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A study of winds exceeding 20 mph at Delhi

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(*Received 19 July 1952*)

ABSTRACT. A study of the winds exceeding 20 mph at Delhi has been made from the anemogram data of the five years 1946-50. The winds have been classified into three groups namely (*i*) winds unassociated with weather (*ii*) winds associated with rain or thundery conditions (*iii*) winds associated with duststorms and thunderstorms. Characteristics of the three groups in respect of their frequencies, maximum speed, direction etc have been noted. Situations causing winds without weather and those causing weather have also been briefly indicated.

Winds exceeding 20 mph occur at Delhi in all the months of the year being most frequent in May and June and least frequent in November. Strong winds unassociated with weather are more pronounced during the period from March to June. Winds associated with rain or thundery conditions are more frequent during monsoon months. The total duration of strong winds is on the average about 600 hours per year 75 per cent of which are associated with west to northwest directions, northwest being most frequent, west coming next, then east and then north. Winds unassociated with weather and those accompanied by rain or thundery conditions reach a maximum speed of 40-45 miles per hour. Winds associated with duststorm and thunderstorm may, however, reach 70 mph. Winds of the first group commence generally between 1000 and 1200 IST except during May to September when they commence at about 0700 IST. Winds of the second group have a greater tendency to occur at noon in March, forenoon in July, both in the forenoon and afternoon in September and in afternoon and evening in May and June. Winds of the third group begin in the noon and afternoon in monsoon and premonsoon months and in the evening or in the early hours of night in other months.

1. Introduction

Krishna Rao (1938) made a study of the squalls at Karachi and similarly Ramaswamy and Majumdar (1950) for Peshawar. In addition to the squalls that have their own importance from different aspects, there may also be at places strong gusty winds whose frequency may be quite high, whose speed may be as high as in the majority of the cases of squalls and whose duration may be many times the duration of the squalls and as such they are also quite significant from the aviation point of view. One of the present authors (1952) made a study of all the types of winds of 20 mph or more that are observed at Allahabad and made a note of the general characteristics of these winds. It is proposed here to make a statistical study of the characteristics of winds of 20 mph or more that are observed at Delhi (Safdarjung aerodrome).

2. Situation of the aerodrome

The Safdarjung aerodrome is located to the south of New Delhi on a slightly undulating plain. The latitude and longitude of the aerodrome are 28° 35′N and 71° 12′ E respectively and its height 696 ft above sea level. The situation of the aerodrome is shown in Fig. 1. The other aerodrome at Palam is at a distance of six and a half miles to the west.

On the eastern side of the aerodrome there is the Jumna river, at a distance of three and a half miles. On the south to the southwestern side, there exist rocky areas of elevation of 1000 ft above sea level at a distance of eight to ten miles.

Towards the northeast and southwest respectively at a distance of about 100 miles from the aerodrome lie the Himalayas running northwest to southeast and the Aravallis running southwest to northeast.

3. General features of wind at Delhi

The general features of the surface winds at Delhi are shown in Fig. 2. They are light to moderate during October to December. The winds show a tendency to increase in strength in January particularly in the afternoon and further increase in the succeeding months. The winds are generally from easterly direction in July throughout the day and night and for some hours in the night in April, May and June. The direction of the wind

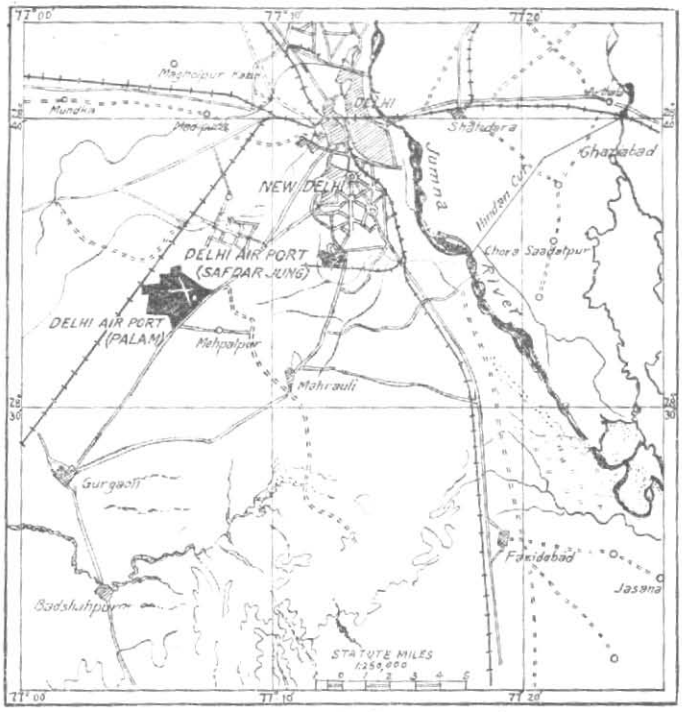

Fig. 1. Situation of the Safdarjung Aerodrome

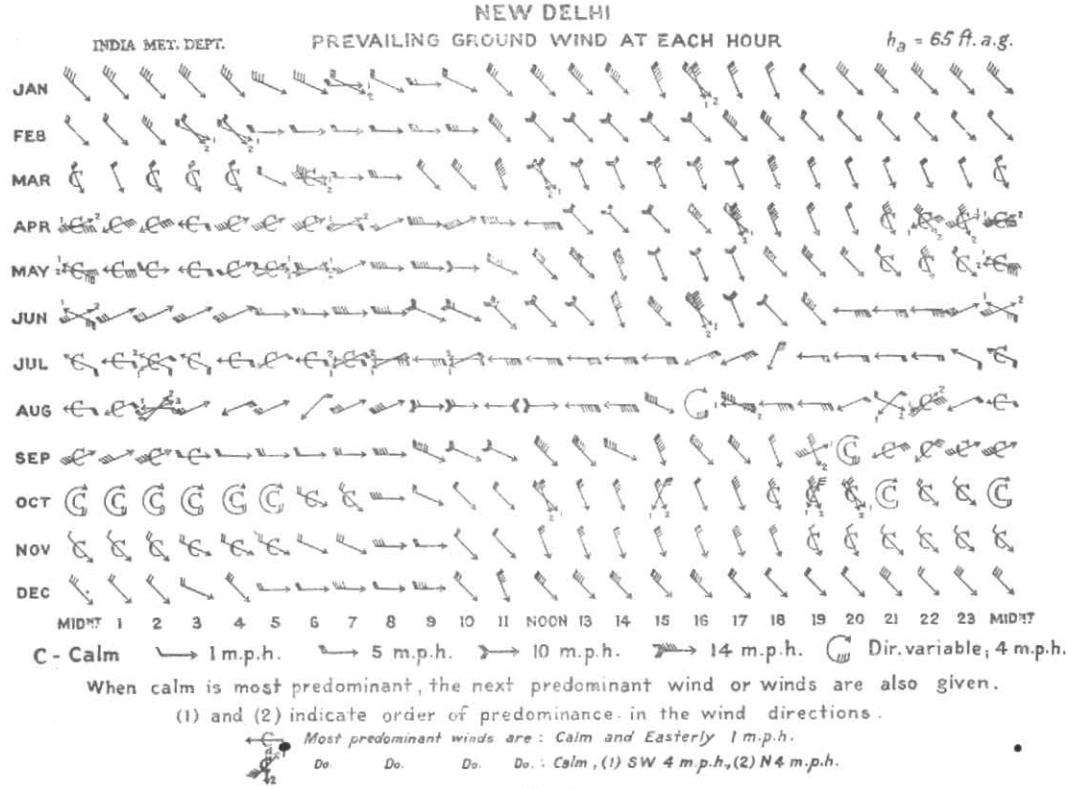

Fig. 2

alternates between east and west in August. During the rest of the year, west to northwest is the general direction of the winds.

4. The data for winds exceeding 20 mph

The data have been collected from the five years' records (1946-50) of the Dine's Pressure Tube Anemograph, installed at the top of the aerodrome building. The head of the anemograph is at a height of 17 ft above the building and 65 ft above the ground.

Occasions when the wind velocity rose to 20 mph or more were noted from the anemograms, together with the highest wind velocity and the corresponding direction. The associated weather was also noted down from the weather diary of the station. When the winds were associated with weather, all such occasions were taken into account, irrespective of the duration of the strong wind. But, when the winds were not associated with weather, only occasions when the winds gusting to 20 mph or more persisted at least for 10 minutes were considered.

On certain days, winds of 20 mph or more have occurred on more than one occasion on the same day. The occasion of the highest wind velocity is incorporated in Table 1, giving the number of days of winds exceeding 20 mph at Delhi. While making further analysis of winds associated with different weather, as in Tables 3, 7 and 10, all the different occasions have been taken into consideration.

5. Winds of 20 mph or more, irrespective of weather

The number of days on which the wind velocity rose to 20 mph or more during the years 1946-50 is shown in Table 1. The main features brought out by this table are—

(*i*) *Number of days*—Winds exceeding 20 mph are observed at Delhi on as many as twenty days on the average in each of the months of May and June, on about eighteen days in April, on about half the days of the months of March, July, August and September. They occur during October to January on five to eight days, November being the month with the least number of days of such winds.

The number of days when winds reach 50 mph or more is, on the average two to three in May, one in each of the months of June and July and one or two in five years in March, April and August.

(*ii*) *Wind velocity*—The highest wind speed reached during the five year period was 70 mph on 20 May 1950.

The upper limit of the wind velocity was in the ranges of 60-70 mph in April, May and June, 50-60 mph in March, July and August and less than 50 mph in other months.

(*iii*) *Wind direction*—Although the direction of the wind of maximum velocity may be in any quadrant, it is mostly east or west in July and more often west in August and September and north or northwest in October. During the other months the winds are more often from some northwesterly direction.

6. Total duration of winds exceeding 20 mph

The number of hours during which winds gusting to 20 mph or more blew from different directions during 1946-50 is shown in Table 2. The total duration of winds exceeding 20 mph is on the average about 600 hours per year, 75 per cent of which is due to winds blowing from the quadrant west to north. Individually, northwest is the direction of longest duration; next comes west, then east and then north, the corresponding percentages being 36, 17 and 12 respectively. During the monsoon period, the easterlies and the westerlies are of the equal durations, while during the hot weather period and also in the remaining months, northwest has the predominant durations.

7. Classification of the strong winds

The occasions of strong winds are classified here into three groups, namely, (*i*) those not being associated with weather excepting dusthaze (during the hot months, particularly in May and June, the winds are laden with thick dust extending upto

TABLE 1

No. of days of winds of 20 mph or more at Delhi during the years 1946—50

Wind Velocity (*mph*)	Wind Direction N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
JANUARY																	
20-29	2	—	—	—	1	2	—	—	3	—	—	—	—	2	9	2	21
30-39	1	—	—	—	1	—	—	—	—	—	—	—	1	—	3	—	6
40-49	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	3	—	—	—	3	2	—	—	3	—	—	—	1	2	12	2	28
FEBRUARY																	
20-29	4	—	1	—	2	—	2	—	1	—	—	—	—	3	10	4	27
30-39	—	1	—	—	2	—	—	—	—	—	3	—	1	—	8	3	18
40-49	2	—	—	—	—	1	1	—	—	—	1	—	—	—	—	—	5
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	6	1	1	—	4	1	3	—	1	—	4	—	1	3	18	7	50
MARCH																	
20-29	8	2	1	—	1	—	1	1	3	—	—	—	1	—	14	4	36
30-39	5	—	1	—	1	—	1	—	3	1	1	—	4	1	13	6	37
40-49	1	—	—	—	1	—	—	—	—	—	—	—	1	—	1	1	5
50-59	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	14	2	2	—	3	—	2	1	6	1	1	—	7	1	28	11	79
APRIL																	
20-29	6	—	—	—	2	—	—	—	2	—	2	—	6	—	10	2	30
30-39	4	—	1	—	2	—	3	—	—	1.	3	2	6	2	23	2	49
40-49	1	—	—	—	1	—	—	—	—	—	—	—	3	—	2	1	8
50-59	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1
60-70	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Total	12	—	1	—	5	1	3	—	2	1	5	2	15	2	35	5	89
MAY																	
20-29	5	—	—	—	4	—	5	—	4	—	2	—	2	2	5	1	30
30-39	2	1	2	—	4	—	—	—	—	—	2	2	8	—	11	10	42
40-49	2	—	2	—	2	—	—	—	1	—	4	—	2	—	2	—	15
50-59	3	—	—	—	—	—	1	—	—	—	2	—	1	—	1	—	8
60-70	1	—	1	—	—	—	—	—	—	—	1	—	1	—	—	—	4
Total	13	1	5	—	10	—	6	—	5	—	11	2	14	2	19	11	99
JUNE																	
20-29	3	—	1	—	1	—	—	1	—	1	1	—	5	1	7	2	23
30-39	7	—	—	—	2	1	1	—	1	—	3	1	17	2	15	2	52
40-49	8	—	1	—	—	—	—	—	2	—	2	—	3	1	8	—	25
50-59	3	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	4
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Total	21	—	2	—	3	1	1	1	3	1	6	1	25	4	31	5	105

Table 1 (*contd*)

Wind Velocity (*mph*)	Wind Direction N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
JULY																	
20-29	—	—	2	1	11	—	2	—	5	—	—	—	5	—	2	1	29
30-39	5	—	2	—	8	—	2	—	6	—	1	1	9	—	1	—	35
40-49	2	—	2	—	1	—	—	—	—	—	1	—	4	—	2	1	13
50-59	—	—	—	—	—	—	—	—	2	—	—	—	1	—	1	—	4
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	7	—	6	1	20	—	4	—	13	—	2	1	19	—	6	2	81
AUGUST																	
20-29	6	—	4	—	4	—	3	—	3	—	4	1	18	—	2	—	45
30-39	6	—	—	—	7	—	2	—	1	—	—	—	4	—	1	—	21
40-49	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
50-59	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	13	—	4	—	12	—	5	—	4	—	4	1	22	—	3	—	68
SEPTEMBER																	
20-29	4	—	3	—	3	—	1	—	1	—	2	—	15	2	3	1	35
30-39	2	1	3	—	8	—	2	—	4	—	—	—	8	1	—	—	29
40-49	—	—	—	—	2	—	—	—	—	—	1	—	1	—	—	—	4
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	6	1	6	—	13	—	3	—	5	—	3	—	24	3	3	1	68
OCTOBER																	
20-29	6	—	—	—	2	—	1	1	—	—	1	1	1	2	7	4	26
30-39	4	—	1	—	1	—	1	—	—	1	—	—	3	—	2	—	13
40-49	1	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	3
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	11	—	1	—	3	—	2	1	—	1	1	1	4	3	10	4	42
NOVEMBER																	
20-29	—	—	—	—	1	—	1	—	1	—	—	—	—	3	15	—	21
30-39	—	—	—	—	—	—	2	—	—	—	—	—	—	—	1	—	3
40-49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	1	—	3	—	1	—	—	—	—	3	16	—	24
DECEMBER																	
20-29	5	—	2	—	1	—	2	—	—	—	—	—	1	2	16	1	30
30-39	1	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	4
40-49	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	6	—	2	—	1	—	2	—	—	—	—	—	2	2	19	1	35

TABLE 2

Total hours of duration from different directions of winds of 20 mph or more at Delhi during the years 1946—50

Month	Wind Direction																	Total
	Variable	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	
Jan	—	5	—	2	—	9	3	2	—	2	—	—	—	—	6	41	5	75
Feb	—	8	5	—	—	28	9	5	—	—	—	7	—	13	10	121	32	238
Mar	2	62	5	17	—	23	1	10	2	17	—	1	—	20	10	189	53	412
Apr	—	47	—	6	7	16	1	26	1	7	—	10	10	44	12	203	29	419
May	10	20	4	7	2	60	—	23	—	20	—	13	7	91	18	108	70	453
Jun	4	37	—	4	—	16	—	8	1	13	7	6	1	129	57	249	30	562
Jul	3	11	—	10	—	70	—	2	1	11	2	4	—	84	—	11	10	219
Aug	2	17	—	1	—	46	—	1	—	2	—	1	2	68	2	5	—	147
Sep	3	9	1	6	—	78	—	8	—	8	—	3	—	65	13	6	—	200
Oct	2	20	—	2	—	4	—	2	—	2	—	—	—	1	9	32	11	85
Nov	—	—	—	—	—	2	—	9	—	3	—	—	—	—	10	56	—	80
Dec	—	18	—	2	—	1	—	6	—	—	—	—	—	—	8	70	5	110
Year	26	254	15	57	9	353	14	102	5	85	9	45	20	515	155	1091	245	3000

10,000/12,000 ft), (*ii*) those associated with rain or thundery conditions (mostly the cases of rain without thunderstorm; at few cases when lightning was seen, but no thunder or rain was observed, are included in this group) and (*iii*) those associated with duststorms or thunderstorms with or without rain.

The characteristics of the winds of the above three groups are summarised in the following sections.

8. Winds exceeding 20 mph, not associated with weather

The statistics regarding the number of occasions of such winds, their directions and speed are given in Table 3.

(*i*) *Number of occasions*—Winds exceeding 20 mph and not being associated with weather, excepting dusthaze, are observed on sixteen to twenty occasions on the average in each of the months from March to June. They occur on seven to ten occasions in February, July, August, September, October and December and on five occasions in November and January.

(*ii*) *Wind velocity*—Barring an isolated case in July, the maximum wind velocity of this group of winds does not rise beyond 45 mph. In the months of August, November, December and January the maximum velocity does not even reach 40 mph.

(*iii*) *Wind direction*—The winds are mostly from west to northwest direction. There is, however, equal chance of easterly direction in July and equal chance of northerly direction in October.

(*iv*) *Time of commencement*—These winds grouped according to their times of commencement are shown for different months in Table 4. They commence more often at about 1100 or 1200 IST during the period from October to January and at about 1000 or 1100 IST in February, March and April. On a number of occasions in April they may even commence at 0800 IST. During the months from May to September the winds often begin at 0700 or 0800 IST. In the months of May and June, winds exceeding 20 mph may in a few cases start even at about 0200 IST and continue till about 1800 IST.

(*v*) *Duration*—The frequencies of the winds of different durations are worked out in Table 5. Although, on occasions, winds exceeding 20 mph and not being associated with weather may continue for about fifteen hours and sometimes may not last even for more than half an hour, their durations are, however, more often

TABLE 3

No. of occasions of winds of 20 mph or more at Delhi during the years 1946—50
(Not associated with weather)

Wind Velocity (*mph*)	Wind Direction N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
JANUARY																	
20-29	2	—	—	—	—	2	—	—	2	—	—	—	—	2	9	2	19
30-39	—	—	—	—	—	—	1	—	—	—	—	—	1	—	3	—	5
40-49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	2	—	—	—	—	2	1	—	2	—	—	—	1	2	12	2	24
FEBRUARY																	
20-29	3	—	1	—	3	—	2	—	—	—	—	—	—	3	11	4	27
30-39	—	1	—	—	2	—	—	—	—	—	1	—	1	—	11	3	19
40-49	1	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	3
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	4	1	1	—	5	1	3	—	—	—	1	—	1	3	22	7	49
MARCH																	
20-29	11	2	1	—	3	—	2	—	2	—	—	—	1	—	16	4	42
30-39	5	—	1	—	1	—	—	—	4	—	1	—	4	—	15	5	36
40-49	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1	1	3
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	16	2	2	—	5	—	2	—	6	—	1	—	5	—	32	10	81
APRIL																	
20-29	8	—	—	1	1	1	1	1	2	—	2	—	7	—	11	2	37
30-39	3	1	—	—	1	—	3	—	1	—	3	—	6	2	23	2	45
40-49	1	—	—	1	—	—	—	—	—	—	—	—	2	—	2	1	7
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	12	1	—	2	2	1	4	1	3	—	5	—	15	2	36	5	89
MAY																	
20-29	7	—	—	—	5	—	7	—	3	—	1	1	4	3	9	1	41
30-39	2	—	4	—	6	—	—	—	2	—	1	2	14	—	13	10	54
40-49	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	2
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	9	—	4	—	11	—	7	—	5	—	2	3	19	3	23	11	97
JUNE																	
20-29	2	—	1	—	5	—	1	—	2	1	1	—	8	3	9	2	35
30-39	5	—	—	—	2	—	1	—	—	—	—	—	15	2	19	4	48
40-49	2	—	—	—	—	—	—	—	—	—	—	—	1	1	6	—	10
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	9	—	1	—	7	—	2	—	2	1	1	—	24	6	34	6	93

TABLE 3 (*contd*)

Wind Velocity (*mph*)	Wind Direction N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
JULY																	
20-29	2	—	—	1	10	—	—	—	3	—	1	—	7	—	3	—	27
30-39	—	—	—	—	5	—	—	—	3	—	—	—	7	—	2	—	17
40-49	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—	1	3
50-59	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	2	—	—	1	16	—	—	—	6	—	1	—	16	—	5	1	48
AUGUST																	
20-29	—	—	1	—	4	—	—	—	1	—	—	1	15	—	1	—	23
30-39	—	—	—	—	5	—	—	—	—	—	—	—	4	—	—	—	9
40-49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	1	—	9	—	—	—	1	—	—	1	19	—	1	—	32
SEPTEMBER																	
20-29	2	—	1	—	3	—	—	—	—	—	—	—	15	1	2	—	24
30-39	1	1	—	—	3	—	—	—	2	—	—	—	6	1	—	—	14
40-49	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	3	1	1	—	7	—	—	—	2	—	—	—	21	2	2	—	39
OCTOBER																	
20-29	5	—	—	—	1	—	1	—	1	—	—	—	2	2	8	4	24
30-39	4	—	1	—	—	—	1	—	1	—	—	—	1	—	2	—	10
40-49	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	2
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	10	—	1	—	1	—	2	—	2	—	—	—	3	3	10	4	36
NOVEMBER																	
20-29	—	—	—	—	1	—	—	—	1	—	—	—	—	3	14	—	19
30-39	—	—	—	—	—	—	2	—	—	—	—	—	—	—	1	—	3
40-49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	1	—	2	—	1	—	—	—	—	3	15	—	22
DECEMBER																	
20-29	6	—	1	—	1	—	2	—	—	—	—	—	—	2	16	1	29
30-39	1	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	4
40-49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	7	—	1	—	1	—	2	—	—	—	—	—	—	2	19	1	33

TABLE 4

Frequency of time of commencement of winds of 20 mph or more at Delhi during 1946—50

(Not associated with weather)

Month	Hours (IST) 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	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	Total
Jan	—	—	—	—	—	—	—	—	—	—	3	8	11	1	—	—	—	—	1	—	—	—	—	—	24
Feb	1	2	—	—	1	—	—	1	3	3	12	10	9	3	2	—	—	—	—	—	—	1	—	1	49
Mar	2	4	1	1	1	—	—	1	2	7	22	12	5	7	3	2	—	2	—	2	2	1	3	1	81
Apr	2	1	2	1	—	—	1	—	12	9	9	18	11	11	5	—	—	1	—	—	3	—	1	2	89
May	2	2	2	6	2	3	3	13	10	3	6	6	9	4	9	4	1	2	1	3	2	2	1	1	97
Jun	1	1	2	3	1	2	9	14	17	8	3	8	5	3	1	—	1	3	1	2	5	1	1	1	93
Jul	—	2	1	1	—	—	1	9	3	7	5	1	2	1	4	2	1	4	1	—	—	—	1	2	48
Aug	—	—	—	—	—	—	—	6	14	1	5	—	1	1	—	1	—	2	—	—	—	—	—	1	32
Sep	—	—	2	—	—	—	—	—	13	7	5	2	2	2	2	2	—	—	1	—	—	1	—	—	39
Oct	—	—	—	—	—	1	—	1	2	2	4	4	9	5	3	—	2	1	—	1	—	1	—	—	36
Nov	—	—	—	—	—	—	—	—	—	—	2	7	7	2	2	1	—	—	—	1	—	—	—	—	22
Dec	—	—	—	—	—	1	—	—	—	1	5	13	10	3	—	—	—	—	—	—	—	—	—	—	33
Year	8	12	10	12	5	7	14	45	76	48	81	89	81	43	31	12	5	15	5	9	12	7	7	9	643

TABLE 5

Duration of winds of 20 mph or more at Delhi during 1946—50

(Not associated with weather)

Month	Duration in hours: Less than ½	½–1	1–2	2–3	3–5	5–7	7–10	10–15	15–20	Total
Jan	2	—	7	3	9	3	—	—	—	24
Feb	2	3	3	4	12	14	9	2	—	49
Mar	4	5	7	12	12	21	17	3	—	81
Apr	5	4	12	4	27	15	17	4	1	89
May	6	7	15	16	19	14	13	5	2	97
Jun	3	6	13	11	18	10	15	14	3	93
Jul	6	8	7	4	13	4	4	1	1	48
Aug	6	2	3	6	7	5	2	1	—	32
Sep	4	2	8	11	6	5	3	—	—	39
Oct	6	4	3	13	9	—	1	—	—	36
Nov	1	—	2	5	8	6	—	—	—	22
Dec	1	2	6	2	15	7	—	—	—	33
Year	46	43	86	91	155	104	81	30	7	643

from three to five hours. In the month of June, also in March, April and May, the duration is seven to ten hours on a number of occasions. To quote two examples of unusually long duration, it may be mentioned that winds exceeding 20 mph blew from some easterly direction between 0200 and 1800 IST on 11 April 1946 and from westerly direction from 0230 to 1820 IST on 14 May 1946.

(*vi*) *Time of maximum gusts*—The time of occurrence of the maximum gusts is shown in Table 6. The maximum gusts occur more frequently at about 1300 IST during the period from October to January and at about 1400 IST during the months of February to May. The time of occurrence of the maximum gusts shifts to about 1000 IST in June, to about 0800 IST in July and August and to about 0900 IST in September.

9. Winds exceeding 20 mph, associated with rain or thundery conditions

The number of occasions of winds exceeding 20 mph in association with rain or thundery conditions, and the wind direction and speed of the maximum wind are indicated in Table 7.

(*i*) *Number of occasions*—Winds exceeding 20 mph and being accompanied with rain or thundery conditions are experienced on six to seven occasions on the average in the months of July, August and September and on one to two occasions in February, March, May and June. During the remaining months, they may occur once in two years on the average.

(*ii*) *Wind velocity*—Although, the maximum wind velocity in an isolated extreme case, may go beyond 50 mph, it is generally within the limit of 45 mph as in the case of winds unassociated with weather.

(*iii*) *Wind direction*—The direction of the wind is more often southwest in March and north in June and August. During the rest of the year, the winds are more frequently from some easterly direction.

(*iv*) *Time of commencement*—The frequency of the time of occurrence of this group of winds is shown in Table 8. These winds may occur at any hour of the day, although there is a greater tendency of their occurrence at noon during March, in the forenoon in July, both in forenoon and afternoon in September and in the afternoon and evening in May and June.

TABLE 6

Frequency of the time of occurrence of maximum wind velocity during 1946—50

(*Not associated with weather*)

Month	Hours (IST)																								
	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	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	Total
Jan	—	—	—	—	—	—	—	—	—	—	—	3	8	2	9	1	—	—	—	1	—	—	—	—	24
Feb	1	—	2	—	—	—	—	1	—	—	3	3	9	6	14	6	2	—	—	1	—	—	—	1	49
Mar	1	1	2	6	1	1	1	—	—	3	2	7	8	9	16	7	4	3	1	1	1	1	1	4	81
Apr	4	1	2	—	1	—	—	1	2	4	5	5	8	18	20	10	4	1	—	1	1	—	—	1	89
May	1	2	0	1	5	2	2	5	6	7	6	4	6	6	12	8	8	5	—	1	2	5	2	1	97
Jun	—	1	—	—	3	—	—	2	9	13	13	11	7	6	7	4	4	2	2	2	2	2	2	1	93
Jul	—	2	—	—	—	—	—	2	8	5	5	2	3	3	6	1	1	4	1	2	0	—	1	2	48
Aug	—	—	—	1	—	—	—	—	8	6	3	4	1	2	1	2	—	2	—	—	—	—	—	—	32
Sep	—	—	—	—	—	—	1	—	4	10	5	4	2	2	4	5	—	—	1	—	—	1	—	—	39
Oct	—	—	—	—	—	1	—	—	1	1	2	2	7	9	5	2	2	1	1	1	—	1	—	—	36
Nov	—	—	—	—	—	—	—	—	—	—	—	4	5	7	3	2	—	—	—	1	—	—	—	—	22
Dec	—	1	—	—	—	—	1	—	—	—	1	4	11	9	4	2	—	—	—	—	—	—	—	—	33
Year	7	8	6	8	10	4	5	11	38	49	47	53	75	79	101	50	25	18	6	11	6	10	6	10	643

TABLE 7

No. of occasions of winds of 20 mph or more at Delhi during the years 1946—50

(Associated with rain or thundery conditions)

Wind Velocity (mph)	Wind Direction N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
JANUARY																	
20-29	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
30-39	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
40-49	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	3
FEBRUARY																	
20-29	—	—	—	—	—	—	—	—	1	—	2	—	—	—	—	—	3
30-39	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	2
40-49	1	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	2
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	1	—	—	—	—	—	—	—	1	—	5	—	—	—	—	—	7
MARCH																	
20-29	1	—	—	—	1	—	1	—	—	—	—	—	1	—	—	—	4
30-39	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	1	3
40-49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	1	—	—	—	1	—	3	—	—	—	—	—	1	—	—	1	7
APRIL																	
20-29	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
30-39	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1
40-49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
50-59	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	1	1	—	—	—	—	—	—	—	1	—	—	—	3
MAY																	
20-29	1	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—	4
30-39	1	—	1	—	—	—	—	—	2	—	—	—	1	—	—	—	5
40-49	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	2	—	1	—	—	—	—	—	5	—	1	—	1	—	—	—	10
JUNE																	
20-29	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	2
30-39	2	—	—	—	1	1	—	—	1	—	1	—	1	—	—	—	7
40-49	2	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	3
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	4	—	—	—	1	1	—	1	2	—	1	—	1	—	1	—	12

TABLE 7 *(contd)*

Wind Velocity (*mph*)	Wind Direction N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
JULY																	
20-29	1	—	2	—	12	—	1	—	1	—	—	—	2	—	1	—	20
30-39	4	—	2	—	4	—	—	—	1	—	—	—	—	—	—	—	11
40-49	1	—	—	—	—	—	—	—	—	—	—	—	3	—	1	—	5
50-59	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	6	—	4	—	16	—	1	—	3	—	—	—	5	—	2	—	37
AUGUST																	
20-29	5	—	3	—	—	—	3	—	2	—	5	—	4	—	1	—	23
30-39	1	—	—	—	—	—	2	—	1	—	—	—	—	—	1	—	5
40-49	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	8	—	3	—	—	—	5	—	3	—	5	—	4	—	2	—	30
SEPTEMBER																	
20-29	—	—	2	—	3	—	1	—	1	—	1	—	3	—	—	1	12
30-39	1	—	1	—	6	—	2	—	2	—	—	—	1	—	—	—	13
40-49	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—	—	2
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	1	—	3	—	10	—	3	—	3	—	1	—	5	—	—	1	27
OCTOBER																	
20-29	—	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	2
30-39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
40-49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	2
NOVEMBER																	
20-29	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1
30-39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
40-49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1
DECEMBER																	
20-29	—	—	1	—	—	—	—	—	—	—	—	—	1	—	—	—	2
30-39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
40-49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	1	—	—	—	—	—	—	—	—	—	1	—	—	—	2

TABLE 8

Frequency of time of commencement of winds of 20 mph or more at Delhi during 1946—50

(Associated with rain or thundery conditions)

Month	Hours (IST)																							Total
	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9 10	10-11	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	
Jan	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	1	—	—	—	—	—	—	—	3
Feb	—	1	1	—	—	—	1	—	—	—	1	1	—	—	—	—	—	—	—	1	—	1	—	—	7
Mar	—	—	—	—	—	—	1	1	—	—	—	—	3	—	—	—	1	—	—	1	—	—	—	—	7
Apr	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	3
May	1	1	1	—	1	—	—	—	—	—	—	—	—	—	—	—	1	—	2	—	—	1	2	—	10
Jun	2	—	—	—	—	—	—	—	1	1	—	—	—	1	—	—	2	—	1	—	—	3	—	1	12
Jul	—	1	1	—	1	1	1	1	—	5	4	3	2	2	2	1	2	2	2	1	2	1	—	2	37
Aug	—	—	—	1	—	1	—	2	—	4	—	3	—	3	1	2	4	1	2	1	3	2	—	—	30
Sep	1	—	1	—	1	1	2	1	2	—	1	3	2	—	—	6	1	3	1	—	1	—	—	—	27
Oct	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	2
Nov	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1
Dec	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1	—	—	—	2
Year	4	3	4	1	4	3	5	5	3	11	7	10	9	6	3	10	13	6	9	4	7	8	3	3	141

(*v*) *Duration*— Table 9 indicates the duration of these winds. The duration is more frequently less than half an hour during the six months from July to December. The winds may, however, continue for five to ten hours on occasions in July, August and September. In August 1948, winds exceeding 20 mph from northerly direction continued for nineteen hours commencing from 0900 IST on 23rd and lasting till 0400 IST on the next day.

During the remaining six months, the winds of this type generally do not last for more than three hours.

10. Winds exceeding 20 mph in association with duststorm or thunderstorm

The figures regarding the number of occasions of such winds, their maximum speed and direction are shown in Table 10.

(*i*) *No. of occasions*—The number of occasions of winds exceeding 20 mph in association with duststorm or thunderstorm is seven to eight per year in May and June. It is four to five in July and two to three in March, April, August, September and October. These winds are absent in November and may occur once in one or two years in the remaining months of December, January and February.

(*ii*) *Wind velocity*—The highest wind velocity in association with duststorms and thunderstorms during 1946-50 was 70 mph, recorded at 1730 IST on 20 May 1950.

The wind velocity in association with duststorms or thunderstorms often rises to 40-50 mph and on some occasions to 60-70 mph in the months of May and June. In the other months, although the wind velocity may exceed 50 mph, it is generally within the limit of 45 mph. In the month of January and February, the wind speed did not even reach 40 mph.

(*iii*) *Wind direction*—In the month of January, the wind direction is from northwest to north or from south and in February it is from north to northeast or east to southeast. In March, the direction lies either in the west to north quadrant or east to south quadrant and in April in the other quadrants of either north to east or south to west. In the months of May and June the direction may lie in any quadrant, but the most frequent directions are southwest to west or northwest to north. Winds of 50 mph or more are also mostly from these directions. In the months of July and September also the maximum wind may blow from any direction, although the direction is more often from west or south

TABLE 9

No. of occasions with different duration of winds of 20 mph or more at Delhi during 1946—50

(Associated with rain or thundery conditions)

Month	Duration in hours (with rain)									Total
	Less than ½	½–1	1–2	2–3	3–5	5–7	7–10	10–15	15–20	
Jan	—	1	1	1	—	—	—	—	—	3
Feb	2	1	2	2	—	—	—	—	—	7
Mar	—	1	—	3	—	3	—	—	—	7
Apr	—	2	—	—	—	1	—	—	—	3
May	5	3	—	2	—	—	—	—	—	10
Jun	5	—	5	1	1	—	—	—	—	12
Jul	13	5	9	3	2	4	1	—	—	37
Aug	19	6	1	1	2	—	—	—	1	30
Sep	11	2	1	2	5	4	—	2	—	27
Oct	2	—	—	—	—	—	—	—	—	2
Nov	1	—	—	—	—	—	—	—	—	1
Dec	2	—	—	—	—	—	—	—	—	2
Year	60	21	19	15	10	12	1	2	1	141

in July and southwest or northeast in September. In August the direction is more often east or north and in October it is either in the north to east or south to west quadrant. An isolated case of this type of wind recorded in December had westerly direction.

(*iv*) *Time of commencement*—Table 11 shows the time of commencement for this group of winds. There is no specific time of commencement of the winds in January. One of the time of occurrence, however, appears to be about 2000 IST. In the months of February, March and April, the winds commence more often in the three hours interval beginning at 2000, 1900 and 1800 IST respectively in the three successive months. In May, the winds may start at any time of the day or night, although they mostly begin between 1400 and 1900 IST. They more often commence between 1300 and 1900 IST in June, between 1200 and 1800 IST in July, between 1100 and 1800 IST in August and between 1300 and 1600 IST in September and they may also occur at night during these months. The cases in October occurred between 1400 and 2100 IST and the isolated case in December at 1400 IST.

(*v*) *Duration*—Table 12 indicates duration of these winds. Duration of the winds exceeding 20 mph, in association with duststorms or thunderstorms is less than half an hour in January and February. The duration is more often less than half an hour also in the months of March, April, July, August, September and October but in these months the duration may be as long as about five hours in a few cases. During May and June, the duration is more often one to two hours and increases to five to seven hours in some cases.

11. Synoptic situations associated with strong winds

(*i*) *Situations causing strong winds without weather (excepting dusthaze)*—Winds of this type are observed to blow over Delhi predominantly from the northwesterly direction. They are also observed on a large number of occasions from westerly, northerly and easterly directions.

The northwesterly direction is connected with the eastward passage of some of the western disturbances through the Punjab (I) and neighbourhood. Conditions for occurrence of the strong winds are favourable when the disturbance is fairly active, no fresh western disturbance immediately

TABLE 10

No. of occasions of wind velocity of 20 mph or more at Delhi during the years 1946–50

(Associated with duststorms or thunderstorms)

Wind Velocity (*mph*)	Wind Direction																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
JANUARY																	
20-29	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	2
30-39	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
40-49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	1	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	3
FEBRUARY																	
20-29	1	—	1	—	1	1	—	—	1	—	—	—	—	—	—	—	5
30-39	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1
40-49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	1	—	1	—	1	1	1	—	1	—	—	—	—	—	—	—	6
MARCH																	
20-29	2	—	—	—	2	—	—	—	2	—	—	—	—	—	—	—	6
30-39	1	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	3
40-49	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	2
50-59	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	4	—	—	—	2	—	1	—	2	1	—	—	2	—	—	—	12
APRIL																	
20-29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
30-39	1	—	2	1	1	—	—	—	—	1	1	1	1	—	—	—	9
40-49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50-59	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
60-70	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Total	2	—	2	1	2	—	—	—	—	1	1	1	1	—	—	—	11
MAY																	
20-29	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	2
30-39	1	2	—	—	1	—	—	—	1	—	1	—	1	—	1	—	8
40-49	3	—	2	—	2	—	—	—	1	1	4	—	1	—	1	—	15
50-59	3	—	—	—	—	—	1	—	—	—	2	—	1	—	1	—	8
60-70	1	—	1	—	—	—	—	—	—	—	1	—	1	—	—	—	4
Total	8	2	3	—	3	—	2	—	2	1	9	—	4	—	3	—	37
JUNE																	
20-29	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
30-39	1	—	—	—	1	—	—	—	1	—	4	1	1	2	1	—	12
40-49	6	—	1	—	—	—	—	—	2	—	2	—	3	—	3	—	17
50-59	3	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	4
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Total	11	—	1	—	1	—	—	—	3	—	6	1	4	2	5	1	35

TABLE 10 (*contd*)

Wind Velocity (*mph*)	Wind Direction																Total
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	
JULY																	
20-29	—	—	—	—	—	—	1	—	1	—	—	—	3	—	—	1	6
30-39	1	—	1	—	—	—	2	—	2	—	1	1	2	—	—	—	10
40-49	1	—	2	—	—	—	—	—	—	—	1	—	—	—	1	—	5
50-59	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	2
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	2	—	3	—	—	—	3	—	4	—	2	1	5	—	2	1	23
AUGUST																	
20-29	1	—	—	—	3	—	1	—	—	—	—	—	1	—	1	—	7
30-39	4	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	6
40-49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50-59	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	5	—	—	—	6	—	1	—	—	—	—	—	1	—	1	—	14
SEPTEMBER																	
20-29	2	—	1	—	—	—	1	—	1	—	2	—	—	1	1	—	9
30-39	—	—	2	—	2	—	—	—	1	—	—	—	1	—	—	—	6
40-49	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	2	—	3	—	2	—	1	—	2	—	3	—	1	1	1	—	16
OCTOBER																	
20-29	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	2
30-39	1	—	1	—	1	—	—	—	—	1	—	—	2	—	—	—	6
40-49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	1	—	1	—	2	—	—	—	—	1	1	—	2	—	1	—	9
NOVEMBER																	
20-29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
30-39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
40-49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
DECEMBER																	
20-29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
30-39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
40-49	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
50-59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1

TABLE 11

Frequency of time of commencement of winds of 20 mph or more at Delhi during 1946—50

(Associated with duststorms or thunderstorms)

Month	Hours (IST)																								Total
	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	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	
Jan	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—	—	3
Feb	1	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	1	—	2	—	6
Mar	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	1	3	2	2	1	1	12
Apr	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	3	1	5	—	—	1	11
May	2	1	—	—	—	1	—	2	—	1	1	1	1	1	3	6	1	7	2	1	1	1	2	2	37
Jun	—	2	—	1	1	2	—	—	—	—	—	—	—	2	2	8	5	5	3	1	—	2	1	—	35
Jul	2	—	1	2	1	—	—	—	—	—	—	—	1	1	3	4	3	1	—	—	2	—	2	—	23
Aug	—	—	1	—	—	—	—	—	—	—	—	2	—	2	1	2	3	2	—	—	1	—	—	—	14
Sep	1	—	2	—	—	—	—	—	2	—	—	—	—	1	5	3	—	1	—	—	1	1	—	—	16
Oct	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	3	—	1	1	—	—	—	—	—	9
Nov	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
Dec	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1
Year	7	3	4	3	2	3	—	2	3	1	1	3	4	8	19	26	12	18	10	6	14	6	8	4	167

TABLE 12

No. of occasions with different duration of winds of 20 mph or more at Delhi during 1946—50

(Associated with duststorms or thunderstorms)

Month	Duration in hours									Total
	Less than ½	½–1	1–2	2–3	3–5	5–7	7–10	10–15	15–20	
Jan	3	—	—	—	—	—	—	—	—	3
Feb	6	—	—	—	—	—	—	—	—	6
Mar	7	1	1	2	—	1	—	—	—	12
Apr	3	2	2	1	1	2	—	—	—	11
May	4	7	12	5	4	4	—	1	—	37
Jun	5	3	10	8	9	—	—	—	—	35
Jul	11	7	3	2	—	—	—	—	—	23
Aug	10	—	1	2	1	—	—	—	—	14
Sep	6	4	3	1	—	2	—	—	—	16
Oct	4	2	—	1	1	1	—	—	—	9
Nov	—	—	—	—	—	—	—	—	—	0
Dec	—	—	—	1	—	—	—	—	—	1
Year	59	26	32	23	16	10	—	1	—	167

overtakes the previous disturbance and no residual or induced low remains over the northern Punjab and neighbourhood. An elongated low extending from the Punjab-Kumaon hills to Bihar also presents a situation of strong winds.

Westerly winds are observed mostly in the hot weather months and during the monsoon period. During the hot weather period steep pressure gradient over Sind and Rajasthan results in these winds. An elongated trough extending from Baluchistan to the Punjabs also causes strong winds on successive days. Strong westerly winds during the monsoon period are generally associated with weak monsoon. During the weak monsoon period in August 1950, westerly winds gusting to 20 to 30 mph blew over Delhi for about ten days in succession commencing at about 0800 IST and lasting for two to four hours each day. In September 1946,

westerly winds gusting to 25 to 35 mph commencing at 0800 IST and lasting for two to five hours continued over Delhi for thirteen days in succession.

Winds from the northerly direction are more often observed in March. They are also observed on a number of occasions in the period from April to June and in October and December. Northerly winds in October and December mostly occur during the day time while those during the summer months occur mostly during the night time. Strong northerly winds in the summer months may occur when a fairly active western disturbance passes away through the Punjab-Kumaon hills in the evening or a prominent duststorm or thunderstorm passes in the vicinity of the station. Winds connected with the western disturbances may continue for seven or eight hours while those connected with the duststorm or thunderstorm may last for one to three hours. The northerly winds in October and December may be due to onrush of the Sub-Himalayan air in connection with the eastward passage of a low pressure system.

Strong winds of easterly direction are more often observed during the active monsoon periods in association with the westward passage of the monsoon depressions from the Bay of Bengal. Gusty winds from east to southeast are also observed in connection with the western disturbances when a well-marked low develops over the Punjabs or a trough extends practically from the Peninsula to the Punjabs with a low over the Punjabs and a secondary over Rajasthan or further south.

Strong dust raising winds from west to northwest during day time in the summer culminate into duststorms or thunderstorms in the afternoon or evening on some days. Similarly strong gusty winds from some easterly direction may also result in rain or thundershowers, particularly during the winter period and beginning of the summer.

(*ii*) *Situations causing weather that may be accompanied with strong winds*—During the winter period, weather occurs over Delhi in connection with some of the western disturbances or their secondaries. In the beginning of the winter many of the western disturbances pass way without producing weather over Delhi. Rain or thundershower occurs over Delhi when an active western disturbance moves eastwards through the Punjabs and induces a secondary over Rajasthan and they are preferably fed with the inflow of the moist air from the Bay of Bengal. In connection with the western disturbances of the winter period, weather generally does not occur over Delhi without its preoccurrence in the west or northwest. On some occasions, thunderstorms from northwest may affect Delhi in the evening and some milder weather from west in the morning. On 15 January 1949, a thunderstorm reported earlier by a pilot to the northwest of Delhi came over Delhi at 1930 IST. Clouds dissolved by midnight but sky again became overcast and assumed threatening appearance on the next morning due to some effect from the west, which was marked earlier by occurrence of thunderstorm at Jodhpur. Sometimes thunderstorm to the westnorthwest at Hissar at night affects Delhi at late night or in the morning. On the 10-11th night of February 1949, a thunderstorm with quarter inch of rain was recorded only by the observatory at Hissar. There were thundery conditions at Delhi on the next morning with a squall of 45 mph from northnorthwest at about 0730 IST. If Karachi gets rain or drizzle, Delhi is very likely to have rain or thundershower.

During the summer months, particularly the earlier ones, duststorms or thunderstorms at Delhi occur in association with the western disturbances or their secondaries in the manner as described for winter period. A western disturbance may also pass directly through Rajasthan and cause the duststorm or thunderstorm. A trough line near Delhi observed by the upper wind shift at 10,000 and 12,000 ft is also a factor for anticipation of the weather.

Although, moderate to strong northwesterly winds over Delhi are suggestive of fair weather during the winter period, such winds in association with southeast to south upper winds near Bikaner are generally followed by duststorms or thunderstorms in the evening or night during the summer months. Onse

of fresh winds from southwest to west particularly in the later summer months results in duststorms and thunderstorms in the afternoon or evening. Strong surface winds during the day time particularly in the months of May and June when dry adiabatic or super adiabatic lapse rate exists over the area upto 10,000 to 15,000 ft cause thick dusthaze extending upto 10,000 to 12,000 ft. Appearance of thick dusthaze upto high level is followed by duststorm or thunderstorm in a day or two. Sometimes the duststorm or thunderstorm may occur after three or four days when other conditions are not favourable. The cumulonimbus clouds causing these duststorms have generally the bases near about the upper levels of the haze layer and may be caused by the heating of the upper levels of the dusthaze.

On some occasions during the summer months, the duststorm or thunderstorm may occur over Delhi without any previous indications. On a number of occasions, however, the duststorm or thunderstorm is observed earlier in the northwest or north at Hissar and Ambala and in the southwest to west in the Jaipur-Bikaner section. Rewari, about 50 miles to the southwest of Delhi often reports occurrence of duststorms or thunderstorms one or two hours before Delhi gets them. The duststorms or thunderstorms when reported by Jaipur alone, may sometimes affect Delhi and at other times may pass south of Delhi. The duststorms or thunderstorms occurring in the Delhi-Jaipur section in the hot summer evening generally move to the east to the Lucknow-Kanpur sector at late night or early morning and die off there.

During the monsoon period, one of the factors affecting weather at Delhi is the depressions that develop in the Bay of Bengal and move in the west or northwest direction. All these depressions, however, do not produce weather over Delhi. Those coming very near Delhi or recurving through, or north of Delhi produce marked weather. Sometimes a low pressure wave moving from west to east apparently makes an arc of convergence which is marked by heavy rain along the arc. Sharp replacement of the easterly winds by westerly ones and *vice versa* generally produces rain during the monsoon period.

During the post monsoon period, the chances of weather over Delhi are small. One or two depressions of the late monsoon period may come up as a low pressure area towards Delhi in October and cause rain or thundershower.

12. Comparison with the winds at Allahabad

Winds exceeding 20 mph are absent at Allahabad in November and December and particularly so also in October, whereas in Delhi, they are observed throughout the year. Delhi has greater frequencies of days of such winds in all the months of the year.

The upper limit of the velocity of the winds not associated with weather is about 40 and 45 mph in the case of Allahabad and Delhi respectively. The small difference may be partly due to the head of the anemograph being on a higher level at Delhi. Excepting the monsoon period, the direction of the winds unassociated with weather is generally west to northwest at Allahabad, while at Delhi, although the direction is west to northwest on many occasions, it may also be from north, or east to southeast on a number of occasions.

The wind speed in association with the duststorm and thunderstorm is within 50 mph on many cases both at Allahabad and Delhi and may rise to 70 mph in a few cases. The record wind speed has been 70 mph at Delhi and 100 mph at Allahabad.

The duration of the duststorms and thunderstorms in the hot months of the year is more at Delhi than at Allahabad.

13. Acknowledgement

We wish to express our thankfulness to Dr. P. K. Sen Gupta and Mr. V. Satakopan for kindly helping us by going through the manuscript of the paper.

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