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P.I.C.A.O.

BY J. DURWARD, M.A.

What is P.I.C.A.O.? Many meteorologists must have asked themselves this question from time to time. The word is actually the abbreviated title of the Provisional International Civil Aviation Organization and the object of this note is to set out the genesis of the organization, its structure, its method of working and its activities, particularly in the field of meteorology.

Historical.—In order to get a clear picture, it will be necessary to go into international civil aviation matters between world wars 1 and 2 in some detail.

At the beginning of world war 1, aviation was in its infancy. During that war there was a rapid development of military aviation and it was clear that there would be rapid developments in international civil aviation after the war. Accordingly, representatives of the Governments who met in Paris in 1919 to make the treaties of peace and the Covenant of the League of Nations prepared also a "Convention relating to the regulation of aerial navigation."

The Convention stated the principles which should govern international flying, in particular, that each state would accord freedom of innocent passage above its territory to the aircraft of other states. It laid down the rules with regard to certificates of airworthiness, and the procedure to be observed on flights from one country to another. It also instituted a permanent Commission, the "International Commission of Air Navigation" to carry out the duties specified in the Convention and to see that the technical annexes to the Convention were amended or extended as necessary.

These annexes specified the details of registration of aircraft, certificates of airworthiness, form of logbook, rules as to lights and signals, rules as to licences, including medical tests for the operating crews and meteorological tests for pilots and navigators, specification of international aeronautical maps and the information to be entered on them, arrangements for the collection and dissemination of meteorological information and finally Customs provisions. The Meteorological Annexe of 1919 was completely revised in 1925 and further revisions were made year by year as aviation developed. These latter were generally technical in character, such as the modification of codes to ensure co-ordination with the International Meteorological Organization (I.M.O.).

The International Commission instituted by the Convention of 1919 was a permanent Commission under the direction of the League of Nations. The representatives of the United States had participated in the preparation of the Convention and its annexes. In particular in the preparation of the Meteorological Annexe, Major Blair, formerly of the Mount Weather upper air station of the United States, took an active part. The inclusion of the " League of Nations " condition had the consequence that the United States did not become a party to the Convention nor participate in the work of the Commission. The Union of Soviet Socialist Republics was also not a party to the Convention. The headquarters of the permanent Commission were in Paris.

As the United States did not adhere to the Convention and was rapidly developing civil aviation in the western hemisphere they called a Convention of the American States at Havana in 1928, and drew up there the " Pan-American Convention " which was broadly confined to a statement of the principles which the states adhering to it would observe in dealing with one another on questions of civil aviation. This Pan-American Convention made no arrangements for specifying uniform standards or for periodical discussion of common problems through the agency of a permanent organization.

The International Commission for Air Navigation was very largely a legislative body and, during the period between the wars, regional conferences were held in Europe to deal with the practical procedures required internationally in the day-to-day operation of the civil aviation services between the countries concerned. The first of such Conferences was the A.F.B.—Anglo-Franco-Belge Conference—which began in 1921, and was gradually extended until it included representatives of practically all the countries of Europe.

In order to ensure proper co-ordination of the meteorological arrangements agreed upon at meetings of this and similar conferences, the International Meteorological Organization instituted at Warsaw in 1935 a special Commission for Aeronautical Meteorology. This commission was constituted of two representatives nominated by the Aviation Authority in each State to represent the Meteorological Service responsible in that State for meeting aviation requirements.

This Commission held meetings at Paris in 1937, at Berlin in 1939, and drew up a system of regulations to form the basis of a complete revision of the Meteorological Annexe of the Air Convention.

When it became apparent that world war 2 would be decided in favour of the Allies within measureable time and United States civil aviation, which had previously been largely confined to the western hemisphere, would be extended to and would indeed become prominent in other continents, it was necessary to consider what should be the regulations governing this and other international flying.

The seat of the International Commission for Air Navigation was in Paris and was inaccessible. As the League of Nations was to be replaced by another organization it was a natural corollary that the International Commission for Air Navigation should also be replaced by another organization. Accordingly a Conference was called at Chicago in November 1944 to consider the preparation of an agreement which could form the basis of a world-wide convention. As Spain was invited to the Conference, the U.S.S.R. refused to participate and is not a signatory to the agreement nor a partner in the organization which grew out of the Chicago Conference and will be described below.

The deliberations of the delegates of the 52 nations represented at Chicago resulted in the adoption of a number of resolutions and recommendations constituting the Final Act of the Conference. The Final Act also contained the texts of the Convention on International Civil Aviation, the International Air Transport Agreement, the International Air Services Transit Agreement and the Interim Agreement on International Civil Aviation.

Twelve draft sets of regulations dealing with technical subjects were adopted as draft Technical Annexes to be incorporated later in the Final Act. Annexe I entitled " Meteorological Protection of International Aeronautics " was based largely on the regulations drawn up by the Commission for Aeronautical Meteorology of the International Meteorological Organization and on the Meteorological Annexe to the 1919 Convention.

The Chicago Conference, recognizing that some time must necessarily elapse before the formalities of ratification of the Convention could be completed, provided through the Interim Agreement for the establishment of a provisional organization of a technical and advisory nature to function until a convention came into force. This is known as P.I.C.A.O. Its seat is in Montreal, and Dr. Alfred Roper, the Permanent Secretary of the International Commission for Air Navigation set up under the 1919 Convention, became the secretary of this new organization.

Organization of P.I.C.A.O.—The governing bodies of P.I.C.A.O. are the Interim Assembly and the Interim Council.

The Interim Assembly is composed of delegates from member states (the number of which in April 1946 was 43). The Assembly meets annually and is responsible *inter alia* for the financial agreements of the Organization, the examination of matters referred to it by the Council and the election of member states to be represented on the Council.

The Interim Council is the executive instrument of the Organization—it constitutes in fact an international parliament on civil aviation matters.

It is composed of not more than 21 member states elected by the Assembly for a period of two years. The Council provides for the establishment of such subsidiary working groups as may be considered desirable, among which there are a Committee on Air Transport, a Committee on Air Navigation and a Committee on the International Convention for Civil Aviation. The Council supervises and co-ordinates the work of these three technical committees, receives and considers their reports, transmits to each member State these reports together with the findings of the Council and makes recommendations to the member States individually or collectively.

The President of the Interim Council is Dr. Edward Warner and the Secretary General, Dr. Albert Roper. The latter is the chief executive officer of the Organization. It is his responsibility to select and appoint the staff and to direct the activities of the bureaux of the secretariat. There are at present three bureaux corresponding broadly to the three committees mentioned above. Each bureau is divided into sections, e.g. the Air-Navigation Bureau includes among others a meteorology section—the chief of which is Mr. F. Entwistle, formerly Assistant Director, Meteorological Office.

How P.I.C.A.O. works.—As stated above, one of the duties assigned to the Council was the establishment of the committees on Air Navigation, Air Transport and the International Convention on Civil Aviation. The first of these " studies, interprets and advises on standards and procedures with respect to communications systems and air-navigation aids and recommends the adoption of minimum requirements and standards ". Due to the amount of detailed work that is involved in the drafting of these standards and recommended practices the work of the Air-Navigation and Air-Transport Committees has been assigned to various technical sub-committees (now called Divisions) including working groups on airfields, air routes and ground aids, rules of the air and air traffic control, meteorology, communications, search and rescue, maps and charts, etc. These Divisions or working groups of the main technical committees consist of representatives of member states and are not to be confused with the corresponding sections of the Secretariat, the staff of which are the administrative staff of P.I.C.A.O. The first meeting of the Meteorological Division was held in Montreal in November 1945 ; the second in October 1946.

To implement the standards and recommendations of the Technical Divisions P.I.C.A.O. launched a programme of regional meetings. These meetings consider the standards and their application to the requirements of particular regions. They also consider the value for civil use of the facilities developed during the war by the Allied Governments. Several such meetings have already been held at :—

Dublin, to consider the North Atlantic region	March, 1946
Paris, to consider the Europe-Mediterranean region	May, 1946
Washington, to consider the Caribbean region	August, 1946
Cairo, to consider the Middle-East region	September, 1946

The findings of these regional conferences are incorporated in a report to the Air-Navigation Committee which forwards its recommendations to the Interim Council, which in turn recommends to member States the implementation of the agreed procedures for a particular region.

Meteorology and P.I.C.A.O.—The function of the Meteorological Division of P.I.C.A.O. is to study, interpret and advise on standards and procedures with respect to the meteorological protection of international aeronautics. To date progress has been as follows :—

Annexe I of the Final Act of Chicago was based on Annexe G of the International Commission for Air Navigation (I.C.A.N.) and the " Règlement " developed by the International Commission for Aeronautical Meteorology (C.I.M.Aé.) at Berlin in 1939. There are 6 sections as follows :—

I. Classification of meteorological information.

II. General organization for meteorological protection of international aeronautics.

III. Networks of meteorological stations.

IV. Telecommunications requirements for the meteorological protection of international aeronautics.

V. Procedures for meteorological protection of flights on international air routes.

VI. Climatological information.

Consideration was given to the contents of Annexe I at the meeting of the Meteorological Division at Montreal in 1945 and the P.I.C.A.O. publication

" Recommendations for Standards, Practices and Procedures", February, 1946, sets the material out under 8 headings :—

1. Definitions.
2. General.
3. Meteorological service for international aeronautics.
4. Classification of meteorological information.
5. Meteorological observing stations and observations.
6. Aeronautical climatology.
7. Telecommunications for meteorology.
8. Procedures for meteorological service on international air routes.

As a result of the Dublin and Paris regional meetings a new publication entitled " Procedures for Air Navigation Services—Meteorology " has been produced. This is intended to apply meantime to the North Atlantic and Europe-Mediterranean regions only. It contains several ideas, however, which may be incorporated later in the Recommendations for Standards, Practices and Procedures after discussion by the Meteorological Division.

Procedures applicable to any one region are published in separate publications—" Supplementary Regional Procedures ". These contain details of meteorological offices, exchange of data, type of meteorological services on various air routes etc. The details of these publications are produced at the regional conferences.

Relationship between P.I.C.A.O. and the I.M.O.—It will be obvious from the scope of the " Recommendations for Standards, Practice and Procedures " that the meteorological activities of P.I.C.A.O. require careful co-ordination with those of the I.M.O. if duplication and consequent waste of effort are to be avoided.

The relationship between P.I.C.A.O. and I.M.O. was discussed at some length at the meeting of the C.I.M.Aé. in Paris in June, 1946. It was agreed by all that the joint efforts of the two organizations should have as their object :—

(*a*) Ensuring the best possible meteorological service for international aviation.

(*b*) Ensuring co-ordination between the meteorological arrangements for aviation and other international aviation arrangements and between the meteorological arrangements for aviation and other sections of the meteorological service.

(*c*) Avoiding confusion in meteorological instructions.

(*d*) Minimising duplication of work.

The efforts of the two organizations should in fact be directed towards the production of general regulations specifying the meteorological arrangements for international aviation which will be the same for all states whether members of the P.I.C.A.O. or not. The following procedure was finally recommended :—

(*a*) P.I.C.A.O. will invite the I.M.O. to send representatives to meetings of the P.I.C.A.O. Meteorological Division.

(*b*) The standards and practices developed at these meetings will be dealt with according to P.I.C.A.O. procedures with a view to their adoption as international standards and recommended practices for the member States of P.I.C.A.O.

(*c*) These standards and practices will also be dealt with according to I.M.O. procedures with a view to recommending them for application by all meteorological services represented in the I.M.O.

(*d*) The P.I.C.A.O. standards and recommended practices will contain a statement to the effect that they have been prepared in collaboration with the I.M.O.

(*e*) With regard to questions of general meteorology, P.I.C.A.O. will continue to accept the recommendations of the I.M.O.

As already mentioned the next meeting of the P.I.C.A.O. Meteorological Division was held in October 1946 and one of its chief duties was the consideration of the " Recommended Standards, Practices and Procedures ", which it is hoped will then be given a large measure of finality. It is too early yet to say how the procedure recommended for adoption in Paris will work in practice but with a good deal of give and take on both sides there is no reason why the two organizations should not work together for the common good.

AN AZIMUTHAL METHOD OF MEASURING CLOUD HEIGHT WITH A SEARCHLIGHT

BY E. G. BILHAM, B.SC., D.I.C.

The normal method of determining the height of the cloud base at night is to direct a vertical searchlight beam on to the cloud and measure the angle of elevation E of the spot of light from a point at a known horizontal distance L from the searchlight. The height h of the cloud base is then given by $h = L \tan E$. The length L of the base line is normally about 1,000 ft.

The precision of the method clearly depends upon the accuracy with which the angle of elevation E can be measured. In practice a limit to the observational accuracy is set by the fact that the spot of light is never sharply defined, because of the diffuse nature of the cloud surface. A reading to the nearest whole degree is therefore the best that can be expected.

Curve I in Fig. 1 shows the relationship between E and h for the case $L = 1{,}000$ ft. It will be seen that for heights exceeding 4,000 ft. the rate of increase of E with h is very small. The increase of elevation between $h = 5{,}000$ ft. and $h = 10{,}000$ ft. is in fact only 5·6 degrees. As E can only be measured to the nearest degree, cloud heights in this range can therefore only be measured to about the nearest 1,000 ft. The new code for height of cloud adopted by the International Meteorological Committee at Paris in 1946 provides for reporting observations to the nearest 300 ft. in this range. Provision is also made for reporting the height of medium cloud as well as low cloud. It is necessary therefore to consider means of improving upon the accuracy obtainable by the present method.

Some improvement in the dispersion of the angles of elevation can be obtained by increasing the length of the base line. Curve II in Fig. 1 shows the result of increasing L to 4,000 ft. Comparing curve II with curve I it will be seen that the slope is increased for heights above about 3,000 ft. and reduced for heights below that value. In other words we secure a gain in the precision of measurement for the greater heights at the cost of a loss in precision for the lower heights. There are, moreover, very serious objections to increasing the base line much beyond 1,000 ft. One objection is the deterioration in the visibility of the spot of light ; another is the increased cost of laying the electric cable between the searchlight and the point of observation.

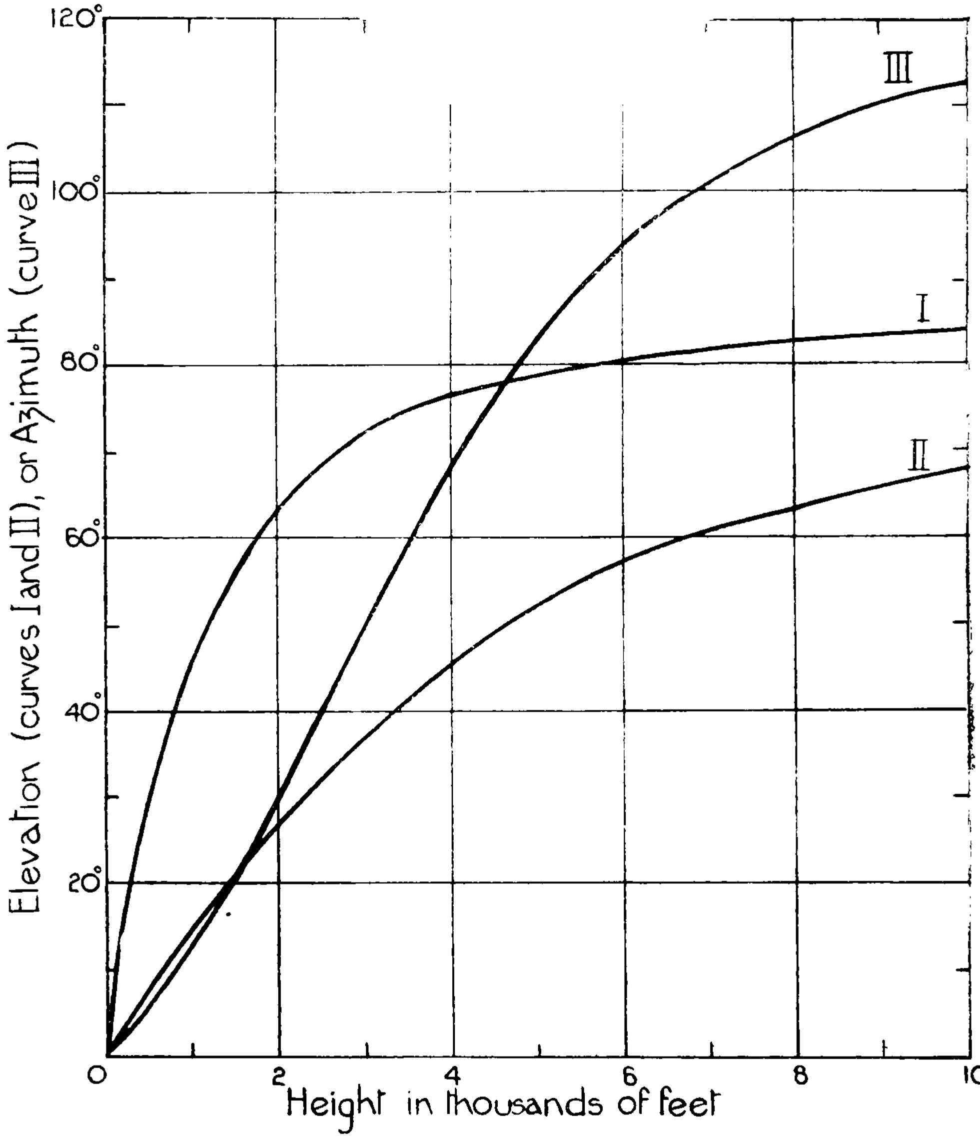


FIG. 1—RELATIONSHIP BETWEEN HEIGHT OF CLOUD BASE AND ELEVATION OR AZIMUTH

Curve I—for vertical beam with base line $L = 1{,}000$ ft.
Curve II—for vertical beam with base line $L = 4{,}000$ ft.
Curve III—for inclined beam with base line $L = 1{,}000$ ft.
$\alpha = 76°, \beta = 45°$

We are therefore led to consider whether any advantage can be obtained by using an inclined searchlight beam instead of a vertical beam.

If the searchlight beam is tilted out of the vertical in a direction transverse to the line of sight, both the azimuth and elevation of the spot of light will vary with the height of the cloud. It is possible therefore to make use of the variation of azimuth to determine the height of the cloud. If, in Fig. 2, α is the angle of inclination of the beam to the horizontal plane, β is the angle of orientation of the beam and θ is the azimuth of the spot of light (δ and θ both being measured from the direction of the base line as zero), it is readily shown that

$$h = L \tan \alpha . \sin \theta . \operatorname{cosec} (\beta + \theta) \qquad ..(1),$$

The simplest case is that in which β is 90°, that is to say, when the beam is tilted in a direction at right angles to the base line. Equation (1) then reduces to

$$h = L \tan \alpha . \ \tan \theta \qquad ..(2)$$

Comparing equation (2) with the equation $h = L \tan E$ we see that the result is the same as that which would be obtained by the elevation method with a base line of length $L \tan \alpha$. If, for example, we used a 1,000 ft. base line and inclined the beam at an angle $\tan^{-1} 4$, or 76°, to the horizontal, equation (2) would become $h = 4{,}000 \tan \theta$, and the curve of relationship between h and θ would be identical with curve II of Fig. 1. In other words we should secure such advantages as are possessed by curve II, with a base line only 1,000 ft. long.

Investigation shows however that we can do very much better if we make the angle of orientation β less than 90°. Curve III shows the relation between height and azimuth for the case $\alpha = 76°$, $\beta = 45°$, $L = 1{,}000$ ft. It will be seen that for heights exceeding 2,000 ft. curve III is substantially steeper than either curve I or curve II. In particular the change of θ between $h = 5{,}000$ ft. and $h = 10{,}000$ ft. is 31 as compared with a change of 5.6° in E (curve I) for the same difference of height, using the same length of base line.

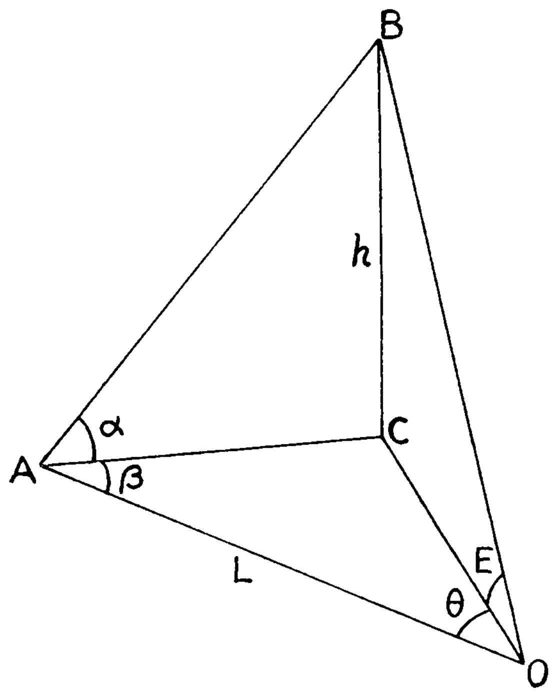


FIG. 2

A—Searchlight
B—Spot of light on cloud
C—Point on ground vertically below B
O—Point of observation
AB—Searchlight beam
AO—Base line of length L

It will be seen from Fig. 2 that

$$BO = (h^2 + CO^2)^{\frac{1}{2}}$$

$$CO = CA \frac{\sin \beta}{\sin \theta} = h . \ \cot \alpha . \ \sin \beta . \ \text{cosec}\ \theta .$$

Thus $BO = h\,(1 + \cot^2\alpha.\ \sin^2\beta.\ \operatorname{cosec}^2\theta)^{\frac{1}{2}}$.

For the case $\alpha = 76°$, $\beta = 45°$ this becomes

$$BO = h\,(1 + \tfrac{1}{32}.\ \operatorname{cosec}^2\theta)^{\frac{1}{2}}.$$

For all values of h above about 1,000 ft. the square root of the quantity in brackets differs little from unity. Consequently the " slant range " of the spot of light is never very different from the height of the cloud.

For heights below about 2,000 ft. the rate of change of elevation with height is very rapid, and is in fact rather more rapid with a tilted beam orientated at 45° to the direction of the base line than with a vertical beam. It is concluded therefore that the best method of applying the searchlight method is to use the inclined beam system here described, making measurements of elevation for heights up to 2,000 ft., and of azimuth for greater heights.

For use when elevation is measured, we have from Fig. 2

$$h = L \sin\beta.\ \operatorname{cosec}(\beta + \theta).\ \tan E \qquad ..(3)$$

where E is the angle of elevation. From this expression, combined with equation (2) values of height in terms of angle of elevation can be calculated.

The value 76° for α was chosen for purposes of illustration, and it is not necessarily the best value to adopt for routine use. We have referred to the steepness of the curves in Fig. 1 in judging the advantages of different systems, but a better method of assessment is to study the variation of the quantity $100\,\triangle h/h$, where $\triangle h$ is the change of height represented by a change of one degree in the measured angle. The quantity $100\,\triangle h/h$ is thus the percentage error of height due to an error of one degree in the angle, and we should select the system for which this quantity is less than some agreed limit over the widest possible range of heights.

By differentiating equation (1) with respect to h and θ we obtain

$$\frac{\delta h}{h} = [\cot\theta - \cot(\beta + \theta)].\ \delta\theta \qquad ..(4)$$

The corresponding expression for a vertical beam is obtained by differentiating $h = L \tan E$, giving

$$\frac{\delta h}{h} = 2 \operatorname{cosec} 2E.\ \delta E \qquad ..(5)$$

In Fig. 3 curves have been plotted for values of α equal to 70°, 75° and 80° (L = 1,000 ft., β = 45°) and the curve for a vertical beam (L = 1,000 ft.) has also been drawn. If we adopt 5 per cent. as the limit of error to be tolerated we see that the required precision is only obtained with the vertical beam between 400 ft. and 2,500 ft. Using the azimuthal method the corresponding range is 900 ft. to 8,500 ft. for $\alpha = 70°$, 1,200 ft. to 11,500 ft. for $\alpha = 75°$, 1,900 ft. to 17,500 ft. for $\alpha = 80°$. As we propose to use the azimuthal method only for heights exceeding 2,000 ft., 80° is about the best value of α to select. There is no advantage in making α greater than 80° because we should get increasingly large errors at the lower end of the scale without any compensating advantages.

As regards β, the angle of orientation, we note that the whole range of azimuths for heights zero to infinity is comprised within the range $\theta = 0$ to $\theta = 180° - \beta$. This consideration indicates that β should be made small. We saw that there was a substantial gain in changing from $\beta = 90°$ to $\beta = 45°$, but a trial calculation for $\beta = 30°$ gave a less favourable curve than that for $\beta = 45°$, the value of $\Delta h/h$ tending to become large at the lower and upper ends of the scale. On the whole it would appear that 45° is about the optimum value.

It is recommended therefore that for the routine application of the method the values $\alpha = 80°$, $\beta = 45°$ should be standardised. The length of the base line should be as near as possible to 1,000 ft. It would be necessary of course to supply the observer with a simple form of theodolite, in which the telescope was replaced by a simple sighting rod or tube, instead of the present alidade. It would also be necessary to supply him with a table for converting readings of elevation and azimuth into heights and the corresponding code figures. A skeleton of such a table, calculated from the standard values, is given in Table I. At no point in the scale would it be necessary for the observer to measure both the elevation and the azimuth though it might be desirable for him to do so, as a check, for heights in the neighbourhood of 2,000 ft.

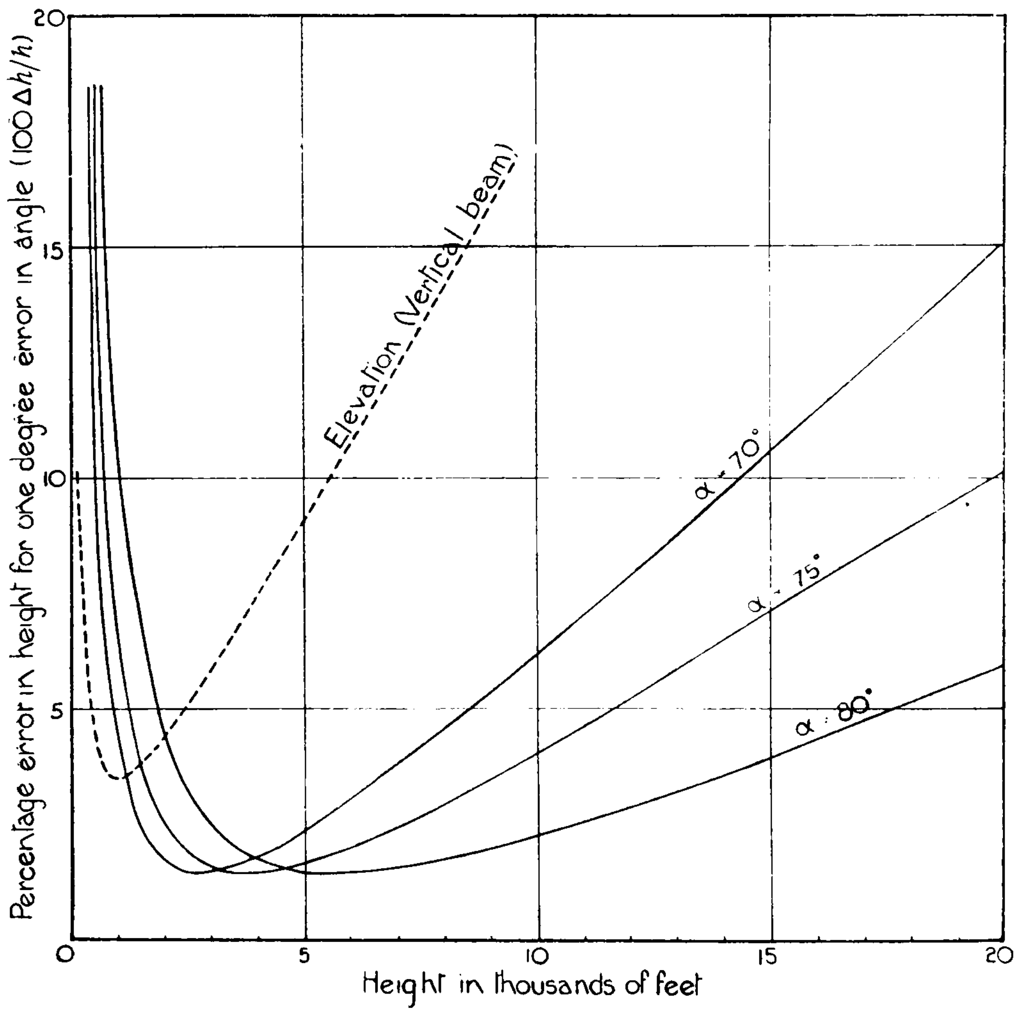


FIG. 3—PERCENTAGE CHANGE OF HEIGHT CORRESPONDING TO ONE DEGREE CHANGE OF AZIMUTH (FULL-LINE CURVES) OR ELEVATION (BROKEN-LINE CURVE)

In conclusion, it is perhaps necessary to point out that only the geometrical aspect has been considered in this note. It is not necessarily true to say that satisfactory measurements up to great heights could be obtained by taking an existing cloud searchlight and tilting it in the manner here recommended. It seems probable that a more powerful searchlight will be necessary to cover the extended range of heights now envisaged. Information on this and other points arising in the practical application of the method will be gained from trials which are planned to be carried out at Dunstable.

TABLE I

$L = 1{,}000$ ft. $\alpha = 80°$, $\beta = 45°$

Elevation	Height	Code figure †	Azimuth	Height	Code figure †
°	ft.		°	ft.	
5	85	01	20	2,140	21
10	170	02	25	2,550	25
15	260	03	30	2,935	29
20	350	03	35	3,300	33
25	425	04	40	3,660	37
30	540	05	45	4,015	40
35	650	07	50	4,360	44
40	760	08	55	4,715	47
45	890	09	60	5,085	51
50	1,040	10	65	5,470	55
55	1,220	12	70	5,880	56
60	1,460	15	75	6,330	56
65	1,750	17	80	6,820	57
70	2,150	21	85	7,380	57
			90	8,020	58
			95	8,780	59
			100	9,740	60
			105	10,960	61
			110	12,610	63
			115	15,030	65
			120	18,980	69

† Code 46* (h_1h_1)

Short base lines.—It will be seen from equation (1) that for given values of α, β and θ the height of the cloud base is directly proportional to L the length of the base line. Consequently, the operational table for any length of base line L can be obtained from the table calculated for $L = 1{,}000$ ft. by multiplying the heights by $L/1{,}000$.

At stations which are not on airfields there is often substantial difficulty in obtaining a base line as long as 1,000 ft., and it is therefore of interest to examine the effect of a large reduction in the value of L. The question is especially important in relation to the use of the method in a ship. We will therefore consider the extreme case of a base line of only 200 ft., which is rather less than the length possible in the corvettes to be used as British ocean weather stations. Table II has been calculated for this length of base line, and $\alpha = 80°$, $\beta = 45°$ as in Table I.

One result is immediately obvious, namely that for the lower heights the precision is very satisfactory. The new Paris code provides for a precision of 10 m. (33 ft.) for heights up to 300 m. (1,000 ft. approximately), and this standard is attained (assuming measurements of azimuth to the nearest whole degree) up to nearly 2,000 ft. The next step in the Paris scales, a precision of

100 m. (330 ft.), is attained up to nearly 5,000 ft., but beyond that point the precision falls off rather rapidly, though it is no worse than that obtained with a 1,000 ft. base line using the ordinary vertical beam method. The conclusion reached is therefore that the azimuthal method should give satisfactory readings of height of low cloud with a base line as short as 200 ft. Medium cloud height (above 8,000 ft.) could only be roughly determined. Difficulties associated with the rolling and pitching of the ship are of course not considered here.

TABLE II

$L = 200$ ft., $\alpha = 80°$, $\beta = 45°$

Azimnth	Height	Azimuth	Height
°	ft.	°	ft.
5	130	90	1,600
10	240	95	1,760
15	340	100	1,950
20	430	105	2,190
25	510	110	2,520
30	590	115	3,010
35	660	120	3,800
40	730	121	4,020
45	800	122	4,280
50	870	123	4,580
55	940	124	4,930
60	1,020	124	5,350
65	1,090	126	5,870
70	1,180	127	6,510
75	1,270	128	7,330
80	1,360	129	8,430
85	1,480	130	9,970

Heights are given to the nearest 10 ft.

THE FREQUENCY OF THUNDERSTORMS AT KEW OBSERVATORY

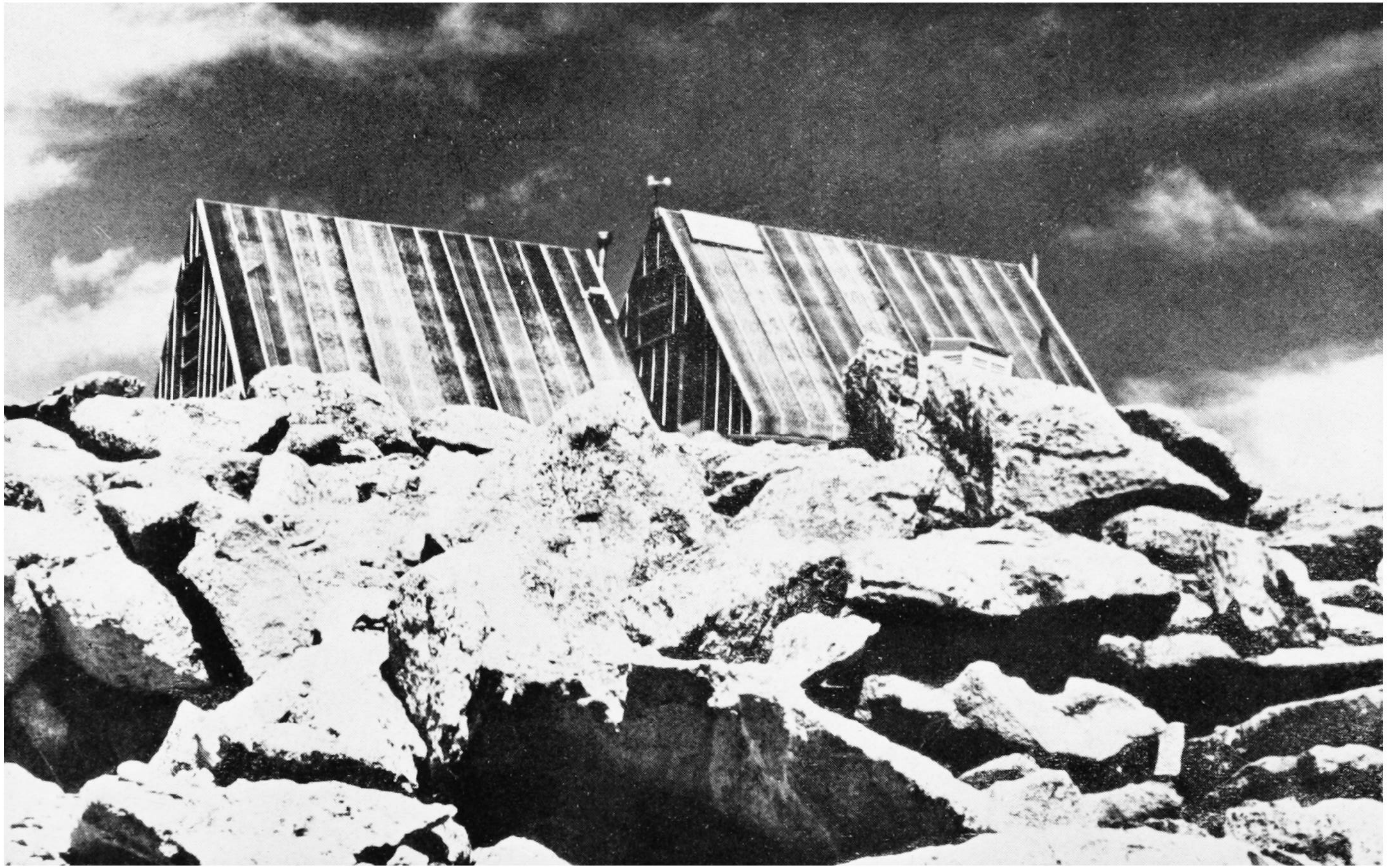
BY B. V. BISHOP

The periods reviewed in this paper are 1887–1945 for secular variation and 1910–35 for dirunal and annual variation. Throughout the period there has been little change in the routine of observations. No specific watch was kept for thunderstorms, but with thunder being an important meteorological phenomenon anyone who heard thunder would inform the observer, and an entry would be made in the register. Under such a system some occasions of thunder would be missed, but the number would be very small in working hours. After the observatory was closed in the evening the resident caretaker took observations at 10 p.m., and he also noted all occasions when he heard thunder through the night. From January, 1914, onwards there was a resident observer as well as a caretaker at the observatory. In this way the record is probably complete between 7 a.m. and 10 p.m. but outside these hours there

Photograph by S.A.A.F.

CLOUD DISPERSAL

This photograph was contributed by Dr. R. Frith, who was the Meteorological Officer at George, South Africa. It illustrates the dispersal of cloud over the lee side of a range of mountains. The cloud covers the sea and the 10-mile wide belt between sea and mountains. The height of the mountains shown varies from about 1,800 ft. in the foreground to 5,200 ft. (the highest peak).



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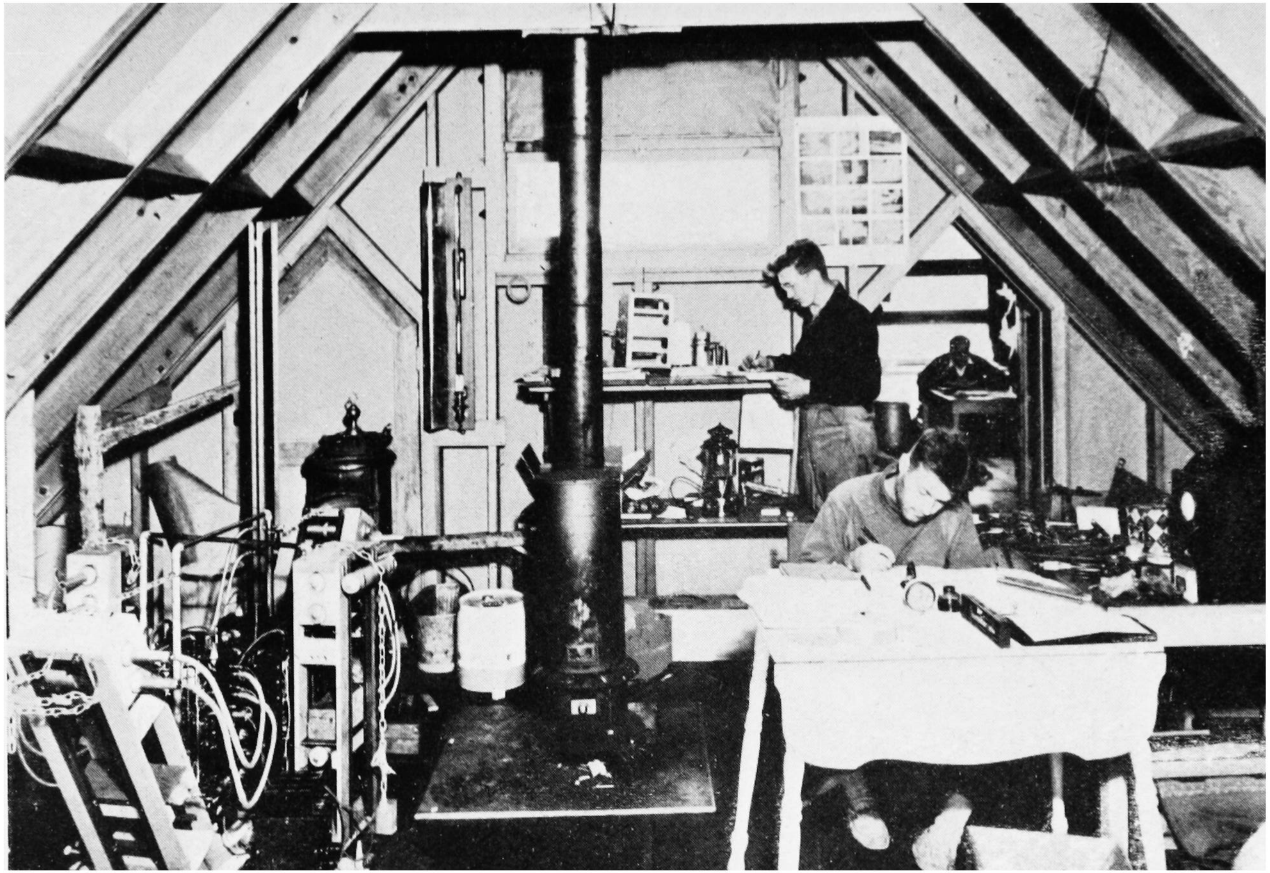
STORM LABORATORY ON THE PEAK OF MT. EVANS, COLORADO, U.S.A.

Living quarters are on the left, research laboratory on the right.
(see p. 115)



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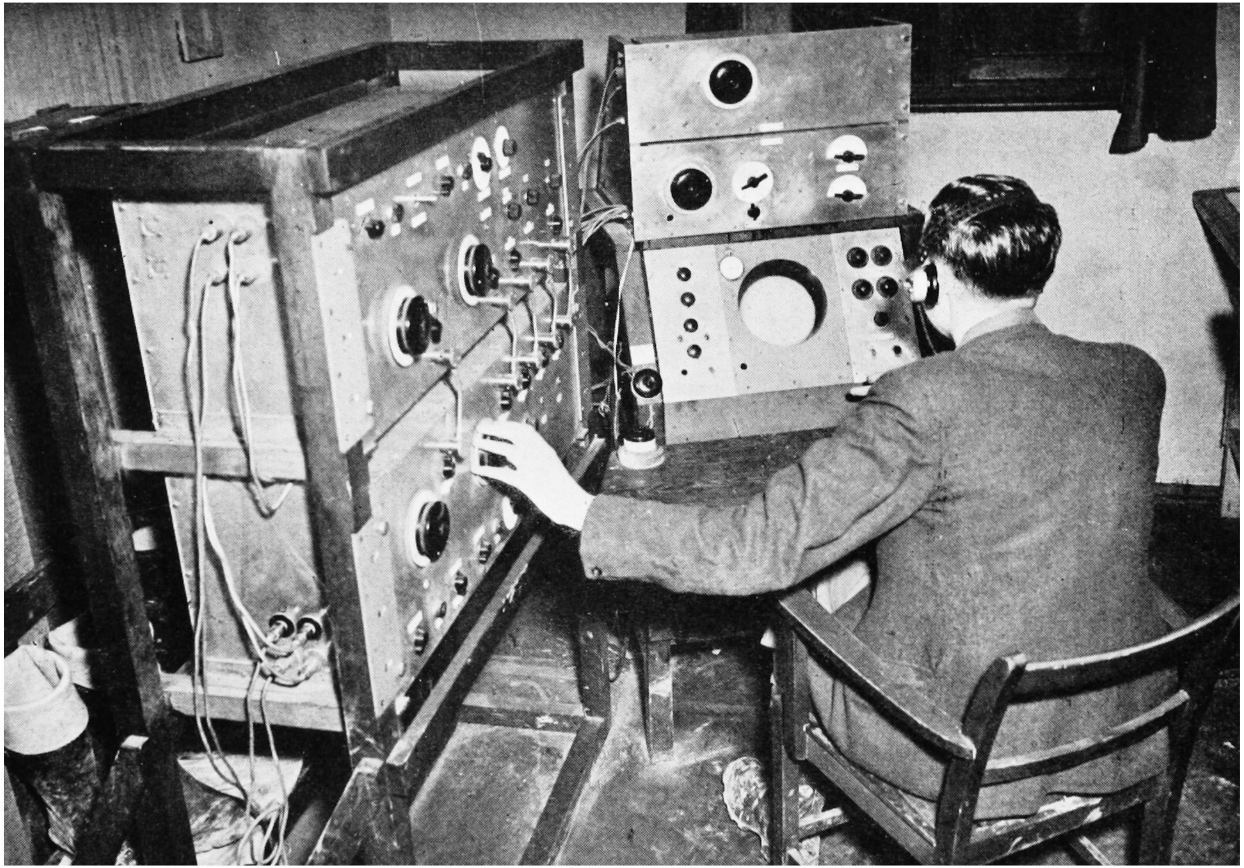
INTERIOR OF THE RESEARCH LABORATORY ON MT. EVANS

(see p. 115)



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" SFERIC " DIRECTION-FINDING APPARATUS AT DUNSTABLE

The bearings of distant-lightning flashes are read on the scale of degrees on the cathode-ray tube. (See article " Sferics " in *Meteorological Magazine*, April, 1947, p. 88) must have been cases of distant thunder which were not reported. In spite of this defect in the method of observing it is considered that the available data give a good representation of the frequency. The years prior to 1910 were not used in computing the diurnal variation owing to the rather large number of occasions when insufficient indication of time was given to enable allocation to definite 2-hour periods.

Secular Variation.—The total number of days on which thunder was heard in each year from 1877 to 1945 is given in Fig. 1. The variations are considerable, the extremes being 27 days in 1924 and 4 days in 1877. The mean is 14·9 days per annum.

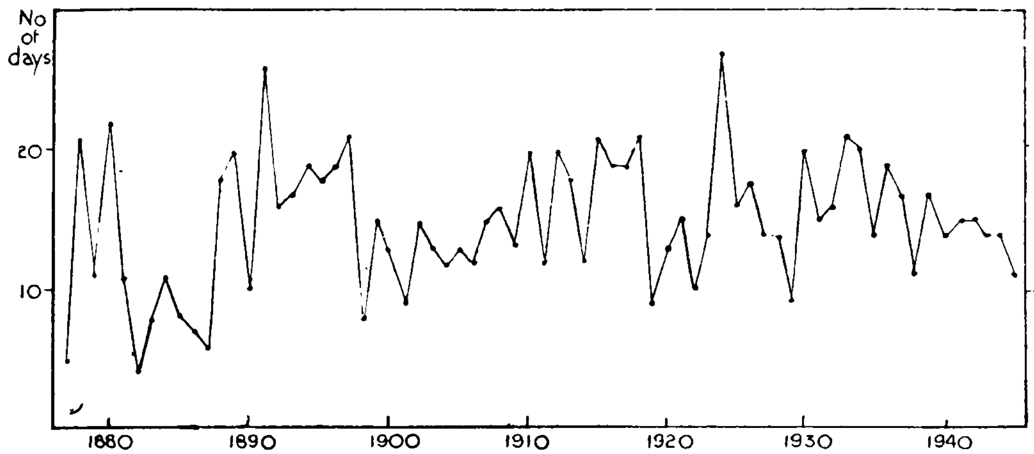

FIG. 1—NUMBER OF DEGS. OF THUNDER IN EACH YEAR AT KEW OBSERVATORY

Annual Variation.—Fig. 2 shows the annual variation at Kew. The figures show that on the average thunder occurred on one day in 11 in summer (May–August), one day in 43 in the equinoctial months (March, April, September and October) and one in 178 in winter (November–February). A comparison of the monthly totals of days with thunder (D) with the totals of two-hourly

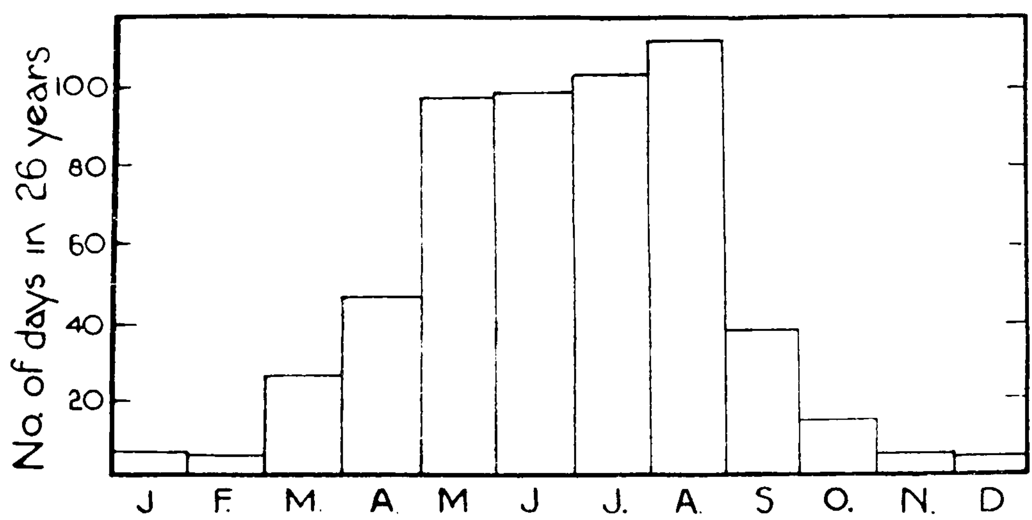

FIG. 2—ANNUAL VARIATION IN THE FREQUENCY OF THUNDER, KEW OBSERVATORY, 1910-35

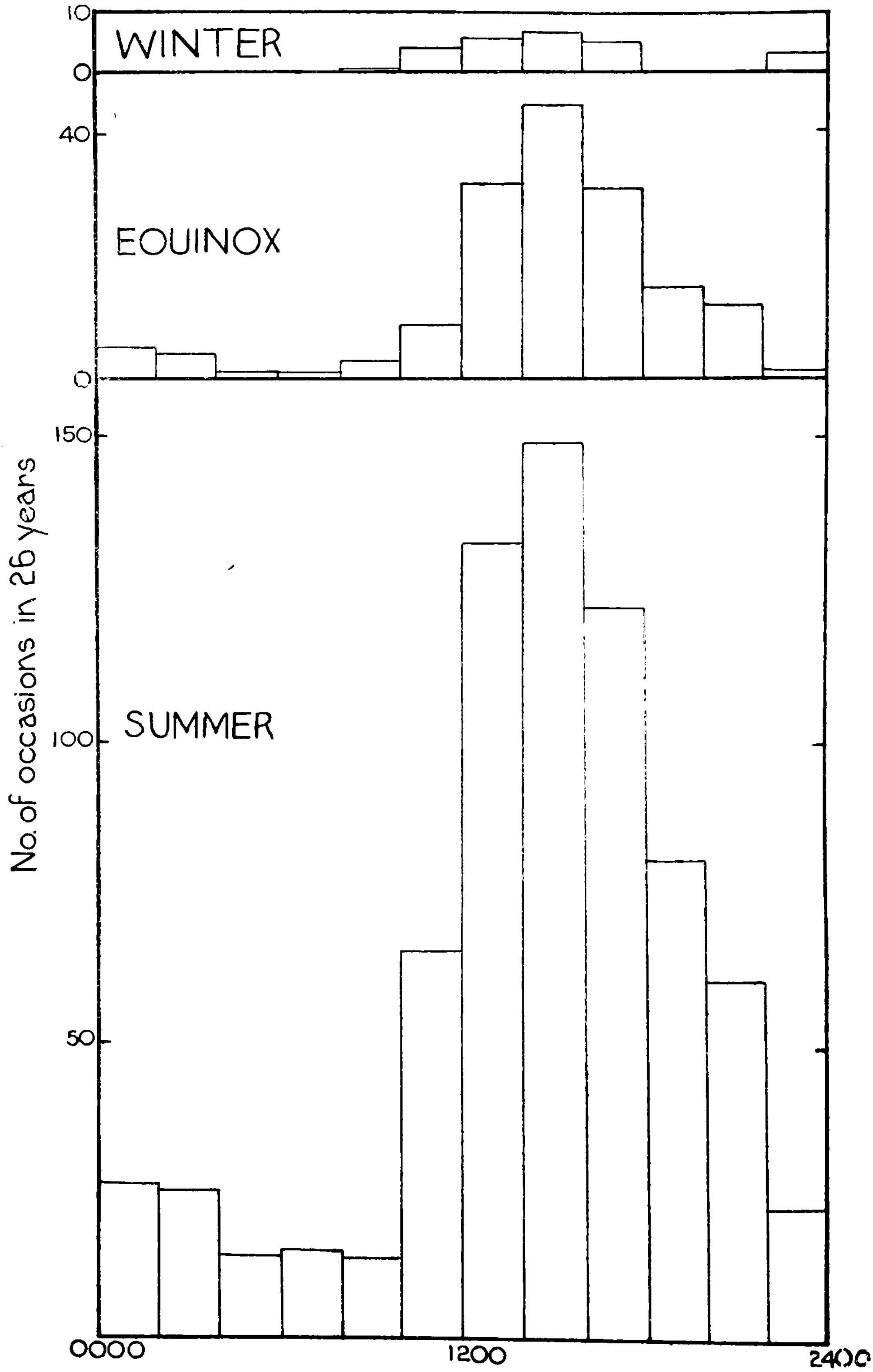

FIG. 3—DIURNAL VARIATION IN THE FREQUENCY OF THUNDER, KEW OBSERVATORY, 1910-35

periods with thunder (H) shows the ratio H/D to be 1·8 in summer, 1·3 in the equinox and 1·2 in winter. During the flat maximum in the summer which is the most notable feature of the annual variation, this ratio remains fairly constant with a maximum of 1·9 in June.

Diurnal Variation.—The number of occasions on which thunder was heard in each two-hourly interval is shown in Fig. 3 for the three seasons. The chief hours of thunderstorm activity are from noon to 6 p.m. in which 58 per cent. of the occasions occur, the rise to the maximum being more rapid than the fall. A comparison of the night hours with those of the early morning when people would normally be awake would seem to bear out the assumption that the effect of the incomplete observational routine mentioned earlier is small.

Comparable data for other parts of England do not seem to be available but valuable information regarding Scotland will be found in " The meteorology of Edinburgh " by R. C. Mossman (*Trans. roy. Soc. Edinburgh*, **38**, 1896, p. 681.), and " The diurnal periods of thunderstorms in Scotland " by A. Buchan (*J. Scot. met. Soc. Edinburgh*, **5**, 1880, p. 324).

METEOROLOGICAL OFFICE DISCUSSIONS

A discussion was held at the Meteorological Office on April 21, 1947, on " The present-day accuracy of meteorological instruments " which had formed the subject of the presidential address given by Mr. W. E. Knowles Middleton to the Canadian Branch of the Royal Meteorological Society in January 1946*. The discussion was opened by Dr. F. J. Scrase who gave a brief outline of the paper, the purpose of which was to consider the effect of the fine structure of the atmosphere on the possible and desirable precision to which meteorological instruments should be read and to enquire whether existing instruments provide such accuracy. This was followed by a short account of the random and systematic errors of mercury barometers and Dr. Scrase concluded by summarising the information now available about the accuracy of the Meteorological Office radio-sonde.

Among the points raised in the discussion which followed was a suggestion that an optimum lag coefficient might be worked out for a thermometer which would be large enough to smooth out the rapid fluctuations but not so large as to mask the longer-period changes of temperature. Another point was the need for a more definite statement of acuracy requirements for synoptic work and a suggestion that these requirements should depend on the frequency of the observations, both in space and time, and on the rate of change of a meteorological element with space and time. The errors of evaporation and rainfall measurements were discussed at some length and the forecaster's need for observations of rate of rainfall rather than amount was stressed. Other points discussed were the accuracy required and obtainable in sea-temperature observations and the value of gust measurements in comparing wind speed in different places.

It is hoped to publish a longer article on this subject shortly.

ERRATUM

January, 1947, page 14, line 24 ; *for* " wind velocities at 13 and 19 metres " *read* " wind velocities at 13 and 95 metres ".

* *Quart. J.R. met. Soc., London*, **72**, 1946, *p*. 32.

METEOROLOGICAL RESEARCH COMMITTEE

The 47th meeting of the Meteorological Research Committee was held on April 11, 1947. Consideration was given to the report of the Tropical-Meteorology Panel and the recommendations of that Panel regarding problems of tropical meteorology for inclusion in the research programme were adopted.

A paper on the diurnal variations of fog at sea was discussed.

ROYAL METEOROLOGICAL SOCIETY

The Symons Memorial Lecture at the Royal Meteorological Society on " Weather Forecasts ", by Mr. E. Gold was given in the rooms of the Society, 49, Cromwell Road, on April 16, 1947.

The lecturer began by referring to the criticism that weather forecasts were wrong nine times out of ten. He said that if there were any person present of that opinion he made him the following offer. On any occasion when the forecast for south-east England issued through the B.B.C. at 5.55 p.m. forecast precipitation in London and there was none before 6 p.m. next day, or made no mention of precipitation and there was precipitation in London before 6 p.m. next day, he (the lecturer) would give him a guinea, on condition that for any occasion when precipitation was forecast and precipitation fell in London before 6 p.m. the next day, or when precipitation was not forecast and no precipitation fell, the person would give him, the lecturer, half a guinea.

The lecturer said that the last previous occasion on which a Symons lecture had been specifically on the subject of weather forecasts was in 1919—a lecture given by Mr. R. G. K. Lempfert. He then mentioned two points made by W. H. Dines 45 years ago, as justifying the lecture and the weather forecaster's effort. The two points were that the man who refused to act because he could not be quite certain of the result of his action would rightly be held to be a lunatic, and that there was the same actual certainty yesterday about the weather of to-day as about the sun rising this morning.

In the preparation of a weather forecast there are broadly five stages—observation, collection, manipulation, analysis and prognosis.

In connexion with manipulation and analysis, a number of new " isopleths " have been introduced for which new specific names were proposed. They are:—

isobaths = lines of equal thickness of the layer of air between two isobaric surfaces.

hydrotherms = lines of equal temperature of the surface water of the sea.

brechotherms = lines of equal wet-bulb temperature (usually on an isobaric surface).

The lecturer also proposed to use " anemolapse " for the vertical change of wind by analogy with " hydrolapse " recently introduced to denote the vertical change of water vapour in the air.

With regard to observations, the instruments had been improved and new instruments added and more detail given in the eye observations. Weather was reported by 100 different specifications. The forms of high, medium and low cloud and the height of the base of cloud were reported separately. It was easier to get the height of the base of cloud by night than it was by day (by means of the cloud searchlight). The same applies to observation of visibility where constant light sources at two or three suitable distances are provided and an optical wedge meter used. But the most notable advance was in respect of upper air observations which were now provided for all levels in the troposphere and well into the stratosphere by the methods known as radio-sonde and radar-wind observations, irrespective of the weather conditions. He mentioned appreciatively the long series of observations—THUM reports—made in vertical ascents by aircraft of the Royal Air Force and the more recent meteorological reconnaissance flights of aircraft flying 500–600 miles out into the Atlantic in all weathers. The results of one such flight made in the middle of the night in mid winter into the centre of one of the deepest Atlantic depressions with a central pressure of 944 mb. were shown plotted on an isobaric chart.

The collection of reports, which are necessarily put into figure code, is made in the United Kingdom on a teleprinter network radiating from the Central Forecasting Office at Dunstable, and in the European exchange partly by teleprinter and partly by collective wireless transmissions from main centres—London, Paris, Rome, Moscow—while the general issue for world use of reports covering the whole European area is made from Rugby. Manipulation is partly by charts and partly by diagrams, notably the tephigram. On charts the information is plotted round the position of the station according to a model agreed upon internationally. The upper air information is used, individually on the tephigram and collectively for the construction of isobaths, contour lines, isotherms and brechotherms on isobaric surfaces, generally the 700, 500 and 300 mb. isobaric surfaces. More detailed information for the lower layers of the atmosphere to give the anemolapse and the hydrolapse is utilised especially in connexion with forecasting fog and the time of its formation.

The drawing of the charts and their analysis calls for a very high degree of technical and professional skill. It has not been found practicable to formulate a rigid rule for the determination of a front. One cannot say that if the discontinuity of temperature exceeds X° there is a front, and if it is less than X° there is no front. It is necessary for the forecaster to assess the combined significance of the temperature, the dew point, the wind, the weather and the sequence of events, as displayed on successive charts, in placing fronts, occlusions or frontal zones on the charts.

The application of the upper air information by tephigrams to forecasting thunderstorms was illustrated by examples and mention made of their use in forecasting maximum temperature. The use of isobaths and contour lines in forecasting the motion of depressions and other isobaric systems was illustrated by the sequence of charts for February 22 to 23, 1946. The very marked divergence in 24 hours of air at different levels, originally in the same vertical, near the middle of a fast moving wedge was also shown, the lower air moving north-east to between Shetland and Norway, while the upper air moved south-east to the Mediterranean.

The sequence of synoptic charts for March 14 to 16, 1947, illustrated a forecast of snow after a fine night, due to the return, as a warm front, of a cold front which had previously moved southwards into France, and the subsequent development of the small intense depression which caused the severe gales on Sunday, March 16.

A second series of charts—March 3 to 6—showed how a warm front which advanced from the south-west across France and the English Channel was retarded so much by ageostrophic winds due to the acceleration parallel to the front of the cold air in advance of it that the warm front instead of moving north into England was stopped at the south coast and reversed its motion to become a cold front moving south into France. The retardation of the front reached the exceptionally large value of 30 knots. It was practically equal to the geostrophic wind in the warm air at right angles to the front.

A third series of charts illustrated the conditions preceding D Day, June 6, 1944. On June 3, 1944, owing to the likelihood of strong winds and low cloud on June 5 the date of the operation was postponed until June 6, when the sting and the cloud in the north-westerly winds were taken out by their passage across the British Isles.

The lecture concluded with a reference to the possibility of devising rules which could be utilised in the construction of an electronic brain for the manipulation of the vast amount of material now at the disposal of the forecaster, and the further possibility that the forecaster's assistance might be required in determining the disposition of places of release of atomic energy designed to modify the weather to fit the prebaratic.

LETTERS TO THE EDITOR

Extremes of low temperature

Since February 9, 1945, when I sent in my letter on unauthenticated extremes of low temperature (published in the *Meteorological Magazine* for February, 1947), the erroneous value −23° F. has been published again in *The Scottish Geographical Magazine*, December, 1945, p. 76, and in *Weather*, January, 1947, p. 2.

Will you please, in your next issue, clear me of responsibility for omitting these from the letter as published, mentioning that the letter dates to February, 1945, and that it was not referred back to me before publishing it now.

W. A. HARWOOD

April 25, 1947.

(NOTE : The two omissions are regretted.—*Ed. M.M.*)

Value of local observations

On Friday, April 4, 1947, the value of a local observation in determining the synoptic situation over a much greater area was demonstrated to me with unusual force.

The 0600 G.M.T. chart on that day showed Scotland in ridge conditions, with an anticyclone centred well to the north and the depression G, 981 mb., at 53° N. 35° W. The depression was well occluded and not expected to develop.

During the forenoon the proverbial local farmer drew my attention, in conversation, to the exceptionally long and heavy cross swell which was running then, with the addition that he expected severe gales over the week-end.

The 1200 G.M.T. chart gave the first indication of the secondary H which deepened considerably, and did in fact produce severe gales in western Scotland. A pilot reported an accurate wind of 62 m.p.h. at 500 ft. over a good part of the Isles that day.

Undoubtedly, the observation of swell enabled the forecast of gales to be made earlier and with greater confidence than would have been the case had the synoptic chart been my only source of information. The observation was the first indication of the vigorous developments which were taking place many hundreds of miles away.

JOHN PATRICK

Stornoway Airport, April 21, 1947.

NOTES AND NEWS

The highest laboratory

The world's highest fixed laboratory, especially constructed and suited to the study of great storms and cosmic rays is on the top of Mt. Evans, Colorado, U.S.A., where scientific research workers are equipped with highly specialized instruments.

Research work started as early as 1931 when A. H. Compton did his first field work on cosmic rays at Summit Lake, which is 1,000 ft. below the peak of Mt. Evans. The wind velocity on the peak is excessively high and at night was often sufficient to scatter the equipment and level the tents which the early workers and their associates used for laboratories and living quarters. There are frequent sleet and heavy snowstorms, and fire hazard prevented the safe heating of tents, consequently the indoor temperatures often fell to 30° F. or lower. Both apparatus and workers were without protection from electric storms.

Yet the scientists have carried on their investigations in meteorology and astrophysics as well as in cosmic rays, and highly valuable data have been secured by the United States Weather Bureau. Later it became evident that if any prolonged or accurate observations were to be made, adequate shelter must be provided for workers and scientific apparatus, and the Massachusetts Institute of Technology collaborated with the University of Denver in erecting the present building.

Mt. Evans, 65 miles from the city of Denver, with an altitude of 14,260 ft., is the highest easily accessible mountain peak in the United States, and there is living accommodation on the highway leading to the laboratory, at altitudes of 6,000, 8,000 and 10,600 ft. above sea level.

The laboratory (see photographs in the centre of this issue) consists of two rooms, one room being used as the actual place for research work and the other one for living quarters. To withstand the high wind velocity, a roof truss construction is employed, which made the omission of side walls possible. Cables fastened to the floor joists run through the pillars of the foundation to heavy metal plates cemented into the rock. The building is thermally insulated and is provided with " no draft " ventilation.

For protection against lightning, the end walls and roof are covered with thin copper shingles and the lower side of the floor is covered with metal hardware cloth. The copper and hardware cloth are joined and earthed, thus converting the whole building into a Faraday cage. The copper of the roof is not thick enough to interfere materially with cosmic ray measurements.

M. LORANT

Retirement of Mr. Corless

Mr. Richard Corless, Assistant Director, retired on April 11, 1947, after service in the Meteorological Office since October 1, 1907. At Sidney Sussex College, Cambridge, he had been 16th Wrangler in 1906 and had taken a First Class in Natural Sciences Tripos Part I in 1907. He was amongst the first of the new category of highly trained scientific officers introduced by the late Sir Napier (then Dr.) Shaw and he joined in the capacity of " Assistant to the Director ", becoming " Clerk of Publications " in 1910 and " Secretary to the Director " in 1913.

This was the era of a new movement in British meteorology. In this period Lempfert, Gold, Whipple and Dobson had also joined the Office : Cave, W. H. Dines and his sons and Harwood were at work on new means of exploring the upper air, Simpson was in the Antarctic, G. I. Taylor on the *Scotia* ; Schuster, Rayleigh, Aitken, C. T. R. Wilson and others were interested and keen in meteorological controversy. New methods of analysis of weather charts were being tried. The scientific interests of Corless, in common with Shaw and Lempfert, lay, in those days, in the tracing of air trajectories, the structure of line squalls and associated phenomena and the structure of depressions. Shaw's thoughts were running on the ideal of a new establishment for investigation and research on the upper air and the physical processes of weather.

The outbreak of war in 1914 brought most of the scientific work, then in hand or planned, to an end and probably changed the whole course of British meteorology. Mr. Corless and others had new responsibilities thrust upon them and his appointment in October, 1916, as Superintendent of Instruments came at a time when the meteorological sections of the British military forces were clamouring for more equipment, particularly for the balloons, theodolites and slide rules required to measure the upper winds needed by airmen and gunners in the various theatres of war. Mr. Corless then as on other occasions " delivered the goods ".

From 1923, Mr. Corless was successively head of the Climatology, British Rainfall and Forecast Branches of the Meteorological Office. In January 1939, he was promoted Assistant Director, having under his charge the Branches concerned with Marine Meteorology, Climatology, Instruments and Personnel.

At the outbreak of war in 1939, it was foreseen that questions of administration and personnel were going to increase enormously in number and complexity and Mr. Corless's directorate responsibilities were thereafter concentrated upon these. Under his charge the numbers of meteorological staff, civilian and military, rose from some 900 in 1939 to about 6,800 at the peak of the war and again, with demobilization and releases, had fallen to about 2,600 at the time of his retirement in April, 1947.

At a meeting held at Victory House on March 31, Sir Nelson Johnson, in making a presentation on behalf of the staff to Mr. Corless, referred to the esteem in which he was held by his colleagues, on account of his high ability and intellectual probity. Mr. Corless in a witty reply gave some interesting information on the inner history of the old Office in Victoria Street and some of the developments of later years.

Mr. Corless was awarded the C.B.E. in 1946.

Retirement of Mr. A. T. Bench

Mr. A. T. Bench retired from the Meteorological Office on March 12, having reached the age of 65, after more than 49 years' service. He entered the Office, which was then housed at 63, Victoria St., on January 24, 1898, as a Boy Clerk in the "Autographic Records" Branch, and became a Probationer in the Forecast Division in September, 1902. He remained in forecasting for 18 years, and his memories of this period include the final telegraphic message from Victoria Street on the removal to South Kensington in 1910, and the receipt of the first wireless message from the Eiffel Tower in 1913. In October, 1920, he was transferred as Principal Assistant to the British Rainfall Organization on its incorporation in the Meteorological Office, passing to the new General Climatology Branch on its formation in 1925. He remained in that Branch until his retirement. His interest in the Meteorological Office was not purely "work" however ; he took an interest in staff activities as Treasurer of the M.O. Staff Council and in other ways. On the outbreak of the war in 1939 he moved with the Climatology Branch to Stonehouse, Glos., and was very helpful to the new assistants who came from all parts of the country, while Mrs. Bench was of the greatest possible help in the Canteen arrangements.

REVIEWS

"*Here is the weather forecast,*" by E. G. Bilham. Size $7\frac{1}{2}$ in. × 5 in. pp. 220. *Illus.* London, Golden Galley Press Ltd. 1947. Price 10*s.* 6*d.* net.

Mr. Bilham's new book lifts the veil, for the layman, on the varieties of activities and processes which converge to the result introduced to millions of listeners by the familiar words of the title. Few readers nowadays will be surprised that there is no mystery to reveal ; the story is one of specialised organization and the application of scientific principles. The answer to the question "How is it done ?" is given here in and around an intricate, well-knit and most interesting survey of the workings of a modern national weather-forecasting service—that of the Meteorological Office, Air Ministry. The interest of this survey, with backward glances at the state of meteorological knowledge and facilities in the early days of the Meteorological Office less than 100 years ago, is enhanced by the increased demands made upon and met by the service, and the additions to the technical resources at disposal during recent years.

Full prominence is given to the numerous aspects of accurate and adequate meteorological observations—whether made from land stations, ships at sea or aircraft—from the more simple instrumental and non-instrumental variety to the use of modern electrical techniques for measuring with almost laboratory precision (comparatively speaking) the wind, pressure, temperature and humidity to great heights. The chapters, describing how radio and radar procedures, still in the relative infancy of their meteorological association, have been adapted to precise meteorological upper air measurements, to the location of thunderstorms and to the detection of thick cloud and rain, will be of wide appeal. These observational matters, the highly efficient telecommunications organization which exists for the rapid collection of the coded reports by the Central Forecasting Office and their distribution to the forecasting centres which meet the requirements of the Services and Civil Aviation, and the arrangements for the international exchange of weather reports form the prelude and support to the sections dealing with, the synoptic charts—surface and upper air—on which the vast amount of observational data is plotted for assimilation and consideration by the forecaster, the behaviour of weather systems, the types of weather and the fundamental notions of forecasting. These latter sections necessarily involve sufficient simple exposition of atmospheric processes. This is skilfully achieved. The final chapter discusses the accuracy attained in forecasts, the prospects for the future and some of the methods which have been tried, with unreliable results, with the object of forecasting for periods of several days or weeks.

The authoritative, attractively written treatment of the whole subject, generously illustrated and provided with a glossary of meteorological terms, is just what is required by the general reader. It gives him an excellent insight into the ways of the weather, will promote a better understanding of the daily weather situation and lead to a better appreciation and extended use of the forecasts available to all by radio and the press and of special forecasts obtainable on application ; also, not improbably, to a demand for the use in forecasts of more technical expressions if thereby the meaning can be better conveyed, or for the publication of adequate weather charts in the press as soon as the paper situation permits. The book merits a wide circulation. It would be a first-rate choice for reading by the upper forms of senior schools. The very few errors of fact noticed are due mainly to changes which have occurred since the author's part was completed (the preface is dated May, 1946) and are unimportant.

H. W. L. ABSALOM

Discussion of upper air data obtained from aeroplane meteorological flights over Peshawar and Quetta during the years 1927–36, by R. Ananthakrishnan. Memoirs of the India Meteorological Department. Vol. XXIX, Part 2, 4to., 12 in. × 9¼ in., pp. 55–88 *Illus.* Delhi, Manager of Publications. 1942. Price Rs. 2–12 or 4*s.* 6*d.*

In this paper, data derived from observations made by the above flights are presented in commendable detail, together with a comparison with soundings over Agra and Poona, and should provide anyone investigating upper air conditions over that part of India with any data required. Values of the various elements at 0·5 Km. or 1 Km. intervals up to 5 Km. above sea level were obtained from the original observations by graphical interpolation ; it would have been helpful if the height column in each table had been headed " Height above M.S.L.", surface readings being given in brackets. Unfortunately it is not stated (either here or in the earlier scientific note to which reference is made) whether readings have been corrected for aircraft speed or not, so there is a possibility that readings as given are about 1·3° F. too high (assuming the same correction, −1·2° F., as was subsequently applied to the Duxford Meteorological Flight readings taken over the same period).

Interesting features shown by the tables are discussed in the accompanying text but there is little that calls for special comment ; the wet-bulb potential temperature tables are particularly interesting, revealing, as they do, the change in stability of the lower layers of the atmosphere throughout the year. The relation between this instability and the incidence of thunderstorms is commented upon. This relation would only be expected to hold however if conditions at higher levels follow the same trend.

A brief note on ice accretion together with a table of freezing levels concludes the paper. As these levels are generally above 3 Km., icing is not likely to interfere with normal flying in these regions.

D. DEWAR

RAINFALL OF MARCH, 1947

Great Britain and Northern Ireland

Co.	Station	In.	Per cent of Av.	Co.	Station	In.	Per cent of Av.
London	Camden Square ..	5·75	314	*Glam.*	Cardiff, Penylan ..	7·57	240
Kent	Folkestone, Cherry Gdns.	5·94	273	*Pemb.*	St. Ann's Head ..	8·94	329
,,	Edenb'dg, Falconhurst	6·06	244	*Card.*	Aberystwyth	5·53	202
Sussex	Compton, Compton Ho.	8·20	296	*Radnor*	Bir. W. W., Tyrmynydd	13·39	249
,,	Worthing, Beach Ho. Pk.	6·63	345	*Mont.*	Lake Vyrnwy	11·30	248
Hants.	Ventnor, Roy. Nat. Hos.	6·90	337	*Mer.*	Blaenau Festiniog ..	14·15	164
,,	Fordingb'dg, Oaklands	7·68	330	*Carn.*	Llandudno	5·38	265
,,	Sherborne St. John ..	6·49	290	*Angl.*	Llanerchymedd ..	6·03	203
Herts.	Royston, Therfield Rec.	5·19	284	*I. Man.*	Douglas, Boro' Cem. ..	7·84	265
Bucks.	Slough, Upton ..	5·41	308	*Wigtown*	Pt. William, Monreith	6·72	236
Oxford	Oxford, Radcliffe ..	5·23	317	*Dumf.*	Dumfries, Crichton R.I.	6·64	222
N'hant	Wellingboro', Swanspool	4·74	265	,,	Eskdalemuir Obsy ..	5·70	116
Essex	Shoeburyness	3·62	268	*Roxb.*	Kelso, Floors	4·06	208
Suffolk	Campsea Ashe, High Ho.	3·51	209	*Peebs.*	Stobo Castle	3·35	116
,,	Lowestoft Sec. School	4·00	248	*Berwick*	Marchmont House ..	5·74	217
,,	Bury St. Ed., Westley H.	4·05	214	*E. Loth.*	North Berwick Res. ..	4·53	241
Norfolk	Sandringham Ho. Gdns.	4·71	248	*Midl'n.*	Edinburgh, Blackfd. H.	3·75	190
Wilts.	Bishops Cannings ..	5·29	235	*Lanark*	Hamilton W. W., T'nhill	3·25	116
Dorset	Creech Grange.. ..	8.43	299	*Ayr*	Colmonell, Knockdolian	5·02	149
,,	Beaminster, East St. ..	8·75	299	,,	Glen Afton, Ayr San.	4·53	108
Devon	Teignmouth, Den Gdns.	8·69	334	*Bute*	Rothesay, Ardencraig ..	3·99	111
,,	Cullompton	6·51	238	*Argyll*	Loch Sunart, G'dale ..	3.00	54
,,	Barnstaple, N. Dev. Ath.	5·78	221	,,	Poltalloch	2·72	71
,,	Okehampton, Uplands	9·42	227	,,	Inveraray Castle ..	2·78	44
Cornwall	Bude, School House ..	6·12	251	,,	Islay, Eallabus ..	4·18	109
,,	Penzance, Morrab Gdns.	9·43	295	,,	Tiree	1·98	59
,,	St. Austell, Trevarna ..	11·65	339	*Kinross*	Loch Leven Sluice ..	4·76	159
,,	Scilly, Tresco Abbey ..	7·71	294	*Fife*	Leuchars Airfield ..	3·48	178
Glos.	Cirencester	7·19	311	*Perth*	Loch Dhu	6·50	99
Salop	Church Stretton ..	6·87	285	,,	Crieff, Strathearn Hyd.	6·54	204
,,	Cheswardine Hall ..	5·05	238	,,	Blair Castle Gardens ..	2·12	81
Staffs.	Leek, Wall Grange P.S.	5·12	188	*Angus*	Montrose, Sunnyside ..	3·07	148
Worcs.	Malvern, Free Library	6·40	330	*Aberd.*	Balmoral Castle Gdns.	3·32	116
Warwick	Birmingham, Edgbaston	6·79	355	,,	Aberdeen Observatory	4·00	166
Leics.	Thornton Reservoir ..	4·71	256	,,	Fyvie Castle	3·54	130
Lincs.	Boston, Skirbeck ..	4·30	276	*Moray*	Gordon Castle	2·60	112
,,	Skegness, Marine Gdns.	4·49	270	*Nairn*	Nairn, Achareidh ..	1·17	64
Notts.	Mansfield, Carr Bank ..	4·94	236	*Inv's*	Loch Ness, Foyers ..	1·73	54
Ches.	Bidston Observatory ..	4·33	228	,,	Glenquoich	2·40	25
Lancs,	Manchester, Whit. Park	4·99	221	,,	Fort William, Teviot ..	1·92	29
,,	Stonyhurst College ..	6·31	171	,,	Skye, Duntuilm ..	2·25	51
,,	Blackpool	5·13	216	*R. & C.*	Ullapool	1·00	27
Yorks.	Wakefield, Clarence Pk.	5·15	286	,,	Applecross Gardens ..	2·05	44
,,	Hull, Pearson Park ..	4·28	235	,,	Achnashellach	1·61	24
,,	Felixkirk, Mt. St. John	4·37	222	,,	Stornoway Airfield ..	1·35	35
,,	York Museum	4·43	264	*Suth.*	Lairg	2·65	85
,,	Scarborough	3·15	175	,,	Loch More, Achfary ..	2·44	50
,,	Middlesbrough.. ..	2·73	174	*Caith.*	Wick Airfield	1·73	76
,,	Baldersdale, Hury Res.	4·47	144	*Shet.*	Lerwick Observatory ..	1·94	61
Norl'd	Newcastle, Leazes Pk.	3·49	169	*Ferm.*	Crom Castle	4·34	140
,,	Bellingham, High Green	4·26	145	*Armagh*	Armagh Observatory ..	..	..
,,	Lilburn, Tower Gdns. ..	6·85	259	*Down*	Seaforde	7·34	251
Cumb.	Geltsdale	4·41	158	*Antrim*	Aldergrove Airfield ..	4·01	160
,,	Keswick, High Hill ..	5·48	122	,,	Ballymena, Harryville..	4·38	139
,,	Ravenglass, The Grove	5·99	194	*Lon.*	Garvagh, Moneydig ..	4·01	129
Mon.	Abergavenny, Larchfield	9·60	316	,,	Londonderry, Creggan	3·96	125
Glam.	Ystalyfera, Wern Ho. ..	12·99	242	*Tyrone*	Omagh, Edenfel ..	4·71	150

WEATHER OF MARCH, 1947

Conditions remained very unsettled throughout the month over the whole of the Atlantic between 40° and 60° N., the British Isles, Baltic Sea, Norwegian waters and Barents Sea, with the continual passage of complex depressions unrelieved by a single interval of more settled weather. Pressure fell below 968 mb. on the 3rd north-east of the Azores and on the 19th in mid Atlantic, below 964 mb. in mid Atlantic on the 21st and in two centres west of the British Isles on the 22nd, and below 968 mb. in mid Atlantic on the 25th and in the St. Lawrence on the 26th. By contrast pressure was high throughout the month over Greenland and Iceland, except for a deep depression over Iceland on the 24th to 25th. Pressure was also generally high south-east of Bermuda and south-west of Spain, but no really stable persistent anticyclone developed.

The average pressure distribution for the month shows an intense high (exceeding 1022 mb.) over Greenland and a rather indefinite high area (above 1016 mb.) from the Great Lakes to the West Indies, while the whole Atlantic from Newfoundland to the British Isles was occupied by a trough of low pressure (below 1000 mb. in the eastern half) which turned north-east over Scandinavia. Pressure was more than 10 mb. above normal between Iceland and Greenland and 13 mb. below normal from Ireland to the Azores.

The severely cold weather of February with considerable snow at times, persisted until the 16th, when milder conditions with rain spread north-east with a gradual thaw. There was heavy snow over much of England and Wales with severe drifting on the 4th and 5th, while in east, central and south Scotland heavy snowstorms occurred during the second week. On both occasions road and rail traffic were seriously interrupted. On the 16th a small depression developed off our south-west coasts and moved north-east across England deepening as it moved. A widespread and severe gale occurred with gusts of 98 m.p.h. at Mildenhall and 93 m.p.h. at Cardington. The second half of the month was fairly mild in the south but it continued unsettled with frequent rain. The melting of the deep snow combined with frequent rainfall produced floods on an unprecedented scale large areas in England being inundated. It was the wettest March in England and Wales since records began to be available in 1868.

As far as can be estimated at present it was the coldest March over Scotland as a whole since before 1901. The lowest temperature recorded in the screen was −6° F. at Peebles, Braemar and Houghall on the 4th and at Braemar on the 8th.

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

	Air Temperature			Rainfall		Sunshine	
	Highest	Lowest	Difference from average daily mean	Percentage of average	No. of days diff. from average	Percentage of average	Percentage of possible duration
	°F.	°F.	°F.	%		%	%
February, 1947							
England and Wales	52	−5	−10·2	82	−3	47	11
Scotland	43	−2	−8·4	43	−5	114	25
Northern Ireland ..	42	12	−8·5	39	−7	75	17
March, 1947							
England and Wales	60	−6	−3·5	255	+7	61	19
Scotland	59	−6	−5·7	105	−1	95	28
Northern Ireland ..	59	(5)	−4·5	156	+1	73	22