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A COMPARISON

OF THE

ANEMOMETER RECORDS

FOR

SHOEBURYNESS AND THE MAPLIN LIGHTHOUSE,

BY

N. K. JOHNSON, B.Sc., and S. N. SEN, M.Sc.

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A COMPARISON OF THE ANEMOMETER RECORDS FOR SHOEBURYNESS AND THE MAPLIN LIGHTHOUSE.

By N. K. JOHNSON, B.Sc., and S. N. SEN, M.Sc.

The following discussion deals with the results which have been obtained from a comparison of winds recorded during the year 1919 at Shoeburyness and the Maplin Lighthouse. Shoeburyness is situated in the extreme south-east corner of the County of Essex. The Maplin Lighthouse, which is five miles from the coast, is situated twelve miles east-north-east of Shoeburyness. The Stations are shown in Fig. 1.

Instruments.

The anemometers at these two places are almost identical in construction. The wind speed is recorded in each case by means of a Dines Pressure Tube Anemometer,* and the wind direction is registered on a Baxendell Recorder.† In the latter instrument the chart is fixed on a drum carried on the vertical spindle from the anemometer head, and the pen is caused to travel downwards with uniform velocity by means of clockwork. The arrangement is therefore the inverse of that in the Halliwell and other instruments in which the drum is rotated by clockwork, and the pen moves up and down with the movement of the vane. The only difference between the Shoeburyness and Maplin instruments is to be found in the fact that whereas at Shoeburyness two separate heads are used for the speed and direction recorders, at the Lighthouse both elements are recorded from a single head.

Exposure at Shoeburyness.

The anemometer is situated about a hundred yards from high-water mark. The heads are carried above the top of a steel girder tower to a height of sixty feet above the surrounding buildings and ninety feet above ground. An avenue of trees about seventy feet high runs parallel to the coast at a distance of 150 yards on the landward side of the anemometer tower. The anemometer head is thus twenty feet higher than the trees and about 150 yards away from them. The exposure of the instrument is therefore perfect for winds from NE. through SE. to SW. A certain amount of screening effect on winds from W. NW and N is to be expected on account of the proximity of the avenue of trees.

* *The Observer's Handbook* (1919 Edition), p. 82.
† *Q.J.R. Met. Soc.*, Vol. XXV., 1899, p. 326.

FIG. 1.

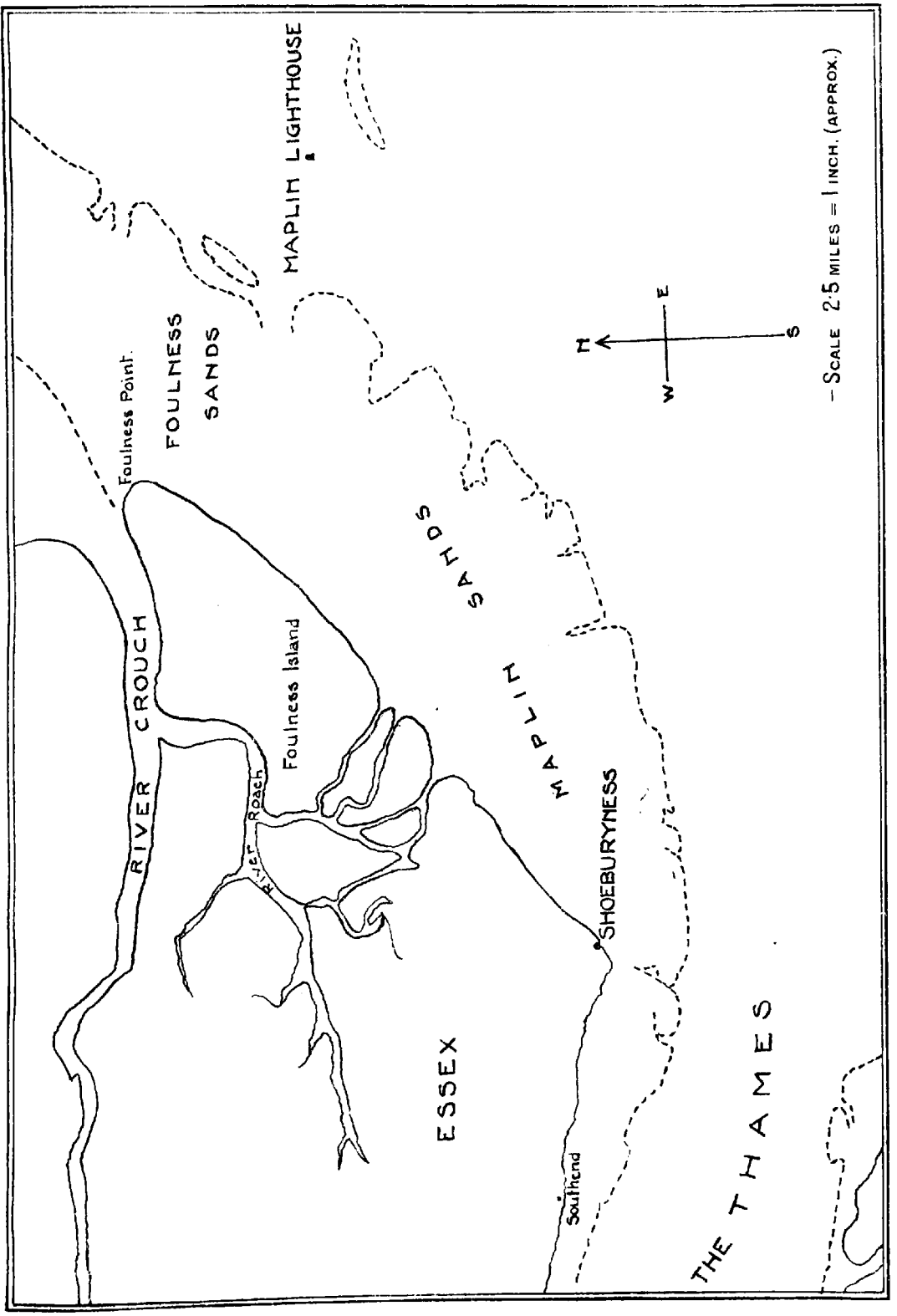
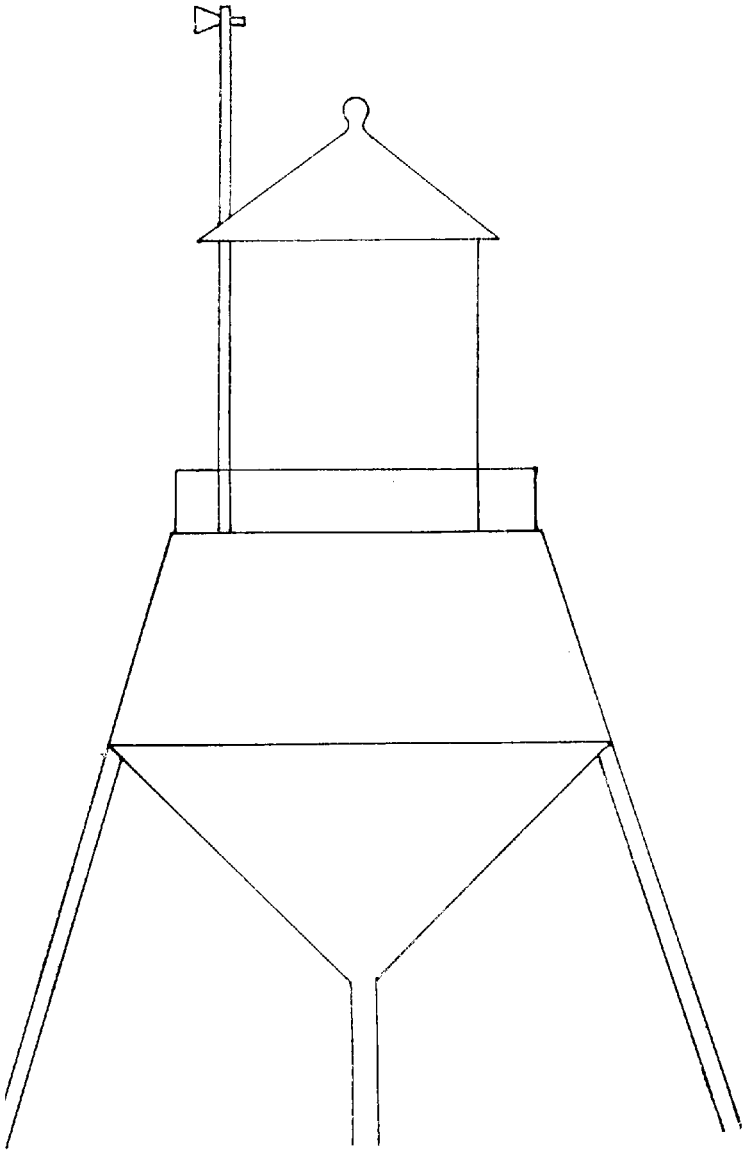

MAPLIN LIGHTHOUSE
Foulness Point
FOULNESS SANDS
RIVER CROUCH
Foulness Island
River Roach
MAPLIN SANDS
SHOEBURYNESS
ESSEX
Southend
THE THAMES
N
E
W
S
SCALE 2·5 MILES = 1 INCH. (APPROX.)

FIG. 2.

ANEMOMETER HEAD AT MAPLIN.



Scale 10 FEET.

Exposure at Maplin.

The anemometer head, which is on the western side of the lighthouse, is supported by a steel tube some five feet above the apex of the roof and fifty feet above the high-water level. The sketch (Fig. 2), which has been made from a photograph, shows the position of the anemometer head in relation to the body of the lighthouse, which is carried on steel and wooden piles. The anemometer head being on the western side of the structure a certain amount of screening effect on east winds might be expected.

Records available for 1919.

The records for the year 1919 are incomplete, the Maplin instrument having been out of order from 12th June to 1st September, both days inclusive. The months for which simultaneous records exist are given below, and they have been grouped as shown.

January.	April.	September.
February.	May.	October.
March.	June.	November.
		December.

The number of hourly tabulations available for both the stations during the whole year is 1,044, of which 103 are calms (*i.e.*, winds of velocity less than five feet per second).

Shoeburyness wind directions have been used throughout, as the direction recording portion of the Maplin instrument was out of order during practically the whole year. It is unfortunate that the spray exerts so much corrosive action, because the inaccessibility of the Lighthouse renders it a difficult task to pay the requisite amount of attention to the instrument.

The Wind Roses.

The wind speeds at 3h., 9h., 15h., and 21h., G.M.T., for both stations were tabulated.* The direction corresponding to each of these speeds was then extracted from the Shoeburyness direction charts. The results of the analysis are given below. The wind speeds were subdivided according to the following scheme, which agrees approximately but not exactly with that employed by the Meteorological Office for the analysis of anemograms.

Group Letter	Description	Speed
A	Calm	Less than 5 ft./sec.
B	Light	5 to 16 ,,
C	Moderate	17 to 35 ,,
D	Strong	36 to 56 ,,
E	Gale	above 56 ,,

* In the year 1919 Wind Components for these particular hours were being computed for Shoeburyness for the *Weekly Weather Report* and the *Geophysical Journal*, in place of like data for Great Yarmouth which are normally published.

x (5)17164 Wt 29842 6869 PF 1052)1260 625 7/22

The scheme used in drawing the wind roses is explained in Fig. 3.

The length of each element in a wind rose indicates the frequency of the winds in each octant, the number of calms appearing as the figure in the centre of the wind rose.

The wind roses are given for each of the four hours 3h., 9h., 15h., and 21h., G.M.T., and for each of the three seasonal divisions already referred to. The wind roses for the two stations are shown side by side for ease of comparison in each case.

The data from which the roses are drawn are contained in Table I.

TABLE I.—WIND ROSE DATA.

Octants.	Total Frequency.	Shoeburyness. 3h. L	M	S	G	9h. L	M	S	G	15h. L	M	S	G	21h. L	M	S	G	Maplin Lighthouse. 3h L	M	S	G	9h. L	M	S	G	15h. L	M	S	G	21h. L	M	S	G
																		JAN., FEB., MAR.															
N	36	5	5	0	0	5	7	0	0	2	3	0	0	6	3	0	0	1	7	2	0	1	9	2	0	0	5	0	0	4	3	2	0
NE	29	2	3	0	0	0	4	2	0	1	5	4	0	3	5	0	0	1	4	0	0	0	3	3	0	2	4	4	0	2	4	2	0
E	34	2	9	0	0	1	2	2	0	2	8	0	0	0	7	1	0	4	6	1	0	1	2	2	0	4	6	0	0	1	6	1	0
SE	46	2	10	0	0	6	8	1	0	2	5	0	0	4	7	1	0	4	6	2	0	3	10	2	0	2	3	2	0	1	9	2	0
S	39	1	7	0	0	1	6	2	0	4	7	1	0	2	3	5	0	1	6	1	0	1	5	3	0	4	6	2	0	1	4	5	0
SW	49	5	4	2	0	5	6	2	0	0	8	5	0	2	8	2	0	3	6	2	0	2	8	3	0	1	6	6	0	3	7	2	0
W	38	4	8	0	0	0	5	0	0	4	2	2	0	10	2	1	0	4	5	3	0	0	4	1	0	3	3	2	0	7	5	1	0
NW	31	4	3	0	0	5	4	0	0	5	6	0	0	2	2	0	0	3	4	0	0	1	7	1	0	4	7	0	0	0	3	1	0
Calms			4				7				5				3				4				7				5				3		
																		APR., MAY, JUN.															
N	25	9	1	0	0	3	2	1	0	1	3	1	0	7	1	0	0	3	3	0	0	2	2	1	1	1	3	1	0	3	4	1	0
NE	31	6	1	1	0	2	3	1	0	1	4	1	0	5	5	1	0	1	6	0	1	1	4	1	0	1	3	2	0	2	8	1	0
E	50	0	4	0	0	4	7	0	0	10	15	0	0	5	4	1	0	0	4	0	0	5	5	1	0	12	13	0	0	4	6	0	0
SE	12	0	3	0	0	2	0	0	0	1	0	1	0	4	1	0	0	1	2	0	0	1	1	0	0	1	0	1	0	3	2	0	0
S	9	1	0	1	0	0	1	0	1	2	1	0	0	2	0	0	0	1	1	0	0	0	1	0	1	3	0	0	0	1	1	0	0
SW	40	8	2	1	0	2	6	0	0	5	3	1	0	4	7	1	0	6	4	0	1	3	4	1	0	4	5	0	0	3	8	1	0
W	42	8	7	0	0	10	3	0	0	1	6	0	0	4	3	0	0	7	8	0	0	6	6	1	0	4	3	0	0	5	2	0	0
NW	23	3	5	0	0	3	2	0	0	2	3	0	0	2	3	0	0	1	5	2	0	1	3	1	0	2	3	0	0	1	3	1	0
Calms			4				10				2				3				4				10				2				3		
																		SEP., OCT., NOV., DEC.															
N	54	8	7	0	0	8	5	0	0	9	4	0	0	8	5	0	0	1	9	5	0	1	10	2	0	3	8	2	0	1	10	2	0
NE	30	0	2	0	0	1	6	0	0	2	10	0	0	2	4	3	0	0	0	2	0	0	3	4	0	1	7	4	0	2	3	4	0
E	21	0	3	0	0	1	5	0	0	7	4	0	0	0	1	0	0	0	2	1	0	1	4	1	0	6	5	0	0	0	0	1	0
SE	22	3	3	0	0	3	2	0	0	2	1	0	0	4	4	0	0	1	5	0	0	2	2	1	0	2	1	0	0	3	4	1	0
S	42	2	5	1	0	4	5	2	0	3	9	1	0	2	7	1	0	2	5	1	0	3	6	2	0	3	9	1	0	1	7	2	0
SW	76	1	10	1	0	6	13	2	0	6	13	1	0	9	13	1	0	1	11	0	0	5	15	1	0	4	13	3	0	8	14	1	0
W	103	18	13	1	0	14	12	0	0	8	14	0	0	10	11	2	0	9	19	4	0	9	15	2	0	3	17	2	0	3	17	3	0
NW	59	10	7	0	0	4	8	2	0	2	9	1	0	9	6	1	0	5	11	1	0	2	9	3	0	1	7	4	0	4	10	2	0
Calms			22				15				13				15				22				15				13				15		

Note.—L = Light wind. M = Moderate wind. S = Strong wind. G = Gale.

Comparisons of Wind Strengths at Shoeburyness and Maplin.

(*a*) **General relation.**—In order to investigate the general relation between wind speeds as measured at Shoeburyness and Maplin, the following method was adopted. The 941 observations of wind were tabulated with regard to the eight points of the compass. Then for each wind direction the correlation

FIG.3

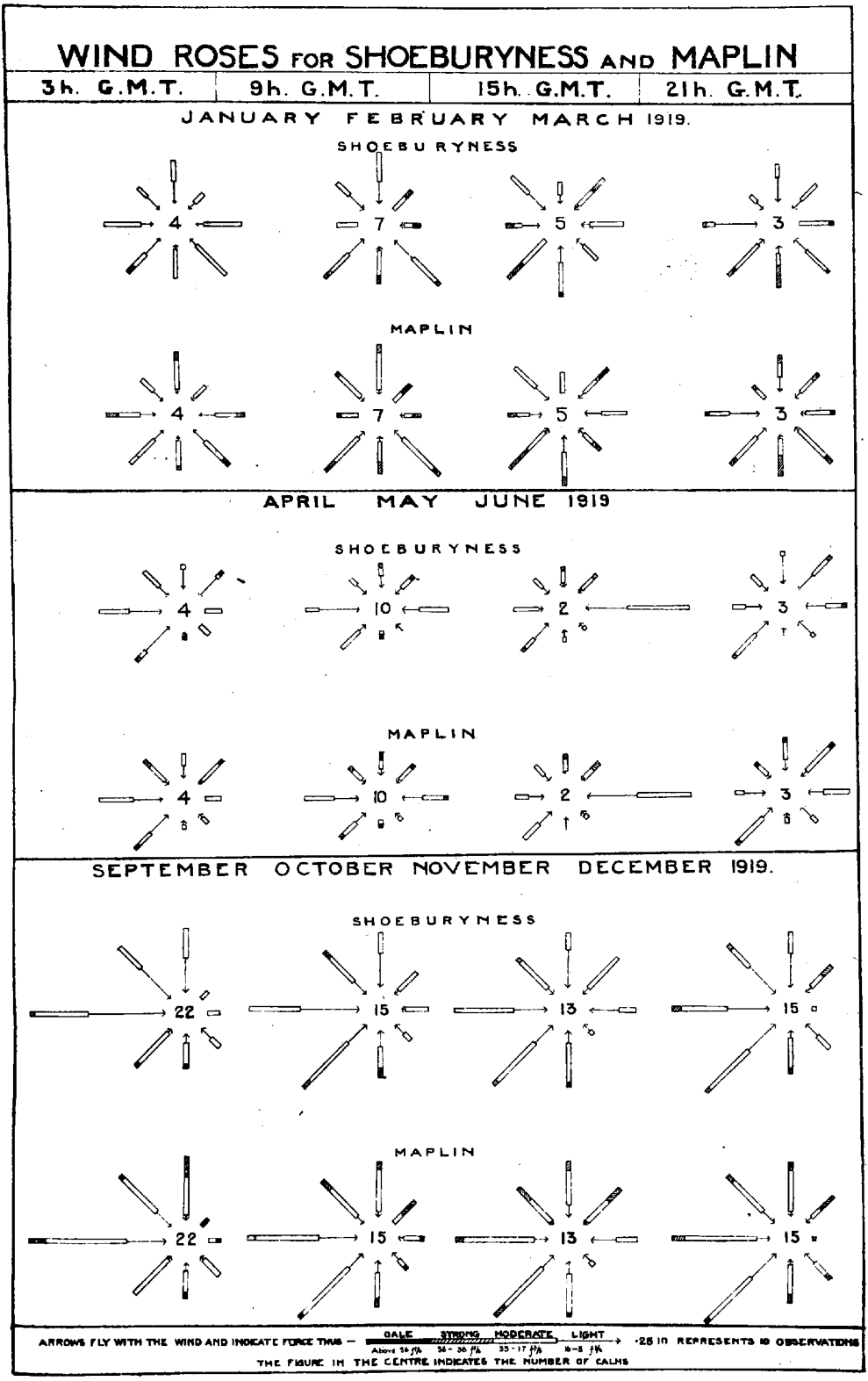
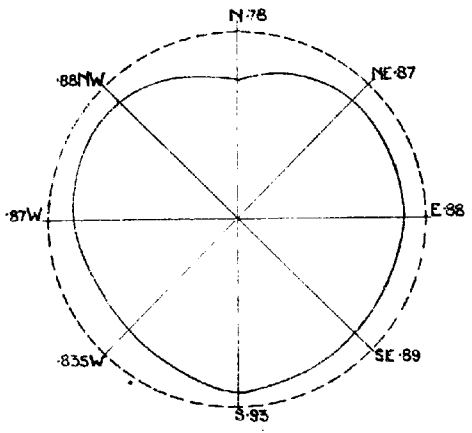

WIND ROSES FOR SHOEBURYNESS AND MAPLIN
3h. G.M.T.
9h. G.M.T.
15h. G.M.T.
21h. G.M.T.
JANUARY FEBRUARY MARCH 1919.
SHOEBURYNESS
4
7
5
3
MAPLIN
4
7
5
3
APRIL MAY JUNE 1919
SHOEBURYNESS
4
10
2
3
MAPLIN
4
10
2
3
SEPTEMBER OCTOBER NOVEMBER DECEMBER 1919.
SHOEBURYNESS
22
15
13
15
MAPLIN
22
15
13
15
ARROWS FLY WITH THE WIND AND INDICATE FORCE THUS —
GALE
Above 55 m/h
STRONG
34 - 55 m/h
MODERATE
11 - 33 m/h
LIGHT
1 - 10 m/h
·25 IN REPRESENTS 10 OBSERVATIONS
THE FIGURE IN THE CENTRE INDICATES THE NUMBER OF CALMS

FIG. 4

CORRELATION COEFFICIENTS

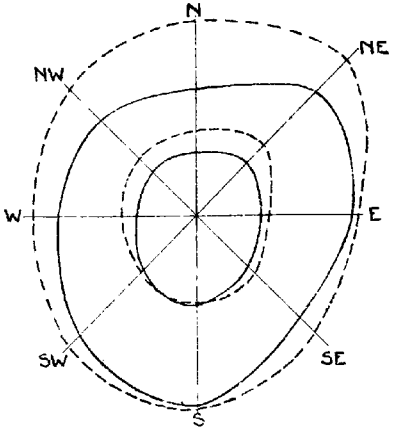


SCALE - 25mm = 1

FIG. 5.

WIND SPEED

MEAN SPEED AND STANDARD DEVIATION



——— SHOEBURYNESS.

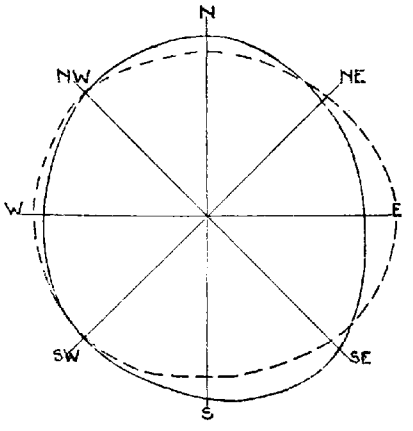
– – – – MAPLIN

SCALE - 1mm = 1 ft/sec

FIG. 6

WIND SPEED

RATIO OF THE STANDARD DEVIATION TO THE MEAN



——— SHOEBURYNESS

– – – – MAPLIN

SCALE-

H.M.S.O. Press, Kingsway, W.C.2.

coefficient between wind speeds at the two stations was calculated in the usual way.

In the following table, in which the results of the computations are set out, x stands for the wind speed at Shoeburyness and y for the wind speed at Maplin, x and y both being measured in ft/sec. The ordinary statistical notation as used in *The Computer's Handbook*, Section V., has been employed.

TABLE II.—CORRELATION BETWEEN WIND SPEEDS AT SHOEBURYNESS AND MAPLIN LIGHTHOUSE.

Octants.	N	NE	E	SE	S	SW	W	NW	All Directions.
Number of observations n	115	90	105	80	90	165	183	113	941
Yearly Means $\bar{x}$	16·7	23·3	21·4	19·9	25·3	22·0	18·2	18·2	20·6
Yearly Means $\bar{y}$	25·7	29·5	21·6	22·5	25·5	24·3	21·8	23·9	24·4
Standard Deviations σ_x	8·1	10·2	8·9	9·9	12·2	10·1	7·8	8·3	9·4
Standard Deviations σ_y	11·3	13·4	9·9	11·2	11·9	10·4	10·1	10·9	11·1
Correlation coefficient r	·72	·87	·88	·89	·93	·83	·87	·88	·86
$b = r\frac{\sigma_y}{\sigma_x}$	1·00	1·14	0·98	1·01	0·91	0·86	1·13	1·16	1·02
$\sigma_x/\bar{x}$	·48	·44	·42	·50	·48	·46	·43	·46	·46
$\sigma_y/\bar{y}$	·44	·45	·50	·47	·43	·46	·46	·46	·46

The remarkably high correlation coefficients show that there is a close relation between the wind speeds at the two stations. The radius of the dotted circle in Fig. 4 represents a correlation coefficient of unity. Appropriate values of the coefficient for the several directions have been plotted and joined by a thick line which forms a more or less heart-shaped figure.

The standard deviation and the yearly mean speed of wind for the different directions are shown diagrammatically, Fig. 5. Distances proportional to the standard deviations and mean speeds are set off from the centre of a star of eight rays. The two large curves represent the yearly mean speeds and the small ones the standard deviations corresponding with the several directions. The broken curves stand for Maplin and the continuous ones for Shoeburyness.

It will be noticed from Table II. that the ratio of the standard deviation to the yearly mean speed is approximately constant for all wind-directions and for the two stations, its value lying between ·42 and ·50; the mean value of this ratio is the same at the two stations. The point is brought out very effectively by Fig. 6, in which this ratio corresponding with the several

directions is plotted for each station. As before the continuous curve is for Shoeburyness, the dotted one for Maplin.

(*b*) **Winds from the Sea.**—It has already been stated that the heads of the instruments at Shoeburyness are ninety feet above ground, whereas the vane at the Maplin Lighthouse is only fifty feet above high water level. On this account alone, we should expect that winds coming from the open sea (*i.e.*, winds between E and S) would show slightly higher speeds at Shoeburyness than at the Lighthouse. At the two stations the actual frequencies of winds from E, SE and S, which we obtain from Table I., are, however, as follows :—

TABLE III.—FREQUENCIES OF WINDS FROM E, SE AND S

Stations	Total	Light	Moderate	Strong	Gale
Shoeburyness - -	275	89	164	21	1
Maplin - - -	275	83	155	36	1

It will be observed that Shoeburyness has a slight predominance of light winds, whilst the strong winds are decidedly more frequent at the Lighthouse—the reverse of what was anticipated. This result is the more unexpected because the anemometer head at Maplin is situated on the western side of the Lighthouse, and a certain amount of screening effect was expected with winds from an easterly direction.

The effect that strong winds are more frequent at Maplin can be explained on general principles by noting that the increased friction over land as compared with the sea causes the air to pile up over the land. In such circumstances the pressure over land is higher than over the sea, and this difference of pressure must tend to reduce the speed of the surface wind as it approaches the shore-line; at the same time there is a change in direction, a refraction of the lines of flow.

(*c*) **Winds from the land.**—A marked diminution in strengths of winds from W, NW and N, *i.e.*, winds from the land, is easily recognisable in the wind roses for Shoeburyness compared with those for Maplin. It is more likely, however, that the phenomenon is more general, and that the effect of the cutting down of the trees would not be very considerable. When a wind blows off the shore it is passing from a region where the surface friction is great to one where it is reduced, the air passes over the water more readily, and gains in speed, so that a few miles from the shore higher winds are to be expected than on the coast. It should be noted also that owing to the lower height of the Maplin

anemometer the contrast between the winds at the two stations is reduced.

A few remarks on the frequency of winds for the various periods and hours are added.

January-February-March Period, 1919.

Apart from the effects of the defective exposure of the Shoeburyness instrument, the two series of wind roses are very similar. There was a somewhat greater prevalence of winds from the south over those from the north, but there was no marked absence of winds from any particular point of the compass at this time of the year.

April-May-June Period, 1919.

During the period April to June, which may be regarded as representative of spring and early summer, there were 251 observations in all, of which 61 were recorded at 3h., 63 at 9h., 64 at 15h., and 63 at 21h., G.M.T. The table below gives the percentage frequency of winds from the various directions at the hours mentioned.

TABLE IV.—PERCENTAGE OF FREQUENCY OF WIND DIRECTION (April to June).

Hours	N	NE	E	SE	S	SW	W	NW	Calm
3h.	9·8	13·1	6·6	4·9	3·3	18·0	24·6	13·1	6·6
9h.	9·5	9·3	17·5	3·2	3·2	12·7	20·6	7·9	15·9
15h.	7·8	9·4	39·1	3·1	4·7	14·1	10·9	7·8	3·1
21h.	12·7	17·5	15·9	7·9	3·2	19·1	11·1	7·9	4·8

As there are no independent observations of wind directions at Maplin, the following remarks apply to Shoeburyness data only.

Land-breeze.—The prevailing winds at 3h. lie in a quadrant centred about west. The high frequency of the west wind, 24·6 per cent. at 3h. to 20·6 per cent. at 9h., is very characteristic. In all probability this effect is to be attributed to the convective land-breeze, the lightness of the west winds as shown in the wind roses confirming this suggestion. Winds between east and south are rare at 3h. G.M.T.

At 9h., although west and south-west winds predominate, the increase of the frequency of east winds from 6·6 per cent. at 3h. to 17·5 per cent. at 9h. is noteworthy as showing the transition from land to sea breeze. As is to be expected, the maximum number of calms occur at about 9h. at this time of the year.

Sea-breeze.—If we compare the wind roses for 15h. with wind roses for other hours at this time of year we find that 15h. roses

are characterised by the great prevalence of light and moderate east winds. From Table II. we also see that the frequency of the east wind increased from 17·5 per cent. at 9h. to 39·1 per cent. at 15h., G.M.T. This wind is, of course, the sea-breeze which is found on the coast on summer afternoons and evenings.

It appears that the convective wind is normal to the average trend of the east coast which runs approximately north and south. The local orientation of the coast line, which is ENE—WSW at Shoeburyness, does not appear to be operative to any appreciable extent, the south-east winds being rare. The obvious feature during these months is the extreme scarcity at all hours of winds from south and south-east. The secondary maximum of SW winds in the wind roses for 15h. is noteworthy. At 21h. wind frequencies at this station are mainly divided between south-west and north-east.

September to December Period, 1919.

During these months the west winds prevailed almost exclusively at all hours, whilst northerly and southerly directions were of secondary importance. Winds from either of the eastern quadrants were rare. It is noteworthy, however, that when a wind did blow from the north-east it was nearly always a strong one.

There was no pronounced variation between the various hours of observation.

Among the minor features it may be noted that the calms were most frequent at 3h. and that the sea-breeze, a light easterly wind at 15h., was not infrequent.

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