

METEOROLOGICAL OFFICE

# THE METEOROLOGICAL MAGAZINE

VOL. 82, No. 978, DECEMBER 1953

---

## RADAR-SONDE STATION AT CRAWLEY

By D. R. GRANT, B.Sc.

**Introduction.**—At a press conference on August 25, 1953, Mullard Ltd gave details of the radar-sonde\* which they have developed in conjunction with the Radar Research Establishment, Ministry of Supply, and which they are at present installing at a specially built Meteorological Office station near Crawley in Sussex.

**Limitations of current system.**—The radio-sonde/radar wind system in current use fails in a number of respects to meet present-day forecasting requirements. The wind-finding equipment, using a radar reflector, is limited in range, and on days of strong upper winds the signal fades at relatively low heights. The failure of the wind-driven switch at low pressures sets a limit to the height at which the radio-sonde can operate, but even at much lower levels there is room for improvement in the accuracy of the pressure, temperature and humidity observations. Errors in pressure measurement are due mainly to the temperature coefficients of the various parts of the pressure-sensitive unit. Errors in temperature measurement caused by the lag of the temperature-sensitive element are appreciable, and errors due to solar radiation increase rapidly as the atmospheric pressure is reduced. Readings of relative humidity become valueless at temperatures below about  $-40^{\circ}\text{C}$ . because of the lag of gold-beater's skin. If the errors in the meteorological units could be eliminated the accuracy of the sonde would depend on the accuracy of the telemetering system used. Although the radio-sonde telemetering is almost good enough to meet the accuracy specified for the radar-sonde, it cannot be used economically in conjunction with the radar-sonde wind-finding equipment. A different telemetering system is therefore required as well as improved pressure-, temperature- and humidity-sensitive elements.

**Improvements expected from radar-sonde.**—The radar-sonde has been designed to measure winds at greater ranges and to a higher accuracy than the present radar-wind system. The telemetering system incorporated in the sonde for measuring pressure, temperature and humidity is capable of an accuracy of 1 part in 1,000. The use of recorders and automatic computers eliminates any human errors, and reduces the staff required for each flight. The

---

\* JONES, F. E., HOOPER, J. E. N. and ALDER, N. L.; The radar-sonde system for the measurement of upper wind and air data. *Proc. Instn elect. Engrs, London*, **98**, 1951, p. 461.

radar-sonde can operate at heights up to more than 80,000 ft., and can therefore be used with special high-altitude balloons for research purposes. Its maximum range of 100 nautical miles enables its transmission to be received from great heights even on days of exceptionally strong winds. The wind-driven switch in the present sonde is replaced by a motor-driven switch which will operate at the same speed at all heights. Errors in pressure caused by the temperature coefficient of the pressure-sensitive unit are reduced, and the errors in temperature due to lag and solar radiation are almost eliminated. At present no improvement in humidity measurement is expected, but development is in hand of suitable humidity-sensitive units which, it is hoped, will give a better performance than gold-beater's skin.

**Radar-sonde wind-finding system.**—The basic difference between the radar-sonde and the existing wind-finding system is the use of an airborne transponder in place of the radar reflector. The transponder is a small transmitter-receiver carried by the balloon. The ground station transmits 2  $\mu$ sec. pulses on a frequency of 152.5 Mc./sec., with a peak power of 50 KW. and with a pulse recurrence frequency of about 400/sec. The transponder receives these pulses and re-transmits them on a frequency of 2,850 Mc./sec. with a peak power of 30 W. The difference in frequency between the ground and airborne transmitters is necessary on account of the difficulty in producing a light and inexpensive airborne receiver on centimetric wave-lengths. The centimetric transmitter in the transponder can be produced in quantity very cheaply, and is, in fact, the first ever designed for mass production. Power supplies for the airborne unit are obtained from three 2.3 v., 2.5 amp. batteries with a vibrator to supply high tension voltages. The complete airborne unit is enclosed in a container made of a very light, thermally insulating, material. During a flight the temperature change inside the unit is less than 10°C. The radio apparatus is thus kept at approximately room temperature.

At the ground station the equipment required for wind finding can be divided into three groups: radar units, computing and recording units, and power supplies. The radar units consist of the aerial unit, the 152.5 Mc./sec. transmitter, the 2,850 Mc./sec. receiver, the display unit and the control column. The aerial unit, shown in the photograph on the centre pages of this Magazine, includes the transmitting Yagi arrays and the receiving aerial which is a nutating dipole and paraboloid reflector. The nutating action is required to keep the dipole in a vertical plane while it is rotated about the focus of the paraboloid to produce a conical scan. A vertical receiving aerial is necessary to receive the vertically-polarized transmission from the balloon. The conical scan is used to obtain amplitude modulation of the incoming signal when the aerial is not directed towards the transponder. An error signal is thus produced, and is fed to a servo system which re-aligns the aerial on to the transponder. The transmitting aerials are mounted on the same pedestal as the reflector and are, therefore, also automatically directed at the transponder. The azimuth and elevation of the transponder at any time are obtained from the azimuth and elevation angles of the aerial unit, and the slant range from the transit time of the pulse to and from the transponder. These three variables are fed to the computer and also to the display unit, where slant range is displayed on a cathode-ray tube and azimuth and elevation on fine and coarse magstrip indicators. The display unit is used only for observation of the performance of the complete system, and is not normally used for measuring winds.

The computer and recorder units calculate and record the wind speed and direction and the height of the transponder at a given time. The normal full scale reading of the wind speed chart is 100 kt., but when a gust exceeds this value the sensitivity is automatically reduced by a factor of two. The height record is given on a similar chart with a full scale reading of 10,000 ft. When this height is reached, the record is switched to read from 10,000 to 20,000 ft., and so on up to 100,000 ft. As the chart can be read to 1 per cent. of the full scale height can always be read to 100 ft., although its accuracy is limited by the computer to 0.5 per cent. The wind direction is displayed on a circular chart which is automatically rotated as the wind direction changes. A recording pen is driven radially inwards across the chart at a constant rate, thus providing a continuous record of wind direction against time. A total time of flight of 100 min. can be covered.

The transmitter, receiver, display unit and control column (which controls the power supplies remotely) are mounted in one radar console. The wind computer is built round the wind-direction recorder and the wind speed and height recorders are mounted as a separate unit (see photographs on centre pages of this Magazine).

Particular attention has been paid to the ease of servicing the ground station. All chassis are easily detachable and there is a comprehensive internal monitoring system for rapid fault finding.

**Radar-sonde telemetering system.**—A station containing the equipment so far described could be used as a wind-finding station. A complete radar-sonde station, measuring in addition to winds, pressure, temperature and humidity, contains two additional units, the telemetering unit and the sonde recorder. The airborne sonde unit contains, in addition to the transponder, the pressure-, temperature- and humidity-sensitive units, a motor-driven switch to connect the units to the circuit in sequence, and a high-precision pulse delay circuit. This circuit is used to generate a pulse at a time interval after the ranging pulse of anything from 200 to 1,200  $\mu$ sec., depending on the value of the meteorological variable. For each pulse transmitted by the ground station there are two pulses transmitted by the airborne sonde. The time interval between the interrogating pulse transmitted by the ground station and the first pulse received back is a measure of the slant range of the sonde, and the time interval between the first and second pulses received is a measure of the meteorological variable. As about 400 pulses are transmitted from the ground every second, and as each meteorological unit is in circuit for about 3 sec., about 1,200 readings of each variable are transmitted before the next unit is connected. In the telemetering unit on the ground the first of the two pulses transmitted by the sonde is used to open an electronic "gate" and the second is used to close it. When this gate is open, pulses from a crystal controlled 1-Mc./sec. oscillator are allowed to pass through it. The number of pulses passing through is counted by electronic counters, and is equal to the time interval in microseconds between the first and second pulses. This interval is measured exactly 1,000 times (i.e. for  $2\frac{1}{2}$  sec. approximately), and the mean of these readings is a measure of the mean value of the meteorological variable during the  $2\frac{1}{2}$ -sec. period. The reason for measuring the interval 1,000 times is to reduce random errors to negligible amounts. The answer, which is printed on a teleprinter in microseconds, is accurate to 1 part in 1,000. The system is

therefore capable of telemetering and recording the meteorological information to an accuracy of 0·1 per cent. of the range of variation experienced in the atmosphere. For example, as the range of variation of pressure is 30 mb. to 1050 mb. pressure can be telemetered to an accuracy of 1 mb. The meteorological units to be used initially are not all capable of giving such high accuracy, but the radar-sonde may be used with improved units when they become available.

The design of the meteorological units for the radar-sonde is being undertaken by Mullard Ltd in conjunction with the Instrument Development Division of the Meteorological Office. In the first sondes the pressure- and humidity-sensitive units will be variable inductances operated by an aneroid capsule and gold-beater's skin respectively. As the pressure unit will be inside the container where temperature variations are small, it is expected that pressure measurement will be considerably more accurate than in the radio-sonde, especially at high levels. A variation in inductance is not, however, suitable for operation of the time-delay circuit in the sonde, and some additional components are required which may introduce small errors in measurement. It is hoped shortly to develop variable resistors controlled by pressure and humidity, which will make full use of the accurate telemetering circuit. A resistive temperature-sensitive unit has already been developed, and will be used in the first sondes. Coiled tungsten wire of very small diameter is used to obtain a room temperature resistance of about 6,000 ohms which is required to operate the telemetering circuit. The small diameter wire has a low lag coefficient and radiation error, and the almost linear variation of resistance against temperature makes calibration easy. It is expected that this temperature unit used in conjunction with the radar-sonde will give upper air temperature to an accuracy far exceeding that obtained with any existing radio-sonde system. A photograph of the pressure, humidity and temperature units is on the centre pages of this Magazine.

In order to keep a check on the performance of the sonde, a reference signal is transmitted for 3 sec. during every cycle in addition to the pressure, temperature, and humidity readings. This signal should give a constant reading, but if it changes slightly (indicating a change in performance of the sonde) it should be possible to make corrections to the readings of the meteorological variables to maintain the high degree of accuracy. Between each 3-sec. period a time of 1 sec. is required to transmit information necessary to ensure the correct operation of the counters. A complete cycle therefore takes about 16 sec. During this time four numbers are printed on the teleprinter indicating pressure, temperature, humidity, and "reference". The meteorological information is also plotted in graphical form to an accuracy of 1 per cent., in order to show up any significant points such as temperature inversions or the tropopause. All the readings recorded are in microseconds, and it is necessary to calibrate the sonde to obtain the relation between microseconds and the meteorological measurements.

**Comparison of accuracy of radar-sonde, and radio-sonde/radar wind systems.**—The following table has been prepared to give some idea of the expected accuracy of the radar-sonde. As no flights have yet been made, the figures are estimates based on tests of the component parts of the system. They may need therefore to be changed later. The standard errors quoted for

the radio-sondes were obtained from a series of experiments carried out in 1947 at two radio-sonde stations. They include errors of observation and instrumental errors which are random as between one sounding and another.

	Present system	Radar- sonde	Radar-sonde with improved meteorological units
Standard error of pressure measurement at 200 mb. (mb.) ... ..	7	3	1
Standard error of temperature measure- ment at all levels (°C.) ... ..	0·6	0·2	0·2
Standard error of humidity measurement at low levels (%) ... ..	5	5	Not known
Error due to lag of temperature unit at 200 mb. in lapse rate of 6°C./Km. (°C.)	0·45	0	0
Error due to solar { at 200 mb. ...	1·8	0·4	0·4
radiation (°C.) { at 10 mb. ...	17·3	1·6	1·6
Standard vector error in wind at 200 mb. when mean wind from 1,000-200 mb. is 60 kt. (kt.) ... ..	5	1-2	1-2

**Conclusions.**—Although flight trials have not yet been carried out, it is clear that the radar-sonde will be capable of making upper air observations at greater heights than the radio-sonde. It is almost completely automatic in operation and easy to maintain and service. The accuracy of the measurements is much higher than in any existing system. The radar-sonde is undoubtedly an important development in upper air instruments, and might well provide a pattern for future stations in this country and in other parts of the world.

### HUMIDITY OVER THE ATLANTIC OCEAN

By P. R. BROWN, M.Sc.

While much work has been carried out in obtaining temperature, wind, weather and cloud statistics over the oceans, the preparation of humidity statistics has received less attention. The main published sources of mean values of humidity over the oceans are the “Atlas of climatic charts of the oceans”<sup>1</sup>, which includes seasonal charts of the depression of the wet bulb, and Száva-Kováts’s charts of mean vapour pressure and mean relative humidity for January and July<sup>2</sup>. The values given in this Atlas of the mean wet-bulb depression, which were obtained directly from ships’ observations, have only limited value as it is not possible to compute mean vapour pressure or relative humidity accurately from them, and Száva-Kováts’s values are only computed indirectly from mean sea-surface temperature. The Marine Branch of the Meteorological Office have computed means of relative humidity for some sample areas on the main shipping routes. These have not been published, but they have been very useful in dealing with inquiries about problems such as the carriage of goods by sea. Owing to the immense amount of work involved it has not yet been practical to prepare charts of humidity over sufficient areas for inclusion in the meteorological atlases of the oceans. The need for accurate humidity statistics over the sea is increasing. World charts of vapour pressure for land areas are being prepared by the World Climatology Branch of the Meteorological Office, and the preparation of values over the oceans will doubtless be required in the foreseeable future. The purpose of this paper is to present the initial results of an attempt to prepare accurate monthly humidity statistics over the oceans and to bring forth any criticism of the methods used.

To obtain such statistics in the form of mean relative humidity or mean vapour pressure it is essential, first, to have a sufficient number of reliable psychrometer readings, and, secondly, to carry out a lot of computation. This computation is necessary as means of relative humidity and vapour pressure cannot be derived accurately from means of wet- and dry-bulb temperatures without the application of corrections which themselves entail considerable computation<sup>3</sup>. The Marine Branch have in their possession a great number of merchant ships' observations, which include readings of dry- and wet-bulb thermometers mounted in small portable screens. These screens are normally suspended on the navigation bridge, the level of which varies mostly between 30 and 70 ft. in British "selected" ships—the average height being about 45 ft. The observations of Black, mentioned in a paper by Sverdrup<sup>4</sup>, indicate that the vertical variation of vapour pressure within this height range of 30–70ft. is not very great.

The reliability of the psychrometer readings and the accuracy of humidity statistics obtained therefrom is discussed later in this paper.

**Method.**—It was not possible to compute humidity statistics for the whole Atlantic Ocean, and it was therefore decided to select eleven 10° squares north of 10°S., seven of these being in the east and four in the west of the Ocean. The squares chosen and the Marsden system of notation are shown in Fig. 1. In squares where land exists, such as Marsden square 181, only ships' observations which are at least five miles from the coast were included. The observations used were those made since 1920, and they were on punched Hollerith cards. All cards for each 10° square for each month were sorted for dry-bulb temperature

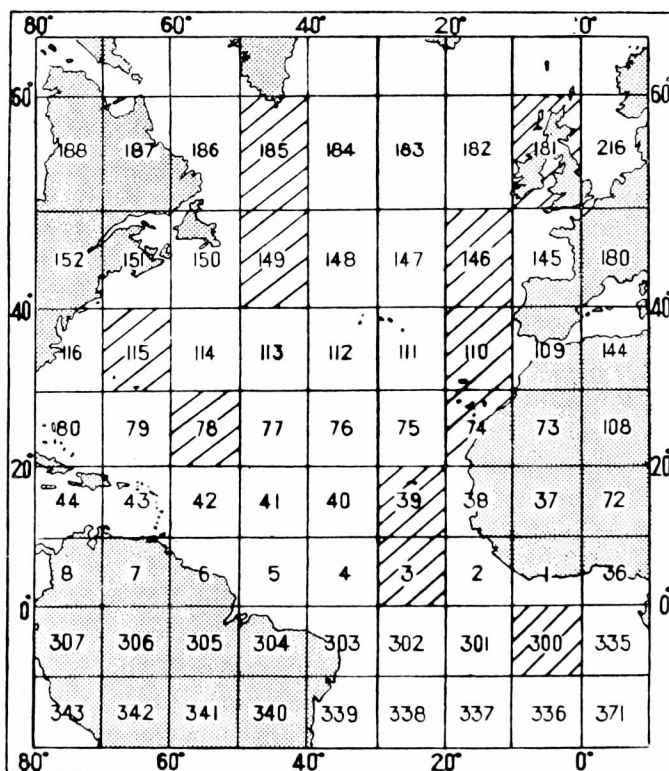


FIG. 1—MARSDEN SQUARE NOTATION SYSTEM

The squares with oblique lines crossing them are those for which humidity means were computed.

and the packs for each dry-bulb temperature sorted for wet-bulb temperature. Then the dry- and wet-bulb temperatures for each of the resultant packs of cards were tabulated, together with the number of cards in the pack. Thus one computation of humidity sufficed for the whole of one of the resultant packs. The mean vapour pressure, the standard deviation of the vapour pressures, the mean relative humidity and the 50-percentile value (median) of the relative humidity were calculated.

**Vapour pressure and relative humidity.**—The monthly values of mean vapour pressure, of the standard deviation of vapour pressures, of the mean and median of relative humidity are shown in Table I, together with the number of observations on which the values are based. The values of vapour pressure are given to the nearest 0·1 mb., and of relative humidity to the nearest one

TABLE I—HUMIDITY VALUES OBTAINED FROM BRITISH MERCHANT SHIP OBSERVATIONS

Marsden Square		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
181	Mean vapour pressure (mb.) ... ..	9·1	8·7	8·8	9·6	11·2	12·9	15·0	14·7	13·8	12·2	10·1	8·6
	Standard deviation of vapour pressure (mb.)	2·1	2·1	1·9	1·9	2·3	2·3	2·6	2·6	2·8	2·8	2·4	1·8
	Mean relative humidity (per cent.)... ..	84	83	83	83	83	85	86	85	85	85	83	81
	Median of relative humidity (per cent.)	85	85	85	85	86	87	87	88	87	87	85	83
	Number of observations	1396	1594	1877	2649	3273	3164	3157	3438	3752	3840	2390	1463
146	Mean vapour pressure (mb.) ... ..	11·1	11·1	11·4	11·3	12·5	14·9	16·7	17·1	16·7	15·2	13·3	11·7
	Standard deviation of vapour pressure (mb.)	2·5	2·3	2·2	2·9	2·3	2·4	2·8	3·1	3·3	3·2	3·1	2·5
	Mean relative humidity (per cent.)... ..	81	81	83	80	81	84	84	83	83	82	81	80
	Median of relative humidity (per cent.)	81	81	84	80	81	86	83	83	83	82	81	80
	Number of observations	3123	3411	3832	3565	3180	3148	3207	3175	3142	3265	3269	3376
110	Mean vapour pressure (mb.) ... ..	13·7	13·7	14·1	14·4	15·2	17·8	20·0	21·2	20·6	19·2	16·9	14·7
	Standard deviation of vapour pressure (mb.)	2·5	2·6	2·5	2·5	2·6	2·5	2·6	2·7	2·8	3·2	3·2	3·1
	Mean relative humidity (per cent.)... ..	76	77	78	77	77	80	81	80	79	78	77	76
	Median of relative humidity (per cent.)	76	76	77	77	77	79	80	80	79	78	77	75
	Number of observations	2360	2798	2717	2607	3136	3110	3089	3008	2805	3136	2758	3006
74	Mean vapour pressure (mb.) ... ..	15·5	15·9	17·1	17·1	17·9	19·4	21·5	23·3	23·1	22·2	19·6	17·1
	Standard deviation of vapour pressure (mb.)	3·2	2·3	2·6	2·4	2·3	2·3	2·3	2·4	2·5	2·6	2·8	2·8
	Mean relative humidity (per cent.) ... ..	74	77	79	78	78	81	84	84	82	81	78	75
	Median of relative humidity (per cent.)	73	77	78	77	78	79	84	85	81	81	79	75
	Number of observations	1842	2174	2255	2226	2426	2426	2433	2457	2467	2406	2286	2198
39	Mean vapour pressure (mb.) ... ..	20·7	20·0	21·0	21·4	21·9	24·3	26·0	28·4	28·9	28·1	25·7	23·1
	Standard deviation of vapour pressure (mb.)	3·2	2·8	2·8	2·9	2·6	2·7	3·1	2·7	2·6	2·9	3·2	3·6
	Mean relative humidity (per cent.)... ..	75	76	79	77	78	82	82	84	82	80	78	77
	Median of relative humidity (per cent.)	74	76	78	77	79	81	81	83	82	79	78	77
	Number of observations	702	995	994	1069	1053	1093	1205	1051	901	1134	1019	927
3	Mean vapour pressure (mb.) ... ..	27·4	26·3	26·9	27·4	27·8	28·4	27·4	27·6	28·0	28·4	28·8	28·3
	Standard deviation of vapour pressure (mb.)	2·6	2·9	3·0	3·1	2·6	2·2	2·5	2·6	2·7	2·3	2·1	2·4
	Mean relative humidity (per cent.)... ..	81	79	80	80	81	82	81	82	81	81	83	82
	Median of relative humidity (per cent.)	81	79	79	79	81	82	81	81	81	81	82	82
	Number of observations	690	801	955	983	1078	897	1150	959	978	983	899	808

TABLE I—HUMIDITY VALUES OBTAINED FROM BRITISH MERCHANT SHIP  
OBSERVATIONS—(continued)

Marsden Square		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
300	Mean vapour pressure (mb.) ...	26.4	27.3	28.5	28.1	26.5	24.5	22.5	22.0	22.2	22.6	23.8	25.0
	Standard deviation of vapour pressure (mb.)	2.9	2.9	3.0	2.9	3.1	3.0	2.2	2.5	2.6	2.9	2.9	3.1
	Mean relative humidity (per cent.) ...	80	78	79	78	77	78	78	79	79	79	80	81
	Median of relative humidity (per cent.)	80	78	78	78	77	77	77	79	80	79	80	81
	Number of observations	1382	1432	1341	1280	1442	1435	1515	1542	1478	1473	1517	1382
185	Mean vapour pressure (mb.) ...	7.0	6.5	7.4	8.9	9.0	10.0	11.2	11.5	10.2	8.7	7.7	7.6
	Standard deviation of vapour pressure (mb.)	2.3	1.8	1.6	2.8	1.6	1.8	1.6	1.8	2.2	2.3	2.1	2.3
	Mean relative humidity (per cent.) ...	84	87	81	81	85	88	91	89	85	84	84	83
	Median of relative humidity (per cent.)	85	89	82	81	85	91	92	92	85	83	83	83
	Number of observations	166	62	59	80	449	1035	1526	1841	1852	1870	1190	342
149	Mean vapour pressure (mb.) ...	8.1	8.3	9.2	11.0	10.9	13.2	17.3	19.4	16.0	12.6	10.5	8.8
	Standard deviation of vapour pressure (mb.)	3.6	3.7	3.6	4.2	4.2	5.0	5.7	5.5	5.5	4.3	4.1	3.8
	Mean relative humidity (per cent.) ...	86	86	83	85	86	87	89	86	83	82	83	84
	Median of relative humidity (per cent.)	88	88	84	88	89	90	90	88	85	83	84	84
	Number of observations	2550	2305	2985	2939	3094	2549	2231	2099	1883	1928	2244	2676
115	Mean vapour pressure (mb.) ...	14.5	13.8	14.2	15.2	19.8	23.0	26.9	28.1	25.9	22.0	17.5	15.5
	Standard deviation of vapour pressure (mb.)	4.8	4.7	4.7	4.6	4.5	4.3	3.7	4.0	4.6	5.6	5.1	4.9
	Mean relative humidity (per cent.) ...	78	77	77	78	81	81	81	81	80	77	74	76
	Median of relative humidity (per cent.)	79	77	78	80	83	83	83	83	82	78	75	76
	Number of observations	1031	850	879	862	1134	884	1370	1460	1080	1106	1049	939
78	Mean vapour pressure (mb.) ...	20.3	19.9	19.3	20.6	23.4	25.8	27.2	28.3	28.1	26.5	23.9	21.5
	Standard deviation of vapour pressure (mb.)	3.2	3.3	3.7	3.5	3.1	2.8	2.7	2.5	2.8	3.1	3.6	3.7
	Mean relative humidity (per cent.) ...	76	76	75	76	79	79	77	77	77	78	77	75
	Median of relative humidity (per cent.)	76	76	74	76	78	78	78	78	78	78	78	75
	Number of observations	1265	1627	1824	1855	1671	1624	1592	1753	1600	1826	1635	1783

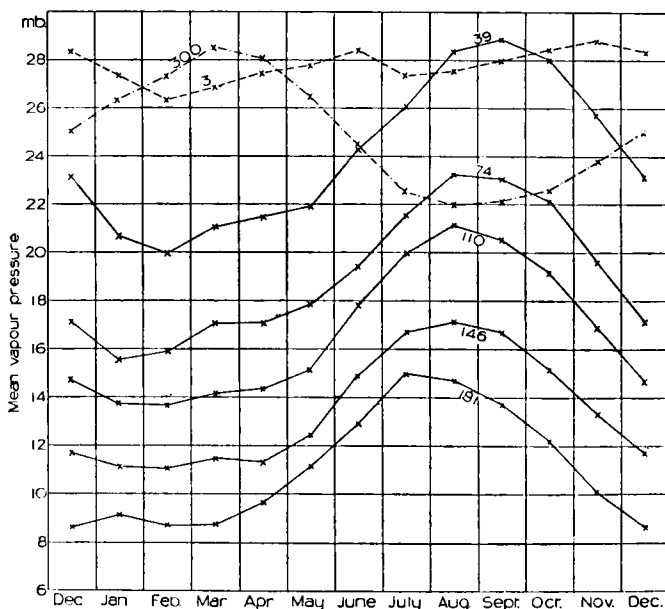


FIG. 2—MEAN VAPOUR PRESSURE IN EASTERN ATLANTIC

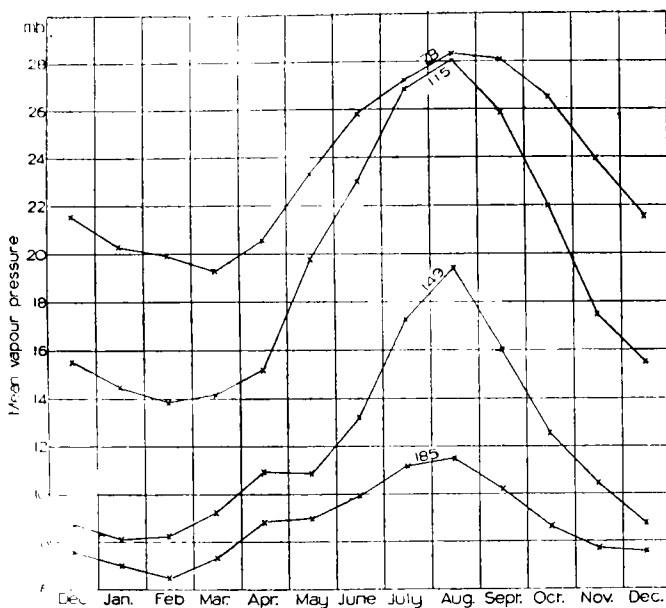


FIG. 3—MEAN VAPOUR PRESSURE IN WESTERN ATLANTIC

per cent. The values of mean vapour pressure for the eastern squares are shown graphically in Fig. 2 and those for the western in Fig. 3.

The values of mean vapour pressure were analysed harmonically, and the amplitudes and times of year of occurrence of the maximum of the twelve-monthly harmonic so obtained are shown in Fig. 4. The amplitudes of the six-monthly harmonic are small compared with those of the twelve-monthly in all the squares considered except Square 3, where they are  $0.71$  mb. and  $0.61$  mb. respectively. The amplitude of the annual variation is less for the squares in the eastern Atlantic than for those in the western part, except for Square 185.

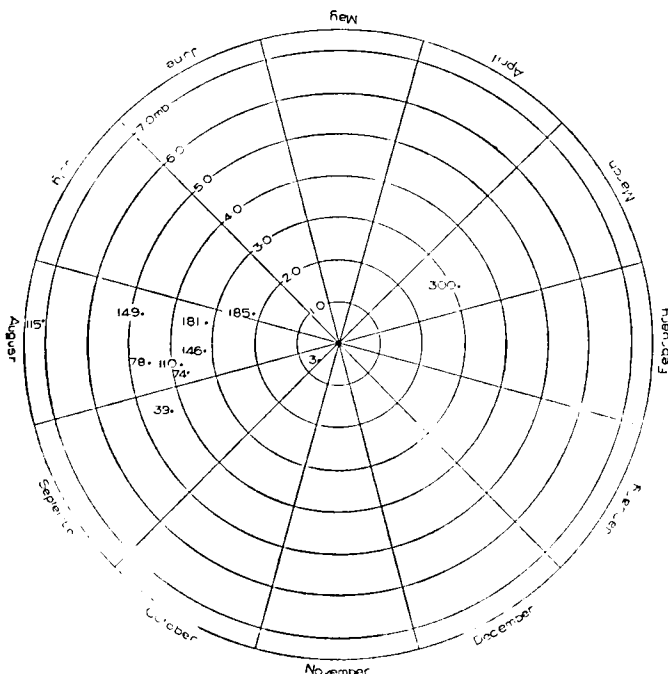


FIG. 4—AMPLITUDES OF ANNUAL VARIATION OF VAPOUR PRESSURE AND TIMES OF THE YEAR OF THE MAXIMA

**Discussion of accuracy.**—To obtain accurate humidity readings aboard ship using a screen it is necessary to ensure that the wet bulb and its fittings and the water employed are clean and free from spray; it is also important to hang the screen to windward to ensure that the flow of air passing the thermometers is unaffected by contact with the ship. The difficulties in carrying out these requirements are often considerable and have led many, including Kuhlbrodt and Wüst, to doubt the reliability of humidity readings made on merchant ships using thermometers in a screen, and the accuracy of statistics based thereon. Wüst<sup>5</sup> has expressed more confidence in the observations made by trained meteorologists on ocean weather ships. The author<sup>6</sup> has shown, however, that there is close agreement between humidity statistics computed from British merchant ship observations and those computed from British ocean weather ship observations, as long as the number of observations is sufficiently large, both sets of observations being made from thermometers in screens. It is doubtless true that many individual observations of humidity taken aboard merchant ships using a screen are liable to appreciable error, especially if the screen is not satisfactorily exposed to windward. The agreement found by the author between the two sets of statistics does suggest, however, that the errors in humidity observations made on merchant ships are of an approximately accidental character, and that errors in means are small when computed from a large enough number of observations.

During prolonged series of simultaneous readings made aboard British ocean weather ships using dry- and wet-bulb thermometers in a screen and an Assmann psychrometer, it has not been possible to show that the Assmann psychrometer gives more accurate humidity readings than those obtained from the screen.

Wüst<sup>5</sup> also points out that the presence of a ship distorts the water-vapour field over the ocean; while this is undoubtedly so, it is not obvious that errors so caused in attempting to observe the humidity in the undisturbed field would be other than approximately random, and so cause any appreciable error in a mean computed from a great number of observations.

Wüst<sup>5</sup> has also made a critical survey of the humidity values obtained by Száva-Kováts<sup>7</sup> by comparison with the observations of the German research ship *Meteor* during the years 1925–27. Száva-Kováts's means of vapour pressure for zones of 5 degrees of latitude for January and July, both for continental and oceanic regions, were obtained by interpolation from charts of isopleths of mean vapour pressure. Over land areas these charts were based on values from a network of land stations. Over the sea they were based on values calculated by computing the saturated vapour pressure at the sea-surface temperatures and applying corrections to allow for salinity, a height of 1·5 m. and wind strength. Száva-Kováts claims that these values for ocean regions were in good agreement with the direct observations from coastal and island stations. A comparison between the January and July means of vapour pressure obtained by the author and those of Száva-Kováts is given in Table II. The means of Száva-Kováts's values for the two relevant 5-degree zones are compared with the values for the corresponding months and squares obtained from British merchant ship observations.

It can be seen that the two sets of values for July are in fair agreement, but that for the region 30 — 60°N. Száva-Kováts's January means are lower than

TABLE II—COMPARISON WITH MEAN VAPOUR PRESSURE OBTAINED BY  
SZÁVA-KOVÁTS

Latitude	January		July	
	Száva-Kováts's mean	British ships Square mean	Száva-Kováts's mean	British ships Square mean
60-50°N.	mb. 4·5	mb. 181 9·1 185 7·0	mb. 11·9	mb. 181 15·0 185 11·2
50-40°N.	7·7	146 11·1 149 8·1	15·6	146 16·7 149 17·3
40-30°N.	12·3	110 13·7 115 14·5	21·3	110 20·0 115 26·9
30-20°N.	17·5	74 15·5 78 20·3	23·7	074 21·5 078 27·2
20-10°N.	23·5	39 20·7	26·2	039 26·0
10- 0°N.	26·8	3 27·4	27·3	003 27·4
0-10°S.	27·3	300 26·4	26·3	300 22·5

TABLE III—COMPARISON OF MEANS FROM BRITISH MERCHANT SHIPS AND THE  
OBSERVATIONS OF THE *Meteor*

Meteor observations						British observations				Meteor observations minus British observations	
Date	Position		No.	Mean relative humidity	Mean vapour pressure	Month	Square	Mean relative humidity	Mean vapour pressure	Relative humidity	Vapour pressure
	N.	W.		%	mb.			%	mb.	%	mb.
Apr. 23	41·6	12·3	3	86	12·5	Apr.	146	80	11·3	+6	+1·2
Apr. 24	39·1	14·9	6	73	11·5	Apr.	110	77	14·4	-4	-2·9
Apr. 25	36·1	17·6				May	74	78	17·9	-2	-0·7
May 11	26·6	18·0	3	76	17·2						
Feb. 14-17	10·2	26·6	19	79	20·5	Feb.	39	76	20·0	+3	+0·5
Feb. 21-23	12·8	21·8									
	16·5	20·5									
	16·9	25·1									
Mar. 2-5	17·1	24·8	21	80	18·8	Mar.	39	79	21·0	+1	-2·2
Mar. 10-11	19·3	21·3									
	17·4	21·6									
	16·9	22·5									
Mar. 14	16·7	25·0	19	79	21·5	May	39	78	21·9	+1	-0·4
Mar. 16	17·8	26·3									
Mar. 17	19·2	27·5									
May 6	14·6	25·8									
May 7	11·5	27·1	6	75	22·7	Feb.	3	79	26·3	-4	-3·6
May 3-7	15·1	28·7				May	3	81	27·8	-2	-0·2
	19·3	25·0				Oct.	3	81	28·4	+1	-0·3
Feb. 12	8·2	29·6	9	79	27·6						
Feb. 13	9·4	27·9									
May 8-10	8·0	27·9									
Oct. 19-26	1·3	29·1	24	82	28·1	Sept.	300	79	22·2	-6	-3·0
	0·6	29·3				Dec.	300	81	25·0	+4	+2·3
	7·2	21·3									
	S.	W.									
Sept. 9-12	9·0	1·5	12	73	19·2						
	9·1	8·4									
Dec. 26-29	2·3	1·8	12	85	27·3						
	1·2	9·1									

any obtained by direct computation for the squares considered. It can also be seen that some of Száva-Kováts's values for the regions of the trade winds are considerably higher than the values computed for comparable squares. Wüst also found that Száva-Kováts's values were too high in the region of the trade winds.

Although humidity over the oceans for any one time of the year varies little from year to year, it is not possible for two reasons to make an exact comparison between the humidity values obtained by the *Meteor* and those given in the paper. First, the few observations by the *Meteor* which were made in the areas considered in this paper are often near the boundaries of the squares, and, secondly, they are often either at the end or the beginning of the month. The observations cannot, therefore, be expected to approximate closely to the mean value of the square for the month. However, those relevant observations of relative humidity and vapour pressure made by the *Meteor* using an Assmann psychrometer during her observations of "profiles" across the Atlantic<sup>8</sup> during 1925-27 are compared in Table III with means obtained by the author. No large systematic difference appears to exist between the two sets of relative humidity values. The differences between the vapour-pressure values are also both positive and negative, but there does seem a slight tendency for the values of vapour pressure obtained by the *Meteor* to be lower.

As has been stated previously the Marine Branch will probably have, in the not too distant future, to consider the preparation of humidity statistics from ships' observations over the whole of the oceans. It is hoped that this paper will bring forth from potential users criticisms and suggestions as to the most convenient form such statistics should take.

#### REFERENCES

1. Washington, U.S. Department of Agriculture. Atlas of climatic charts of the oceans. Washington, 1938.
2. SZÁVA-KOVÁTS, J.; Verteilung der Luftfeuchtigkeit auf der Erde. *Ann. Hydrogr., Berlin*, **66**, 1938, p. 373.
3. SUMNER, E. J. and TUNNELL, G. A.; Determination of the true mean vapour pressure of the atmosphere from temperature and hygrometric data. *Met. Mag., London*, **78**, 1949, p. 258 and p. 295.
4. SVERDRUP, H. U.; The humidity gradient over the sea surface. *J. Met., Lancaster Pa*, **3**, 1946, p. 1.
5. WÜST, G.; Wasserdampf und Niederschlag auf dem Meere als Glieder des Wasserkreislaufs. *Dtsch. Hydrogr. Z., Hamburg*, **3**, 1950, p. 111.
6. BROWN, P. R.; Humidity over the sea. *Ann. Met., Hamburg*, **5**, 1952, p. 293.
7. SZÁVA-KOVÁTS, J.; Zonal distribution of humidity in the earth's atmosphere. *Időjárás, Budapest*, **51**, 1947, p. 54.
8. KUHNBRODT, E. and REGER, J.; Die meteorologischen Beobachtungen. Methoden, Beobachtungsmaterial und Ergebnisse. Wissenschaftliche Ergebnisse der Deutschen Atlantischen Expedition auf dem Forschungs- und Vermessungsschiff *Meteor* 1925-1927. Band XIV. Berlin und Leipzig, 1936.

### ERRORS OF TEMPERATURE MEASUREMENTS CAUSED BY THE EXHAUST OF JET AIRCRAFT

By B. C. V. ODDIE, B.Sc. and W. H. IRESON

At stations where jet aircraft operate, it may happen that the blast of hot air from the engines is directed towards the meteorological enclosure. When this occurs there is the immediate inconvenience that it is impossible to take reliable dry- and wet-bulb thermometer readings while the blast continues; and in addition it may cause entirely false readings of the maximum thermometer.

It was possible, with the co-operation of the Royal Air Force, Finningley, to carry out three experiments designed to discover the magnitude of the errors,

and the distances at which they might be appreciable. The first experiment was exploratory, and details need not be given. The second was carried out on March 23, 1953. A Meteor aircraft (2 Rolls-Royce Derwent engines) was arranged with its tail pointing south-east, and the engines were run at the maximum taxi-ing speed of 7,000 r.p.m. The wind was 8.5 ft./sec. (5 kt.) from S., i.e. there was a component of some 6 ft./sec. against the jets; the air temperature was 54°F., and the weather fine and cloudless but hazy (visibility 2,200 yd.). At 100 yd. behind the aircraft no effect whatever could be perceived. At 50 yd., however, there was a considerable rise of temperature; the maximum reading of temperature was 86.5°F., giving an increase of 32.5°F. Finally, eleven maximum thermometers were set up, at a height of 4 ft. above the ground, along a line at right angles to the axis of the aircraft and 30 yd. behind the jets. Near the centre thermometer a portable cup anemometer was set up. The readings given by this installation are shown in Fig. 1.

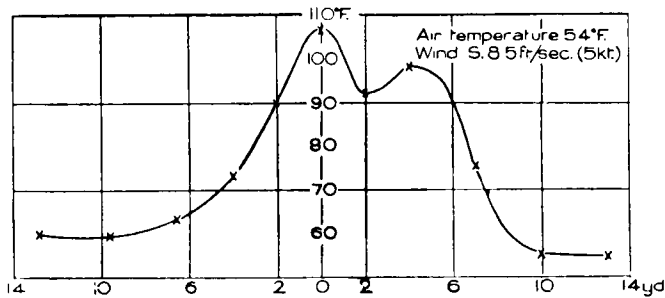


FIG. 1—TEMPERATURE ALONG A LINE 30 YD. FROM OUTLET OF JETS,  
MARCH 23, 1953, 1700–1727 G.M.T.  
Jets pointing south-east. Wind speed at mid point of line 37 ft./sec.

In the second experiment, on May 27, 1953, the tail of the aircraft pointed down wind, and temperatures were taken every ten yd. from 60 to 200 yd., along what was judged to be the centre line of the exhaust stream. Conditions at the time were—wind NW. 25 ft./sec. (15 kt.), (20 ft./sec. at 4 ft.), weather fair,  $\frac{3}{8}$  cumulus cloud at 3,000 ft., visibility 6½ miles. The results are plotted in Fig. 2.

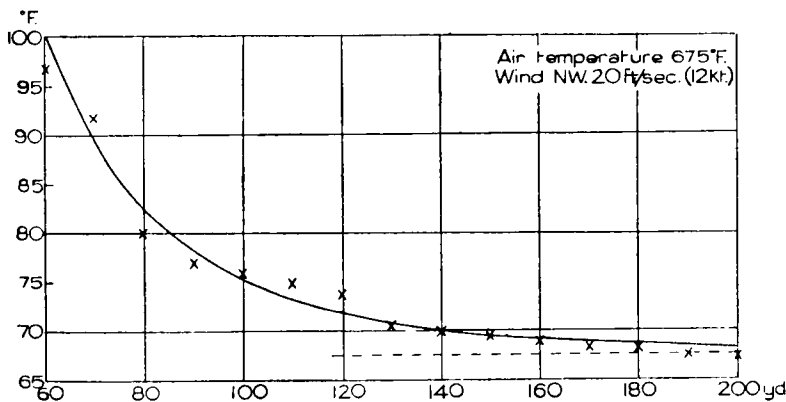


FIG. 2—TEMPERATURE ALONG CENTRE LINE OF EXHAUST STREAM, MAY 27, 1953,  
1455–1520 G.M.T.

**Discussion of results.**—The curve plotted in Fig. 2 is

$$T = 2.16 \times 10^9(x + 30)^{-4} + 67.5$$

where  $T$  is in degrees Fahrenheit and  $x$  in yards. It will be seen that this expression fits the points quite well, but it is not suggested that there is a general law of this form.

If it is assumed that the two experiments are comparable, the time taken by the exhaust gases to disperse and their range in still air at the surface can be determined from them. Let these two quantities be  $t$  sec. and  $d$  ft. In the second experiment, the gases were completely dispersed 570 ft. from their source, with a following wind of 20 ft./sec. Thus

$$d + 20t = 570.$$

Of the first experiment, it is only known that the gases reached a distance of between 150 and 300 ft. against a headwind of 6 ft./sec. There is no measure of  $t$  here, since the gases ceased to advance when their own speed was still 6 ft./sec., i.e. when it balanced the wind speed. Probably it would not be far wrong to assume that the time taken to reach this condition was about  $\frac{2}{3}t$ . From this experiment, then

$$d - 6 \times \frac{2}{3}t \simeq 225.$$

The solution of these two equations is approximately  $t = 14.4$  sec. and  $d = 283$  ft. or about 94 yd.

The argument is loose; but if it is assumed that the two experiments are comparable, a few trials will show that no values greatly different from these will account for the facts.

The Derwent engine, at 7,000 r.p.m., ejects about 650 ft.<sup>3</sup> of air per second, at a speed of 520 ft./sec. and a temperature of 716°F. (380°C.). It seems strange that this formidable blast cannot penetrate more than a hundred yards in still air, but such is apparently the case.

One may tentatively apply the result to find out what "safety distance" would be needed to render meteorological instruments entirely immune from the effects of Derwent engines. It may be assumed that, since the energy used in dispersing the gases comes largely from the engines, the time which is required is not very dependent on meteorological factors, i.e. the gases will always be fairly completely dispersed 14 sec. after emission, and that engines will rarely be run when wind speeds exceed 50 ft./sec., which is nearly gale force. These lead to a "safety distance" of about 330 yd.

At many airfields, of course, it would be impossible or intolerably inconvenient to place the meteorological enclosure so far from all areas on which engines are likely to be run. It is suggested that the following precautions would be sufficient, and are also necessary.

(i) Avoid any site which is down wind (with respect to the prevailing wind) of any area used for running engines, unless the distance is 300 yd. or more.

(ii) Avoid any site which is within 100 yd. of an area used for running engines. This will ensure freedom from gross errors, and also that no errors need be feared except when the wind is along the line from the aircraft area to the screen.

These distances would doubtless have to be increased somewhat for more powerful types of engine.

Convenient sites for screens are often close to taxi-tracks. It is evident that positions on the outside of a bend or corner in the track are to be avoided, since every aircraft negotiating the turn is liable to direct its exhaust straight at the screen. A position beside a straight section (or inside a bend) of the track, is probably satisfactory provided it is 40 yd. or so away, since the gases from a passing aircraft will affect the screen for a few seconds only, and are unlikely to cause appreciable errors.

This view may be worth examining further. If  $H$  is the heat capacity in calories of one cubic foot of air at “normal” temperature—say  $59^{\circ}\text{F}$ .—it will be found from the figures already given that the heat output of the Meteor with both engines at maximum taxi-ing speed is about 210,000  $H/\text{sec}$ . If the aircraft were taxi-ing at 37 ft./sec., this quantity of heat would suffice to leave behind a trail of warm air of hemi-cylindrical form,  $10^{\circ}\text{F}$ . warmer than its surroundings and nearly 30 ft. in radius. While this is of course an impossible form, it gives an idea of the errors likely to occur. If there were a wind of 10 ft./sec. from runway to screen (120 ft. away) it would take over 12 sec. for the trail to reach the screen, and from the above there is reason to believe that it will be almost completely dispersed in that time. If the wind is stronger—say 20 ft./sec.—dispersal may not be complete when the trail reaches the screen. But even if its original form remained unaltered, it would pass, in these conditions, in 3 sec., and the thermometers would not respond noticeably. Unreal as the imagined conditions are, they strongly suggest that the merely passing aircraft is not a serious problem.

A somewhat different approach to the original experiments is instructive. The very great fall of temperature in the first few seconds after the gases leave the engine shows that they mix rapidly with a large quantity of the surrounding air; and it may be assumed therefore that they lose momentum mainly by the same process. There should therefore be a simple relationship between the fall in temperature and the fall in speed, at least near the centre of the jet.

Let  $T$  be the temperature and  $v$  the speed of the exhaust gases. Let  $T_1$  be the temperature of the surrounding air, and  $v_1$  its component speed parallel to the jet, and let  $T_2$  be the temperature at some point P at or near the axis of the jet, and  $u$  the speed, assumed parallel to the axis. Suppose the atmosphere at P to consist of one part (by weight) of exhaust gas mixed with  $n$  parts of air. Since there is no appreciable difference in specific heats,

$$T - T_2 = n(T_2 - T_1).$$

Again by conservation of momentum

$$v + nv_1 = u(n + 1).$$

Eliminating  $n$ ,

$$u = v_1 + \frac{(v - v_1)(T_2 - T_1)}{T - T_1}, \qquad \dots\dots (1)$$

or alternatively

$$T_2 = \frac{T(u - v_1) + T_1(v - u)}{v - v_1}. \qquad \dots\dots (2)$$

As already stated, for the Derwent engine at 7,000 r.p.m.  $v = 520$  ft./sec. and  $T = 716^{\circ}\text{F}$ . (or  $380^{\circ}\text{C}$ .). To this last—though it is scarcely significant—may be added  $22^{\circ}\text{F}$ . to allow for the kinetic energy of the gases.

In the first experiment,  $v_1 = -6$  ft./sec.,  $T_2 = 106.4^\circ\text{F.}$ , and  $T_1 = 54^\circ\text{F.}$  Substituting these values into equation (1),  $u = 34$  ft./sec. The measured value of  $u$  was 37 ft./sec. Agreement so good must of course be partly accidental.

Prandtl\* shows that the speed at points on the axis of a jet is inversely proportional to the distance from the point of origin. If this result is combined with equation (2), an expression for temperature at points on the axis of a jet is obtained which is quite unlike that plotted in Fig. 2. However, there is no real discrepancy, for the conditions are very different. The jet considered by Prandtl\* is dispersed entirely by turbulent mixing, whereas the hot exhaust gases are lost from ground level mainly by convection.

Equation (2) might possibly be applied in some cases, where a jet has been directed up wind towards a screen, in order to determine whether the temperature readings have been affected. For, clearly, the exhaust jet cannot advance in this direction beyond the point where  $u = 0$ ; and this gives

$$T_2 = \frac{-v_1 T + v T_1}{v - v_1},$$

$$\text{or } T_2 - T_1 = - \frac{v_1 (T - T_1)}{v - v_1}$$

$$\cong -1.2v_1.$$

Thus, even if the wind speed is as low as 10 ft./sec., the thermometers should either be unaffected or in error by at least  $+12^\circ\text{F.}$  However, the circumstances would have to be considered with some care, in applying the rule.

By the use of equation (1), it is easy to estimate, from the temperatures shown in Fig. 1, the total amount of heat per second passing through an area 1 ft. deep and coinciding with the line of thermometers. This turns out to be about one-twelfth of the heat output of the engine, which is certainly of the right order.

## NIGHT COOLING UNDER CLEAR SKIES AT SHAWBURY

By T. H. PARRY

W. E. Saunders<sup>1</sup> has shown that the cooling curve on a radiation night is not smooth, but is characterized by a steep decline in the evening at the commencement of the cooling period, followed by a more gradual decline, with the two phases separated by a marked discontinuity in the rate of cooling. Two equations were given for forecasting the screen temperature at the change of cooling rate ( $T$ ) in terms of  $T_{\max}$  (maximum day temperature) and  $T_d$  (dew point at the time of  $T_{\max}$ ), at Northolt, according to whether there was or was not an afternoon inversion with base at or below 900 mb.

Saunders discusses the effect of recent rainfall etc. on  $T$ , and gives graphs of the following values for Northolt:—

- (i) Time of the evening discontinuity throughout the year.
- (ii) Subsequent cooling from  $T$  to  $T_{\min}$  for inversion and non-inversion cases under carrying conditions of wind speed (where  $T_{\min}$  is the final temperature of the subsequent cooling period).

An investigation along similar lines has been carried out for Shawbury. The results achieved are set out below, and some comparison is made with those found by Saunders for Northolt.

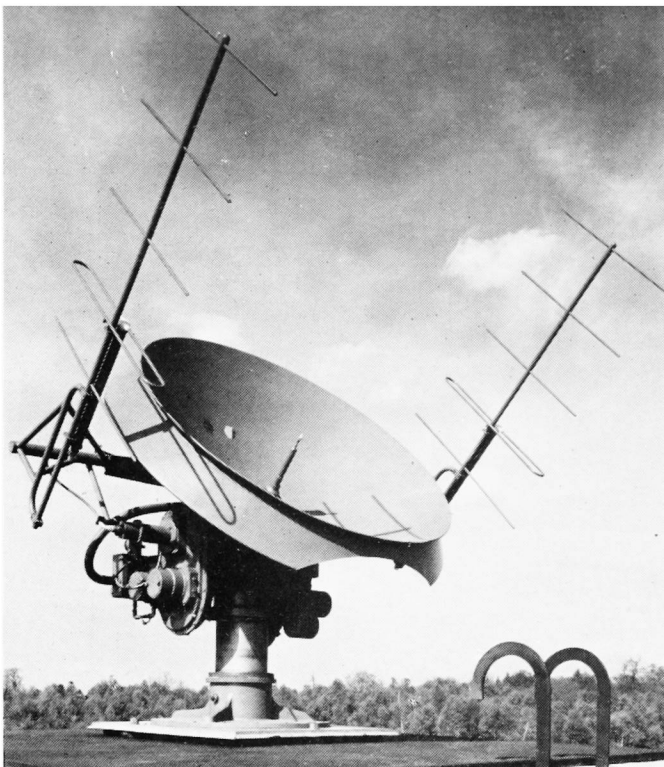
---

\* PRANDTL, L.; *Essentials of fluid dynamics*. London, 1952.



*Reproduced by courtesy of Mr. Gib Arcus*

CLOUD FUNNEL OVER SOUTH SCOTLAND, JUNE 7, 1953  
see p. 376.



*Reproduced by courtesy of Mullard Ltd*

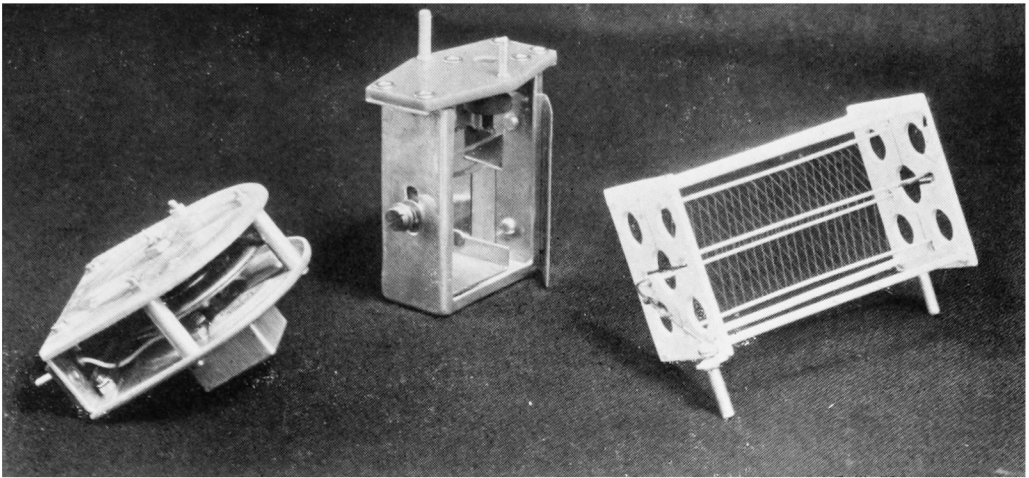
# **RADAR-SONDE AERIAL UNIT**

This shows the Yagi transmitting arrays and the receiving dipole and reflector.



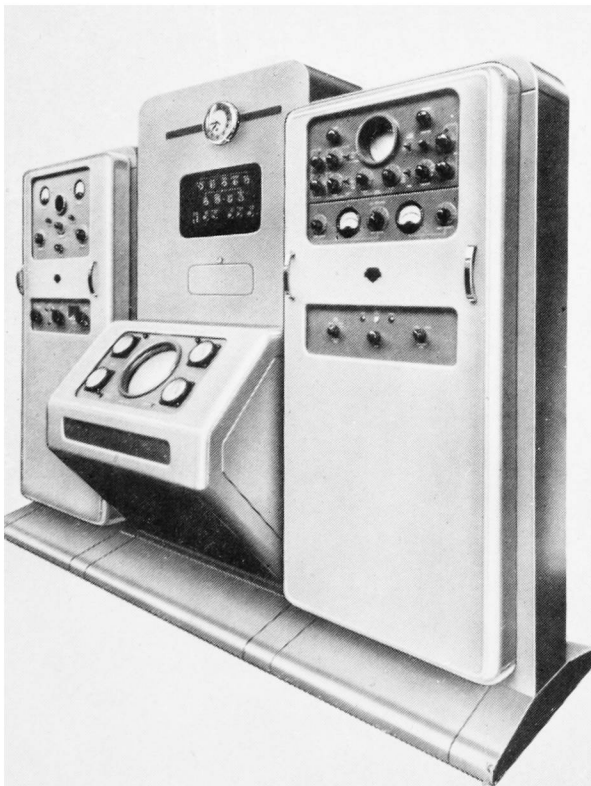
*Reproduced by courtesy of Mullard Ltd*

# **RADAR-SONDE WIND-DIRECTION RECORDER INCORPORATING THE WIND COMPUTER**



*Reproduced by courtesy of Mullard Ltd*

# **RADAR-SONDE PRESSURE-, HUMIDITY- AND TEMPERATURE-SENSITIVE UNITS**



*Reproduced by courtesy of Mullard Ltd*

# **RADAR-SONDE TRANSMITTER, RECEIVER, DISPLAY UNIT AND CONTROL COLUMN**

The transmitter is on the left, the receiver on the right, and the display unit and control column in the centre.



*Reproduced by courtesy of R. M. Poulter*

IRIDESCENT WAVELIKE CLOUDS, UXBRIDGE, 1630, FEBRUARY 19, 1953  
see p. 376.

**Method.**—Initially, as likely radiation nights occurred, half-hourly temperature readings were taken, and a note made of the other parameters etc., to accumulate data for the investigation. It soon became clear, however, that this would prove too lengthy a procedure to yield results within a reasonable time. Accordingly, recourse was made to past records and all radiation nights from January 1949 to March 1953 were examined. Day maximum temperature, night minimum temperature, and state of ground at 1800 G.M.T. were extracted from the *Daily Register* for all occasions.

Those nights when radiation conditions existed for the beginning only of the cooling period were also utilized for the purpose of evaluating the value and time of occurrence of the evening temperature discontinuity.

An estimate of the value and time of occurrence of  $T$  was made from the thermograph records taken in conjunction with the hourly temperature records in the *Daily Register*. Difficulty was sometimes experienced and estimates were necessarily partly subjective, but care was taken to avoid excessive smoothing. The appropriate *Daily Weather Reports* were used for making estimates of the gradient wind speeds and also for separation of the data into “inversion” and “non-inversion” cases, i.e. according to the presence or absence of an air-mass inversion at or below 900 mb.

**Results.**—Suitable equations for the value of the evening temperature discontinuity  $T$  proved to be:—

With no inversion (131 occasions, standard deviation  $0.23^{\circ}\text{F.}$ )

$$T = \frac{1}{2}(T_{\max} + T_d) - 2.5^{\circ}\text{F.}$$

With inversion at or below 900 mb. (28 occasions, standard deviation  $0.67^{\circ}\text{F.}$ )

$$T = \frac{1}{2}(T_{\max} + T_d) - 3.4^{\circ}\text{F.}$$

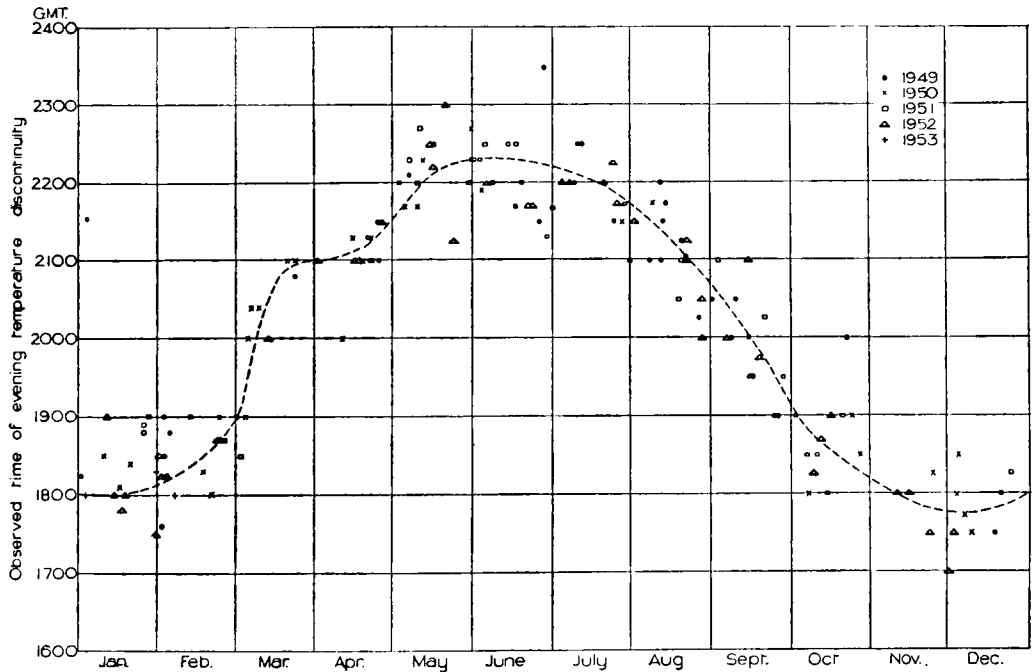


FIG. 1—VARIATION OF TIME OF EVENING TEMPERATURE DISCONTINUITY, SHAWBURY, 1949-53

The inversion cases give a result very close to that found by Saunders for Northolt, but in the absence of an inversion a rather lower value of  $T$  was found.

While Saunders<sup>1</sup> finds a difference of  $3.4^{\circ}\text{F}$ . between the inversion and non-inversion values for Northolt, it may be noted that Pedlow<sup>2</sup> finds a difference of only  $0.6^{\circ}$  between the two (for 8 and 13 cases respectively) at Rye, compared with the  $0.9^{\circ}$  difference for Shawbury.

Fig. 1 shows the variation of the time of the evening temperature discontinuity  $T$  throughout the year. In general,  $T$  would seem to occur nearly an hour later than at Northolt, of which only some 10 min. can be accounted for by variation in longitude, etc. Differences in soil and topography are probably the main reasons for this; the soil at Shawbury being of a rather light, loamy nature.

The curve shows a sharp rise during the first week in March with a second, less marked, rise at the end of April, as opposed to the slight fall in September at Northolt followed by the more pronounced fall at the beginning of October. Saunders<sup>1</sup> accounts for the irregularities by suggesting that they mark the transition to the winter period during which the topsoil remains premanently moist. If so, it may well be that the lighter, more easily drained soil at Shawbury dries out more rapidly in spring than the Northolt clay, and is also slower to revert to the moist winter conditions later in the year. It is not impossible of course that these irregularities may be merely chance, and that the curve for  $T$  is really symmetrical about a midsummer axis.

No definite indications were found to confirm the variation in the time of  $T$  found at Northolt with wet and dry top soil during the summer. This phenomenon may have been masked, however, by the coarser method of evaluation of  $T$  employed, although it is not improbable that the effect would be less marked on lighter soils.

Curves of subsequent cooling from  $T$  to  $T_{\min}$  are shown in Fig. 2. Originally diagrams were prepared in the same manner as employed by Saunders, but as

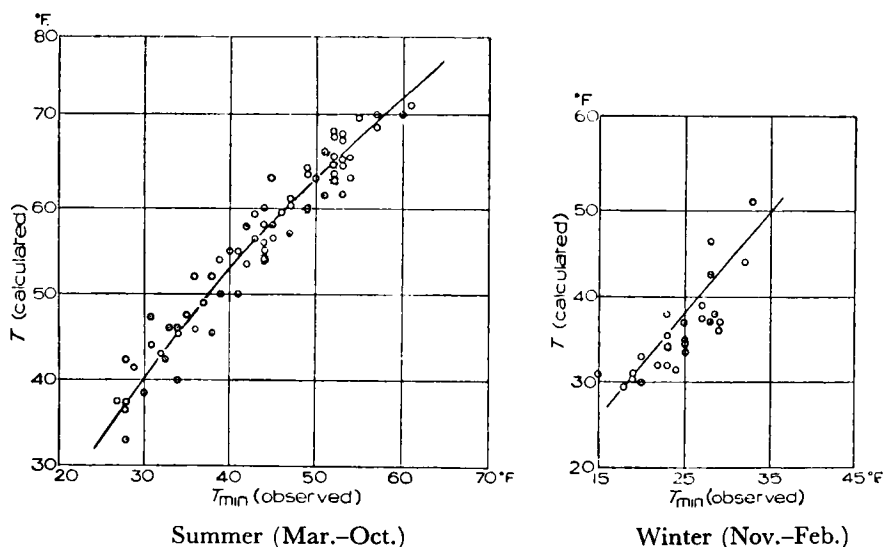


FIG. 2—RELATION BETWEEN INITIAL AND FINAL TEMPERATURES OF THE PERIOD OF SUBSEQUENT COOLING  
Gradient wind speed  $\leq 24$  m.p.h.

it proved impossible to discriminate to the same extent, the simpler presentation of Fig. 2 was employed. All cases of gradient wind 0–24 m.p.h. were divided into the two periods as shown on the diagram. No advantage was gained by separating them into categories of “calm” and “light wind”. This was not altogether surprising, as in view of its rather sheltered situation (except from the north-west) surface winds on cooling nights tend to be rather lighter at Shawbury than might be expected, even with quite moderate gradients.

No marked differences in the subsequent cooling of inversion and non-inversion cases were noted. Even at Northolt this would only be expected in winter but at Shawbury no tendency for greater cooling in more stable air masses could be found. This may possibly be linked to the closer similarity in the two equations for  $T$ .

After allowing for the different forms of presentation, the diagram gives results agreeing reasonably well with those for Northolt although slightly greater cooling is indicated during the winter at least.

Too few occasions with strong winds occurred to be of value. Fig. 3 is merely a reproduction of Saunders’s curve for Northolt with the Shawbury values superimposed. The broken line is probably more nearly representative of Shawbury, especially as even with quite moderate gradients surface winds tend to be consistently lighter than elsewhere.

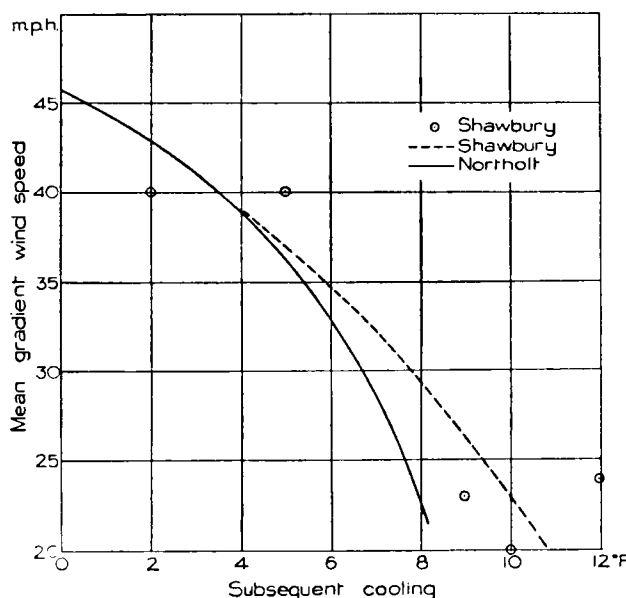


FIG. 3—RELATION BETWEEN THE MEAN GRADIENT WIND SPEED AND THE SUBSEQUENT COOLING FOR OCCASIONS OF STRONGER WIND

It also seems reasonable to postulate that a combination of radiation night with strong gradient normally occurs over the British Isles with NW.–N. wind direction. Under these circumstances, penetration of cloud from the Irish Sea gives partly cloudy conditions at Shawbury when most inland stations experience clear skies, accounting for the paucity of the occasions shown on Fig. 3.

#### REFERENCES

1. SAUNDERS, W. E.; Some further aspects of night cooling under clear skies. *Quart. J.R. met. Soc., London*, **78**, 1952, p. 603.
2. PEDLOW, R. H.; A note on night cooling under clear skies. *Met. Res. Pap., London*, No. 742, 1952.

## DIFFERENCES IN VISIBILITY BETWEEN A WEEK-DAY AND SUNDAY NEAR TO AN INDUSTRIAL AREA

By R. A. S. RATCLIFFE, B.A.

An investigation on this subject was carried out on the data available at the meteorological office at Finningley. Finningley is very liable to industrial smoke pollution; it is 5 miles east-south-east of Doncaster, approximately 20 miles north-east of Sheffield and Rotherham and 25–35 miles south-east of the main industrial belt of the West Riding of Yorkshire. In practice it is subject to industrial smoke for all surface wind directions between approximately SSW. and NNW.

The data analysed consisted of the Finningley records for Friday and Sunday from 1946–52 inclusive, for the winter six months from October 1 to March 31 only. Friday was chosen as a representative week-day. Observations for even hours from 0600–1800 G.M.T. (7 observations a day) were extracted.

Visibility observations were divided into 5 ranges as indicated in the table below. At a jet training station 3,000 yd. is the minimum visibility for a full flying programme. The other divisions in the table are those limits which define the necessity for issue of a special report under current Meteorological Office practice.

Range of visibility	Friday		Sunday	
	No. of observations	Percentage frequency	No. of observations	Percentage frequency
below 880 yd.	106	8·3	83	6·5
880–2,000 yd.	164	12·9	143	11·2
2,000–3,000 yd.	157	12·3	132	10·4
3,000 yd.–3½ miles	300	23·5	240	18·9
above 3½ miles	547	43·0	674	53·0
Total	1,274	100	1,272	100

The results show that Sunday, on the average, has better visibility than Friday. For instance visibility is 3,000 yd. or less on 33·5 per cent. of occasions on Friday compared with 28·1 per cent. of occasions on Sunday. Also Sunday has 53·0 per cent. of occasions with visibility greater than 3½ miles while Friday only has 43·0 per cent. The investigation showed no significant difference between the results for October–December and those for January–March.

It is possible to obtain a rough verification of these results by inquiries to local industrial concerns. These reveal that whereas the British Electric Authority make no change in the working of their power stations at the week-end, the Area Coal Board and the English Steel Corporation at Sheffield state that such coal-burning plant as they have either shuts down completely or is considerably damped down on Saturday afternoons and Sundays. Doncaster Airport also states that of the 14 factory chimneys smoking in the vicinity of the airfield on week-days, all are smokeless on Sundays.

It is probable that there is more household smoke on Sundays, but this apparently is not enough to offset the smaller amount of industrial pollution.

It is interesting to note that it is possible to take advantage of this observed difference in average visibility between Sundays and week-days: the R.A.F. at Worksop (10 miles from Finningley) arranged to make Saturdays and Sundays full working days during the last winter, taking Tuesday afternoon and Wednesday off to compensate them. This affords a good practical example of adapting a task to gain as much advantage as possible from the weather.

## OFFICIAL PUBLICATIONS

The following publications have recently been issued:—

*Annual Report of the Director of the Meteorological Office*, presented by the Meteorological Committee to the Secretary of State for Air, for the year April 1, 1952, to March 31, 1953.

The Meteorological Office, which forms part of the Air Ministry, provides meteorological services for a variety of needs. The greatest call on these services comes from the Royal Air Force and civil aviation, as well as the general public, but industrial undertakings and public corporations are among the numerous bodies which now obtain regular weather information for their special requirements. The report describes the organization needed to do this work and the lines along which advances are being made.

The increasing demand for forecasts of weather within the stratosphere has been taken a stage further by the introduction of jet aircraft in commercial flying, as well as through their wider use by the Royal Air Force. Much effort has been directed to improving upper air soundings and to extending our understanding of the mechanics of the upper atmosphere. A radar-sonde theodolite, the first instrument of its kind, is in course of erection at Crawley, in Sussex. The existing network of radio-sonde stations has maintained its programme of ascents, and systematic observations have been made by high-flying aircraft of significant weather features such as clear-air turbulence and high-cloud development. Experimental work on specific upper air problems has been carried out by a Mosquito aircraft of the Meteorological Research Flight at South Farnborough.

There was no major change in the network of overseas stations staffed by the Meteorological Office, which extends from the Far East to the West Indies and the Falkland Islands and includes the Western Zone of Germany. The political situation added to the difficulties and discomforts at Middle East stations, but services were maintained without interruption.

Research continued on short-range forecasting for general purposes, and a promising development was the investigation of mathematical methods requiring the use of an electronic computer. Further work was also done on medium-range forecasting, that is on the provision of forecasts in somewhat general terms for periods of four days ahead. No satisfactory method exists for forecasting for long periods, but a programme of research has been planned.

Such forecasts as those to the British Electricity Authority for the estimation of the hour-by-hour demand for electricity, or warnings to local authorities of the likelihood of snow, are now provided regularly. But again, as in previous years, there have been inquiries on widely differing problems, such as the effect of strong wind and extreme temperature on overhead cables, the feasibility of extracting water from certain rivers, the association of weather and bronchitis, and the protection of potatoes in storage and in transit.

### GEOPHYSICAL MEMOIRS

*No. 91—Vertical profiles of mean wind in the surface layers of the atmosphere.* By E. L. Deacon, B.Sc.

A set of sensitive recording cup anemometers was installed in 1941 over an open grassland site at Porton, Wiltshire, adjacent to equipment for recording vertical temperature gradient. The wind-profile observations obtained there

up to 1945, together with some data for other surfaces including the sea, have been analysed with particular attention to the effects of roughness of the surface and of thermal stratification.

The well known logarithmic relationship of Prandtl is shown to be a very adequate representation of the wind profiles under neutral conditions. For other conditions of stability the form of the wind profiles and the gustiness of the wind is found to be satisfactorily related to the Richardson number except under very stable conditions. The effect of thermal stratification on the wind profile is small near the surface but increases markedly with height, in keeping with the fact that the Richardson number is very close to zero at the surface and increases numerically almost linearly with height. A generalized wind-profile relationship is proposed which enables the eddy viscosity to be evaluated, and this is compared with some previous formulations. Observations bearing on the critical value of the Richardson number for the onset of turbulence are discussed in relation to the laboratory results of Reichardt.

**LETTERS TO THE EDITOR**  
**“Remarkable” rises in temperature**

Mr. W. B. Painting’s<sup>1</sup> letter in the June 1953 issue of the *Meteorological Magazine* was a most interesting contribution and presented valuable suggestions for further study. However, I was perplexed by the choice of “remarkable” as a word to be used in the title to his account. It must be assumed that a rise of 13°F. in 2 hr. is remarkable merely for Waddington in December.

At Alston, Cumberland, I have in my charge two bimetallic thermographs. Each is housed in a large Stevenson screen along with certified maximum and minimum thermometers which enable a weekly check on accuracy to be made. One station has been set up as near to the South Tyne River as is possible, whilst the other is about 170 ft. higher and  $\frac{3}{4}$  mile away at Nether Park on the western side of the valley. The following table shows frequencies of temperature rises of 10°F. or more within 2 hr.

TABLE I—FREQUENCY OF VARIOUS TEMPERATURE RISES IN 2 HR.  
January–June 1953

	Temperature rise (°F.)									Total
	10°	11°	12°	13°	14°	15°	16°	17°	18°	
Riverside, 900 ft. ...	7	4	6	2	5	2	3	2	1	32
Nether Park, 1,070 ft.	13	4	8	4	0	0	0	1	0	30

As may be expected, the valley bottom site experiences the greatest frequency of sharp rises. Two factors contribute:—

- (i) After radiation nights the inversion is removed.
- (ii) The aspect of the higher station, on an east-facing hill, accounts for lower maxima due to the acute angle of solar insolation from midday onwards.

In consequence the valley bottom has a greater range of temperature in anticyclonic weather, and since the times of maxima and minima usually coincide at the two stations the rise also must be greater at the riverside.

Frequencies for the months are shown in Table II, but few conclusions can be drawn. However the accompanying average cloud amounts give a correlation which may be of value. March 1953 was itself remarkable (Green<sup>2</sup>) and

TABLE II—FREQUENCY OF TEMPERATURE RISES OF 10°F. OR MORE IN 2 HR. AND OF CLOUD AMOUNT

		January-June 1953						Total
		Jan.	Feb.	Mar.	Apr.	May	June	
Riverside	... ..	0	0	16	5	3	8	32
Nether Park	... ..	0	0	16	5	2	7	30
		<i>oktas</i>						
Cloud amount	...	6.5	7.1	5.1	5.9	5.9	5.9	...

as a result the high number recorded against it must be something of a phenomenon. During this single month rises of 13° or more in 2 hr. were registered on 7 days at the lower station, and on 2 days at Nether Park.

The greatest rise was 18° in 2 hr. on March 25 when the temperature rose from 35° to 53° between 0600 and 0800 G.M.T. Using different time units other “remarkable” rises for Alston’s riverside station have been 14° in 1¼ hr. on March 6; 23° in 3 hr. on April 23; and 8° in approximately ¼ hr. on July 16.

Compared with the frost hollow near Rickmansworth<sup>3</sup>, however, I am sure that not even these figures can claim to be “remarkable”.

W. E. RICHARDSON

*Alston climatological station, The Grove, Alston, July 1953.*

REFERENCES

1. PAINTING, W. B.; Remarkable changes in the screen temperature at Waddington. *Met. Mag., London*, **82**, 1953, p. 185.  
2. GREEN, F. H. W.; A remarkable low humidity. *Weather, London*, **8**, 1953, p. 182.  
3. HAWKE, E. L.; Thermal characteristics of a Hertfordshire frost-hollow. *Quart. J. R. met. Soc., London*, **70**, 1944, p. 23.

Evaporation of dew from funnel of rain-gauge

I noticed this morning that there was dew on the outside, the vertical face and on the narrow sloping rim of the newly installed 5-in. copper rain-gauge (Meteorological Office pattern) but no dew on the funnel inside. There was a moderate amount of dew on the grass, and I rather expected to find a trace in the gauge but it was quite dry.

I think the dryness is due to the base of the gauge being buried in the relatively warm ground, which results in the funnel being warmed by radiation and convection and thus preventing the deposition of dew. I mention the matter because it indicates a defect in the gauge as a collector of precipitation, especially in the autumn when the ground is very warm and the deposition of dew is often particularly heavy.

Possibly covering the under surface of the funnel with a non-conducting layer, or filling up the space with suitable packing would minimize or remove the defect. The splayed base of my gauge is only half buried at present. The warming effect would therefore be slightly less than if it had been fully buried. The order of magnitude of this result of the warming of the funnel by radiation from the warmer base beneath it, may be estimated as follows:

A conservative estimate of the difference of temperature between the base and the funnel on a night when dew is being deposited in appreciable amount is 5°F. The funnel would then receive from the base about 4 per cent. more radiation than it returned to the base. This excess would amount to about 1 gm.cal./cm.<sup>2</sup>/hr. If this heat were used to evaporate dew it would, in 6 hr.,

evaporate approximately 0.1 mm. Thus the heat is enough to evaporate a relatively heavy dew. Convection would add to the excess heat received by the funnel.

Probably the funnel actually has its temperature raised enough to prevent the dew being deposited and the heat from the funnel is transferred to the air above it. It is to be noted that this is a one-way effect. At any time of year on a radiation night, the base of the gauge beneath the funnel will be warmer than the funnel. In winter the base may also be the warmer during cold rain, and cause a little evaporation from the funnel of the order of 0.1 mm. in 6 hr.

E. GOLD

8 Hurst Close, London N.W.11, September 24, 1953

## NOTES AND NEWS

### Cloud funnel over south Scotland

An unusually well marked cloud funnel was observed near Peebles by Mr. Rogerson of Edinburgh and his brother-in-law, Mr. Gib Arcus of New Zealand, who took a photograph of the funnel. Mr. Rogerson describes the phenomenon as follows:—"About 6.30 p.m. on June 7, 1953, while motoring from Peebles to West Linton, we ran into heavy rain from a thunder cloud. After passing through the rain, we noticed that one end of the cloud was becoming elongated and was moving south at considerable speed, almost like a tornado or whirlwind, but drawn out parallel to the earth's surface. There was great agitation in the part of the cloud funnel nearer to us, i.e. near the base of the cloud, the whirling movement apparently being clockwise looking up along the funnel. There was no thunder or lightning." It has been ascertained that the photograph was taken looking towards the south-east from a point approximately five miles south-west of Eddleston.

On the day in question, the weather was generally fair over the whole of the British Isles, and showers were very isolated occurrences. In fact the 1400 G.M.T. ascents at Leuchars and Stornoway show definite stability above about 12,000 ft., which, with freezing level at 8,000 ft., reduced the chance of heavy showers. No atmospheric were reported on the day in question. Winds from 1,000 to 4,000 ft. were very light;  $280-290^\circ < 5$  kt. at 2000 G.M.T. at Leuchars,  $110-40^\circ < 8$  kt. at Liverpool, and  $200^\circ 15$  kt. at Stornoway. Thus the carrying of the cloud funnel to the south cannot be explained in terms of a general drift. Rather, the fact that the cloud funnel was parallel to the ground tends to bear out the theory of Wegener\* who suggested that waterspouts originate in a horizontal vortex hidden inside the base of a cumulonimbus cloud.

P. E. PHILLIPS

### Iridescent wavelike clouds

The photograph facing p. 369 was taken at Uxbridge at 1630 G.M.T. on February 19, 1953 and illustrates the description of the wavelike clouds† given by Mr. Barrington in the *Meteorological Magazine* for August 1953.

Mr. Poulter remarks that the iridescent colouring was very fine, and suggests that these are just the type of clouds which are not suited to nephoscope observations to obtain the wind velocity.

\* WEGENER, A.; Beiträge zur Mechanik der Tromben und Tornados. *Met. Z.*, Braunschweig, 45, 1928, p. 201.

† BARRINGTON, C. R.; Iridescent wavelike clouds. *Met. Mag.*, London, 82, 1953, p. 248.

## REVIEW

*Vision through the atmosphere.* By W. E. Knowles Middleton. 10 in. × 7 in., pp. xiv + 250, *Illus.*, Toronto University Press. London: Geoffrey Cumberlege, 1952. Price: 68s.

By far the greater part of this book deals with matters with which the meteorologist is not directly concerned. The author discusses the scattering of light by spherical water particles; the properties of the eye; the “visual range”\* of objects and lights in an idealized atmosphere with known optical properties (it being the responsibility of the meteorologist to measure these optical properties); vision through telescopes; the visibility of objects caught in searchlight beams; the visibility of flashing lights, and of coloured lights and objects; and so on. These chapters contain extensive, up-to-date, and critical reviews of published work on these topics together with a few illustrative examples. Middleton deduces, for instance, that if we had a range of “International Orange” mountains we should expect some to vanish in the distance while others still further off were again visible. (We are entirely with the author in describing this possibility as “mercifully hypothetical”!)

Fog lamps are mentioned but not very helpfully. The author writes: “. . . people can be found who deny that such lamps are of any use whatsoever, and others who insist that they are of great value.” He concludes that the trouble is that fogs are not all the same. It is in this connexion that Middleton warns the reader that absorption (as distinct from scattering) is a complication which cannot yet be satisfactorily taken into account in practical applications of visual theory. He writes: “We hesitate to predict what further opinions on the extinction of light in fogs might accrue, if it were usual to make experiments in dust-storms! . . . In this book we shall use the word ‘fog’ to refer to aerosols containing a large number of water droplets of radius greater than, say, 2 microns”. We shall return to this point later, but it is worth while mentioning that any theory of visibility in a fog, which is based on the assumption of no absorption will fail, not only in a duststorm, but also, for example, at London Airport.

These matters are discussed in Chapters I to VIII. The following two chapters, Chapters IX and X, are chapters avowedly written round a sermon; and the text of the sermon is this: that the meteorologist should “abandon the entire scheme of marks and estimates, make good instrumental measurements of the extinction coefficient and then *calculate something which will be of interest to the user of the datum.*”

Now it is sound practice never to use for routine measurements (and especially when the measurements are to be made by untrained, or semi-trained, observers) any instrument more complex than is necessary to obtain the accuracy required. And if the required accuracy can be obtained without the use of an instrument then it would be foolish to use one. The author does discuss the accuracy achieved by non-instrumental methods (albeit making the debatable assumption that the instrumental methods and the theory are both unquestionable)—but he does not discuss at all what accuracy is required by the user. Even the least critical reader is unlikely to be led astray by the author’s rhetoric: “the datum which results from the observation [of visibility] has almost no relation to the optical state of the atmosphere at the time” and “It is now his [the

---

\* The “visual range” of an object is the maximum distance from which that object can be seen.

author's] considered belief that there is only one way in which meteorological observations of this element [visibility] can be rescued from complete futility". These statements are too exaggerated to be taken seriously. Moreover on p. 221 we find this remarkable statement: "If it is objected that the estimates of  $V$  have been found adequate, he [the author] would answer that they have not been found nearly adequate for the purposes of the modern aviator who is trying to land a fast aircraft in marginal weather, and that efforts are actually being made to do something about this. One of the things that is actually being done with conspicuous success in the United Kingdom is to station an observer at the touchdown end of the runway to look at exactly what the pilot has to look at and tell him what he sees. Markers are furnished at intervals down the edges of the runway." In fact, the only circumstance in which it is suggested that our present technique might not be adequate concerns aviation; and there "conspicuous success" is being achieved with the use of markers and non-instrumental methods. Therefore any proposal to abandon this method in favour of instrumental measurements of the extinction coefficient would need strong support on other grounds. What are these other grounds? Middleton suggests none.

The one that occurs to us—it is one which is bound to occur to every scientist—is this: it is difficult to be certain that no benefit would accrue from more accurate measurements; it might be that if the measurements could be made more accurately some use could be found for them. Let us consider this.

There is no doubt that an instrument which measures the extinction coefficient would measure that quantity more accurately than it can be deduced from our present measurements of visibility; but it is far from being established that there would be, in fact, greater accuracy in the information supplied to the user. For consider:

(a) Users invariably require to know not what the visibility is, but what the visibility will be. Moreover there is no doubt that the inaccuracy of forecasting visibility (due largely to the enormous effect on the visibility of small changes of temperature or humidity or wind) far outweighs inaccuracy of measurements.

(b) Nor would improved basic observations of visibility enable better forecasts to be made. What matters to the forecaster are not the optical properties of the atmosphere, but the constitution of the atmospheric aerosol—the size, number and nature of the solid and liquid particles contained therein. If it had been possible to survey, as routine, the nature of the atmospheric aerosol at synoptic reporting stations then we should undoubtedly know a good deal more than we do about the formation of fog. Our present visibility estimates do give some information about the atmospheric aerosol—but very little; and improving the accuracy of measurement would not increase the information, since the connexion between the optical properties of the atmosphere and the atmospheric aerosol is most complex. For instance the same visibility, or the same extinction coefficient, can arise from quite different distributions of aerosol.

(c) Moreover, and this is perhaps the most important point of all, it is by no means established that an estimate of visual range computed from a measure of the extinction coefficient would, in fact, be any better than that obtained by present, more direct, methods. Even Middleton appears to be somewhat uneasy about this. On p. 78 we read: "there is now a general agreement that, *at least in conditions of fairly good seeing*, the atmosphere attenuates contrast in accordance with an exponential law." This is an assumption which is at the basis

of the whole of the work in this book. The italics are ours. And, in another place, “. . . it should be noted [in an account of Middleton’s own experiments] that no assumptions about the light or the atmosphere are made, the contrast itself being measured directly”. We see then that unless there are “conditions of fairly good seeing” one cannot rely upon the contrast behaving as it is assumed to behave; and that, unless one actually measures the contrast (and the author is not suggesting that we do this) any further calculation may be marred by incorrect assumptions about the light or the atmosphere.

It is interesting to consider these assumptions in more detail. On p. 136 Middleton writes: “At this point it will be well to halt, and look back at the theoretical road we have travelled. We should indeed go back to Chapter IV, and consider the assumptions upon which our fundamental equations for the attenuation of contrast were derived (p. 61). Most of these are purely geometrical, but there are three which are often only approximately fulfilled, namely those regarding the curvature of the earth, the uniformity of the atmosphere in the horizontal, and the uniformity of the illumination. The first of these is of negligible importance unless the visual range is very great . . . But the non-fulfilment of the other two is responsible for much of the difficulty of attempts to verify the theory in any precise manner. Anyone who has conducted such experiments must have been exasperated by the rapid changes (in time and therefore presumably in space) in the extinction coefficient. These are especially notable in actual fog. The illumination of the air is also seldom spatially or temporally constant, except on a very clear cloudless day.”

No indication is given of the order of magnitude of the errors which are likely to arise on these accounts. They are apparently large enough to prevent any precise verification of the theory.

There is a further point, to do with absorption. A measure of the extinction coefficient does not distinguish between scatter and absorption, and, except perhaps for a black object, the same extinction coefficient may be associated with different “visual ranges”. Middleton writes (p. 107): “It appears that whenever  $B_0 \neq 0$  [intrinsic brightness  $B_0$  not zero], that is to say for any object but a black one, the simple exponential law expressed by equation (4.25) holds only if there is no true absorption. It is evident from equation (4.27) that a fairly dark object for which  $C_0$  [the intrinsic contrast] approaches  $-1$  will not be seriously affected, but white objects may have an intrinsic contrast of well over  $+1$ , and their behaviour in an absorbing atmosphere can only be predicted by applying equation (4.26) with the prior knowledge of how much absorption and how much scattering go to make up  $\sigma$  [the extinction coefficient].” (The argument is not easy to follow because equation (4.26) is obtained from equation (4.25) by differentiating. On the face of it if equation (4.25) does not hold, neither would equation (4.26).) Middleton deduces the odd result that, under certain conditions of lighting, a snow-covered mountain would have its apparent contrast raised by added absorption!

It is evident that if absorption is present it matters; and on p. 64 we find this statement: “. . . absorption is frequently of comparable magnitude to scattering”.

Now it may be that none of these effects—absorption and non-uniformity of atmosphere or illumination—nor all of them together, will have any serious effect on the value of the visual range computed from a measure of the extinction

coefficient. But we are certainly not sure of that. If in point of fact, the present state of the theory is such that the visual range can be obtained from a measure of the extinction coefficient no more accurately than we can now obtain it, then the last prop for the suggestion that we “abandon the whole scheme of marks and estimates” disappears. No one would be any better off—and instead of our present remarkably simple methods we should be using elaborate devices involving photo-electric cells, lamps, lenses, mirrors, galvanometers, constant voltage supplies and so on. Moreover, if this scheme were used for the benefit of the aviator who is trying to land a fast aircraft in marginal weather the consequences of an erroneous computation of the visual range, on account of either faulty instrumentation or faulty theory, might be disastrous.

Oddly enough in a book devoted very largely to “selling” instruments to meteorologists, the only good reason known to the reviewer for using instruments is not mentioned. This is that an instrument can be made to indicate (or record) at a distance. Although the relation between the readings of this instrument and the visual range of any particular object, or set of objects, is complex and may not be amenable to accurate calculation, nevertheless a change in the extinction coefficient will almost certainly mean a change in the visual range—and that is something it is useful for the forecaster at a busy airport to know.

If an apparently inordinate amount of space has been devoted to discussing but two chapters of this book, it is because these chapters are of direct concern to the meteorologist and because Middleton places very great stress upon them. In the conclusion to his book he writes: “It is thus up to the meteorologists to decide whether or not they wish to use the modern techniques and information which have been made available to them by the devoted labours of so many physicists, psychologists, physiologists, and engineers—or to remain in the grip of an outmoded empiricism.”

The meteorologists’ answer to that challenge would be this. We realize that any deduction of the visual range of a specified object based upon our present observations of visibility may not be very accurate, unless we are ourselves observing the same object as we do on an airfield; but we have yet to see any evidence that, in practice, a better result would follow the use of a measure of the extinction coefficient.

The book is well produced and, on the whole, easy to read—although the reviewer had difficulty in one or two places in following the argument. For example on p. 90 it is not correct that a straight line on a log-log graph necessarily indicates that the product of the two quantities plotted is constant. There are remarkably few printing errors.

R. FRITH

### RETIREMENT

Mr. S. T. A. Mirrlees (Head of R.A.F. (overseas) Branch) retired from the Meteorological Office on September 30 after 33 years’ service.

Mr. Mirrlees graduated from Aberdeen University with honours in mathematics and natural philosophy in 1914, and, being already a member of the University Company of the 4th Gordons, he joined the battalion in September 1914, proceeded to France in March 1915, was wounded in an attack on the Menin Road and returned to England in June of that year. He then joined the

Meteorological Section of the Royal Engineers (under the leadership of Major E. Gold) and served at various observation stations near the front line. He was at a front-line station in the Fifth Army just before the great retreat of March 1918, and managed to bring all his staff, himself and most of his equipment back to Headquarters which itself was retreating. He was commissioned in August 1918, returned to the United Kingdom in January 1919 to complete his teaching course interrupted by the war, and finally joined the Meteorological Office in September 1920. Between 1920 and 1939 he served at outstations (Grain, Felixstowe, Holyhead, Kew Observatory, Leuchars) and at Headquarters (Aviation Services Division and General Climatology Division). In 1939 he took charge of the meteorological office at Gibraltar, and on his return to the United Kingdom in 1942 he was appointed Head of the R.A.F. (overseas) Branch—a position he occupied until his retirement.

Much of the work by which he is known was done in the General Climatology Division during the years 1927–33, and published in various *Geophysical Memoirs*—“Meteorological results of the British Arctic air-route expedition”\*, (with C. E. P. Brooks) “Meteorological results of journeys in the southern Sahara made by Rennell Rodd”†, and, the most important of all (also with Brooks) “A study of atmospheric circulation over tropical Africa”‡. This last work has stood the test of time. Additional data gathered subsequently have done little but prove how accurate the original charts were. The work incidentally has proved of much importance in the war against the locust, the migratory habits of which are largely determined by the wind structure in the lower layers. It is thus fitting that Mr. Mirrlees should have been a member of the Advisory Committee on Anti-Locust Research.

Amongst other contributions to meteorological literature might be mentioned “Climatology and forecasting”§, “Notes on southern hemisphere circulation”||, “The weather on a Greenland air route”\*\* and (with C. E. P. Brooks) “Irregularities in the annual variation of the temperature of London”††. The special Appendix on Gibraltar in the Mediterranean Naval handbook was written by him based on the first-hand knowledge he had acquired during his service there.

In the R.A.F. (overseas) Branch he did a great deal of the preliminary work, including costing, in connexion with the proposal for a unified Colonial Meteorological Service—a proposal which had ultimately to be abandoned. The work done, however, proved very valuable subsequently in assessing the United Kingdom subventions to the various Colonial meteorological authorities for services rendered outside what would be regarded as the normal scope of their meteorological service.

The work of Mr. Mirrlees was characterized throughout by thoroughness and meticulous attention to detail. His motto always has been “what is worth doing is worth doing well”. His retirement will mean a considerable loss to the Meteorological Office, which he leaves with the good wishes of all those with whom he has been associated.

---

\* *Geophys. Mem.*, London, **7**, No. 61, 1934.

† *Geophys. Mem.*, London, **5**, No. 48, 1929.

‡ *Geophys. Mem.*, London, **6**, No. 55, 1932.

§ *Met. Mag.*, London, **74**, 1939, p. 40.

|| *Met. Mag.*, London, **78**, 1949, p. 315.

\*\* *Geogr. J.*, London, **80**, 1932, p. 15.

†† *Quart. J.R. met. Soc.*, London, **56**, 1930, p. 375.

Mr. J. Durward expressed the good wishes of the staff to Mr. Mirrlees at Victory House on September 30 and presented him on their behalf with a portable typewriter. He described Mr. Mirrlees as one who took every possible action to verify the accuracy of his statements.

Mr. Mirrlees thanked the staff in a witty reply which included an Aberdonian story appropriate to the occasion.

### METEOROLOGICAL OFFICE NEWS

**The R.A.F.V.R. in Portugal.**—History was made when a small meteorological unit was sent to Portugal to brief a Coastal Command Squadron during Exercise "Mariner" from September 24 to October 4, 1953. The forecasters, Sqn-Ldr R. M. Poulter, O.B.E., R.A.F.V.R. and Fg-Off. M. J. Merrick, R.A.F.V.R. joined the Squadron of Shackleton aircraft at Ballykelly (Northern Ireland) and flew with them on September 22 to Montijo, near Lisbon. The Squadron was the first detachment from a foreign country to operate from Portugal and the meteorologists the first representatives of the R.A.F.V.R. to work in that country. The Portuguese Meteorological Service gave valuable help.

**Retirement.**—Mr. C. S. Durst retired on November 22, 1953, from the post of Assistant Director (Investigations). At a crowded meeting in the conference room of Victory House that afternoon he was given by Dr. R. C. Sutcliffe a present from his colleagues in the form of a cheque he intends to use for the purchase of one or two woodcuts. In expressing his thanks Mr. Durst recounted some interesting stories, grave and gay, of the people and events with which he had been connected.

Mr. Durst has accepted a temporary appointment in the Meteorological Office.

**Courses for climatological observers.**—Two courses, for climatological observers who forward returns to the Meteorological Office but are not on the staff, were held in October 1953; forty-one observers attended. In addition to formal instruction at the Training School, visits were arranged to the climatological and instrument branches of the Office at Harrow and to the forecast unit at Air Ministry.

**Sports.**—At the Air Ministry Swimming Gala held at Marshall Street Baths on November 3, Miss C. W. Fleming of the Meteorological Office won the Civil Service Ladies' breast-stroke championship. This is the first occasion on which a member of the Air Ministry staff has won a Civil Service swimming championship. Miss Fleming also won the Air Ministry Ladies' championship.

The Meteorological Office, represented by Messrs. Lewis, Martindale, Franklin and Wood, won the Air Ministry Men's inter-divisional championship for the fifth successive year. Mr. Martindale won the Men's handicap and Miss J. Baird was second in the Ladies' handicap. During the past season the Air Ministry Swimming Club have won the Harper Trophy, the Civil Service Swimming League, Division III, and were runners-up in the Civil Service Water Polo League and the London Business Houses League.

### WEATHER OF OCTOBER 1953

Mean pressure was above normal over most of Europe but below normal over the Mediterranean, Spain and most of the North Atlantic except over the region just west of the Azores. The highest mean pressure was 1022 mb. over east Europe; the greatest excess above normal was 6 mb. over Scandinavia. The lowest mean pressure was 995 mb., which occurred between Iceland and Greenland, and was as much as 9 mb. below normal.

Mean temperature was above normal over the whole of Europe; the excess was 3° to 4°F. in most places but reached 7°F. in parts of Scandinavia. Mean temperature was also above normal over North America generally to the extent of 4° to 7°F.

In the British Isles the weather in most areas was drier and less sunny than the average, though rainfall exceeded the average over much of west Scotland and south-eastern England. Fog recurred fairly frequently and was sometimes slow to clear. In England and Wales the month was much less windy than is usual in October; at Oxford, for example, in a record going back to 1881, only one October, 1951, had a lower total run of wind.

At the beginning of the month pressure was high over the Continent and very low over Iceland and a warm south-west air stream covered most of the British Isles; temperature reached 70°F. at some places on the 1st and 2nd and touched 73°F. at Raunds, East Bergholt, Cromer and Ipswich on the 1st. A gale occurred in northern districts of Scotland on the 1st. A cold front moving south-east gave considerable rain locally, chiefly in north-western districts on the 1st to 3rd (0·93 in. at Inveraray Castle, Argyllshire on the 1st and 1·10 in. at Achnashellach, Ross and Cromarty, on the 2nd). On the 3rd to 4th an anticyclone moved in from the Atlantic and mainly dry, cooler weather prevailed over much of the country until the 11th, but some heavy rain occurred locally in north Scotland from the 9th to 11th (3·05 in. at Glenquoich, Inverness-shire on the 10th). A complex trough of low pressure came in from the west and south-west on the 12th and during that night and the next day there were some fairly heavy falls of rain. A ridge of high pressure followed, giving a short spell of mainly dry weather, but another trough moving east across the country gave more rain from the 15th to 17th. Subsequently a large anticyclone moved quickly north-east from south-westward of Ireland to reach southern Scandinavia by the 19th; dry weather prevailed over most of the country until the 19th and over much of England and Wales until the 21st. From the 22nd to the end of the month an unsettled southerly to south-westerly type of weather prevailed with frequent rain, which was sometimes heavy from the 23rd or 24th onward; thunder occurred locally on several days. Among the heavier daily falls were 2·05 in. at Llyn Fawr Reservoir, Glamorgan, on the 26th and 2·82 in. at Southampton, 2·26 in. at Patterdale, Westmorland and 2·22 in. at Winchester, Hampshire, on the 31st. Wind reached gale force locally in the Hebrides on the 24th and 29th, and on the 26th to 27th an intense trough moving eastward gave a widespread southerly gale, which was severe on west and north-east coasts.

The general character of the weather is shown by the following provisional figures:—

	AIR TEMPERATURE			RAINFALL		SUNSHINE
	Highest	Lowest	Difference from average daily mean	Per-centage of average	No. of days difference from average	Per-centage of average
	°F.	°F.	°F.	%		%
England and Wales ...	73	25	—0·3	72	—6	91
Scotland ...	69	24	+1·8	73	—4	92
Northern Ireland ...	66	32	+0·5	73	—5	91

# RAINFALL OF OCTOBER 1953

## Great Britain and Northern Ireland

County	Station	In.	Per cent. of Av.	County	Station	In.
<i>London</i>	Camden Square ...	2·79	106	<i>Glam.</i>	Cardiff, Penylan ...	3·56
<i>Kent</i>	Dover ... ..	3·12	80	<i>Pemb.</i>	Tenby ... ..	3·58
"	Edenbridge, Falconhurst	4·08	113	<i>Radnor</i>	Tyrmynydd ... ..	3·71
<i>Sussex</i>	Compton, Compton Ho.	4·21	92	<i>Mont.</i>	Lake Vyrnwy ... ..	2·78
"	Worthing, Beach Ho. Pk.	4·37	121	<i>Mer.</i>	Blaenau Festiniog ...	4·68
<i>Hants.</i>	Ventnor Park ... ..	3·08	77	"	Aberdovey ... ..	2·68
"	Southampton (East Pk.)	5·66	144	<i>Carm.</i>	Llandudno ... ..	1·73
"	South Farnborough ...	3·14	98	<i>Angl.</i>	Llanerchymedd ...	2·85
<i>Herts.</i>	Royston, Therfield Rec.	2·95	108	<i>I. Man</i>	Douglas, Borough Cem.	5·00
<i>Bucks.</i>	Slough, Upton ... ..	2·66	95	<i>Wigtown</i>	Newton Stewart ...	4·58
<i>Oxford</i>	Oxford, Radcliffe ...	2·20	76	<i>Dumf.</i>	Dumfries, Crichton R.I.	3·76
<i>N'hants.</i>	Wellingboro' Swanspool	1·54	61	"	Eskdalemuir Obsy. ...	3·55
<i>Essex</i>	Shoeburyness ... ..	1·57	67	<i>Roxb.</i>	Crailing ... ..	1·57
"	Dovercourt ... ..	1·68	70	<i>Peebles</i>	Stobo Castle ... ..	2·71
<i>Suffolk</i>	Lowestoft Sec. School ...	1·67	60	<i>Berwick</i>	Marchmont House ...	1·46
"	Bury St. Ed., Westley H.	2·62	97	<i>E. Loth.</i>	North Berwick Res. ...	0·94
<i>Norfolk</i>	Sandringham Ho. Gdns.	2·91	96	<i>Mid'n.</i>	Edinburgh, Blackf'd. H.	1·28
<i>Wilts.</i>	Aldbourne ... ..	3·94	117	<i>Lanark</i>	Hamilton W. W., T'nhill	1·90
<i>Dorset</i>	Creech Grange... ..	3·07	60	<i>Ayr</i>	Colmonell, Knockdolian	4·84
"	Beaminster, East St. ...	4·16	93	"	Glen Afton, Ayr San. ...	5·10
<i>Devon</i>	Teignmouth, Den Gdns.	2·78	72	<i>Renfrew.</i>	Greenock, Prospect Hill	4·89
"	Ilfracombe ... ..	2·82	62	<i>Bute</i>	Rothesay, Arden Craig ...	4·19
"	Okehampton ... ..	4·84	80	<i>Argyll</i>	Morven (Drimnin) ...	6·83
<i>Cornwall</i>	Bude, School House ...	2·05	50	"	Poltalloch ... ..	5·82
"	Penzance, Morrab Gdns.	2·70	58	"	Inveraray Castle ...	5·93
"	St. Austell ... ..	2·78	53	"	Islay, Eallabus ... ..	4·40
"	Scilly, Tresco Abbey ...	2·05	54	"	Tiree ... ..	4·45
<i>Somerset</i>	Taunton ... ..	3·09	90	<i>Kinross</i>	Loch Leven Sluice ...	2·01
<i>Glos.</i>	Cirencester ... ..	2·45	74	<i>Fife</i>	Leuchars Airfield ...	1·47
<i>Salop</i>	Church Stretton ... ..	2·41	66	<i>Perth</i>	Loch Dhu ... ..	6·00
"	Shrewsbury, Monkmere	1·95	70	"	Crieff, Strathearn Hyd.	1·72
<i>Worcs.</i>	Malvern, Free Library...	2·24	75	"	Pitlochry, Fincastle ...	2·87
<i>Warwick</i>	Birmingham, Edgbaston	2·21	79	<i>Angus</i>	Montrose, Sunnyside ...	1·26
<i>Leics.</i>	Thornton Reservoir ...	2·41	86	<i>Aberd.</i>	Braemar ... ..	2·18
<i>Lincs.</i>	Boston, Skirbeck ... ..	2·40	88	"	Dyce, Craibstone ...	1·89
"	Skegness, Marine Gdns.	2·50	91	"	New Deer School House	1·61
<i>Notts.</i>	Mansfield, Carr Bank ...	2·18	72	<i>Moray</i>	Gordon Castle ... ..	0·75
<i>Derby</i>	Buxton, Terrace Slopes	2·53	52	<i>Nairn</i>	Nairn, Achareidh ...	0·80
<i>Ches.</i>	Bidston Observatory ...	1·18	36	<i>Inverness</i>	Loch Ness, Garthbeg ...	1·58
"	Manchester, Ringway...	2·08	67	"	Glengquoich ... ..	11·23
<i>Lancs.</i>	Stonyhurst College ...	1·86	41	"	Fort William, Teviot ...	5·68
"	Squires Gate ... ..	1·70	48	"	Skye, Broadford ... ..	11·84
<i>Yorks.</i>	Wakefield, Clarence Pk.	1·45	51	"	Skye, Duntuilin ... ..	7·20
"	Hull, Pearson Park ...	1·60	54	<i>R. &amp; C.</i>	Tain, Mayfield... ..	1·06
"	Felixkirk, Mt. St. John...	2·01	70	"	Inverbroom, Glackour...	2·22
"	York Museum ... ..	1·59	59	"	Achnashellach ... ..	6·57
"	Scarborough ... ..	1·45	46	<i>Suth.</i>	Lochinver, Bank Ho. ...	2·94
"	Middlesbrough... ..	1·50	50	<i>Caith.</i>	Wick Airfield ... ..	1·17
"	Baldersdale, Hury Res.	1·67	45	<i>Shetland</i>	Lerwick Observatory ...	3·51
<i>Nor'l'd.</i>	Newcastle, Leazes Pk....	1·29	42	<i>Ferm.</i>	Crom Castle ... ..	1·82
"	Bellingham, High Green	1·39	35	<i>Armagh</i>	Armagh Observatory ...	2·09
"	Lilburn Tower Gdns. ...	1·71	46	<i>Down</i>	Seaforde ... ..	2·54
<i>Cumb.</i>	Geltsdale ... ..	1·84	49	<i>Antrim</i>	Aldergrove Airfield ...	2·06
"	Keswick, High Hill ...	3·35	60	"	Ballymena, Harryville...	2·53
"	Ravenglass, The Grove	2·50	58	<i>L'derry</i>	Garvagh, Moneydig ...	2·91
<i>Mon.</i>	A'gavenny, Plâs Derwen	5·29	115	"	Londonderry, Creggan	2·84
<i>Glam.</i>	Ystalyfera, Wern House	5·64	82	<i>Tyrone</i>	Omagh, Edenfel ...	2·92

Printed in Great Britain under the authority of Her Majesty's Stationery Office  
By Geo. Gibbons Ltd., Leicester