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TEMPERATURE AND HUMIDITY GRADIENTS IN THE FIRST 100 M. OVER SOUTH-EAST ENGLAND

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TEMPERATURE AND HUMIDITY GRADIENTS IN THE FIRST 100 M. OVER SOUTH-EAST ENGLAND

SUMMARY

Temperature and humidity have been recorded at four heights up to 106·7 m. above ground level at a site in south-east England over a period of three years. The data, so obtained, have been analysed to give the mean variation of temperature and humidity at each height, and of the lapse rates of these quantities for each month. Mean monthly and yearly values of the lapse rates of the same two quantities are also given. Maximum values of the lapse rate of temperature and of humidity have been extracted for each month, and the effect of the state of the sky upon the gradients of temperature and humidity is considered. The frequencies of the various magnitudes of the lapse rates of temperature and humidity have been computed. The temperature and humidity structure of the lower layers of the atmosphere is examined in detail for an occasion of radiation fog.

INTRODUCTION

The thermal structure in the first hundred metres of the atmosphere has been investigated in experiments carried out at Leafield[1]* and Porton[2]; although desirable on many meteorological grounds, corresponding information on the distribution of humidity is not available. The need for such information was emphasized in connexion with the propagation of radio and radar signals, for the propagation path depends upon the refractive index of the medium through which it is passing. The refractive index of the atmosphere depends upon the temperature and humidity structure. Observations were therefore instituted at Rye, Sussex, with the object of investigating the distribution of temperature and water vapour in the first hundred metres of the atmosphere. The results are given below. The humidity data presented are the first of their kind to be published; the temperature data supplement those referring to Leafield and Porton.

PART I—INSTRUMENTAL

§ 1—SITE

The meteorological station at Rye, Sussex, is situated in latitude 50° 58′ 21″ N. and longitude 0° 48′ 16″ E., at an altitude of 3·8 m. (12 ft.) above sea level. It is towards the western end of Romney Marsh, 5 Km. north-north-east from the nearest point of the coast of the English Channel. From east-north-east to west-south-west through south the ground is practically flat to the coast; to the north and north-east it is 15 to 20 Km. before rising ground is encountered in the Downs and the Weald; and to the west and north-west it is 4 to 6 Km. before the land rises fairly sharply to about 60 m. (200 ft.).

* The index numbers refer to the bibliography on p. 60.

The marsh is predominantly grassland with a little arable, dissected by dykes with only rare low embankments. There are few trees, no woodlands, and only scattered farmsteads. A broken line of buildings from 3 to 8 m. (10 to 26 ft.) high, however, stretches to the south-west from within 40 m. of the enclosure and instrument tower to a distance of about 320 m., and to the east-north-east of the instrument tower (about 110 m. (361 ft.) high) are two similar towers in line at intervals of 62 m. Four wooden towers, 76 m. (250 ft.) high stand 220 m. to the south-west, and two 37-m. (120-ft.) towers stand 180 m. to the south-east. The site is surrounded by an iron fence, 3 m. (10 ft.) in height, which is about 55 m. distant to the south-east where it is nearest to the enclosure.

Fig. 1 shows two views of the terrain.

§ 2—INSTRUMENTS

Normal climatological instruments were maintained as well as the temperature and humidity apparatus. Continuous records were made of the following meteorological variables :—

(i) Aspirated dry-bulb temperature at a height of 1·1 m. (3 ft. 6 in.).

(ii) Differences in air temperature over the height intervals between 1·1 m. (3 ft. 6 in.) and the levels 15·2 m. (50 ft.), 47·2 m. (155 ft.) and 106·7 m. (350 ft.).

(iii) Relative humidity at the height of each thermometer.

(iv) Wind velocity and direction at a height of 12·7 m. (42 ft.)—effective height 10 m. (33 ft.).

(v) Sunshine.

(vi) Starshine.

Tower.—Instruments were mounted at 15·2 m., 47·2 m. and 106·7 m. on the west side of the most westerly of three steel towers which lie in an east-north-east–west-south-west line. The tower is of an open lattice construction, 23 m. square at the base, with cantilevered wooden-floored platforms at heights of 15, 61 and 107 m., projecting 7, 11 and 7 m. respectively from the side of the tower. Wooden-floored gangways run round the tower within its circumference at approximately every 15 m., one of these being used in mounting a screen at 47·2 m.

Aspirated screens.—The temperature and humidity elements were housed in aspirated screens (see Fig. 2), each of which consisted of a box of sheet-iron 25 cm. × 25 cm. × 40 cm., the front plate being detachable for access to the sensitive elements. The screen and front plate were so constructed that when fully assembled the four sides of the screen were of double sheeting separated by 2·5 cm. In the base was fitted an inflow duct of 15 cm. × 9 cm. cross-section and 15 cm. long, and to the top was fitted an open cylinder 23 cm. high and 18 cm. diameter in which was suspended an electric motor driving a four-bladed fan with about 2 mm. clearance from the cylinder walls. The speed of the motor was 2,700 rev./min. giving a rate of aspiration over the elements of about 3·5 m./sec. A canopy over the cylinder protected the whole from rain. All surfaces were painted white.

One screen was mounted at 1·1 m. on a metal stand in the enclosure, about 3 m. from the foot of the tower. The other three were mounted to slide on angle-iron rails projecting 1·5 m. from the tower (see Fig. 3). Normally the screens occupied positions at the ends of the rails, though at times vibration set up by individual motors made it necessary to bring in the appropriate screen to a distance of about 1 m. for quieter running. The screens could be retracted on to the platforms for maintenance. Those at 15·2 m. and 106·7 m. projected from the western edge of the western cantilever platforms ; that at 47·2 m. from the western edge of the gangway at that height. Heights were measured to the levels of the inflow ducts at the bottom of the screens.

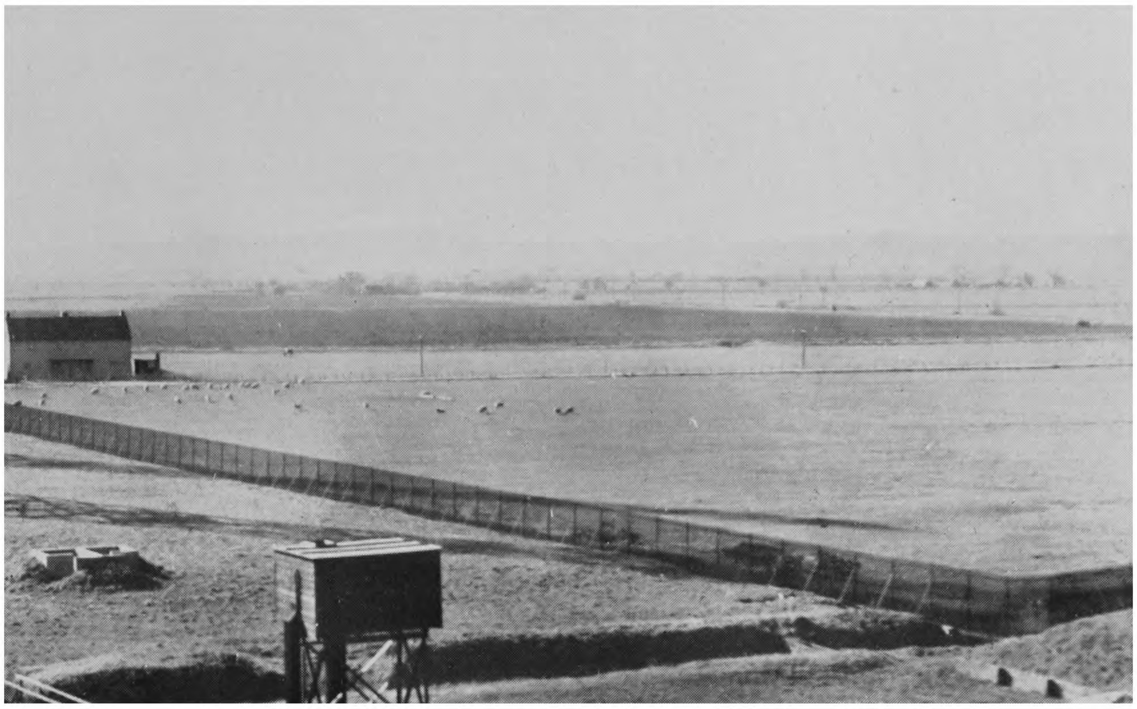

Photo by R.A.F.

Looking west

Photo by R.A.F.

Looking north-east

FIG. 1—VIEW FROM INSTRUMENT TOWER

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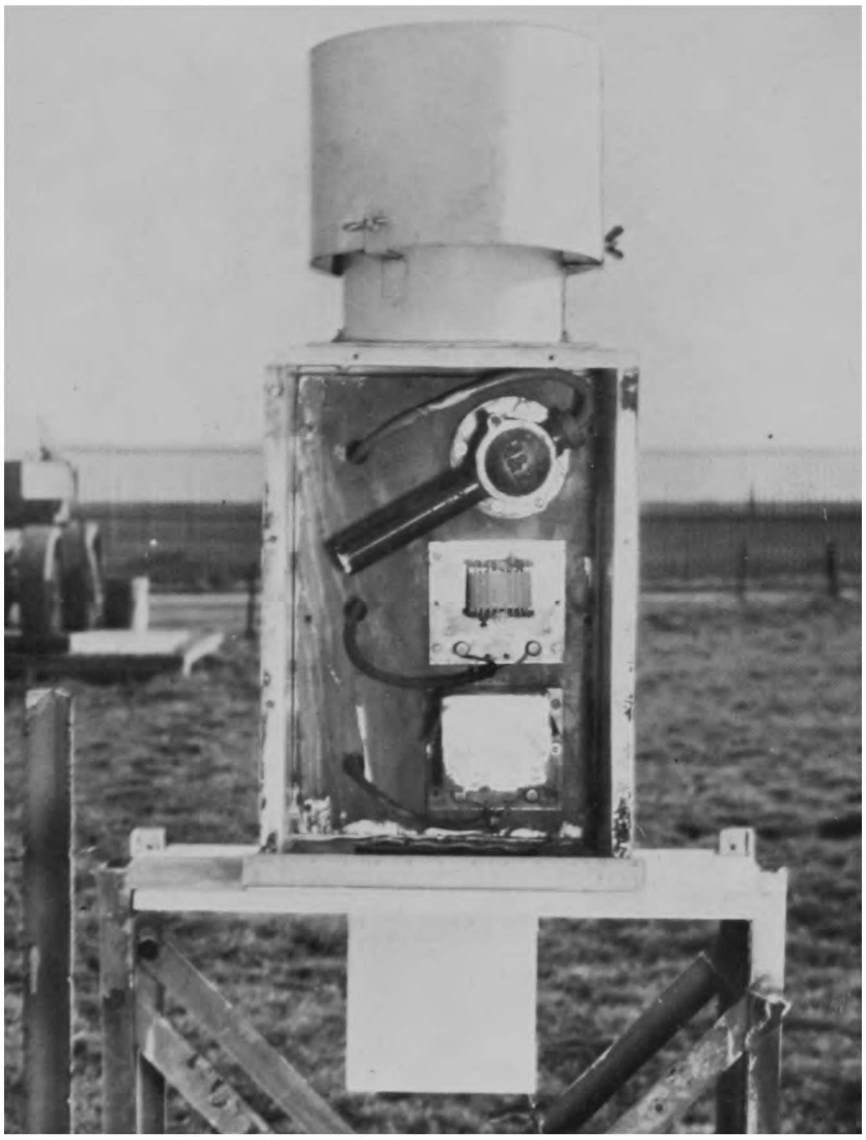


Photo by R.A.F.

FIG. 2 ARRANGEMENT OF THERMOMETER AND HUMIDITY ELEMENTS IN ASPIRATED SCREEN

Dust cover and upper element removed

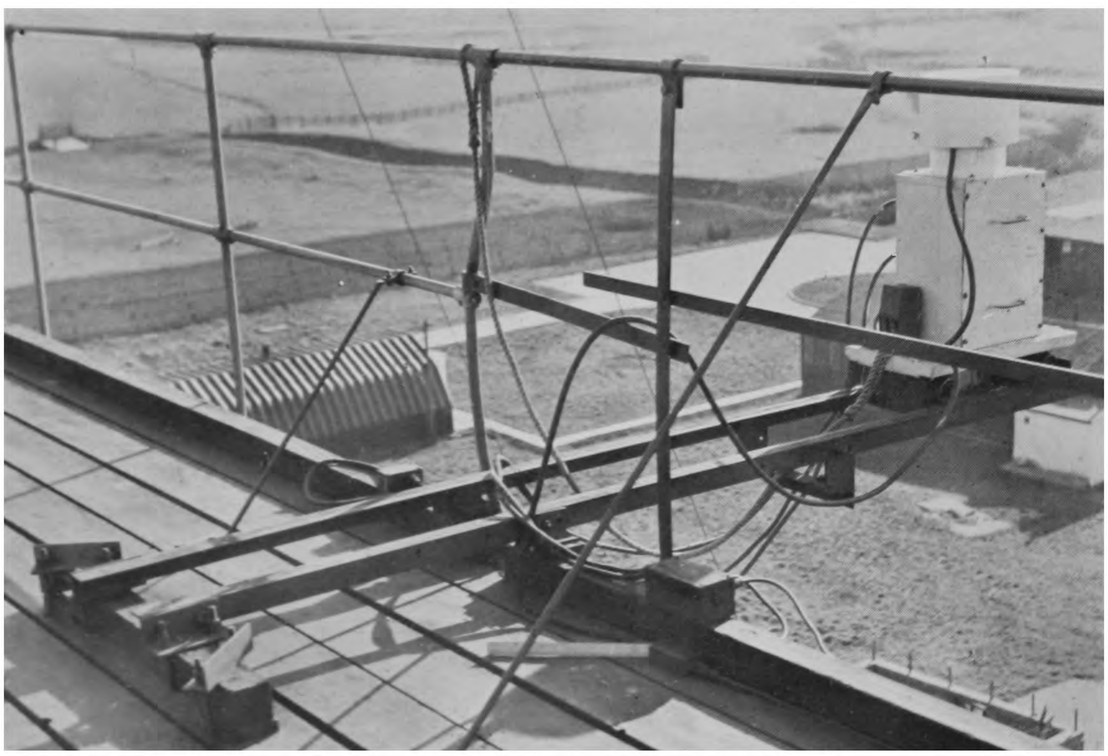


Photo by R.A.F.

FIG. 3 DEVICE FOR RETRACTION OF SCREEN

Temperature measurements.—The temperature of the air was measured by nickel resistance thermometers mounted in the screens, two at 1·1 m. and one each at 15·2 m., 47·2 m., and 106·7 m. These elements had a resistance which was 100 ohms at 32° F. and which varied by approximately 0·25 ohm for each degree Fahrenheit change in temperature.

The elements were connected by cable (in which the copper core is held in compressed magnesium oxide insulation, the whole being sheathed in copper tubing) to recording pyrometers. These are essentially out-of-balance Wheatstone bridges with a device by which the galvanometer needle is pressed against an inked ribbon and chart for 5–10 sec. every 30 sec. A system of mercury switches, cam-operated by an electric clock, brought the various elements in turn into circuit, their records being differentiated by the use of different coloured inked ribbon. The travel of the chart was 12·77mm./hr.

One of these recorders was used with one of the 1·1 m. thermometers as the unknown resistance to give a single trace of actual temperature at that height.

In the other recorder, the 15·2 m. element was used as one standard resistance, and the second 1·1 m. element and those at 47·2 m. and 106·7 m. were compared with it in turn, so that the three traces on the chart indicated the temperature differences over the intervals 1·1 to 15·2 m., 15·2 to 47·2 m. and 15·2 to 106·7 m. A shunt could be placed across the galvanometer to double the range of the instrument (from $\pm 10°$ to $\pm 20°$ F.) on occasions when large inversions were expected. All the leads were compensated to allow for variation of their resistance with temperature. The recorder room was kept, as far as possible, at a temperature of 60–62° F. to prevent convectional disturbances inside the recorder casings.

Humidity measurements.—Humidity was measured by Gregory hygrometers. In these, the sensitive element is a strip of fabric impregnated with lithium chloride and stretched on platinum-coated electrodes carried on a styrene frame, the electrical resistance of the treated fabric varying in an inverse manner with relative humidity.

In detail, two styrene annuli of 5 cm. diameter were separated by 20 platinum-coated rods 35 mm. long and 6 mm. apart, the whole forming a cylindrical cage. The treated fabric, 3 cm. wide, lay over the electrodes and was kept taut by two small helical springs. Alternate electrodes were connected together, so that the resistance measured was that of 19 strips of fabric in parallel, each 6 mm. long and 30 mm. wide. The resistance at the standard temperature of 59° F. varied with relative humidity as follows :—

Relative humidity %	Resistance ohms	Relative humidity %	Resistance ohms
30	158,490	80	241
45	8,091	90	135
50	3,908	95	103
60	1,099	100	80
70	457		

The element was protected from dust and other similar impurities by a metal box 9 cm. × 9 cm. × 8 cm., with four fine copper-gauze windows 7 cm. × 2·5 cm., two on the underside of the box and one on each of two vertical sides. Two elements (one for high and the other for low humidities) were housed in each screen.

Cables (similar to those used for the temperature recorder) from the elements led to two recorders with circuits as shown in Fig. 4. A stabilizing and reducing unit transformed the mains supply to 2 volts a.c. (to prevent electrolysis) which was passed through the element. The resultant current was measured, after being rectified, by a galvanometer with a recording mechanism similar to that of the temperature recorders. The charts, which travelled at

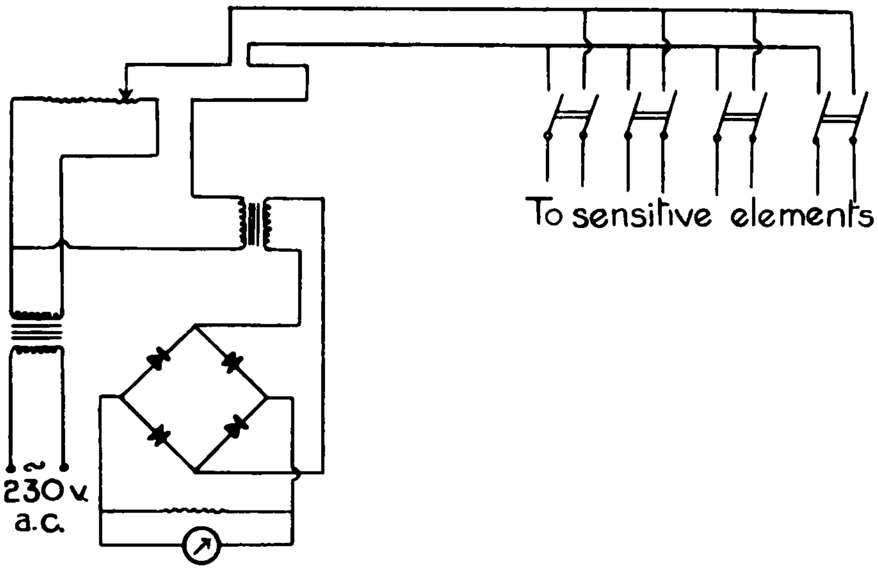


FIG. 4—CIRCUIT DIAGRAM FOR GREGORY HYGROMETER

12·77 mm./hr., had a non-linear scale of relative humidity. On the original instrument the spacing was :—

	Relative humidity (per cent.)						
	30–40	40–50	50–60	60–70	70–80	80–90	90–100
	millimetres						
Scale	2·5	14	29·5	29	21	16	12·5

Because of the crowding of the scale at the lower end, a second recorder and corresponding set of elements were introduced with a different mains unit and galvanometer setting, whereby low humidities were recorded on a chart with the spacing :—

	Relative humidity (per cent.)			
	10–20	20–30	30–40	40–50
	millimetres			
Scale	14	32·5	60	16·5

Because of the large changes in the resistance of the elements, no compensating leads were required in the hygrometer circuit.

§ 3—CALIBRATIONS AND ACCURACY

Temperature.—Calibrations were carried out as often as opportunity allowed in suitable weather, i.e. under conditions of overcast sky with a fresh to strong breeze and no fog or precipitation. On the average such occasions occurred ten or twelve times a year. Assmann psychrometers were placed beside the screens taken in pairs, and readings taken every minute for 20 minutes. The means of the dry-bulb readings were compared with the means recorded (as actual temperatures or as temperature differences) over the same period. In general, the corrections to the recorder readings indicated by these tests were less than $\pm 0{\cdot}3°$ F., and variation with temperature or with the passage of time was very slight.

The scale of the actual temperature chart (0–10° F. = 1·5 cm. ; 90–100° F. = 1·2 cm.) only allowed of readings correct to $\pm 0{\cdot}2°$ F., and individual readings at times of rapid change may have been 0·3° F. in error. The temperature-difference record, with a uniform scale of 2° F. = 1·25 cm., permitted a margin of error as low as $\pm 0{\cdot}05°$ F.

Humidity.—Humidity calibrations were carried out in the same way and at the same time as temperature calibrations, though the relative humidity indicated by the recorders had to be corrected for temperature before it could be compared with the psychrometer readings.

The temperature coefficient of the elements is a function of the relative humidity, and corrections were applied according to a chart supplied by the makers of the instrument. These corrections were of the order of 3 per cent. relative humidity per 10° F. departure from the standard temperature of 59° F. No calibration was carried out below 32° F. however, and, though the correction curves are sensibly straight lines from above 60° to 32° F., some error may have been introduced in assuming that the curves continue in the same fashion below that range.

Relative humidities could be read to 0·1 per cent., but no attempt was made to read to finer limits than 0·5 per cent. With the possible exception of occasions of very low temperature, corrections for temperature and instrument error can be guaranteed to well within this margin. The correction resulting from calibration was of the order of ± 2 per cent. for new elements, but increased slowly with time. Elements were generally used for some six months or so, by which time the error was of the order of ± 6 per cent., but was then liable to a sudden and large increase. Similar sudden increases may occur whenever the elements are exposed to wet fog, which greatly increases their subsequent resistance due to the loss of lithium chloride dissolved in the water which collects on the elements and then drains away.

In general, then, relative humidities correct to $\pm 0{\cdot}5$ per cent. were obtainable. These, together with the temperatures deduced from the recorded temperature at 1·1 m. and the temperature-differences between 1·1 m. and the other heights, were used to obtain absolute humidities in milligrams per cubic metre. The possible errors of $\pm 0{\cdot}2°$ F. and $\pm 0{\cdot}5$ per cent. relative humidity produced errors in absolute humidity which varied from about ± 35 mg./m.^{3} at 15° F. to about ± 250 mg./m.^{3} at 75° F., and about 330 mg./m.^{3} at 85° F.

Lag.—At the speed of aspiration (approximately 3·5 m./sec. air flow over the elements) the lag coefficient of the thermometers was about 5 min. and that of the humidity elements about 3 min. As calibration was always performed at times of almost steady temperature and humidity, this slight asynchronism was ignored.

§ 4—PERIOD OF THE OBSERVATIONS

The observations were, as nearly as could be achieved, continuous over the period July 1945–June 1948 inclusive. It was necessary, however, to cease all recording during January 1948. The separate monthly records represent the following numbers of complete days of observations :—

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
55	62	77	83	85	74	70	77	77	71	81	67

With only three years' observations it is desirable to assess the extent to which the average weather during the observations agrees with the average weather over a longer period. For this purpose the mean monthly sunshine total for the period of observations is compared below with the mean monthly values for the neighbouring town of Hastings during the period 1906–1935.

MEAN MONTHLY SUNSHINE AS A PERCENTAGE OF THE NORMAL AT HASTINGS

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
118	71	99	125	99	99	113	104	78	110	84	99

Figures used in the compilation of tables and curves for " clear and overcast summer and winter days " relate to the following occasions :—

CLEAR DAYS

Summer : 1945 ; July 8 and 13 ; Aug. 3, 4 and 5.
1946 ; July 2, 7 and 10.
1947 ; June 25 ; July 15 ; Aug. 9, 13–16 (inclusive), 24, 25, 27 and 28.

Winter : 1947 ; Jan. 16 and 18.
1948 ; Feb. 25.

OVERCAST DAYS

Summer : 1945 ; July 10 ; Aug. 1 and 20.
1946 ; Aug. 20.

Winter : 1945 ; Dec. 22.
1946 ; Jan. 24 and 29 ; Feb. 7, 12, 13, 14, 15 and 26 ; Dec. 23.
1947 ; Feb. 11–17 (inclusive) and 20 ; Dec. 6, 12 and 13.

PART II—TEMPERATURE RECORDS

§ 5—PRELIMINARY REMARKS

A broad survey of the temperature records obtained during the three years of observation at Rye shows that the main properties of the temperature field are little different from those described by Sir Nelson Johnson and G. S. P. Heywood in *Geophysical Memoirs* No. 77, " An investigation of the lapse rate of temperature in the lowest hundred metres of the atmosphere "[1], in which the results of similar experiments carried out at Leafield are discussed. The results from the Rye experiments are, therefore, presented in a somewhat brief fashion, particular points of similarity with the results to be found in the above publication being indicated from time to time.

The method of analysis of the records and the method of presentation of the results follow closely those methods initiated in *Geophysical Memoirs* No. 77, which are akin to those used by Sir Nelson Johnson in *Geophysical Memoirs* No. 46, " A study of the vertical gradient of temperature in the atmosphere near the ground "[2]. *Geophysical Memoirs* No. 46 deals with experiments carried out at Porton. Direct comparison of the results obtained at Leafield and at Porton can thus be made with the results obtained at Rye.

All temperatures in this Memoir are given in degrees Fahrenheit, and Greenwich Mean Time is used throughout. Hourly values were extracted from the traces, the value allotted to each hour being the mean over a period of twenty minutes centred on the hour in question. The temperature differences are taken as positive when temperature increases with height, and negative when it decreases upwards. The former of these conditions is generally known as an inversion whilst the latter will be referred to as a lapse.

It is convenient to denote the intervals between 1·1 m. and successive heights by letters X to Z, the values of the dry adiabatic lapse rate over each of these height intervals being as follows :—

Interval X, 1·1– 15·2 m.....—0·25° F.
Interval Y, 1·1– 47·2 m.....—0·83° F.
Interval Z, 1·1–106·7 m.....—1·90° F.

§ 6—MEAN HOURLY VALUES AND DIURNAL VARIATION OF THE TEMPERATURE LAPSE RATE

The mean hourly values of the temperature differences over each height interval for each month are given in Table I. If the values in Table I are plotted in the form of temperature-height profiles as in Fig. 8 of *Geophysical Memoirs* No. 77 it can be seen that the general appearance of the two sets of curves is remarkably similar ; for this reason such a figure has not

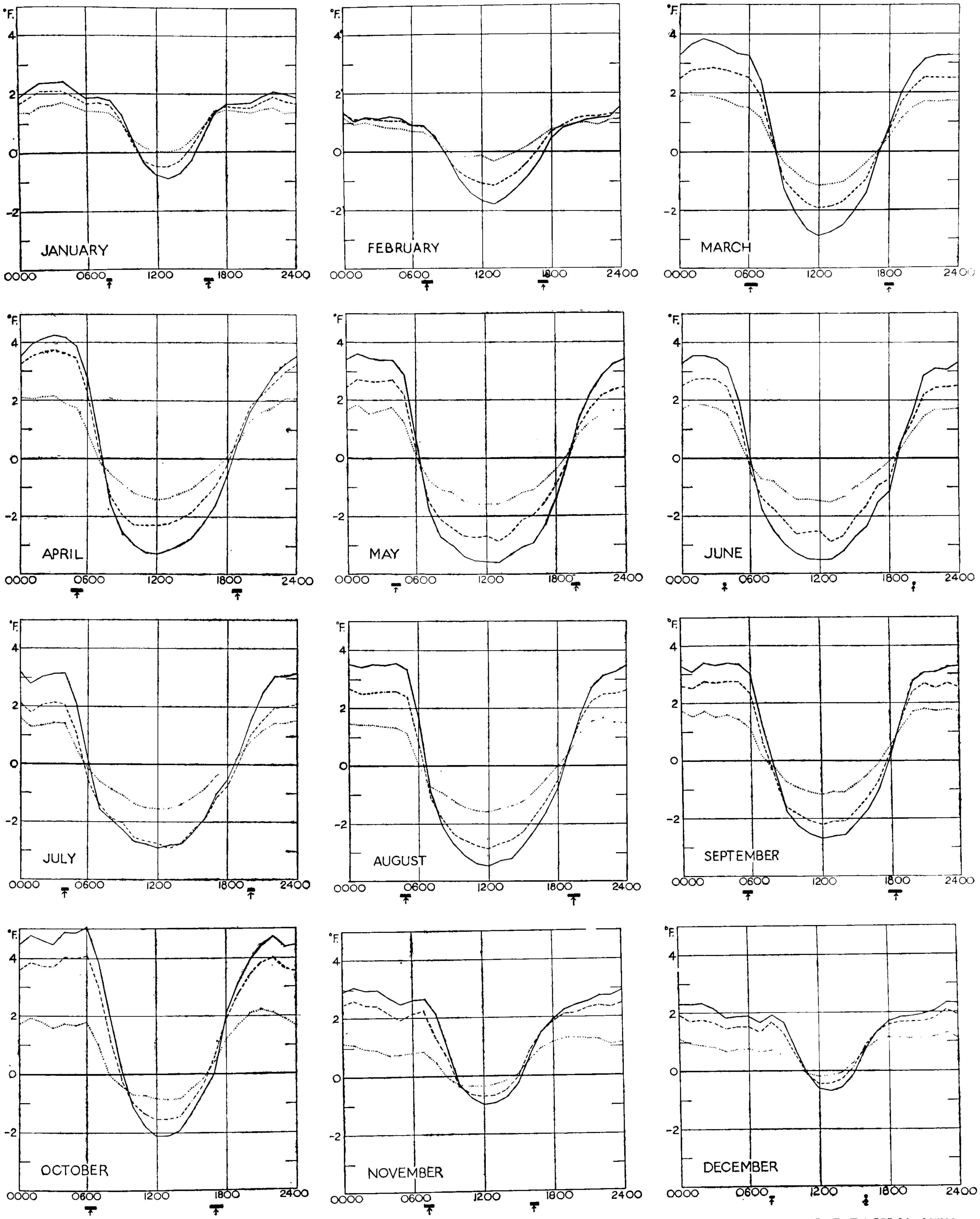


FIG. 5—DIURNAL VARIATION OF TEMPERATURE DIFFERENCE OVER THREE HEIGHT INTERVALS FOR EACH MONTH

The curves show the temperature difference over the following intervals
········· 15·2–1·1m. – – – – – – 47·2–1·1 m.————106·7–1·1 m.

The arrows indicate times of sunrise and sunset, the limits for each month being shown by the length of the bar immediately above the arrow.

TABLE I—MEAN HOURLY VALUES OF THE TEMPERATURE

	Height interval	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100
	m.						degrees Fahrenheit					
January ..	106·7–47·2	+0·26	+0·28	+0·30	+0·33	+0·22	+0·18	+0·19	+0·19	+0·21	+0·03	−0·10
	47·2–15·2	+0·48	+0·54	+0·49	+0·38	+0·32	+0·24	+0·29	+0·27	+0·09	−0·08	−0·44
	15·2– 1·1	+1·38	+1·55	+1·60	+1·69	+1·57	+1·41	+1·39	+1·33	+1·00	+0·41	+0·16
February ..	106·7–47·2	−0·04	+0·02	+0·04	+0·14	+0·10	+0·02	+0·05	−0·06	+0·02	−0·25	−0·48
	47·2–15·2	+0·17	+0·16	+0·18	+0·24	+0·23	+0·19	+0·18	+0·09	−0·18	−0·49	−0·74
	15·2– 1·1	+0·95	+1·00	+0·92	+0·82	+0·82	+0·74	+0·69	+0·46	+0·03	−0·16	−0·17
March	106·7–47·2	+0·88	+1·01	+0·88	+0·79	+0·69	+0·73	+0·53	+0·08	−0·33	−0·73	−0·90
	47·2–15·2	+0·84	+0·88	+0·96	+1·02	+1·08	+1·00	+0·74	+0·13	−0·60	−0·74	−0·77
	15·2– 1·1	+1·93	+1·94	+1·88	+1·77	+1·58	+1·54	+1·14	+0·25	−0·36	−0·65	−0·99
April	106·7–47·2	+0·40	+0·47	+0·49	+0·54	+0·46	+0·60	+0·33	−0·23	−0·60	−0·72	−0·95
	47·2–15·2	+1·49	+1·54	+1·59	+1·77	+1·70	+1·28	+0·35	−0·79	−1·09	−1·07	−0·97
	15·2– 1·1	+2·06	+2·14	+2·17	+1·88	+1·76	+0·94	−0·11	−0·55	−0·88	−1·20	−1·31
May	106·7–47·2	+0·86	+0·79	+0·73	+0·68	+0·69	+0·25	−0·30	−0·61	−0·63	−0·73	−0·82
	47·2–15·2	+0·88	+1·11	+1·01	+0·97	+0·96	+0·18	−0·74	−1·01	−1·20	−1·19	−1·11
	15·2– 1·1	+1·87	+1·57	+1·65	+1·75	+1·25	+0·05	−0·73	−1·04	−1·15	−1·43	−1·57
June	106·7–47·2	+0·81	+0·77	+0·71	+0·69	+0·51	+0·16	−0·35	−0·68	−0·81	−0·68	−0·89
	47·2–15·2	+0·86	+0·94	+0·95	+0·91	+0·80	−0·19	−0·69	−0·90	−1·06	−1·19	−1·15
	15·2– 1·1	+1·88	+1·84	+1·77	+1·56	+0·67	−0·21	−0·68	−0·79	−1·10	−1·41	−1·39
July	106·7–47·2	+1·02	+1·01	+0·98	+1·07	+0·97	+0·67	−0·11	−0·05	−0·07	−0·12	−0·11
	47·2–15·2	+0·51	+0·71	+0·74	+0·69	+0·56	−0·36	−0·83	−0·96	−1·14	−1·17	−1·18
	15·2– 1·1	+1·28	+1·33	+1·41	+1·41	+0·51	−0·17	−0·60	−0·88	−1·07	−1·37	−1·49
August	106·7–47·2	+0·90	+0·96	+0·88	+0·95	+0·95	+0·75	+0·17	−0·24	−0·35	−0·53	−0·63
	47·2–15·2	+1·08	+1·12	+1·21	+1·26	+1·23	+0·74	−0·39	−0·89	−1·16	−1·15	−1·21
	15·2– 1·1	+1·42	+1·42	+1·36	+1·32	+1·15	+0·07	−0·72	−0·93	−1·20	−1·43	−1·56
September ..	106·7–47·2	+0·58	+0·65	+0·63	+0·62	+0·61	+0·72	+0·59	+0·22	−0·18	−0·43	−0·51
	47·2–15·2	+0·96	+1·01	+1·22	+1·19	+1·32	+1·21	+0·55	−0·29	−0·88	−0·91	−0·98
	15·2– 1·1	+1·56	+1·74	+1·51	+1·59	+1·43	+1·12	+0·13	−0·21	−0·72	−0·93	−1·06
October ..	106·7–47·2	+0·93	+0·86	+0·74	+0·86	+0·89	+0·98	+0·92	+0·81	+0·38	−0·18	−0·45
	47·2–15·2	+1·89	+1·95	+2·13	+2·28	+2·31	+2·27	+1·99	+1·17	+0·21	−0·31	−0·58
	15·2– 1·1	+1·97	+1·81	+1·60	+1·76	+1·69	+1·80	+0·97	−0·03	−0·41	−0·69	−0·77
November ..	106·7–47·2	+0·46	+0·56	+0·57	+0·58	+0·55	+0·49	+0·41	+0·63	+0·22	−0·05	−0·14
	47·2–15·2	+1·52	+1·48	+1·54	+1·45	+1·23	+1·34	+1·44	+1·04	+0·65	+0·05	−0·25
	15·2– 1·1	+1·09	+0·95	+0·88	+0·72	+0·74	+0·80	+0·80	+0·47	−0·05	−0·33	−0·38
December ..	106·7–47·2	+0·55	+0·54	+0·49	+0·39	+0·35	+0·34	+0·30	+0·29	+0·33	+0·22	+0·02
	47·2–15·2	+0·70	+0·90	+0·86	+0·81	+0·80	+0·78	+0·71	+0·77	+0·77	+0·34	−0·02
	15·2– 1·1	+0·97	+0·88	+0·81	+0·64	+0·73	+0·76	+0·65	+0·69	+0·57	+0·21	−0·11

been included, it being concluded that the main physical features are as discussed by Johnson and Heywood. Detailed features are different, as might be expected bearing in mind the differences in the sites chosen for the experiments. For example the mean lapse rate between 1·1 and 15·2 m. at 1200 in January is practically zero compared with the adiabatic rate found at Leafield between 1·2 and 12·4 m.; in June the mean lapse rates at 1200 over the intervals 1·1–15·2 m. and 1·1–106·7 m. are respectively 5·7 and 1·8 times the adiabatic lapse rate compared with lapse rates 8·0 and 2·2 times the adiabatic lapse rate found at Leafield over similar intervals.

DIFFERENCE OVER THREE HEIGHT INTERVALS FOR EACH MONTH

1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	
					degrees Fahrenheit								
−0·32	−0·40	−0·41	−0·37	−0·20	−0·03	+0·05	+0·14	+0·16	+0·22	+0·19	+0·23	+0·22	January
−0·49	−0·49	−0·42	−0·30	−0·15	+0·05	+0·14	+0·13	+0·18	+0·23	+0·35	+0·45	+0·28	
+0·02	0·00	+0·09	+0·42	+0·93	+1·36	+1·45	+1·40	+1·33	+1·46	+1·52	+1·32	+1·39	
−0·57	−0·60	−0·57	−0·50	−0·50	−0·41	−0·24	−0·13	−0·17	−0·11	−0·03	−0·09	+0·02	February
−0·91	−0·86	−0·81	−0·69	−0·52	−0·34	−0·09	+0·06	+0·15	+0·18	+0·24	+0·16	+0·19	
−0·14	−0·30	−0·15	0·00	+0·23	+0·53	+0·78	+0·90	+1·00	+1·04	+0·98	+1·15	+1·18	
−0·95	−0·87	−0·79	−0·64	−0·46	−0·02	+0·12	+0·35	+0·54	+0·61	+0·70	+0·77	+0·77	March
−0·77	−0·77	−0·71	−0·63	−0·57	−0·04	+0·13	+0·50	+0·67	+0·80	+0·86	+0·79	+0·82	
−1·12	−1·08	−1·00	−0·72	−0·37	0·00	+0·53	+1·17	+1·51	+1·74	+1·68	+1·72	+1·70	
−0·97	−0·91	−0·92	−0·88	−0·81	−0·63	−0·38	−0·26	−0·12	+0·06	+0·26	+0·25	+0·28	April
−0·91	−0·91	−0·87	−0·82	−0·75	−0·61	−0·22	+0·21	+0·51	+0·61	+0·80	+0·92	+1·18	
−1·40	−1·34	−1·19	−1·01	−0·63	−0·35	+0·05	+0·65	+1·33	+1·63	+1·86	+2·12	+2·10	
−0·92	−0·76	−0·77	−0·92	−0·95	−0·80	−0·45	+0·07	+0·29	+0·50	+0·68	+0·89	+0·96	May
−1·08	−1·23	−1·13	−0·94	−0·88	−0·75	−0·48	−0·13	+0·27	+0·48	+0·67	+0·76	+0·82	
−1·57	−1·58	−1·41	−1·18	−1·06	−0·76	−0·40	+0·09	+0·83	+1·26	+1·52	+1·62	+1·64	
−0·93	−0·59	−0·56	−0·72	−0·75	−0·56	−0·44	−0·05	+0·23	+0·66	+0·71	+0·65	+0·79	June
−1·10	−1·38	−1·32	−1·07	−0·86	−0·52	−0·59	+0·20	+0·37	+0·78	+0·74	+0·76	+0·79	
−1·43	−1·49	−1·33	−0·98	−0·77	−0·45	−0·11	+0·36	+0·90	+1·43	+1·69	+1·69	+1·74	
−0·14	+0·09	−0·03	−0·13	+0·02	+0·13	+0·19	+0·26	+0·52	+0·93	+1·07	+1·05	+1·09	July
−1·21	−1·38	−1·33	−1·13	−1·05	−0·78	−0·64	−0·21	+0·25	+0·35	+0·51	+0·56	+0·52	
−1·51	−1·52	−1·40	−1·15	−0·87	−0·40	−0·10	+0·30	+0·81	+1·19	+1·44	+1·45	+1·57	
−0·64	−0·64	−0·63	−0·54	−0·49	−0·39	−0·27	−0·07	+0·16	+0·43	+0·61	+0·68	+0·87	August
−1·24	−1·22	−1·19	−1·03	−0·88	−0·77	−0·49	+0·01	+0·46	+0·68	+0·84	+1·01	+1·14	
−1·59	−1·47	−1·39	−1·21	−0·84	−0·43	−0·03	+0·46	+1·18	+1·57	+1·66	+1·53	+1·47	
−0·51	−0·52	−0·50	−0·47	−0·42	−0·32	−0·13	+0·07	+0·37	+0·37	+0·51	+0·55	+0·70	September
−1·02	−1·03	−1·02	−0·89	−0·81	−0·59	−0·19	+0·28	+0·69	+0·88	+0·82	+0·92	+0·86	
−1·13	−1·05	−1·05	−0·78	−0·45	−0·06	+0·54	+1·15	+1·73	+1·81	+1·74	+1·79	+1·73	
−0·58	−0·59	−0·57	−0·45	−0·25	−0·63	+0·11	+0·33	+0·48	+0·58	+0·72	+0·71	+0·87	October
−0·68	−0·68	−0·59	−0·43	−0·23	+0·19	+0·64	+1·08	+1·40	+1·64	+1·89	+1·77	+1·82	
−0·86	−0·87	−0·83	−0·47	−0·14	+0·45	+1·27	+1·72	+2·06	+2·22	+2·13	+1·91	+1·77	
−0·30	−0·27	−0·29	−0·22	−0·15	−0·03	+0·06	+0·12	+0·27	+0·28	+0·35	+0·39	+0·48	November
−0·30	−0·36	−0·31	−0·07	+0·27	+0·55	+0·73	+0·86	+0·87	+1·06	+1·19	+1·27	+1·36	
−0·39	−0·32	−0·17	+0·05	+0·57	+0·97	+1·13	+1·27	+1·30	+1·24	+1·21	+1·09	+1·12	
−0·16	−0·25	−0·30	−0·21	−0·10	−0·02	+0·08	+0·16	+0·19	+0·27	+0·24	+0·27	+0·38	December
−0·25	−0·27	−0·23	−0·15	+0·08	+0·32	+0·42	+0·51	+0·56	+0·56	+0·65	+0·77	+0·81	
−0·20	−0·17	−0·05	+0·26	+0·77	+1·05	+1·17	+1·15	+1·11	+1·10	+1·16	+1·31	+1·12	

The values given in Table I have been plotted in Fig. 5 showing the diurnal variation of the temperature differences for the three intervals X, Y and Z. It is interesting to compare these curves with similar curves in *Geophysical Memoirs* Nos. 46 and 77. In the first place the curves are similar in shape, as might be expected since they are graphical representations of the effects on temperature of the same physical causes. Although the lowest intervals are not the same in each series of experiments the curves relating to the interval 1·2 to 17·1 m. for Porton may be compared with interval A (1·2 to 12·4 m.) for Leafield and with interval X of Fig. 5 for Rye.

With the exception of January the time of change-over from mean inversion to lapse is nearly the same in each series of experiments for any month. At Rye the figure shows that in January there is not a mean lapse from 1·1 to 15·2 m., but in the midday period there is an almost isothermal layer.

The feature noted at Leafield and Porton, that the change-over from inversion to lapse occurs almost simultaneously at all levels, is not quite so marked in some months at Rye, and the difference in time of the change from lapse to inversion in the evening shows differences of the same order as given in *Geophysical Memoirs* No. 77.

It will be noted that the July lapses in the top layer, between the levels 47·2 and 106·7 m., are small compared with the June and August lapses in the same layer, and at 1300 there is a small inversion. This may be a sea-breeze effect and requires further investigation. The night inversion in this layer is more marked in July than in June and August.

§ 7—MEAN MONTHLY AND YEARLY VALUES OF THE TEMPERATURE LAPSE RATE

The hourly values of the temperature differences given in Table I have been meaned by months, and the results are given in Table II.

It will be seen that in every month the average temperature structure between 1·1 and 15·2m. is an inversion, and that the mean inversion is stronger than that found at Leafield over the interval 1·2 to 12·4 m., even allowing for the height difference between corresponding levels. In the summer months the mean gradient at Leafield and Porton was a lapse in contradistinction to the inversion found at Rye.

TABLE II—MEAN VALUES OF THE TEMPERATURE DIFFERENCE OVER THREE HEIGHT INTERVALS FOR EACH MONTH

	Height interval		
	15·2–1·1 m.	47·2–15·2 m.	106·7–47·2 m.
		degrees Fahrenheit	
January	+1·09	+0·11	+0·07
February	+0·55	−0·13	−0·18
March	+0·66	+0·24	+0·16
April	+0·45	+0·21	−0·18
May	+0·05	−0·16	−0·05
June	+0·14	−0·17	−0·06
July	+0·01	−0·33	−0·43
August	+0·08	−0·05	+0·12
September	+0·50	+0·14	+0·13
October	+0·84	+0·96	+0·31
November	+0·62	+0·78	+0·21
December	+0·69	+0·96	+0·18
Annual mean	+0·47	+0·21	+0·02

The mean inversion frequently decreases with height with exceptions in May, June and August, but the higher levels do not show a small lapse at all times of the year ; there is a lapse in summer months and an inversion in winter months, the annual mean being almost isothermal. The winter-month inversion is probably due to the presence of the sea which is warmer than the land. The warm air from the sea will, for certain wind directions, ascend over the cold air over the land at a small angle of say 1/200 and will affect the temperatures inland above a height of 30 m. (100 ft.) ; there will be no marked frontal effect owing to mixing.

§ 8—TEMPERATURE LAPSE RATES ON CLEAR AND OVERCAST DAYS

In this section it is proposed to examine the effect which the state of the sky produces upon the lapse rate in a similar manner to the investigations in *Geophysical Memoirs* Nos. 46 and 77. A departure from the selection of data made in those publications is made in order that a larger number of cases may be included in each category. The criterion for a clear day remains as continuous or almost continuous traces on the sunshine recorder and night-sky camera over the 24 hr. period from midnight to midnight. For an overcast day a complete absence of trace on both recorders has been required. In addition the conditions for the 6 hr. (instead of 12 hr. as for Porton and Leafield) preceding the 24-hr. period in question were required to conform to the appropriate criterion. The definition of summer days was extended to include the months July and August as well as June, while that of winter days was extended to include January and February as well as December. The criteria form a strict set of conditions, and the extension of the meaning of summer and winter days still yields only very few cases of overcast days in summer and clear days in winter. The observations used in the compilation of tables and curves for clear and overcast days relate to the occasions which are tabulated in § 4.

Table III gives the mean hourly values of the temperature differences over the three height intervals for clear and overcast days in summer and winter, and Fig. 6 shows the graphical representation. Table IV gives the wind speed for each of the groups of observations as measured on the Meteorological Office pressure-tube anemograph at a height of 12·7 m.

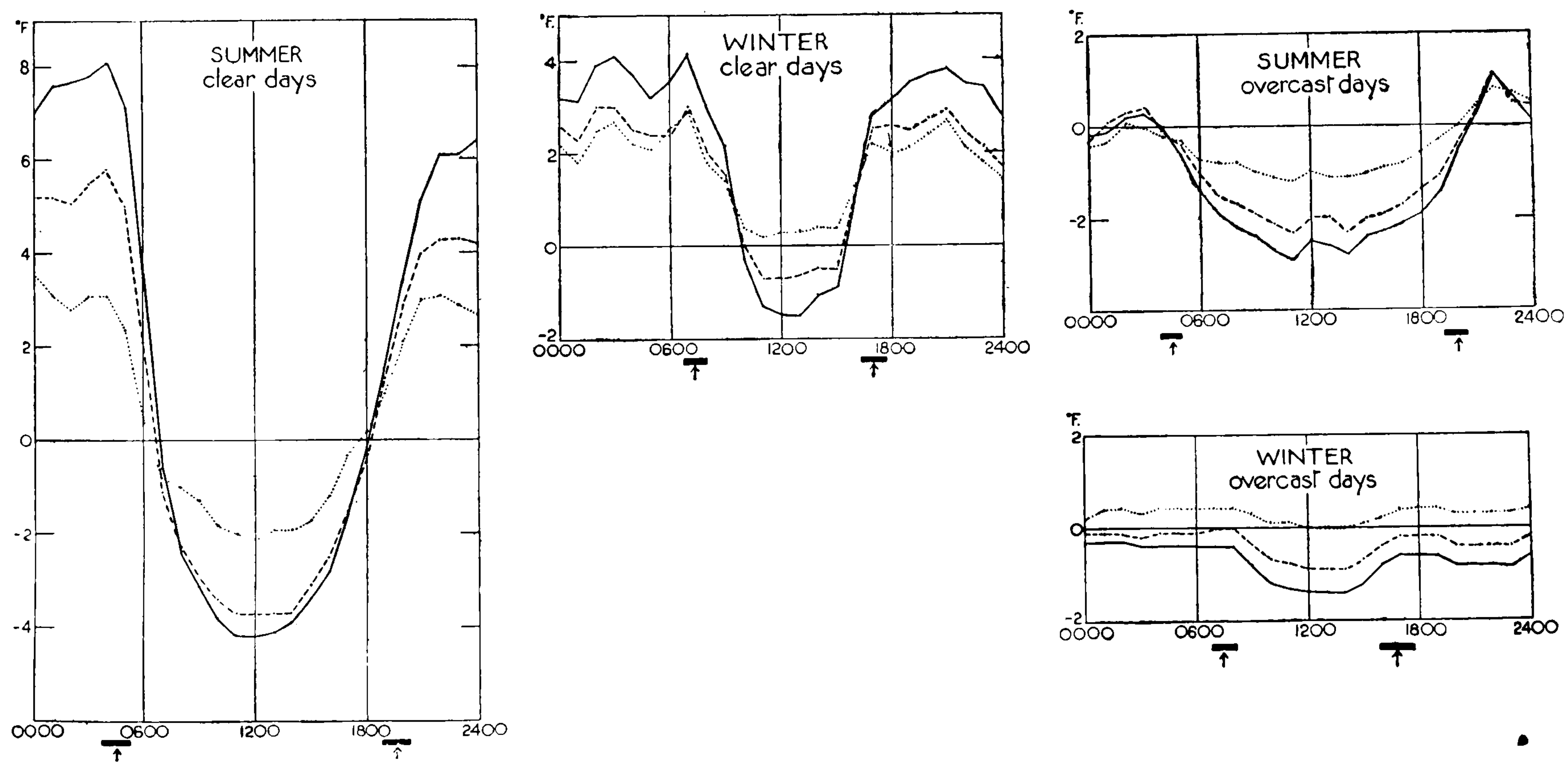


FIG. 6—DIURNAL VARIATION OF TEMPERATURE DIFFERENCE OVER THREE HEIGHT INTERVALS FOR CLEAR AND OVERCAST DAYS IN SUMMER AND WINTER

The curves show the temperature difference over the following intervals

········15·2–1·1 m. – – – – – 47·2–1·1 m. ———106·7–1·1 m.

The arrows indicate times of sunrise and sunset, the limits for each month being shown by the length of the bar immediately above the arrow.

TABLE III—MEAN HOURLY VALUES OF THE TEMPERATURE DIFFERENCE OVER THREE

Height interval	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100
m.						*degrees Fahrenheit*						
						CLEAR DAYS						
						Summer (19 occasions)						
106·7–47·2	+1·8	+2·4	+2·6	+2·3	+2·3	+2·1	+1·3	+0·5	−0·1	−0·2	−0·4	−0·5
47·2–15·2	+1·7	+2·1	+2·3	+2·4	+2·7	+2·6	+1·6	−0·3	−1·3	−1·6	−1·6	−1·7
15·2– 1·1	+3·5	+3·1	+2·8	+3·1	+3·1	+2·4	+0·5	−0·8	−1·0	−1·3	−1·8	−2·0
						Winter (3 occasions)						
106·7–47·2	+0·6	+0·8	+0·9	+1·1	+1·3	+0·8	+1·1	+1·1	+1·0	+0·6	−0·3	−0·6
47·2–15·2	+0·4	+0·5	+0·5	+0·3	+0·3	+0·3	−0·1	+0·1	+0·2	+0·1	−0·4	−0·9
15·2– 1·1	+2·2	+1·8	+2·5	+2·7	+2·2	+2·1	+2·5	+2·9	+1·8	+1·4	+0·4	+0·2
						OVERCAST DAYS						
						Summer (4 occasions)						
106·7–47·2	+0·1	−0·2	−0·1	−0·1	+0·1	−0·2	−0·4	−0·4	−0·5	−0·5	−0·6	−0·6
47·2–15·2	+0·1	+0·4	+0·2	+0·4	+0·1	−0·1	−0·3	−0·7	−0·9	−0·9	−1·0	−1·1
15·2– 1·1	−0·4	−0·3	+0·1	0·0	−0·2	−0·3	−0·7	−0·8	−0·8	−1·0	−1·1	−1·2
						Winter (21 occasions)						
106·7–47·2	−0·2	−0·2	−0·2	−0·2	−0·3	−0·3	−0·3	−0·4	−0·4	−0·4	−0·5	−0·5
47·2–15·2	−0·3	−0·5	−0·5	−0·5	−0·5	−0·5	−0·5	−0·4	−0·4	−0·7	−0·8	−0·9
15·2– 1·1	+0·2	+0·4	+0·4	+0·3	+0·4	+0·4	+0·4	+0·4	+0·4	+0·3	+0·1	+0·1

Summer, clear days.—On clear days in summer the maximum lapse over interval X is −2·1° F. occurring at 1200, while that over interval Z is −4·2° F. occurring at 1100 and 1200. From the mean curves for summer months the corresponding maximum lapses are −1·6° F. at 1200 in August and −3·5° F. at 1200 in August. The inversion maxima over X and Z for clear nights in summer are +3·5° F. at 0000 and +8·1° F. at 0400, while the mean curves for the three months give +1·9° F. at 0100 in June and +3·6° F. at 0100 and 0200 in June. The mean curves for the summer months and those for clear skies are similar with increased amplitudes in the latter set. The inversion is seen to build up more rapidly in the evening with clear skies. The figures quoted for lapses and inversions are similar to those for Leafield except that the night inversions in the upper layers at Rye are greater than those at Leafield. This may be a reflection of the difference in site. It would be expected that there would be a greater tendency to drainage of cold air from the Leafield site, which would lower the ceiling of the night inversion and diminish the intensity of the inversion at the greater heights.

Winter, clear days.—On clear days in winter there is no lapse in interval X in the mid-day period; there is a minimum inversion of +0·2° F. The maximum lapse in interval Z is

TABLE IV—MEAN HOURLY VALUES OF WIND SPEED

	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100
						metres per second					
CLEAR DAYS											
Summer	1·3	1·2	1·2	1·2	1·2	0·8	1·6	2·2	2·6	3·1	3·6
Winter	4·2	4·3	3·7	3·6	2·2	3·6	3·0	3·3	3·3	4·8	5·8
OVERCAST DAYS											
Summer	1·1	1·0	1·0	1·6	1·6	2·1	2·2	3·1	3·4	2·9	3·6
Winter	3·7	3·9	3·8	3·9	4·1	4·1	4·1	4·3	4·3	4·4	4·5

HEIGHT INTERVALS FOR CLEAR AND OVERCAST DAYS IN SUMMER AND WINTER

1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	Height interval
					degrees Fahrenheit								m.
					CLEAR DAYS								
					Summer (19 occasions)								
−0·5	−0·4	−0·2	−0·3	−0·3	−0·1	+0·1	+0·2	+0·5	+1·1	+1·8	+1·8	+2·2	106·7–47·2
−1·6	−1·8	−1·8	−1·4	−1·3	−1·2	−0·5	+0·3	+0·8	+1·0	+1·2	+1·4	+1·5	47·2–15·2
−2·1	−1·9	−1·9	−1·7	−1·2	−0·3	+0·2	+1·0	+2·1	+3·0	+3·1	+2·9	+2·7	15·2– 1·1
					Winter (3 occasions)								
−0·8	−0·9	−0·6	−0·4	−0·2	+0·3	+0·5	+1·0	+1·0	+0·9	+1·1	+1·3	+1·1	106·7–47·2
−1·0	−0·9	−0·9	−0·9	−0·2	+0·3	+0·6	+0·4	+0·3	+0·2	+0·3	+0·3	+0·3	47·2–15·2
+0·3	+0·3	+0·4	+0·4	+1·3	+2·2	+2·0	+2·1	+2·4	+2·7	+2·1	+1·8	+1·4	15·2– 1·1
					OVERCAST DAYS								
					Summer (4 occasions)								
−0·5	−0·6	−0·5	−0·4	−0·4	−0·4	−0·5	−0·3	−0·1	−0·1	0·0	+0·1	−0·3	106·7–47·2
−1·0	−0·9	−1·2	−1·0	−1·0	−0·9	−0·8	−0·8	−0·4	−0·1	+0·3	−0·2	−0·1	47·2–15·2
−1·0	−1·1	−1·1	−1·0	−0·9	−0·8	−0·6	−0·3	0·0	+0·4	+0·8	+0·7	+0·5	15·2– 1·1
					Winter (21 occasions)								
−0·5	−0·5	−0·5	−0·5	−0·4	−0·4	−0·4	−0·4	−0·4	−0·4	−0·4	−0·4	−0·4	106·7–47·2
−0·9	−0·9	−0·9	−0·8	−0·6	−0·6	−0·6	−0·6	−0·7	−0·7	−0·7	−0·7	−0·6	47·2–15·2
0·0	0·0	0·0	+0·1	+0·2	+0·4	+0·4	+0·4	+0·3	+0·3	+0·3	+0·3	+0·4	15·2– 1·1

−1·5° F. at 1200 and 1300. The comparison figures for all states of the sky are −0·3° and −1·8° F. at 1300 in February. On clear winter days the maximum inversions are respectively +2·7° F. at 2100 and 0300 and +4·1° F. at 0300, the comparable maxima for all states of the sky being +1·7° and +2·4° F. at 0400 in January. The number of clear days in winter is only three and from such meagre data no conclusions were drawn. Nevertheless an interesting point arose with regard to the three clear days examined. There was snow cover on only one of these days, February 25, 1948, and on this day only was there a lapse of temperature in interval X in the midday period. The air stream was from the east, and over Europe was very cold near the surface combined with a strong surface inversion which inhibited turbulent transfer. On passing over the much warmer surface in England (and over the sea) a lapse of temperature was set up. On both the other occasions the air passing over Rye, from the south-west, was warmer at the surface although there was a strong surface inversion, and this led to a persistence of the inversion.

Summer, overcast days.—On overcast days in summer the maximum lapses in the two layers being considered are −1·2° and −2·9°F. at 1100, the comparable lapse rates for all states

CORRESPONDING TO THE OCCASIONS SHOWN IN TABLE III AND TABLE XVII

1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	
					metres per second								
4·0	4·1	4·1	4·5	4·4	3·8	3·4	2·4	1·6	1·4	1·5	1·4	1·4	CLEAR DAYS
6·3	6·4	5·7	5·8	5·1	4·2	3·7	3·1	3·9	4·6	5·2	4·6	4·8	
3·1	3·1	2·9	3·3	3·6	4·1	3·7	2·5	1·9	1·1	1·6	1·7	2·5	OVERCAST DAYS
4·3	4·4	4·1	4·2	4·1	4·3	3·9	4·4	4·8	5·1	5·2	4·9	4·8	

of the sky being −1·6° and −3·5° F. as given above. The maximum inversions are +0·8° and +1·1° F. These figures show the small variations of temperature on overcast days compared with those on mean days, and, of course, with those on clear days.

Winter, overcast days.—In winter the maximum lapses in the two layers being considered are −0·0° and −1·4° F. about midday; there is a maximum inversion of 0·4° F. in interval X and a minimum lapse of −0·3° F. in interval Z. On overcast days in winter the temperature variations are small, as is easily seen in Fig. 6. It will be noted that above 15·2 m. there is always a mean lapse of temperature on overcast days in winter.

These conclusions from the Rye data serve to bear out those made by Johnson and Heywood from the Leafield data.

§ 9—MAXIMUM VALUES OF THE TEMPERATURE LAPSE RATE

From the hourly values of the temperature differences over the three height intervals the largest hourly values of both lapses and inversions occurring during each month have been extracted. These values are given in Tables V and VI, together with the hour and date of occurrence, the state of the sky and the wind speed at 12·7 m.

Maximum lapses.—During the three years in which observations were recorded the greatest lapse between 1·1 and 15·2 m. was −5·2° F., between 15·2 and 47·2 m., −5·0° F. and between 47·2 and 106·7 m., −4·5° F. These lapses occur in May, June and May respectively and represent 20, 8·7 and 4·2 times the dry adiabatic lapse rate. The maximum December lapses over the same three intervals are −2·5°, −1·6° and −2·2° F. or 10, 2·8 and 2·1 times the adiabatic lapse rate.

The maximum lapses occur in the lowest layer about noon; of the 40 recorded maxima set out in Table V (on five occasions the maximum for a given month occurred twice) 26 were between 1100 and 1300. In the interval 15·2 to 47·2 m., although the maximum lapse is still most frequent about midday, there is a wider dispersion in time of occurrence, and in the interval 47·2 to 106·7 m. the dispersion is more marked, the maximum lapse occurring as late as 2400 in December.

As regards the state of the sky, in the lowest layer the maximum lapse occurs mainly with clear skies or broken cloud, although one example of the maximum lapse occurring in a thunderstorm is noted in June 1947. In the upper layers, however, the maximum lapse occurs more frequently with cloudy conditions than it does in the lowest layer.

The mean values of the wind speeds (at 12·7 m.) on occasions of maximum lapse in the layers X, Y, Z are 3·5, 5 and 4 m./sec. respectively. On some occasions of maximum lapse in the two upper layers the wind speed was 10–14 m./sec. (at 12·7 m.).

Maximum inversions.—During the three years of observation the maximum inversions in the layers 1·1 to 15·2 m., 15·2 to 47·2 m. and 47·2 to 106·7 m. were 13·6°, 14·8° and 14·5° F. respectively, the months of occurrence being January 1947, September 1946 and February 1947.

Inversion extremes occur at all times of the night in the lowest layer; out of 38 readings 17 occur after midnight. In the middle layer out of 44 readings only 8 occur at or before midnight and 19 occur at or before 0300; in the top layer out of 39 readings only 9 occur at or before midnight while 17 occur at or after 0500. These figures are indicative of the upward growth of the nocturnal inversion.

The sky is almost always clear or only partially clouded at the time of the maximum inversion in the layer 1·1 to 15·2 m.; the same is true of the middle layer except that fog is

TABLE V—MAXIMUM HOURLY VALUES OF TEMPERATURE LAPSE IN EACH MONTH

	1945					1946					1947					1948				
	Day	Max. lapse	Time of occur-rence	Sky	Wind	Day	Max. lapse	Time of occur-rence	Sky	Wind	Day	Max. lapse	Time of occur-rence	Sky	Wind	Day	Max. lapse	Time of occur-rence	Sky	Wind
		° F.			m./sec.		° F.			m./sec.		° F.			m./sec.		° F.			m./sec.
HEIGHT INTERVAL 106·7–47·2 m.																				
Jan.	..	..	..	..	..	27	−1·9	1500	b	calm	12	−1·9	1500	b	5·3	..	..	..	..	..
Feb.	..	..	..	..	..	9	−1·5	1100	b	10·2	24	−2·9	1700	bc	calm	26	−1·5	1000	b	10·2
Mar.	..	..	..	..	..	29	−2·2	1300	b	4·9	9	−3·6	1400	bc	4·0	28	−3·5	1300	b	0·9
Apr.	..	..	..	..	..	8	−1·8	1400	bc	6·7	22	−2·0	0900	c	5·3	12	−2·4	1700	bc	..
May	..	..	..	..	..	19	−3·1	1500	bc	3·1	15	−1·7	1500	bc	6·2	7	−4·5	0700	b	0·9
June	..	..	..	..	..	1	−1·9	1700 1800	bc	6·2 6·7	7	−1·4	1500	bc	8·5	11	−4·4	1800	bc	1·3
July	20	−1·5	1400	c	11·1	1 4 4	−1·7	0900 1000 1100	c bc bc	1·3 calm 0·9	19	−0·9	0700	cf	calm	..	..	..	..	..
Aug.	28	−2·9	1600	bc	4·0	19 27	−0·8	1100 1200	c bc	6·7 5·3	27	−0·8	1300	b	5·8	..	..	..	..	..
Sept.	30	−1·6	2100 2200	c	calm	30	−0·9	1500	b	2·7	23	−1·2	1600	bc	1·3	..	..	..	..	..
Oct.	30	−2·1	1400	b	2·7	21	−1·0	1700	bc	calm	16	−1·4	1700	c	1·8	..	..	..	..	..
Nov.	3	−1·0	1300 1400 1500	bc bc bc	5·3 3·6 3·1	5	−1·6	1200	b	calm	8	−1·2	1600	c	3·1	..	..	..	..	..
Dec.	20	−2·2	1300	bc	4·0	18	−1·3	1600	c	5·8	1	−1·0	2300 2400	c c	3·6 2·7	.. ..	.. ..	.. ..	.. ..	.. ..
HEIGHT INTERVAL 47·2–15·2 m.																				
Jan.	..	..	..	..	..	14 15	−1·0	1400 1500	bc b	8·0 4·0	24	−1·9	1200	cps	4·5	..	..	..	..	..
Feb.	..	..	..	..	..	21	−1·9	1200	bc	12·0	18	−3·0	1400	c	6·7	18	−1·5	1200	b	9·3
Mar.	..	..	..	..	..	30	−2·0	1100	b	3·1	25	−2·9	0900	b	3·6	13	−2·0	1600	bc	calm
Apr.	..	..	..	..	..	15	−3·4	0900	b	0·4	13	−2·2	0900	b	3·6	12	−4·3	1000	b	..
May	..	..	..	..	..	12	−2·0	1300	bc	4·5	1 30	−1·9	1200 1300	c b	5·8 1·3	7	−4·0	1000	b	1·3
June	..	..	..	..	..	14 18 27 27 28 30	−2·0	1400 1400 1100 1200 1400 1000	c bc c c bc c	6·2 10·2 6·2 7·6 6·7 4·5	12 26	−2·5	1400	b c	6·2 1·8	11	−5·0	1300	b	0·4
July	8	−3·0	0800	b	0·9	30	−1·9	1100	c	8·5	26	−3·4	1400	b	4·5	..	..	..	..	..
Aug.	2	−3·0	1300 1400	b b	4·0 3·1	4 9	−1·4	1500 1100	b c	2·2 1·3	29 30	−2·6	1000 1100	bc c	3·1 4·5	..	..	..	..	..
Sept.	2	−2·3	1300	bc	8·0	1	−1·0	1400	bc	6·7	3	−2·8	1300	bc	1·3	..	..	..	..	..
Oct.	7	−1·9	1300	bc	1·3	17 17 18 21	−0·9	1200 1400 1100 1200	bc c c c	8·5 8·9 6·2 4·9	26	−1·6	1100 1200	bc bc	6·7 5·8	..	..	..	..	..
Nov.	18	−1·5	1200	bc	4·0	30	−0·9	1600	c	8·0	8	−0·8	1400	c	6·2	..	..	..	..	..
Dec.	9 18 18	−0·8	1500 1100 1200	bc bc bc	calm 12·9 13·7	28	−1·6	1600	c	0·4	8	−1·4	1100	bc	5·3	..	..	..	..	..

TABLE V—*continued*

	1945					1946					1947					1948				
	Day	Max. lapse	Time of occur-rence	Sky	Wind	Day	Max. lapse	Time of occur-rence	Sky	Wind	Day	Max. lapse	Time of occur-rence	Sky	Wind	Day	Max. lapse	Time of occur-rence	Sky	Wind
		° F.			m./sec.		° F.			m./sec.		° F.			m./sec.		° F.			m./sec.
HEIGHT INTERVAL 15·2–1·1 m.																				
Jan.	..	..	..	..	..	3	−2·1	1300	b	3·6	1	−0·6	1300	bc	calm	..	..	..	..	..
Feb.	..	..	..	..	..	24	−1·8	1000 1100	b b	6·2 6·7	18	−1·7	1300	c	7·1	15	−1·6	1300	c	2·2
Mar.	..	..	..	..	..	25	−4·6	1300	bc	3·6	25	−2·6	1000	b	3·6	29	−3·8	1300	c	4·5
Apr.	..	..	..	..	..	19	−4·6	0900	b	0·9	10 29	−2·2	1200	b	2·2 8·5	23	−4·8	1000	bc	4·5
May	..	..	..	..	..	7	−2·5	1400	bc	8·9	24	−3·1	1100	bc	4·0	30	−5·2	1200	bc	4·0
June	..	..	..	..	..	12	−2·6	1000	c	3·6	28	−3·2	1200	ctlrm	3·6	11	−4·4	1800	bc	1·3
July	3	−3·8	1100	bc	3·6	3 10	−3·1	1200 1100	bc b	1·3 3·1	26	−3·5	1400	b	4·5	..	..	..	..	..
Aug.	3	−3·4	1200 1400	b b	2·2 3·1	27	−2·1	1100	b	4·5	8	−2·9	1000	b	1·3	..	..	..	..	..
Sept.	17	−4·4	1400	bc	5·3	30	−1·8	1300	b	1·3	17	−2·6	1100	bc	1·8	..	..	..	..	..
Oct.	8	−2·6	1100	bc	4·9	11	−1·5	1300	b	6·7	17 21 21	−1·8	1100 0900 1000	c b b	3·5 4·5 0·4	..	..	..	..	..
Nov.	3	−3·0	1200	bc	2·7	5	−2·0	1200	bf	calm	6	−1·4	1000	oF	0·9	..	..	..	..	..
Dec.	20	−2·5	1300	bc	4·0	18	−1·1	1200	b	7·6	1	−1·5	1000	bm	calm	..	..	..	..	..

TABLE VI—MAXIMUM HOURLY VALUES OF TEMPERATURE INVERSION IN EACH MONTH

	1945					1946					1947					1948				
	Day	Max. inver-sion	Time of occur-rence	Sky	Wind	Day	Max. inver-sion	Time of occur-rence	Sky	Wind	Day	Max. inver-sion	Time of occur-rence	Sky	Wind	Day	Max. inver-sion	Line of occur-rence	Sky	Wind
		° F.			m./sec.		° F.			m./sec.		° F.			m./sec.		° F.			m./sec.
HEIGHT INTERVAL 106·7–47·2 M.																				
Jan.	..	..	..	..	..	27	4·5	1100	bcf	1·8	8 19	4·1	0200 1100	bcf bc	1·3 2·7	..	..	..	..	..
Feb.	..	..	..	..	..	28	5·0	0400	bf	1·8	24	14·5	0900	b	1·8	28	5·4	2200	bcm	calm
Mar.	..	..	..	..	..	30	8·4	0400	bff	1·8	29	3·8	0600	cpr	5·3	9	12·3	2400	b	1·3
Apr.	..	..	..	..	..	13	7·2	0700	bm	calm	13	8·9	2200	b	calm	18	6·6	0600	bff	calm
May	..	..	..	..	..	30	4·6	0200	bc	calm	29	11·8	2000	b	1·3	2	4·0	1300	c	4·5
June	..	..	..	..	..	7	4·2	0200	bc	calm	3	13·6	2300	b	calm	23	4·0	0200 0500	bc bc	calm 0·9
July	13	10·5	2200	b	4·9	2	6·9	0100	bc	calm	28	8·1	0600	bc	3·6	..	..	..	..	..
Aug.	4	5·3	0100	b	calm	22	5·1	0500	c	calm	16	5·1	0500	b	1·8	..	..	..	..	..
Sept.	12 30	3·5	2200 0300	cm bm	8·0 1·3	26	4·8	2200	c	calm	15	9·4	2400	b	0·4	..	..	..	..	..
Oct.	14	6·3	0600	bm	1·3	7	3·1	0600	bc	calm	21	8·0	0900	b	4·5	..	..	..	..	..
Nov.	11 29	4·8	0100 0400	bc bcm	4·0 calm	5	10·2	0800	bm	calm	6	11·4	0800	oF	0·4	..	..	..	..	..
Dec.	7	6·5	1000	c	0·9	22	5·8	0100	b	calm	1	9·3	0300	oF	calm	..	..	..	..	..

TABLE VI—*continued*

	1945					1946					1947					1948				
	Day	Max. inver-sion	Time of occur-rence	Sky	Wind	Day	Max. inver-sion	Time of occur-rence	Sky	Wind	Day	Max. inver-sion	Time of occur-rence	Sky	Wind	Day	Max. inver-sion	Time of occur-rence	Sky	Wind
		° F.			m./sec.		° F.			m./sec.		° F.			m./sec.		° F.			m./sec.
HEIGHT INTERVAL 47·2–15·2 M.																				
Jan.	..	..	..	..	..	7	5·9	2300	bcm	calm	3	8·0	0200 0300	bm bm	calm calm	..	..	..	..	..
Feb.	..	..	..	..	..	28	3·2	0700	bcf	2·7	24	8·7	0600	b	2·2	29	7·4	0800	bm	calm
Mar.	..	..	..	..	..	26	8·2	0600	bm	1·8	9	4·7	1400	bc	4·0	6 12	10·6	2100 0700	bff b	calm calm
Apr.	..	..	..	..	..	16	8·6	0400	bm	2·2	14	8·6	0300	b	calm	13	7·7	0200	b	..
May	..	..	..	..	..	1 22	4·2	0500 0400	b bc	3·1 1·3	31	9·6	0500	b	calm	7	5·6	0700	b	0·9
June	..	..	..	..	..	7	5·0	0500	b	calm	2	10·1	2000	bc	1·8	14 24	2·8	0100 0400 0500	b bc bc	0·9 0·4 0·9
July	14	2·8	0200	b	3·1	10 12	4·8	0400 0500	b bc	calm calm	27	6·4	0300	bcf	calm	..	..	..	..	..
Aug.	3	6·8	0500	b	0·9	16	8·8	0500	bc	calm	9	7·8	0600	b	calm	..	..	..	..	..
Sept.	30	6·8	0100 0200	bm bm	1·3 0·9	16	14·8	0600	bc	calm	4	10·2	0500	bm	calm	..	..	..	..	..
Oct.	9	11·1	0500	bcm	calm	7	5·9	2400	b	calm	22	11·4	0200	b	1·8	..	..	..	..	..
Nov.	25 29	8·6	2400 0100	cf bm	calm calm	4	13·4	2300 2400	bf	calm	7	13·5	0600	bc	0·4	..	..	..	..	..
Dec.	20	10·1	0900	b	calm	22	12·4	0400	bc	calm	1	7·8	0900	bm	0·9	..	..	..	..	..
HEIGHT INTERVAL 15·2–1·1 M.																				
Jan.	..	..	..	..	..	8	9·3	0100	bc	1·8	30	13·6	0200	bc	calm	..	..	..	..	..
Feb.	..	..	..	..	..	24	4·4	2400	b	0·4	24	12·7	0200	b	0·9	29	9·2	2300 2400	b b	1·3 1·8
Mar.	..	..	..	..	..	27	6·8	0200	bm	1·8	3	6·4	0600	b	calm	12	10·0	2000	b	calm
Apr.	..	..	..	..	..	15	9·2	0500	bm	1·3	26	7·9	2300	b	calm	18	8·5	0300	b	calm
May	..	..	..	..	..	15 16 19	6·4	2100 2300 2300	bc bc b	calm	30	7·5	0400	b	calm	22	8·6	0100	b	1·8
June	..	..	..	..	..	7	7·3	0100	b	calm	25	9·0	0100	b	calm	20	6·2	2200	bc	3·1
July	16	6·5	2400	b	0·4	7	6·6	2200	b	calm	3	6·8	2200	b	calm	..	..	..	..	..
Aug.	5	7·4	0100	b	calm	16	6·9	0200	bc	calm	8	8·6	2100	b	calm	..	..	..	..	..
Sept.	29	7·1	2000	b	0·9	16	8·7	0200	b	calm	10	10·6	2400	b	calm	..	..	..	..	..
Oct.	9	10·6	2100	bc	calm	6	5·8	2400	c	1·8	22	11·8	0500	bc	1·8	..	..	..	..	..
Nov.	15	8·1	1900	bc	3·1	4	9·2	2000	bm	calm	1	9·9	0700	c	calm	..	..	..	..	..
Dec.	7	7·8	2200	bcm	calm	21	8·2	2400	b	calm	8	6·2	0100	cf	calm	..	..	..	..	..

occasionally reported and the frequency of fog at the time of maximum inversion in the upper layer increases. This agrees with the general physical picture envisaged in the building up of the nocturnal inversion, the inversion in the upper layers often reaching its maximum when the lower layers are already sufficiently cooled for fog to form.

The wind speed at the time of maximum inversion is invariably small, the mean wind measured in the lowest layer at the times of occurrence in the three layers starting at the lowest, being 0·6 m./sec., 0·8 m./sec. and 1·4 m./sec.

An exceptional inversion.—In Table VI all the maximum inversions for February 1947 fall on the same day. February 24, 1947 has, therefore, been considered in rather more detail. The general synoptic situation shows a high-pressure system centred over northern France and Germany, Rye being in the north-west section of the anticyclone. A light NE. wind, not exceeding 2·5 m./sec. was recorded during the day. There was a blue sky with slight haze, the visibility being about 7 Km. The snow depth was rather less than 4 in. These conditions are ideal for the formation of a large inversion near the ground, for it is well known that the fall of temperature at the surface consequent upon the nocturnal radiation is enhanced by the presence of snow cover, clear skies and a light wind. The temperature recorded in the first 12 hr. of the day is given in Table VII.

TABLE VII—EXCEPTIONAL INVERSION OF TEMPERATURE ON FEBRUARY 24, 1947

	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200
	degrees Fahrenheit												
TEMPERATURE													
106·7 m.	24·2	23·8	23·8	23·8	23·7	23·9	23·6	22·7	25·9	33·9	33·6	34·8	34·1
47·2 m.	19·4	18·8	19·9	18·3	18·4	18·7	19·2	19·1	20·0	19·4	23·2	29·7	32·9
15·2 m.	17·5	17·5	17·5	16·1	11·8	11·2	10·5	10·6	11·7	12·3	17·8	26·2	33·4
1·1 m.	9·6	8·8	4·8	5·4	6·1	3·9	3·9	2·1	5·3	8·4	14·3	21·2	25·4
LAPSE OF TEMPERATURE													
106·7–47·2 m.	4·8	5·0	3·9	5·5	5·3	5·2	4·4	3·6	5·9	14·5*	10·4	5·1	1·2
47·2–15·2 m.	1·9	1·3	2·4	2·2	6·6	7·5	8·7	8·5	8·3	7·1	5·4	3·5	−0·5
15·2–1·1 m.	7·9	8·7	12·7	10·7	5·7	7·3	6·6	8·5	6·4	3·9	3·5	5·0	8·0
106·7–1·1 m.	14·6	15·0	19·0	18·4	17·6	20·0	19·7	20·6	20·6	25·5*	19·3	13·6	8·7
47·2–1·1 m.	9·8	10·0	15·1	12·9	12·3	14·8	15·3	17·0	14·7	11·0	8·9	8·5	7·5

Grass minimum temperature, 1° F. Weather, bm_0. Visibility, 4–6 miles at 0900. State of ground, 8 rather less than 4 in. snow. 8-in. earth temperature, 33·2° F. at 0900.

* At 0900 the 106·7–47·2 differential temperature trace exceeded even the double range of the chart. The figures entered in the record are, if anything conservative estimates ; the true figures may be 0·1° or 0·2° F. in excess of these.

It is seen from the table that the temperature at three of the heights reaches its minimum value at about the same time, 0700. At this time the inversion from 1·1 to 47·2 m. is a maximum, but the maximum inversion from 1·1 to 106·7 m. occurs later than 0900, while the maximum inversion from 1·1 to 15·2 m. occurs earlier at 0200. The early time of occurrence of the maximum inversion layer X can be explained in terms of heat transport. The nocturnal radiation draws its heat supply from both the earth and the atmosphere above. In the early stages before heat diffuses downwards sufficiently rapidly the surface temperature falls quickly and sets up a strong inversion from the surface upwards. As the temperature falls further the contribution from the air makes itself felt more, and the inversion near the surface decreases while that in the layer Y is increased. Even after sunrise when the surface temperature is rising heat is being diffused downwards more rapidly from above thus increasing the inversion in the upper layer Z. This is plain from the table for the increase of temperature at 1·1 m. from 0700 to 0900 is 6·3° F. while that at 106·7 m. is 11·2° F.

§ 10—FREQUENCY OF OCCURRENCE OF TEMPERATURE LAPSE RATES OF VARIOUS MAGNITUDES

The hourly values of the temperature differences between the levels 1·1 to 15·2 m., 15·2 to 47·2 m. and 47·2 to 106·7 m. during the three years have been analysed to show the frequency of occurrence of temperature differences of given magnitude. Table VIII shows the monthly frequencies of temperature differences between the stated limits expressed as percentages of the total number of hourly readings.

In the interval 1·1 to 15·2 m. it will be seen that the maximum frequencies all lie in one of the two ranges (—0·1 to —1·0) and (0·0 to 0·9), and their general distribution follows that in the interval 1·2 to 12·4 m. for Leafield. The layer between 47·2 and 106·7 m. is similarly in agreement with the Leafield results for the layer 57·4 to 87·7 m., while the intermediate layer 15·2 to 47·2 m. generally leans to the distribution in the upper layer at Leafield.

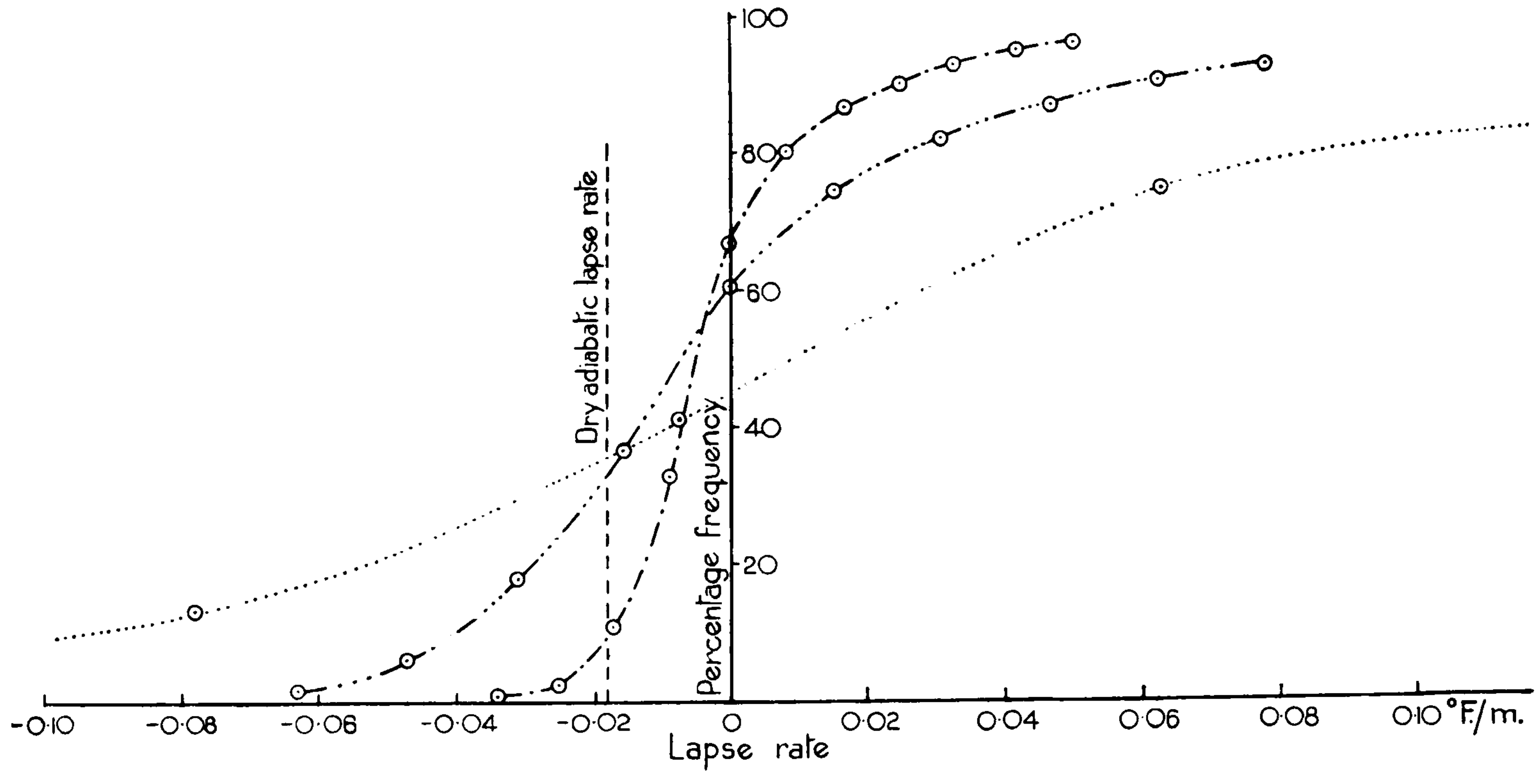


FIG. 7—OGIVE OF PERCENTAGE FREQUENCY OF LAPSE RATE OF TEMPERATURE

The curves show the percentage frequencies over the following intervals

⊙·······⊙ 15·2–1 m. ⊙—···—⊙ 47·2–15·2 m. ⊙—·—·⊙ 106·7–47·2 m.

The average frequencies for the year are given in Table VIII, and are plotted in the form of an ogive* in Fig. 7. The co-ordinates in the ogive are lapse rate (in degrees Fahrenheit per metre) and percentage frequency by which the lapse rate is exceeded. Any ogive thus takes all ordinate values between 0 and 100. The central part has been drawn on a large scale, and all the curves become zero to the left and 100 to the right. The three curves are thus represented on one diagram and can be compared directly. The frequency of large lapses near the ground is much greater than at the other levels, as is the frequency of large inversions. It is also true that the frequency of large lapses and inversions is greater in the middle layer than it is in the top layer.

* See Appendix I

TABLE VIII—PERCENTAGE FREQUENCY OF OCCURRENCE

Temperature difference (° F.)

	−3·4 to −3·0	−2·9 to −2·5	−2·4 to −2·0	−1·9 to −1·5	−1·4 to −1·0	−0·9 to −0·5	−0·4 to 0·0	+0·1 to +0·5	+0·6 to +1·0	+1·1 to +1·5	+1·6 to +2·0	+2·1 to +2·5	+2·6 to +3·0	+3·1 to +3·5
	percentage frequency													
	HEIGHT INTERVAL 106·7–47·2 M.													
Jan.	..	..	..	0·6	2·4	17·1	48·8	13·6	5·9	3·8	2·9	2·3	1·1	0·8
Feb.*	..	0·1	..	0·1	5·5	35·4	44·8	5·5	2·7	1·3	0·7	0·7	0·5	0·5
Mar.*	0·1	0·3	1·2	3·7	12·1	26·0	22·0	10·1	6·9	4·5	3·7	1·8	1·8	1·0
Apr.	..	..	0·5	4·4	22·5	31·4	14·5	8·7	5·0	2·9	2·7	2·0	2·0	0·9
May*	..	0·7	1·1	2·9	18·6	28·2	21·2	6·7	5·1	3·3	2·9	1·9	1·7	1·6
June*	0·1	0·1	0·4	2·9	17·1	28·6	23·4	9·6	5·3	2·5	2·1	2·3	1·5	0·8
July	..	..	..	0·1	1·7	11·7	42·4	17·3	8·0	4·8	3·9	2·8	2·3	1·1
Aug.	..	0·9	3·1	2·7	5·1	14·7	28·4	21·1	7·7	4·9	3·6	2·8	2·3	1·2
Sept.	..	..	..	0·2	4·1	23·8	37·6	15·0	6·5	3·7	2·2	2·3	1·9	1·1
Oct.	..	..	0·2	1·6	3·3	12·8	42·9	16·7	6·4	3·9	2·9	2·1	2·5	0·8
Nov.*	..	..	..	0·1	0·3	12·4	53·2	16·2	6·7	3·7	2·4	1·8	1·1	0·8
Dec.	..	..	0·1	0·1	1·1	15·9	49·3	17·9	6·3	2·6	1·7	1·0	1·2	0·6
Year	..	0·2	0·6	1·7	8·3	21·7	34·8	13·2	6·1	3·5	2·6	2·0	1·7	1·0

	Mar. −3·9 to −3·5	May −3·9 to −3·5	June −4·4 to −3·5
*Further observations (%)	0·1	0·1	0·3

Temperature difference (° F.)

	−3·4 to −3·0	−2·9 to −2·5	−2·4 to −2·0	−1·9 to −1·5	−1·4 to −1·0	−0·9 to −0·5	−0·4 to 0·0	+0·1 to +0·5	+0·6 to +1·0	+1·1 to +1·5	+1·6 to +2·0	+1·9 to +2·5	+2·6 to +3·0	+3·1 to +3·5
	percentage frequency													
	HEIGHT INTERVAL 47·2–15·2 M.													
Jan.	..	..	..	0·6	7·9	19·1	33·2	17·7	7·7	5·3	2·3	2·2	1·1	1·1
Feb.	0·1	0·1	0·4	5·2	20·5	11·6	29·7	15·7	6·0	4·3	1·9	0·9	0·7	0·5
Mar.†	..	0·1	0·3	2·5	16·0	24·6	21·2	10·8	6·8	3·6	2·9	1·8	2·0	0·9
Apr.†	0·1	0·5	2·0	4·4	10·0	23·3	22·4	9·7	7·2	4·8	3·6	2·2	2·1	1·7
May†	0·5	1·0	2·7	6·1	15·3	25·6	18·8	10·0	5·2	3·1	2·8	1·9	2·2	1·3
June†	0·3	1·1	2·7	7·4	15·9	25·4	17·4	11·4	5·5	4·2	2·1	1·6	1·0	0·6
July	0·1	0·2	2·6	9·9	17·7	25·6	17·7	8·8	6·7	4·3	2·6	1·4	0·4	0·5
Aug.	0·1	0·4	2·9	9·4	13·8	17·6	18·2	10·8	7·8	5·4	4·4	3·4	2·5	1·6
Sept.†	..	0·1	1·1	4·3	16·9	17·3	22·6	12·7	7·7	5·0	3·3	1·8	1·6	1·7
Oct.†	..	..	..	0·6	6·0	13·3	22·3	17·4	9·9	6·5	4·6	3·3	3·8	1·8
Nov.†	..	..	..	0·1	0·4	7·7	32·9	21·7	13·6	8·1	4·3	2·3	2·3	1·1
Dec.†	..	..	..	0·1	1·6	9·3	36·4	21·8	11·8	7·9	2·9	1·7	1·6	1·1
Year	0·1	0·3	1·3	4·3	11·9	18·6	24·0	13·8	8·0	5·2	3·2	2·1	1·8	1·2

	Apr. −4·4 to −3·5	May −3·9 to −3·5	June −5·4 to −3·5
†Further observations (%)	0·2	0·2	0·3

Temperature difference (° F.)

	−5·0 to −4·1	−4·0 to −3·1	−3·0 to −2·1	−2·0 to −1·1	−1·0 to −0·1	0·0 to +0·9	+1·0 to +1·9	+2·0 to +2·9	+3·0 to +3·9
	percentage frequency								
	HEIGHT INTERVAL 15·2–1·1 M.								
Jan.	..	..	0·1	0·2	12·4	53·4	16·9	5·5	3·6
Feb.	..	..	..	1·4	34·2	46·6	8·0	3·3	2·2
Mar.	0·1	0·4	2·3	9·1	25·3	34·2	10·1	6·0	4·4
Apr.	0·6	0·7	2·9	14·4	29·6	22·4	10·2	6·0	4·6
May	0·4	1·5	7·0	17·0	27·5	25·2	8·7	4·3	3·4
June	0·3	2·0	4·4	14·3	27·0	29·5	9·9	4·8	2·5
July	..	1·5	6·3	15·0	29·6	28·5	8·2	5·2	2·9
Aug.	..	0·4	4·7	23·3	28·7	19·8	9·0	5·6	3·8
Sept...	0·1	0·2	2·2	11·6	29·1	30·7	10·2	5·8	3·6
Oct.	..	..	0·6	7·6	35·3	27·4	7·6	6·4	3·9
Nov.	..	..	0·1	1·2	36·6	38·6	9·6	5·9	2·8
Dec.	..	..	0·1	0·5	17·5	57·7	11·8	5·0	3·2
Year	0·1	0·6	2·7	10·1	28·1	33·6	10·0	5·3	3·4

OF TEMPERATURE DIFFERENCES OF VARIOUS VALUES

Temperature difference (° F.)

+3·6 to +4·0	+4·1 to +4·5	+4·6 to +5·0	+5·1 to +5·5	+5·6 to +6·0	+6·1 to +6·5	+6·6 to +7·0	+7·1 to +7·5	+7·6 to +8·0	+8·1 to +8·5	+8·6 to +9·0	+9·1 to +9·5	+9·6 to +10·0	+10·1 to +10·5	
percentage frequency														
HEIGHT INTERVAL 106·7–47·2 M.														
0·4	0·2	..	..	..	..	..	..	..	..	..	..	..	..	Jan.
0·7	0·6	0·2	0·3	0·1	..	..	..	..	..	..	..	..	0·1	Feb.*
0·9	0·9	0·8	0·3	0·3	0·1	0·4	0·2	0·2	0·2	0·1	0·2	0·1	0·4	Mar.*
0·7	0·4	0·7	0·3	0·2	0·2	0·2	0·2	..	..	0·1	..	..	..	Apr.
1·0	0·8	0·3	0·1	0·3	..	0·2	0·2	0·1	0·1	0·2	0·2	..	..	May*
1·0	0·3	0·1	0·2	0·3	0·3	0·1	0·1	0·1	0·2	0·1	0·2	0·1	..	June*
1·1	1·0	0·7	0·4	0·3	0·1	0·2	0·1	..	0·1	..	0·1	..	0·1	July
0·9	0·4	0·1	0·2	..	..	..	..	..	..	..	..	..	..	Aug.
0·4	0·5	0·2	0·1	0·1	0·1	0·1	0·1	0·1	0·1	..	0·1	..	..	Sept.
0·7	0·5	0·7	0·6	0·6	0·2	0·2	0·4	0·1	..	..	..	..	..	Oct.
0·2	0·1	0·3	0·1	..	0·2	0·2	0·2	0·1	0·1	..	0·1	0·1	0·1	Nov.*
0·3	0·6	0·2	0·3	0·1	0·1	..	0·2	0·1	0·1	0·1	0·1	..	..	Dec.
0·7	0·5	0·4	0·2	0·2	0·1	0·1	0·1	0·1	0·1	..	0·1	..	..	Year

	Feb. +14·5 to +10·6	Mar. +12·5 to +10·6	June +14·0 to +10·6	Nov. +11·5 to +10·6
*Further observations (%)	0·1	0·4	0·4	0·1

Temperature difference (° F.)

+3·6 to +4·0	+4·1 to +4·5	+4·6 to +5·0	+5·1 to +5·5	+5·6 to +6·0	+6·1 to +6·5	+6·6 to +7·0	+7·1 to +7·5	+7·6 to +8·0	+8·1 to +8·5	+8·6 to +9·0	+9·1 to +9·5	+9·6 to +10·0	+10·1 to +10·5	
percentage frequency														
HEIGHT INTERVAL 47·2–15·2 M.														
0·5	0·1	0·5	0·2	0·2	0·2	..	0·2	0·2	..	..	..	..	..	Jan.
0·4	0·3	0·5	0·3	0·1	0·1	0·1	0·2	..	0·1	0·1	..	..	..	Feb.
1·6	1·3	0·6	0·5	0·3	0·3	0·2	0·2	0·5	0·2	0·2	0·2	0·2	0·2	Mar.†
1·3	1·2	1·1	1·0	0·1	0·4	0·3	0·3	0·2	0·1	0·1	..	..	..	Apr.†
1·0	0·7	0·6	0·3	0·2	..	0·1	0·1	..	..	..	..	..	..	May†
0·5	0·5	0·5	0·5	0·3	0·2	0·2	0·2	0·2	..	0·1	0·2	0·1	0·1	June†
0·7	0·2	0·1	0·1	0·2	0·1	..	..	..	..	..	..	..	..	July
0·8	0·2	0·2	0·1	0·1	0·2	0·2	..	0·1	..	0·1	..	..	..	Aug.
0·9	0·6	0·3	0·2	0·4	0·1	0·2	0·3	0·1	0·2	0·2	0·2	..	0·1	Sept.†
1·5	1·3	0·9	1·2	1·4	0·5	0·3	0·8	0·5	0·1	0·3	0·2	0·2	0·2	Oct.†
1·3	0·4	0·3	0·4	0·3	0·3	0·2	0·2	0·4	0·3	0·1	0·1	0·3	0·3	Nov.†
1·0	0·7	0·4	0·2	0·2	0·3	0·3	0·1	0·1	..	0·2	..	0·2	0·2	Dec.†
1·0	0·6	0·5	0·4	0·3	0·2	0·2	0·2	0·2	0·1	0·1	0·1	0·1	0·1	Year

	Mar. +11·0 to +10·6	Sept. +15·0 to +10·6	Oct. +16·0 to +10·6	Nov. +13·5 to +10·6	Dec. +12·5 to +10·6
†Further observations (%)	0·2	0·3	0·6	1·0	0·3

Temperature difference (° F.)

+4·0 to +4·9	+5·0 to +5·9	+6·0 to +6·9	+7·0 to +7·9	+8·0 to +8·9	+9·0 to +9·9	+10·0 to +10·9	+11·0 to +11·9	+12·0 to +12·9	+13·0 to +13·9	
percentage frequency										
HEIGHT INTERVAL 15·2–1·1 M.										
2·9	1·7	1·5	0·5	0·7	0·4	..	..	0·2	0·1	Jan.
1·3	1·0	0·7	0·5	0·5	0·1	0·1	0·1	0·1	..	Feb.
2·6	2·4	1·1	0·5	0·2	0·4	0·1	..	..	..	Mar.
3·5	3·0	1·4	0·5	0·1	0·1	..	..	..	..	Apr.
2·4	1·1	1·2	0·1	0·1	..	..	..	..	..	May
1·9	1·0	0·8	0·5	0·3	0·1	..	..	..	..	June
1·7	0·7	0·4	..	..	..	..	..	..	..	July
2·2	1·5	0·8	0·1	0·2	..	..	..	..	..	Aug.
2·8	1·2	1·3	0·5	0·5	0·3	0·1	..	..	..	Sept.
3·9	3·1	2·1	0·8	0·8	0·3	0·2	0·1	..	..	Oct.
2·6	1·3	0·7	0·4	0·1	0·1	..	..	..	..	Nov.
1·9	1·3	0·6	0·4	0·1	..	..	..	..	..	Dec.
2·5	1·6	1·0	0·4	0·2	0·1	..	..	..	..	Year

§ 11—MEAN DIURNAL VARIATION OF TEMPERATURE AT EACH HEIGHT

Three-year means.—Table IX gives the mean hourly values of the aspirated dry-bulb element at 1·1 m.; the mean hourly values in this case were obtained in the same way as for the differential temperature charts. Curves showing the actual temperatures for the four heights 1·1, 15·2, 47·2 and 106·7 m. are shown in Fig. 8, the values being obtained by using Table I and Table IX.

The curves are similar to those of *Geophysical Memoirs* No. 77, and the features noted in that publication are substantiated by the present results from Rye. An interesting feature not noted before is the small maximum about midnight, noticeable in the January curve. This feature has a corresponding minimum in the inversion of temperature as can be seen in Fig. 5. It is perhaps difficult to assert whether this is a real effect in the physical sense or an oddity of the curves for the three years in question. No attempt has been made to deal with small irregularities shown up on the curves in the observations.

TABLE IX—MEAN HOURLY VALUES OF TEMPERATURE

	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100
						degrees Fahrenheit					
January	33·2	33·0	32·9	32·7	32·8	32·8	32·5	32·2	32·9	34·3	35·9
February	32·6	32·4	32·4	32·3	32·3	32·3	32·2	32·7	34·1	35·6	36·9
March	36·9	36·6	36·5	36·4	36·3	36·2	36·8	39·2	42·3	44·2	46·4
April	40·1	39·7	39·3	38·9	38·9	40·1	43·3	46·8	49·5	51·2	52·8
May	45·4	45·1	44·8	44·4	44·9	47·8	50·9	53·6	55·2	56·7	58·0
June	50·4	49·9	49·6	49·6	51·0	53·9	56·5	58·9	60·3	61·2	61·8
July	55·2	54·5	54·3	54·0	54·8	57·1	59·9	62·1	64·2	65·4	66·6
August	54·5	54·1	53·5	53·3	53·5	55·3	58·4	61·3	63·7	65·5	66·9
September	53·3	52·7	52·4	52·0	52·0	52·3	54·5	57·2	59·5	61·0	62·3
October	46·6	46·5	46·2	45·8	45·5	45·3	46·1	48·6	51·4	54·0	55·8
November	40·9	40·9	40·9	41·0	41·0	40·8	40·7	41·3	43·1	45·1	46·5
December	37·4	37·3	37·4	37·7	37·4	37·2	37·2	37·0	37·4	38·8	40·5

The times of occurrence of maximum temperature at each height have been determined by the accurate plotting of the temperature observations on an open scale. The results for June and December are shown in the upper part of Table X together with the lag in the time of maximum over each interval of height. The flatness of the December curves in the region of the maximum introduces uncertainties; in June certain of the points do not lie on a smooth curve and so permit alternative curve constructions and consequent uncertainty in the time of occurrence of a maximum. In June the time of occurrence of maximum temperature at 1·1 m. is 1414 and at 106·7 m. 1528, so that the lag is 74 min. which is comparable with the lag of 85 min. found at Leafield over the interval 1·2 to 87·7 m. In December the lag is 42 min., the maximum near the ground occurring 50 min. before that in June, which is comparable with the relevant figures for Leafield. In general the estimations of time are too unreliable to draw firm conclusions for the intermediate levels.

Means for clear and overcast days.—The temperatures at the four heights have been plotted in Fig. 9 for clear and overcast days in summer and in winter in the same way as the mean temperature curves in Fig. 8, the basic data being provided by Table III and Table XI the latter of which gives the mean hourly values of the aspirated dry-bulb temperature at 1·1 m.

On clear days the morning minima occur at about the same time, at about sunrise, the minimum at the level 1·1 m. occurring earlier by between one-half and one hour. On overcast days in summer the morning minimum at 1·1 m. occurs before sunrise and the minima at higher levels occur later according to height, that at 106·7 m. occurring about two hours after sunrise. In winter on overcast days the temperature variation at all levels is small, and the maxima and minima are so flat that precision of timing is not possible. It will be seen that the maximum temperatures at 1·1 and 15·2 m. are the same.

The curves and tables show that on the average clear summer day the temperature at the end of the 24-hr. period exceeds that at the beginning by 1·6° F. On clear days in December there is a rise in temperature over the 24-hr. period of 0·6° F. compared with the fall noted for Leafield.

The times of occurrence of maximum temperature have been determined and are shown in the lower part of Table X. On clear summer days the maximum occurs at 1·1 m. at 1410 which is practically the same time as for mean June days, while at 106·7 m. the maximum occurs at 1512, the lag being 62 min. which is rather less than on a mean June day, in contradistinction to the result found for Leafield. On clear winter days the maximum temperature at 1·1 m. occurs at 1336 and the lag at 106·7 m. is 81 min. compared with 42 min. on the mean December day. On clear summer days the greatest portion of the lag occurs between 1·1 and 15·2 m. but on clear days in winter the greatest lag is between 15·2 and 47·2 m.

AT A HEIGHT OF 1·1 M. FOR EACH MONTH

1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	
						degrees Fahrenheit							
36·7	37·5	37·7	37·1	35·7	34·2	33·9	33·9	34·0	33·8	33·8	34·0	34·0	January
37·6	38·6	38·6	38·1	37·3	36·0	34·8	34·2	33·9	33·5	33·1	32·7	32·2	February
47·5	48·2	48·4	48·1	47·2	45·5	42·7	40·5	39·4	38·7	38·4	38·0	37·8	March
53·3	53·5	53·6	53·4	52·7	51·4	48·9	45·9	44·0	43·1	42·3	41·8	40·6	April
58·8	59·5	59·6	59·1	58·7	57·5	55·5	52·8	50·0	48·5	47·4	46·6	46·2	May
62·7	62·9	63·2	63·0	62·4	61·4	59·9	57·7	55·2	53·4	52·3	51·7	51·0	June
67·4	67·9	68·3	68·0	67·6	66·1	64·8	62·4	59·5	57·9	57·0	56·4	55·7	July
67·9	68·3	68·5	68·1	67·3	66·3	64·1	60·9	58·3	56·9	56·1	55·5	54·9	August
63·3	63·8	64·1	63·4	62·6	61·1	58·6	56·3	54·9	54·4	54·2	53·7	53·3	September
56·9	57·5	57·5	56·4	55·2	52·9	50·7	49·3	48·4	47·7	47·3	47·3	46·9	October
47·3	47·9	47·6	46·6	45·1	43·6	43·1	42·6	42·3	41·8	41·5	41·3	40·9	November
41·6	42·1	42–0	41·3	39·9	39·1	38·7	38·3	38·0	37·8	37·5	37·2	37·2	December

TABLE X—TIMES OF OCCURRENCE OF MAXIMUM TEMPERATURE AT VARIOUS HEIGHTS

	Height						
	1·1 m.		15·2 m.		47·2 m.		106·7 m.
June	1414		1444		1518?		1528
		(30)		(34)?		(10)?	
December	1324		1330		1336		1406?
		(6)		(6)		(30)?	
Summer Clear days ..	1410		1445		1500		1512
		(35)		(25)		(12)	
Winter Clear days ..	1336?		1333?		1445?		1457?
		(−3)?		(12)		(12)?	
Overcast days ..	1252?		1300?		1303?		1309?
		(8)?		(3)?		(6)?	

The figures in brackets are the lag (in minutes) in the time of maximum over each interval of height.

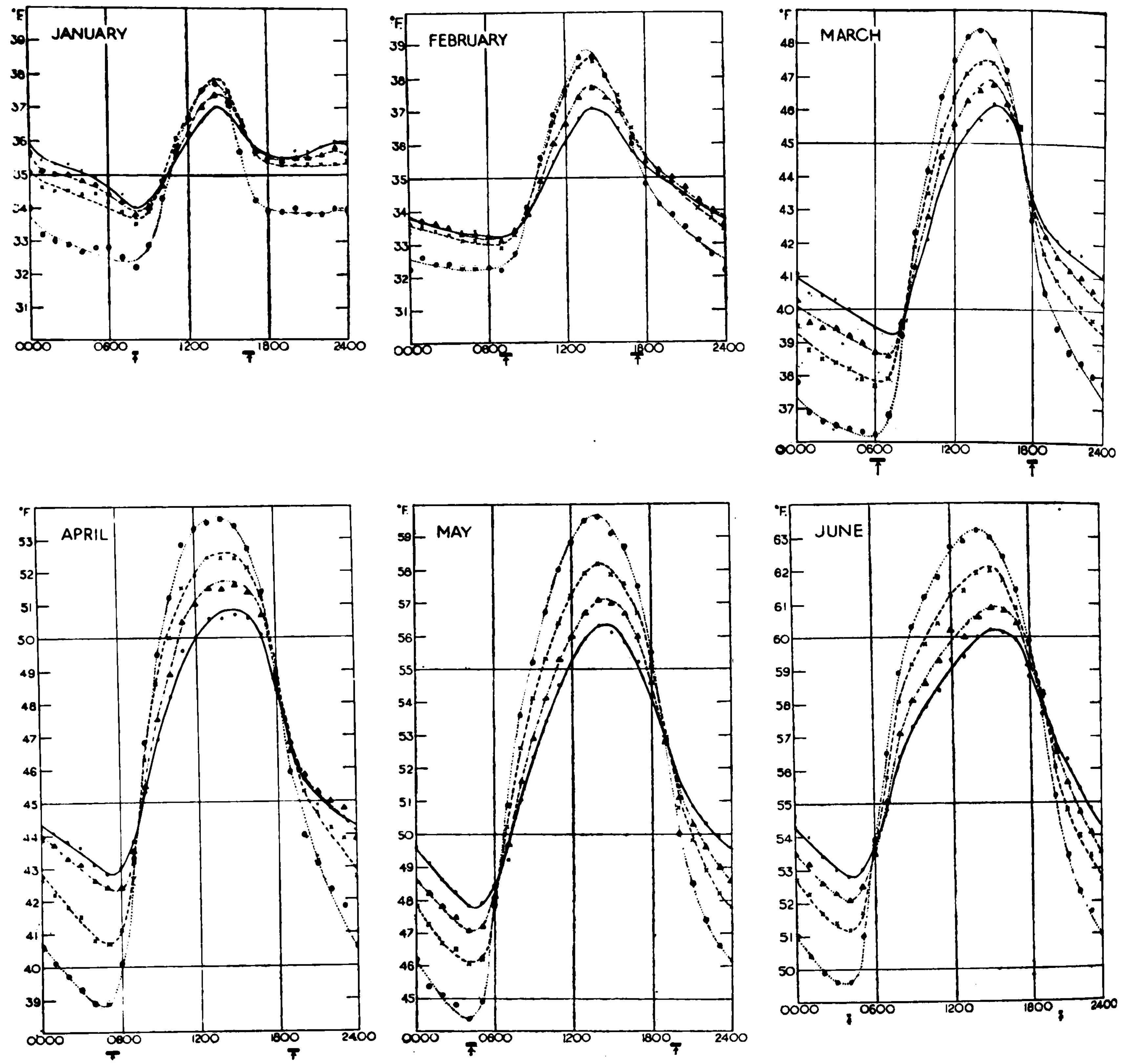


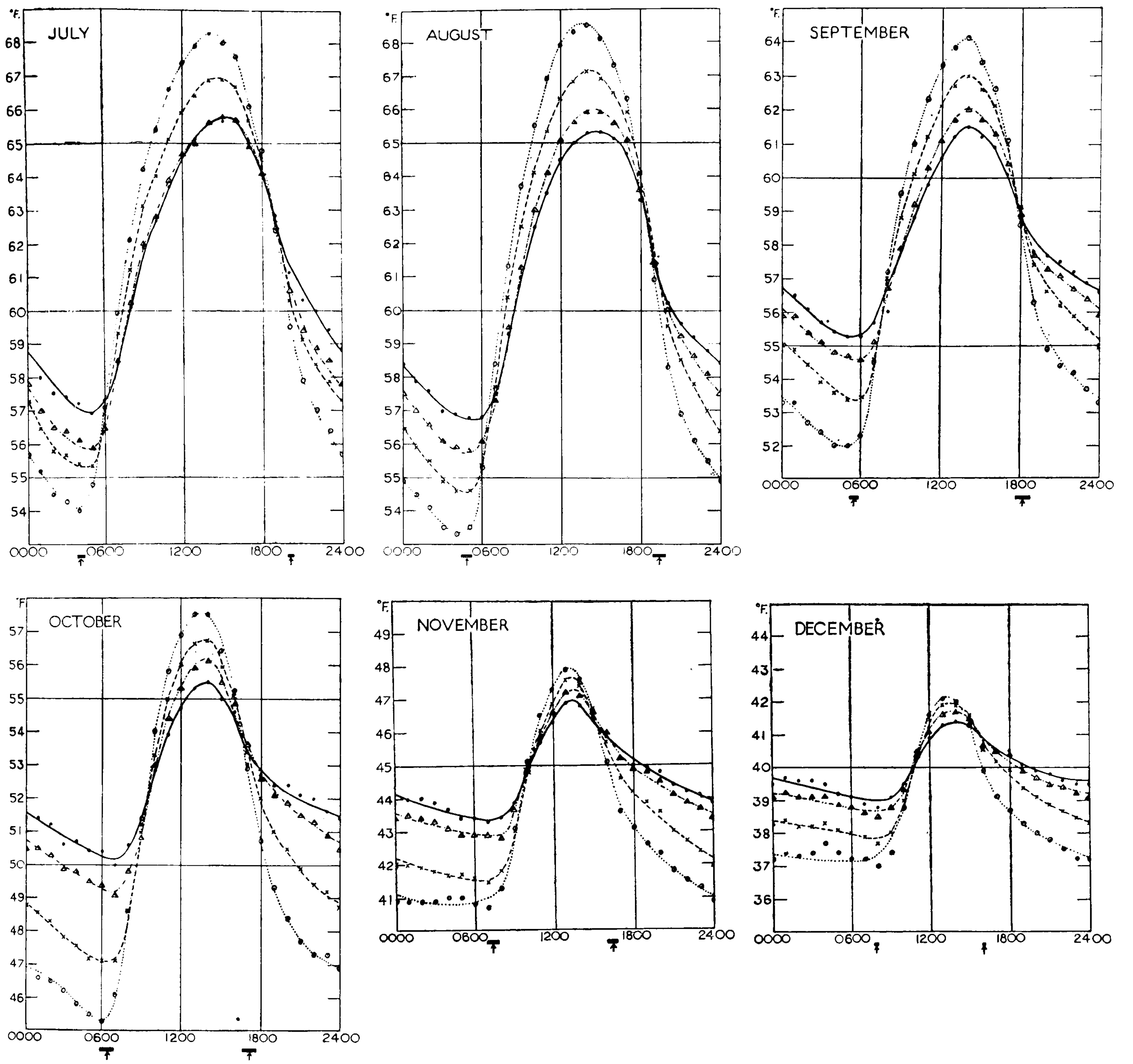
FIG. 8—DIURNAL VARIATION OF TEMPERATURE

The curves show the temperature at the following heights

The arrows indicate times of sunrise and sunset, the limits for each month

TABLE XI—MEAN HOURLY VALUES OF TEMPERATURE AT A HEIGHT OF

	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100
	degrees Fahrenheit											
CLEAR DAYS												
Summer	54·2	53·4	52·9	52·3	51·8	52·6	56·5	62·1	66·8	69·9	72·7	74·4
Winter	35·5	35·5	34·3	34·0	34·1	34·1	33·8	33·0	34·2	36·3	39·5	41·3
OVERCAST DAYS												
Summer	56·7	56·3	55·4	54·6	54·7	54·8	55·3	55·8	56·7	58·1	59·4	59·8
Winter	35·5	35·5	35·4	35·3	35·2	35·1	35·0	34·9	34·9	35·3	36·0	36·5



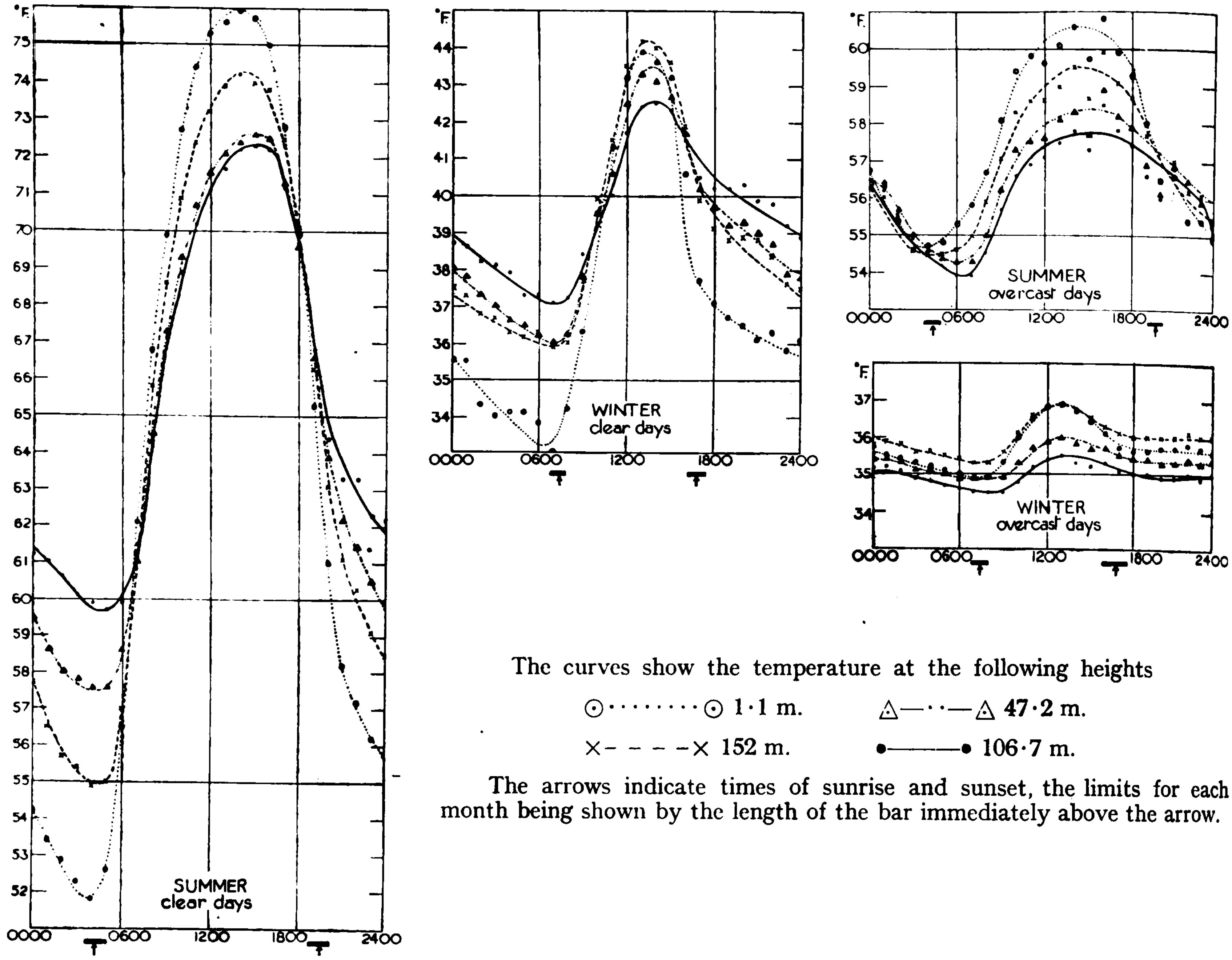
AT FOUR HEIGHTS FOR EACH MONTH

⊙········⊙ 1·1 m. ×– – – –× 15·2 m. △—··—△ 47·2 m. •———• 106·7 m.

being shown by the length of the bar immediately above the arrow.

1·1 M. FOR CLEAR AND OVERCAST DAYS IN SUMMER AND WINTER

1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	
					degrees Fahrenheit								
75·3	75·6	75·9	75·7	75·0	72·8	69·9	65·3	61·0	58·2	57·2	56·2	55·8	CLEAR DAYS
43·2	43·9	43·6	43·2	40·6	37·7	37·1	36·7	36·5	36·1	36·3	35·8	36·1	
59·6	60·1	60·6	59·7	60·8	59·9	59·3	58·0	56·5	56·6	55·4	55·4	54·9	OVERCAST DAYS
36·8	36·9	36·7	36·4	36·1	35·7	35·6	35·6	35·7	35·7	35·8	35·7	35·6	



The curves show the temperature at the following heights

⊙········⊙ 1·1 m. △—··—△ 47·2 m.

×– – – –× 152 m. •———• 106·7 m.

The arrows indicate times of sunrise and sunset, the limits for each month being shown by the length of the bar immediately above the arrow.

FIG. 9—DIURNAL VARIATION OF TEMPERATURE AT FOUR HEIGHTS FOR CLEAR AND OVERCAST DAYS IN SUMMER AND WINTER

TABLE XII—DIURNAL RANGE OF TEMPERATURE AT VARIOUS HEIGHTS

	Height 1·1 m.	15·2 m.	47·2 m.	106·7 m.
	degrees Fahrenheit			
January ..	5·5	4·3	3·6	3·0
February..	6·4	5·6	4·6	3·9
March ..	12·2	9·7	8·2	7·1
April ..	14·7	11·7	9·2	7·9
May ..	15·2	10·8	8·8	7·4
June ..	13·6	10·8	8·8	7·4
July ..	14·3	11·6	9·9	8·8
August ..	15·2	12·5	10·1	8·5
September	12·1	9·6	7·4	6·2
October ..	12·2	9·6	7·0	5·5
November	7·2	6·1	4·4	3·6
December	5·1	4·2	3·2	2·6

	Height 1·1 m.	15·2 m.	47·2 m.	106·7 m.
	degrees Fahrenheit			
SUMMER				
Clear days ..	24·1	19·3	15·0	12·6
Overcast days	6·2	5·4	4·6	4·6
WINTER				
Clear days ..	10·9	8·3	7·3	5·4
Overcast days	2·0	1·6	1·1	1·0

Diurnal range of temperature.—The mean diurnal range of temperature for each height in each month, and also the mean diurnal range for clear and overcast days in summer and winter, are given in Table XII. The range is greatest in summer and least in the winter. On clear summer days the range is greatly increased at all levels being about twice that of the mean range. On overcast winter days the mean diurnal range is small at all levels.

§ 12—EFFECT OF SNOW COVER

In order to consider the effect of snow cover on the gradient of temperature the data have been extracted and meaned for days when there was a complete cover throughout the 24 hr. and predominantly the snow was not melting. There are 14 such days, namely December 16–17, 1946, January 25–28 and 30–31, 1947, February 22–25, 1947, and February 20–21, 1948; out of the 360 hourly readings there are only seven at which the temperature recorded at 1·1 m. exceeded 32° F., and no occasions upon which the snow remained unfrozen throughout the 24 hr. The results are given in Table XIII, and have been plotted in Figs. 10 and 11 which show in Fig. 10 the diurnal variation of temperature lapses over the three intervals X, Y, Z, and in Fig. 11 the diurnal variation of temperature at 1·1 and 106·7 m.

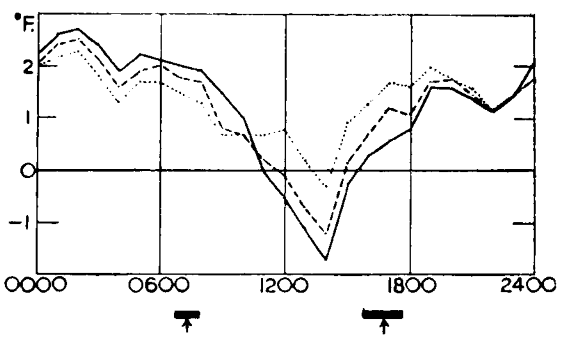


FIG. 10—DIURNAL VARIATION OF TEMPERATURE DIFFERENCE OVER THREE HEIGHT INTERVALS ON OCCASIONS OF SNOW COVER

The curves show the temperature differences over the following intervals

····· 15·2–1·1 m. – – – – 47·2–1·1 m.
———106·7–1·1 m.

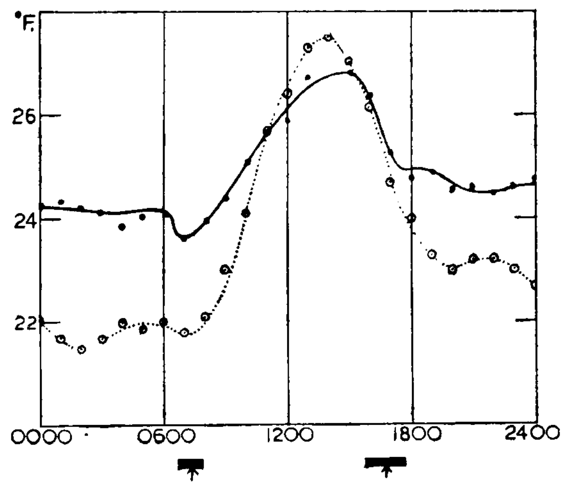


FIG. 11—DIURNAL VARIATION OF TEMPERATURE ON OCCASIONS OF SNOW COVER

The curves show the temperature at the following heights

⊙ ···· ⊙ 1·1 m. •———• 106·7 m.

In the interval X the inversion is strengthened by the presence of snow covering the earth, the maximum inversion being 2·3° F. compared with the February maximum of 1·7° F. The maximum inversion in the interval Z is little changed, however, being 2·7° F. compared with the January maximum of 2·4° F. The times of occurrence of these maximum lapses is a little earlier than those for all states of the ground. When there is snow cover there is a mean lapse in interval X at only one hour, 1400. In this respect the results follow those of the mean January results, in which no lapse is recorded. The maximum lapse in the Z interval is −1·7° F. at 1400 which is rather less than the maximum lapse of −1·8° F. at 1300 in February.

Turning to the actual temperature at 1·1 m. the maximum temperature occurs at 1400, the same time as for all states of the ground; the minimum temperature occurs at 0200 which is earlier than for all states of the ground, for which the minimum occurs about dawn. This can be explained by considering the heat flow to the surface, which is compounded of heat flow in the air and in the ground itself. The temperature at the surface must be such that the heat lost, mainly by radiation, balances the heat reaching the surface. The rate of loss of heat from the surface by radiation is substantially constant, being proportional to the fourth power of the absolute temperature, whereas the rate of supply increases as the surface temperature falls and sets up a larger temperature gradient near the surface. Often the temperature gradients in the

TABLE XIII—MEAN HOURLY VALUES OF TEMPERATURE AT 1·1 M. AND

	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100
						degrees Fahrenheit						
TEMPERATURE 1·1 m.	22·0	21·7	21·5	21·7	22·0	21·9	22·0	21·8	22·1	23·0	24·1	25·7
TEMPERATURE DIFFERENCE												
106·7–47·2 m. ..	+0·2	+0·2	+0·2	+0·3	+0·3	+0·3	+0·1	0·0	+0·1	+0·7	+0·3	−0·2
47·2–15·2 m. ..	0·0	+0·2	+0·2	+0·3	+0·3	+0·2	+0·3	+0·3	+0·4	+0·1	0·0	−0·5
15·2– 1·1 m. ..	+2·0	+2·2	+2·3	+1·8	+1·3	+1·7	+1·7	+1·5	+1·3	+0·7	+0·7	+0·7

earth and air are too small to prevent the temperature continuing to fall until insolation is effective. With snow cover there is a rather more rapid fall of temperature at the surface combined with an originally lower temperature at sunset; the net result is that the temperature gradient in the ground is enhanced and equilibrium reached more quickly, after which the temperature falls no further. This explanation is idealized, but accounts for the main physical effects occurring at the surface. The minimum temperature at levels near the surface occurs correspondingly earlier.

PART III—HUMIDITY RECORDS

§ 13—METHOD OF COMPUTATION

Humidity is expressed here in milligrammes of water vapour per cubic metre; as in the case of the temperature records Greenwich Mean Time is used throughout. Hourly values were computed from each hourly value of temperature and relative humidity for the three years, the value allotted to each hour being the mean value of the humidity over a period of 20 min. centred on the hour in question. The humidity differences constructed from these readings are taken as positive when humidity increases with height and negative when it decreases upward. The former of these conditions is termed an inversion, the latter a lapse, agreeing with the terminology used in presenting the temperature records.

§ 14—MEAN HOURLY VALUES AND DIURNAL VARIATION OF THE HUMIDITY LAPSE RATE

The mean hourly values of humidity differences over each height interval for each month are given in Table XIV. These values have been plotted in two ways.

In Fig. 12 they are plotted to show the mean variation of humidity with height for each hour. Taking the curves as a whole the most obvious feature is the rapid decrease of gradient with height; the largest variations occur in the lower layers which are nearest to the boundary surface between earth and atmosphere. In the upper layers there is usually a fairly constant mean gradient, generally a lapse.

During the middle of the day there is a humidity lapse near the surface in all months. In the summer months this lapse is much greater than in the winter months; at midday over the interval X the mean lapse for December and January is -120 mg./m.^{3}, whereas the mean for June and July is -680 mg./m.^{3} or rather more than five times the winter lapse. In the layer from 15·2 to 47·2 m. the similar means are -105 mg./m.^{3} and -385 mg./m.^{3} so that the summer lapse is about four times as great as the winter lapse. As we have already seen the temperature curves similarly show a greater lapse near the surface in summer than in winter. At the lower winter temperature the humidity lapse rate is less for saturated air than in summer, when temperature is higher, for the same temperature difference, e.g. if the temperature at the

OF TEMPERATURE DIFFERENCE ON OCCASIONS OF SNOW COVER

1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	
					degrees Fahrenheit								
26·4	27·3	27·5	27·0	26·1	24·7	24·0	23·3	23·0	23·2	23·2	23·0	22·7	TEMPERATURE
−0·4	−0·4	−0·5	−0·3	−0·4	−0·6	−0·3	−0·1	−0·2	−0·1	0·0	0·0	+0·3	TEMPERATURE DIFFERENCE
−0·9	−0·9	−0·9	−0·8	−0·6	−0·5	−0·5	−0·3	0·0	−0·1	0·0	0·0	0·0	
+0·8	+0·2	−0·3	+0·9	+1·3	+1·7	+1·6	+2·0	+1·8	+1·6	+1·2	+1·5	+1·8	

1·1 m. level is 42° F. and that at 15·2 m. is 40° F. then the humidity gradient is only about half what it is when the temperatures are 62° and 60° F. There exists a potentially greater lapse in summer than in winter, even when the temperature lapses are the same. In summer at midday the turbulent convection processes carry away the moisture more readily than they do in winter, which again tends to greater humidity lapses in summer than in winter.

Fig. 12 also shows the general humidity structure throughout the day. In January there is an inversion of humidity near the surface at the beginning of the day. This inversion of humidity is broken down after sunrise to give way to a lapse which in its turn is broken down and an inversion is reformed during the afternoon and persists until dawn the next day. These features are repeated in all months, with the period in which there is a lapse of humidity gradually lengthening as the summer is approached. In June the humidity inversion in the night period is not at all well marked. In the autumn months the reverse series of events takes place, the lapse period gradually shortening.

The October, November and December curves are worthy of special attention. In that part of the period during which there is a lapse near the surface they show a different structure in the middle layer from that of other months; there is an inversion of humidity or greatly reduced lapse of humidity above the lapse near the surface. There is no parallel feature in the temperature records.

The distribution of humidity in the vertical depends largely upon two factors, diffusion by turbulent processes and advection. When measurements are made at a single site it is difficult to deal with advection, since there are no comparable measurements in the direction from which the air is coming. Attention may be concentrated upon diffusion in attempting to explain points arising from the experimental results, at least in the lowest layers, since for the most part the immediately surrounding country is not dissimilar from that at the site and a horizontal uniformity in the structure of the atmosphere may be expected.

A notable exception may arise when there is an on-shore wind; advection may well need accounting for then if the turbulence is insufficient for the effects from the new boundary conditions to spread through the layer up to the top of the tower by the time the air reaches the observation site. The turbulent structure in the atmosphere depends upon many factors, including the thermal structure of the atmosphere.

The limitation of the saturation vapour density at a given temperature must also be remembered. This is particularly important near the ground which is often the source of moisture during the day when evaporation takes place. For example, in March at 1200 the mean temperature at 1·1 m. is 47·5° F., in October 56·9° F. The ratio of the saturated vapour densities at these temperatures is about 1 : 1·4. The mean vapour density in March is also less than in October, and is in the ratio 1 : 1·4, which means that the relative humidity is about the same for both months.

To return to the profiles for October, November and December, investigation indicated that with on-shore winds the mean humidity profile showed a general lapse and the vapour density

TABLE XIV—MEAN HOURLY VALUES OF THE HUMIDITY

	Height interval	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100
	m.	*milligrammes per cubic metre*										
January ..	106·7–47·2	−30	−40	−40	−50	−40	−50	−50	−50	−50	−50	−60
	47·2–15·2	−80	−70	−80	−110	−100	−100	−70	−100	−160	−160	−130
	15·1–1·1	+150	+180	+190	+220	+170	+140	+100	+100	+70	−30	−70
February ..	106·7–47·2	−40	0	0	+20	+20	0	−10	−10	−30	−60	−50
	47·2–15·2	−50	−50	−50	−40	−30	−30	−40	−50	−100	−120	−80
	15·1–1·1	+20	+40	+30	+30	+20	+10	+10	−20	−80	−100	−80
March	106·7–47·2	+10	0	−10	0	+30	+40	+40	−40	−100	−120	−50
	47·2–15·2	+40	+60	+90	+80	+50	+70	+30	−60	−180	−190	−100
	15·1–1·1	+260	+270	+260	+250	+240	+240	+170	0	−110	−90	−80
April	106·7–47·2	−10	+30	+40	+30	+20	+70	+20	−50	0	−40	−60
	47·2–15·2	+90	+60	+80	+120	+130	+70	−70	−180	−100	−20	−20
	15·1–1·1	+160	+190	+220	+200	+180	+30	−260	−380	−310	−310	−280
May	106·7–47·2	+20	−10	+60	+40	+30	−40	−80	−70	−50	+50	−20
	47·2–15·2	−200	−140	−140	−90	−90	−300	−480	−250	−220	−220	−170
	15·1–1·1	+140	+100	+150	+110	0	−300	−550	−610	−530	−530	−540
June	106·7–47·2	0	−40	−50	−60	+20	−10	−130	−30	+40	+70	−20
	47·2–15·2	−200	−120	−140	−120	−170	−410	−360	−260	−240	−240	−280
	15·1–1·1	+10	−20	+20	0	−270	−600	−810	−860	−810	−780	−730
July	106·7–47·2	−170	−120	−10	−30	−70	−140	−250	−90	−20	−40	−80
	47·2–15·2	−410	−330	−340	−280	−320	−560	−570	−380	−400	−430	−470
	15·1–1·1	+240	+360	+350	+410	+230	−50	−340	−460	−460	−560	−590
August	106·7–47·2	−210	−150	−110	−120	−100	−130	−350	−260	−200	−200	−220
	47·2–15·2	−60	−30	+50	+70	+90	−70	−340	−320	−300	−340	−390
	15·2–1·1	+100	+120	+120	+130	+90	−250	−570	−730	−580	−530	−520
September ..	106·7–47·2	−180	−130	−110	−90	−80	−100	−160	−250	−300	−250	−220
	47·2–15·2	−80	−30	+20	+20	+70	+40	−150	−330	−340	−320	−270
	15·2–1·1	+130	+210	+170	+230	+180	+90	−150	−220	−450	−450	−490
October ..	106·7–47·2	−260	−230	−250	−200	−120	−70	−70	−90	−240	−360	−370
	47·2–15·2	+210	+210	+270	+320	+310	+310	+220	+20	−90	−120	−130
	15·2–1·1	+300	+260	+200	+260	+270	+320	+70	−210	−370	−380	−390
November ..	106·7–47·2	−30	0	−10	−30	−20	−40	−50	−10	−90	−110	−80
	47·2–15·2	−200	−190	+220	+220	+180	+180	+210	+120	+30	−60	−60
	15·2–1·1	+70	+40	+20	0	+30	+60	+40	−10	−160	−260	−250
December ..	106·7–47·2	+50	+50	+40	+20	0	+10	0	+10	0	−20	−80
	47·2–15·2	+140	+170	+170	+130	+140	+140	+120	+140	+120	+70	0
	15·2–1·1	+60	+50	+40	+30	+40	+40	+50	+50	+30	−50	−110

was greater than with off-shore winds. Details are given in Table XV of the humidity records at 1500 for October. With off-shore winds the mean humidity profile evidences the small inversion in the middle layers. A possible explanation may be found in the relatively greater supply of moisture which may be expected from the surface in the last three months of the year compared with that in the first three months. The moisture supply is dependent upon the temperature of the air near the surface; with higher temperature there is greater evaporation and a correspondingly greater supply of moisture from the surface. The mean temperature

DIFFERENCE OVER THREE HEIGHT INTERVALS FOR EACH MONTH

milligrammes per cubic metre

1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	
−120	−100	−130	−120	−120	−100	−100	− 80	− 70	− 50	− 40	− 40	− 70	January
−190	−210	−160	−170	−140	−150	−160	−180	−150	−150	−110	−100	−100	
−100	− 60	− 80	− 20	+ 30	+120	+110	+100	+ 80	+130	+130	+130	+150	
− 50	− 40	− 50	− 50	− 60	− 30	− 20	− 30	− 30	− 20	− 20	− 20	− 10	February
− 90	− 70	− 30	− 20	− 20	− 20	− 30	− 10	− 50	− 50	− 30	− 30	− 70	
− 70	− 70	− 60	− 50	− 60	− 60	− 40	− 30	− 10	+ 20	+ 20	+ 10	+ 40	
− 20	− 30	− 50	− 70	− 60	− 80	− 50	− 20	− 20	− 10	− 20	− 10	0	March
− 10	+ 30	+ 30	+ 20	+ 20	0	0	+ 10	0	− 10	+ 10	+ 30	+ 50	
− 70	− 60	− 60	− 20	+ 10	+ 70	+130	+160	+220	+280	+260	+260	+250	
+ 10	− 20	− 30	− 20	− 30	− 50	− 50	− 70	− 30	− 30	− 40	− 30	− 10	April
− 40	− 60	− 50	− 30	− 10	− 50	0	− 10	+ 40	+ 30	+ 30	+ 30	+ 40	
−290	−290	−270	−230	−190	−120	−100	0	+ 50	+ 80	+140	+180	+190	
+ 30	+ 90	+ 30	+ 40	+ 70	+ 70	+ 90	+ 70	+ 70	+110	+ 60	+ 50	+ 20	May
−190	−180	−100	−160	−190	−210	−200	−290	−280	−290	−220	−220	−210	
−530	−590	−620	−490	−490	−390	−290	−220	− 50	− 10	+ 80	+ 80	+110	
− 30	+ 20	− 50	+ 10	+ 40	+ 30	− 40	+ 20	+ 20	+ 60	+ 10	+ 70	+ 20	June
−260	−240	−200	−210	−190	−210	−220	−250	−200	−200	−220	−180	−130	
−770	−760	−780	−710	−710	−670	−610	−490	−340	−180	− 90	− 60	− 40	
− 70	− 70	−120	−130	− 60	−110	−110	−220	−170	−200	−170	−200	−150	July
−510	−520	−470	−440	−480	−470	−460	−420	−450	−460	−440	−410	−420	
−590	−590	−570	−570	−540	−450	−380	−330	− 90	+ 80	+140	+200	+290	
−250	−220	−190	−200	−240	−260	−280	−360	−280	−310	−360	−320	−180	August
−380	−380	−330	−340	−330	−320	−370	−360	−350	−270	−230	−180	−100	
−530	−430	−460	−420	−400	−430	−540	−420	−240	− 60	0	0	+ 60	
−260	−270	−290	−280	−270	−290	−270	−310	−320	−310	−300	−310	−280	September
−260	−250	−260	−190	−180	−230	−210	−140	−120	−180	−200	−110	−130	
−480	−450	−410	−410	−380	−340	−270	−130	+ 50	+ 90	+100	+160	+170	
−430	−400	−430	−310	−330	−350	−260	−260	−280	−220	−190	−180	−210	October
−160	− 80	− 30	+ 10	0	− 60	− 60	+ 60	+ 90	+100	+150	+100	+180	
−340	−350	−280	−280	−220	−120	+ 20	+150	+250	+290	+270	+240	+220	
−100	− 60	− 50	− 60	− 60	− 20	− 50	− 40	− 40	− 20	− 50	− 60	− 40	November
0	+ 70	+ 90	+ 80	+160	+110	+100	+ 80	+ 90	+120	+160	+170	+170	
−180	−150	−120	− 70	− 10	0	+ 40	+ 70	+ 80	+ 70	+ 80	+ 70	+ 80	
−110	− 80	− 80	− 50	− 20	− 20	0	0	0	0	+ 10	+ 10	+ 20	December
− 20	− 10	+ 40	+ 50	+ 50	+120	+ 90	+ 90	+110	+120	+130	+150	+150	
−140	−160	−130	− 80	+ 30	+ 50	+ 70	+ 70	+ 60	+ 60	+ 90	+110	+ 80	

is higher in December than January, November than February and October than March. On comparing the humidity profiles for these pairs of months, the difference is most marked between October and March, when the difference of mean temperature is the greatest. More moisture is expected to be transferred upwards near the ground owing to the greater supply. If, however, the rate of diffusion is much the same in both months in the upper levels there will be a greater tendency to accumulate moisture in the middle levels in October than in March, which will result in a much less steep lapse in the middle layers and a steeper lapse in the top layers in October, as is found.

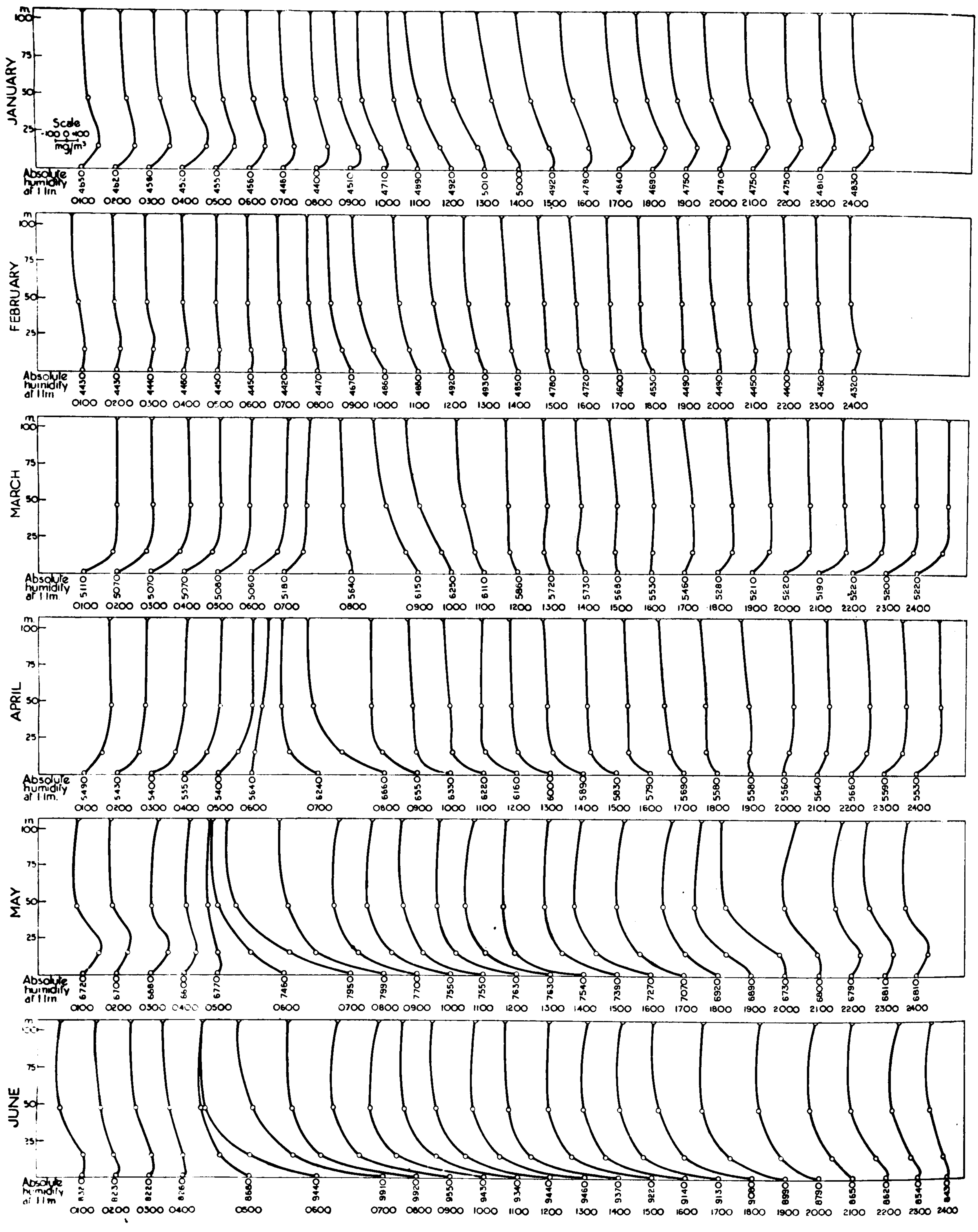
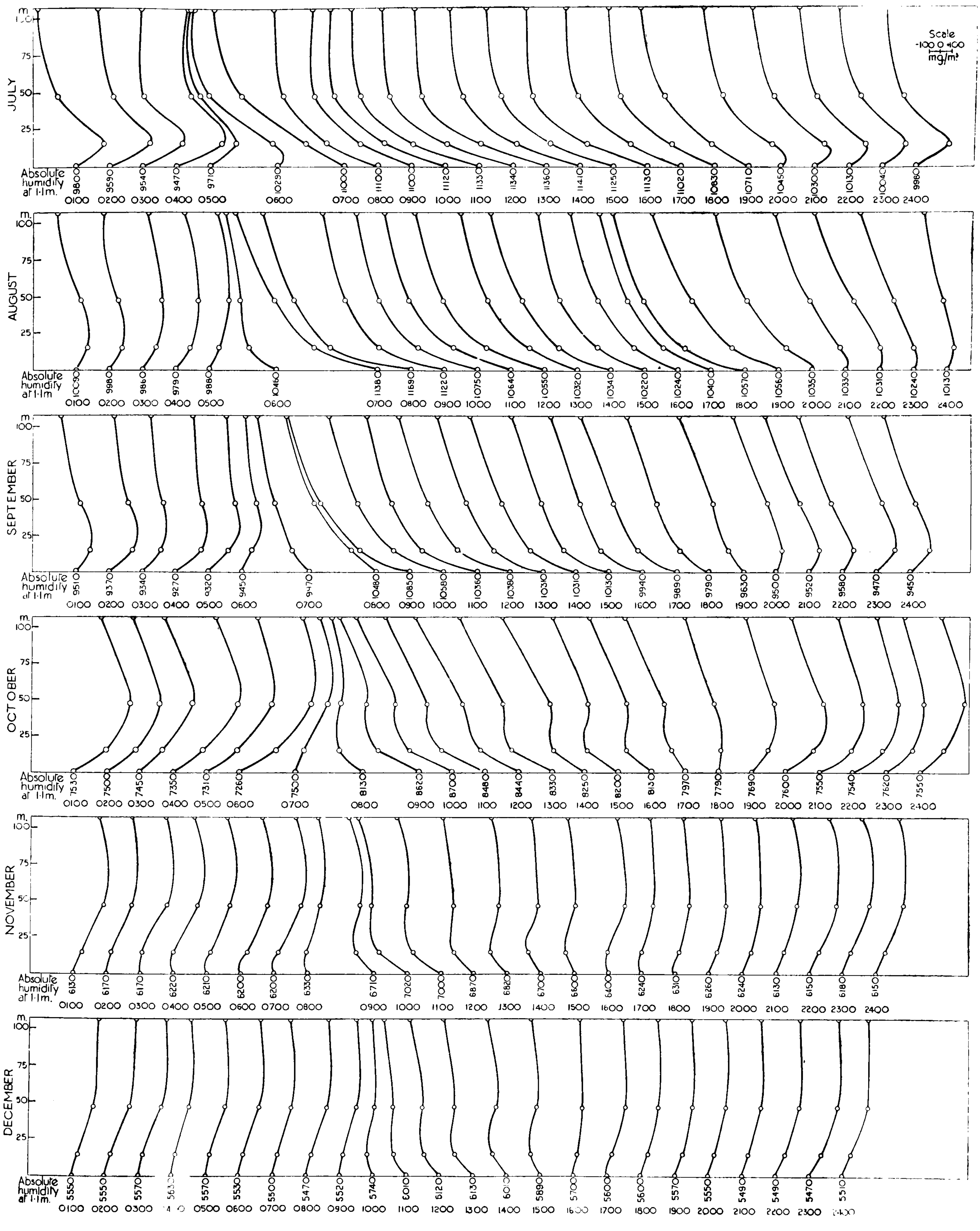


FIG. 12—MEAN VARIATION OF HUMIDITY



WITH HEIGHT FOR EACH HOUR

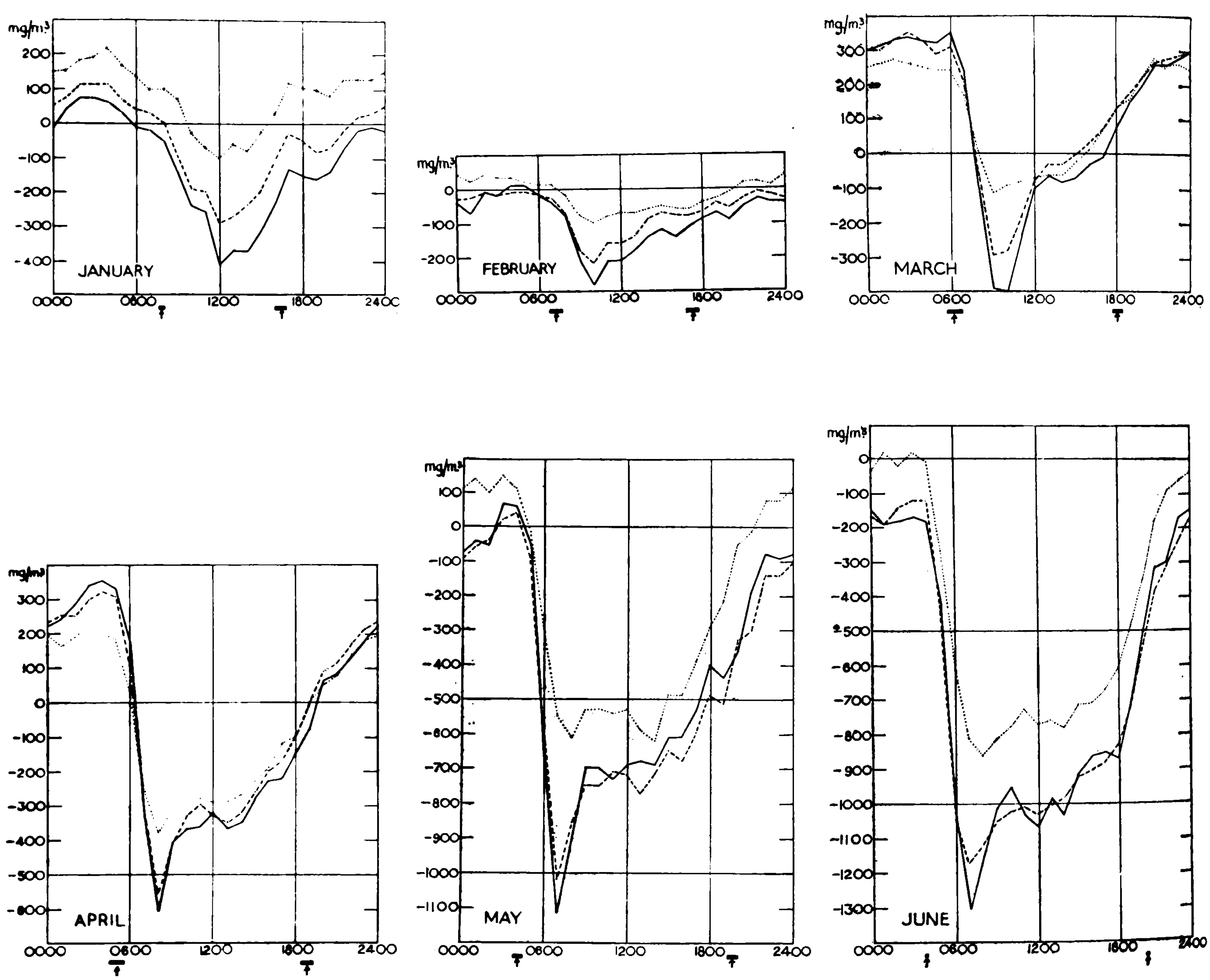
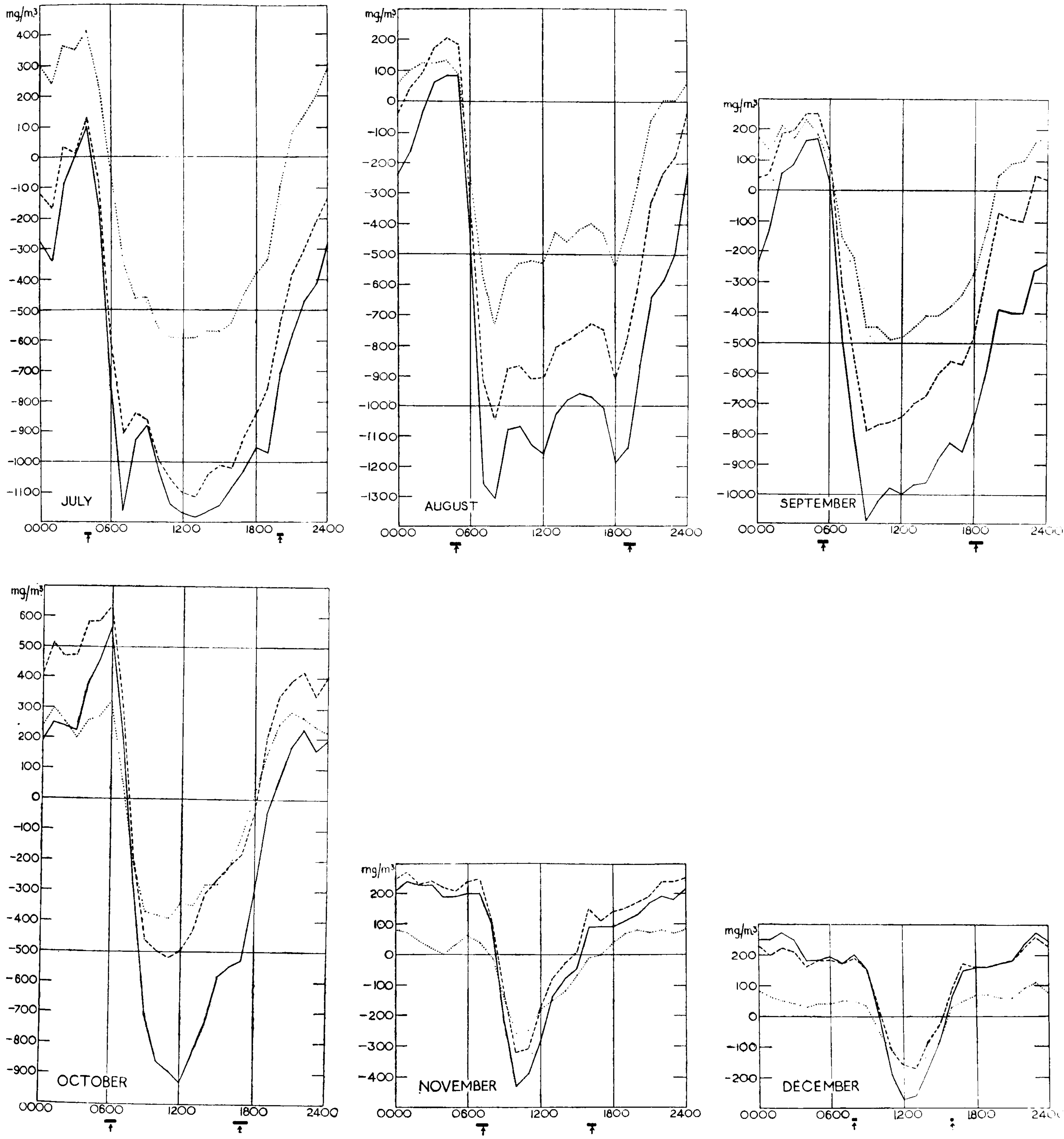


FIG. 13—DIURNAL VARIATION OF HUMIDITY DIFFERENCE

The curves show the humidity differences over the following intervals

The arrows indicate times of sunrise and sunset, the limits for each month



OVER THREE HEIGHT INTERVALS FOR EACH MONTH

······ 15·2–1·1 m. – – – – 47·2–1·1m. ——— 106·7–1·1 m.

being shown by the length of the bar immediately above the arrow.

TABLE XV—MEAN VALUES OF THE HUMIDITY AT 1·1 M. AND OF HUMIDITY DIFFERENCES AT 1500 IN OCTOBER FOR OFF-SHORE AND ON-SHORE WINDS

	Humidity at 1·1 m.	Humidity difference at 15·2–1·1 m.	47·2–15·2 m.	106·7–47·2 m.
		milligrammes per cubic metre		
Off-shore winds (25 cases)	8,390	−270	+ 40	−380
On-shore winds (5 cases)	9,680	−320	−250	−570

Off-shore winds are defined as those between 240° and 50°. On-shore winds are defined as those between 135° and 210°.

All other directions, and winds less than 4 m.p.h., are regarded as indeterminate, except for the first hour of a wind less than 4 m.p.h. following a wind in one of the significant categories of at least three hour's duration.

Fig. 13 displays the data of Table XIV in a different manner showing the diurnal variation of lapse rate from 1·1 m. upwards for each month. In January in the interval X an inversion of humidity predominates. At midnight there is an inversion of about 150 mg./m.^{3} which rises to a maximum at 0400 and then falls fairly steadily until at about two hours after sunrise the inversion changes over to a lapse. The maximum lapse occurs some hours after sunrise, and there is a secondary maximum, usually much smaller, later in the afternoon, after which the lapse decreases steadily until at about sunset the lapse changes over to an inversion which generally increases steadily in magnitude until after sunset, and thereafter remains fairly constant. The sequence of changes described for the interval X is repeated in all other months although the time of change over from inversion to lapse and *vice versa* bears no well defined relation to the time of sunrise and sunset. As the year proceeds lapses increase in magnitude, and the day-time period of lapse increases until in June the inversion is ill defined and short-lived, a lapse predominating. The double maxima become marked, and in August there are three distinct maxima. The time of the first maximum lapse comes earlier until in May, June and July it is approximately at 0700. In the autumn the reverse series of events takes place, the duration of the lapse period decreasing.

The general features of the night inversion and day lapse are explained by the cooling and extraction of moisture by the deposition of dew during the night, followed by the heating and evaporation during the day and the setting up of a turbulent régime. The question of double maxima will be discussed later.

In the interval Z in January the mean lapse persists over a much longer period than does that in interval X. The curves in Fig. 12 show that this is not true generally. In March, April, October, November and December the lapse occurs over much the same period for the two intervals, while in the remaining months the period of inversion is very short, being non-existent in June.

Apart from January, February, June and July the change-over from inversion to lapse after sunrise occurs almost simultaneously in all three intervals, so that the atmosphere then has approximately constant humidity. In June and July the departures from simultaneity are more marked than in the other months. The same is not true of the change-over from lapse to inversion, so that in the evening there is no time when the humidity gradient is zero.

Another feature of the curves of Fig. 13 is the correlation between the shapes for any given month. The time co-ordinates of the maxima and minima are nearly the same for the three curves, so that the maximum lapse, for example, occurs at nearly the same time for each of the intervals X, Y and Z. This may be traced to the same agency acting at all levels. This feature, of course, was noticed in the case of temperature, and in *Geophysical Memoirs* No. 77 use was made of the fact in order to elicit information about the turbulent structure in the lowest levels.

In some months double maxima of inversions occur at night. The differences are not great and probably may be traced to the variation in cloud cover. When the sky clears there is a tendency for the inversions to increase owing to the cooling near the ground; when the sky becomes overcast there is a reverse tendency. The net average effect may well be to produce local small maxima.

§ 15—MEAN MONTHLY AND YEARLY VALUES OF THE HUMIDITY LAPSE RATE

The hourly values of the humidity differences given in Table XIV have been meaned by months and the results are given in Table XVI.

It will be seen that except in January, March, October and December the average humidity structure in the lowest layer is a lapse; of the exceptional months October and December show small inversions and the last three months of the year can be said to have zero humidity gradient. January and March have, on the other hand, appreciable inversions. Over the height interval 15·2 to 47·2 m. there is a lapse excepting for the last three months of the year and in March and April when the layer has constant humidity. The tendency to form an inversion in the last three months of the year in the middle layer during the day has already been noted, and is reflected in the appreciable figures for the whole month. The lapses over this height interval and also over interval X are greatest in the summer months.

TABLE XVI—MEAN VALUES OF THE HUMIDITY DIFFERENCE OVER THREE HEIGHT INTERVALS FOR EACH MONTH

	Height interval		
	15·2–1·1 m.	47·2–15·2 m.	106·7–47·2 m.
		milligrammes per cubic metre	
January	+80	−130	−70
February	−20	−50	−30
March	+120	0	−30
April	−60	0	−10
May	−250	−210	+30
June	−460	−220	0
July	−180	−430	−120
August	−270	−230	−230
September	−130	−160	−230
October	+10	+80	−250
November	−20	+120	−50
December	+20	+100	−10
Annual mean ..	−90	−90	−80

Over the height interval from 47·2 to 106·7 m. there is a general lapse with the exception of May and June. These lapses are greatest in late summer and early autumn and least in late spring and early summer.

The mean annual lapse rate is entered at the foot of Table XVI. For the three years under consideration the average humidity structure was a lapse at all heights.

§ 16—HUMIDITY LAPSE RATES ON CLEAR AND OVERCAST DAYS

In this section it is proposed to examine the effect which the state of the sky produces upon the lapse rate of humidity. The criteria for clear and overcast days has already been given in § 8, and the following observations of humidity correspond to the same days for which the

TABLE XVII—MEAN HOURLY VALUES OF THE HUMIDITY DIFFERENCE OVER THREE

Height interval	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100
m.	*milligrammes per cubic metre*											
	CLEAR DAYS											
	Summer (19 occasions)											
106·7–47·2	−340	−360	−260	−120	−190	−310	−260	−370	−140	−120	−190	−200
47·2–15·2	−320	−160	− 90	+ 20	+220	+190	− 90	−670	−540	−470	−530	−700
15·2– 1·1	+580	+490	+580	+750	+770	+590	−120	−730	−920	−650	−560	−480
	Winter (3 occasions)											
106·7–47·2	−190	−230	−270	−220	−140	−190	−120	−130	−180	− 50	−100	−230
47·2–15·2	−150	− 50	− 90	− 80	−110	−220	−240	−180	−140	− 50	−380	−340
15·2– 1·1	+370	+340	+450	+500	+400	+380	+440	+470	+310	+250	+ 20	− 80
	OVERCAST DAYS											
	Summer (4 occasions)											
106·7–47·2	−470	−470	−450	−260	−130	−400	−140	−140	− 30	0	− 10	− 90
47·2–15·2	−440	−390	−480	−290	−260	−370	− 40	−290	−310	−350	−350	−290
15·2– 1·1	−300	−270	−130	−170	−210	−220	−270	−290	−240	−160	−280	−190
	Winter (21 occasions)											
106·7–47·2	− 10	0	+ 10	− 10	− 30	− 20	− 10	− 40	− 40	− 30	− 60	− 60
47·2–15·2	− 80	−110	− 70	− 80	− 70	− 80	− 50	− 20	− 30	− 70	−100	−120
15·2– 1·1	− 70	− 50	− 70	− 80	− 30	− 20	− 60	− 70	− 70	−110	−130	−130

Mean hourly values of wind velocity corresponding to these occasions will be found in Table IV.

temperature observations were given in Table III and the wind observations in Table IV. The mean hourly observations of humidity difference are given in Table XVII and plotted in Fig. 14.

Summer, clear days.—On clear days in summer the maximum inversion of humidity over the interval X is 770 mg./m.^{3} while the maximum inversion from the mean monthly curves is 410 mg./m.^{3}; both these maxima occur at 0400. The maximum lapse on clear days in this interval is −920 mg./m.^{3}, that from the mean curves −860 mg./m.^{3}, both occurring at 0800. Hence the rate of change of lapse rate on clear days is −1,690 mg./m.^{3}/4 hr.; for all states of the sky it is −890 mg./m.^{3}/4 hr. in July. The maximum inversion and maximum lapse, for all states of the sky, do not occur in the same month. In the evening the change from lapse to inversion occurs on clear days after 2000 and the magnitude of the change from 1900 to 2200 is 630 mg./m.^{3}/3 hr., while the maximum change for all states of the sky occurs in July at about the same time, the change being 470 mg./m.^{3}/3 hr. In the interval X the curves for clear days and for all states of the sky are much the same in general shape with the clear-day amplitudes and slopes magnified. In the interval Z the period of inversion on clear days is from about 0100 to 0500, longer than in any of the three summer months for all states of the sky. The magnitude of the inversion +800 mg./m.^{3} is eight times that of the maximum inversion occurring at 0400 in July. The maximum lapse, −1,770 mg./m.^{3}, exceeds that for all states of the sky, −1,310 mg./m.^{3} occurring in August. The change from inversion to lapse is −2,570 mg./m.^{3}/3 hr. In interval Z the amplitudes and slopes of the curves are again increased on clear days compared with those for all states of the sky.

It is interesting to consider the layers 15·2 to 47·2 m., and 47·2 to 106·7 m. In the former there is a maximum inversion of 220 mg./m.^{3} compared with 90 mg./m.^{3} for all states of the sky, while the comparative maximum lapse figures are respectively −730 and −570 mg./m.^{3} In the latter there is always a lapse on clear days, ranging from −100 to −480 mg./m.^{3} whereas for all states of the sky there is a maximum inversion of 70 mg./m.^{3} at 2300 in June and a maximum lapse of −360 mg./m.^{3} at 1900 in August.

HEIGHT INTERVALS FOR CLEAR AND OVERCAST DAYS IN SUMMER AND WINTER

1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	Height interval
milligrammes per cubic metre													m.
CLEAR DAYS													
Summer (19 occasions)													
−230	−130	−140	−100	−160	−210	−350	−480	−390	−410	−350	−330	−240	106·7–47·2
−600	−600	−570	−470	−580	−600	−670	−700	−730	−630	−710	−370	−370	47·2–15·2
−570	−400	−360	−390	−440	−340	−450	−340	− 80	+190	+290	+380	+430	15·2– 1·1
Winter (3 occasions)													
−270	−330	−300	−270	−360	−350	−130	−130	−160	−130	−170	−120	−140	106·7–47·2
−370	−310	−260	−280	−160	−190	−180	−170	−180	−170	−110	− 80	− 20	47·2–15·2
+ 60	+ 50	+110	+110	+ 90	+260	+290	+380	+410	+400	+280	+290	+180	15·2– 1·1
OVERCAST DAYS													
Summer (4 occasions)													
− 30	+ 20	+ 50	− 80	− 90	−130	−150	− 90	− 30	−200	−250	−320	−190	106·7–47·2
−270	−230	−270	−310	−230	−220	−220	−320	−270	−370	−150	−340	−250	47·2–15·2
−290	−250	−180	−220	−320	−330	−250	−170	−150	− 10	− 10	− 10	−160	15·2– 1·1
Winter (21 occasions)													
− 70	− 50	− 60	− 50	− 40	− 20	− 40	− 40	− 40	− 30	− 40	− 60	− 50	106·7–47·2
−100	−100	− 70	− 90	− 70	− 30	− 30	− 30	− 20	− 40	− 50	− 40	− 40	47·2–15·2
−120	−110	−110	− 90	− 60	− 70	− 80	− 90	−100	− 80	− 70	− 70	− 50	15·2– 1·1

Winter, clear days.—Turning to clear days in winter there is a predominant inversion in interval X with only a slight lapse at 1100. This is a reflection in humidity of the slight temperature inversion noted in § 8. The maximum inversion is 500 mg./m.^{3} which is about two-thirds that for clear summer days, and about double that for all states of the sky at 0400 in January. In interval Z the maximum lapse is −650 mg./m.^{3} compared with a maximum for all states of the sky of −410 mg./m.^{3} at 1200 in January, and a maximum inversion of 200 mg./m.^{3} compared with a maximum for all states of the sky of 270 mg./m.^{3} in December. As there are only three examples of clear days in winter it would be unsafe to draw any firm conclusions.

Summer, overcast days.—On overcast days in summer it is noticeable that there is a persistent lapse of humidity in interval X, with a maximum of −330 mg./m.^{3} corresponding to the normal thermal structure in overcast conditions, the maximum inversion corresponding to the inversions of temperature, and the minimum inversions with the midday temperature lapses. The damping of the amplitude of humidity gradient corresponds, of course, to the small temperature changes in this interval and below, and a diminishing of the variations in evaporation at the surface. There is sometimes little turbulence on such days which indicates a tendency for gradients to persist. In the intervals Y and Z there is also a persistent lapse of humidity, the maxima and minima being −740 and −160 mg./m.^{3} and −1,210 and −400 mg./m.^{3} respectively ; the range in which the humidity lies is thus less than for all states of the sky and hence than on clear days. Turning to the interval 15·2 m. to 47·2 m. there is a persistent lapse of humidity from −40 to −480 mg./m.^{3} which is to be compared with a maximum inversion of 220 mg./m.^{3} on clear days and 90 mg./m.^{3} on all occasions and a maximum lapse of −730 mg./m.^{3} on clear days and −570 mg./m.^{3} on all occasions. On the whole the curve for overcast days in this interval has a smaller amplitude than that for either clear days or that for all states of the sky. As there are only four examples of overcast summer days reliable opinions cannot be formed.

Winter, overcast days.—On overcast days in winter there is an almost universal lapse of humidity ; the smallness of the lapse gradients is remarkable, just as in the corresponding temperature curves.

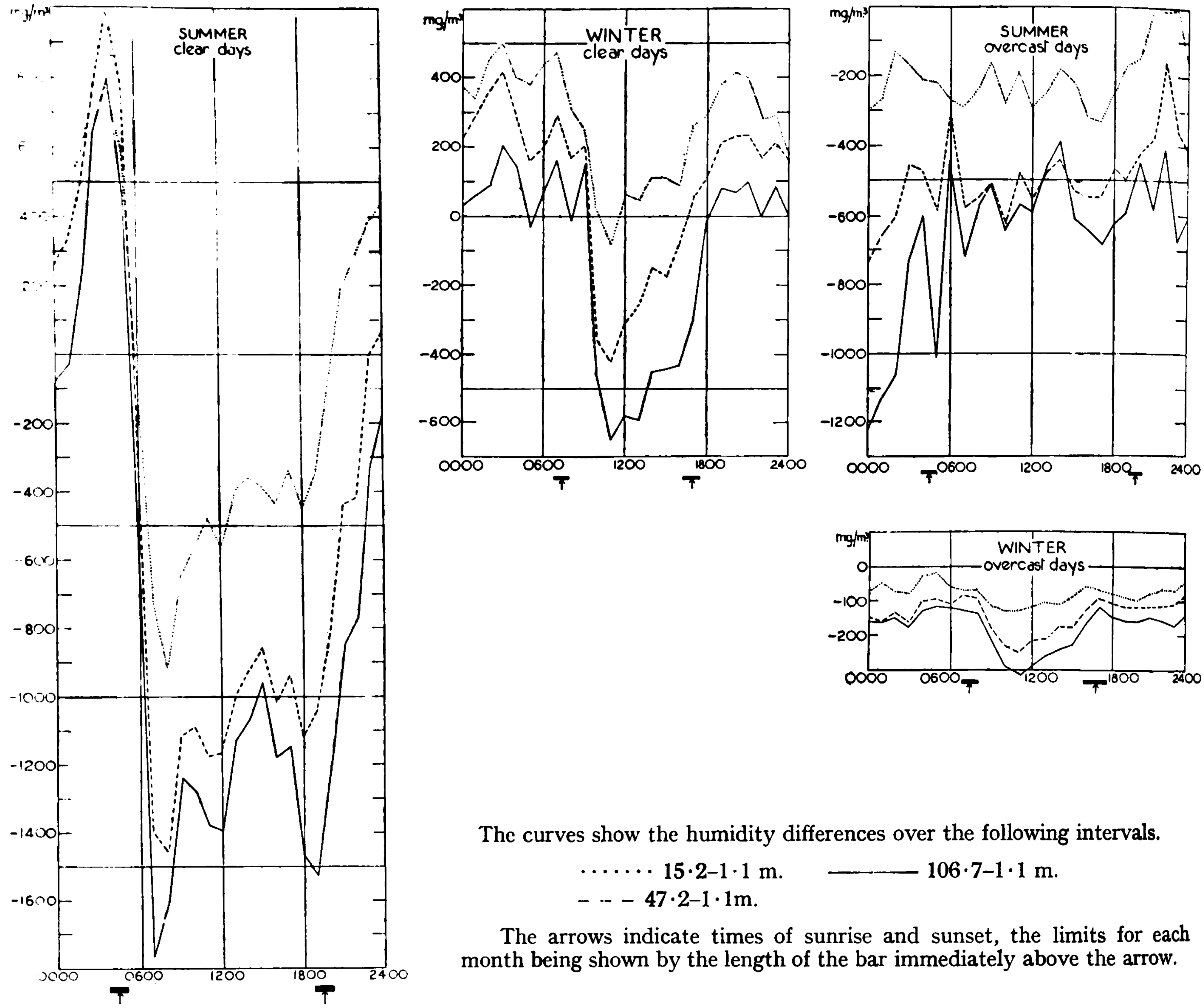


FIG. 14—DIURNAL VARIATION OF HUMIDITY DIFFERENCE OVER THREE HEIGHT INTERVALS FOR CLEAR AND OVERCAST DAYS IN SUMMER AND WINTER

§ 17—MAXIMUM VALUES OF THE HUMIDITY LAPSE RATE

From the hourly analysis of the humidity differences over the three height intervals the largest hourly values of both lapses and inversions occurring during each month have been extracted. These values are given in Tables XVIII and XIX, together with the date and time, the state of the sky and the wind velocity at 12·7 m.

Maximum lapses.—During the three years the greatest hourly lapses in the three intervals 1·1 to 15·2 m., 15·2 to 47·2 m. and 47·2 to 106·7 m. were respectively −5,750 mg./m.³ in May 1947, −4,200 mg./m.³ in November 1947 and −4,480 mg./m.³ in October 1947. It is interesting to note the months in which these lapses occur for the corresponding maximum temperature lapses occurred in May or June. There is also a marked variation in lapses from year to year. In the lowest layer there are four maximum lapses exceeding −3,000 mg./m.³, three occurring in May, June and August 1947, and one in June 1948. In the middle layer there are again four

TABLE XVIII—MAXIMUM HOURLY VALUES OF HUMIDITY LAPSE IN EACH MONTH

	1945					1946					1947					1948				
	Day	Max. lapse	Time of occurrence	Sky	Wind	Day	Max. lapse	Time of occurrence	Sky	Wind	Day	Max. lapse	Time of occurrence	Sky	Wind	Day	Max. lapse	Time of occurrence	Sky	Wind
		mg./m.^{3}			m./sec.		mg./m.^{3}			m./sec.		mg./m.^{3}			m./sec.		mg./m.^{3}			m./sec.
HEIGHT INTERVAL 106·7–47·2 M.																				
Jan.	..	..	..	..	..	27	− 980	1400	b	calm	15	−1320	1800	b	8·5	..	..	..	..	..
Feb.	..	..	..	..	..	3	− 390	2300	c	11·1	27	− 360	1400	c	2·7	29	−1050	1000	b	calm
Mar.	..	..	..	..	..	26	−1520	1000	b	calm	25	−1260	2400	b	6·7	6	−3000	1500	b	0·4
Apr.	..	..	..	..	..	13	−1330	0900	b	calm	16	−1050	{2100 / 2400}	bm / bm	{calm / 0·9}	18	−3190	1000	b	calm
May	..	..	..	..	..	23	−1590	0800	b	0·9	28	−3150	0200	b	0·9	7	−1380	0800	b	1·8
June	..	..	..	..	..	7	−1400	0700	bc	calm	24	−3040	0200	b	calm	8	−2600	2100	c	0·9
July	13	−2070	0500	bc	0·4	10	−2460	0100	b	0·4	24	−2500	2200	c	calm	..	..	..	..	..
Aug.	3	−1500	0500	b	0·9	4	−3450	1900	bc	calm	8	−3400	2200	b	calm	..	..	..	..	..
Sept.	10	−1070	0200	c	calm	30	−3300	1900	bc	calm	15	−4070	2400	b	0·4	..	..	..	..	..
Oct.	14	−1660	1200	bc	3·6	3	−1550	1300	c	1·3	6	−4480	1900	bf	calm	..	..	..	..	..
Nov.	3	−1020	1200	bc	3·1	5	−3390	1200	b	calm	6	−1000	0700	o F	1·8	..	..	..	..	..
Dec.	17	−1010	0700	c	8·9	26	− 570	1200	bc	4·5	1	−1610	1100	bcm	0·9	..	..	..	..	..
HEIGHT INTERVAL 47·2–15·2 M.																				
Jan.	..	..	..	..	..	31	− 530	1400	c	6·7	3	− 980	0500	b	4·5	..	..	..	..	..
Feb.	..	..	..	..	..	25	− 690	1000	c	calm	24	− 830	1200	b	calm	29	−1520	2000	b	1·3
Mar.	..	..	..	..	..	30	− 940	1100	b	3·1	28	− 890	2000	c	1·8	13	−2640	1100	b	calm
Apr.	..	..	..	..	..	20	−1510	1700	b	3·6	26	−1290	2300	b	calm	27	−2020	0900	c	calm
May	..	..	..	..	..	19	−2420	2200	b	2·2	28	−2060	0700	b	3·1	25	−1380	0700	c	4·9
June	..	..	..	..	..	28	−2050	1100	c	3·6	3	−3530	0600	b	calm	8	−1960	1000	c	3·1
July	14	−2510	0800	c	1·8	13	−2450	1600	cTR	calm	29	−2250	1300	bc	5·8	..	..	..	..	..
Aug.	3	−2800	2200	b	calm	13	−1430	2300	bc	2·2	18	−3700	1200	bc	3·6	..	..	..	..	..
Sept.	8	−1350	0700	c	5·8	26	−1260	1700	c	calm	19	−2060	1000	c	1·3	..	..	..	..	..
Oct.	9	−2030	1100	b	6·2	3	−1130	1200	c	2·7	6	−3500	1800	bcf	calm	..	..	..	..	..
Nov.	15	− 820	0800	c	2·2	6	− 990	1000	b	4·5	6	−4200	1200	bf	calm	..	..	..	..	..
Dec.	20	− 770	1300	bc	4·5	20	− 810	1200	b	4·0	1	− 400	1400	c	2·2	..	..	..	..	..
HEIGHT INTERVAL 15·2–1·1 M.																				
Jan.	..	..	..	..	..	22	− 470	1200	cm	1·8	1	− 780	1300	bc	calm	..	..	..	..	..
Feb.	..	..	..	..	..	6	−1010	1600	c	7·6	25	− 340	1400	bc	0·9	29	—1380	1000	b	calm
Mar.	..	..	..	..	..	20	−1080	0900	bc	8·9	{7 / 28}	− 650	{1800 / 1200}	bc / c	{6·2 / 4·0}	10	—2420	1000	b	5·8
Apr.	..	..	..	..	..	13	−1990	1000	bm	1·3	27	−1990	0800	bc	calm	13	−1550	0900	b	..
May	..	..	..	..	..	16	−2000	0800	c	calm	30	−5750	1400	b	3·6	26	−1520	0600	bc	5·8
June	..	..	..	..	..	17	−2740	0800	c	4·9	3	−3390	1200	b	0·4	26	−3810	0800	c	0·9
July	6	−1410	1200	bc	6·2	3	−2060	1600	bc	2·7	4	−2890	1500	c	2·7	..	..	..	..	..
Aug.	6	−1820	0900	bc	4·0	16	−2250	0900	c	4·0	19	−4810	1800	c	3·1	..	..	..	..	..
Sept.	3	−1740	1300	c	3·6	16	−2700	0900	bc	2·7	3	−2940	0900	b	0·9	..	..	..	..	..
Oct.	25	−1870	0300	c	7·1	8	−1940	1000	bc	2·7	9	−1820	0900	b	calm	..	..	..	..	..
Nov.	3	−1570	1100	c	calm	6	−2100	1100	b	4·5	7	−2390	1000	c	5·8	..	..	..	..	..
Dec.	20	−1520	1300	bc	4·0	2	−1010	0100	c	7·6	10	− 880	1400	b	1·8	..	..	..	..	..

TABLE XIX—MAXIMUM HOURLY VALUES OF HUMIDITY INVERSION IN EACH MONTH

	1945					1946					1947					1948				
	Day	Max. inversion	Time of occurrence	Sky	Wind	Day	Max. inversion	Time of occurrence	Sky	Wind	Day	Max. inversion	Time of occurrence	Sky	Wind	Day	Max. inversion	Time of occurrence	Sky	Wind
		mg./m.^{3}			m./sec.		mg./m.^{3}			m./sec.		mg./m.^{3}			m./sec.		mg./m.^{3}			m./sec.
	HEIGHT INTERVAL 106·7–47·2 M.																			
Jan.	..	..	..	..	..	21	1070	2100	bm	0·9	8	720	0200	bcf	1·3	..	..	..	..	..
Feb.	..	..	..	..	..	9	590	2300	bc	3·1	24	1190	0900	b	1·8	14	690	0400	bm	1·3
Mar.	..	..	..	..	..	30	1620	0400	bff	1·8	22	470	0700	c	6·2	16	1920	1200	c	3·6
Apr.	..	..	..	..	..	17	1130	1200	c	6·7	16	1550	0200	bffc	0·9	19	2510	0200	bc	2·2
May	..	..	..	..	..	19	990	1600	bc	2·7	31	3300	2100	c	2·2	10	2410	1300	bc	2·2
June	..	..	..	..	..	7	1500	0200	bc	calm	3	2230	2100	bc	2·2	5	1720	0900	c	4·5
July	15	1170	1300	bc	8·9	2	1980	0100	bc	calm	27	1710	2400	bc	2·2	..	..	..	..	..
Aug.	4	1880	0500	b	calm	16	1380	0600	c	calm	4	1400	0100	b	calm	..	..	..	..	..
Sept.	8	1110	0100	b	1·8	7	910	0300	c	0·4	4	1160	0400	bm	calm	..	..	..	..	..
Oct.	12	1740	1900	bff	calm	7	590	0600	bc	calm	7	2920	0800	bcm	calm	..	..	..	..	..
Nov.	5	990	0800	bc	2·7	5	2050	0800	bm	calm	6	670	1300	b	calm	..	..	..	..	..
Dec.	14	1230	1900	c	calm	11	1050	0100	b	calm	12	860	0200	c	1·8	..	..	..	..	..
	HEIGHT INTERVAL 47·2–15·2 M.																			
Jan.	..	..	..	..	..	7	1210	2300	bcm	calm	10	630	1000	cpr	calm	..	..	..	..	..
Feb.	..	..	..	..	..	5	520	2300	b	3·6	24	610	0800	b	2·2	13	1010	0500	bm	calm
Mar.	..	..	..	..	..	26	1190	0600	bm	1·8	10 17	240	0700 1700	cf c	4·5 4·9	7	2050	0200	bff	calm
Apr.	..	..	..	..	..	13	1440	0500	bm	calm	16	600	0300	bffc	1·3	18	1620	0400	b	calm
May	..	..	..	..	..	20	760	1400	c	4·9	30	2560	1300	b	1·3	11	1790	1400	bc	1·3
June	..	..	..	..	..	7	1060	0500	b	calm	27	2690	2000	b	0·4	11	1210	1400	b	2·7
July	4	240	0500	bc	calm	2	1420	0400	b	0·4	14	2480	1100	bc	calm	..	..	..	..	..
Aug.	12	2010	0500	bc	1·3	16	2120	0500	bc	calm	17	1820	1300	bc	3·6	..	..	..	..	..
Sept.	17	1300	2000	c	1·8	16	3610	0600	bc	calm	5	2430	0500	bm	calm	..	..	..	..	..
Oct.	31	2970	0600	bff	calm	12	1020	0500	bc	3·6	13	2950	0300	bff	calm	..	..	..	..	..
Nov.	5	1660	0300	bf	calm	4	3230	2300	bf	calm	6	1500	0700	o F	1·8	..	..	..	..	..
Dec.	20	20	0900	b	calm	22	1400	0500	bc	calm	1	1150	0900	bm	0·9	..	..	..	..	..
	HEIGHT INTERVAL 15·2–1·1 M.																			
Jan.	..	..	..	..	..	8	1650	0100	bc	1·8	3	2220	0400	b	0·9	..	..	..	..	..
Feb.	..	..	..	..	..	1	750	1300	bc	7·6	24	1310	1200	b	calm	27	1000	2300	b	calm
Mar.	..	..	..	..	..	29	1190	1800	b	3·1	17	1000	1300	bc	3·6	13	950	0700	b	1·3
Apr.	..	..	..	..	..	15	1550	0500	bm	1·3	20	1450	0200	b	0·9	18	1910	0300	b	calm
May	..	..	..	..	..	20	1460	0100	b	1·3	24	1710	0100	bf	calm	7 12	680	0400 1300	b c	1·3 0·9
June	..	..	..	..	..	7	1860	0100	b	calm	23	2160	0200	bc	calm	26	1210	0400	bc	calm
July	11	1150	2400	b	calm	2	1680	0400	b	0·4	27	2540	0100	bcf	calm	..	..	..	..	..
Aug.	4	1570	0200	b	calm	4	2030	0100	b	calm	9	2420	0400	b	calm	..	..	..	..	..
Sept.	16	2470	1400	bc	9·3	16	2020	0200	b	calm	10	2630	2400	b	calm	..	..	..	..	..
Oct.	9	3000	2100	bc	calm	21	1120	2000	bc	1·8	22	3130	0600	b	1·8	..	..	..	..	..
Nov.	4	1970	2400	bf	calm	4	2220	0700	b	calm	1	1850	0700	c	calm	..	..	..	..	..
Dec.	7	1240	1600	cm	calm	21	880	2400	b	calm	8	1160	0100	cf	calm	..	..	..	..	..

lapses exceeding $-3{,}000$ mg./m.^{3} in May, August, October and November 1947. In the top layer there are ten lapses exceeding $-3{,}000$ mg./m^3., three occurring in 1946, five in 1947 and two in 1948. The figure $-3{,}000$ mg./m.^{3} taken here as critical has no physical significance as a criterion; and it seems that the three 12-monthly cycles, starting in July 1945, show well marked differences in maximum lapses.

Reverting to a consideration of the lowest layer it is seen that, although clear or only partially cloudy skies are predominant, an overcast sky often does occur at the time of maximum lapse, in contradistinction to the conditions prevailing at the time of maximum lapse of temperature. The average wind speed at the time of maximum lapse rate is a little over 3 m./sec. while winds up to 9 m./sec. are found.

In the middle layer the maximum lapse rate can occur with either overcast, clear or partially clouded skies as in the lowest layer. Two points of special interest are worthy of note. First, in July 1946 the maximum lapse rate occurred in a thunderstorm whch heavy rain and no wind. Secondly, in October and November 1947 the maximum lapse rate occurred in the presence of fog. The average wind on occasions of maximum lapse is lighter than in the lowest layer, being a little over 2 m./sec., and the wind range reaches only 6·7 m./sec. as compared with 8·9 m./sec. in the layer beneath.

In the top layer it is noted that the maximum lapse occurs much more frequently on clear or partially cloudy days and correspondingly less frequently on overcast days. There is also a greater number of occasions on which there is a calm at the time of maximum lapse, and the mean wind speed is only 1·5 m./sec. The occasions of strong wind speeds are associated with comparatively small maximum lapses; in particular that of February 1946 should be noted.

The times of occurrence of maximum lapse rate are of interest. An examination of the times of occurrence of the maximum lapse rate of temperature (§9) shows that they are grouped about noon with the dispersion increasing with height. In the lowest layer the times of occurrence of maximum lapse rate of humidity are grouped about 0900, 16 of the 35 occasions falling between 0800 and 1000, but there is a wider dispersion about the mean than for temperature. In the second layer the times are grouped about 1100 with 13 of the 35 occasions falling between 1000 and 1200 and with quite a wide dispersion; in the top layer there is little grouping at all, and the maximum lapse rate occurs at almost any time of the day. Thus the expected time of occurrence of the maximum lapse rate of humidity is less definite than that of temperature.

On comparing the times of occurrence of the maximum lapse rate with the time of occurrence of the minimum in the curves of Fig. 13, fair agreement is found on many occasions as might be expected. In May and August 1947 the maximum lapse occurs at about the time of the second minimum in the curves of Fig. 13, while in July the minimum is very flat and covers the period from 1000 to 1500. There are some wide divergences which could not be explained except by detailed consideration of the situation at the time, notably in October 1945 and December 1946.

Maximum inversions.—During the three years the maximum hourly inversions in the three layers were respectively 3,130 mg./m.^{3} in October 1947, 3,610 mg./m.^{3} in September 1946 and 3,300 mg./m.^{3} in May 1947. It should be noted that these values are of the same order as the maximum lapse values, being about two-thirds of them. In the lowest layer there are four monthly maxima exceeding 2,500 mg./m.^{3}, three of them occurring in July, September and October 1947 and one in October 1945. In the middle layer there are six occasions upon which the arbitrary figure is surpassed, three in May, June and October 1947, two in September and November 1946 and one in October 1945. In the top layer there are three occasions, in May and October 1947 and in April 1948. It is concluded that 1947 shows greater inversions than 1946, just as it was concluded that it shows greater lapses.

Consider now the state of the sky and the wind speed at the times of maximum inversion. It is immediately seen from the table that in the first layer there is frequently a clear or only partially clouded sky with maximum inversion, and that when the sky is clouded the maximum inversion is generally small. It is interesting to note that fog is reported several times. The mean wind speed accompanying maximum inversions is only about 1 m./sec. and many calms are reported. The upper two layers show mainly the same characteristics with wind speeds less than 2 m./sec., and maximum inversions may be expected to occur with light winds and clear or only partially clouded skies, although once, in January 1947, rain and cloud were reported.

The times of occurrence of maximum inversions are also of interest. In the lowest layer the times are grouped about 0100, 15 occurrences falling in the period 2400 to 0200; in the middle layer the times are grouped about 0500, 19 occurrences falling in the period 0300 to 0700.

There is a wider scatter in the top layer, the most favoured times being 0100 and 0200. The maxima of the curves in Fig. 13 cover quite an appreciable period, not being well defined like the minima, and it is difficult to compare the times of maxima for the months, given in Table XIX, with the times of maxima for the curves of Fig. 13. Nevertheless some of the maxima in Table XIX occur when the monthly mean curves show a maximum lapse; such individual cases would need special scrutiny with regard to the prevailing conditions.

§ 18—FREQUENCY OF OCCURRENCE OF HUMIDITY LAPSE RATES OF VARIOUS MAGNITUDES

The hourly values of humidity difference over the height intervals 1·1 to 15·2 m., 15·2 to 47·2 m. and 47·2 to 106·7 m. during the three years have been analysed to show the frequency of occurrence of humidity differences of various magnitudes. Table XX shows the monthly frequencies of humidity differences between the stated limits, expressed as a percentage of the total number of hourly readings.

Considering the lowest layer, in November, December and January the maximum frequency lies between −10 and −100 mg./m.³ which is, of course, a lapse. In February and March the

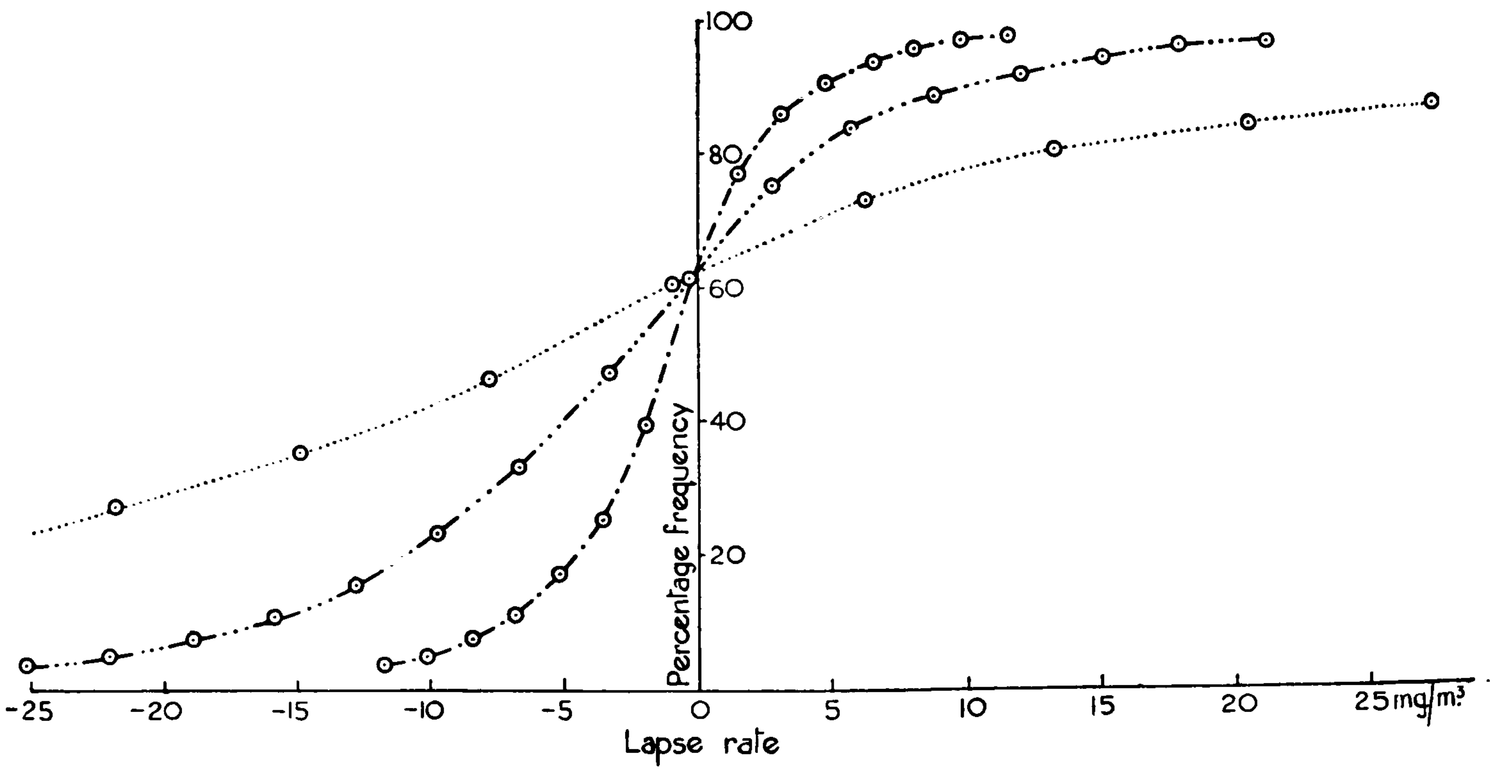


FIG. 15—OGIVE OF PERCENTAGE FREQUENCY OF LAPSE RATE OF HUMIDITY

The curves show the percentage frequencies over the following intervals.

⊙ ····· ⊙ 15·2–1·1 m. ⊙—···—⊙ 47·2–15·2 m. ⊙—·—·⊙ 106·7–47·2 m.

TABLE XX—PERCENTAGE FREQUENCY OF OCCURRENCE OF HUMIDITY DIFFERENCES OF VARIOUS VALUES

HEIGHT INTERVAL 106·7–47·2 M.

Humidity lapse (mg./m.³)

	−3000 to −2910	−2900 to −2810	−2800 to −2710	−2700 to −2610	−2600 to −2510	−2500 to −2410	−2400 to −2310	−2300 to −2210	−2200 to −2110	−2100 to −2010	−2000 to −1910	−1900 to −1810	−1800 to −1710	−1700 to −1610	−1600 to −1510	−1500 to −1410	−1400 to −1310	−1300 to −1210	−1200 to −1110	−1100 to −1010	−1000 to −910	−900 to −810	−800 to −710	−700 to −610	−600 to −510	−500 to −410	−400 to −310	−300 to −210	−200 to −110	−100 to −10
															percentage frequency															
Jan.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·1	..	..	..	0·4	0·3	0·3	0·7	1·0	1·7	3·2	8·0	19·2	31·5
Feb.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·1	0·2	0·2	0·1	0·2	..	0·4	0·8	3·8	12·8	42·0
Mar.	0·1	..	..	..	..	0·1	..	..	..	..	..	..	..	0·1	0·3	..	0·1	0·2	0·2	0·2	0·2	0·1	0·8	1·0	1·6	2·3	3·4	7·3	16·1	25·5
Apr.*	..	..	..	0·1	..	..	..	..	..	..	..	..	..	..	0·1	..	0·1	0·1	0·3	0·3	0·1	0·3	0·7	1·1	1·5	1·6	3·5	8·9	18·2	18·8
May	..	..	..	..	0·1	..	..	..	..	..	..	..	0·1	..	0·1	0·1	0·1	0·1	0·2	0·4	0·5	1·0	1·1	1·7	2·2	2·9	4·4	7·1	8·5	14·7
June*	0·1	..	0·1	..	0·1	..	..	..	..	..	0·1	..	0·2	0·1	0·1	0·2	0·2	0·2	0·3	0·5	0·6	0·6	1·1	1·6	1·8	2·5	3·8	6·6	11·0	16·1
July	..	..	..	..	..	0·2	0·2	0·1	..	0·2	0·1	0·3	0·1	0·1	0·3	0·4	0·4	0·6	0·6	1·0	1·0	1·2	1·5	1·9	3·2	3·3	4·9	7·7	12·7	16·3
Aug.*	..	..	..	0·1	..	0·2	..	0·1	0·1	0·1	0·1	..	0·2	0·2	0·4	0·2	0·3	0·5	1·1	0·8	1·4	1·6	2·6	3·5	4·7	6·0	9·9	12·7	14·4	12·6
Sept.*	..	0·1	0·2	0·2	..	..	0·1	0·1	0·1	0·2	0·1	0·2	0·2	0·2	0·5	0·3	0·4	0·1	0·6	0·9	1·1	1·4	2·1	2·7	3·9	7·3	12·7	14·9	13·1	10·9
Oct.*	..	0·1	..	..	0·1	0·1	..	..	0·1	0·1	0·2	0·1	0·1	0·3	0·2	0·1	0·3	0·3	0·5	0·3	0·9	1·4	2·2	2·7	6·1	10·9	14·4	17·4	13·6	9·7
Nov.*	..	..	..	..	..	..	..	..	..	..	..	0·1	0·1	..	..	..	0·1	..	0·1	0·2	0·4	0·2	0·3	0·2	1·0	1·2	3·0	6·1	15·9	27·8
Dec.	..	..	..	..	..	..	..	..	..	..	..	..	..	0·1	..	0·1	0·1	..	0·1	0·1	..	0·1	0·1	0·1	0·3	0·4	1·4	2·5	12·4	37·0
Year	..	..	..	..	..	0·1	..	..	..	..	..	0·1	0·1	0·1	0·2	0·1	0·2	0·2	0·4	0·4	0·6	0·7	1·1	1·5	2·3	3·4	5·5	8·7	13·9	21·2

	Apr. −3200 to −3010	June −3100 to −3010	Aug. −3500 to 3010	Sept. −4100 to −3010	Oct. −4500 to −3010	Nov. −3400 to −3010
* Further observations (%)	0·1	0·1	0·4	0·3	0·4	0·2

Humidity inversion (mg./m.³)

	0 to +90	+100 to +190	+200 to +290	+300 to +390	+400 to +490	+500 to +590	+600 to +690	+700 to +790	+800 to +890	+900 to +990	+1000 to +1090	+1100 to +1190	+1200 to +1290	+1300 to +1390	+1400 to +1490	+1500 to +1590	+1600 to +1690	+1700 to +1790	+1800 to +1890	+1900 to +1990	+2000 to +2090	+2100 to +2190	+2200 to +2290	+2300 to +2390	+2400 to +2490
											percentage frequency														
Jan.	22·7	6·7	2·3	0·9	0·2	0·3	0·3	0·1	0·1	..	0·2	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Feb.	23·5	11·0	2·8	1·4	0·3	0·2	0·2	..	..	..	0·1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Mar.	15·3	19·6	5·4	3·8	2·5	1·5	0·6	0·4	0·6	0·3	0·3	0·1	0·1	0·2	0·1	..	0·1	0·1	..	0·1	..	..	..	..	..
Apr.†	15·4	9·9	6·8	4·8	2·8	1·7	1·0	0·5	0·4	0·2	0·3	0·2	0·2	..	0·1	0·1	0·1	0·1	..	..	..	..	..	..	..
May†	15·1	12·5	9·5	5·4	3·7	1·3	1·3	0·9	0·8	0·6	0·4	0·3	0·4	0·1	0·3	0·4	0·2	0·1	0·1	0·1	..	0·1	..	..	0·1
June	15·2	13·9	7·8	5·7	2·9	1·5	1·1	1·0	1·0	0·4	0·2	0·5	0·2	0·1	0·1	0·3	0·1	0·1	..	0·1	0·1	..	0·1	..	..
July	14·0	10·8	6·2	3·8	2·5	1·2	0·8	0·7	0·1	0·1	0·2	0·2	0·1	0·3	0·2	..	..	0·1	..	0·1	..	..	..	..	..
Aug.	9·6	5·6	3·6	2·5	1·4	0·8	0·6	0·7	0·5	0·1	0·2	0·1	..	0·2	0·1	0·1	..	..	0·1	..	..	..	..	..	..
Sept.	8·8	5·6	3·2	2·8	1·3	1·9	0·7	0·6	0·3	0·3	..	0·2	..	..	..	..	..	..	..	..	..	..	..	..	..
Oct.†	6·9	3·8	1·8	1·2	0·7	0·9	0·4	0·1	0·2	0·2	0·1	0·2	0·2	0·2	0·2	..	0·1	0·1	..	..	..	0·1	..	..	..
Nov.	28·6	8·7	3·2	0·9	0·4	0·5	0·4	0·2	0·3	0·1	0·1	..	..	..	0·1	..	..	..	..	..	0·1	..	..	..	..
Dec.	29·6	8·3	3·2	1·6	0·8	0·9	0·1	0·3	0·1	0·1	0·1	..	0·1	..	..	..	..	..	..	..	..	..	..	..	..
Year	16·8	8·9	4·8	3·0	1·7	1·1	0·6	0·5	0·4	0·2	0·2	0·2	0·1	0·1	0·1	0·1	..	..	..	..	..	..	..	..	..

	Apr. +2500 to +2590	May +2500 to +3090	Oct. +2500 to +2990
† Further observations (%)	0·1	0·1	0·2

TABLE XX—*continued*

HEIGHT INTERVAL 47·2–15·2 M.

Humidity lapse (mg./m.³)

percentage frequency

	−2500 to −2410	−2400 to −2310	−2300 to −2210	−2200 to −2110	−2100 to −2010	−2000 to −1910	−1900 to −1810	−1800 to −1710	−1700 to −1610	−1600 to −1510	−1500 to −1410	−1400 to −1310	−1300 to −1210	−1200 to −1110	−1100 to −1010	−1000 to −910	−900 to −810	−800 to −710	−700 to −610	−600 to −510	−500 to −410	−400 to −310	−300 to −210	−200 to −110	−100 to −10
Jan.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·2	0·2	0·3	0·6	1·7	5·0	11·3	16·0	18·6	21·8
Feb.	..	..	..	..	..	..	..	..	..	0·1	0·1	..	..	..	0·1	0·2	0·1	0·3	0·5	0·4	1·0	2·8	7·5	24·2	16·7
Mar.*	..	..	0·1	..	..	..	..	..	..	..	..	0·2	0·1	0·1	0·1	0·2	0·5	0·5	1·1	2·3	3·1	5·3	9·4	13·7	15·0
Apr.	..	..	..	..	0·1	..	..	..	..	0·1	..	0·1	0·1	0·1	0·3	0·4	0·6	0·7	0·7	1·6	2·1	3·6	6·8	12·2	17·0
May	..	..	..	..	0·1	..	..	0·1	..	..	0·4	0·2	0·5	0·3	0·8	1·0	1·3	1·6	3·4	5·1	7·8	10·4	14·2	15·2	13·1
June*	0·1	0·1	..	..	0·3	0·2	0·2	0·1	0·2	0·1	0·2	0·3	0·6	0·5	1·0	1·1	1·6	2·1	3·4	4·9	8·4	10·5	15·1	13·6	10·7
July*	0·2	0·1	0·1	0·2	0·4	0·1	0·4	0·5	0·7	0·5	0·8	1·3	1·7	1·4	2·5	2·9	3·3	3·7	6·2	6·7	9·0	13·2	14·1	12·6	7·2
Aug.*	0·1	..	..	..	..	0·1	0·3	..	0·2	0·1	0·2	0·4	0·5	0·7	1·1	1·5	2·2	2·9	4·1	6·5	7·3	11·3	13·7	13·7	10·2
Sept.	..	..	..	..	0·1	0·1	0·1	0·1	..	0·1	0·1	0·2	0·3	0·8	1·0	1·3	0·7	2·7	3·9	6·4	8·7	8·8	12·0	11·4	8·7
Oct.*	..	..	..	..	0·2	..	0·1	..	0·1	..	0·2	0·2	0·2	0·1	0·3	0·3	0·9	0·4	1·1	2·8	4·2	7·4	12·5	12·4	10·0
Nov.*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·1	0·2	0·2	0·2	0·3	0·5	1·9	4·8	11·3	17·7
Dec.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·1	0·1	0·1	0·1	0·4	0·9	2·3	10·4	34·7
Year	..	..	..	..	0·1	..	0·1	0·1	0·1	0·1	0·2	0·2	0·3	0·3	0·6	0·8	1·0	1·3	2·2	3·3	4·9	7·2	10·6	14·0	14·2

	Mar. −2700 to −2510	June −3600 to −2510	July −2600 to −2510	Aug. −3700 to −2510	Oct. −3500 to −2510	Nov. −4200 to −2510
* Further observations (%)	0·1	0·1	0·1	0·4	0·2	0·2

Humidity inversion (mg./m.³)

percentage frequency

	0 to +90	+100 to +190	+200 to +290	+300 to +390	+400 to +490	+500 to +590	+600 to +690	+700 to +790	+800 to +890	+900 to +990	+1000 to +1090	+1100 to +1190	+1200 to +1290	+1300 to +1390	+1400 to +1490
Jan.	16·1	4·3	1·9	1·1	0·4	0·2	0·2	0·1	..	0·1	..	..	0·1	..	..
Feb.	27·1	13·1	3·4	1·2	0·4	0·3	0·1	..	0·1	0·1	0·1	..	..	..	..
Mar.	12·5	12·9	9·3	4·9	2·5	2·2	1·3	0·8	0·4	0·2	0·3	0·2	0·1	0·1	0·2
Apr.	20·4	16·3	7·9	3·4	2·3	1·3	0·9	0·5	0·3	0·3	0·2	0·2	0·2	..	0·1
May	7·7	6·8	2·9	2·1	0·8	0·8	0·5	0·4	0·2	0·1	..	0·1	..	..	..
June	8·3	6·6	3·3	1·6	1·9	0·8	0·3	0·4	0·3	0·3	0·2	0·1	0·1	0·1	..
July	3·5	1·8	1·8	0·8	0·8	0·2	0·2	0·3	0·1	0·2	..	0·1	0·1	0·1	0·1
Aug.	7·7	4·7	2·7	1·8	1·6	0·8	0·5	0·5	0·5	0·4	0·2	0·3	0·3	0·1	0·1
Sept.†	10·9	6·3	5·5	2·7	2·3	1·7	0·8	0·4	0·5	0·2	0·3	0·1	0·1	0·1	0·2
Oct.	7·3	5·5	5·7	4·8	7·0	3·5	3·1	2·5	1·2	1·2	0·7	0·4	0·2	0·4	0·4
Nov.†	20·4	14·0	8·8	6·0	5·4	2·5	1·5	0·8	0·3	0·4	0·5	0·1	0·4	0·3	0·3
Dec.	21·2	13·4	8·2	6·0	4·8	2·9	1·1	0·7	0·7	0·6	0·1	0·2	0·2	0·1	0·1
Year	13·4	8·9	5·3	3·1	2·5	1·5	0·9	0·6	0·4	0·3	0·2	0·1	0·1	0·1	0·1

	+1500 to +1590	+1600 to +1690	+1700 to +1790	+1800 to +1890	+1900 to +1990	+2000 to +2090	+2100 to +2190	+2200 to +2290	+2300 to +2390	+2400 to +2490	+2500 to +2590	+2600 to +2690	+2700 to +2790	+2800 to +2890	+2900 to +2990
Jan.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Feb.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Mar.	..	0·2	0·1	0·2	0·1	0·1	..	..	..	..	..	..	..	..	..
Apr.	..	0·1	..	..	..	..	..	..	..	..	..	..	..	..	..
May	..	..	0·1	0·1	..	..	..	..	..	..	..	..	..	..	..
June	0·1	..	..	0·1	0·1	..	..	..	..	0·1	..	0·1	..	..	..
July	..	0·1	..	..	..	..	..	..	..	0·1	..	..	..	..	..
Aug.	0·1	0·1	0·2	0·2	..	0·1	0·1	..	..	..	..	..	..	..	..
Sept.†	0·1	0·2	0·1	0·1	0·1	0·2	0·2	..	0·1	0·1	..	..	..	..	0·1
Oct.	0·4	0·2	0·3	0·2	0·1	0·2	0·1	0·4	0·4	0·1	0·2	0·2	..	0·1	0·1
Nov.†	0·2	0·2	0·1	..	0·1	0·1	0·1	0·1	..	0·2	..	..	..	0·1	..
Dec.	..	0·1	..	0·1	..	0·1	..	..	..	..	..	..	..	..	..
Year	0·1	0·1	0·1	0·1	..	..	..	..	..	..	..	..	..	..	..

	Sept. +3000 to +3690	Nov. +3000 to +3290
† Further observations (%)	0·1	0·2

TABLE XX—*continued*
HEIGHT INTERVAL 15·2–1·1 M.
Humidity lapse (mg./m.³)

percentage frequency

	−2500 to −2410	−2400 to −2310	−2300 to −2210	−2200 to −2110	−2100 to −2010	−2000 to −1910	−1900 to −1810	−1800 to −1710	−1700 to −1610	−1600 to −1510	−1500 to −1410	−1400 to −1310	−1300 to −1210	−1200 to −1110	−1100 to −1010	−1000 to −910	−900 to −810	−800 to −710	−700 to −610	−600 to −510	−500 to −410	−400 to −310	−300 to −210	−200 to −110	−100 to −10
Jan.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·2	..	0·1	0·4	1·2	4·5	13·2	29·1
Feb.	..	..	..	..	..	..	..	..	..	..	..	0·1	..	..	0·1	..	..	0·1	..	0·5	1·1	4·8	7·5	12·4	27·0
Mar.	0·1	..	..	..	..	..	..	..	..	..	..	..	0·1	0·1	0·1	..	0·3	0·2	0·6	0·8	1·4	2·4	3·8	7·9	15·0
Apr.	..	..	..	..	..	0·1	..	0·1	0·1	0·1	0·1	0·2	0·1	0·2	0·4	0·5	1·0	1·0	1·9	2·8	5·0	7·6	10·6	14·1	13·3
May*	..	0·2	0·2	0·1	..	0·1	0·4	0·3	0·2	0·7	0·7	0·9	1·0	1·2	1·7	2·2	2·5	3·3	5·0	4·1	5·8	7·4	9·1	9·8	9·9
June*	0·1	0·3	0·3	0·5	0·6	0·3	0·6	0·3	0·6	0·6	1·0	1·2	2·0	2·3	3·5	4·2	4·6	5·7	5·8	8·4	8·4	8·4	8·3	7·1	5·7
July*	..	..	..	..	0·2	0·1	..	0·1	0·2	0·2	0·7	0·7	1·1	0·8	1·8	3·0	3·6	4·5	6·1	5·5	6·2	7·5	8·2	8·2	8·9
Aug.*	0·1	..	0·1	0·3	0·1	0·1	0·3	0·1	0·3	0·2	0·4	0·8	0·6	1·3	1·8	2·8	3·8	5·1	6·7	6·7	9·0	10·1	9·0	9·6	6·4
Sept.*	..	..	0·1	0·1	0·1	..	0·1	0·1	0·2	0·1	0·2	0·3	0·7	1·2	1·6	2·3	3·4	2·9	5·0	6·3	7·6	9·3	8·6	6·7	6·0
Oct.	..	..	..	..	..	0·1	0·1	0·1	..	0·2	0·1	0·1	0·3	0·6	0·9	1·2	2·0	2·2	3·2	4·9	5·7	10·1	8·3	8·9	8·0
Nov.	..	0·1	..	..	0·1	..	0·1	0·1	0·1	0·1	0·1	..	0·1	0·1	0·1	0·1	0·2	0·9	0·7	1·5	1·6	4·3	7·7	17·1	25·2
Dec.	..	..	..	..	..	..	..	..	..	0·1	..	..	..	0·1	0·1	..	0·1	0·1	0·2	0·7	1·6	3·5	10·1	13·9	21·2
Year	..	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·2	0·3	0·4	0·5	0·7	1·0	1·4	1·9	2·3	3·0	3·6	4·6	6·5	8·1	10·7	14·1

	May	June	July	Aug.	Sept.
	−3100 to −2510	−3900 to −2510	−2900 to −2510	−4900 to −2510	−3000 to −2510
* Further observations (%)	0·2	1·3	0·1	0·3	0·4

Humidity inversion (mg./m.³)

percentage frequency

	0 to +90	+100 to +190	+200 to +290	+300 to +390	+400 to +490	+500 to +590	+600 to +690	+700 to +790	+800 to +890	+900 to +990	+1000 to +1090	+1100 to +1190	+1200 to +1290	+1300 to +1390	+1400 to +1490	+1500 to +1590	+1600 to +1690	+1700 to +1790	+1800 to +1890	+1900 to +1990	+2000 to +2090	+2100 to +2190	+2200 to +2290	+2300 to +2390	+2400 to +2490	+2500 to +2590	+2600 to +2690	+2700 to +2790	+2800 to +2890	+2900 to +2990
Jan.	17·9	11·3	7·7	3·6	2·8	1·6	1·2	1·4	1·1	1·0	0·5	0·2	0·2	0·3	0·2	0·2	0·1	..	..	..	..	..	0·1	..	..	..	..	..	..	..
Feb.	30·0	8·3	2·6	2·3	1·4	0·7	0·5	0·3	0·3	0·1	0·1	..	..	0·1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Mar.	21·2	15·0	9·1	6·8	5·1	3·2	2·0	1·7	0·9	0·4	0·4	0·6	0·2	0·1	0·1	0·1	0·2	0·1	..	0·1	..	..	..	..	..	..	..	..	..	..
Apr.	12·5	9·3	5·9	3·6	3·1	2·8	1·3	0·8	0·5	0·3	0·4	0·3	0·3	0·1	0·2	0·1	..	..	..	0·1	..	..	..	..	..	..	..	..	..	..
May	10·0	7·4	4·9	2·9	1·9	1·5	0·9	0·8	0·6	0·6	0·2	0·2	0·3	0·2	0·2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
June	5·6	2·8	1·6	1·1	1·2	0·8	0·7	0·7	0·8	0·2	0·3	0·4	0·7	0·2	0·2	0·2	0·1	0·2	0·2	0·1	0·1	0·1	..	..	..	..	..	..	..	..
July	6·9	6·0	4·2	2·3	1·7	1·6	1·5	0·7	1·0	0·7	0·9	0·7	1·1	0·7	0·5	0·2	0·5	0·2	0·2	0·1	0·3	0·1	0·1	0·1	0·1	0·1	..	..	..	..
Aug.	4·4	3·9	3·1	2·2	1·7	1·5	1·6	1·1	1·1	0·7	0·4	0·6	0·4	0·5	0·3	0·2	0·2	..	0·2	0·2	0·1	0·1	0·1	..	0·1	..	..	..	..	..
Sept.	6·4	6·9	5·8	4·1	2·3	2·1	1·7	1·4	1·1	0·9	0·8	0·8	0·5	0·3	0·3	0·4	0·3	0·3	0·2	0·3	0·2	..	0·1	0·1	0·1	0·1	0·1	..	..	..
Oct.†	8·7	6·3	4·3	3·7	3·0	2·8	2·5	2·0	1·2	1·5	0·9	1·1	0·3	0·8	0·9	0·7	0·8	0·3	0·4	0·2	0·1	0·2	0·1	0·1	0·2	0·1	..	..	..	0·1
Nov.	19·0	7·6	2·8	2·1	2·2	2·0	0·5	0·9	0·8	0·6	0·4	0·3	0·1	0·1	0·1	0·2	..	0·2	0·1	0·1	..	..	0·1	..	..	..	..	..	..	..
Dec.	17·7	12·4	6·7	5·0	1·9	1·5	1·4	0·9	0·3	0·3	0·1	0·1	0·1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Year	13·0	8·0	4·9	3·3	2·4	1·9	1·3	1·1	0·8	0·6	0·5	0·4	0·4	0·3	0·2	0·2	0·2	0·1	0·1	0·1	0·1	..	..	..	..	..	..	..	..	..

	Oct.
	+3000 to +3190
† Further observation (%)	0·2

maximum frequency lies between 0 and 90 mg./m.³ In the remainder of the months, except for May, the maximum frequency lies in the lapse region ; in May the frequencies in the contiguous regions 0 to 90, −10 to −100 and −110 to −200 mg./m.³ are all much the same, so that a very slight change enables one to fit May into the general scheme having maximum frequency lying in the lapse region, except for February and March. In February the maximum is not sharp on the lapse side, but in March it is sharper on the lapse side than it is on the inversion side.

In the layer from 15·2 to 47·2 m. the maximum frequency for all months except February, April and November lies in the lapse region. In the layer 47·2 to 106·7 m. the maximum frequency for all months except May and November lies in the lapse region. It is worthy of note that when the maximum frequency lies in the inversion region it is always in the interval 0 to 90 mg./m.³

The average frequencies for the year are also listed in Table XX and are plotted in Fig. 15.

The curves show that great lapses and great inversions, expressed in milligrammes per cubic metre, are most frequent in the lowest layer, and least frequent in the upper layer, while the frequency of near-zero lapses and inversions is greatest in the top layer and least in the lowest layer.

§ 19—MEAN DIURNAL VARIATION OF HUMIDITY AT EACH HEIGHT

The mean hourly values of the humidity at 1·1 m. are given in Table XXI, the hourly mean being found by the same method of averaging as used for the other charts. By using Table XIV we can construct the mean hourly values at the other three levels. The data are plotted in Fig. 16.

TABLE XXI—MEAN HOURLY VALUES OF HUMIDITY

	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100
					milligrammes per cubic metre						
January	4650	4620	4580	4520	4550	4560	4460	4400	4510	4710	4890
February	4430	4430	4440	4460	4450	4450	4420	4470	4670	4860	4880
March	5110	5070	5070	5070	5080	5060	5180	5640	6150	6250	6110
April	5490	5430	5400	5350	5400	5640	6240	6660	6550	6330	6220
May	6720	6700	6680	6600	6770	7460	7950	7990	7700	7550	7550
June	8320	8230	8220	8260	8680	9440	9910	9920	9550	9430	9340
July	9800	9590	9540	9470	9710	10290	11000	11100	11000	11120	11330
August	10090	9980	9860	9790	9880	10460	11380	11690	11220	10750	10640
September	9510	9370	9340	9270	9320	9450	9970	10480	10850	10580	10360
October	7530	7500	7450	7350	7310	7260	7500	8130	8620	8700	8480
November	6130	6170	6170	6220	6210	6200	6200	6330	6710	7020	7000
December	5550	5550	5570	5630	5570	5530	5500	5470	5520	5740	6010

TABLE XXII—MEAN HOURLY VALUES OF HUMIDITY AT A HEIGHT

	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100
						milligrammes per cubic metre						
CLEAR DAYS												
Summer .. .	9670	9550	9480	9370	9280	9520	10620	12420	12590	11780	11180	11060
Winter	4780	4930	4770	4740	4790	4760	4660	4540	4710	4980	5480	5540
OVERCAST DAYS												
Summer	10650	10700	10370	10190	10260	10140	10170	10190	10180	10040	9850	9710
Winter	5290	5320	5350	5330	5280	5190	5170	5140	5150	5250	5410	5470

A point worthy of note is that the humidity is greater in summer than in winter, largely owing to the fact that the saturated vapour pressure at winter temperature is less than at summer temperature. At 60° F. the saturated vapour pressure is about twice that at 40° F. There is also potentially a greater supply of moisture by evaporation at the higher summer temperature. A second point to be noted is the general similarity in the shape of the four curves for any given month ; in particular the maxima and minima occur at much the same time within the accuracy of timing, and gradient maxima are therefore not due to changes at any one level while the other levels remain roughly constant in humidity.

A feature of the curves, with few exceptions, is a distinct minimum in the dawn period when the temperature curves also show a minimum and the saturated vapour pressure is a minimum. After dawn the humidity rises sharply to a maximum about midday in winter, but advances in time as the summer is approached so that the maximum occurs as early as 0700–0800 in June. The humidity then falls but rises again to a second maximum in the midday period ; this second maximum is not noticeable in winter, when it is masked by the first maximum, but is quite marked in summer, when more than one local maximum can be found. The explanation of the double maxima lies in the role that turbulence plays in redistributing the moisture content of the air. After dawn there is evaporation at the surface owing to the temperature rise caused by insolation, and the humidity rises at all levels, the diffusing agency being slight turbulence. As the morning proceeds turbulence increases and carries away moisture from the lower atmosphere rather more quickly than it is supplied by evaporation, so that the net effect is a decrease in humidity. At midday the evaporation is a maximum at the surface, counter-balancing the loss of water vapour carried upward by turbulence, and shortly after midday there is a second maximum. In the afternoon both evaporation and turbulence decrease, but the turbulence acts through a deeper layer than that in which the readings were taken and the

AT A HEIGHT OF 1·1 M. FOR EACH MONTH

1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	
					milligrammes per cubic metre								
4920	5010	5000	4920	4780	4640	4690	4750	4780	4750	4750	4810	4830	January
4920	4930	4850	4780	4720	4600	4530	4490	4490	4450	4400	4360	4320	February
5860	5720	5730	5680	5530	5460	5280	5210	5220	5190	5220	5200	5220	March
6160	6000	5890	5830	5790	5690	5580	5580	5560	5640	5660	5590	5530	April
7630	7630	7540	7390	7270	7070	6920	6890	6730	6800	6790	6810	6810	May
9440	9460	9370	9220	9140	9130	9080	8990	8790	8650	8620	8540	8430	June
11340	11360	11410	11250	11130	11020	10830	10710	10450	10300	10130	10040	9980	July
10550	10320	10340	10220	10240	10400	10570	10560	10350	10330	10310	10240	10130	August
10380	10310	10310	10130	9940	9890	9790	9630	9500	9520	9580	9470	9450	September
8440	8330	8250	8200	8130	7970	7790	7690	7600	7550	7540	7620	7550	October
6870	6820	6700	6600	6400	6240	6310	6260	6240	6130	6150	6180	6150	November
6120	6130	6010	5890	5700	5600	5600	5570	5550	5490	5490	5470	5510	December

OF 1·1 M. FOR CLEAR AND OVERCAST DAYS IN SUMMER AND WINTER

1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	
					milligrammes per cubic metre								
10470	10250	10090	9950	10200	10270	10430	10440	10470	10080	10210	10170	10270	CLEAR
5450	5450	5430	5310	5180	4970	5050	5000	4850	4760	4840	4840	4950	DAYS
9970	10030	10180	10400	10990	11000	10750	10800	10280	10630	10140	10190	9650	OVERCAST
5490	5510	5450	5440	5400	5340	5350	5350	5390	5400	5450	5420	5390	DAYS

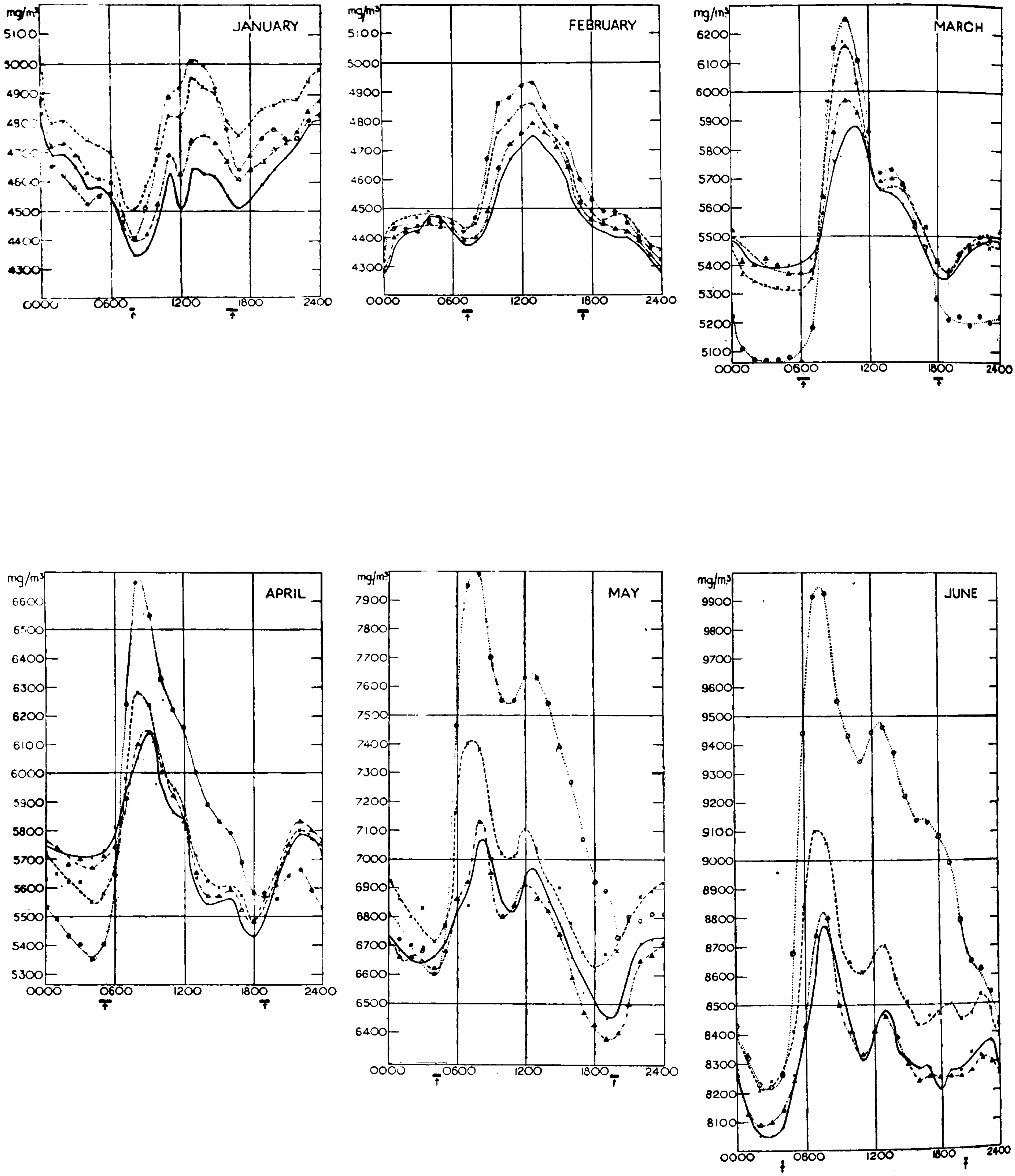
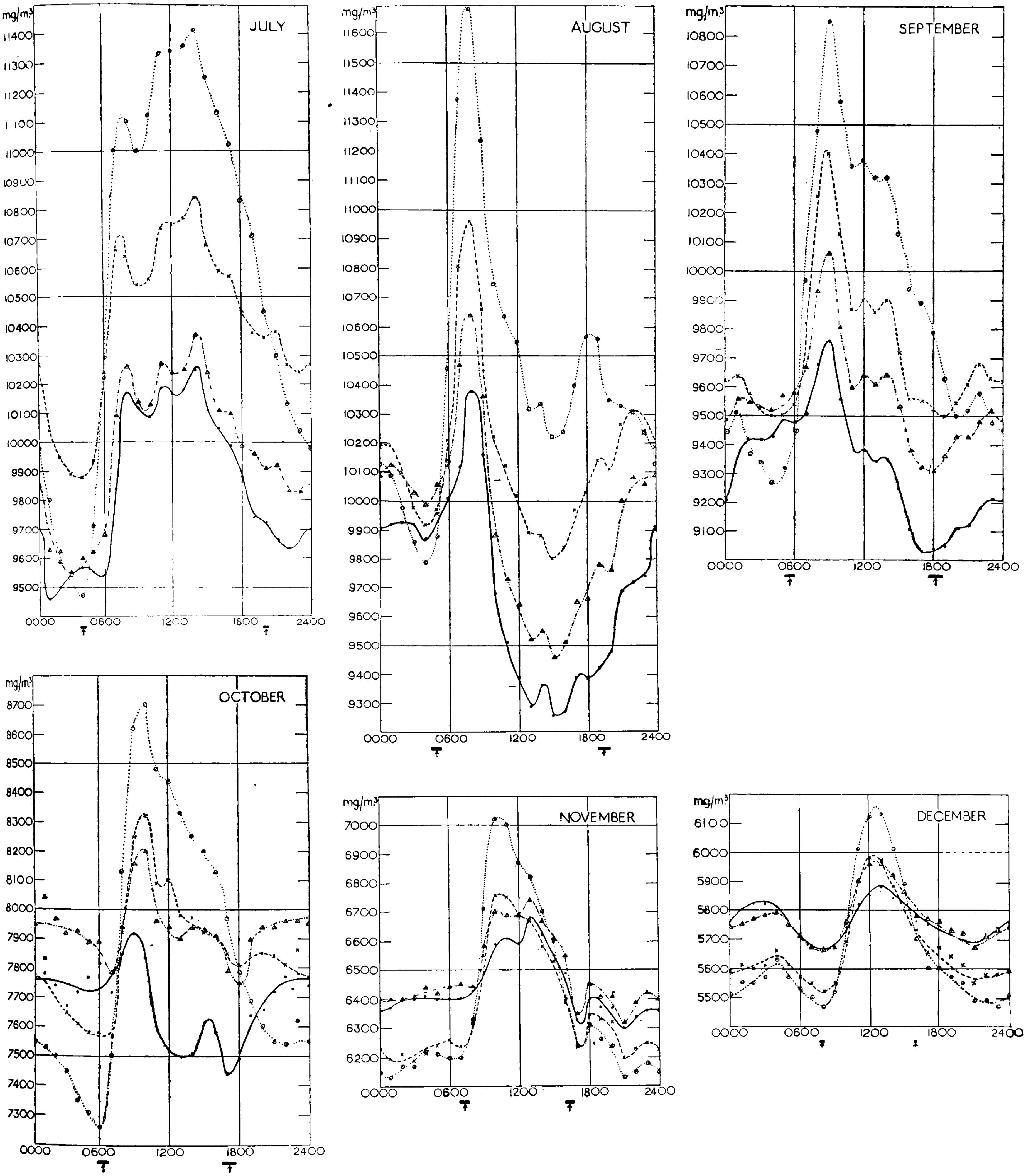


FIG. 16—DIURNAL VARIATION OF HUMIDITY

The curves show the humidity at the following heights ⊙··········⊙ 1·1 m.

The arrows indicate times of sunrise and sunset, the limits for each month



AT FOUR HEIGHTS FOR EACH MONTH

× - - - - × 15·2 m. △—·—△ 47·2 m. •———• 106·7 m.

being shown by the length of the bar immediately above the arrow.

humidity decreases. Secondary maxima later are probably due to water vapour being diffused downwards, from a humidity inversion above, as the temperature falls, and condensation takes place at the ground level.

The humidity at the four heights has been obtained for clear and overcast days in summer and in winter, and is given in Table XXII and plotted in Fig. 17.

On clear days in summer we notice that at 1·1 m. the maximum humidity is about 12,600 mg./m.³ occurring at 0800, the corresponding maximum for all states of the sky being 11,690 mg./m.³ in August. On overcast days the maximum is about 11,000 mg./m.³ at 1700. The outstanding feature on clear days in summer is that there is no second maximum in the early afternoon, which shows that on clear days the increased turbulence is more effectively transporting moisture upwards. There is a secondary maximum at 1·1 m. at 2000.

A second feature worthy of note is that the vapour density increases on a clear summer day, being greater at the end of the day than at the beginning. The corresponding increase in temperature has already been noted in § 11, and the humidity increase may be explained by remarking that the temperature increase allows some of the evaporated moisture to remain uncondensed at the end of the day. On overcast days in summer the reverse is true of temperature and humidity. Examination of the curves for clear winter days and overcast summer days shows some erratic features which, in a statistic of such few cases, are dependent upon the smallness of the sample and probably have no physical significance.

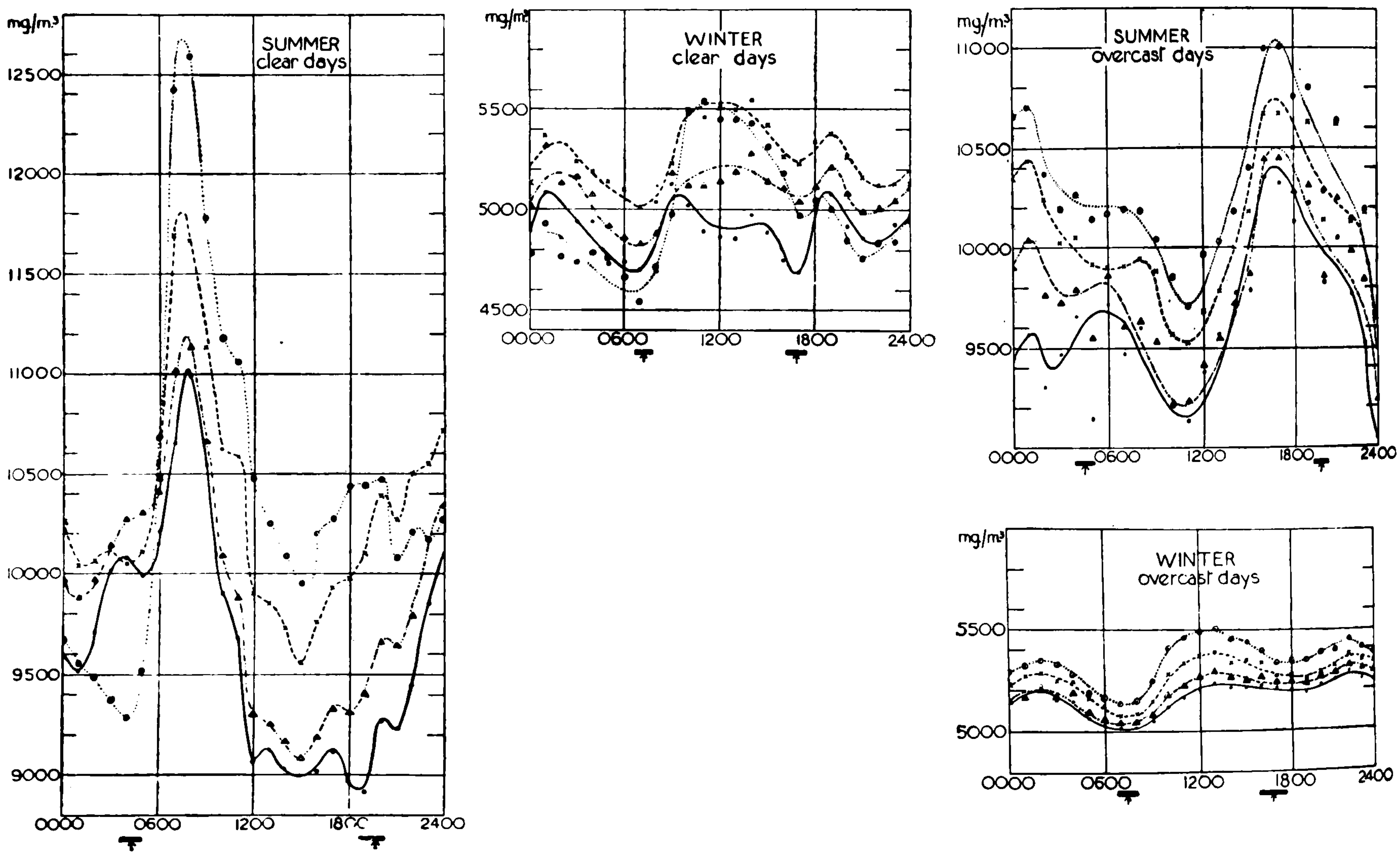


FIG. 17—DIURNAL VARIATION OF HUMIDITY AT FOUR HEIGHTS FOR CLEAR AND OVERCAST DAYS IN SUMMER AND WINTER

The curves show the humidity at the following heights

⊙·······⊙ 1·1 m. × – – – – × 15·2 m. △··—··—△ 47·2 m. •———• 106·7 m.

The arrows indicate times of sunrise and sunset, the limits for each month being shown by the length of the bar immediately above the arrow.

TABLE XXIII—DIURNAL RANGE OF HUMIDITY AT VARIOUS HEIGHTS

	Height 1·1 m.	15·2 m.	47·2 m.	106·7 m.
	milligrammes per cubic metre			
January	610	480	480	560
February	610	500	500	470
March	1,190	860	60	520
April	1,200	800	660	710
May	1,390	770	750	690
June	1,700	890	710	720
July	1,940	960	820	790
August	2,900	1,160	1,180	1,120
September	1,580	900	750	650
October	1,440	750	450	480
November	890	500	420	380
December	660	460	300	210
SUMMER				
Clear days ..	3,310	2,130	2,040	2,070
Overcast days ..	1,350	1,180	1,230	1,300
WINTER				
Clear days ..	1,000	760	770	440
Overcast days ..	370	330	280	280

On overcast winter days there is a small range of humidity with a flat minimum about dawn and a flat maximum a little after midday. The corresponding temperature curves show similar small variations.

The diurnal ranges of humidity at the four levels have been extracted and are given in Table XXIII. At all levels the diurnal range generally increases in the first eight months of

TABLE XXIV—TIMES OF OCCURRENCE OF MAXIMUM HUMIDITY AT VARIOUS HEIGHTS

	Height 1·1 m.		15·2 m.		47·2 m.		106·7 m.
June	0730	(0)	0730	(5)	0735	(25)?	0800?
December	1233	(15)	1248	(21)	1309	(6)	1315
Summer							
Clear days ..	0736	(−3)	0733	(6)	0739	(6)	0745
Winter							
Overcast days ..	1242	(23)	1315	(15)?	1330?	(30)?	1400?

The figures in brackets are the lag (in minutes) in the time of maximum over each interval of height.

the year and decreases again in the last four months. On clear days in summer the diurnal range is considerably enhanced, and on overcast days is rather greater, except at 1·1 m., compared with the range for all states of the sky. On clear winter days the diurnal range is greatest at the lowest level, being half as great again as the range for all occasions. The diurnal range for overcast winter days is small.

The times of occurrence of maximum humidity at various heights have been found and are tabulated in Table XXIV. There is little difference between the figures for mean June and for clear summer days, or between those for mean December and overcast winter days.

§ 20—EFFECT OF SNOW COVER

The data for humidity on those occasions when snow cover was present, as in § 12, have been extracted, and the hourly means are given in Table XXV. The vapour density is small, as might be expected in view of the low temperature. The inversions and lapses are small, and there is a general lapse of humidity above 15·2 m. The lapse in interval X extends from 1300 to 1600, and occurs later than on the mean winter days.

TABLE XXV—MEAN HOURLY VALUES OF HUMIDITY AT 1·1 M.

	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100
					milligrammes per cubic metre						
HUMIDITY 1·1 m.	2830	2800	2790	2790	2760	2730	2660	2650	2740	2830	2990
HUMIDITY DIFFERENCE											
106·7–47·2 m. ..	− 60	− 80	− 70	− 40	− 50	− 50	− 90	− 50	+ 10	− 30	− 90
47·2–15·2 m. ..	− 70	− 70	− 90	−110	−110	− 80	− 60	− 30	− 60	− 60	−120
15·2– 1·1 m. ..	+130	+150	+120	+ 90	+ 70	+ 50	+ 70	+ 70	+ 50	+ 20	+ 20

PART IV—RADIATION FOGS

§ 21—STRUCTURE OF RADIATION FOGS

The temperature structure in radiation fogs has been considered by Johnson and Heywood[1], and here that account is expanded, taking into consideration the humidity structure.

It will be appreciated that the experiments carried out at Rye were not primarily concerned with the structure of early morning fogs. No visual observations, such as observations of cloud visibility or depth of fog, were made at Rye between about 1800 and 0800 the next morning, and the sole guide during this period is the record of the night-sky camera. Since the incidence of radiation fog is often local it has been thought best not to use the observations of weather from nearby meteorological stations, for it cannot be concluded that the weather conditions on nights of strong nocturnal cooling at a given station are representative of an area about it.

Occasions that satisfy two criteria have been considered. First, that the fog was caused by nocturnal cooling, eliminating those occasions when the fog was probably due to advection or to advection and radiation combined; secondly, that fog was actually reported at Rye next morning when the first visual observations were made. In the summer many radiation fogs have cleared before 0800; the two criteria therefore bring under review more fogs in the autumn-to-spring period than in the summer period. On this count no statistics of the occurrence of radiation fogs are offered.

In considering the full records from the instruments during the period from before the formation of fog to after the dispersal, reliance has been placed upon the night-sky-camera records to determine the time of onset of fog. The obscuration of *Polaris* has been taken to indicate the presence of fog, except on certain occasions where obscuration has been transient, and the relevant records of temperature and humidity have indicated that fog was not probable; on these occasions it is probable that small amounts of cloud have temporarily obscured *Polaris*.

General conclusions.—As might be expected, individual fogs vary very considerably in detail, but after the examination of the cases general conclusions as to the structure of radiation fogs have been drawn. The temperature structure in a radiation fog has been described in *Geophysical Memoirs* No. 77 in some detail; the conclusions reached here agree in the main with those found in that publication. The conclusions drawn from the Rye data are:—

(i) Inside the fog the relative humidity is almost constant

(ii) Well below the fog top there is little gradient of temperature

(iii) Well below the fog top there is little gradient of vapour density

(iv) Across the top of the fog there is an inversion of temperature which is often large

AND OF HUMIDITY DIFFERENCE ON OCCASIONS OF SNOW COVER

1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	
					milligrammes per cubic metre								
2990	3060	3050	2980	2920	2850	2830	2760	2790	2830	2810	2830	2850	HUMIDITY
−100	− 80	− 70	− 70	− 90	−110	−100	−100	− 90	−110	− 60	− 60	− 60	HUMIDITY
−180	−140	−110	−110	− 80	−110	−100	− 90	−120	−100	− 80	−100	− 90	DIFFERENCE
+ 70	− 60	− 70	− 50	− 10	+ 10	0	+ 40	+ 20	+ 20	+ 20	+ 70	+100	

(v) Above the fog there may be quite dry air and a lapse of vapour density which may be quite large.

Of these conclusions (iii) follows from (i) and (ii).

Sequence of events.—Before proceeding to illustrate the general conclusions by examples the sequence of events that normally takes place in the formation of fog will be considered. When the outgoing radiation at the earth's surface exceeds the incoming radiation the temperature commences to fall, and the temperature of the air above falls; at 1·1 m. the temperature falls steadily. At the same time the vapour density at 1·1 m. falls steadily, but in such a way that the relative humidity increases steadily. At some relative humidity, dependent upon the structure and constitution of the air, fog commences to form near the surface and to build upwards. During this period of temperature fall the temperature inversion builds up and at the same time the humidity inversion builds up. As the fog deepens the rate of fall of temperature at 1·1 m. is retarded, as is the rate of fall of vapour density. This retardation of the rate of fall of temperature and vapour density occurs at successive levels as the fog depth increases. After dawn the temperature and vapour density rise rapidly; while the temperature and humidity inversions, which have been breaking down in the lower parts of the fog commence to break down across the fog top and some time later the fog disperses. Fig. 18 shows the trend of events for temperature and vapour density at the four levels; the data refer to October 30–31, 1945. The times at which the various phenomena take place and the gradients form vary from fog to fog, and Fig. 18 should not be taken as more than a general indication of the sequence of events.

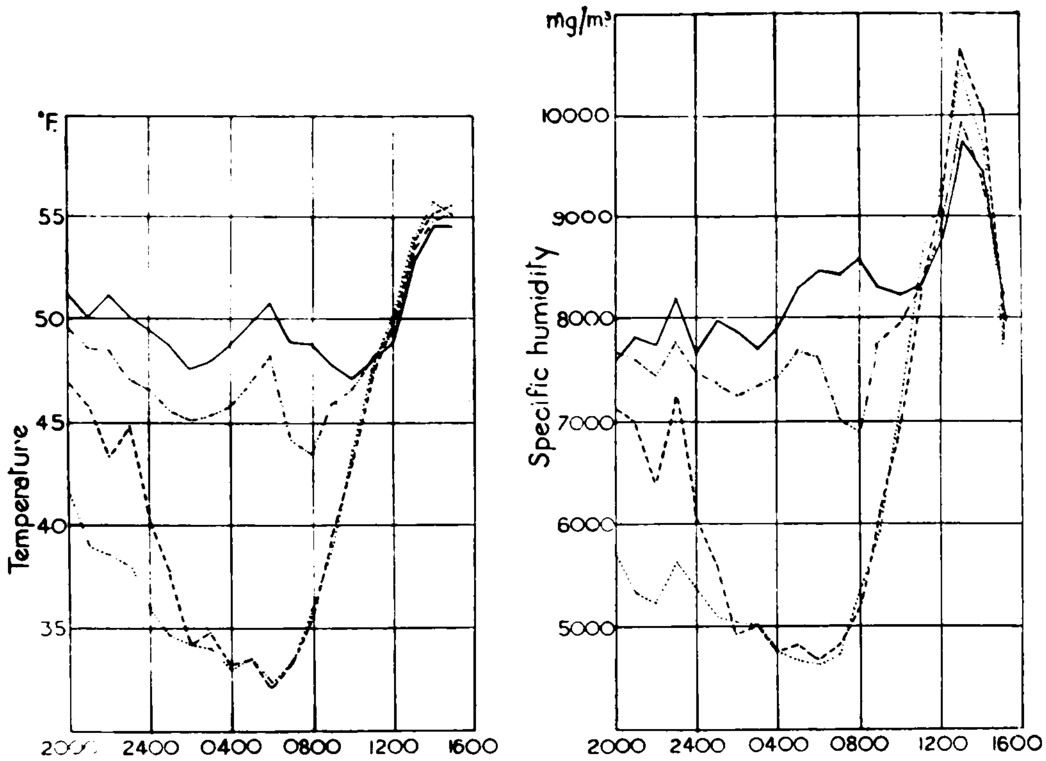


FIG. 18—VARIATION OF TEMPERATURE AND HUMIDITY DURING OCTOBER 30-31, 1945

The curves show the variation at the following heights

······· 1·1 m. – – – – – – 15·2 m. —·—·— 47·2 m. ——— 106·7 m.

Relative humidity inside radiation fog.—The first general conclusion is that the relative humidity inside radiation fog is almost constant. At Rye it is not necessary for the relative humidity to be 100 per cent. for fog to form. Fogs are noted with relative humidity as low as about 89 per cent.; it should be added that in cases of fog with low relative humidity it was often found that there was a northerly wind drift, and undoubtedly part of the poor visibility was due to pollution from the industrial areas to the north.

In almost all the occasions of fog that were examined it was found that, after the fog commenced to form, the relative humidity at 1·1 m. showed little variation usually with a slight increase. Moreover as the fog top became higher the relative humidity at successive levels also assumed this fairly constant value. An illustrative example is the fog of October 30–31, 1945, and the relevant data are given in Table XXVI.

This example was chosen as it was used for the figures illustrating the general sequence of events. The values in italics are those in which the elements were probably in fog, although it may not have been as thick at the higher as at the lower elements. It is clear from the readings of relative humidity that the fog built upwards from the surface, and that there was little variation in the relative humidity, either vertically or with time, once any element was engulfed.

Temperature inside and above the fog.—Reverting to Table XXVI it is seen that while the fog was below the level 15·2 m. there was a strong temperature inversion between the levels 1·1 and 15·2 m. As the fog deepened this inversion was broken down, and after 0100 the gradient of temperature in this layer was quite small. As the fog deepened the temperature inversion in the layer 15·2 to 47·2 m. increased rapidly but decreased again as the fog top approached 47·2 m. As the decrease in this layer took place the inversion in the top layer increased, but at this stage the process was checked by insolation. The features noted here are repeated in many of the examples that have been examined, and the physical explanation is not far to seek. There is nocturnal radiation from the earth's surface; this sets up an inversion near the surface. In fog the radiation is absorbed and re-emitted both upward and downward with the effect that the radiative surface is virtually moved to some surface in the fog while the layer below is almost isothermal. There is, of course, cooling at all levels, but the level near

TABLE XXVI—RADIATION FOG OF OCTOBER 30–31, 1945

	Relative humidity				Temperature	Temperature difference			Humidity	Humidity difference		
	1·1m.	15·2m.	47·2m.	106·7m.	1·1m.	15·2–1·1m.	47·2–15·2m.	106·7–47·2m.	1·1m.	15·2–1·1m.	47·2–15·2m.	106·7–47·2m.
	per cent.				*degrees Fahrenheit*				*milligrammes per cubic metre*			
2000	82·0	83·0	81·0	75·0	41·7	+5·4	+ 2·5	+1·7	5740	+1400	+ 550	−120
2100	84·5	85·5	83·5	81·5	39·0	+6·8	+ 2·8	+1·5	5330	+1680	+ 590	+ 220
2200	83·0	85·5	84·5	79·5	38·6	+4·8	+ 4·1	+2·7	5230	+1180	+1030	+ 270
2300	*92·0*	91·5	89·5	84·5	38·0	+6·8	+ 2·4	+3·0	5610	+1620	+ 560	+ 410
2400	*94·5*	*93·0*	90·5	82·5	35·9	+4·4	+ 6·2	+3·0	5390	+ 710	+1390	+ 170
0100	*94·5*	*94·0*	90·5	86·5	34·6	+2·2	+ 8·8	+3·2	5100	+ 450	+1850	+ 560
0200	*95·0*	*93·0*	90·5	88·5	34·2	+0·1	+10·8	+2·6	5040	− 110	+2310	+ 640
0300	*95·0*	*94·5*	92·0	87·5	34·0	+0·8	+10·6	+2·6	5010	0	+2340	+ 350
0400	*94·5*	*93·5*	90·5	86·0	33·0	+0·2	+12·6	+3·0	4770	0	+2660	+ 480
0500	*91·5*	*93·5*	89·5	86·5	33·5	0·0	+13·5	+2·8	4670	+ 150	+2880	+ 600
0600	*91·5*	*93·5*	85·0	85·5	32·9	−0·3	+15·7	+2·5	4620	+ 60	+2970	+ 810
0700	*92·5*	*93·5*	91·5	90·5	33·4	0·0	+10·7	+4·9	4720	+ 100	+2230	+1370
0800	*93·5*	*93·5*	*92·5*	92·0	35·9	−0·2	+ 7·8	+5·4	5330	− 90	+1700	+1620
0900	*94·0*	*94·5*	*93·5*	*93·5*	39·0	+0·5	+ 6·5	+1·8	5920	+ 210	+1630	+ 560
1000	*94·5*	*94·5*	*93·5*	*94·0*	43·7	−0·6	+ 3·5	+0·6	7180	− 190	+ 960	+ 300
1100	*94·5*	*94·0*	*93·5*	*93·5*	48·0	−0·5	+ 0·4	−0·1	8510	− 240	+ 50	0
1200	*95·0*	*95·0*	*95·0*	*94·5*	50·2	−0·4	− 0·4	−0·4	9220	− 100	− 190	− 140
1300	*94·0*	*96·0*	92·0	92·0	54·0	−0·1	− 0·6	−0·5	10430	+ 230	− 720	− 190
1400	82·0	86·5	81·5	82·5	55·9	−0·7	− 0·3	−0·2	9760	+ 270	− 660	+ 40
1500	67·0	65·5	70·5	69·5	55·1	+0·6	− 0·4	−0·6	7700	+ 30	+ 450	− 260

		Weather	Cloud	Visibility
October 30, 1945	1500	b	tr, Cu, Ci	6¼–12½ miles
October 31, 1945	0900	f	sky obscured	200–500 yd.
	0900–1500	f, cm_0, b	..	..
	1500	b	1 tenth, Cu, Sc	6¼–12½ miles

Wind at 10 m. light and variable throughout.

the fog top which is acting as the virtual radiative surface must cool most rapidly, and hence the strong inversion measured is from the element somewhere below the fog top to that above the fog top. In this case before the strong inversion was completely transmitted to the layer between 47·2 and 106·7 m. insolation after dawn halted the process. The general conclusions (ii) and (iv) are therefore capable of physical explanation.

Humidity structure in the fog.—Reverting again to Table XXVI it is seen that there was a strong humidity inversion which broke down near the surface as the fog deepened. At the same time the humidity inversion built up in the next layer and finally in the top layer. On this occasion there was downward diffusion of water vapour and the vapour density at 106·7 m. gradually increased through the night. The humidity inversion was through the fog top and the gradient

TABLE XXVII—RADIATION FOG OF OCTOBER 6–7, 1947

	Relative humidity				Humidity difference		
	1·1m.	15·2m.	47·2m.	106·7m.	15·2–1·1m.	47·2–15·2m.	106·7–47·2m.
	per cent.				*milligrammes per cubic metre*		
2300	91·5	92·0	50	44·5	+1400	−3150	− 210
2400	91·5	92·0	71	48·0	+1320	− 870	−1850
0100	92·0	92·5	84	48·5	+1750	− 10	−2850
0200	92·0	92·0	67	45·0	+1850	−1490	−1540
0300	92·5	91·5	63·5	47·5	+1400	−1370	− 940

of vapour density in the fog itself was small. On the other hand cases in which the air above the fog is dry and there is a lapse of humidity are quite common. An example is afforded by the fog of October 6–7, 1947. A short representative extract from the data covering the middle period of the fog is given in Table XXVII.

In this case the shallow fog did not extend much above 15·2 m. There was therefore a temperature inversion between 1·1 and 15·2 m., and so with constant relative humidity an inversion of vapour density. This may well be concentrated in the upper portion of the fog. Above the fog there was a strong lapse of vapour density.

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APPENDIX I—THE OGIVE

In a work that is closely modelled on *Geophysical Memoirs* No. 77 because it deals with very similar experimental results it may seem that some explanation is necessary for the change in representing the frequency distributions graphically. The ogive has been used rather than the more usual forms of representation because it has certain advantages.

Consider the method of setting up frequency curves from given data. An interval (x_r, x_{r+1}) of length δx_r, is selected and the number of cases, n_r, in which the experimental results fall in this interval counted; e.g. if x measures lapse rate the number of cases in which the lapse rate falls between two specified values is counted. Thus n_r is a function of δx_r. In order that frequencies over intervals shall be directly comparable it is necessary that we choose the interval δx_r the same, say δx, over the whole stretch of x. The frequency curve is then constructed by taking n_r/N as ordinate at the centre of the interval (x_r, x_{r+1}) of length δx where $N = \Sigma n_r$ is the total number of observations.

The area under the frequency curve is

$$\Sigma \frac{n_r}{N}\,\delta x = \delta x\, \Sigma \frac{n_r}{N}$$
$$= \delta x.$$

Thus the frequency curve and the area under it are both dependent upon the dissection of the x-axis.

It is often not convenient to choose δx the same for two sets of data, but if we do not do so the frequency curves are not directly comparable. We seek, therefore, a form of curve which is independent of the dissection; such a curve, called the ogive, has as ordinate at x_r, $\Sigma n_r/N$ taken over the stretch to the left of x_r. This ordinate is independent of the dissection and depends only on x_r. Denoting the ordinate by y, in the integral form we have

$$y = \frac{1}{N}\int_{-\infty}^{x_r} n.\,dx,$$

and the integral is the limit of sums independent of the method of dissection. The derivative at x_r is

$$y' = \frac{n(x_r)}{N}$$

which is the frequency of distribution. Hence the relative frequencies of distribution at x_r and x_s are proportional to the slopes of the ogive at these points; moreover two different distributions have relative frequencies at x_r and x_s in proportion to the slopes at x_r and x_s of the ogives representing the distributions, providing the ogives are drawn to the same scale. It is this independence of the dissection analysis which allows distributions to be directly compared that made ogives preferable to frequency distributions for this Memoir.

The ogive takes all values from 0 to 1 and is monotonic; most often it is continuous. Where the experimental results can lead only to certain specified values the ogive is a step function. For example, if the temperature gradient can only take one value, say the dry adiabatic lapse rate, then the ogive is zero to the left of the value representing the dry adiabatic lapse rate and +1 to the right.

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