles from the east coast of the Indian Peninsula, which runs almost exactly north to south at that latitude and the sea is nearest towards the southeast at a distance of 55 miles. The country between Tiruchirapalli and the east coast is all plain with elevation not exceeding 300 feet. It may be expected that on some occasions, when the sea breeze is sufficiently strong, it may penetrate as far inland as Tiruchirapalli.

During November to March, the prevailing winds are from NE-E and may be considered more or less as permanent sea breeze. During June to September the prevailing winds are from the west. During the first half of this season, the gradient winds are so strong that no sea breeze could be expected to reach Tiruchirapalli. In August and September, however, the west winds weaken in the afternoon and a reversal of wind direction takes place on some days on which the normal pressure gradient are sufficiently weak. It is possible that this reversal of wind, which

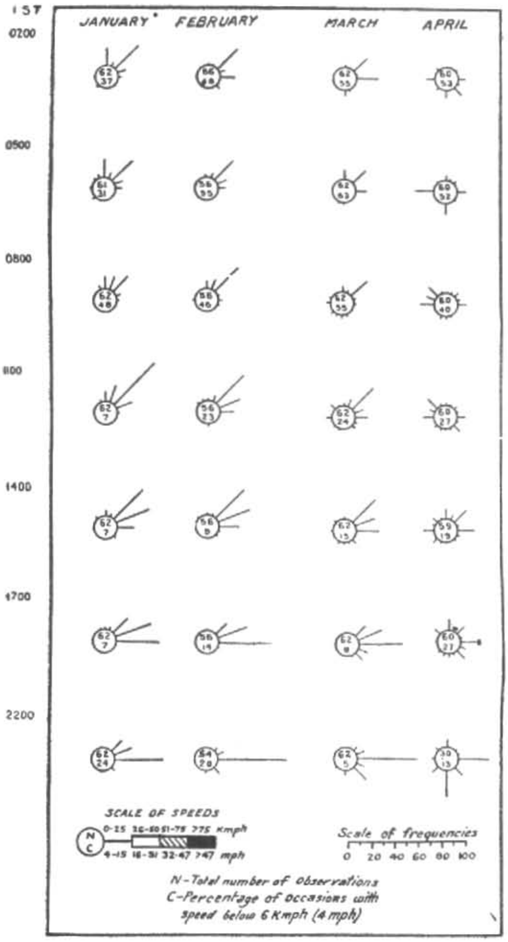

Fig. 7 (a)

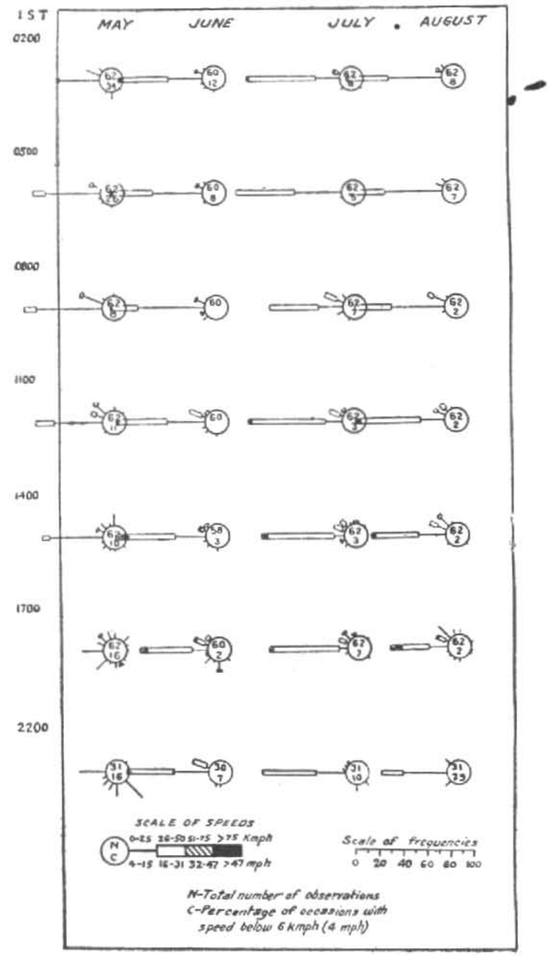

Fig. 7 (b)

Wind Roses for Tiruchirapalli airfield

occurs at about 1800 IST in these months as well as in April, May and October is the sea breeze though no definite and conclusive evidence for the same can be given in the absence of autographic records of pressure, temperature and humidity. However, a comparison of the mean easterly component of winds upto 2 km over Tiruchirapalli during the months April, May, August, September and October in respect of the two years 1945 and 1946 reveals that the easterly component predominates in the afternoon upto a height of about 1·5 km in the months April, May, August and September and to a height of about 1·0 km in October with a maximum concentration between 0·5 and 0·6 km a.s.l. The difference between the mean easterly component of wind in the morning* (E_m) and that in the afternoon (E_a) at the different heights are given in Table 4. Further from the sequence of changes indicated in the charts† of hourly observations of current weather and of upper winds, it appeared that on some days sea breeze did penetrate as far

* The morning observations were made at 0900 IST in 1945 and 0700 IST in 1946

† A specimen of such a chart has been given in Appendix I of Ind. Met. Dep. Tech. Note No. 27 (1949)

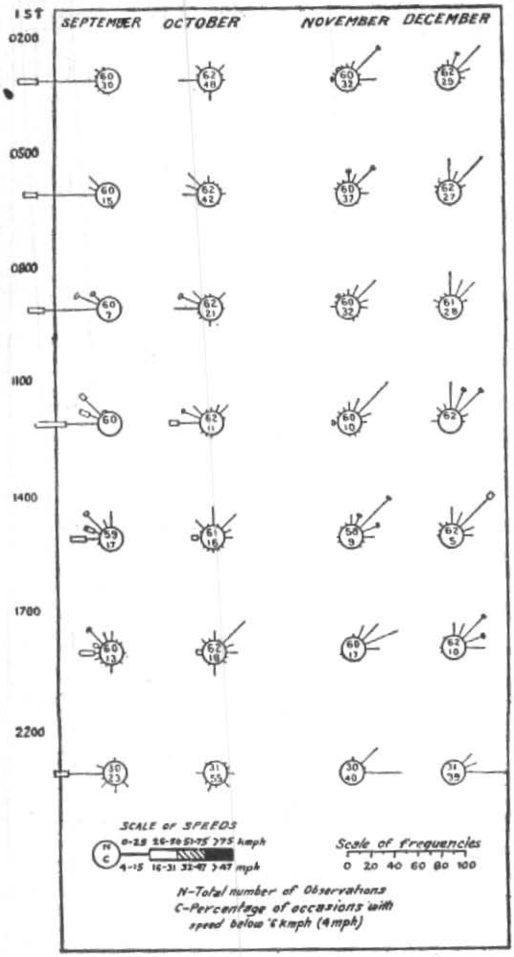

Fig. 7 (c) Wind Roses for Tiruchirapalli airfield

TABLE 4

Difference in the mean easterly component of wind over Tiruchirapalli (E_m)—(E_a) 1945-46

Height a.s.l. (km)	April (mps)	May (mps)	August* (mps)	September (mps)	October (mps)
2·0	0·85	1·72	0·45	1·43	0·88
1·5	—1·82	—0·21	—2·44	—0·16	0·35
1·0	—3·70	—3·79	—4·67	—4·24	—1·56
0·6	—4·64	—6·89	—4·80	—7·05	—3·28
0·5	—4·75	—7·02	—4·39	—6·98	—3·47
0·3	—3·85	—6·14	—2·48	—5·21	—3·92
0·15	—3·53	—4·98	—1·58	—4·22	—3·74
Surface	—2·09	—2·81	—0·09	—2·17	—2·09

* Data for only 1945 has been used as the registers for 1946 were not available

TABLE 5

Frequency of occasions on which there was a definite wind shift from some westerly direction to some easterly direction at Tiruchirapalli airfield

Month	Total No.	Hours (IST) 11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24
Feb	1					1								
Mar	8				2 (1)	2 (1)	2	2						
Apr	23	1	3		1 (1)	11 (4)	1 (2)	2 (3)	3 (6)	(1)	1 (1)			
May	22	3	1	1	1 (1)	1 (1)	2 (3)	1 (7)	3 (5)	5 (2)	3 (3)	(1)	(2)	1 (1)
Jun	3		1			(1)	(4)	(1)		2				
Jul	3			1			(1)	2		(2)	(2)			
Aug	5					1	(1)	(1)	1 (3)	3 (2)		(1)		
Sep	18					4	6 (2)	1 (5)	3 (2)	3	1 (3)	(3)		(2)
Oct	36	4		(2)	15 (2)	4 (3)	3 (2)	6 (1)	3 (2)	1	(2)	(1)	(1)	

NOTE—The number of occasions when thunderstorms occurred at the station during the intervals stated are given in bracket by the side

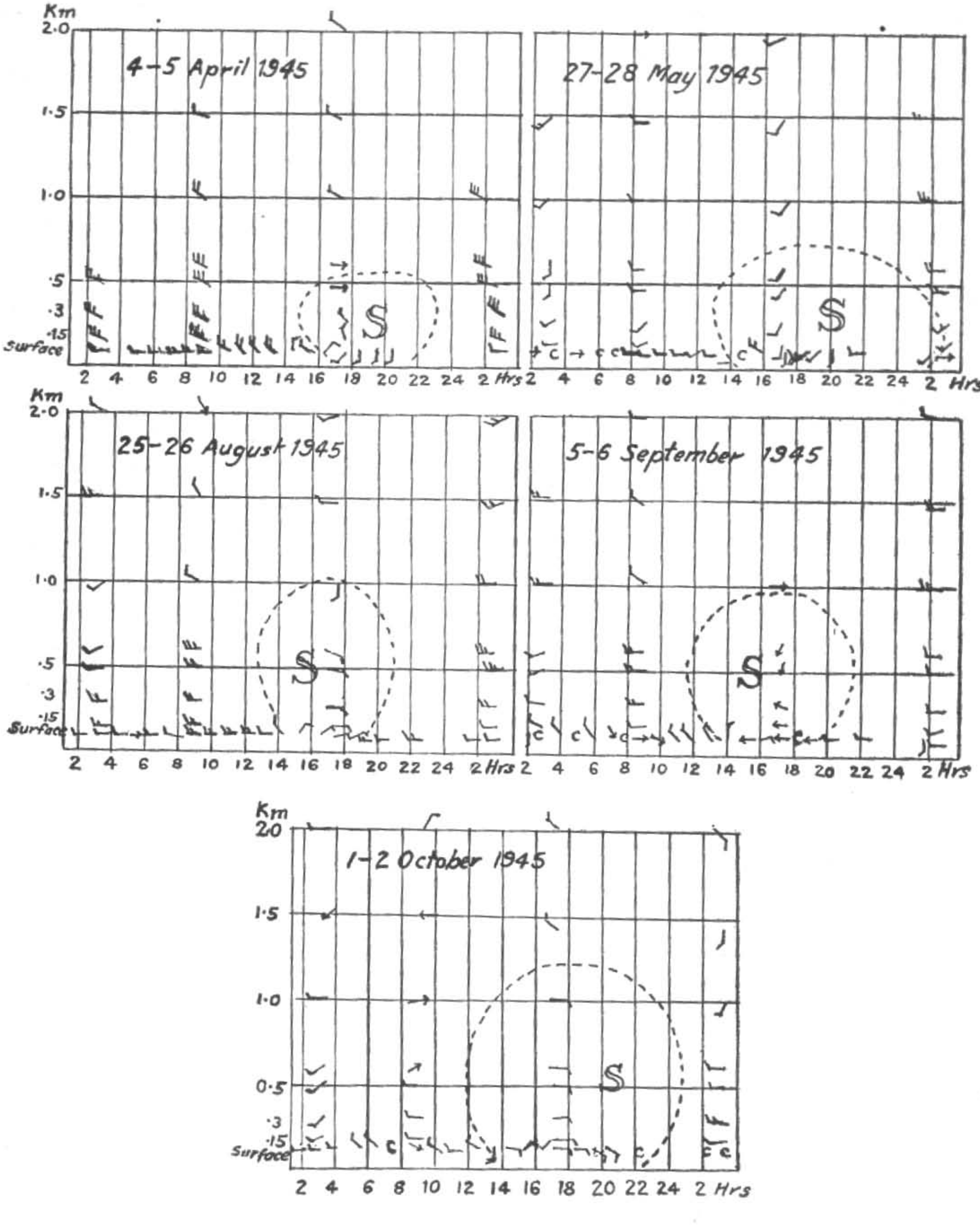

Fig. 8. Seabreeze at Tiruchirapalli

as Tiruchirapalli. In Fig. 8 are given the upper wind observations upto 2 km and the hourly observations of surface winds on one day in each of the five months. These with the background of figures in Table 4 further lend support to this view. The probable period and the height upto which the sea breeze was affecting Tiruchirapalli are also indicated in this diagram. Roy (1941) from a study of the pilot-balloon winds made at Madras had shown that the thickness of the layer in which the easterly component of wind over Madras gains in strength from the morning to afternoon increases from a value of about 0·4 km in January to one of 1·8 km in August after which it again decreases. As already explained, due to the strong westerly winds over Tiruchy during June and July and to some extent in August and September such a diurnal variation is not perceptible at Tiruchy during June and July and for the lesser intensity during August and September. Hatcher and Sawyer (1947), however, observed that the depth of sea breeze did not appear to exceed 500 to 700 ft on the majority of occasions in April and May in Madras. They further stated that usually a westerly current extended from the top of the sea breeze to 2000 to 3000 ft.

It may be mentioned that on some occasions even though there was a reversal of wind from a westerly to an easterly direction, it appeared that it was not actually the sea breeze but was due to some thunderstorms to the east probably induced by the sea breeze front. The number of occasions on which there was a definite wind shift from some westerly to some easterly direction during the two years 1945 and 1946 are given in Table 5, and the number of occasions when thunderstorms occurred at the station during the intervals stated are given by the side in brackets.

8. Acknowledgements

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