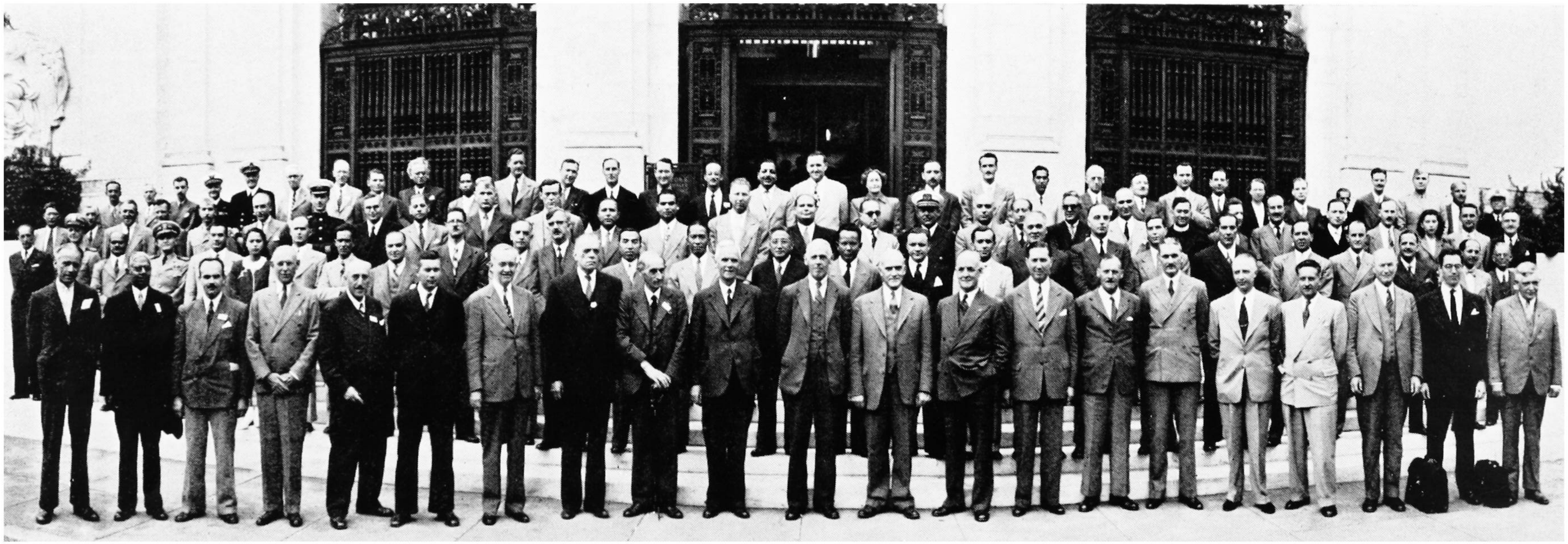

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INTERNATIONAL METEOROLOGICAL ORGANIZATION—CONFERENCE OF DIRECTORS—WASHINGTON, D.C., U.S.A.

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THE MEETING OF THE INTERNATIONAL METEOROLOGICAL ORGANIZATION IN TORONTO AND WASHINGTON (*continued*)

AUGUST, SEPTEMBER, OCTOBER 1947

The Climatological Commission (President, Dr. F. X. R de Souza, Brazil; British delegate, Dr. C. E. P. Brooks) met from August 4 to 25, and discussed a wide variety of subjects. The scope of the Commission was defined as climatological investigation of surface and upper air conditions, the application of climatology to other sciences and various forms of human activity (agriculture, aviation, shipping, industry, engineering, medicine, social science, etc.), rules for the computation and publication of climatological data, maintenance of reliability and homogeneity of meteorological observations, and dissemination of climatological data by wireless telegraphy and their possible application to seasonal forecasts.

The Commission was greatly concerned with making the most of the great masses of meteorological observations now being accumulated, and recommended the use of standard cards on which the daily observations would be punched for use in tabulating machines. This process has already been widely used in the United States, and has made possible calculations which would otherwise have been too costly in man hours. A Sub-Commission was appointed to assemble the necessary technical data for surface observations and to design a standard system for international use. For the rapidly growing mass of upper air data, a series of standard cards designed in the British Meteorological Office was accepted as suitable. The possibilities of machine methods were demonstrated to the Commission by representatives of the International Business Machine Company.

Each meteorological service was also asked to issue an annual volume of climatic statistics according to a standard form for permanent reference. For immediate use, e.g. in experimental long-range forecasting, the Commission recommended the resumption of the pre-war arrangement by which monthly mean values for a number of selected stations were broadcast not later than the 5th of the following month. The proposed broadcasts will be in code, and give the station number, the mean pressure, temperature and relative humidity, and the amount of rain. For purpose of comparison normal values are to be included in the first broadcasts, and will also be circulated by post.

The practical use of climatic data was discussed at length, particularly in relation to aviation. In conjunction with I.C.A.O. a standard series of climatological frequency tables was planned to give the best practicable representation of flying conditions at airports.

It was recognised that there is also a wide field for the application of climatology to other human concerns, such as health, agriculture and industry, and a permanent Sub-Commission was formed to develop these applications.

The Commission for Hydrology (Vice-President, Dr. M. Bernard, United States; British delegate, Dr. C. E. P. Brooks) met from August 4–15. The President, Dr. Urivayev of the U.S.S.R., was unable to attend, and Mr. Merrill Bernard was elected Vice-President and took the Chair at all meetings. This was the first meeting of a new Commission, and some time was spent in defining its scope, which was limited to the purely meteorological aspects, the hydrological cycle of precipitation, in evaporation, transpiration, percolation and surface run-off. The hydrological problems of the different countries proved to be very diverse, some countries being preoccupied with questions of water supply and others with forecasting river levels and floods. Among the matters dealt with in resolutions, were co-ordination and exchange of information between countries sharing the same river basin, the standardization of hydrological instruments and methods, and the compilation of a hydrological glossary and international bibliography. Progress was made in the preparation of a multi-lingual dictionary of hydrology.

On August 10 a party of Commonwealth members of the Commission enjoyed a visit to Niagara and the Queenstown Power Station under the able guidance of Mr. C. G. Cline of Canada, who aptly termed himself " the delegate for Niagara Falls ".

The Commission on Agricultural Meteorology (Vice-President, Mr. R. Feige, Palestine; British delegate, Dr. C. E. P. Brooks) met from August 11–23. In the absence of the President, D. V. V. Sinelshikov (U.S.S.R.), Mr. R. Feige (Palestine) was elected Vice-President and presided throughout a very successful meeting. The Commission dealt with phenology, statistical studies of weather and crops, the establishment of networks of " agro-meteorological " stations, long-range forecasts, soil erosion and soil conservation, and also outlined plans for an international journal of agricultural meteorology and for the teaching of agricultural meteorology in agricultural colleges.

Phenological observations are an important part of the data of agricultural meteorology, and suggestions were made for the preparation of an international list and atlas of suitable plants and animals, and the correlation of phenological and crop data. It was also resolved to compare the progress of the various crops at different stages of their growth, obtained by crop and sampling observations, with weather data to establish the minimum requirements of each crop. The Commission recommended the study of advanced statistical methods of analysis in order to make the most of the data so obtained. The meteorological observations required go far beyond the normal practice at crop-weather stations, and include continuous measurements of temperature and of soil humidity. The Commission asked the C.I.M.O. to foster the development of a suitable instrument for measuring soil moisture.

The Commission expressed strong views on the necessity for further research in extended range and seasonal forecasts, which could be expected to yield large economic returns, and it formed a Permanent Sub-Commission to encourage agricultural forecasting of all types.

The teaching of agricultural meteorology should form an essential part of training in agriculture, and the Commission went so far as to prepare abstracts of two suitable courses in the subject, elementary and advanced.

The Commission for Bibliography and Publications (President M. Mezin, France; British delegate, Dr. C. E. P. Brooks) met from September 2–10. This Commission was formed in 1929 to prepare a scheme of subject classification based on the Universal Decimal Classification, but its scope has been enlarged to include all matters concerning publications, resulting in a very long agenda. One of the main tasks of the Commission was to reorganise the world exchange of meteorological information—both observational data and papers on original research. This exchange broke down during the war, and has now to be restarted and extended to include the numerous articles of meteorological interest which appear in scientific and trade journals. The latter are often difficult to trace and obtain, and the Commission recommended the wide extension of a practice developed in Norway, where the meteorological service buys reprints of such papers and distributes them freely to other countries.

An essential means of exchanging information is by bibliographies. The Commission has outlined a proposal that each meteorological service should send lists of all meteorological documents appearing in its country to a central authority, which will at short intervals arrange and duplicate them for sale at a small cost. A basis already exists in the " Bibliographie Signalétique " prepared by the National Meteorological Office of France, and it is hoped that this can be made more complete by international co-operation. It is also hoped to extend the bibliography to include manuscripts, microfilms, motion pictures and catalogues of photographs.

The arrears of the war years received much attention, and the Commission recommended that meteorological services print all important works which appeared in their countries during the war and have not yet been generally issued. If printing is impracticable, microfilm copies should be made for countries requiring them. To this end, each service is urged to arrange facilities for making and reading microfilms. The occupying governments in ex-enemy countries are urged to do the same.

Another major task was the revision of the classification of meteorological literature. The existing classification has served since 1936, but the great extension of knowledge in the past few years, notably in radio technique for the study of the upper atmosphere, has impelled the Commission to draw up a list of proposed revisions and additions. The changes are being submitted to the International Federation for Documentation, and, if accepted, will be incorporated in the Universal Decimal Classification and should come into general use in 1949.

The Commission was also concerned with proposals to publish an international journal of meteorology, possibly in sections each dealing with one branch of the science. Such a journal appears to be especially necessary in the domain of agricultural meteorology (see above). Proposals were also made for the preparation of a glossary of meteorological terms, a multi-lingual dictionary, and a manual for meteorological librarians.

Commission on Projections for Meteorological Charts (President, Mr. I. R. Tannahill, United States; British delegate, Mr. J. Durward). The Commission's main task was to review the decisions taken at its only previous meeting, Salzburg 1937, on account of the greater map areas now needed by meteorological services in connexion with international aviation.

New projections recommended for synoptic charts were:

(*a*) Stereographic projection for the polar regions on a plane cutting the earth at latitude 60°.

(*b*) Conformal conic projections for middle latitudes with standard parallels of 30°, 60° in the northern and 10°, 40° in the southern hemisphere.

(*c*) Mercator projection for the equatorial regions with true scale at latitude $22\frac{1}{2}°$.

It was suggested that in principle the standard projection for climatological charts should be of the equal area type.

Standard scales were recommended for charts ranging from $1:40 \times 10^6$ for world charts to $1:7{\cdot}5 \times 10^6$ or $1:10 \times 10^6$ for charts of a continent. The Commission proposed that charts should be printed in the two colours brown (or ochre) and blue when practicable.

A study of requirements for the location of " sferic " and radar observations resulted in the establishment of a sub-commission to examine the use of a special stereographic or gnomonic projection.

An attempt to find a conformal projection suitable for a world-wide synoptic chart was unsuccessful.

Social and other activities.—The meetings were not all of a scientific nature, our hosts having given much thought and attention to the social side. An official welcome to Canada was given to the delegates by the Dominion Government on August 15, when the Rt. Hon. J. L. Haley, Minister of Justice, received them, while the Deputy Minister of Transport, Cdr. C. P. Edwards, congratulated them on their work and bade them farewell on behalf of the Government at a dinner on September 11. Receptions were also held by the Province of Ontario, and the City and University of Toronto.

Much time was given to the Conference by the Toronto radio stations. Among those who broadcast were Mr. E. Gold and Cdr. C. Frankcom.

Conference of Directors (President, Sir Nelson Johnson). The Technical Commissions finished their work in Toronto on September 15, and a week later the Conference of Directors opened in Washington. The Agenda contained, in addition to the examination of some 400 resolutions submitted by the Technical Commissions, a proposal to form a World Meteorological Convention and another to seek affiliation to the United Nations.

With regard to the Convention, the I.M.O. has hitherto been a semi-official association of Directors of Meteorological Services, but the increased importance of meteorology in a number of directions has led to a widespread belief that the I.M.O. should become an intergovernmental organization which would enhance its status and place it in a more favourable position to enlist official support.

The proposal for a Convention gave rise to protracted discussion, and it was clear that some of the delegates were not without misgivings as to the wisdom of a change in the existing organization. Eventually, after safeguards had been provided to ensure the equality of meteorological services on technical matters, a World Meteorological Convention was drafted and signed by 33 countries. It will come into force on ratification by 30 countries, and the World Meteorological Organization (W.M.O.) will take over the assets and obligations of the I.M.O. which will then cease to exist.

A decision to seek affiliation to the United Nations was quickly reached once the subject of the Convention had been settled. With the assistance of delegates from the United Nations who were present at the Conference, a draft agreement was drawn up which, after approval by a majority of members of the I.M.O., will be submitted to the United Nations. If this is accepted the W.M.O. will be linked with the United Nations as a Specialised Agency.

On the technical side, the Conference approved over 200 resolutions of the Technical Commissions, and took note of about an equal number. Two new Commissions were formed, one to study radio-electric meteorology and the other to deal with problems of arctic and antarctic meteorology. At two sessions, attended by delegates from I.C.A.O., measures were agreed upon to co-ordinate the activities of I.C.A.O. and I.M.O. in meteorological matters.

The Toronto and Washington meetings, considered either separately or as a whole, were most successful, and well repaid the sustained effort that was required from the delegates. Considerable progress was made both on the technical side and in improving the machinery for applying meteorology to human welfare. One of the most important results was, of course, the signing of the international Convention. This decision to effect a fundamental change in the status of the I.M.O. illustrates the determination of members to adapt the I.M.O. to modern world conditions. Another promising feature was the emphasis placed upon research, and at the meetings of the Technical Commissions it was gratifying to notice that the delegates included a high proportion of younger scientists of marked ability and originality of outlook.

NOTES ON THE I.C.A.N. ALTIMETER AND HEIGHT AND AIR SPEED COMPUTER

BY G. A. BULL, B.SC.

Part II

The height and air speed computer is a circular slide rule, shown in the photograph facing p. 48, designed to provide more accurate values of the height and air speed of an aircraft than those read directly off the altimeter and air speed indicator. It is not intended for use above 30,000 ft. The Mark IIA type is arranged to correct the indicated air temperature for adiabatic temperature rise due to the speed of the aircraft.

The computer gives an improved value of height from the indicated height, the temperature of the air, and the subscale setting of pressure.

The computer is designed approximately on the assumption of temperature increasing downwards from the aircraft at the rate of 1·98°C./1,000 ft. but only satisfies this assumption exactly if the ground pressure is 1013·2 mb. The computer takes no account of the variation of gravity with height or latitude.

Notation.

H_i = height indicated by altimeter in thousands of feet
H_c = corrected height given by computer
H_c' = corrected height on assumption of I.C.A.N. lapse rate between aircraft and ground
H_t = true height of aircraft
T_H = absolute temperature at aircraft levels as read by aircraft thermometer
P_H = pressure at aircraft level (mb.)
P_G = ground pressure set on subscale
T_G = ground temperature
P_0 = 1013·2 mb.
T_0 = 288°A.
l = 1·98°C./1000 ft.
n = g/lR = 5·256

Then from equation (3) (Part I) we have

$$H_i = \frac{T_0}{l}\left\{\left(\frac{P_G}{P_0}\right)^{1/n} - \left(\frac{P_H}{P_0}\right)^{1/n}\right\}. \quad \ldots (7)$$

The differential equation for the variation of pressure with height is

$$\frac{dP}{P} = -\frac{nldz}{T_H + lH_c' - lz}, \quad . (8)$$

where z = height, since T_H = temperature at height H_c'

Integrating this equation,

$$\left(\frac{P_G}{P_H}\right)^{1/n} = \frac{T_H + lH_c'}{T_H}. \quad \ldots (9)$$

From (7) and (9), equating values of $(P_H/P_G)^{1/n}$ we have

$$\frac{T_H}{lH_c'} = \frac{T_0\left\{1 - \dfrac{lH_i}{T_0}\left(\dfrac{P_0}{P_G}\right)^{1/n}\right\}}{lH_i\left(\dfrac{P_0}{P_G}\right)^{1/n}}, \quad \ldots (10)$$

whence, taking logarithms to base 10,

$$\log H_c' = \log H_i + \frac{1}{n}\log P_0 - \frac{1}{n}\log P_G - \log\left\{T_0 - lH_i\left(\frac{P_0}{P_G}\right)^{1/n}\right\} + \log T_H. \ldots (11)$$

The computer is, however, based on the formula*

$$\log H_c = \log H_i + \frac{1}{n}\log P_0 - \frac{1}{n}\log P_G - \log\left\{T_0 - lH_i\right\} + \log T_H \quad \ldots (12)$$

The two formulae differ only in the term $(P_0/P_G)^{1/n}$ multiplying H_i. This does not have much effect so that H_c is nearly equal to H_c'.

To see what difference there is, note that

$$\frac{H_c}{H_c'} = \frac{lH_i}{T_0 - lH_i}\left\{1 - \left(\frac{P_0}{P_G}\right)^{1/n}\right\} \quad \ldots (13)$$

---

* This formula is given in the relevant Air Ministry instructions.

so that, to the first order in $(P_O - P_G)/P_O$

$$H_c' - H_c = \frac{lH_i^2}{T_O - lH_i} \cdot \frac{P_O - P_G}{nP_O} \qquad \text{.. (14)}$$

Even if P_G is as low as 950 mb. the difference between H_c' and H_c is only 10 ft. at 10,000 ft. and 90 ft. at 30,000 ft.

We now consider the errors in H_c due to the actual atmosphere below the aircraft not having I.C.A.N. lapse rate. If the harmonic mean temperature between aircraft and ground is greater in the real atmosphere than in one with I.C.A.N. lapse rate then the computer will give a height less than the true height and conversely. The error will be greatest in magnitude and positive in sign when there is an inversion. A lapse rate greater than the I.C.A.N. value gives a negative error but since the lapse rate can never greatly exceed the I.C.A.N. value large negative errors will not occur.

If the real atmosphere has a lapse rate λ the relation between H_c' and H_t is

$$\left.\begin{aligned} \left(\frac{T_H}{T_H + lH_c'}\right)^{1/l} &= \left(\frac{T_H}{T_H + \lambda H_t}\right)^{1/\lambda} \\ \text{or } \left(1 + \frac{lH_c}{T_H}\right)^{1/l} &= e^{H_c/T_H} \text{ if } \lambda = 0 \end{aligned}\right\} \qquad \text{.. (15)}$$

Numerical values for atmospheres of constant lapse rate are easily deduced from formulae (15).

Thus if the real atmosphere has an inversion of 1°C./1,000 ft., such as may reasonably happen in winter over several thousand feet, the error

$$H_c' - H_t = 3H_t^2/2T_H,$$

terms of order H_t^3/T_H^2 and less being neglected.

At 5,000 ft. for $T_G = 270$°A. the error is + 140 ft.

If the real atmosphere has a dry abiabatic lapse rate the error

$H_c' = H_t = -\frac{1}{2}H_t^2/T_h$ neglecting terms of order H_t^3/T_H^2 and higher, so that at 10,000 ft. the error would be − 210 ft. if $T_G = 270$°A.

Further tests using the computer itself to find H_c were made with the 5-year means of January and July temperatures over Mildenhall, a measurement of upper air temperature taken through an intense winter inversion and finally with a record taken at Madras on a day of thunderstorms during the SW. monsoon. The values found are set out in Table V. It is assumed that T_H as read by the aircraft thermometer is the true temperature at aircraft level. The error in H_c due to an error δT_H is easily seen to be $H_c \delta T_H / T_H$. For example, at 30,000 ft. T_H is about 230°A. giving an error of 130ft. for every degree error in T_H.

It will be seen that a very considerable improvement in knowledge of height is obtained at high levels by using the computer, while the association of positive errors in the corrected height with inversion or small lapse rate and negative errors with steep lapse rates is clear.

The change in sign of the error in corrected height from positive to negative at high levels in two of the ascents is a reflection of the increase in lapse rate with height.

TABLE V—INDICATED AND COMPUTED HEIGHTS

Pressure P_H	Temp-perature T_h	True height H_t	Height indicated by altimeter H_i	Error in indicated height	Corrected height H_c	Error in corrected height
mb.	°C.	ft.	ft.	ft.	ft.	ft.
Mildenhall (5-year means in January)						
1000		0	0	0	0	0
900	0	2,780	2,877	+ 97	2,800	+ 20
800	− 4	5,850	6,027	+ 177	5,900	+ 50
700	− 9	9,270	9,507	+ 237	9,400	+130
600	−16	13,130	13,429	+ 299	13,245	+115
500	−25	17,560	17,915	+ 355	17,720	+160
400	−37	22,760	23,208	+ 448	22,800	+ 40
Mildenhall (5-year means in July)						
1000		0	0	0	0	0
900	11	2,900	2,877	− 23	2,900	0
800	5	6,080	6,027	− 53	6,110	+ 30
700	0	9,620	9,507	− 113	9,750	+130
600	− 7	13,620	13,429	− 191	13,800	+180
500	−16	18,210	17,915	− 295	18,250	+ 40
400	−26	23,620	23,208	− 412	23,500	−120
Hanover (January 31, 1947)						
1013	−12	0	0	0	0	0
1000	−12	320	363	+ 43	330	+ 10
900	− 7	3,000	3,240	+ 240	3,080	+ 80
882	− 3					
800	− 5	6,030	6,390	+ 360	6,250	+220
700	−12	9,430	9,876	+ 446	9,650	+220
600	−21	13,240	13,792	+ 552	13,400	+160
500	−29	17,580	18,278	+ 698	17,800	+220
400	−43	22,640	23,571	+ 931	22,570	− 70
300	−57	28,760	30,059	+1,299	28,500	−260
Madras (August 20, 1947)						
1000	30	0	0	0	0	0
900	26	3,050	2,877	− 173	3,060	+ 10
800	18	6,390	6,027	− 363	6,380	− 10
700	10	10,070	9,507	− 563	10,020	− 50
600	4	14,220	13,429	− 791	14,200	− 20
500	− 6	18,990	17,915	−1,075	19,000	+ 10
400	−18	24,500	23,208	−1,292	24,550	− 40
300	−34	31,410	29,696	−1,714	31,000	−410

Note.—The true heights were computed from the tephigram. No corrections have been applied for variation of gravity with height. The value of g used in constructing the tephigram is the same as that used in the I.C.A.N. atmosphere so that the errors in the indicated and computed heights are unaffected by ignoring the gravity correction.

The sign of the error in the indicated height is less directly associated with lapse rate. High positive errors in indicated heights are associated with temperatures lower than standard for the height and conversely.

Air speed computer.—The air speed computer gives an improved value of air speed using the same scales as the height computer.

If V_c is the corrected air speed V_i the speed shown by the air speed indicator, ρ the air density at aircraft level, and ρ_0 the density at 1013·2 mb. and 288°A., then

$$\rho_0 V_i^2 = \rho V_i^2, \qquad \text{.. (16)}$$

so that $$\frac{P_O}{T_O} V_i^2 = \frac{P_H}{T_H} V_c^2,$$

whence $$V_c^2 = \frac{T_H P_O V_i^2}{T_O P_G \left\{ 1 - \frac{l H_i}{T_O} \left(\frac{P_O}{P_G} \right)^{1/n} \right\}^n}, \qquad .. (17)$$

whence taking logarithms and neglecting the difference between 1 and $(P_O/P_G)^{1/n}$ we have

$$\log V_c = \log V_i + \tfrac{1}{2} \log T_H - 2{\cdot}628 \log (288 - 1{\cdot}98 H_i) - \tfrac{1}{2} \log P_G + 6{\cdot}7364 \qquad .. (18)$$

since $\frac{1}{2} \log 1013{\cdot}2 + 2{\cdot}628 = 6{\cdot}7364$

This is the formula which the instrument applies*.

No error due to the real atmosphere differing from the I.C.A.N. one can occur since the velocity depends only on pressure and temperature at aircraft level. The error is due solely to putting $(P_O/P_G)^{1/n} = 1$ and the percentage error due to this is

$$\frac{100 l H_i}{T_O - l H_i} \cdot \frac{P_O - P_G}{n P_O}$$

which is less than ½ per cent. even at 30,000 ft. with a subscale setting of 950 mb.

NOTE ON SOME CASES OF AIRCRAFT ICING

BY JACQUES COCHEMÉ, B.SC.

Introduction.—During certain operational trials carried out by Transport Command Development Unit, R.A.F., in a York aircraft, a meteorological air observer was included in the crew. The facilities for making observations on these trials were exceptionally good; the meteorological observer had more time than usual for observation as opposed to log keeping and computation, and, in the York, the wind screen of the pilot's cockpit (the meteorological air observer sat in the second pilot's seat) is so shaped that many particles hit it fairly squarely. It is therefore an exceptionally good " observation place ".

Observations.—The data collected during 21 relevant occasions or runs are given in the table on pages 34 and 35. With the exception of run 12, which was below cloud base, all these runs were carried out in cloud at the flying heights stated. Most temperatures were taken in clear air before entering cloud as the penetrations were of short duration and the observer's attention was concentrated on other items during that time.

The entries in the column headed " Particles observed " refer to types identified with fair certainty. They are not intended to constitute an exclusive list of the kinds of particles present in each cloud. By globular snow is meant a rounded particle, opaque and densely white, which appeared to be tightly packed. Snow flakes, on the other hand, presented the usual feathery appearance. Water drops appeared as transparent discs on the wind screen (beyond a certain size, not met during the runs, the discs are " starred "). In the case of relatively small drops detection was only possible in the corners of the screen after a layer the thickness of several particles had accumulated. Fine ice crystals were identified as a powdery deposit on the corners of the screen but

* See relevant Air Ministry instructions.

Run	Date	Locality	Cloud type	Flying height	Pressure	Temperature
				ft.	mb.	°F.
1	9.1.47	Scilly	Cb with large anvil, 5,000 ft. tall. Dissolving cloud thin at the waist. Base: 3,000 ft., top: 14,000 ft.	9,000	—	7 (clear air)
2	9.1.47	Scilly	Cb, more active, with anvil 2,000 ft. globular up to the anvil. Base: 2,500 ft., top: 13,000 ft.	9,000	—	—
3	9.1.47	Scilly	Young, well rounded, globular cumulus, developing	6,000	—	18 (clear air)
4	9.1.47	Scilly	Same as in run 2	5,000	—	22 (clear air)
5	13.1.47	Bristol Channel ..	Cb with large sprawling base and anvil. Base: 2,500 ft., top: 18,000 ft.	11,000	—	1 (clear air)
6	13.1.47	Gower Peninsula..	Cb with large sprawling base, heavy central column with anvil. Base: 3,000 ft., top: 18,000 ft.	9,000	—	4 (clear air)
7	13.1.47	Gower Peninsula	Same as in run 6	4,000	—	24 (clear air)
8	17.1.47	Isle of Man ..	Sc, base: 4,000 ft., top: 6,000 ft. No rain below	5,400	835	22 (clear air)
9	17.1.47	Belfast	Sc layer with Cu tops,possibly orographic. Rain in patches below. Base: 2,500 ft., tops: 6,000 ft. and 7,500 ft.	5,600	825	18 (clear air)
10	17.1.47	Tiree	Cb, base: 2,500 ft., top: 15,000 ft.	10,000	700	5 (clear air)
11	17.1.47	Barra	Cb, base: 2,500 ft., top: 17,000 ft., anvil: 2,000 ft. in height	15,700	555	−19 (clear air)
12	24.1.47	off Essex	Cu giving snow showers. Base: 1,500 ft., top: 7,000 ft.	1,100	990	25 (in shower)
13	24.1.47	52° 30′ N. 3° 00′ E.	As in run 12	6,000	830	6 (clear air)
14	24.1.47	52° 30′ N. 3° 00′ E.	As in run 12	4,500	880	11 (clear air)
15	24.1.47	52° 30′ N. 3° 00′ E.	As in run 12	3,000	930	16 (clear air)
16	31.1.47	Massif Central 48° 50′ N. 1° 11′ W.	Ac, base: 11,000 ft., top: 16,000 ft.	14,500	575	−16 (in cloud)
17	18.3.47	Pembroke ..	Cb, base: 2,500 ft., top: 15,000 ft. End of a row	—	750–715	16 (clear air) 16 (in cloud)
18	18.3.47	Pembroke ..	Cb, base: 3,000 ft., top: 14,000 ft.	8,500	740	16 (clear air)
19	18.3.47	Pembroke ..	As in run 18	6,000	800	26 (in cloud)
20	18.3.47	Cork	Cb with large sprawling base. Base: 2,000 ft., top: 15,000 ft.	—	—	19 (clear air)
21	18.3.47	Cork	As in run 20	7,100	770	22 (clear air)

Air-speed	Time in cloud	Particles observed	Type of icing	Rate of icing	Turbulence
kt.	min.				
175	{ ⅓ 1	Fine globular snow	Fine grained snow pack	Slow	Continuous 2
—	⅓	Globular snow ..	Snow conglomerate or pack	Moderate	Continuous 4
170	½	Supercooled water droplets	Clear granular ..	Moderate	Continuous 2
170	⅓	Snow larger than in run 2	Snow pack	Rapid	Continuous 5
160	½	Snow, globular about ⅛-in. diameter	Opaque snow pack	Rapid	Continuous 3
170	1	Snow, about $\frac{3}{16}$-in. diameter	Opaque snow pack	Moderate	Continuous 2
170	{ 1 1	Rain drops Snow flakes	Clear granular No record	Rapid	Continuous 3
170	2½	Small water drops ..	Fine clear granular	Slow	Continuous 2
160	2	Small water drops ..	Clear granular ..	Moderate	Continuous 2
170	2	Fine ice crystals ..	None	—	Continuous 2
160	2	Fine ice crystals ..	None	—	Continuous 1
180	1½	Large snow flakes ..	None	—	Continuous 2
190	2	Snow	Opaque snow pack	Rapid	Continuous 3
180	2	Snow	Opaque snow pack	Rapid	Continuous 3
170	2	Large snow.. ..	Opaque snow pack	Rapid	Continuous 4
160	10	Snow, about ⅛-in. diameter	Opaque snow pack	Moderate	Continuous 2
150 } 155 }	4	Supercooled drops ..	Semi-opaque fine granular	—	—
150	3	Fine snow, water drops near end of run	At end of run: clear fine granular	Slow	Continuous 2
160	3	Fine snow	Snow pack	Slow	Continuous 2
160	4	Fine snow	Semi-clear fine snow pack	Slow	Continuous 4
160	6	Fine snow	Semi-opaque granular snow pack	Moderate	Continuous 3

mainly on the " Rebecca " aerial, a thin antenna, painted black, sticking out of the side of the aircraft, and against which the particles were pressed for a fraction of a second and seen, invariably, as aggregates of rods. Two more types of particles may have been present but much uncertainty remains attached to their observation. The first, suspected during runs 9, 20 and 21, resembled frozen drizzle, the difference between it and a water drop being an apparently less plastic behaviour on impact. The second consisted of a snow flake to which water was adhering either in the form of drops or as a film. Its presence was suspected during runs 4, 5, 13, 14 and 16. The impression was gained that, at the flying heights stated in those runs, the clouds were " mixed clouds ", i.e. contained both water and ice, either separately or actually united.

Turbulence is expressed in an arbitrary scale where 10 represents most severe or disastrous bumpiness.

Discussion. *No icing in dry clouds.* (Runs 10 and 11).—Run 11 is a typical case of absence of icing in ice cirrus, cumulogenitus or not, at low temperatures. The cloud is dry and the particles left in it are small and can penetrate an aircraft as sand does a house during a sandstorm, but they do not adhere to its outside surface.

The absence of icing in run 10 is a rare and most interesting observation. The mechanism is thought to have been the same as for run 11, but the level, both absolutely and as a fraction of the total height of the cloud, is relatively low, and the temperature relatively high for ice accretion not to take place. This becomes more obvious if one compares run 10 with, for instance, run 6, where under similar conditions of height and temperature icing was readily deposited. The cloud of run 10 was dissolving and there was probably no ascending current at the flying height. Large particles had sunk below it and wet particles disappeared, giving a relatively tall anvil with a thin waist and unusually good visibility inside it. The flying height corresponded to the waist of the anvil.

In the writer's experience flying in cirrus cumulogenitus or anvils is a safe procedure with respect to icing; but the cloud must have characteristic tenuous anvil structure and be well above cauliflower-shaped convective masses. Carburettor icing, however, with engines which are prone to it, will take place in this type of cloud if the temperature is sufficiently low and the carburettor and intake heating left switched on, since the heat provided is then just sufficient to make the ice crystals sticky.

Icing in water clouds. (Runs 3, 8, 9, and 17).—Runs 8 and 9 are text-book cases in all respects, even as regards temperature. Clear granular ice of fine grain was obtained. A thick deposit would have been opaque, though not white, like accretion due to fine granular snow of the same size of particle. In both cases the drops were small, less than 1-mm. diameter. Such icing is only dangerous if it is allowed to accumulate for a long time, as might happen at night if the layer is continuous and no change in level effected.

It is interesting to compare the cloud of run 3 with an older convection cloud which was adjacent to it, that of runs 2 and 4. At 6,000 ft. and 18°F. there appeared to be nothing but water droplets in the cloud of run 3.

Icing in mixed cloud. (Runs 1, 2, 4–7, 13–16, 18–21).—14 out of the 18 cases of icing listed are attributed to snow. But for snow to adhere to an aircraft, " cement " is necessary in the form of water. This is well shown in runs 12 to 15.

On the day of these runs, during the cold spell of 1947, a layer of cold unstable air some 7,000 ft. thick was moving across the North Sea, from east to west. After a few miles of sea track that air filled with convective clouds giving snow showers. One of these was crossed at three different heights (runs 13–15), and in each case the snow began to accumulate on the wind screen, spinners and leading edges. The previous run (12) had been below cloud and in snow, and no accretion had taken place at a temperature of 25°F. It is assumed that the difference between run No. 12 and the other three is that there was water as well as snow in the rising air in cloud and that it was a mixture of the two which caused icing. Below cloud, on the other hand, the snow flakes were descending and dry and could not stick to the aircraft. Convection appeared to be moderately active in the cloud.

Nevertheless flying in a cloud containing snow particles does not always imply that icing will form. The following occasion, which is not listed, illustrates this point: on the very cold morning of January 31, 1947, the crew were at Lyneham waiting to take off for Malta. Snow showers were occurring about twice an hour. We took off after a shower, climbed on track and the following temperatures and cloud formations were observed:—

Pressure (mb.)	990 (surface)	975	950	900	850	800	750	720
Temperature (°F.)	25	26·4	25·2	21·0	16·8	11·6	6·4	2·0

Cloud:—10 tenths stratus, 2,000–2,800 ft., 925–900 mb.
8 tenths stratus, 875–860 mb.
1 tenth cumulus tops to 700 mb.
2 tenths altocumulus, 750–700 mb.

The cumulus and altocumulus were avoided. No icing was experienced whilst crossing the stratus layers although there were some snow flakes in them. It would appear that the fine particles in the stratus were either too small to cause icing or that they were already frozen. That they were too small could be attributed to the fact that there was no convection to feed them and that the presence of the snow flakes would tend to reduce them to their smallest possible size under the existing conditions, owing to differences in vapour pressure.

Further south, another very interesting run took place that day, run 16. The temperature at the base of the cloud of this run must have been about -4°F.; nevertheless, for ice accretion to take place at the rate observed, it must be supposed that there was supercooled water in it as well as snow. There was also some convection as evidenced by the turbulence. This was the run during which the presence of snow flakes with water adhering to them was most strongly suspected.

Conclusions.—It is suggested that icing in convection clouds containing snow is a common occurrence, because a mixture of snow and water is also a common occurrence over a wide temperature range below freezing. It is thought that this mixture may even be found with water and snow in actual contact with each other. That such conditions should readily give rise to icing is obvious. The water and snow are comparable to mortar and bricks and the accretion can be rapid since much of the latent heat of crystallization has already been given off.

It is suggested that this type of icing predominates increasingly in frequency and importance as the temperature decreases down to the very low temperatures at which icing is now known to occur.

This ice accretion of the snow-pack type occurring in mixed clouds must, together with its attendant circumstances, be given its proper place amongst the various kinds of icing now that flying takes place over a far greater range of height, temperature, and cloud conditions.

In order to interpret and reconcile the foregoing observations it is suggested that for the production of supercooled water, necessary to give rise to ice accretion either alone or mixed with ice crystals, not only must the temperature be in the right range but the rate of cooling by ascent in the cloud must exceed a critical value which itself varies with the temperature. It appears probable in fact that the formation and size as well as the suspension of supercooled water drops in cloud depend on the rate of cooling by ascent. This state of water would be ephemeral, especially at very low temperatures, and would not endure in the absence of sufficient convection. This suggestion implies an intimate relationship between convection in clouds, due either to steady updraughts or cellular activity, and most kinds of ice accretion.

LONDON MATHEMATICAL SOCIETY

On Thursday December 18, 1947, Mr. G. K. Batchelor gave a lecture to the London Mathematical Society entitled " Progress and difficulties in the theory of isotropic turbulence ".

Atmospheric turbulence plays an important part in many meteorological processes and its elucidation is of material interest to the meteorologist. However, turbulence in the atmosphere is undoubtedly still more complex than the isotropic turbulence in an incompressible fluid discussed by Mr. Batchelor. In the latter the mean velocity over a long period is zero (or uniform) at all points, and the averaged properties of the motion have spherical symmetry.

Mr. Batchelor explained that the fundamental problem of turbulence theory was to derive the statistical characteristics of the turbulent motion from the equations of motion of a viscous fluid and the equation of continuity. We could not hope to specify the detail of the motion, but we might expect that some statistical characteristics would become independent of the initial conditions (e.g. the correlation between velocities at pairs of points).

Mr. Batchelor first discussed turbulent motion under conditions in which the quadratic terms of the equations of motion can be neglected. A solution was obtainable which gave the rate of decay of turbulent energy as inversely proportional to $t^{5/2}$ ($t =$ time); and also gave solutions for other statistical properties. Such conditions of turbulence occur in the final stages of dissipation of turbulent energy and theoretical deductions are well verified by experiment.

Mr. Batchelor then turned to the more general turbulent conditions in which the quadratic terms cannot be neglected and for which no complete theoretical solution had yet been obtained. However, certain statistical relationships were deducible from the equations of motion, and had been verified by wind-tunnel experiments on isotropic turbulence. This fact gave confidence that the equations of motion for a viscous fluid were in fact applicable to such turbulence. Various other fundamental statistical relationships appeared from wind tunnel experiments; in particular the turbulent energy decayed inversely as the time during the initial stages when the quadratic terms played a significant part in the equations of motion. The theoretical explanation of this was the subject of current research.

In conclusion Mr. Batchelor discussed the distribution of turbulent energy among eddies of various sizes and in particular the energy relations of the small-scale eddies which are simultaneously present with the larger ones and the behaviour of which has many interesting properties.

J. S. SAWYER

LETTER TO THE EDITOR

Hypostereograms

Mr. Tricker's hypostereograms, reproduced in the August 1947 issue of the *Meteorological Magazine* are of much interest, but there is a point regarding their interpretation which calls for mention. The stereoscopic effect depends upon relative horizontal displacements between corresponding points in the left and right images. In an ordinary stereogram in which the two images are produced simultaneously by two cameras separated by a fixed or variable horizontal distance the displacement is inversely proportional to the distance from the cameras, and a faithful representation of the distribution in space of the different objects in the picture is obtained when the pictures are viewed in a stereoscope.

In stereograms produced by Mr. Tricker's method, in which the displacement is produced by tranverse movement of the object between the two exposures, the displacement is proportional to the velocity and inversely proportional to the distance. Thus a faithful representation will not be obtained unless the velocity v of all objects appearing in the picture is the same. For all objects forming part of the landscape, v is zero. Consequently there is no displacement and the landscape appears " at the back of everything ", as Mr. Tricker points out. If the wind increases with height, the higher clouds will apparently be brought nearer to the viewer and *vice versa*. The stereoscopic representation of skyscapes in which there are clouds at different levels is therefore liable to be considerably distorted, and the stereograms cannot be expected to give anything more than a broad qualitative idea of the three-dimensional distribution.

E. G. BILHAM

January 8, 1948

NOTES AND NEWS

The year 1947 provided the greatest variety of abnormal weather over the British Isles since regular observations began. The severity of the latter part of the winter 1946–7, the rain and floods of March, and the drought and warmth of late summer and autumn, were all unprecedented for a very long period. The year also included the two longest spells of continuous easterly wind for at least 66 years, one giving severe winter weather and the other the warmth and sunshine of August. The weather has been discussed briefly month by month in the *Meteorological Magazine*, and the character of the winter was described in two articles in the issues for March and April. From the latter discussion it appears that in this country the winter of 1946–7 was by far the most severe in Great Britain since at least 1881, while in Holland it was probably the most severe since that of 1788–9. The April issue included a map of the deviations of mean pressure from normal in February 1947, which shows a great excess of pressure (exceeding 25 mb.) north-west of Iceland, and a deficit of 10–15 mb. over the eastern Atlantic in 40–50°N. The chart of actual pressures (reproduced here as Fig. 1) showed a decrease from 1035 mb. in north-east Greenland to 1002 mb. in mid Atlantic (latitude 50°N.) associated with the persistent strong easterly winds. An upper anticyclone extended northwards simultaneously with the surface anticyclone but was further to the west; after February 4 the upper winds were mainly westerly though weaker than usual. Broadly speaking, the belt of strong upper westerlies was displaced southward, associated with the large temperature deficiency over the British Isles and adjacent part of Europe.

The chart of deviations for March is rather similar, but the area of deficient pressure has spread over the British Isles. Fig. 2 shows the actual pressures; the area below 1000 mb. from Ireland westwards marks the scene of great cyclonic activity, which gave rise to heavy snow in the first half of March, and rain in the second half. This was the wettest March in England since 1747, and the rain and melting snow combined to cause disastrous floods.

In April (Fig. 3) the normal type of south-westerly circulation returned but with unusual intensity, pressure being 10 mb. below normal north of Iceland and 10 mb. above normal on the Riviera. There was much deep cold air over the Atlantic and occasionally over the British Isles; upper air pressure and temperature were well below average. A series of deep depressions travelled eastwards or north-eastwards across the British Isles or between Iceland and Scotland; these and the associated SW. winds brought Scotland the wettest April since before 1869.

The weather of May, June and July was not remarkably abnormal, though pressure continued low over the Atlantic and northern Ireland had heavy rain, especially in May and June. There was an excess of southerly winds at all heights with a corresponding excess of temperature. The record-breaking heat on the continent in late June and late July was associated with high upper air pressure. August however brought more NE. winds, abnormal heat and drought. The period August 9 to September 2 was unique in the persistence of high pressure over north-west Europe and E.–NE. winds over a large part of south-east England, unbroken except for local land and sea breezes on the south coast. Fig. 4*a* shows the mean pressure at M.S.L. during this period, and Fig. 4*b* shows the height of the 300 mb. isobaric surface in feet. A high level of this surface represents an anticyclone in the upper air. Fig. 4*b* is based partly on direct observations and partly on interpolated values. The upper winds over the British Isles were unusually light for a longer period than any previously known since observations began in 1940. The surface air over this country was not especially dry, owing to moisture from the North Sea, which resulted in much morning fog and stratus in eastern and northern districts, but the usual anticyclonic subsidence led to mainly dry stable conditions aloft, only broken during a thunderstorm in London on August 23.

A high pressure in the upper troposphere and the corresponding high and cold stratosphere is a necessary condition for a persistent anticyclone, but it is not in itself sufficient. The dynamics and thermodynamics of the troposphere

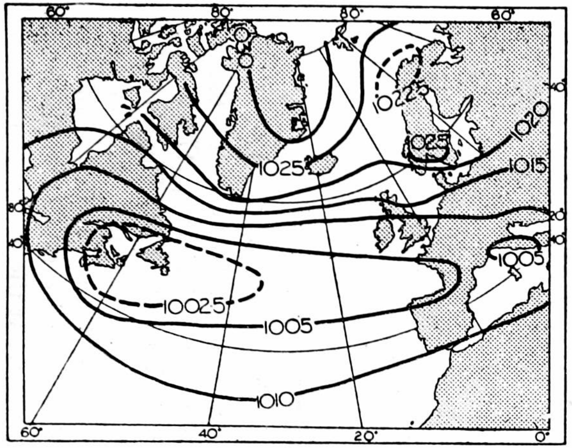


FIG. I—MONTHLY MEAN PRESSURE, FEBRUARY 1947

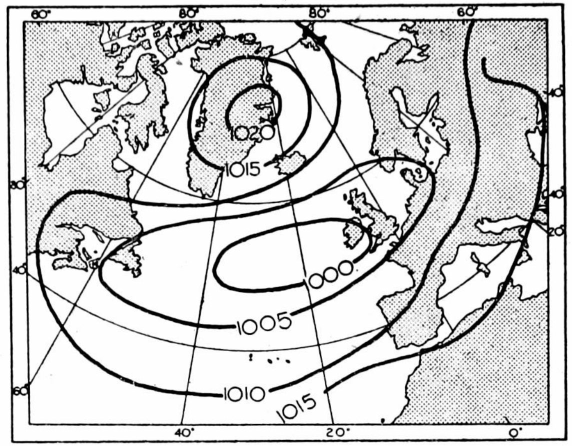


FIG. 2—MONTHLY MEAN PRESSURE, MARCH 1947

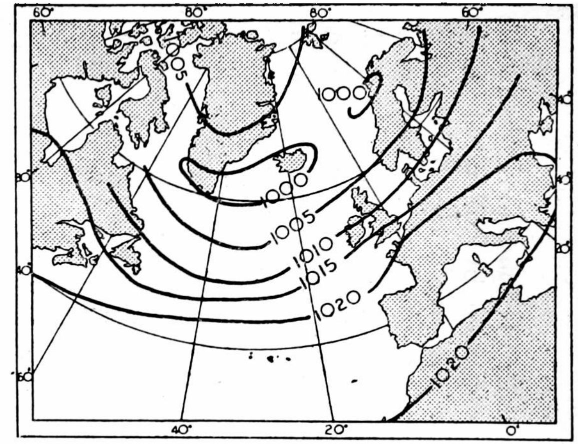


FIG. 3—MONTHLY MEAN PRESSURE, APRIL 1947

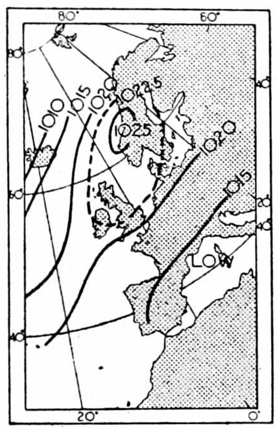


FIG 4*a*—MEAN PRESSURE AT M.S.L., AUGUST 9—SEPTEMBER 2, 1947

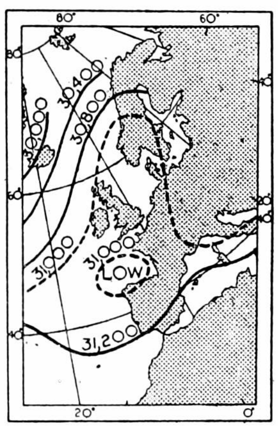


FIG. 4*b*—MEAN HEIGHT OF 300 MB., SURFACE, AUGUST 9—SEPTEMBER 2, 1947

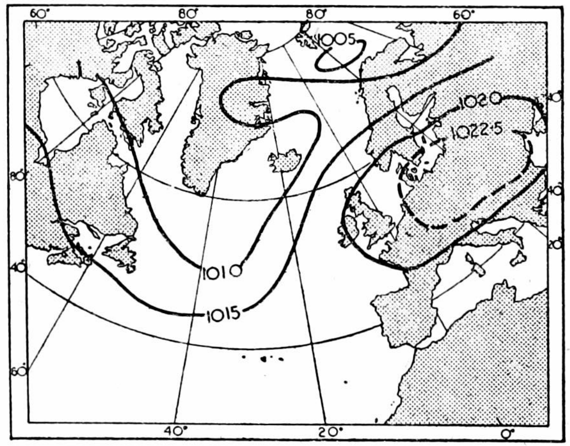


FIG. 5—MONTHLY MEAN PRESSURE, OCTOBER 1947

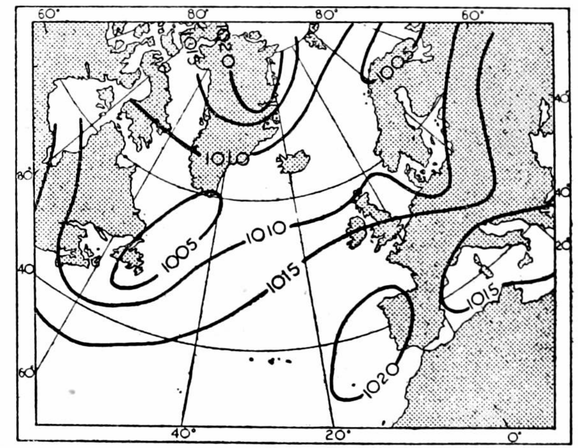


FIG. 6—MONTHLY MEAN PRESSURE, DECEMBER 1947

are certainly of great importance, and more especially the conditions associated with the successive regenerations normally accompanied by the rapid subsidence of fresh masses of polar air. These processes are a kind of mutual interaction between the anticyclone system and the surrounding conditions.

A feature of the period was the steep upper gradient over Canada. Depressions moved quickly eastward across Canada into the Atlantic and then turned north-east up the Denmark Strait. Deep cold air never penetrated east of longitude 30°W. It is the advance of deep cold air and the associated upper trough which is liable to lead to the collapse of a warm anticyclone.

The conditions in the autumn resembled those of 1921; in that year conditions were anticyclonic until November 12 and there was no wet spell in south-east England until January 1922. Another feature which has often been noted in previous dry spells was much in evidence this autumn, namely the light rainfall in a variety of synoptic situations, any one of which could easily have given much more rain. The most remarkable month was October (Fig. 5) when an anticyclone covered central and western Europe, in late October the anticyclone at the 300 mb. level lay over Scandinavia. Over England and Wales this was the driest October, probably since 1809, but Scotland lay partly outside the influence of the anticyclone and the month was not as dry as October 1946. September and November were also dry over England and Wales. The anticyclones of September to November were of a normal type, the exceptional feature being their frequency. They mostly developed close to the British Isles.

Anticyclonic conditions returned in December (Fig. 6) when pressure was high from Spain to the north of Scotland (see p. 45). This month was the seventh consecutive dry month in England and Wales.

For the year as a whole the temperature, rainfall and sunshine differed little from normal. The following table shows the general character of the weather:—

	Air Temperature			Rainfall		Sunshine	
	Highest	Lowest	Difference from average daily mean	Percentage of average	No. of days difference from average	Percentage of average	Percentage of possible duration
	°F.	°F.	°F.	%		%	%
England and Wales	94	−6	+0·4	93	−19	99	33
Scotland	87	−6	0·0	97	−21	102	29
Northern Ireland ..	83	5	+0·3	105	−21	96	29

C. E. P. BROOKS.

First Director of Radio Research

The Lord President of the Council has approved the promotion of Dr. R. L. Smith-Rose, D.Sc., Ph.D., M.I.E.E., to the new post of Director of Radio Research in the Department of Scientific and Industrial Research (D.S.I.R.). Dr. Smith-Rose will be in charge of the radio research work of the Department for which a new station will eventually be established. The new station will incorporate the work now being carried out in the Radio Division of the National Physical Laboratory, and the Radio Research Station (D.S.I.R.) at Slough and also work at present being done for D.S.I.R. at the Telecommunications Research Establishment at Malvern. Dr. Smith-Rose has been Superintendent of the Radio Division of the National Physical Laboratory since 1939.

OBITUARY

Mr. W. H. Pick, B.Sc., F.C.P., F.Inst.P. It is with very great regret that we have to record the death of Mr. William H. Pick on Boxing Day, December 26, 1947. His passing will leave a distinct gap in the staff of the Meteorological Office, while he will be missed by an even wider circle of friends in the Royal Air Force.

He was born in Hackney on January 14, 1891, and educated in London. Adopting teaching as a profession, he took his teaching diploma from the London Day Training College, after first graduating in science from University College, London, in 1911. He began his teaching career at Basingstoke and it was while here that he first showed his interest in meteorology. With the help of his pupils he maintained an observing station there for several years which sent in returns to the Meteorological Office.

He joined the Meteorological Section, R.E., in 1917, and was commissioned in 1918. On the cessation of hostilities on the Western Front he was placed in charge of the Meteorological Detachment serving with the British Forces in north Russia.

In early 1920 after his release from the forces he joined the staff of the Meteorological Office as a Senior Professional Assistant and was posted to the Royal Air Force College at Cranwell where he lectured on meteorology for many years. There was at that time no suitable text-book for his students and the preparation of one, "A Short Course in elementary meteorology", occupied his attention for some time. It was a task for which his early training and natural bent eminently suited him and the publication was an immediate success; edition after edition was called for. He was promoted to Assistant Superintendent in 1922.

The Meteorological Office, Cranwell, during his service, was the training station for several newcomers to the professional staff who will remember with especial gratitude his inspiring and wise teaching.

In 1928 he left Cranwell to become a senior forecaster at Headquarters.

In 1932 he was posted to Andover, at that time the headquarters of Wessex Bombing Area. Blind flying in cloud and its attendant risks of icing and collision was then one of the major problems of the Royal Air Force, and he later compiled a comprehensive report on the meteorological aspects of cloud and blind flying. Following the introduction of the "Carpenter" scheme in 1935 he was assimilated as Senior Technical Officer.

The outbreak of the second world war found him meteorological advisor to Bomber Command. This was followed by periods of service at Headquarters in London, with the Ministry of Home Security and Anti-Aircraft Command. The end of the war, however, found him again occupied with the training of pilots at South Cerney. He was assimilated to the grade of Principal Scientific Officer on the introduction of the Scientific Civil Service in 1946. It was while still at South Cerney that the end came so unexpectedly.

Pick's largest contribution to the literature of meteorology was the "Short Course in Elementary Meteorology" which, written originally for the cadets at Cranwell, became very popular in schools throughout the country. Pick was a keen investigator of meteorological problems and was particularly interested in visibility. His papers on that subject published as *Professional Notes* or in the *Quarterly Journal of the Royal Meteorological Society* dealt with downward visibility from the air, visibility in saturated air, the connexion between air-mass type and visibility, and the visibility experienced at Cranwell in different wind directions and speeds. In addition, he wrote a *Professional Note* on the upper wind observations made under his direction in north Russia, articles in the *Quarterly Journal* on the persistence of types of pressure distribution over the British Isles and on mammato-cumulus cloud, and in this magazine on the forecasting of night-minimum temperatures.

Pick was very interested in educational psychology and wrote various papers on that subject in educational journals. He wrote also many articles and character sketches for *Blighty*, some of the London magazines and the *Royal Air Force Quarterly*. These were characterised by a real delicacy of touch which savoured not a little of that master of pastoral lyrics, Robert Herrick, from whose relatives he traced descent.

An interesting example of his combination of educational and meteorological ability was his thesis on the " Teaching of meteorology in Secondary Schools " for which, with his " Short Course", he was awarded in 1922 the Diploma of Fellowship of the College of Preceptors. His abilities as a teacher made him at one time in considerable demand as a lecturer to schools and societies mainly on meteorological topics.

He was for many years a Fellow of the Royal Meteorological Society, serving on its Council and occupying himself particularly with financial matters from 1931 to 1936. He was also a Fellow of the Chemical and Royal Astronomical Societies and of the Institution of Physics.

Pick was held in very high regard in the Royal Air Force, especially by his former pupils at Cranwell, many of whom had risen to senior rank. He was of independent character maintaining his point of view with persistence, even vehemence. A man of wide reading on many topics, he was an entertaining companion in leisure hours.

He married late in life in March 1944 and we would like to extend to his widow our deepest sympathy in her sorrow.

S. F. WITCOMBE

REVIEW

The correlation between weather and yield of winter wheat in the Netherlands, by J. P. M. Woudenberg, Koninklijk Nederlandsch Meteorologisch Instituut, No. 102, Mededeelingen en Verhandelingen 50. 8vo., 9½-in. × 6¾-in. pp. 43. (English summary pp. 39-42). 's.Gravenhage, 1946.

This paper is divided into two sections, the first of which contains a large number of useful correlation coefficients, laborious to compute but making good use of crop and weather data, for the three regions, Gröningen, Zeeland and south Limburg. In the second section these data are used to describe the ideal climate for winter wheat, but the results are unconvincing. Any appreciation of this paper must therefore deal with the two sections separately.

In the first section the general trends of the yields are first eliminated and then, for each region, some 80 or 90 correlation coefficients are calculated between the adjusted yields and the rainfall, sunshine and temperature over various periods of the year. The largest of these coefficients between the yield and each element are then combined into multiple correlation coefficients (called " total correlation coefficients " in this paper). For each region these coefficients are about 0·7, and they relate the yield to June and July rainfall and sunshine and to winter temperatures. It would have been useful if the author had given some indication of the statistical significance of his coefficients, but this omission is not serious as sufficient information is given for estimating the significance levels.

In the second section of the paper, the coefficients, together with some other material, are used to define the ideal climate for winter wheat in each locality. However, the definitions include phrases such as " not too mild " and " rather dry ", and they are of very little use. They purport to describe the ideal weather during seven periods between sowing and harvest and for each year (about 1921–40)· the weather is assessed by awarding marks for the various periods; the yield of winter wheat is then estimated from the annual totals. Except for south Limburg, the computed yields are close to the actual yields, but the author admits that his method is " very subjective " and it is very doubtful whether different estimates would be comparable. However, there is a more serious objection to the methods of this second half of the paper—the treating of a fundamentally biological problem by purely statistical methods. This fault also the author admits by implication when he points out that the ideal climate applies only to normal years and that it must be changed after very cold winters or very mild springs. There can be little doubt that whenever the weather is very different from the average the ideal climate for the plant from that time onwards in that season will change, and that to speak of a mean " ideal climate " ignores both the variability of the weather in these latitudes and the adaptability of the plant.

W. H. HOGG

WEATHER OF DECEMBER 1947

Pressure was high over the Arctic at the beginning of the month with depressions over Europe and the North Atlantic from the 1st to 8th. These were especially severe between Newfoundland and Greenland, where pressure fell below 972 mb. on the 6th and 968 mb. on the 8th. On the 9th a developing anticyclone spread over the British Isles and became intense, persisting until the 19th; on the 17th pressure exceeded 1044 mb. north of Ireland. On the 20th to 24th it receded south-west and then south and weakened, while pressure was generally low over the Arctic, especially to the north of Europe. On the 24th and 25th a deep depression developed over Iceland, and conditions were very stormy in north-west Europe until the 28th; on the 27th pressure at Wick (Scotland) fell to 966 mb. North-westerly winds in the rear of this depression brought cold conditions and snow during the last three days of the month.

The map of mean pressure distribution shows an area of pressure exceeding 1020 mb. over north-east Greenland, from Madeira to Portugal and south of the Great Lakes of America. Pressure was below 1005 mb. between Newfoundland and South Greenland and in the north of Norway, and was generally low over Scandinavia. The greatest deficits of pressure from normal (exceeding — 5 mb.) lay between Nova Scotia and Newfoundland, and over central Europe and the Baltic; pressure was considerably above normal in the Arctic, central and eastern North Atlantic, Ireland and Scotland, the excess exceeding 10 mb. between Iceland and north-east Greenland.

The weather of the British Isles was generally dry, rather mild and dull. There were cold spells at the beginning and end of the month, particularly during the first three days but roughly from the 5th to 25th it was mainly mild and over much of England and Wales the mild weather persisted until the 28th. In the opening days a wedge of high pressure moved north over Great Britain and some unusually low temperatures were registered; for example, 6°F. at Kelso and Dalwhinnie on the 2nd and Braemar on the 3rd, and 11°F. at Porton on the 1st and Ampleforth on the 2nd. A minimum temperature of 20°F. at Edinburgh on the 2nd was the lowest recorded there in December since 1908. Day temperatures were also very low. On the 5th a deep depression over the Bristol Channel moving north caused moderately heavy rainfall in the south of England and rather severe gales in the south-west; gusts of 77 and 73 m.p.h. were registered at Pendennis Castle and St. Ann's Head respectively. Some snow and sleet showers occurred during the first five days.

A change to very unsettled conditions took place on the 24th; local gales were reported daily from the 25th to 29th, while heavy rainfall occurred at times, particularly in Wales on the 26th. Widespread wintry precipitation occurred on the 29th and 30th, falls of snow up to six inches being reported on Donside, Aberdeenshire. On the closing day a ridge of high pressure moved east over the country, but it was quickly followed by troughs associated with an Atlantic depression and rain spread to all districts by the evening.

The table below shows that there was a considerable deficiency of rainfall, particularly in Scotland. Rainfall exceeded the average, however, in the extreme north of the Scottish mainland, over part of the West Riding of Yorkshire, in an area covering east England from south Norfolk to east Kent and including the Thames estuary, at a few scattered places elsewhere in England, and locally in counties Armagh and Down.

The duration of bright sunshine was appreciably below the average but the percentages at individual stations were irregular, the variation being partly due to the incidence of fog. In Scotland and Northern Ireland a deficiency was practically general, but locally in the eastern half of England and the northern Midlands more than the average was registered.

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 difference from average	Percentage of average	Percentage of possible duration
	°F.	°F.	°F.	%		%	%
England and Wales	58	11	+1·2	83	−3	87	15
Scotland	58	6	+0·6	58	−4	74	11
Northern Ireland ..	55	18	+1·1	76	−7	57	13

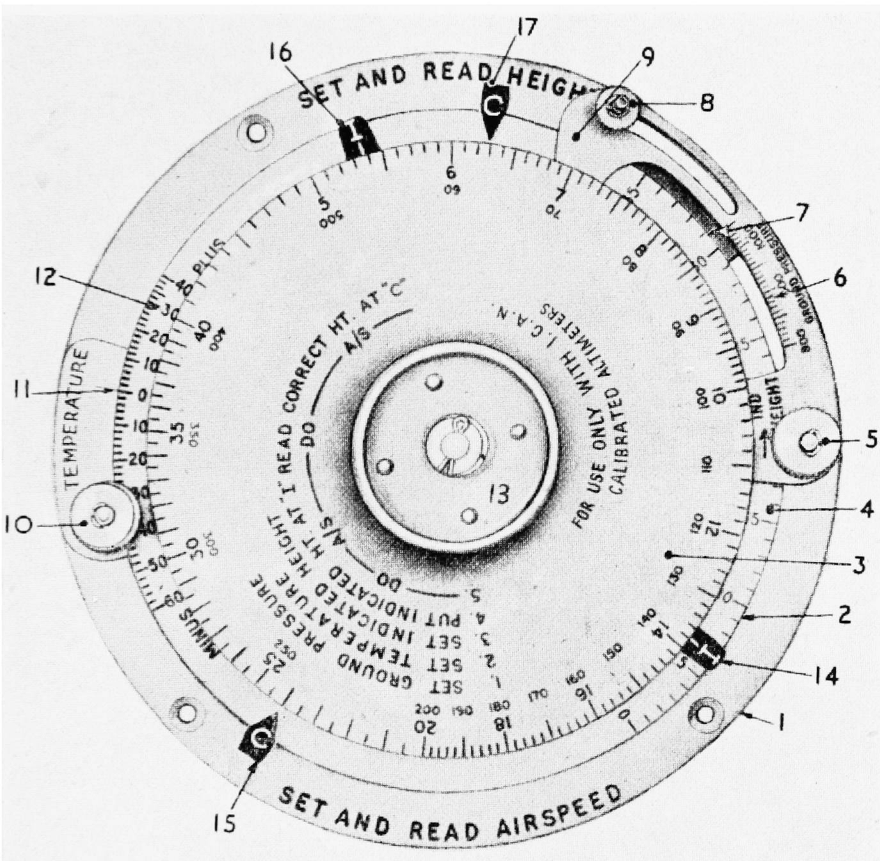
RAINFALL OF DECEMBER 1947

Great Britain and Northern Ireland

County	Station	In.	Per cent of Av.	County	Station	In.	Per cent of Av.
London	Camden Square ..	2·27	95	*Glam.*	Cardiff, Penylan ..	3·68	73
Kent	Folkestone, Cherry Gdns.	3·41	106	*Pemb.*	St. Ann's Head ..	4·20	88
,,	Edenbridge, Falconhurst	2·69	82	*Card.*	Aberystwyth	3·65	92
Sussex	Compton, Compton Ho.	3·43	82	*Radnor*	Bir. W. W., Tyrmynydd	6·16	75
,,	Worthing, Beach Ho. Pk.	2·30	76	*Mont.*	Lake Vyrnwy	6·28	90
Hants.	Ventnor, Roy. Nat. Hos.	3·43	104	*Mer.*	Blaenau Festiniog ..	9·51	75
,,	Fordingbridge, Oaklands	3·51	89	*Carn.*	Llandudno	1·63	56
,,	Sherborne St. John ..	3·07	93	*Angl.*	Llanerchymedd ..	2·91	66
Herts.	Royston, Therfield Rec.	2·84	122	*I. Man.*	Douglas, Boro' Cem. ..	2·35	48
Bucks.	Slough, Upton ..	2·53	100	*Wigtown*	Port William, Monreith	2·01	44
Oxford	Oxford, Radcliffe ..	1·76	72	*Dumf.*	Dumfries, Crichton R.I.	2·31	54
N'hant.	Wellingboro', Swanspool	2·26	96	,,	Eskdalemuir Obsy. ..	3·13	45
Essex	Shoeburyness	2·04	111	*Roxb.*	Kelso, Floors	1·84	79
Suffolk	Campsea Ashe, High Ho.	3·37	147	*Peebles.*	Stobo Castle	2·69	71
,,	Lowestoft Sec. School ..	2·18	94	*Berwick*	Marchmont House ..	1·66	59
,,	Bury St. Ed., Westley H.	2·88	120	*E. Loth.*	North Berwick Res. ..	1·61	75
Norfolk	Sandringham Ho. Gdns.	2·40	94	*Midl'n.*	Edinburgh, Blackf'd. H.	2·19	94
Wilts.	Bishops Cannings ..	2·47	75	*Lanark*	Hamilton W. W., T'nhill	2·60	60
Dorset	Creech Grange.. ..	3·71	84	*Ayr*	Colmonell, Knockdolian	2·42	43
,,	Beaminster, East St. ..	3·28	69	,,	Glen Afton, Ayr San. ..	3·42	53
Devon	Teignmouth, Den Gdns.	2·04	48	*Bute*	Rothesay, Ardencraig ..	2·82	52
,,	Cullompton	3·99	91	*Argyll*	Loch Sunart, G'dale ..	3·87	44
,,	Barnstaple, N. Dev. Ath.	3·26	74	,,	Poltalloch	3·10	49
,,	Okehampton, Uplands	6·14	87	,,	Inveraray Castle ..	4·65	47
Cornwall	Bude School House ..	3·80	87	,,	Islay, Eallabus ..	3·03	51
,,	Penzance, Morrab Gdns.	3·46	61	,,	Tiree	3·46	66
,,	St. Austell, Trevarna ..	4·40	72	*Kinross*	Loch Leven Sluice ..	2·08	53
,,	Scilly, Tresco Abbey ..	3·20	68	*Fife*	Leuchars Airfield ..	1·19	49
Glos.	Cirencester	2·03	61	*Perth*	Loch Dhu	3·68	37
Salop	Church Stretton ..	3·02	86	,,	Crieff, Strathearn Hyd.	1·89	42
,,	Cheswardine Hall ..	2·74	97	,,	Blair Castle Gardens ..	1·83	48
Staffs.	Leek, Wall Grange P.S.	2·95	79	*Angus*	Montrose, Sunnyside ..	1·90	68
Worcs.	Malvern, Free Library	2·26	82	*Aberd.*	Balmoral Castle Gdns...	2·08	62
Warwick	Birmingham, Edgbaston	2·28	85	,,	Aberdeen Observatory	2·37	74
Leics.	Thornton Reservoir ..	2·31	86	,,	Fyvie Castle	2·35	69
Lincs.	Boston, Skirbeck ..	2·02	94	*Moray*	Gordon Castle	1·61	60
,,	Skegness, Marine Gdns.	2·17	99	*Nairn*	Nairn, Achareidh ..	1·43	70
Notts.	Mansfield, Carr Bank	2·25	78	*Inv's*	Loch Ness, Foyers ..	2·00	45
Ches.	Bidston Observatory ..	1·98	75	,,	Glenquoich	7·06	48
Lancs.	Manchester, Whit. Park	2·75	85	,,	Fort William, Teviot ..	3·59	35
,,	Stonyhurst College ..	4·45	92	,,	Skye, Duntuilm ..	3·42	55
,,	Blackpool	2·78	85	*R. & C.*	Ullapool	3·99	66
Yorks.	Wakefield, Clarence Pk.	2·54	105	,,	Applecross Gardens ..	3·59	56
,,	Hull, Pearson Park ..	2·12	88	,,	Achnashellach	4·24	45
,,	Felixkirk, Mt. St. John	2·17	90	,,	Stornoway Airfield ..	4·02	68
,,	York Museum	1·79	80	*Suth.*	Lairg	2·26	56
,,	Scarborough	1·34	56	,,	Loch More, Achfary ..	9·32	101
,,	Middlesbrough.. ..	1·41	73	*Caith.*	Wick Airfield	3·53	115
,,	Baldersdale, Hury Res.	3·72	100	*Shet.*	Lerwick Observatory ..	3·70	77
Norl'd	Newcastle, Leazes Pk.	2·44	104	*Ferm.*	Crom Castle	3·33	80
,,	Bellingham, High Green	1·89	52	*Armagh*	Armagh Observatory ..	3·18	102
,,	Lilburn, Tower Gdns...	2·23	85	*Down*	Seaforde	4·29	104
Cumb.	Geltsdale	2·39	63	*Antrim*	Aldergrove Airfield ..	1·67	49
,,	Keswick, High Hill ..	2·73	41	,,	Ballymena, Harryville..	2·75	62
,,	Ravenglass, The Grove	1·96	43	*Lon.*	Garvagh, Moneydig ..	2·44	61
Mon.	Abergavenny, Larchfield	2·72	61	,,	Londonderry, Creggan	3·41	78
Glam.	Ystalyfera, Wern House	6·23	75	*Tyrone*	Omagh, Edenfel ..	3·00	71

CLIMATOLOGICAL TABLE FOR THE BRITISH COMMONWEALTH, AUGUST 1947

Stations	Pressure: Mean of day M.S.L.	Pressure: Diff. from normal	Temperatures: Absolute Max.	Temperatures: Absolute Min.	Temperatures: Mean values Max.	Temperatures: Mean values Min.	Temperatures: Mean values ½ (Max. and Min.)	Temperatures: Mean values Diff. from normal	Temperatures: Wet bulb	Relative humidity	Mean cloud amount	Precipitation: Total	Precipitation: Diff. from normal	Precipitation: Days	Bright Sunshine: Daily mean	Bright Sunshine: Percentage of possible
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	tenths	in.	in.		hrs.	%
London, Kew Observatory	1019·9	+5·0	87	49	77·5	58·8	68·1	+5·9	60·7	69	5·1	0·40	−1·84	4	8·4	58
Gibraltar	1014·6	−1·9	98	65	85·5	70·3	77·9	+1·9	72·1	81	2·5	0·00	—	0	—	—
Malta	1013·4	−1·4	95	69	89·4	74·8	82·1	+3·0	75·4	60	1·8	0·28	—	2	11·2	83
St. Helena	1018·5	−1·4	69	52	61·1	54·0	57·5	+0·2	54·0	96	9·8	2·08	−0·58	21	—	—
Freetown, Sierra Leone	1013·1	+2·0	85	69	80·3	73·9	77·1	+0·8	75·1	92	8·8	43·85	+7·28	31	2·1	17
Lagos, Nigeria ..	1013·7	+0·7	85	68	82·1	71·5	76·8	−1·1	74·7	90	9·5	8·80	—	21	1·4	11
Kaduna, Nigeria ..	1012·2	—	88	64	81·9	67·5	74·7	+0·5	70·6	87	9·3	15·24	+2·92	27	3·7	30
Chileka, Nyasaland ..																
Salisbury, Rhodesia ..																
Cape Town ..	1019·7	−0·6	74	41	63·9	47·9	55·9	+0·3	50·6	88	5·8	2·51	−0·86	17	—	—
Germiston, South Africa	1022·4	—	79	29	72·4	44·6	58·5	—	45·5	40	0·3	0·00	—	0	10·5	94
Mauritius	1022·1	+1·5	79	55	75·2	62·1	68·7	+0·2	62·4	73	4·9	2·15	−0·10	23	8·0	70
Calcutta, Alipore Obsy.	1001·7	+1·0	95	75	89·5	79·5	84·5	+1·3	80·3	91	8·5	15·34	+1·96	26	4·2	33
Bombay	1004·4	−1·5	90	74	86·3	77·4	81·9	+1·1	77·6	88	8·9	20·56	+6·11	21	2·8	22
Madras	1004·4	−1·1	99	74	92·0	78·6	85·3	−0·7	76·8	76	7·1	2·92	−1·62	11	6·0	48
Colombo, Ceylon ..	1008·7	−0·6	87	73	84·4	76·7	80·5	−0·7	75·7	84	8·9	9·23	+5·99	19	4·3	35
Singapore	1008·6	−0·9	91	71	87·7	74·5	81·1	0·0	77·4	80	—	6·85	−1·10	18	—	—
Hongkong	1007·6	+2·8	95	74	87·5	77·6	82·5	+0·4	78·5	86	—	22·62	+8·22	24	6·1	47
Sydney, N.S.W. ..	1017·1	−1·1	81	39	63·9	47·1	55·5	+0·5	47·6	63	4·3	1·68	−1·29	10	6·9	65
Melbourne	1016·3	−1·7	66	32	57·0	42·5	49·7	−1·3	44·3	70	6·9	1·27	−0·60	15	3·7	35
Adelaide	1019·0	−0·2	71	39	59·9	46·0	52·9	−1·1	47·7	68	6·7	3·05	+0·51	15	5·0	46
Perth, W. Australia ..	1019·6	+0·7	73	37	63·9	46·3	55·1	−0·9	51·1	66	5·0	2·15	−3·50	12	6·4	59
Coolgardie	1020·7	+1·4	79	31	65·0	43·1	54·1	+0·5	46·2	63	4·3	0·19	−0·80	5	—	—
Brisbane	1018·9	−0·3	78	44	70·6	51·5	61·1	+0·7	53·9	60	4·5	0·50	−1·51	6	6·7	60
Hobart, Tasmania ..	1010·0	−3·4	64	33	54·6	40·2	47·4	−0·6	41·8	68	7·1	3·24	+1·41	19	6·2	60
Wellington, N.Z. ..	1013·6	−1·5	65	33	54·2	42·7	48·5	+1·2	45·7	80	7·6	4·89	+0·40	18	4·7	45
Suva, Fiji	1014·6	+0·4	84	64	78·5	68·8	73·7	+0·1	70·0	82	7·2	3·05	−5·24	19	4·2	37
Apia, Samoa ..	1012·0	−0·3	89	67	85·8	72·8	79·3	+1·5	74·8	75	6·0	3·03	−0·60	11	7·1	61
Kingston, Jamaica ..	1014·6	+1·1	94	72	90·5	75·1	82·8	+1·3	75·0	71	4·0	3·18	−0·37	7	8·3	65
Grenada, W. Indies ..	1014·7	+2·1	88	72	85·9	76·0	80·9	+1·2	77·2	79	7·1	6·92	−2·41	22	—	—
Toronto	1018·4	+3·0	93	49	82·2	64·5	73·3	+6·1	64·9	84	4·4	2·36	−0·43	5	8·2	59
Winnipeg	1011·6	−1·6	96	39	78·3	57·9	68·1	+4·3	58·6	93	5·5	4·53	+2·37	15	8·7	60
St. John, N.B. ..	1018·3	+3·0	78	47	72·2	56·2	64·2	+3·6	58·7	85	6·1	1·01	−2·85	9	8·5	60
Victoria, B.C. ..	1015·6	−1·3	78	42	71·2	48·3	59·7	0·0	50·3	90	4·0	0·27	−0·37	5	10·2	71



HEIGHT AND AIRSPEED COMPUTER MK. II

1, 2, 3 Discs
4 Height scale
5 Control knob
6 Ground-pressure scale
7 Index mark
8 Control knob
9 Limb
10 Control knob
11 Index mark
12 Temperature scale
13 Centre pin
14, 15, 16, 17 Mechanically linked pointers

(see p. 29)

Photograph by R.A.F.

ALTOCUMULUS CASTELLATUS OVER WITHERNSEA

Taken from 22,000 ft., September 23, 1943

Photograph by R.A.F.

CUMULUS AND FRACTOCUMULUS OVER THE SEA AT 54°00′N. 6°20′E.

Taken from 26,000 ft. looking east by south, September 6, 1944