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## WORLD METEOROLOGICAL ORGANIZATION

### **Eighth Session of the Executive Committee, April 17-30, 1956**

By SIR GRAHAM SUTTON, D.Sc., F.R.S.

When the Executive Committee met in Geneva on April 17, one of its first duties was to designate an acting elected member to replace Dr. A. Nyberg of Sweden, who was appointed as an elected member by Congress last year but who now sits as President of the European Regional Association. The Committee designated Dr. I. J. Lugeon, the Director of the Swiss Meteorological Service for the vacancy thus created. Dr. Lugeon was a member of the Executive Committee during the first financial period and has had much experience in international meteorology.

Although the session was short, a great deal of work was accomplished. As usual, the Committee split into two Working Committees; one to deal with technical questions under Dr. M. A. F. Barnett of New Zealand, the other to deal with administrative and financial problems under Prof. H. A. Ferreira, of Portugal. Both Working Committees performed their tasks expeditiously, but some difficult questions had to be postponed until the next session, and the general opinion was that two weeks is not long enough to complete the work which confronts the Executive Committee at its annual sessions.

The task of the Executive Committee is to supervise the work of the World Meteorological Organization between sessions of Congress. This means that at every session, the work of the Regional Associations and the Technical Commissions has to be reviewed, the annual budget approved and various matters connected with the central administration considered. This year the Committee had before it the report of the session of Regional Association VI (Europe) at Dubrovnik, as well as arrangements for the International Geophysical Year. For the latter, the scheme whereby the Secretariat of the World Meteorological Organization will act as the main collecting centre of meteorological information for the world was further considered, in both its technical and financial implications, and some important decisions were taken. The basis of the scheme is that the World Meteorological Organization Secretariat will reproduce the data on micro-opaque cards and afterwards sell sets of these cards to any country or institution which requires them.

The micro-opaque card system is likely to prove of considerable interest to meteorologists, who are becoming increasingly embarrassed by the problem of storing records and charts in an easily accessible form. A single card, measuring

3 in. × 5 in. can contain from 40 to 60 pages of material and can be read with comfort with the special viewing apparatus in a well lit room. Full details are given in the *WMO Bulletin*\*.

Among other matters, the Committee considered the problem of permanent accommodation for the World Meteorological Organization in Geneva. There are two possibilities: to make use of the proposed extension to the Palais des Nations or to accept the offer of the Canton of Geneva to rent a separate new building adjacent to the Palais. After much debate, the Executive Committee, by a large majority, decided to recommend to Members that the Canton offer be accepted in principle, and that the President and Secretary-General should be authorized to enter into detailed negotiations at an early date.

At the Second Congress last year, it was decided to utilize the greater part of the remaining funds of the old International Meteorological Organization to create a prize for outstanding work in the field of meteorology. The first recipient of the International Meteorological Organization Memorial Prize is Dr. T. Hesselberg who retired from the post of Director of the Norwegian Meteorological Service last year. The Executive Committee decided at this session that the Prize should consist of a substantial sum of money, a gold medal and a certificate with a citation. There was a lively and amusing debate on the language for the inscription on the medal, and finally it was decided to use Latin. The translation will be entrusted to an eminent classical scholar who, no doubt, will need to exercise his ingenuity to convey essentially modern concepts in the language of a long-dead civilization.

The weather during the session was anything but good, and this may well have influenced the Executive Committee when it decided that the next session will be in September 1957.

### **AVERAGE WIND AT 60 MB.**

By J. K. BANNON, B.A. and R. A. JONES, M.Sc.

The average winds over the world at levels up to 100 mb. (approximately 16 Km.) have been described by Brooks and others<sup>1</sup> and more recently by Jenkinson<sup>2</sup>. This note presents charts of average winds at 60 mb. (approximately 20 Km.) prepared from the few data available for that level. A full description of methods of preparing these charts and tables of mean resultant vector winds and frequencies of wind directions at the 60-mb. level are contained in a report to the Meteorological Research Committee<sup>3</sup>.

The charts were constructed from data obtained from many varied sources:

Radar wind and pilot-balloon observations<sup>4-21</sup>.

Acoustical propagation studies for some American and Panama Canal Zone stations<sup>22-25</sup>.

Contour-height data<sup>2,26,27</sup>.

Temperature data<sup>4,26,28-31</sup>.

The charts, Figs. 1-4, show the average stream-lines and isotachs for the months of January, April, July and October. In temperate and high latitudes the contour lines of the height of the 60-mb. pressure surface are taken as stream-lines and the isotachs are also derived from these contours, using the

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\* RIGBY, M.; Use of micro-opaque cards in meteorology. *WMO Bull., Geneva*, 5, 1956, p.53.

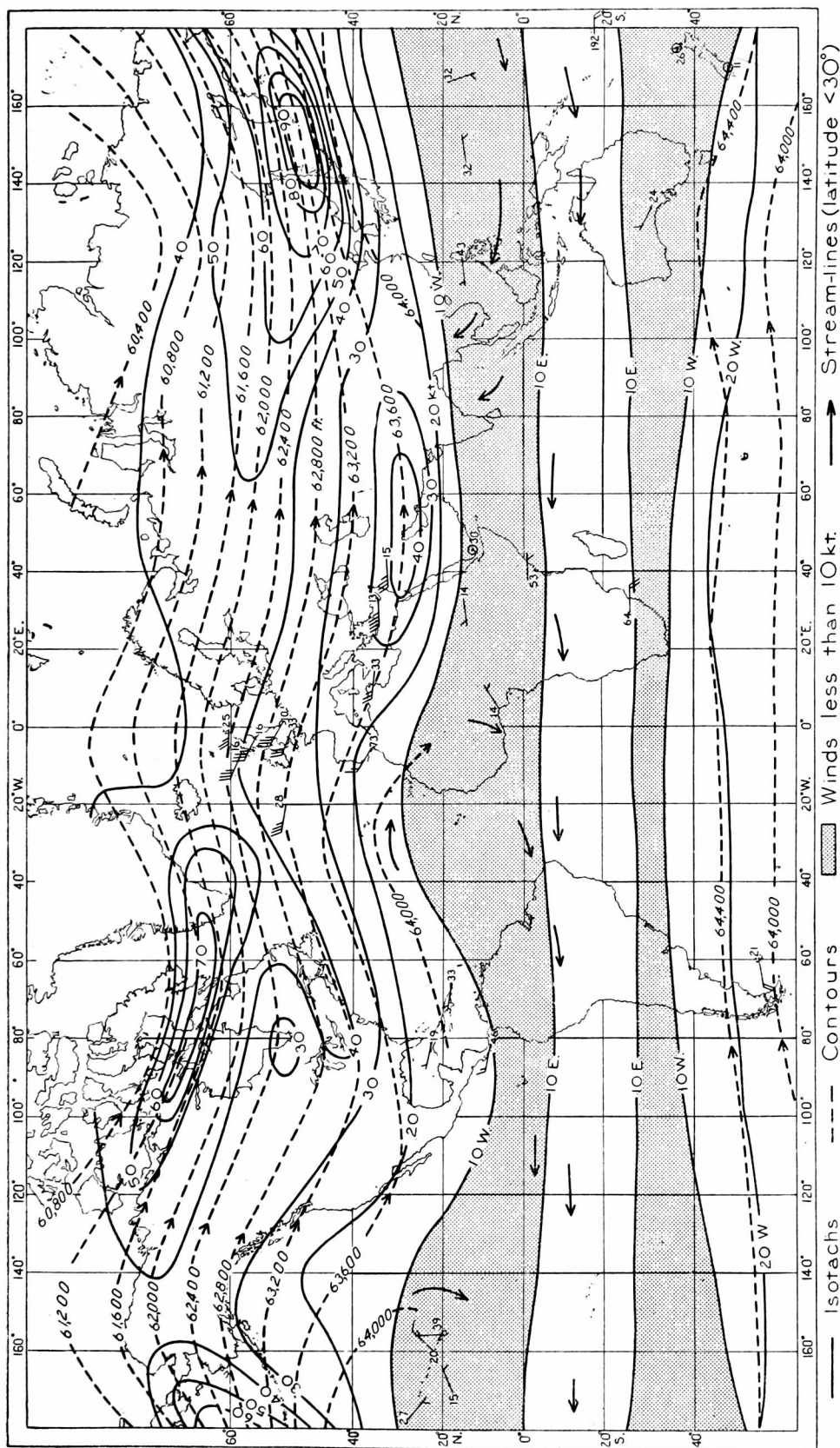
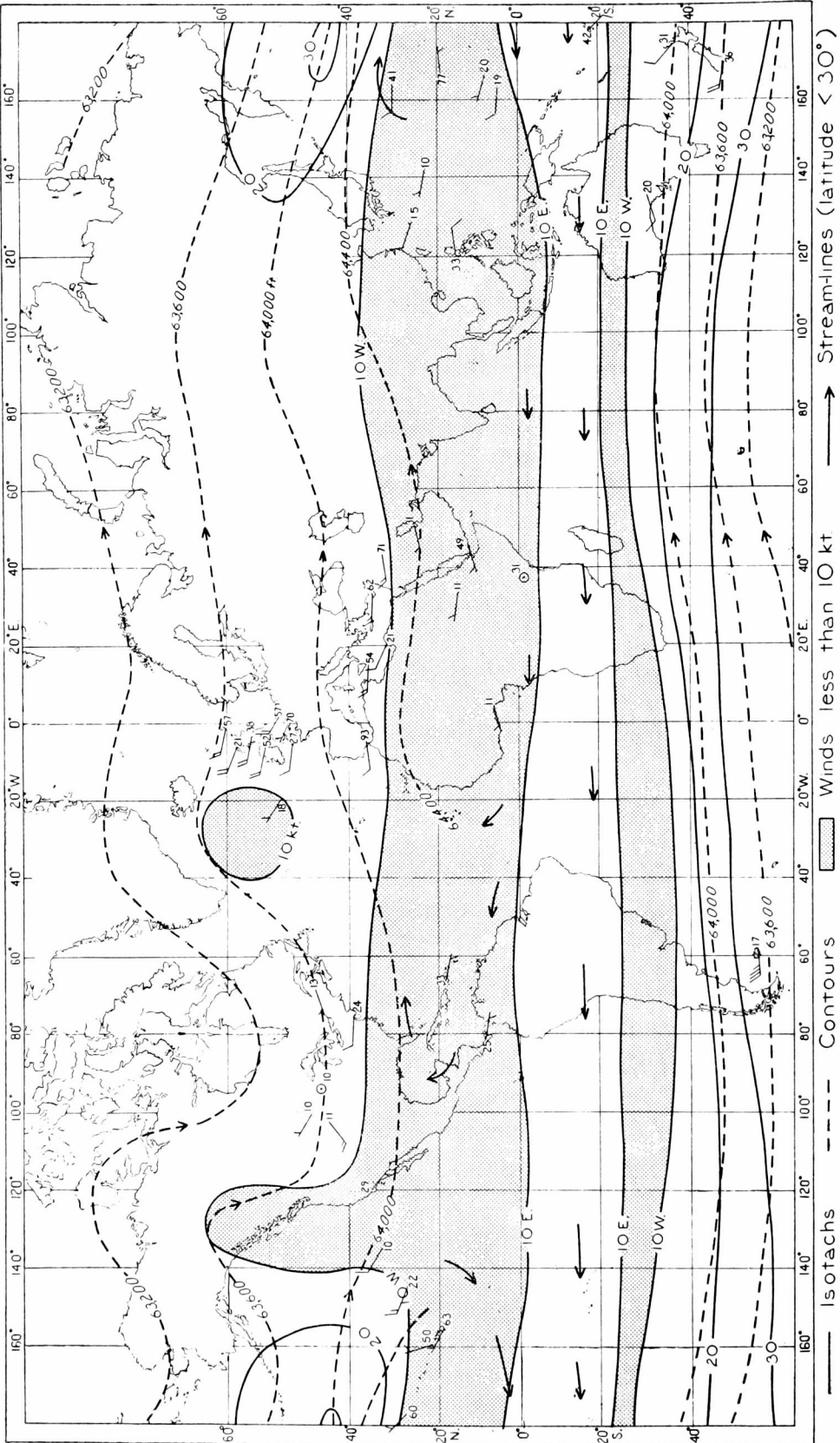


FIG. 1—MEAN WIND FLOW AT 60 MB., JANUARY  
 Number of observations is indicated near each wind arrow; wind speeds in knots are shown by conventional barbs





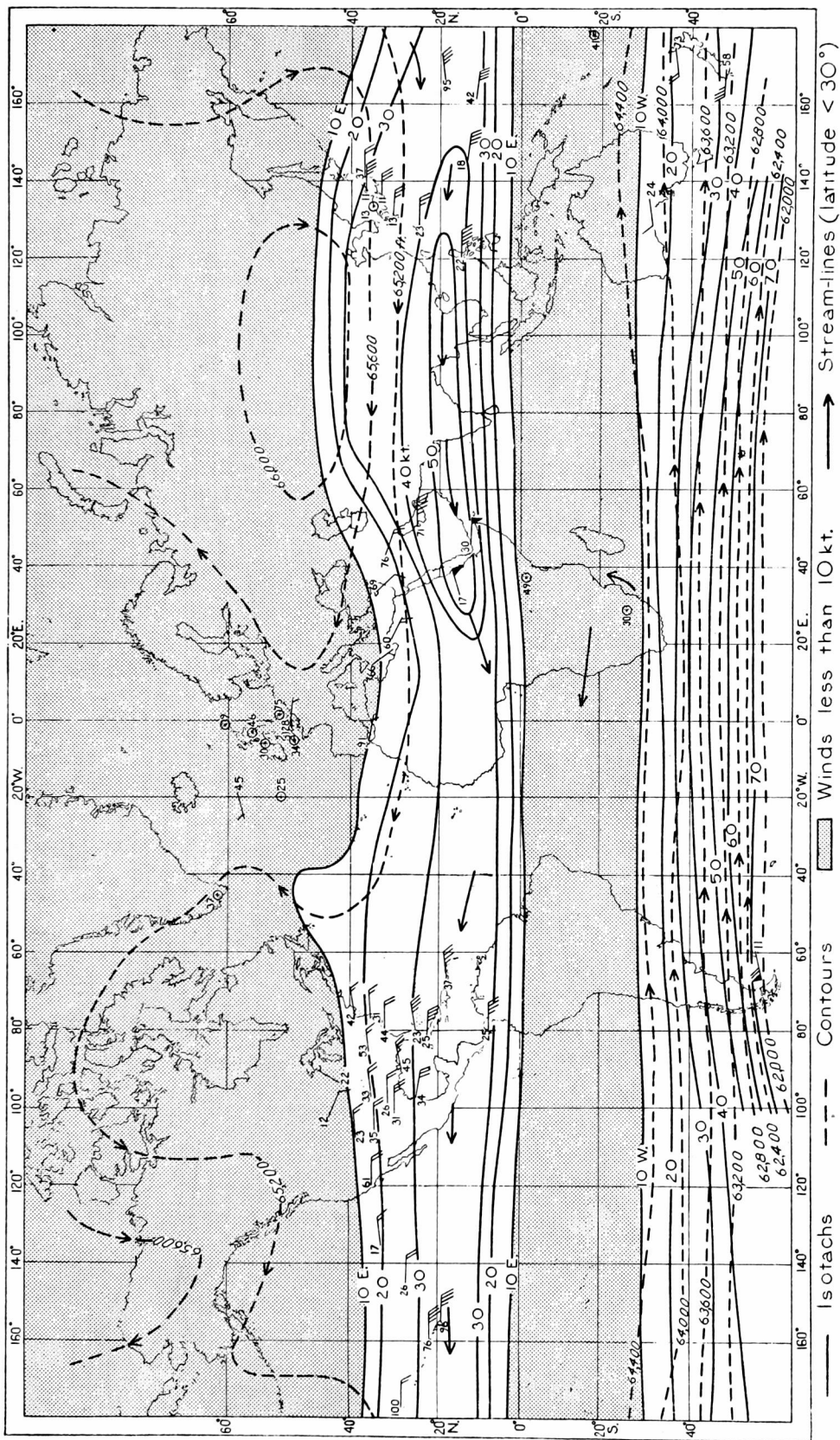


FIG. 3—MEAN WIND FLOW AT 60 MB., JULY  
 Number of observations is indicated near each wind arrow; wind speeds in knots are shown by conventional barbs

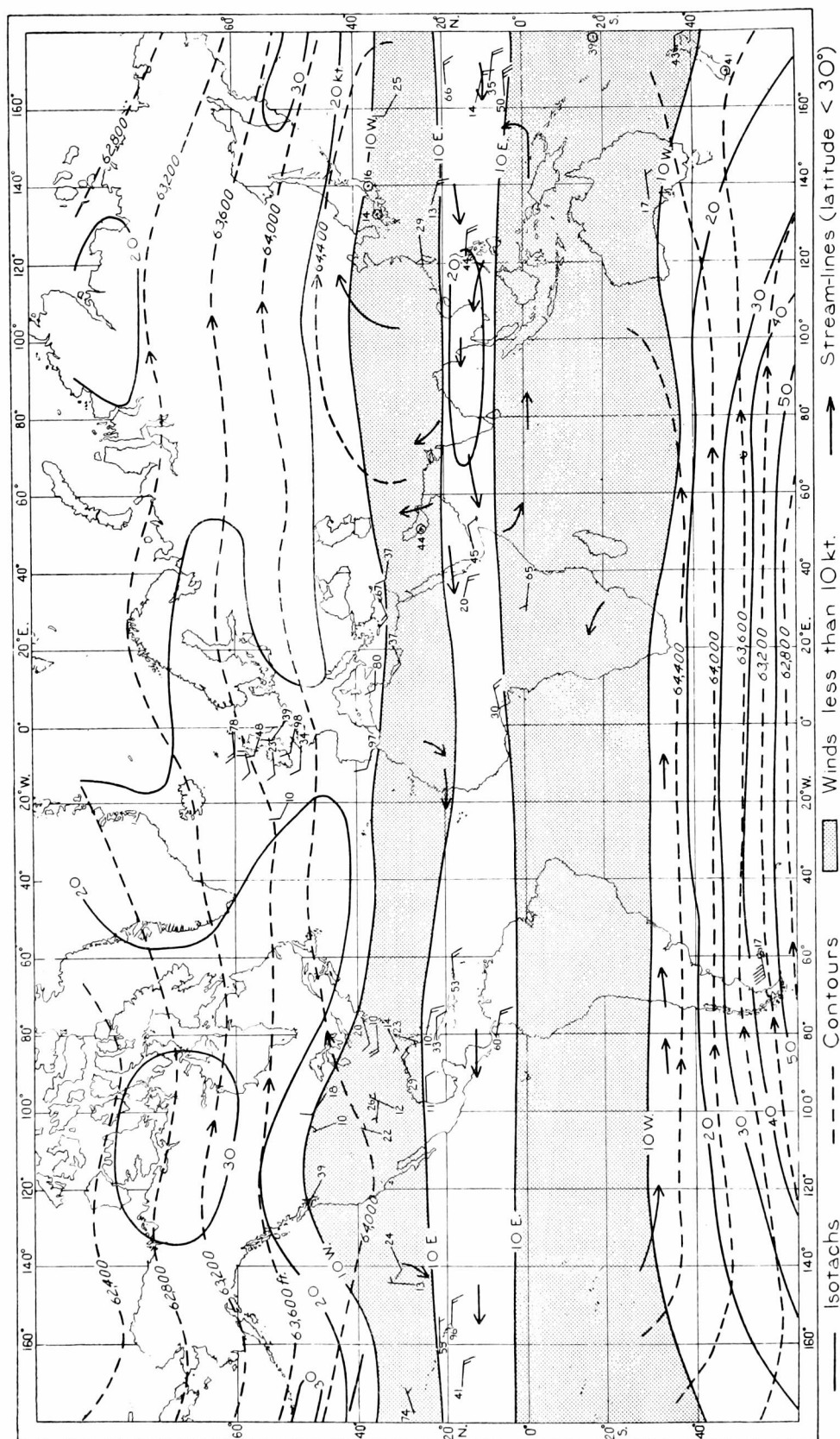


FIG. 4—MEAN WIND FLOW AT 60 MB., OCTOBER

geostrophic relation<sup>32</sup>. For latitudes less than about 30°, the stream-lines and isotachs are based on direct observation of wind. Average vector resultant winds are plotted on the charts, the number of observations from which each resultant was computed being indicated at the head of the arrow.

The contours of the 60-mb. surface were constructed from charts of the height of the 100-mb. surface, the latter having been computed in the Upper Air Climatology Branch from charts of temperature<sup>28</sup> at standard levels up to 100 mb. The thickness of the layer 100–60 mb. was computed from the temperature at 100 mb. and the lapse rate in the layer, estimated from the scanty data available; this thickness was then added to the 100-mb. heights to obtain the 60-mb. chart. The resulting contours at 60 mb. may be in error in many places. Errors may be significant over Siberia and some regions in the southern hemisphere, where observations at all heights are few or non-existent; elsewhere errors are probably not large and the general pattern is satisfactorily defined. Contour charts of the 100-mb. and 50-mb. surfaces over North America<sup>26</sup> were consulted when drawing the 60-mb. contours in that region.

In the tropics, the data are so few that the charts drawn from them may not give an adequate description of even the main features.

Palmer<sup>33</sup> has suggested that a narrow band of steady westerlies (Berson westerlies) is to be found near the equator at heights between 18 and 23 Km. at all seasons. Palmer's evidence for this stream is mainly from observations made in the west and central Pacific in certain months<sup>34,35</sup>. A few observations at Singapore<sup>36</sup> (less than 10 in each month), even fewer from Batavia and a year's data from Canton Island (3°S., 172°W.)<sup>37</sup> (which became available after Figs. 1–4 had been drawn) comprise the only other evidence known to the authors in support of this suggestion. No attempt therefore was made to chart this westerly flow which is light when it can be found and seems to cover a small area.

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## WEA—AN AUTOMATIC WEATHER-FORECAST SERVICE

By W. R. HANSON, B.Sc.

The first automatic weather-forecast service by telephone in the United Kingdom came into operation at midnight on March 4-5 this year. It provides a forecast for a period of 9 hr. for the London area within a 20-mile radius of Oxford Circus. This forecast is intended for the needs of those living or working within that area, but it is also available in any part of the country should people in the provinces have a particular interest in London's weather. In the latter part of 1955 and the first two months of 1956 the General Post Office and the Meteorological Office had been working on plans for the launching of this service and, after a trial period of three weeks, a figurative switch was thrown and the service made available on the public telephone network.

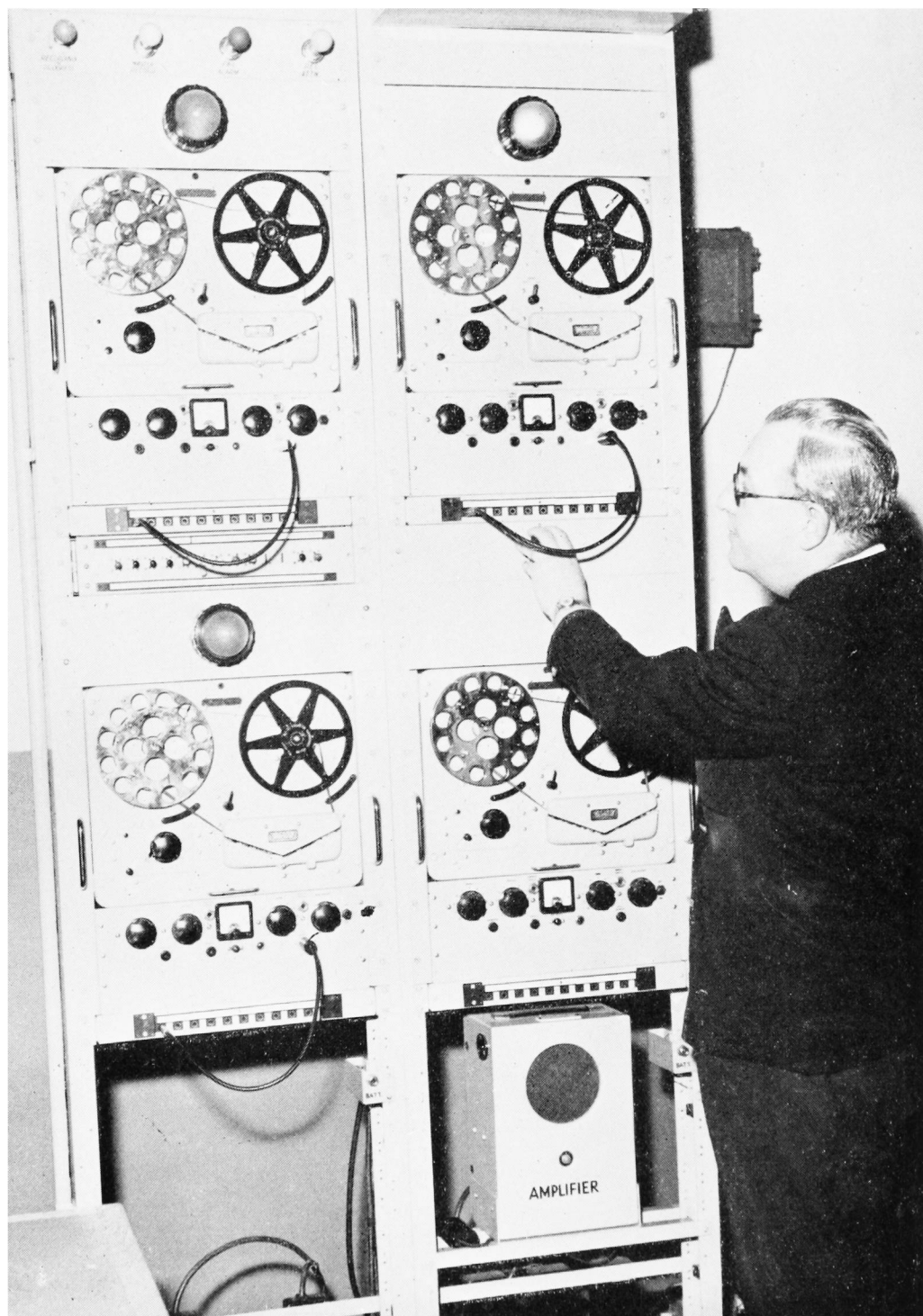
The fact that TIM and WEA are both automatic telephone services might lead one to suppose that they are operated in the same way. This is not so. TIM is automatic from start to finish. It is operated from discs which are "geared" into the controlling clock, changing the message in step with the time. WEA is operated by speech from a magnetized tape, and, although the 9-hr. period of validity is carried forward with the passage of time, there is nothing automatic about the changing of a forecast when this becomes necessary.

[To face p. 200



GENERAL POST OFFICE TELEPHONIST RECORDING WEATHER FORECAST





TAPE RECORDERS USED IN AUTOMATIC WEATHER-FORECAST SERVICE

The arrangements behind the scenes for the operation of this service are relatively straightforward. The Meteorological Office provides the forecasts and the General Post Office staff record these on tape for transmission from a London telephone exchange. The writing of the forecasts, however, is made rather more difficult by the need to keep within the rigid limits of the transmitting apparatus.

Each forecast must be written in such a way as to occupy a maximum of either 15 or 30 sec. of reading time including a pause at the end of the forecast. This pause must not be longer than 4 sec. or else the break-down mechanism will come into operation. It must also take into account the fact that the forecast will be read by any member of the General Post Office telephonist staff at the exchange and not by specially selected announcers, hence the normal pitfalls of everyday speech and of weather terminology in particular must be avoided in composing the message.

While the forecast specifically covers a period of 9 hr. from the time the subscriber makes his call, it avoids any artificial ending to the weather in the middle of normal daily activities by the inclusion of an outlook extending to some recognized division of the day. This arrangement demands that the forecast must be kept constantly under review since the period of validity of the 9-hr. forecast is carried forward with the passage of time. Fresh forecasts are therefore not issued at set times but whenever the 9-hr. period enters changing weather or when the time divisions used on the forecast become invalid. This has been found to give flexibility in the application of the forecast to the subscribers' needs.

Once the forecast is prepared the process of telephoning, checking back, recording and transmitting becomes a fixed routine in which the particular characteristics of the apparatus used by the General Post Office take a controlling part. The recording is done with the aid of a control or cut-out clock and microphone with head attachment as shown in the photograph facing p. 200. The recording telephonist first times with a stop watch her own reading of the message. When she feels that she can read the forecast satisfactorily and in the correct time, the telephonist informs the General Post Office engineer in the adjoining room. The red "proceed" lamp will glow as soon as the recording equipment is ready, and then one second after pressing the control-clock button the telephonist will read the forecast with one eye on the clock.

The telephonist must finish reading between the 26th and 29th seconds whether reading a short 14-sec. forecast twice or a long forecast once. The control clock is set to stop after 29 sec. and to disconnect automatically the microphone and glow lamp from the recording circuit. So after a check run the endless tape is ready to provide the forecast for the 620 lines that have been set aside to carry calls on WEA 2211 simultaneously. It is perhaps interesting to note in passing that even with all these lines the "number engaged" signal, showing saturation, has been reported.

A battery of four tape recorders, shown in the photograph facing this page, takes care of such matters as continuity during fresh recordings, or the risk of break-down in the primary circuit. It is the practice to make the recordings on two tape machines so that should a fault develop in the operating one, a gap of more than 5 sec. will automatically cut out that machine and bring in the machine that is at "stand-by". The third machine is employed for making



the new recordings while the current forecast is still being transmitted. The fourth machine is for use in an emergency when the failure cannot be dealt with by the existing cut-out device.

In the first month of its use by the public, the total number of calls on WEA was 561,377. This figure was swollen in the first week by callers who were merely curious, but the calls far outnumber those that were made for similar information before the introduction of WEA. This may be because the previous service was not publicized sufficiently, though it is more likely to be due to the impersonality of the present service. The man in the street has a certain timidity when asking for information from any scientific source. Perhaps he fears that he may be questioned about the reasons for asking, or that he may be giving unnecessary trouble to someone. Whatever the reason may be, the fact remains that the great majority of those now using the weather service did not previously make telephone calls to ascertain the weather. For comparison, the total number of "weather" calls at the London Office for the previous month, February, was 17,128. Other countries who introduced this service some years ago found the same striking increase when it was brought in. In Western Germany, Frankfurt-on-Main, a city of about half-a-million population, introduced this kind of weather service on April 27, 1953, and the total number of calls made on it the following month, May, was 27,522. This figure was more than twice the number of inquiries for the whole of the previous year at the Frankfurt Weather Office.

It is too early yet to draw long-term conclusions concerning WEA. The seasons carry their own peculiar weather interests for the public and these usually bring weather inquiries to a peak in summer months. However, if the present public interest in WEA is a comment on its usefulness then its future is assured.

## NOCTURNAL DISSIPATION OF STRATOCUMULUS CLOUD

By D. G. JAMES, Ph.D.

**Summary.**—Occasions were selected when extensive sheets of stratocumulus cloud were reported during the afternoon. These occasions are divided into two classes: those when the cloud sheet dispersed within 12 hr. of an afternoon radio-sonde ascent, and those when the cloud persisted through the night. The physical and dynamical processes operating on the cloud are examined statistically, and some of them are shown to be significantly different for the two classes. A combination of three parameters is obtained which may have some forecasting value.

**Introduction.**—The difficulty encountered in forecasting the dissipation or persistence of a sheet of stratocumulus cloud suggests that the cloud layer is in a delicate state of balance with its environment.

Subsidence or ascent within the air mass at cloud heights can dissipate or reinforce the cloud sheet, whilst advective changes may transfer the layer from one locality to another. Radiation from the cloud layer produces a net flux of heat outwards which cools the cloud sheet, and mixing by eddy diffusion occurs at cloud base and top with the air below and above the layer; in addition the radiative cooling of the cloud may be sufficient to produce mixing by convective turbulence at the cloud base. Generally, analysis of surface synoptic charts and radio-sonde observations gives little indication as to which processes dominate the behaviour of the cloud sheet, though instances of considerable vertical motion or advection at cloud levels would at once be

evident. Thus it seemed desirable to select a number of cases and examine them statistically for significant differences between the means of the parameters (or combination of the parameters) involved, for the two classes of dissipating and non-dissipating cloud.

**Selection of cases.**—The choice of examples for statistical analysis was made from the years 1952–54, and was governed by the following simple criteria:

(i) The stratocumulus sheet was bounded at its top by a dry type inversion, i.e. a rapid decrease of humidity with height through the region of temperature increase (this was realized in almost all cases of non-frontal stratocumulus).

(ii) There was no surface front within 400 miles of the locality of the cloud sheet.

(iii) The cloud base was above the expected condensation level of thermal convection over land during the previous day, and of any convection from the sea. All cases considered were of cloud sheets over land.

(iv) The cloud sheet was extensive, covering perhaps several hundred square miles, and gave almost complete cover, i.e. greater than 6 oktas for at least two consecutive hours. The cloud was considered to have dissipated if the sheet had broken to 2 oktas or less for at least two consecutive hours.

(v) Only nocturnal dissipation or persistence was considered because there was then no continuous maintenance of the cloud by convection from the surface.

In general, cloud bases were determined from surface observations and cloud tops from the vertical temperature profiles obtained by radio-sonde ascents at the same time. In some cases, when the cloud bases reported from the ground were not fully consistent with the vertical temperature profiles indicated by the ascents, the values of the cloud bases used were obtained by the use of the temperatures and dew points given by the soundings. Several cases were rejected where the cloud bases so obtained were completely at variance with those reported from the ground.

**Advection and vertical motion.**—Advective changes were rarely responsible for the dissipation of sheets of stratocumulus cloud of the type considered. This was concluded from the examination of hourly surface charts in cases when the stratocumulus dispersed, i.e. extensive areas of cloud present at one hour had almost completely vanished by the next. The process of dispersal when it occurred was usually quite sudden, and no cases were observed in which the edge of the cloud sheet retreated steadily with the wind as would be expected with advective clearance. It did appear, however, that local fluctuations in cloud height were often caused by minor advective changes.

Consideration of the potential temperatures, humidity mixing ratios and wet-bulb potential temperatures of soundings through the air masses relevant to the cloud sheets showed little evidence that vertical motion in the atmosphere was the chief cause of the persistence or dissipation of the cloud.

Although, on occasions, subsidence of the order of 4–5 mb./hr. could be detected at 700 mb. and above, little direct evidence of the influence of subsidence could be observed at cloud heights. In order that a cloud sheet should disperse by subsidence alone, a descent at least equal to the thickness of the cloud would be required. No such change was evident on any of the occasions considered. Thus it was thought that, for the cases selected, advective changes and vertical motions in the air masses were not primarily responsible for the behaviour of the cloud sheet.

**Radiation from the cloud.**—The net radiative flux from a cloud sheet was calculated for several cases by use of the Elsasser radiation chart. The loss of heat flux was of the order of 20 cal./cm.<sup>2</sup>/3 hr. and varied little from case to case, being almost independent of cloud thickness. Thus the variation of radiative flux did not seem to be a principal factor in determining persistence or dissipation of the cloud sheet. To calculate the cooling of the cloud layer the cloud was regarded as a black body, and the cooling depended greatly upon cloud thickness. Hewson<sup>1</sup> has demonstrated how such cooling could be responsible for the dissipation of scattered fragments of cloud. In this process the cloud fragments cool by radiation and sink relative to the environment, so ultimately dispersing. In considering such a mechanism Hewson neglects any compensating up-currents in the environmental air. This is quite legitimate if the cloud comprises only isolated fragments. If, however, the cloud amount is substantial, or indeed the cloud is continuous, the up-currents cannot be neglected in this way. They would almost certainly have the effect of continuously reforming the cloud. Thus Hewson's process cannot be invoked to explain the dissipation of a continuous sheet of stratocumulus cloud. The effect of the radiational cooling of the cloud is to establish an adiabatic lapse rate below the cloud, and thus convective mixing between the cloud and the air below. Such convective mixing could in theory result in the dispersal of the cloud provided the sub-cloud air was dry enough not to reach saturation at cloud height. It was found that the extreme dryness necessary did not occur; in fact, convective mixing with the air below the cloud would, in general, retard rather than assist dissipation of the cloud.

In the course of carrying out the radiation calculations it was noted that the calculated amount of cooling of the cloud was considerably greater than that suggested by successive radio-sonde ascents, even after allowing for the latent heat released by additional condensation. This fact supports the idea that continuous mixing with the air above and/or below cloud must be important processes in maintaining the temperature of the cloud and these were, therefore, considered further.

**Turbulent mixing with air above the cloud top.**—Turbulent mixing caused by eddy diffusion at the cloud-inversion interface would cause much warmer and drier air to enter the cloud. Consequently it was thought that there might be a significant difference between the warmth and dryness of the air above the cloud for the two classes of dissipation and persistence.

The depression of the dew point below dry-bulb temperature at a given pressure level was used as a simple parameter, and Table I was constructed relating the persistence or dissipation of the cloud (within 12 hr. of the radio-sonde ascent used) with the maximum depression within 50 mb. above the cloud top. It was thought that the error in estimating cloud top was such that

the parameter used would be more representative than if a much smaller or much greater depth of air above cloud was taken. This was shown to be so when tables similar to Table I were prepared for the dew-point depression within 25 mb. and 100 mb. of the cloud top.

TABLE I—MAXIMUM VALUE OF DEPRESSION OF DEW POINT WITHIN 50 MB. ABOVE THE CLOUD TOP

|                                | Mean                      | Standard deviation | Standard error of mean | No. of cases |
|--------------------------------|---------------------------|--------------------|------------------------|--------------|
|                                | <i>degrees Fahrenheit</i> |                    |                        |              |
| Breaks within 12hr. ... ..     | 24                        | 13                 | 2.6                    | 26           |
| No breaks within 12 hr. ... .. | 28                        | 14                 | 2.7                    | 27           |

“Student’s” *t* evaluated for the difference between the means in Table I gave *t* = 1.60 which showed that the means were significantly different at about the 10 per cent. level. The dryness of the air above the cloud must, therefore, be relevant to the problem of dissipation.

**Turbulent mixing with air below the cloud base.**—In all the cases examined the air below the cloud was not dry enough for any mixing at the cloud base to produce dissipation of the cloud. The radiative cooling of the cloud was usually great enough for the establishment of a dry adiabatic layer directly below the cloud, so that mixing by convective turbulence as well as eddy diffusion took place at these levels. These processes probably acted as a retarding factor on any dissipating mechanism produced by mixing through the inversion.

Table II presents the means and standard deviations of the hydrolapses averaged through 50 mb. below the cloud base for cases of “breaks” and “no breaks” in the stratocumulus sheets.

TABLE II—HYDROLAPSES OVER 50 MB. BELOW THE CLOUD

|                                | Mean  | Standard deviation | Standard error of mean | No. of cases |
|--------------------------------|---|--------------------|------------------------|--------------|
|                                | $10^{-2} \times \text{grammes per kilogram per millibar}$ |                    |                        |              |
| Breaks within 12 hr. ... ..    | 1.1   | 0.8                | 0.16                   | 26           |
| No breaks within 12 hr. ... .. | 1.5   | 0.8                | 0.16                   | 27           |

Evaluation of “Student’s” *t* for the means above gave *t* = 1.77 which indicated that the means were significantly different at about the 10 per cent. level.

**Effect of cloud thickness.**—Table III presents the means and standard deviations of the observations of cloud thickness for the two classes of “breaks” and “no breaks”.

TABLE III—OBSERVATIONS OF CLOUD THICKNESS

|                                | Mean             | Standard deviation | Standard error of mean | No. of cases |
|--------------------------------|------------------|--------------------|------------------------|--------------|
|                                | <i>millibars</i> |                    |                        |              |
| Breaks within 12 hr. ... ..    | 33.5             | 20.0               | 3.9                    | 26           |
| No breaks within 12 hr. ... .. | 43.5             | 19.0               | 3.9                    | 27           |

For the above means, "Student's"  $t = 1.86$  which showed that the difference between the means was significantly different from zero at about the 10 per cent. level.

**Combination of the parameters.**—Tables I, II and III suggest that it would be worth devising a new parameter by a combination of the three variables used in the preparation of the tables. The new parameter was defined as

$$\xi = x + \alpha y + \beta z,$$

where  $x$  is the maximum depression in degrees Fahrenheit of dew point below the temperature at any pressure level up to 50 mb. above the cloud top,  $y$  is the average hydrolapse in grammes per kilogramme per millibar  $\times 10^{-2}$  in the 50 mb. below the cloud base,  $z$  is the cloud thickness in millibars, and  $\alpha$  and  $\beta$  are constants to be determined by the condition that the departure from zero of the difference between the means of  $\xi$  for cases of "breaks" and "no breaks" should have maximum significance. The conditions were determined by maximizing "Student's"  $t$  for the difference between the two means of  $\xi$ , and the final parameter was obtained as

$$\xi = x - 9.15y - 0.77z.$$

Table IV presents the means and standard deviations of  $\xi$  for the two classes of cloud behaviour.

TABLE IV—VALUES OF THE PARAMETER  $\xi$   
 $\xi = x - 9.15y - 0.77z$

|                                | Mean                      | Standard deviation | Standard error of mean | No. of cases |
|--------------------------------|---------------------------|--------------------|------------------------|--------------|
|                                | <i>degrees Fahrenheit</i> |                    |                        |              |
| Breaks within 12 hr. ... ..    | -12.1                     | 18.9               | 3.71                   | 26           |
| No breaks within 12 hr. ... .. | -28.4                     | 16.4               | 3.35                   | 27           |

"Student's"  $t$  now has the value of 3.36, which indicates that the means are significantly different at about the 0.2 per cent. level; the form of  $\xi$  is the best relationship that can be obtained by a linear combination of the three parameters used.

Fig. 1 shows the distribution of values of  $\xi$  for cases of "breaks" and "no breaks"; 74 per cent. of the cases of "no breaks" have values of  $\xi$  less than -20, whilst 76 per cent. of the cases of "breaks" have values of  $\xi$  greater than -20. These figures would be somewhat better were it not for two cases of each type which fall well to the wrong side of the dividing line at  $\xi = -20$ . These cases are perhaps worthy of some discussion if only to illustrate the difficulties encountered.

One case of dissipating cloud gives  $\xi = -65.8$  which is well to the wrong side of the dividing line at  $\xi = -20$ . This large value is given mainly by an assessed cloud thickness of 90 mb. which was consistent with the observations of cloud base (2,500-3,000 ft.). However, a thickness of 30 mb. is easily possible from the ascent, but this would require a cloud base of 4,500 ft.

A second case of dissipating cloud gives  $\xi = -60.2$  which is again to the wrong side of the dividing line. The cloud thickness used was 30 mb., although

any value up to 70 mb. was possible, and hence uncertainties in the cloud thickness alone could not have been responsible for the excessively large value of  $\xi$ . The hydrolapse above the cloud had a shallow slope, but was verified by comparison with other soundings in the same air mass.

One case of persisting cloud gives  $\xi = 14.1$ , well to the wrong side of  $\xi = -20$ . This discrepancy is again attributed to lack of definite information regarding cloud base and top. A thickness of 10 mb. was used in the statistical study implying a cloud base of 4,000 ft. This was a case when the surface reports of cloud base were rejected in favour of assessment from the ascent. Had the surface observations been accepted (2,000–3,000 ft.) a value for cloud thickness of from 120 to 70 mb. would have been indicated. It is possible, of course, that there were two layers in this case.

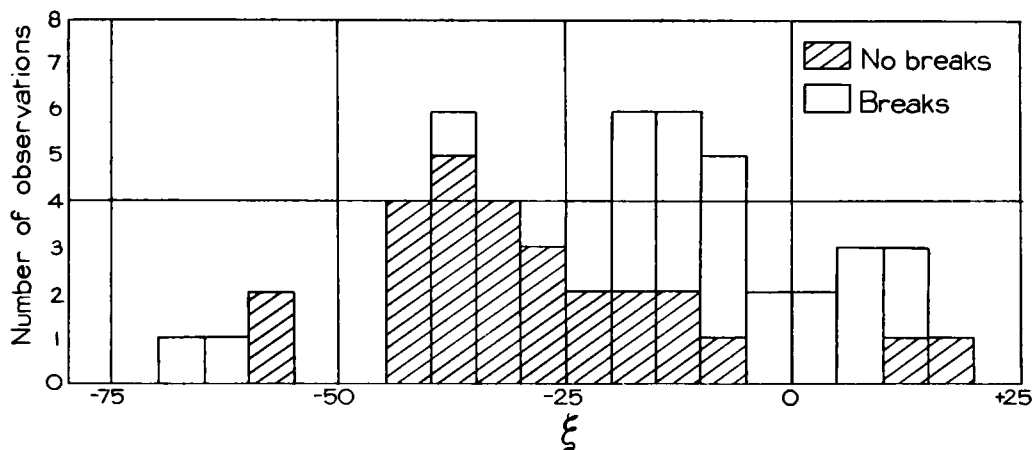


FIG. 1—FREQUENCY OF OCCASIONS OF STRATOCUMULUS CLOUD CLASSIFIED ACCORDING TO THE VALUES OF  $\xi = x - 9.15y - 0.77z$

The final point well to the wrong side of  $\xi = -20$  is given by  $\xi = 19.6$  for persisting cloud. The cloud was assumed to be 35 mb. thick with a base of 4,000 ft., although in surface observations the base was given as 2,000–3,000 ft. It is possible that there could have been two cloud layers, the first as already assumed, and the second with base 2,000 ft. and thickness 35 mb. The air above this lower layer was not very dry, and it is also possible that the layer was being reinforced by convection from the sea surface.

It is concluded that the most glaring discrepancies in the indication provided by the combined parameter  $\xi$  almost certainly arise from the difficulties and uncertainties of assessing cloud thicknesses in the absence of positive information.

**Conclusions.**—In the cases examined, there was little evidence to show that vertical motion in the atmosphere was responsible for the dispersal or persistence of stratocumulus cloud.

Hewson's processes for the dissipation of broken and scattered cloud by differential radiation could not explain the dispersal of a continuous sheet of cloud. Although mixing at the cloud base with air below was always present, exceedingly dry air below the cloud would have been required for dissipation.

Radiative cooling of the cloud sheet caused an intensification of the mixing process at cloud base, and could not produce dissipation of the cloud.

Turbulent mixing of the cloud with the dry air above seemed to be significant in the subsequent behaviour of the cloud.

A combination of three parameters expressing the warmth and dryness of the air above cloud, the hydrolapse below cloud, and cloud thickness gave means, the difference between which differed significantly from zero for cases of "breaks" and "no breaks". This result may be of some value for forecasting.

If mixing with the air above and below a stratocumulus layer is the main controlling process determining whether the cloud layer will persist or dissipate, it is doubtful whether any more specific criteria for the dispersal of the cloud can be developed on the basis of synoptic observations because of their limitations for determining the essential parameters—cloud thickness and humidity distribution above and below cloud.

#### REFERENCE

1. HEWSON, E. W.; The dissipation of scattered and broken cloud. *Quart. J. R. met. Soc., London*, **74**, 1948, p. 243.

### PATTERN OF RAINFALL

By A. F. JENKINSON, M.A.

The curve fitted by Mr. Thomson<sup>1</sup> to the values  $N_r$  of the number of hours with rainfall greater than or equal to  $r$  mm. is a special case of the more general curve

$$N_r = a \exp(-\lambda r^{1/n}). \quad \dots \dots (1)$$

The total rainfall  $R$  can be obtained since

$$\begin{aligned} R &= \int_0^\infty -r d(N_r) \\ &= \int_0^\infty N_r dr \\ &= \int_0^\infty a \exp(-\lambda r^{1/n}) dr. \end{aligned}$$

On substituting  $t = \lambda r^{1/n}$  we evaluate the integral as

$$R = \frac{a n!}{\lambda^n}, \quad \dots \dots (2)$$

and so

$$\frac{R}{N_r} = n! \lambda^{-n} \exp(\lambda r^{1/n}). \quad \dots \dots (3)$$

The parameter  $n$  (which is greater than 1) shows the type of rainfall, of temperate-latitude type (low rates of rainfall) when  $n$  has lower values or of tropical type (high rates of rainfall) when  $n$  has higher values. The values of  $n$  can be mapped.

Nevertheless, Mr. Thomson's curve fitting reduces the number of parameters in the fit for  $N_r$  from three to two, and for  $R/N_r$  from two to one, and is thus most useful. By giving  $n$  the constant value 2, equation (3) becomes

$$\frac{R}{N_r} = \frac{2}{\lambda^2} \cdot 10^{0.4343\lambda \sqrt{r}},$$



or writing  $k = 0.4343\lambda$  to keep Mr. Thomson's  $k$

$$\frac{R}{N_r} = \frac{1}{2.65k^2} \cdot 10^{k\sqrt{r}}. \qquad \dots\dots\dots (4)$$

That is, the constant  $C$  in Mr. Thomson's and Mr. Waldo Lewis's work<sup>2</sup> is given by

$$\frac{1}{C} = 2.65k^2. \qquad \dots\dots\dots (5)$$

The numerical fitting used by Mr. Waldo Lewis<sup>2</sup>

$$\frac{1}{C} = 3.30k^2 - 0.24$$

overlooks the theoretical considerations expressed by equation (5).

Equation (4), which with Mr. Thomson's constant  $n (=2)$  has the single parameter  $k$ , can be used to fit corresponding values of  $R/N_r$  and  $r$  for stations all over the world; and then the values of the parameter  $k$  will show the rainfall type, as can be seen from the values of  $k$  quoted by Mr. Thomson and Mr. Waldo Lewis;  $k$  increases with latitude, and it has small values for tropical rainfall types. From equation (4), taking common logarithms,

$$\log_{10}(R/N_r) = k\sqrt{r} - 0.423 - 2 \log_{10} k. \qquad \dots\dots\dots (6)$$

The values of the expression on the right-hand side of equation (6) can be tabulated for different values of  $k$  and  $r$ . They are given in Table I for  $k = 0.3, 0.4, \dots, 1.6$  and  $r = 0.1, 1, 2, \dots, 7$  mm.

TABLE I—VALUES OF  $\log_{10}(R/N_r) = k\sqrt{r} - 0.423 - 2 \log_{10} k$

| $k$ | $r$ or more millimetres of rain |      |      |      |      |      |      |      |
|-----|---------------------------------|------|------|------|------|------|------|------|
|     | 0.1                             | 1    | 2    | 3    | 4    | 5    | 6    | 7    |
| 0.3 | 0.71                            | 0.92 | 1.04 | 1.14 | 1.22 | 1.29 | 1.35 | 1.41 |
| 0.4 | 0.50                            | 0.77 | 0.94 | 1.06 | 1.17 | 1.26 | 1.35 | 1.43 |
| 0.5 | 0.34                            | 0.68 | 0.89 | 1.15 | 1.18 | 1.30 | 1.41 | 1.50 |
| 0.6 | 0.21                            | 0.62 | 0.87 | 1.16 | 1.22 | 1.36 | 1.49 | 1.61 |
| 0.7 | 0.11                            | 0.59 | 0.88 | 1.10 | 1.29 | 1.45 | 1.60 | 1.74 |
| 0.8 | -0.03                           | 0.58 | 0.91 | 1.16 | 1.38 | 1.56 | 1.74 | 1.89 |
| 0.9 | -0.05                           | 0.57 | 0.94 | 1.23 | 1.47 | 1.68 | 1.87 | 2.05 |
| 1.0 | -0.10                           | 0.58 | 0.99 | 1.31 | 1.58 | 1.82 | 2.03 | 2.22 |
| 1.1 | -0.16                           | 0.59 | 1.04 | 1.39 | 1.69 | 1.95 | 2.19 | 2.40 |
| 1.2 | -0.20                           | 0.62 | 1.12 | 1.50 | 1.82 | 2.10 | 2.36 | 2.59 |
| 1.3 | -0.24                           | 0.65 | 1.19 | 1.60 | 1.95 | 2.26 | 2.53 | 2.79 |
| 1.4 | -0.27                           | 0.69 | 1.27 | 1.71 | 2.09 | 2.46 | 2.72 | 2.99 |
| 1.5 | -0.30                           | 0.73 | 1.35 | 1.83 | 2.23 | 2.62 | 2.90 | 3.20 |
| 1.6 | -0.32                           | 0.77 | 1.43 | 1.94 | 2.37 | 2.79 | 3.09 | 3.40 |

Interpolating from Mr. Thomson's data for Poona,

|                    |     |     |     |      |      |      |      |      |      |      |
|--------------------|-----|-----|-----|------|------|------|------|------|------|------|
| $r$ (mm.)          | ... | ... | ... | 1    | 2    | 3    | 4    | 5    | 6    | 7    |
| $\log_{10}(R/N_r)$ | ... | ... | ... | 0.64 | 0.91 | 1.10 | 1.25 | 1.37 | 1.46 | 1.54 |

If we fit a value of  $k$  to equation (6) for the values of  $\log_{10}(R/N_r)$  and  $k\sqrt{r} - 0.42 - 2 \log_{10}k$  for the values of  $r = 1, 2, \dots, 7$  mm., then from Table I the sums of squares of differences for  $k = 0.4, 0.5, 0.6, 0.7$  are respectively 0.0581, 0.0184, 0.0124, 0.0710 with a minimum (determined graphically) at  $k = 0.58$  and

$$\left. \begin{aligned} R/N_r &= 1.12 \cdot 10^{0.58\sqrt{r}} \\ \log_{10} R/N_r &= 0.05 + 0.58\sqrt{r} \end{aligned} \right\} \qquad \dots\dots\dots (7)$$

The approximate values of  $R/N_r$  for  $r = 1, 2, \dots, 7$  mm. as observed and as calculated by Thomson using  $R/N_r = 1.05 \times 10^{0.57\sqrt{r}}$ , and as calculated from equation (7) are given in Table II.

TABLE II—VALUES OF  $R/N_r$

|              |     |     | $r$ or more millimetres of rain |     |    |    |    |    |    |
|--------------|-----|-----|---------------------------------|-----|----|----|----|----|----|
|              |     |     | 1                               | 2   | 3  | 4  | 5  | 6  | 7  |
| Observed     | ... | ... | 4.4                             | 8.2 | 13 | 18 | 23 | 29 | 35 |
| Thomson      | ... | ... | 3.7                             | 6.8 | 10 | 15 | 20 | 26 | 34 |
| Equation (7) | ... | ... | 4.3                             | 7.4 | 14 | 16 | 22 | 29 | 38 |

It should be noted that a unique value of  $k$  cannot really be obtained by curve fitting. Much depends on which part of the curve we are most interested in. For example, the value 0.58 which was obtained for  $k$  from equation (7) by fitting the part of the curve for  $r = 1, 2, \dots, 7$  mm. would have been changed to 0.63 had the point  $r = 0.1$  mm. also been included; and another different value would have been obtained by considering the section of the curve for  $r > 7$  mm.

The use of equation (3) enables the curve to be fitted more accurately, but there is then a corresponding difficulty in interpreting  $\lambda$  and  $n$ , and the bold step taken by Thomson of giving  $n$  the fixed value 2 may be considered well worth while.

#### REFERENCES

1. THOMSON, A. B.; One aspect of the pattern of rainfall. *Met. Mag., London*, **83**, 1954, p. 293.
2. LEWIS, R. P. WALDO; The pattern of rainfall. *Met. Mag., London*, **84**, 1955, p. 366.

[It was because I had myself already worked out the theory given in the beginning of Mr. Jenkinson's note and arrived at his equation (5) that I was led to extend the results given in Mr. Thomson's paper and to write my own note. Equation (5) was subsequently abandoned because it just does not fit the values of  $C$  and  $k$  obtained in practice. Moreover, I cannot feel that equation (5) has any real theoretical justification. The formula

$$\frac{R}{N_r} = C \times 10^{k\sqrt{r}} \quad \dots \dots \dots (8)$$

appears to fit the facts well for numbers of tabular hours with  $r$  mm. or more of rain in each (at least for  $r$  up to 10 or 15 mm.), but to change from these essentially discontinuous quantities to smoothly varying rates of rainfall and infinitely divisible periods of time  $dN_r$ , and then to integrate up to an infinite rate of rainfall is not in any strict sense admissible. The argument has heuristic value, and tells us to look out for a relation not very different from equation (5), but so would an even simpler "dimensional" treatment. The point of my note is quite simple: equation (8) fits the rainfall data for individual stations extremely well and

$$\frac{1}{C} = 3.30 k^2 - 0.24,$$

for values of  $k > 0.5$ , fits values of  $C$  and  $k$  obtained in practice extremely well—much better than equation (5). No theoretical significance is claimed, though it is pointed out that some practical use may be made of the second equation.—R. P. WALDO LEWIS].

## COMPARISON OF WEATHER CONDITIONS DURING JULY AND AUGUST 1954 AND 1955

By R. E. BOOTH

The fine weather experienced during July and August 1955 stands out in contrast with the poor summer of 1954. It is noteworthy, however, that the weather in England and Wales during the first half of 1955 followed the same general pattern as it did in 1954, being on the whole cold, wet and unsettled with temperature below, and rainfall above, the average. In both years a cold and rather severe winter was followed by a sunny and very dry April. Each of the succeeding seven months of 1954 had considerably more than average rainfall, and in 1955 May and June were also unusually wet, but in July there was a major change.

In 1954 July and August were windy, cool, dull and wet, but in 1955 these two months were very different; they were quiet, warm and sunny with long periods without rain.

The unusually low temperature experienced throughout England and Wales during July and August 1954 resulted in the mean temperatures for these months being  $3\cdot5^{\circ}\text{F.}$  and  $2\cdot3^{\circ}\text{F.}$  respectively below the monthly averages; the July average was in fact the lowest since 1922. Low day temperatures were mainly responsible. At Kew, the monthly mean daily maximum temperature for July was more than  $6^{\circ}\text{F.}$  below the average, and the highest temperature recorded there during August,  $57^{\circ}\text{F.}$  on the 19th, was the lowest maximum in any August since 1931. At Ross-on-Wye the highest temperature recorded during July 1954,  $70^{\circ}\text{F.}$ , was the lowest July maximum since 1880. Rainfall during these two months in 1954 was appreciably above the average, 124 and 139 per cent. for July and August respectively, while the corresponding percentages of sunshine were 70 and 75. It is worth noting that July was an unusually windy month, the windiest July since 1909 at Southport and since 1936 at Kew.

In sharp contrast, the brilliantly fine weather of July and August 1955 broke many records. The mean temperature for England and Wales in July was  $1\cdot9^{\circ}\text{F.}$  above the average, and in August the average was exceeded by as much as  $3\cdot5^{\circ}\text{F.}$ ; there were only two warmer Augusts in the present century, those of 1911 and 1947. The mean temperature of the two months taken together was more than  $5\frac{1}{2}^{\circ}\text{F.}$  above the corresponding figure for 1954. Temperature reached  $90^{\circ}\text{F.}$  in both months for the first time since 1947,  $12^{\circ}\text{F.}$  and  $9^{\circ}\text{F.}$  above the maxima in corresponding months the previous year. July and August had nearly four times as much rain in 1954 as in 1955; taken together these two months in 1955 were the driest in the whole series of rainfall records since 1869. July was drier on only four occasions, 1885, 1898, 1911 and 1935, and there have only been two drier Augusts, 1940 and 1947. Most places were affected to a greater or less extent by lack of rain; the drought period which began in many places on July 4 continued at some until August 8. Camborne in Cornwall had 33 rainless days, July 1–August 2, and a total rainfall during the two months of only 0.36 in. There was more than twice as much sunshine during July in 1955 as in 1954 and August figures in 1955 were half as much again as in the preceding year. At some stations in north-west England it was the sunniest July for 70 years<sup>1</sup>.

Throughout July 1954 an anticyclone was situated near the Azores but at no time did it spread over the British Isles sufficiently to establish fine weather; on almost every day part of the country at least was under the influence of a low-pressure system. During August as well, frequent and active depressions from the Atlantic dominated the weather in most parts of the country. In 1955 mainly anticyclonic conditions were experienced over the country for practically the whole of July and the major part of August.

In the upper air, cold troughs moved quickly across the Atlantic to the British Isles during the first few days of July 1954. A pronounced upper cold pool associated with an occluded surface depression remained in the neighbourhood of the North Sea from the 4th to the 7th; scattered thunderstorms occurred during this period, chiefly in eastern districts. The whole system moved towards the Baltic Sea on the 8th allowing the broad westerly flow in middle latitudes of the Atlantic to make some progress across the British Isles, but the flow was blocked over Russia as shown in Fig. 1. Minor upper troughs and ridges in this stream were associated with the frequent passage of small but sometimes active surface secondary depressions or troughs across the country, but from the 13th to the 23rd the perturbations in the zonal flow were of a greater amplitude, and more vigorous surface depressions gave some days of widespread rain particularly on the 17th and 18th. A blocking anticyclone formed over eastern Canada on the 23rd and the flow of cold air down the Davis Strait on its eastern flank eventually gave rise to an extensive upper trough to the south of Greenland (see Fig. 2). An upper cold trough moved slowly eastward reaching the North Sea by the 28th. During this time the weather over the British Isles was very disturbed, with heavy rain, scattered thunderstorms and wind reaching gale force in many places.

The blocking pattern over North America persisted during the first week of August 1954 but had receded to western Canada by the 4th, and a large cold trough then dominated the Atlantic north of  $50^{\circ}\text{N.}$  Atlantic depressions deepened as they moved east; a large and complex low-pressure area remained in the eastern Atlantic from the 4th to the 6th, after which the

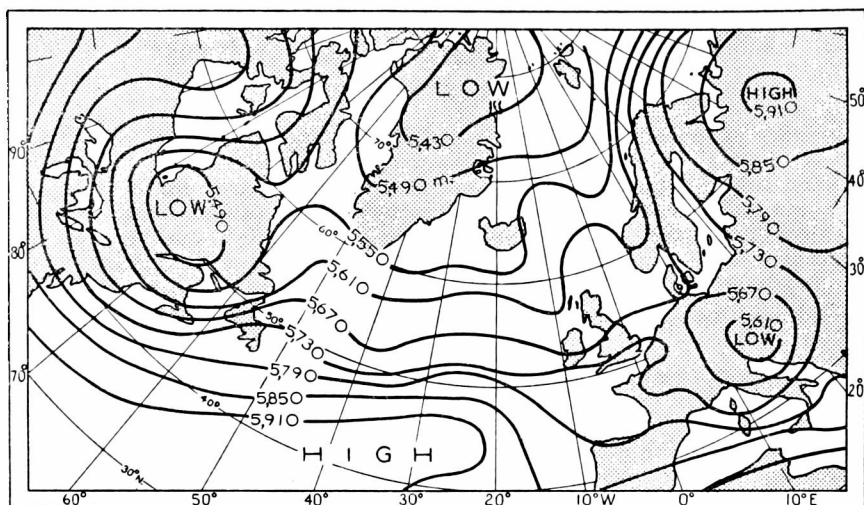


FIG. 1—500-MB. CONTOURS, 1500 G.M.T. JULY 8, 1954

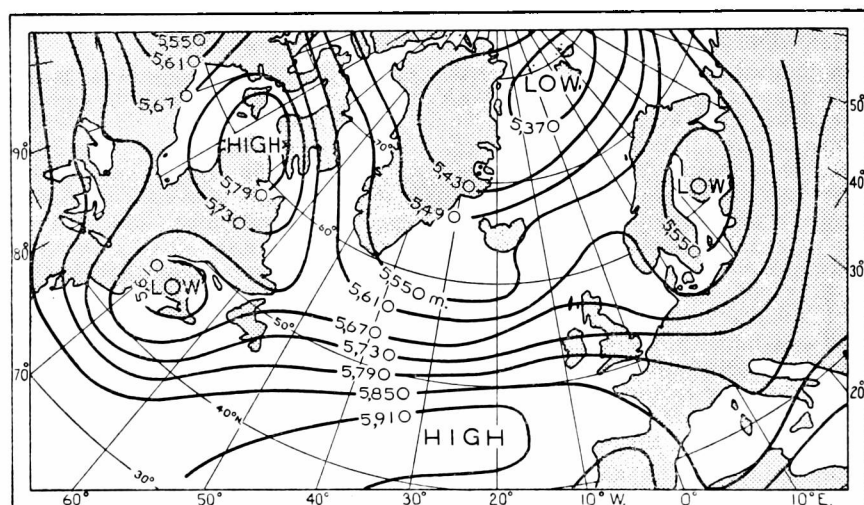


FIG. 2—500-MB. CONTOURS, 1500 G.M.T. JULY 23, 1954

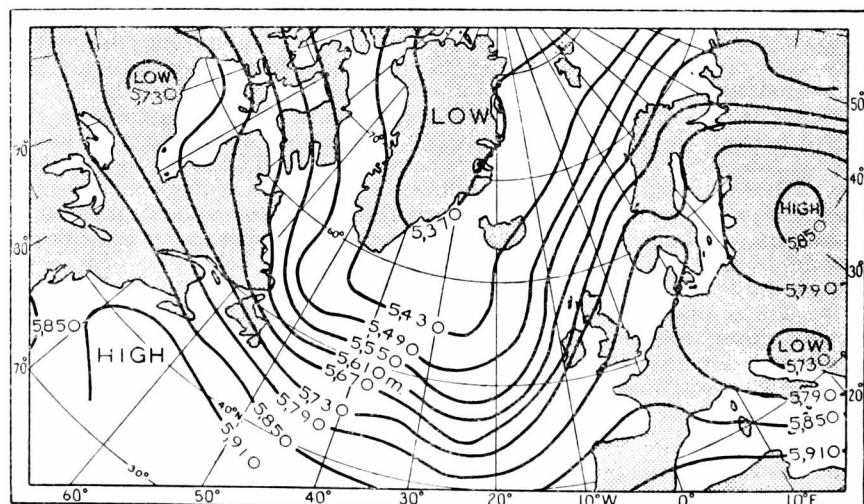


FIG. 3—500-MB. CONTOURS, 1500 G.M.T. AUGUST 16, 1955

lowest surface pressure was slowly transferred to the British Isles. The Atlantic upper trough also moved eastward, and it seemed probable that this was now being maintained by a flow of arctic air from a region east of Greenland. During this time small perturbations developed in the strong zonal field to the south of the upper trough between  $40^{\circ}$  and  $50^{\circ}\text{N.}$  and moved fairly quickly eastward in company with small surface secondaries. By the 14th the lowest surface pressure had moved eastward to the Baltic and the cold upper trough had given place to a more or less normal ridge and trough pattern over the Atlantic, and this pattern soon extended over North America as well. On the 19th one of these upper ridges became more than usually developed and cut off a small cold pool to the south of Great Britain which intensified and drifted south-eastwards attaining its maximum development over central Europe on the 25th. At the surface an anticyclone developed north-eastwards, and by the 23rd became centred over the Norwegian and Greenland Seas; a NE.-N. arctic air stream was established over the British Isles from the 21st to the 25th. Another upper warm ridge developed north-eastwards on the 27th, and at the same time there was a temporary extension across the southern part of the country of a surface ridge from the Azores anticyclone which gave two or three days of fine weather in the south with temperatures in the lower seventies for the first time since the 5th.

In July 1955 a blocking pattern became established over north-west Europe during the first week and persisted for the remainder of the month. A tongue of cold air penetrated south-eastwards into north-west Germany on the 4th and 5th while a frontal system, with surface pressure rising all round it and a well marked ridge above, moved eastwards towards the British Isles. The upper ridge was quickly followed by a second which amalgamated with it; this augmented upper ridge joined up in the warm air over Scandinavia cutting off a cold pool over east Germany and completing the blocking pattern. From then on the zonal westerlies were mainly near to, or to the north of, Scotland, and for much of the month a cold pool existed over France or Germany and a thermal ridge over the British Isles or Scandinavia. Except for the first few days high pressure persisted from the region of the Azores to Scandinavia, and the weather on most days was fine and warm though light easterly winds brought low cloud inland over eastern districts at night.

At the beginning of August 1955 the British Isles was mainly under the influence of the declining ridge of the blocking pattern of the previous month. This ridge was slowly displaced westwards by an intensifying upper trough which moved south over the North Sea. As the trough moved southward an accompanying surface cold front brought the first appreciable rain for several weeks to north and east England and much cooler conditions. From the 6th to the 9th an upper Atlantic warm ridge intensified considerably and ultimately re-established the blocking pattern which had been present most of July. An upper cold pool was cut off and moved to central Europe. From the 10th to the 15th England remained under the influence of the upper cut-off low which had extended westwards, and thundery rain and thunderstorms extended to most southern and central districts. Scotland, however, remained dominated by the blocking anticyclone. Increased cyclonic activity in the eastern Atlantic from the 14th to the 19th was associated with an intense upper trough which had been developing in mid Atlantic and which approached the British Isles on the 16th and 17th (see Fig. 3). From the 20th to the 25th an upper ridge and anticyclonic conditions were re-established over the country with temperatures rising in the south to between  $85^{\circ}$  and  $90^{\circ}\text{F.}$  The warm spell was gradually brought to an end by a renewal of thunderstorms over the Midlands and south-east England as a cold pool moved westwards from Germany. A deepening upper trough on the Atlantic approached giving less settled weather during the last two days of the month.

Maps of mean monthly contours at 500 mb., Figs. 4 and 5, give the combined effect of all the upper air developments during July of each year, and show in a striking manner how the main characteristics of the thermal pattern in the neighbourhood of the British Isles in July 1954 were reversed in July 1955. The trough over the North Sea in 1954 was replaced by a ridge the following year; upper winds approaching the British Isles from the Atlantic had a definite northerly component in 1954, whereas in 1955 they had a southerly component and decreased markedly in speed towards the west of Ireland; mean upper winds were light in the region of Iceland in 1954 and were strong further south, whereas in 1955 the position was reversed and they were strong near Iceland and lighter further south. The pronounced trough over the North Sea in 1954 is interesting. An examination of the tracks of depressions during the month showed that the majority moved from a point south of Iceland to southern Scandinavia or else became quasi-stationary off southern Norway, frequently drawing arctic air over the British Isles and the North Sea. Most of the depressions approached the British Isles from a point north of west in the general direction of the isopleths on the mean chart which seems to indicate that thermal steering during the month had some effect. Fig. 5 shows quite clearly the persistent upper ridge over the British Isles during July 1955, and a trough to the south of this ridge—a well recognized blocking pattern; the general track of depressions after the first five days of the month was in fact north-eastwards following the general run of the isopleths on this chart.

From the foregoing it can be inferred that the very fine weather of July 1955 was associated with a sustained blocking pattern over or near the British Isles. Although August 1955 was

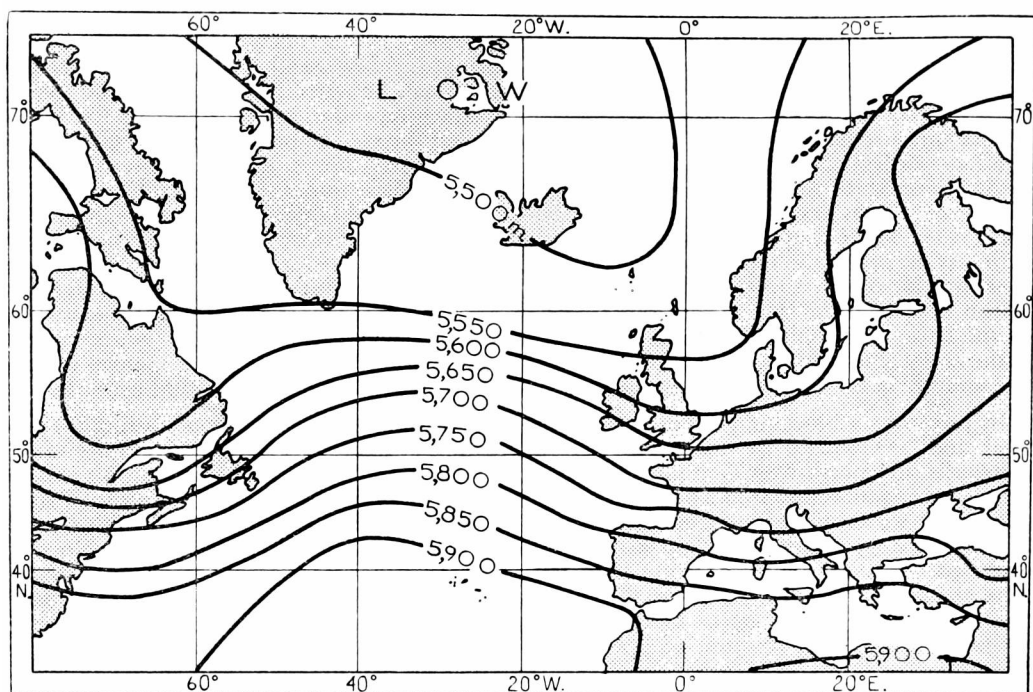


FIG. 4—MEAN 500-MB. CONTOURS FOR JULY 1954

not quite such a good month the blocking pattern was present most of the time, though occasionally interrupted and not so marked as in the previous month. During the cold and wet months of July and August 1954 the upper air pattern was markedly fluid in character throughout the whole period (see Fig. 4); the poor weather can be attributed to the fact that a blocking pattern in the upper air did not at any time become established near the British Isles except during the last few days of August. Blocking patterns over North America or Russia in the general westerly stream sometimes appeared to be linked with increasing cyclonic activity over the British Isles. The block to the zonal westerlies over Russia during July 9–17, 1954 (see Fig. 1) was accompanied by an increase in the activity of very small depressions over the British Isles;

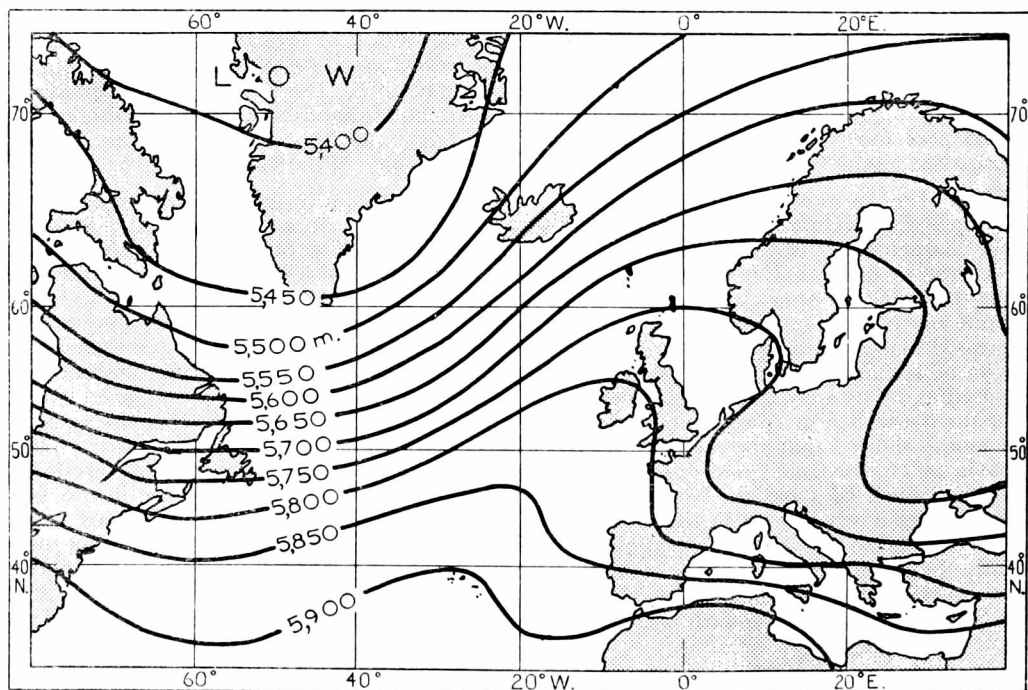


FIG. 5—MEAN 500-MB. CONTOURS FOR JULY 1955

the blocking pattern, which formed over eastern Canada on July 23, 1954 (see Fig. 2), allowed a deep upper trough to be formed east of Greenland with arctic air flowing down the Davis Strait; this in turn gave rise to unusually deep Atlantic depressions which later affected the British Isles.

It would be hard to find two other consecutive years which, after apparently being so similar during their early months, gave such good examples of blocking and fluid thermal patterns respectively as did 1955 and 1954 in July.

#### REFERENCE

1. BOOTH, R. E.; The sunny weather of July 1955. *Met. Mag., London*, **84**, 1955, p. 381.

### OFFICIAL PUBLICATIONS

The following publications have recently been issued:—

*Handbook of meteorological instruments. Part I. Instruments for surface observations.*

General instruction in the care and manipulation of instruments at Meteorological Office stations has, until recently, formed part of the scope of the "Meteorological observer's handbook". In a post-war revision of Meteorological Office publications it was decided to reduce the amount of information on instruments in the "Observer's handbook" to that necessary for their routine operation and day-to-day maintenance, and to publish a comprehensive handbook of meteorological instruments giving full information on the design, installation, operation, maintenance and performance of all instruments used at Meteorological Office stations, together with some information about other types of instruments in order to illustrate different principles.

This, the first part of the "Handbook of meteorological instruments", is concerned with instruments for surface observations; further parts will describe instruments for upper air observations and for geophysical measurements.

#### GEOPHYSICAL MEMOIRS

*No. 94—Meteorological results of the Balaena expedition, 1946–47.* By H. H. Lamb, M.A.

Part I of this Memoir describes the general organization of the *Balaena* expedition and the meteorological arrangements, including instrumental gear. Certain aspects of the unknown geography of the Antarctic continent and its bearing upon the meteorological work are considered here and in the later sections. Part II presents the meteorological results in terms of observation summaries and such lessons as can safely be learnt from them. The observations themselves are fully tabulated in the Appendices. An important part of the effort on this expedition was devoted to weather analysis over the Southern Ocean and to the experimental provision of a forecasting service for the remote Antarctic whaling grounds in the Indian Ocean and Australian sector. Part III consists of a description of the methods used and an appraisal of this forecasting experiment.

The best maps of Antarctica and the off-lying islands, reefs and ice-shelves, which the reader may find helpful in studying this report of the *Balaena* expedition, are amongst the items listed in the classified bibliography.

### LETTER TO THE EDITOR

#### Dust devil observed at Coalburn, Lanarkshire

At 1400 G.M.T. on April 29, 1956 my attention was attracted by a noise as of escaping steam which appeared to be approaching fairly fast (probably at 15 m.p.h.). Coming towards me from a north-east direction was a whirlwind into which had been sucked grass and light twigs. The largest of these was almost 12 in. in length and  $\frac{1}{4}$  in. in diameter. I estimated the width of disturbance at 5 ft. It passed within a few feet of me and dissipated a few yards further on. At the time it was dead calm and there had previously been bright periods amounting to 4 hr. sunshine. Screen temperature was at the maximum for the day (50°F.).

I estimate the height to which the grass was carried as about 10–12 ft. and I think it had a clockwise motion. The nearest trees, from where the twigs must have come, are 80 yd. from where I was standing. In the vicinity of the trees there is a flat expanse of ashes which might have become heated;



another 20 yd. further away there is a large corrugated iron building. The sky was partly overcast with cumulus, and an hour later the temperature reading was  $48.2^{\circ}\text{F.}$ , relative humidity was 41 per cent., with vapour pressure 4.7 mb.

J. ROSS

*Coalburn, May 4, 1956.*

[A col was centred over Scotland during April 29 lying between an anti-cyclone centred over the Norwegian Sea and a ridge extending over Ireland from the Azores anticyclone. Polar air covered the North Sea and Great Britain. During the night this air was sufficiently unstable over the sea to allow showers to drift over Leuchars, but during the day subsidence aloft caused an inversion to form at 6,000 ft. thus preventing deeper convection. Below 6,000 ft. the air was unstable, and became more so during the day in the lowest layers with a superadiabatic lapse rate between 1017 and 982 mb.; 3 oktas of cumulus formed at 2,500 ft. spreading out as stratocumulus beneath the inversion. These are fairly typical convection conditions for the time of year. The only unusual feature which could have caused the development of the dust devil was, as Capt. Ross suggests, the exceptionally strong radiational heating over the expanse of ashes.

Dust devils are unusual at such a low temperature, presumably because sufficiently steep lapse-rates are not often produced. F. E. Dixon\* recorded the occurrence of dust devils at Dublin Airport on May 12, 1949, a day on which the screen maximum was only  $51^{\circ}\text{F.}$  They occurred then on a dust surface heated to a temperature of about  $89^{\circ}\text{F.}$ —Ed., *M.M.*]

## NOTES AND NEWS

### Dust cloud in the stratosphere over western Europe

July 24—August 4, 1953

The dust clouds at about 49,000 ft. over western Europe in late July and early August 1953 have been described by L. Jacobs<sup>1</sup> and F. Volz<sup>2</sup>, while F. Volz<sup>2</sup>, G. de Vaucouleurs<sup>3</sup> and S. Fritz<sup>4</sup> have discussed the effects of the cloud on solar radiation.

For completeness of the record it should be added that the *Volcano Letter*<sup>5</sup> gives a full account of the volcanic eruption of which brief mention is made in Jacobs's article. The volcano Mount Spurr, Alaska,  $61^{\circ}18'\text{N.}$ ,  $152^{\circ}15'\text{W.}$  80 miles west of Anchorage, Alaska erupted at 5 a.m. on July 9, 1953. The eruptive cloud was seen from aircraft to reach up to 60,000 or 70,000 ft. and to have an estimated diameter of 30 miles. The ash cloud moved eastward and produced complete darkness at Anchorage from 1 to 3 p.m. Ash fell at Anchorage to a depth of  $\frac{1}{4}$  in. The main eruption was confined to the 9th, but the volcano continued in a state of moderate steadily diminishing activity for the rest of the month. The eruption was from a vent at 7,000 ft., and was the first strong activity of the volcano in the 200 yr. of recorded history of the area.

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3. VAUCOULEURS, G. DE; Dust clouds in the stratosphere. *Met. Mag.*, London, **83**, 1954, p. 311.
4. FRITZ, S.; Opacity of the atmosphere after July 1953. *Met. Mag.*, London, **85**, 1956, p. 110.
5. WILCOX, R. E.; Eruption of Mount Spurr, Alaska. *Volcano Lett.*, Hawaii, No. 521, 1953, p. 8.

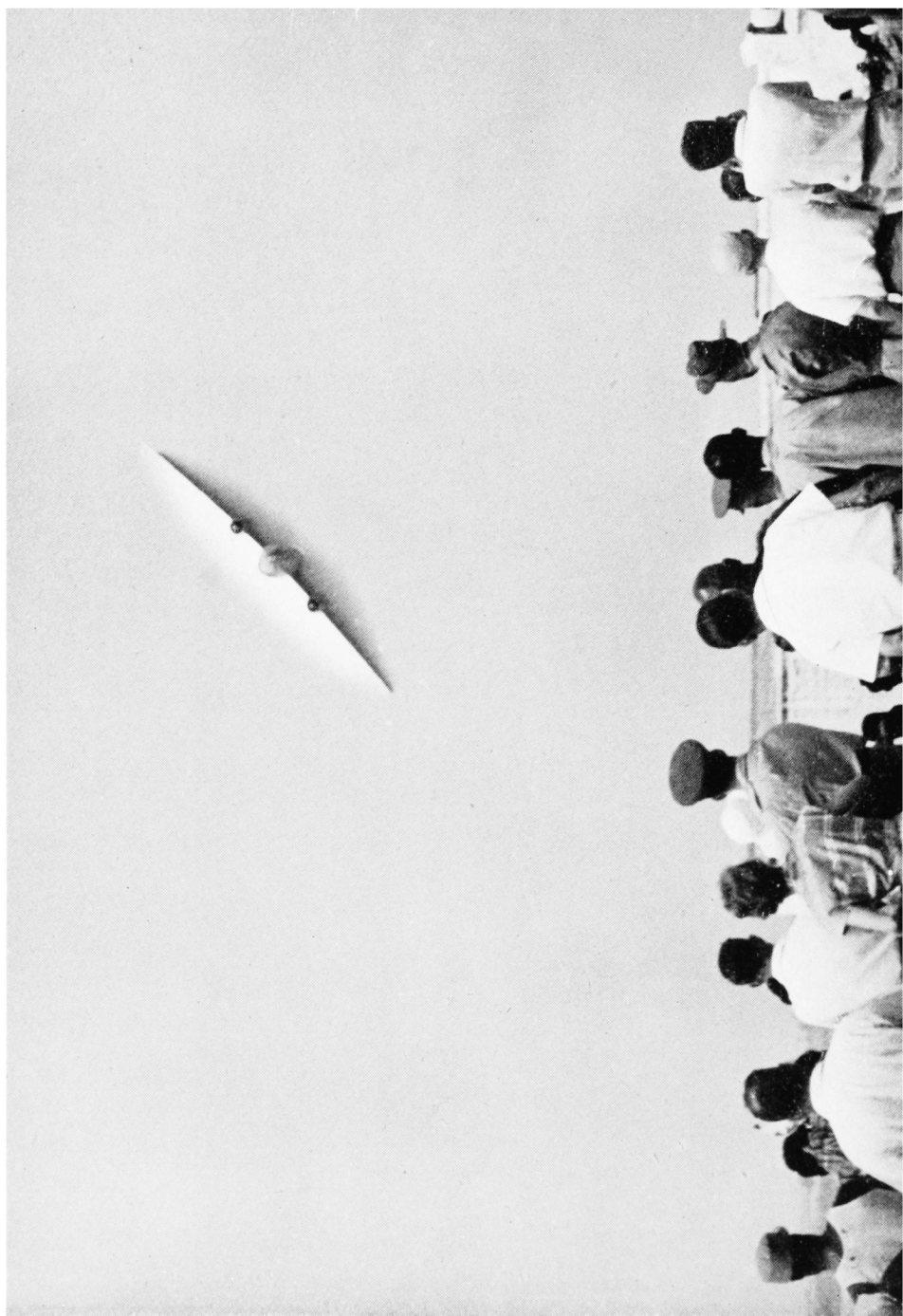
\* DIXON, F. E.; Dust devils at Dublin Airport. *Met. Mag.*, London, **78**, 1949, p. 206.



*Photograph by the late Mr. M. C. Gillman*

**CUMULONIMBUS CLOUD BEFORE SUNSET**

Taken from Dar-es-Salaam, British East Africa, looking inland.



Reproduced by courtesy of Capt. T. M. King

LOW-FLYING CANBERRA AIRCRAFT ENVELOPED IN CONDENSATION AURA, FEBRUARY 4, 1956

### Aircraft condensation aura

The photograph facing this page was taken by Capt. T. M. King on the occasion of the Queen's visit to the Gold Coast when six Canberra aircraft gave a display of low flying and aerobatics on the morning of February 4, 1956 along the coast between Christiansborg Castle (the Governor's residence) and Accra, a distance of about  $2\frac{1}{2}$  miles.

On several occasions during the display an aircraft would suddenly become enveloped in an aura of self-made cloud lasting no more than a second or two. Although Capt. King exposed a complete roll of a film this was the only picture in which he managed to photograph the phenomenon. The photograph was taken looking eastwards towards Accra. The onset was so sudden that, on the first two occasions, some of the crowd thought the aircraft was exploding.

It was a fine morning and at the time of the photograph (1030 G.M.T.) the sky was cloudless with a few patches of haze over the sea. Nevertheless the visibility was more than 8 miles and ships  $2\frac{1}{2}$  miles away off Accra could be seen clearly. There are cliffs, 30–40 ft. high, all along the coast with a few slight indentations but no promontories; inland the land is undulating with one or two native huts and some palm trees 100 yd. from the cliff edge. The aura only seemed to occur when the aircraft passed at high speed through a patch of very slight haze at about 100 ft. above sea level approximately over the cliff edge. In interviews afterwards the airspeed was stated to be 550 m.p.h.

The phenomenon is clearly of the same origin as that described by R. F. Jones\* in connexion with a similar condensation photographed at Farnborough in September 1954. Areas of low pressure develop on the wing surface which lead to adiabatic cooling in the slowly moving boundary layer in contact with the wing. The depth of the boundary layer and the drop in pressure both increase with increasing airspeed, but each depends very closely on the aerodynamic qualities of the wing. The relation may be expressed very roughly by the formula

$$p - p_0 = \frac{1}{2} k \rho u^2$$

where  $u$  is the airspeed,  $p$  the pressure on the wing surface,  $p_0$  the ambient pressure,  $\rho$  the air density and  $k$  a function of the shape of the aerofoil and the distance from the leading edge. For straight subsonic flight at zero angle of incidence†  $k$  is positive with a value about 1.0 near the leading edge but a short distance away it soon becomes negative, and for most of the distance along the aerofoil would have a value about  $-0.2$ , the precise values depending on the wing profile‡. If we assume a value of  $-0.2$  and take the known conditions at Accra [pressure 1000 mb. at a height of 300 ft., airspeed 550 m.p.h. (= 250 m./sec. approximately), surface air temperature  $83\frac{1}{2}^{\circ}\text{F}$ ., surface dew point  $72^{\circ}\text{F}$ .] then the drop in pressure at the wing surface will be 68 mb. This is not quite sufficient for adiabatic condensation in straight flight.

However, the sea temperature off Accra in February is normally above  $80^{\circ}\text{F}$ . and an observation by s.s. *John Holt* in  $4^{\circ}36'\text{N}$ .  $3^{\circ}12'\text{W}$ . the following

\* JONES, R. F.; Condensation phenomena at the Exhibition of the Society of British Aircraft Constructors at Farnborough. *Met. Mag.*, London, **84**, 1955, p. 93.

† See GOLDSTEIN, S.; Modern developments in fluid dynamics. Oxford, 1938, p. 524.

‡ For higher subsonic speeds the numerical values of  $k$  away from the leading edge increase rapidly particularly on the upper wing surface, see HOWARTH, L.; Modern developments in fluid dynamics. High speed flow. Oxford, 1953, p. 622.

day measured a sea temperature of 78°F. So that if we can assume the wet-bulb temperature at least 78°F. with the onset of the sea-breeze bringing patches of moister air (the haze patches described earlier) over the cliffs, condensation would occur with an adiabatic fall of no more than 50 mb. As a rule during the display the airspeed was insufficient or the air too dry for the aura to form. But over the cliff edge where the sea-breeze was just beginning to break through in patches the air would be moist enough to condense about  $1\frac{1}{2}$  gm. of water droplets in each cubic metre of air, quite sufficient to produce the observed effect. The effect is accentuated by higher speeds at the end of a dive (when the angle of incidence of the aerofoil is least) or by increased values of  $k$  during a turn but it is likely that the patchy onset of the sea-breeze was the most important contributing factor.

P. B. SARSON

### Night cooling curves for Achnagoichan

Recent suggestions<sup>1</sup> relating to the significance of spring anomalies in the times of the discontinuities ( $T_c$ ) occurring on clear nights have led to the examination of a Scottish record maintained at high level. The thermograph at Achnagoichan (57°09'N. 3°49'W. height 1,000 ft.) is controlled by the Nature Conservancy on a site which has much in common with Alston, Cumberland where the records have already been analysed. Both are about 1,000 ft. above the sea, and their aspects are similar. The significant difference is that of latitude, and it was considered probable that a northerly station like Achnagoichan might exaggerate the effects determined at English stations because of the greater variations in lengths of daylight.

The exceptional number of clear nights during 1955 has been helpful to this study, and Fig. 1 shows the final plotting. The charts were for weekly periods

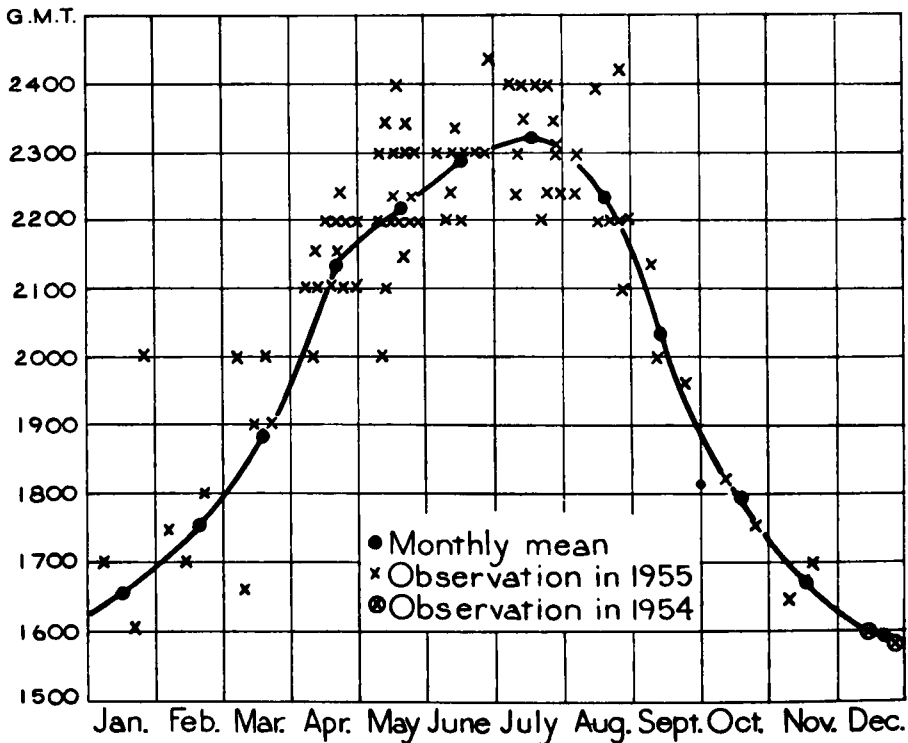


FIG. 1.—ANNUAL VARIATION OF TIME OF EVENING DISCONTINUITY OF TEMPERATURE

so that a time unit of 30 min. forms the limit of accuracy. The spring bulge appears to suggest early drying out, but in view of the controversial aspects of this topic stimulated by Bruce<sup>2</sup> it has been deemed proper to reproduce all the points on the graph so that it may be judged that the curve-fitting is in order.

The plotting of the temperatures at the discontinuity against the resulting minima was disappointing since occasions of low temperatures without snow cover were not recorded. As a result the contention arising from the Alston analysis<sup>1</sup> that 15°F. is the absolute minimum under these conditions received no further support. The graph is almost linear and is so disposed as to give

$$T_{\min} \approx T_r - 6$$

throughout the entire winter-summer range of minima between 0°F. and 62°F., irrespective of snow cover.

W. E. RICHARDSON

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2. BRUCE, W. J.; Night cooling curves for Wahn, Germany. *Met. Mag., London*, **84**, 1955, p. 105.

#### REVIEWS

*Problems and control of air-pollution*. Edited by F. S. Malette. 9½ in. × 6 in., pp. vi + 272, *Illus.* Reinhold Publishing Corporation, New York and Chapman & Hall Ltd., London, 1955. 60s.

Atmospheric pollution is a subject which arouses verbosity if not eloquence in a large number of people. The vast quantities of smoke and other impurities discharged each day into the atmosphere inspire well justified anger in all of us, but those who have to make a study of air pollution are also beset by the acres of print that are covered with writings upon this subject. There is clearly much in common between air pollution and sin. Everyone is against them but comparatively few do anything positive about either. One need only spend a foggy morning in an industrial area to become convinced that the one sin calling for urgent and drastic remedies is air pollution.

The literature on atmospheric pollution is so enormous that anyone trying to keep abreast of even a few of the different aspects must occasionally give way to a sense of frustration at the immensity of his task. A special welcome is therefore given to this book which consists of the papers presented at the First International Congress on Air Pollution held in March 1955, and sponsored by the American Society of Mechanical Engineers. The various papers, 25 in all, provide an up-to-date account of many of the most important problems associated with the occurrence of air pollution and with the possibilities of exercising greater control over it.

The first chapter deals with the growth and moulding of public opinion and is by Sir Hugh Beaver, who was Chairman of the Committee on Air Pollution set up by the British Government shortly after the disastrous London smog of December 1952. Then follows a chapter on the responsibilities of management in which it is demonstrated that industrialists, provided they have a social conscience, can do much to reduce the worst effects of pollution without waiting for the compulsion of legislation. These two chapters on the complementary roles of a responsible management and an enlightened public opinion form a social document of the first importance.

The next set of chapters is concerned with the discussion of important gaps in our knowledge of air pollution in such fields as biology, health, meteorology and engineering. Professor Hewson, whose writings are well known to readers of this Magazine, contributes a chapter on meteorology and gives an informative appreciation of the difficult problems of estimating ground concentrations of pollution that still await a comprehensive solution.

An important section of the book is devoted to the question of removing sulphur dioxide from flue gases before their release into the atmosphere. Sulphur dioxide is produced wherever fuel, whether in the form of coal, coke or oil is burnt, and, as the report of the Beaver Committee states, in Great Britain about 5 million tons of this highly toxic gas are discharged to the air each year. The removal of sulphur dioxide is therefore a question of extreme importance but the costs are enormous and it appears that effective measures must await the development of a recovery process that would yield substantial quantities of saleable sulphur and sulphur compounds.

The value of each section of the book is considerably enhanced by comprehensive bibliographies and altogether the organisers of the Congress are to be congratulated on this permanent record of their initiative. In these days it is customary for the reviewer to raise his eyebrows when the price of a book is much in excess of what it would have been if published before the last war. Relative values are not easily assessed but it is considered that the price of this book, taking account of the general contents and the number of illustrations and diagrams, is not unduly high.

P. J. MEADE

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*Frontiers to space.* By Eric Burgess.  $8\frac{3}{4}$  in.  $\times$   $5\frac{1}{2}$  in., pp. xvi + 174, *Illus.*, Chapman and Hall Ltd, London, 1955. Price: 21s.

Probably the most significant development in meteorology during the last few years has been the provision and use of routine measurements of wind, temperature and humidity up to considerable heights in the atmosphere. At present the ceiling of the radio-sonde balloon is at least as high as that of aircraft for which forecasts have to be made on a routine basis, and, moreover, it is above 90 per cent. or so of the mass of the atmosphere. Many meteorologists are therefore well content that the study of conditions at higher altitudes should be in the hands of the geophysicists, ionosphericists, and astronomers rather than be treated as yet another branch of meteorology. However, since the basic driving force for our weather is radiation from the sun and long-term forecasts can only follow from a study of solar-terrestrial relations it seems that ultimately the outer atmosphere will have to be studied in detail by meteorologists for this reason alone. Besides being considerably less accessible the outer atmosphere is, however, certainly no easier to study than the troposphere. A large number of new problems such as those of ionization, photochemistry and radiation conditions in the far ultra-violet end of the solar spectrum arise.

In "Frontiers to space" Mr. Burgess has attempted to summarize the present state of our knowledge of the atmosphere from the troposphere to outer space. Although investigations by other methods are not neglected, he is chiefly concerned with rockets, and has collected together in a single account all the information given up to date in many technical papers and reports about the American high-altitude rocket experiments. Extensive bibliographies are included. Some information is also given on the French rocket programme.



The arrangement of the early chapters of the book is to describe the main features of the work in the firing of rockets and how the experiments are made. An outline is given of the main physical features of the outer atmosphere, and then the principal investigations—those of pressure, temperature and composition—are dealt with in turn. Medical experiments with mice and monkeys are also described briefly. A good summary of our knowledge of the ionosphere both as derived from surface experiments and the rocket work is followed by a chapter on solar radiation. The results of the radiation measurements are to the meteorologist perhaps the most interesting section of the book. Before they became available our knowledge of the solar spectrum below  $3,000^{\circ}\text{A.}$  was very slight because of absorption of radiation below  $3,000^{\circ}\text{A.}$  by the ozone layer between about 20 and 60 Km. above the earth's surface. A great deal of information on this subject has been gained in recent years. As well as measurements of the solar spectrum and the ozone layer, information has been obtained on air glow both by day and by night. Finally there are two chapters on investigations of cosmic-ray phenomena and on artificial satellites, which, although more of astronomical or general scientific than of meteorological interest, complete the story of the rocket programme and point to the further work which must be done before space travel can be contemplated.

The general stress throughout the book is on experimental methods and techniques, the description of the phenomena to be investigated and the results obtained tending to be overshadowed by the accounts of the engineering methods in the experiments. The book abounds in excellent photographs of the rockets and the measuring gear, cut-away sections of the installations, and in line and block diagrams. In some respects the detail given appears to be too full for all but rocket enthusiasts. It is not of much interest to the general reader to learn for instance that a given type of rocket fired at a given time had a flight of a given duration, and then to find out that the experiment was a failure because a small part of the apparatus failed to operate. This emphasis on technology is however probably a true reflection of the stage attained at present by the research workers. While most meteorologists will admit that they ultimately owe practically all their present data at lower levels to the achievements of technologists, many are likely to be impatient in reading a book of this type when two thirds or so of it describes experimental methods and the remaining third results. Moreover the scope of the subjects covered is so very considerable that the reader will have to have a very wide field of interest to reap full benefit from all its various sections.

This book, however, should be generally welcomed as the first attempt to condense all the information now available into a short connected account, and can readily be used as a first introduction into the study of the outer atmosphere before a more intensive study of a particular aspect of the work is undertaken. It is not entirely free from errors and obscurities. For example the discussion of winds at high levels on pp. 69–71 does not leave the reader with a clear picture of the general circulations, and the fact that these winds vary with altitude and are subject to tidal influences seems to have been ignored. This is not surprising in a book covering so many facets of the subject, but the few errors that exist are comparatively minor and do not detract from its value to the general reader. Its production and layout are excellent.

R. J. MURGATROYD

## HONOURS

The following awards were announced in the Birthday Honours List, 1956:—

C.B.E.

Mr. S. P. Peters, Deputy Director, Meteorological Office

M.B.E.

Mr. G. A. Howkins, Senior Scientific Officer, Meteorological Office

Mr. R. J. Williams, Senior Experimental Officer, Meteorological Office

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Sir Graham Sutton, C.B.E., F.R.S., Director of the Meteorological Office, received the honorary degree of Doctor of Science at Leeds University on Thursday, May 17, 1956.

## OBITUARY

*Mr. John Ransome Bright.*—It is with deep regret that we learn of the death of Mr. J. R. Bright, Senior Scientific Assistant, on May 28, 1956, at the age of 33. He joined the Office as a Temporary Meteorological Assistant in December 1940, and after a course at the training school he served for some time at aviation outstations. Since 1944 he has been employed on radio-sonde and sferics duties. At the time of his death he was serving at Hemsby.

## METEOROLOGICAL OFFICE NEWS

**Ocean weather ships.**—The following is an extract taken from a report of the Master of an ocean weather ship:

*o.w.s. Weather Recorder.*—Voyage 67—On a bright summery day, the first day of British Summer Time, we arrived at the Great Harbour after a voyage which had been truly delightful. With the exception of a couple of days of strong force gale, on the day of the mail drop and the day of relief by the *Cirrus*, the weather has been very kind to us and for the first time in years we were able to have a boat out on a full scale ASR exercise when advantage was taken to try out the "Salvita" boat radio. Later that day rubber dinghy races were arranged between the departments.

The food has been very well cooked and the menu varied. The films have been very good indeed and these films twice weekly certainly break up the monotony of the voyage.

**Sports activities.**—*Netball.*—The Meteorological Office Ladies Netball team won the Air Ministry tournament on May 26, 1956 for the eighth consecutive year. A team from the Central Forecasting Office, Dunstable gained fourth place.

*Chess.*—The Air Ministry chess championship of 1955–56 has been won for the third time by Mr. P. M. Shaw; second was Dr. J. Pepper, third Mr. P. B. Sarson. This is the first occasion that all three top places have been attained by members of the Meteorological Office. It is the seventh time in ten years that the Meteorological Office has provided the Air Ministry chess champion.

*Contract bridge.*—This year's Air Ministry Contract Bridge individual championship has been won by Mr. G. T. Smith. Mr. A. E. Milne was joint runner-up.

## WEATHER OF MAY 1956

The month was remarkable for a degree of approach to regular zonal movement of depressions in both Atlantic and Pacific sectors seldom seen in May. In the case of the Atlantic this was clearly associated with greater extent and intensity than usual of the residual cold trough

over the north-eastern half of North America (anomaly  $-5^{\circ}\text{C.}$  both south-east and south-west of Hudson Bay, but  $+5^{\circ}\text{C.}$  over New Mexico). The depressions travelled on tracks well to the north-east, commonly passing through the Denmark Strait and up the east coast of Greenland. There was a remarkable absence of the usual May anticyclones over north Greenland and Iceland. The mean map for the month shows a well developed Iceland low, 8 mb. deeper than usual and displaced far to the north-east from its usual May position off Labrador. The Azores anticyclone was also more intense than usual and displaced 500 miles to the north-east. Maximum anomalies were  $-12$  mb. in north Iceland, north-east Greenland and Jan Mayen and  $+9$  mb. north of the Azores. North-east Siberia was also rather colder than usual (maximum anomaly  $-3^{\circ}\text{C.}$ , whilst Japan had anomalies of  $+1^{\circ}$  to  $+4^{\circ}\text{C.}$ ) and the low off south-west Alaska was 5 to 7 mb. deeper than normal on the mean map. The monsoon depression over south Asia was 6 mb. deeper than usual in May and the monsoonal development of low pressure over Siberia also appeared more advanced than usual.

Rainfall was well above normal over central and south-western India, and in a belt from Burma to Indo-China, the Philippines and southern Japan. Ceylon and north-west India and the Punjab however remained dry. Rainfall was also over twice the normal for May in parts of Iceland and west and north Norway. Notably dry weather over eastern Scandinavia and the Baltic accompanied the persistent westerlies in that region.

In the British Isles, May was sunny and very dry. Over a broad area of the Atlantic, to the north-west of the country, there was much cyclonic activity, which frequently affected north-western districts but was of little significance further south. During the first half of the month pressure was high from the Azores to western Europe, and for much of the remainder, a ridge of varying intensity extended from an anticyclone over the Atlantic to the British Isles.

During the first week slight rain or drizzle occurred daily in many places though sunny periods predominated. Temperature rose fairly steadily and by the 5th exceeded  $70^{\circ}\text{F.}$  locally in southern England and was in the middle sixties in Scotland and northern Ireland. London Airport and Mildenhall reached  $76^{\circ}\text{F.}$  on the 6th, but persistent sea fog over parts of the south and west coasts kept temperatures  $20^{\circ}\text{F.}$  lower. At the beginning of the second week frontal activity spread further south and on the 9th there was rain at times over most of the country. The following two days were showery with gales in Scotland on the 11th. Winds were mainly between W. and NW. and the weather showery with sunny periods during most of the third week; on the 16th cooler air spread south and an anticyclone moved eastward in the cold air, becoming centred over Ireland on the 19th. Ground frost was widespread for several nights and there was some slight air frost, but on the 21st a slow southerly drift of wind developed and temperatures rose progressively to reach the middle seventies locally in England on the 23rd. From the 25th to the 27th the Azores anticyclone extended eastward across the British Isles and weather was warm and sunny in most districts; more than 15 hr. of sunshine were recorded at many places and temperature reached  $76^{\circ}\text{F.}$  at Renfrew on the 27th and 28th and  $78^{\circ}\text{F.}$  at London Airport on the 28th. A depression from Portugal moved slowly northwards bringing outbreaks of thundery rain to England on the 29th, but the 31st brought a change to a north-westerly flow over the whole country.

May was the fourth successive month of dry weather in most parts of the British Isles, rainfall in many places over the four months February to May being only about a quarter of the normal amount. Kew Observatory had its driest May since 1896 with only 0.22 in. while at Tyne-mouth it was the driest since records began in 1864. Rainfall was less than half an inch over a wide area of the Midlands and central southern England. Sunshine was generally well above average. Most areas had 120–130 per cent. of their average, and very few places recorded less than 200 hr. during the month. On the Air Ministry roof more sunshine was recorded than in any month since June 1952. Growth of vegetation, especially grass and corn, was slow because of the continued dry weather. Frosts, particularly during the early hours of the 19th–21st and 27th damaged young potato haulms, beans, strawberry plants, black currants and in some cases top fruit. Forest and heath fires, some very serious, were frequent.

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 |
|                       | $^{\circ}\text{F.}$ | $^{\circ}\text{F.}$ | $^{\circ}\text{F.}$                | %                      |                                     | %                      |
| England and Wales ... | 82                  | 23                  | +1.4                               | —5                     | 39                                  | 128                    |
| Scotland ...          | 78                  | 24                  | +1.9                               | +1                     | 101                                 | 102                    |
| Northern Ireland ...  | 70                  | 27                  | +1.8                               | 0                      | 56                                  | 95                     |

# RAINFALL OF MAY 1956

## Great Britain and Northern Ireland

| County          | Station                     | In.  | Per cent. of Av. | County             | Station                   | In.  | Per cent. of Av. |
|-----------------|-----------------------------|------|------------------|--------------------|---------------------------|------|------------------|
| <i>London</i>   | Camden Square ...           | 0·43 | 24               | <i>Glam.</i>       | Cardiff, Penylan ...      | 1·07 | 44               |
| <i>Kent</i>     | Dover ...                   | 0·34 | 20               | <i>Pemb.</i>       | Tenby ...                 | 1·01 | 44               |
| "               | Edenbridge, Falconhurst     | 0·50 | 27               | <i>Radnor</i>      | Tyrmynydd ...             | 0·96 | 28               |
| <i>Sussex</i>   | Compton, Compton Ho.        | 0·37 | 17               | <i>Mont.</i>       | Lake Vyrnwy ...           | 1·51 | 47               |
| "               | Worthing, Beach Ho. Pk.     | 0·34 | 21               | <i>Mer.</i>        | Blaenau Festiniog ...     | 5·43 | 96               |
| <i>Hants.</i>   | St. Catherine's L'thouse    | 0·42 | 26               | "                  | Aberdovey ...             | 1·90 | 76               |
| "               | Southampton (East Pk.)      | 0·28 | 14               | <i>Carn.</i>       | Llandudno ...             | 0·78 | 44               |
| "               | South Farnborough ...       | 0·20 | 11               | <i>Angl.</i>       | Llanerchymedd ...         | 1·70 | 72               |
| <i>Herts.</i>   | Harpenden, Rothamsted       | 0·56 | 29               | <i>I. Man</i>      | Douglas, Borough Cem.     | 1·48 | 59               |
| <i>Bucks.</i>   | Slough, Upton ...           | 0·19 | 11               | <i>Wigtown</i>     | Newton Stewart ...        | 1·47 | 56               |
| <i>Oxford</i>   | Oxford, Radcliffe ...       | 0·33 | 18               | <i>Dumf.</i>       | Dumfries, Crichton R.I.   | ...  | ...              |
| <i>N'hants.</i> | Wellingboro' Swanspool      | 0·49 | 25               | "                  | Eskdalemuir Obsy. ...     | 3·87 | 117              |
| <i>Essex</i>    | Southend, W. W. ...         | 0·37 | 26               | <i>Roxb.</i>       | Crailing ...              | 0·75 | 37               |
| <i>Suffolk</i>  | Felixstowe ...              | 0·74 | 56               | <i>Peebles</i>     | Stobo Castle ...          | 1·53 | 67               |
| "               | Lowestoft Sec. School ...   | 0·73 | 45               | <i>Berwick</i>     | Marchmont House ...       | 0·65 | 26               |
| "               | Bury St. Ed., Westley H.    | 0·83 | 46               | <i>E. Loth.</i>    | North Berwick Gas Wks.    | 0·52 | 27               |
| <i>Norfolk</i>  | Sandringham Ho. Gdns.       | 1·04 | 57               | <i>Midl'n.</i>     | Edinburgh, Blackf'd. H.   | 0·57 | 28               |
| <i>Wilts.</i>   | Aldbourne ...               | 0·45 | 22               | <i>Lanark</i>      | Hamilton W. W., T'nhill   | 1·77 | 74               |
| <i>Dorset</i>   | Creech Grange ...           | 0·55 | 27               | <i>Ayr</i>         | Prestwick ...             | 1·46 | 75               |
| "               | Beaminster, East St. ...    | 0·67 | 33               | "                  | Glen Afton, Ayr San. ...  | 2·83 | 94               |
| <i>Devon</i>    | Teignmouth, Den Gdns.       | 0·76 | 42               | <i>Renfrew</i>     | Greenock, Prospect Hill   | 3·68 | 113              |
| "               | Ilfracombe ...              | 0·91 | 44               | <i>Bute</i>        | Rothsay, Arden Craig ...  | ...  | ...              |
| "               | Princetown ...              | 2·01 | 47               | <i>Argyll</i>      | Morven, Drimnin ...       | 4·48 | 139              |
| <i>Cornwall</i> | Bude, School House ...      | 0·76 | 41               | "                  | Poltalloch ...            | 2·84 | 98               |
| "               | Penzance ...                | 1·64 | 74               | "                  | Inveraray Castle ...      | 7·36 | 187              |
| "               | St. Austell ...             | 1·02 | 42               | "                  | Islay, Eallabus ...       | 2·59 | 98               |
| "               | Scilly, Tresco Abbey ...    | 1·61 | 95               | "                  | Tiree ...                 | 2·99 | 120              |
| <i>Somerset</i> | Taunton ...                 | 0·28 | 16               | <i>Kinross</i>     | Loch Leven Sluice ...     | 1·72 | 70               |
| <i>Glos.</i>    | Cirencester ...             | 0·68 | 32               | <i>Fife</i>        | Leuchars Airfield ...     | 0·63 | 32               |
| <i>Salop</i>    | Church Stretton ...         | 0·40 | 16               | <i>Perth</i>       | Loch Dhu ...              | 5·56 | 124              |
| "               | Shrewsbury, Monkmore        | 0·42 | 22               | "                  | Crieff, Strathearn Hyd.   | 1·64 | 66               |
| <i>Worcs.</i>   | Malvern, Free Library ...   | 0·79 | 37               | "                  | Pitlochry, Fincastle ...  | 1·80 | 85               |
| <i>Warwick</i>  | Birmingham, Edgbaston       | 0·58 | 25               | <i>Angus</i>       | Montrose, Sunnyside ...   | 0·44 | 22               |
| <i>Leics.</i>   | Thornton Reservoir ...      | 0·59 | 29               | <i>Aberd.</i>      | Braemar ...               | 1·22 | 51               |
| <i>Lincs.</i>   | Boston, Skirbeck ...        | 0·64 | 36               | "                  | Dyce, Craibstone ...      | 0·52 | 20               |
| "               | Skegness, Marine Gdns.      | 0·53 | 31               | "                  | New Deer School House     | 0·71 | 33               |
| <i>Notts.</i>   | Mansfield, Carr Bank ...    | 0·40 | 19               | <i>Moray</i>       | Gordon Castle ...         | 0·42 | 20               |
| <i>Derby</i>    | Buxton, Terrace Slopes      | 1·27 | 41               | <i>Nairn</i>       | Nairn, Achareidh ...      | 1·02 | 57               |
| <i>Ches.</i>    | Bidston Observatory ...     | 0·74 | 39               | <i>Inverness</i>   | Loch Ness, Garthbeg ...   | 3·04 | 122              |
| "               | Manchester, Ringway ...     | 0·99 | 46               | "                  | Loch Hourn, Kinl'hour     | 9·24 | 172              |
| <i>Lancs.</i>   | Stonyhurst College ...      | 2·33 | 82               | "                  | Fort William, Teviot ...  | 7·68 | 195              |
| "               | Squires Gate ...            | 1·06 | 51               | "                  | Skye, Broadford ...       | 7·45 | 177              |
| <i>Yorks.</i>   | Wakefield, Clarence Pk.     | 0·58 | 29               | "                  | Skye, Duntuilum ...       | 4·64 | 163              |
| "               | Hull, Pearson Park ...      | 0·59 | 31               | <i>R. &amp; C.</i> | Tain, Mayfield ...        | 1·68 | 82               |
| "               | Felixkirk, Mt. St. John ... | 0·63 | 34               | "                  | Inverbroom, Glackour ...  | 4·64 | 155              |
| "               | York Museum ...             | 0·91 | 46               | "                  | Achnashellach ...         | 7·40 | 175              |
| "               | Scarborough ...             | 0·87 | 46               | <i>Suth.</i>       | Lochinver, Bank Ho. ...   | 3·49 | 137              |
| "               | Middlesbrough ...           | 0·36 | 19               | <i>Caith.</i>      | Wick Airfield ...         | 1·43 | 69               |
| "               | Baldersdale, Hury Res.      | 1·10 | 44               | <i>Shetland</i>    | Lerwick Observatory ...   | 2·60 | 124              |
| <i>Norl'd.</i>  | Newcastle, Leazes Pk. ...   | 0·37 | 19               | <i>Ferm.</i>       | Crom Castle ...           | 1·42 | 51               |
| "               | Bellingham, High Green      | 0·84 | 35               | <i>Armagh</i>      | Armagh Observatory ...    | 1·29 | 54               |
| "               | Lilburn Tower Gdns. ...     | 0·38 | 16               | <i>Down</i>        | Seaford ...               | 0·87 | 33               |
| <i>Cumb.</i>    | Geltsdale ...               | 1·43 | 55               | <i>Antrim</i>      | Aldergrove Airfield ...   | 0·83 | 37               |
| "               | Keswick, High Hill ...      | 3·14 | 98               | "                  | Ballymena, Harryville ... | 1·26 | 44               |
| "               | Ravenglass, The Grove       | 2·47 | 88               | <i>L'derry</i>     | Garvagh, Moneydig ...     | 1·38 | 54               |
| <i>Mon.</i>     | A'gavenny, Plás Derwen      | 1·05 | 35               | "                  | Londonderry, Creggan      | 2·36 | 90               |
| <i>Glam.</i>    | Ystalyfera, Wern House      | 2·59 | 74               | <i>Tyrone</i>      | Omagh, Edenfel ...        | 2·20 | 85               |