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MR. E. GOLD, C.B., D.S.O., F.R.S.

METEOROLOGICAL OFFICE

# THE METEOROLOGICAL MAGAZINE

VOL. 76. No. 905. NOVEMBER, 1947

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**ERNEST GOLD, C.B., D.S.O., F.R.S.**

On October 31, 1947, Mr. E. Gold retired from the Meteorological Office after 41 years' service. His career may be regarded as starting when he went up to St. John's College, Cambridge, at the beginning of the century. He used his time to such good purpose that in 1903 he emerged as Third Wrangler and followed this up by obtaining a First Class in the Natural Science Tripos in the following year.

Mr. Gold came to the Meteorological Office in June, 1906, and was appointed Superintendent of Instruments. Shortly afterwards he was elected a Fellow of St. John's College, Cambridge, but he remained with the Meteorological Office. The following year, however, he was appointed Schuster Reader in Dynamical Meteorology, and returned to Cambridge for three years. During this period he carried out his well known investigation into the radiative equilibrium in the stratosphere and produced the first scientific explanation of its isothermal condition. His paper in the *Proceedings of the Royal Society* is one of the classics of meteorology, and was probably largely instrumental in securing his election as a Fellow of the Royal Society a few years later.

After his return to the Meteorological Office in 1910, Mr. Gold held the post of Superintendent of Statistics, which covered what is now called Climatology.

Shortly after the outbreak of the first world war, Mr. Gold was commissioned as a Captain in the Royal Engineers (Meteorological Service). He eventually rose to the rank of Lt. Colonel and Commandant of the Meteorological Service in France. He was mentioned in dispatches in December, 1915, awarded the D.S.O. in January, 1916, and the O.B.E. in January, 1919.

On his return to the Meteorological Office he was given the rank of Assistant Director, and was made responsible for all questions connected with observations and instruments.

During the interval between the wars, however, much of his effort and interest were devoted to international meteorology, in which he was destined to play a leading part. When the International Meteorological Organization (I.M.O.)

formed a new Commission in 1920 to deal with questions of synoptic meteorology, Mr. Gold was elected its President, and held the post until October, 1947. During this period, the Commission for Synoptic Weather Information (best known as the C.S.W.I.) met on ten occasions and passed some 400 resolutions, which played a fundamental part in ensuring the development of meteorological practices on uniform lines in all countries. The degree of initiative taken by the C.S.W.I. is indicated in the fact that as early as 1929 it was considering the possibility of applying facsimile reproduction methods to synoptic meteorology.

Mr. Gold also served as a member of three other Commissions of the I.M.O., viz. the Aerological Commission, the Commission for Aeronautical Meteorology, and the Commission for the Projection of Meteorological Charts. He was, in addition, President of the Meteorological Sub-Commission of the International Commission for Aeronautical Navigation from its formation in 1919 until its functions were taken over by the International Civil Aviation Organization in 1946. It would be difficult to exaggerate the importance of the part which Mr. Gold has played in international meteorological affairs during the last 28 years.

On the outbreak of the second world war, he was within a short distance of retiring age, but the war seemed to urge him to new heights of attainment, and gave him full opportunity to display his brilliant gifts of initiative, scientific ability and organising skill. It is not too much to say that the efficiency of the meteorological services during the war was in large measure due to Mr. Gold's efforts. His services were recognised by the award of the C.B. in 1942, and the American Medal of Freedom with Silver Palm in 1946.

Turning now to the personal aspect, those who have had the good fortune to work with Mr. Gold have found him not only an able scientist and administrator, but also a colleague possessing great human understanding and sympathy. He was always ready to put his sound judgment and experience at the disposal of his colleagues, and anybody seeking his advice was sure of a sympathetic hearing. Two of his outstanding qualities were the thoroughness with which he examined every problem which came before him, and the dialectical skill which he displayed in argument. A man of strong character and great ability, he enjoyed the confidence of all who worked with him. Such natural gifts would have gained eminence in any profession, and the Meteorological Office counts itself fortunate that Mr. Gold chose a meteorological career. All his many friends will wish him health and happiness in his well earned retirement.

## **METEOROLOGY AT THE BRITISH ASSOCIATION**

The British Association for the Advancement of Science, which had dispersed from Dundee when war broke out in 1939, returned to Dundee this year for the annual meeting and assembled under the Presidency of Sir Henry Dale, O.M., F.R.S. The general theme of the meeting, "Swords into Ploughshares", was illustrated in the President's inaugural address by reference to the advances made in physical and medical sciences under the stress of war-time requirements, and the developments in aeronautics, radio and other fields of technology, which

have peace-time uses. The first meeting of Section A (Mathematics and Physics) was devoted to a discussion on the peace-time application of nuclear fission which was opened by Dr. J. D. Cockcroft, C.B.E., F.R.S., who described the construction and initial operation of the atomic pile recently completed at Harwell, and was continued by other speakers who referred to peace-time uses of the pile for producing radio-active isotopes, providing particles for bombarding atomic nuclei in order to learn more about their structure, and as an eventual source of industrial power.

In his presidential address to Section A, Sir Edward Appleton, K.C.B., F.R.S., dealt with applications of radio to meteorology and astronomy. By means of the cathode-ray oscillograph the wave form of lightning discharges and the changes at different distances from the discharge have been studied. It has been found that in a thunderstorm the leader stroke from cloud to ground, which is of a discontinuous nature, is the origin of a series of electro-magnetic pulsations of relatively high quasi-frequency, and the main discharge, which takes place as a return stroke along the ionised trail blazed by the leader, is the origin of the main atmospheric wave form of lower quasi-frequency. It is interesting to note that the apparently greater number of atmospherics heard on a radio receiving set at night does not imply that thunderstorms are more frequent at night, but is due to the reception of atmospherics from greater distances owing to ionospheric reflection. The cathode direction-finding technique\*, used for locating thunderstorms by obtaining simultaneous cross-bearings from three or four well separated receiving stations was later described in some detail by Dr. R. L. Smith-Rose, who also referred to the narrow-sector recorder type of apparatus designed some twenty years ago. It is necessary to use frequencies in the band 10–30 Kc./sec. (wave-length 30–10 Km.) for receiving atmospherics in order to avoid interference by normal radio-communication, broadcasting, and navigational aids. Visual observations on the cathode-ray direction finder are restricted to the strongest flashes; these occur some 5 to 10 times a minute and emanate from storm areas at ranges up to 1,000 miles. Centres of activity are sometimes associated with cold fronts and at other times concentrated towards the apex of the warm sector† suggesting that here the ascensional velocity of the warm air is greatest; in partly occluded depressions the majority of atmospherics emanate from the non-occluded part. Future developments indicated by Dr. Smith-Rose include photographic recording to overcome the present limitations on the rate at which measurements can be made. The outstanding technical problem however is the provision of means for rapidly transferring the angular data to a plotting centre and transforming them into locations on a map. The eventual use of a single observing station to determine not only the bearing but also the range of an atmospheric is hardly more than an interesting speculation at present; in certain limited circumstances the distance of a flash may be measured from an examination of the wave form but this does not seem possible under all conditions.

Another application of radio to meteorology referred to by Sir Edward Appleton was the detection of radar echoes from falling rain. Raindrops scatter energy from a beam of radio waves, the scattering being more pronounced the shorter the wave-length. If pulses of centimetric waves are used, the echoes

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\* See *Met. Mag. London*, **76**, 1947, p. 78.

† See *Met. Mag. London*, **76**, 1947, p. 161.

from heavy rainstorms can be detected by this back-scattered radiation which can be displayed on cathode-ray tubes from which the range, bearing, and elevation or height, of the precipitation may be read.\*

The apparatus is similar to that developed during the war for detecting the movements of aircraft and shipping. On many occasions reflections appeared on the set from objects at considerable distances; at Bombay, for example, where during the monsoon ships were normally detected up to ranges of 20 miles, abnormal conditions in the hot season disclosed ships commonly at distances of 200 miles (in one case at 700 miles), and parts of the Arabian coast 1,000 to 1,500 miles away. This phenomenon, which also affects television, is due to super-refraction, an account of which was given by Dr. H. E. G. Booker. Radio rays are subject to refraction in the same way as optical rays; they are never quite straight since the density and refractive index of the air decrease with height; in a well mixed air mass downward curvature of the rays, equal to about one fifth of the earth's curvature, is produced. Abnormal propagation of radio waves due to super-refraction is widespread at centimetric wave-lengths, moderate at metric wave-lengths, exceptional at decametric wave-lengths, and unknown at longer wave-lengths. This result is not due to the variation of refractive index with wave-length but arises because, when an atmospheric radio duct is formed by certain conditions of temperature and humidity gradient in the lowermost layers, it acts as a wave-guide such as is used for piping centimetric waves to and from a radiator; such a pipe is an efficient conductor only of waves which are below a certain wave-length, and the longer the wave-length the larger the pipe that is required. In the atmosphere long waves respond only to the crude average of atmospheric gradients whereas sufficiently short waves are affected by the fine structure. In the British Isles a typical duct involving super-refraction of centimetric waves extends only to a height of some hundreds of feet. The meteorological conditions for super-refraction in such a layer are high potential temperature and relatively dry air aloft; this necessitates fine, non-turbulent weather and abnormal propagation is usually associated with nocturnal inversions and with anti-cyclonic conditions over the sea (damp surface). An equatorial climate, being turbulent, is not favourable for abnormal propagation; in a tropical climate, it is most intense; in a temperate climate it is occasionally experienced; little is known of conditions in polar regions.

Dr. E. G. Dymond described the Kew radio-sonde, the development of which was started at the National Physical Laboratory and was taken over by the Meteorological Office at the outbreak of war. The entire radio-sonde weighs 1,400 gm. (3 lbs.), of which 300 gm. is in the special battery with lead negatives replaced by zinc and having an operating capacity of  $1\frac{1}{2}$  hrs. It is flown suspended from a balloon of seamless latex rubber which is inflated with hydrogen to a diameter of about 5 ft. expanding to 15 ft. or more before bursting at heights of 60,000–65,000 ft. and occasionally 80,000 ft. The power of the transmitter, although only 30–40 mw., is sufficient to give measurable signals at ranges of 100 miles from the starting point since the instrument is then at high elevation. The accuracy of the radio-sonde is necessarily less than that attained

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\* Such apparatus is being used by the Meteorological Office at East Hill and similar, though lighter, apparatus is being developed by the Ministry of Supply for installation in aircraft to enable pilots to detect cumulonimbus cloud in darkness.

by normal instruments on the ground, not only because of the need to keep cost and complexity to a minimum, but also due to the extreme temperature range to which it is subjected in flight (from perhaps  $+80^{\circ}\text{F.}$  to  $-90^{\circ}\text{F.}$  in 40 min.). Average probable errors in pressure, temperature and relative humidity are 5 mb.,  $1^{\circ}\text{F.}$  and 10 per cent., the last figure only being attained in the lower layers of the atmosphere because the gold-beater's skin which is used for measuring humidity ceases to function efficiently at extremely low temperatures.

The application of radio to wind measurement was discussed by Mr. H. L. Wright. The need for observations of upper winds at ever increasing heights in order to meet the growing demands of aviation and the obvious limitations of the purely visual method of wind measurement by theodolite led to the development of the radio wind-measurement technique.\* In this, the bearing of a signal emitted from an airborne radio-sonde transmitter is received on rotatable aerial systems at three stations set at the corners of a triangle with sides some 20–30 miles long. By plotting the three simultaneously observed bearings at a central control station, speeds and directions of upper winds are determined to the bursting height of the balloon. The height of the transmitter at any instant is determined by calculation from values of pressure, temperature and humidity registered by the radio-sonde. The radio direction-finding method is expensive in manpower. Moreover, the observed bearings are subject to inaccuracies, the source of which it is not possible to identify in every case. A more accurate method of wind measurement is by use of radar equipment whereby the range and elevation as well as the bearing of a free balloon carrying a metallised reflector (frequently the same balloon carries also a radio-sonde transmitter) can be determined from a single observing station with a consequent reduction in use of manpower. The probable vector error of winds found by radar is only 1 or 2 knots which is about half the error in the direction-finding method. The main disadvantage of the radar method is that in very strong winds the balloon is carried out of range of the equipment (at present 40 miles) before reaching the desired extreme height. Radar wind-measurement equipment has now been installed at almost all British radio-sonde stations in the United Kingdom and overseas, and observations of upper winds are made every 6 hours at the principal stations and every 12 hours elsewhere. In the British ocean weather ships essentially similar radar equipment is in use with the addition of stabilising compensation for the ship's motion.

The use of radio for obtaining information on conditions in the ionosphere was described by Sir Edward Appleton. The ionosphere, in which air is relatively strongly ionised owing to the absorption of ultra-violet light, consists of three layers, the D layer at 60–70 Km. which is weakly ionised, the E layer at 100 Km., and the F layer at 230 Km. The structure of the ionosphere is observed by projecting radio waves vertically upwards and measuring the group-time of flight of the waves up to the reflecting layer and back; in this way the equivalent height of the layer is determined. As the frequency is increased the waves penetrate further into the layer from which they are reflected until ultimately a critical frequency is reached; from the value of the critical frequency the maximum ionization in the layer can be deduced. The D layer acts chiefly

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\* See *Met. Mag. London*, 76, 1947, p. 217.

as an absorbing region but the reflection of extremely low frequency waves from it has been detected. Using these methods it has been found that the ionization in the E layer starts to increase at sunrise, reaches a maximum at noon, and sinks to a low value through the night. The ionization in the F layer shows a similar solar dependence but does not always reach its maximum at noon nor decay so rapidly at sunset. Ionization waxes and wanes with sunspot activity; and observations have shown that the density increased by as much as 50 to 60 per cent. from the sunspot minimum of 1934 to the sunspot maximum of 1937. This implies a still greater increase, 120 to 150 per cent., in the intensity of ultra-violet light, a result which is in striking contrast to the constancy of solar radiation received at ground level during the same period. The percentage increase in the diurnal variation of the earth's magnetic field from 1934 to 1937 was also about 50 to 60 per cent., and the equality of this increase with that in ionization affords confirmation of Balfour Stewart's theory that the small daily regular changes of terrestrial magnetism are due to currents flowing in the upper atmosphere, the conductivity of which is proportional to ionization concentration. The currents arise from a species of dynamo action due to the rhythmic tidal motion of the ionised layer across the earth's permanent magnetic field. The forced oscillations of 730 cycles a year due to the sun are manifested in the semi-diurnal variations of pressure seen on barograms at equatorial stations. Using radio methods it has been shown that the E layer rises and falls by the unexpectedly large amount of 1 Km. with lunar tidal motion (about 705 cycles a year) twice during a lunar day.

Another application of radio for obtaining information on conditions at high atmospheric levels arises from the influence exerted by the earth's magnetic field on the refracting properties of an ionised layer constituted by free electric charges of electronic mass. The ionosphere is a doubly-refracting medium in that a radio wave entering it is split up into two characteristic components in opposite senses. Under certain conditions this magnetic influence causes an incident radio pulse to split into two separate reflected pulses which arrive back at the ground with slightly different delay times. Use of this method has shown that the intensity of the magnetic field at a height of 300 Km. is about 10 per cent. less than that at the ground.

Dr. A. B. Lovell described the use of radio to detect meteors. When a meteor enters the atmosphere it produces a dense trail of electrons at 80-120 Km. above the earth's surface which scatter energy from an incident radio beam. Simultaneous radio and visual watches indicate that a 3rd magnitude meteor produces about  $10^{10}$  electrons per cm. path and the distribution of intensities leads to the result that the same mass of meteoric material exists in each magnitude. Meteoric showers can of course be detected in daylight by radar observations; such observations revealed a vast meteor shower, which began on May 1, 1947, and was still continuing 53 days later; the intensity and duration of this shower make it unique compared with any hitherto found by visual observations. Mr. J. S. Hey referred to the use of Army radar apparatus operating on 5 m. for meteor detection. During the Giacobinid shower of 1946, stationary echoes were recorded broadside to the meteor trail and also fast-moving echoes were shown arising from ionization immediately around the approaching meteor; from these echoes the velocity of the meteor was deduced to be 23 Km./sec. (about 50,000 m.p.h.).

Sir Edward Appleton and Mr. Hey referred to the curious solar phenomenon revealed by radio that whereas the radio-waves emitted at a black-body temperature of  $6,000^{\circ}\text{K}$ . (to which the visible and thermal radiations from the sun correspond), should be of so slight an intensity as to be undetectable, extremely strong radio-emissions are in fact observed during period of solar activity, especially on 5 m. The intensity is more than a million times stronger than that to be expected and the effective solar temperature corresponding to peak intensities is nearly  $10^{12^{\circ}}\text{K}$ . Sudden large increases in intensity of solar radio emissions were observed to coincide with the great sunspots of 1946, and were associated with large scale "fade-outs" of radio communication on long-distance links. Mr. M. Ryle described experimental work at the Cavendish Laboratory, Cambridge, on solar radiation on wave-lengths of 1.7 m. and 3.75 m., the results of which indicate an equivalent black-body temperature of about  $10^{10}$  K. increasing considerably during the passage of large sunspots. By varying the spacing between the aerials of the receiving system the diameter of the source can be determined, and it has been found by this method that the source of these powerful emissions is only some  $10'$  of arc in diameter, little larger than the sunspot itself, and implies that in this small region the effective temperature is about  $10^{10^{\circ}}\text{K}$ .

The meeting provided ample evidence of the peace-time applications of radio developments during the war and of the manifold uses of radio in meteorology, not only for obtaining day-to-day information about the earth's atmosphere both at moderate levels and at heights unattainable by other means, but also for increasing our knowledge of the external influences affecting the atmosphere. There can be no doubt that further work along the lines described, for which there is still much scope, and other new developments, which cannot fail to continue, will increase the debt which meteorology already owes to radio physics.

H. L. WRIGHT

## A METEOROLOGIST IN THE ANTARCTIC

BY H. H. LAMB, M.A.

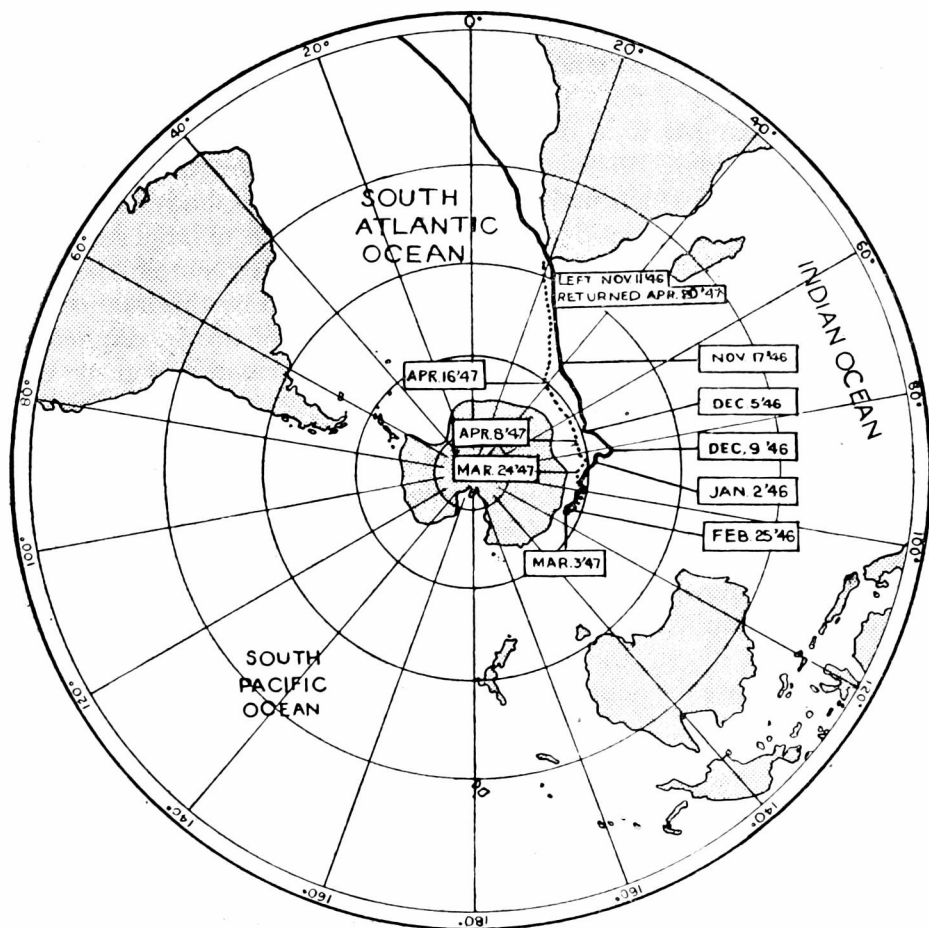
### Part II

The 1946-7 whaling season, whilst Europe shivered in a bitter winter, was a fine summer in the Antarctic. Weather was rated fit for unrestricted flying up to a 6-hour range on 53 of the 141 days which the *Balaena* spent on the whaling grounds, and fit for restricted flying on 37 other days—together over 63 per cent. of the days of the season. Even so sunshine was notably a rarity over the wide spaces of the Southern Ocean, where quiet, overcast weather is typical of the best conditions. Sunshine however, became more frequent near the coast of Antarctica, particularly between  $104^{\circ}$  and  $108^{\circ}\text{E}$ .

We had sailed south-east from the Cape of Good Hope on November 11, 1946, to reach the first ice on the 16th and start fishing for sperm whales near  $55^{\circ}\text{S}$ .  $40^{\circ}\text{E}$ . on the 17th. From this point the factory proceeded on erratic and variable courses, governed by the whaling operations, but in a general south-easterly direction, halting occasionally where many whales were found. A point near  $65^{\circ}\text{S}$ .  $115^{\circ}\text{E}$ ., off the coast of Antarctica in the Australian sector, was the furthest point reached, about the beginning of March. The taking of the large blue and fin whales was restricted by international agreement, for



the sake of the preservation of the species, to the period December 8, 1946, to April 7, 1947. During the last few weeks of the season we worked our way westwards, keeping to the edge of the pack-ice as before. The ship called in at Cape Town, homeward-bound, on April 20, after a crossing of the Roaring Forties and Fifties which involved four days of continuous storm, in which some damage was sustained by the vessel from the heavy seas.



VOYAGE OF THE WHALING FACTORY SHIP *Balaena*, 1946-7

Storms did not hinder us as often as had been feared on the whaling grounds south of 55°S. in eastern Antarctic waters. There were only 30 days on which the wind exceeded force 5, which was the critical value for the Walrus aircraft alighting on open sea; and often ice shelter was available. Only the bigger swells get past the first lines of drift ice and broken pack. All the smaller ripples are combed out, and the strange, smooth billows of a big swell which rumple the icefields on certain days are amongst the oddest sights of the Antarctic. In these conditions the Walrus could alight on the lagoons and sheltered bays in the ice with wave heights up to 10 to 20 ft.

Ice formation on the aircraft was avoided by flying in snow or cloud as little as possible. Anti-icing paste is not handy for use on biplanes with many struts and cross-wires. That icing is possible and might be serious was shown by the heavy growths of ice which formed on the masts and rigging

of the ship on eight isolated days with fog between mid November and mid April. The amounts on these eight days alone suggested that direct ice deposit from fog and stratus on the steeper parts of the windward coasts of Antarctica might be comparable with the total precipitation of types normally counted in annual rainfall figures.

The network of meteorological observing stations, from which regular reports could be used to deduce the weather patterns over the waters traversed in the whaling voyage, was always sparse; and the factory was sometimes 1,500 miles or more from the nearest observing station. To this sparse network could be added reports from our own aircraft and occasionally from one of our whale-boats on longer whaling reconnaissances up to 500 miles from the factory; but the promised reports from the other factories in Antarctic waters did not in general materialise, owing to the highly competitive nature of the whaling industry and the precautions which are taken to keep secret each vessel's movements, until the season is over.

Reports from the Falkland Islands and the stations in their dependencies farther south on the islands in the Atlantic sector and in Graham Land therefore constituted the only information available from high latitudes apart from our own observations. These stations and Tristan da Cunha, which also occupied a key position, were more than 4,000 miles away; yet their importance is such that the loss of these reports due to a radio fade-out could be felt even in the Australian sector 180 degrees of longitude away. And their loss for several days in succession would render an interruption of the forecasting service necessary. Fortunately this seldom happened.

One was in this way driven to map the weather over a very wide area every day; for, no matter how far east we went, the Falklands group of reports could never be dispensed with. Ultimately the maps covered more than half the southern hemisphere, and in an experimental series which lasted from March 20 to March 27, 1947, they were completed right across the South Pole, without any serious inconsistencies coming to light in the observations culled from widely separated sectors. In many longitudes south of about 62°S. in the Indian Ocean and Australian sectors our weather was obviously influenced by the topography of the unknown land, at distances ranging from 30 to 200 miles farther south. This was awkward for forecasting at first, but one soon learnt what to expect; since the orographic effects seemed to be as regular and dependable in their occurrence as orographic effects are everywhere. Thus, whilst the weather maps prompted interesting conclusions about the weather patterns over Antarctica as a whole and about the south polar anti-cyclones, the observations made on the factory near the coast of Antarctica almost inevitably suggested ideas about the geography of the unknown land.

This process of reasoning back from observed meteorological effects to a diagnosis of the nature of the geographical features causing them may be unique. The chief of the tentative conclusions was the hypothesis of a major topographical barrier running through East Antarctica from near 80°S. 80°E. towards the coast near 100°E. This may be either a great range of mountains or the main crest of the ice-cap; and it will be interesting to see whether its existence is ever confirmed by eye observation. Since returning to England I have learnt that a German expedition in 1939 found that the ice-cap reached the hitherto unknown height of 15,000 ft. near 80°S. in Queen Maud Land (Atlantic sector);

this area lies on a direct extension of the line of the supposed great topographical barrier in East Antarctica, which served well as a basis for many successful weather forecasts for the eastern whaling grounds visited by *Balaena* between  $80^{\circ}$  and  $115^{\circ}$ E. Singularities in the wind régime observed off shore also suggested ideas about the general form of the unknown coast line, the most interesting being the suspected existence of an inlet or fjord near  $107^{\circ}$ E., just west of the hill ranges of the Budd Coast, which were sighted between  $109^{\circ}$  and  $114^{\circ}$ E.

A few further points may be mentioned in conclusion. The meteorological task on this expedition had been undertaken with great diffidence as to what might be possible, and forecasting was begun on an explicitly experimental basis. Gradually the disinterested work of independent checkers showed that the results were justifying the attempt. The standpoint which produced this result was a conviction about the basic soundness of the existing theories of fronts and depressions, which were rigorously applied, and a completely open mind with regard to whatever local factors and influences might come to light. Both aspects of this position brought rewards. The former led to a further vindication of the accepted theories, and demonstrated their application to new regions of the earth, showing indeed a regularity which made up for the lack of a close network of weather observing stations. It would not however have been possible to complete the weather maps over the vast expanses of the Southern Ocean but for an assumption, that the subtropical anticyclones (located happily in latitudes where reporting stations and ships are more plentiful) control the weather patterns of the Far South, where the depressions are steered by the currents of warm air guided into higher latitudes by these anticyclones. During the greater part of its life history, and particularly at its prime, the influence of one of these high-pressure centres was assumed to be paramount over wide areas and all else secondary. The assumption worked well, and agrees with the evidence that the weather over the limitless Southern Ocean is by no means so uniform and devoid of characteristic differences in different longitudes as was formerly supposed. This discovery may suggest a greater emphasis on the study of the rôle of stable anticyclones in controlling the weather patterns over wide areas in the northern hemisphere. Over the Southern Ocean the typical régime is wave disturbances, first formed near the western extremities of the anticyclones about  $30^{\circ}$ S., travelling south-east and occluding and deepening, then sometimes coalescing in high latitudes with older, fully occluded centres, to form the deepest depressions and worst storms of the Southern Ocean.

The necessarily open-minded attitude to the occurrence of local effects led to hints of geographical discovery in a peculiarly interesting and quite unforeseen manner. One weather phenomenon which came as a surprise was the observation of large cumulus and cumulonimbus clouds on over 30 days in the far south. These were considered to occur in most cases in air streams of very cold origin over Antarctica which had spent long over open sea and were in some cases returning towards the continent. The cloud tops were estimated at 17,000 to 20,000 ft. on one or two occasions, and showers of small hail fell. Nevertheless, stratus and stratocumulus clouds prevail, and the upper air temperatures observed suggest successive shallow air masses separated by stable layers, which may well represent successive frontal surfaces, to correspond with the bunches of occlusions commonly seen on the surface maps, as the normal structure of the lower atmosphere over the southern parts of the Southern

Ocean; deep adiabatic layers only occur after the air masses have been modified by considerable heating from the sea surface, and after various stages of transition from successive parallel belts of stratiform cloud, with or without snow and fog, to well scattered cumulus were observed in northward-moving air masses between 50° and 60°S.

STATISTICS OF *Balaena's* OBSERVATIONS SOUTH OF 50°S.

|                  | Barometric<br>pressure | Air<br>temperature | Beaufort<br>wind force |
|------------------|------------------------|--------------------|------------------------|
|                  | mb.                    | °F.                |                        |
| Average value .. | 982                    | 28·7               | 3·9                    |
| Highest value .. | 1013                   | 37·8               | 11                     |
| Lowest value ..  | 960                    | 12·1               | 0                      |

A selection of photographs will be found at the end of this number.

**HIGH PILOT-BALLOON ASCENTS AT PIARCO, TRINIDAD**

BY J. C. W. WICKHAM.

Twelve months' experience of pilot-ballooning at Piarco, Trinidad, has shewn that, with 100-gm. balloons and the standard Meteorological Office Mk. IV theodolite, it is possible, fairly frequently, to follow balloons and obtain values of the wind speed and direction to theoretical heights (i.e. assuming a constant rate of ascent) of well over 40,000 ft.; indeed, on occasions, 90-in. balloons have been followed well above this height. This might be thought surprising when one considers that Trinidad lies in a maritime air mass and is subject to tropical weather.

There are three British stations in the south-eastern Caribbean Sea: Piarco (Trinidad), Pearl's airfield (Grenada) and Seawell airfield (Barbados). From a comparison of ascents made at these stations it is evident that on the average the Trinidad balloons can be followed to much greater heights than can the others. It is found that by careful choice of time, either immediately after dawn or one to two hours before sunset, high ascents can often be made in clear skies.

The table shows pilot-balloon ascents in excess of theoretical heights of 40,000 ft. made at Piarco between September, 1946, and February, 1947. The number of these ascents is so far limited and it is impossible to generalise from them, but the following statements about the winds above 40,000 ft. can be made from those available:—

- (1) Approximately 60 per cent. of these winds lie between 220° and 320°.
- (2) Approximately 70 per cent. have a westerly component.
- (3) Of the remaining 30 per cent. 3 out of 4 lie between 360° and 90°.

In Trinidad the dry season extends from January to May; the presence of haze in the lower atmosphere when this season is well established, and of abundant cirrus in the last two months of the dry season rendered ascents to 40,000 ft. impossible from the end of February, 1947, to the time of writing (June, 1947). The haze in the lower atmosphere does not extend very often above 10,000 ft. and balloons which ascend beyond this height are rarely lost in haze; this is because the elevation of such ascents is practically always relatively

PILOT-BALLOON ASCENTS IN EXCESS OF THEORETICAL HEIGHTS OF 40,000 FT. MADE AT PIARCO, TRINIDAD,  
BETWEEN SEPTEMBER, 1946, AND FEBRUARY, 1947

| Date                 | .. | .. | Sept.<br>19 | Sept.<br>20 | Oct.<br>1 | Oct.<br>11 | Oct.<br>16 | Oct.<br>25 | Nov.<br>3 | Jan.<br>9    | Jan.<br>27 | Feb.<br>11 | Feb.<br>19   |
|----------------------|----|----|-------------|-------------|-----------|------------|------------|------------|-----------|--------------|------------|------------|--------------|
| Time (G.M.T.)        | .. | .. | 1100        | 1100        | 1100      | 1100       |            |            | 1100      | 1300         | 1100       | 1300       | 1100         |
| ft.                  |    |    | ° kt.       | ° kt.       | ° kt.     | ° kt.      | ° kt.      | ° kt.      | ° kt.     | ° kt.        | ° kt.      | ° kt.      | ° kt.        |
| 5,000                | .. | .. | 100 18      | 110 13      | 130 12    | 120 7      | 100 17     | 120 15     | 100 15    | 090 23       | 060 8      | 070 17     | 090 22       |
| 10,000               | .. | .. | 100 15      | 110 14      | 110 14    | 090 13     | 090 6      | 110 8      | 120 12    | 070 12       | 110 9      | 030 8      | 250 8        |
| 15,000               | .. | .. | 090 16      | 090 19      | 060 15    | 050 2      | 100 13     | 100 12     | 110 10    | 140 15       | 100 1      | 080 19     | 200 8        |
| 20,000               | .. | .. | 090 18      | 100 13      | 090 9     | 030 10     | 070 7      | 130 6      | 310 1     | 220 7        | 030 12     | 070 17     | 050 6        |
| 25,000               | .. | .. | 130 22      | 090 13      | 070 5     | 180 6      | 090 2      | 350 4      | 300 5     | 230 25       | 030 10     | 350 20     | 250 8        |
| 30,000               | .. | .. | 080 10      | 130 15      | 170 16    | 150 14     | 320 10     | 320 19     | 280 14    | 230 20       | 320 18     | 070 10     | 250 8        |
| 35,000               | .. | .. | 110 9       | 340 5       | 210 9     | 210 15     | 330 11     | 300 25     | 290 16    | 270 30       | 240 18     | 170 14     | 200 12       |
| 40,000               | .. | .. | 050 22      | 340 16      | 230 20    | 250 28     | 300 20     | 290 31     | 290 22    | 200 14       | 230 16     | 270 6      | 210 8        |
| 45,000               | .. | .. |             | 140 13      |           | 250 28     | 280 20     | 310 34     |           | 220 12       | 330 17     | 070 10     | 330 5        |
| 50,000               | .. | .. |             | 120 29      |           | 220 10     | 280 22     | 230 25     |           | 360 3        | 060 8      | 080 15     | 330 10       |
| 55,000               | .. | .. |             |             |           | 220 23     | 290 27     | 310 20     |           | 360 25       | 290 22     | 140 19     | 260 18       |
| 60,000               | .. | .. |             |             |           |            | 280 30     |            |           |              | 290 16     | 040 35     |              |
| 65,000               | .. | .. |             |             |           |            |            |            |           |              | 020 6      |            |              |
| 70,000               | .. | .. |             |             |           |            |            |            |           |              | 090 15     |            |              |
| Maximum height (ft.) | .. | .. | 40,500      | 50,700      | 41,000    | 54,750     | 62,750     | 55,750     | 40,500    | 55,400       | 70,700     | 63,000     | 55,000       |
| How lost             | .. | .. | Behind Cu   | Behind Cu   | Behind Cu | Behind Cu  | Behind Cu  | Near sun   | Burst     | Behind cloud | Burst      | Burst      | Behind cloud |

high, and the effective haze thickness consequently relatively shallow. Practically all the balloons which are reported lost in haze are lost below 10,000 ft. and their angle of elevation is relatively low ( $12-15^{\circ}$ ).

It would seem then that the two conditions for high ascents are a light wind and/or an early reversal with height. If there is a light wind the balloon rises more nearly vertically and so passes through a lesser haze thickness than would be occasioned by a strong or moderate wind.

The peculiar wind structure of this area allows these conditions to be satisfied fairly frequently both in summer and in winter, because in winter when the trade winds are strong the reversal to a westerly wind occurs at a comparatively low height (8,000–15,000 ft.), while in summer when the reversal takes place above 20,000 ft. the easterly winds of the lower layers have decreased in speed.

It seems that above the dry-season haze top (8,000–10,000 ft.) there is very pure air and little cloud apart from cirrus, while in the wet season the cloud-free air is absolutely clear and unless the balloon bursts early the skilful observer has a very good chance of an ascent to a theoretical height of 10 miles.

### ROYAL METEOROLOGICAL SOCIETY

At the meeting of the Society held at 49 Cromwell Road on October 15, Prof. G. M. B. Dobson, President, in the Chair, the following papers were read :—  
*Sverre Petterssen, P. A. Sheppard, C. H. B. Priestley and K. R. Johannessen—An investigation of subsidence in the free atmosphere.*

This paper gives the results of an investigation carried out at Dunstable during the latter part of the war at the request of the Meteorological Research Committee. It includes a theoretical discussion of subsidence and a large number of statistical tables giving the magnitude of the subsidence at different levels and its relation to other factors. Prof. Sheppard, who introduced the paper, concentrated mainly on the statistics, and emphasised that the investigation was concerned only with prolonged subsidence of substantial amount over large areas. It aimed at presenting the facts rather than at discussing their implications.

During the discussion which followed the value of such statistics was emphasised. The apparent large subsidence at 300 mb. (Tables XI and XII) was commented on. Both Sir Charles Normand and the President pointed out that humidity observations at high levels are not sufficiently accurate to be used for computations of subsidence. The absence of a correlation between subsidence and barometric tendency (Table XIV) was attributed to the concentration on substantial subsidence rather than on its earlier stages. Table XIII shows a marked relation between subsidence and high pressure, and this implies a rise of pressure at an earlier stage. Reference was also made to the complex problems presented by low cloud sheets and the inversions above them.

*G. D. Robinson—Notes on the measurement and estimation of atmospheric radiation.*

The paper concerns measurements of infra-red temperature radiation in cloudless conditions at Kew Observatory using two radiometers, one of them constructed by Mr. W. H. Dines and first described in the *Meteorological Magazine* in 1920.\* Some 10 to 15 per cent. of the radiation received from the atmosphere

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\* *Met. Mag. London*, 55, 1920, p. 189.

may, on occasion, originate in the first one or two metres and since distances of this order are involved when calibrating the instruments, a number of corrections must be applied, a fact which was not realised when Dines' measurements were made, since the emissivities of short atmospheric paths had not then been measured. The corrections are developed, and on applying them it is shown that consistent results are obtained with two very different types of radiometer. Measurements of atmospheric emission are then compared with computations made from Elsasser's radiation chart using temperatures and humidities given by radio-sonde ascents. The divergences between computed and observed values are discussed and it is shown that they may be referred to two causes. The first is a variable radiation due mainly, but possibly not entirely, to particulate matter, the second is the over-estimation of the emissivity of long path lengths of water vapour. Using a modification of a technique due to F. A. Brooks new emissivities are estimated from the measurements, and the construction of a simplified empirical chart radiation chart using them is described. Finally a method of estimating the outward nocturnal radiation without the use of a radiometer is explained.

In the discussion which followed the reading of the paper, both Dr. J. M. Stagg and Prof. D. Brunt said that the surprising feature was not that observations differed from computations made from Elsasser's radiation charts, but that the divergences were as small as those actually found. Prof. Brunt explained several assumptions underlying Elsasser's method, and showed how, in the case of the widths of the lines of the water-vapour spectrum, the recent measurements have shown that the assumption was considerably in error.

## **LETTER TO THE EDITOR**

### **Record high temperature for Vienna**

On August 5, 1947, a maximum temperature of  $100.3^{\circ}\text{F}$ . was recorded at the R.A.F. Meteorological Office, Schwechat airport, Vienna, which is about eight miles south-east of the centre of the city. This was the highest official temperature ever recorded in Vienna or its environs since the beginning of records in 1775. The previous maximum temperature recorded was  $98^{\circ}\text{F}$ . in July, 1857. This was recorded at the old Central Institute of Meteorology, Vienna. The exposure at Schwechat is no doubt slightly more conducive to high extremes than the Vienna exposure due to the bare and flat nature of the surrounding land and also to the fact that it is at a slightly lower altitude. The present Central Institute of Meteorology is at Hohe Warte, Vienna. The Hohe Warte site only recorded  $95^{\circ}\text{F}$ . on August 5, 1947, but even so, that was the highest recorded at that site.

A pronounced feature of the synoptic chart for August 5, which strongly contributed to the extreme heat over central and south-east Europe that day, was the existence of an anticyclone over the Black Sea. This anticyclone together with a trough of low pressure which covered the western Mediterranean resulted in the establishment of a strong south to south-westerly upper current which very probably originated from north Africa. Contour charts at 500 and 700 mb. and radio-pilot balloon ascents for Vienna confirmed that a strong south to south-westerly current had become well established aloft.

A cold occlusion passed Vienna at 1635 G.M.T. The maximum temperature was recorded between 1330 and 1400 G.M.T. when the relative humidity was

only 19 per cent. The approach of the front and the accompanying southerly drift ahead of it appears to have given the mercury the extra kick required to break the record. This effect was noticed at Klagenfurt on July 30, 1947 when, just prior to the passage of a very weak cold front, the temperature, which had mounted steadily to reach 94°F., suddenly rose to 96°F. in a matter of a few minutes to the accompaniment of a slight southerly wind, then dropped rapidly as the wind changed to light northerly.

The general warmth over the area was also believed to be largely due to the föhn effect induced by the south-westerly current passing over the Alps. The synoptic situation prevailing that day was more representative of winter than summer. In winter the föhn brings fair, very mild conditions to the Vienna area. Snow melts under maximum temperatures of about 50°F. The added effect of this föhn to a normal hot summer day undoubtedly helped to produce the record maximum temperature.

A.H.Q. (Rear), Austria, September 22, 1947.

A. H. GORDON

T. M. DAVIES

## NOTES AND NEWS

### Diurnal variation of thunderstorms

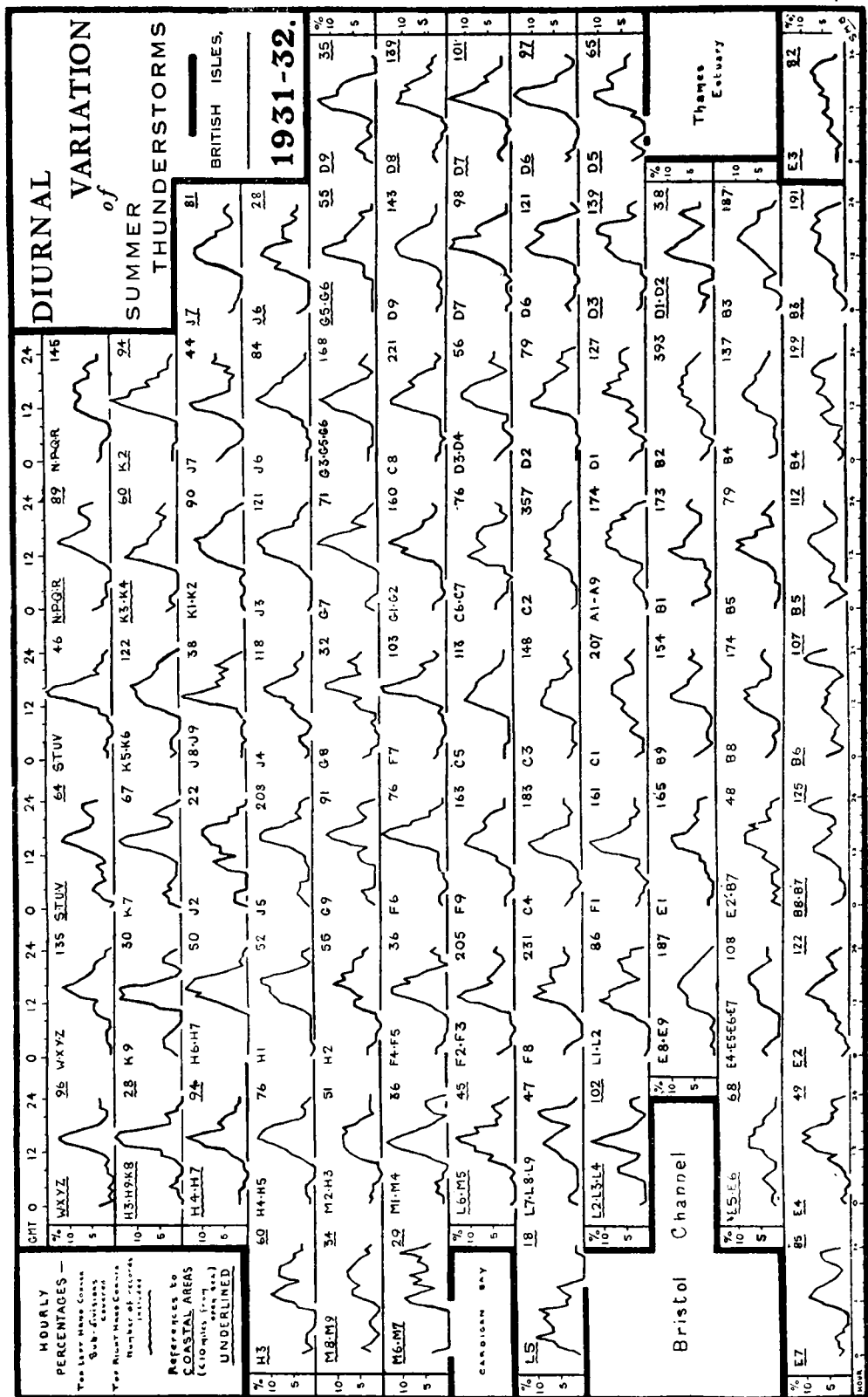
Following Mr. Bishop's interesting paper in the May 1947 issue of the *Meteorological Magazine*, some further figures in regard to the diurnal variation of thunderstorms in other parts of the British Isles may be of use. These figures have already been published in *Summer Thunderstorms*, 1932, the second report of the Thunderstorm Census Organization, and are reproduced by permission.

The wide variation in the hours of thunderstorm maxima and minima between different districts of the British Isles suggested that some indication of storm travel might be obtained from a detailed examination of hourly frequency. Accordingly an analysis of about 10,000 records of the times of storms in the two winters (January to March) of 1925 and 1926, and in the two summers (April to September) of 1931 and 1932, was made. These data provided 92 sets of hourly percentage figures, and distinction has been made between coastal and inland districts, a coastal district being defined as wholly within ten miles of the open sea. Summer storms only are considered first.

The sets of percentage figures are shown graphically in Fig. 1 in which the arrangement of the sets is roughly geographical. The districts, E 7, E 4, etc., are those used in the Thunderstorm Survey and are fully specified in the "List of Stations". The main divisions are lettered as follows :—

- A: England, London County.
- B: England, South-eastern Counties.
- C: England, South Midland Counties.
- D: England, Eastern Counties.
- E: England, South-western Peninsula.
- F: England, West Midland Counties.
- G: England, North Midland Counties.
- H: England, North-western Counties.
- J: England, Yorkshire.
- K: England, Northern Counties.
- L: South Wales.
- M: North Wales and Isle of Man.





N P Q R: Southern Scotland.  
 S T U V: Northern Scotland.  
 W X Y Z: Ireland.

Each main division is subdivided into nine numbered parts. References to coastal areas are underlined, and the number of records included in each group is given at the top right-hand corner of each graph.

Obviously, the period under discussion is far too short, but the movements of the times of maximum storm frequency across the country can be interpreted along the following lines:—

(a) A line of maximum storm frequency advances north-eastward from the Bristol Channel area about 1200 G.M.T.; the eastern portion of this line joins another line moving northward over Hampshire and Sussex, and the combined line moves north-eastward until it arrives over the counties of Lincoln, Huntingdon and Cambridge, and north-east Essex at 1700. The northern part of the line goes to sea off Spurn Point about 1800 while the southern portion runs off the coasts of Norfolk and Suffolk from 1900 to 2000.

(b) A secondary line moves northward out of the Thames Estuary from 1100 to 1200 and becomes a contributory cause of the maxima at 1400 and 1500 in Norfolk and Suffolk.

(c) Similar phenomena make their appearance over the Mersey and Humber Estuaries around 1400, and in both cases the lines move inland.

(d) The night storms present an entirely different picture: the lines of maximum intensity run roughly east and west, and their northward travel is most noticeable over the eastern half of southern England. Storms previously formed on the continent strike the Sussex coast around 2000 and travel up to Norfolk producing a maximum there from 0200 to 0300 the following morning.

A combination of circumstances produces an absolute maximum around 2200 in the Isle of Wight and New Forest area. This is interesting in that it appears to be the latest absolute maximum in any part of the country.

So far only summer storms have been discussed, but the analysis agrees well with results which have been obtained by an independent method. Table I shows comparative results for summer and winter, the main maxima being printed in heavy type.

TABLE I—DIURNAL VARIATION OF SUMMER AND WINTER THUNDERSTORMS IN THE BRITISH ISLES, EXPRESSED AS THE PERCENTAGE PER HOUR OF THE TOTAL

| <i>Coastal regions (within 10 miles of the open sea)</i>     |     |            |             |            |            |            |     |     |            |            |     |     |  |
|--|-----|------------|-------------|------------|------------|------------|-----|-----|------------|------------|-----|-----|--|
| Hour .. .. .   | 1   | 2          | 3           | 4          | 5          | 6          | 7   | 8   | 9          | 10         | 11  | 12  |  |
| Summer (1931 and 1932)                                       | 1.7 | 1.8        | 1.7         | <b>2.0</b> | 1.6        | <b>1.7</b> | 1.4 | 1.8 | 2.2        | 3.4        | 4.8 | 6.8 |  |
| Winter (1925 and 1926)                                       | 4.1 | 3.5        | 3.2         | 4.1        | 4.4        | <b>4.5</b> | 3.2 | 2.6 | 2.1        | 1.5        | 0.9 | 1.1 |  |
| Hour .. .. .   | 13  | 14         | 15          | 16         | 17         | 18         | 19  | 20  | 21         | 22         | 23  | 24  |  |
| Summer (1931 and 1932)                                       | 8.7 | <b>9.4</b> | 9.2         | 7.6        | 6.6        | 5.3        | 4.6 | 4.0 | 3.9        | <b>4.4</b> | 3.5 | 2.4 |  |
| Winter (1925 and 1926)                                       | 1.7 | 3.1        | 5.0         | 5.4        | <b>5.6</b> | 5.0        | 7.0 | 7.9 | <b>8.2</b> | 6.7        | 5.3 | 3.9 |  |
| <i>Inland regions (more than 10 miles from the open sea)</i> |     |            |             |            |            |            |     |     |            |            |     |     |  |
| Hour .. .. .   | 1   | 2          | 3           | 4          | 5          | 6          | 7   | 8   | 9          | 10         | 11  | 12  |  |
| Summer (1931 and 1932)                                       | 2.0 | 1.7        | 1.5         | 1.0        | <b>1.1</b> | <b>1.1</b> | 1.0 | 1.2 | 1.6        | 3.3        | 5.0 | 7.0 |  |
| Winter (1925 and 1926)                                       | 3.2 | 2.1        | 1.5         | 1.3        | <b>1.4</b> | 1.0        | 0.8 | 0.7 | 1.1        | 1.7        | 1.7 | 2.9 |  |
| Hour .. .. .   | 13  | 14         | 15          | 16         | 17         | 18         | 19  | 20  | 21         | 22         | 23  | 24  |  |
| Summer (1931 and 1932)                                       | 8.7 | 9.7        | <b>10.0</b> | 9.0        | 7.9        | 6.1        | 4.7 | 3.8 | <b>3.9</b> | 3.5        | 3.0 | 2.2 |  |
| Winter (1925 and 1926)                                       | 4.4 | 7.6        | 8.8         | <b>9.2</b> | 8.7        | 8.5        | 7.7 | 6.2 | 4.9        | <b>5.2</b> | 5.1 | 4.3 |  |

As would be expected, the main maximum frequency in inland areas occurs in the summer around 1500 and in the winter an hour later. In coastal areas

the summer maximum occurs at 1400 while in winter the afternoon maximum at 1700 is surpassed by the evening maximum at 2100.

The evening maxima occur generally in both summer and winter, in both inland and coastal areas, around 2100 and 2200. The early morning maxima occur in both seasons and in all areas from 0400 to 0600, and are most pronounced on the coast in winter.

S. MORRIS BOWER

### "Range" of values in a series of observations

We were recently asked what was the difference to be expected between the highest and lowest values in a series of  $n$  observations. This problem is of some interest and does not appear to have been discussed before.

It is well known that the standard deviation  $\sigma_d$  of the differences between two independent series of observations with standard deviations  $\sigma_1$  and  $\sigma_2$  is given by  $\sigma_d^2 = \sigma_1^2 + \sigma_2^2$ . Consequently, if we have a single series of observations with a near normal distribution and standard deviation  $\sigma$ , and take a number of pairs at random, the standard deviation  $\sigma_d$  of their differences should be  $\sigma\sqrt{2}$ . In a series of  $n$  observations there are  $n(n-1)/2$  possible pairs, and the distribution of the differences between these pairs (all differences being zero or positive) should give half a normal frequency curve with standard deviation of  $\sigma\sqrt{2}$ .

To test this, the mean temperatures of 100 Januaries at Greenwich, 1841-1940, were used and the 4,950 differences were tabulated. The results are shown by the vertical columns in Fig. 1. The distribution of the individual mean

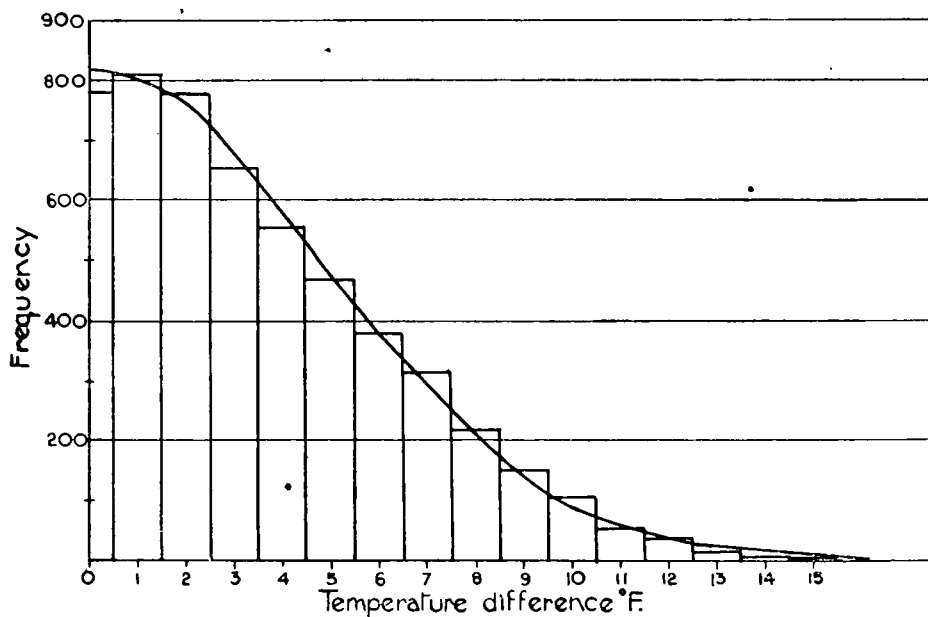


FIG. 1.—DISTRIBUTION OF DIFFERENCES BETWEEN PAIRS OF VALUES OF AVERAGE TEMPERATURES AT GREENWICH IN JANUARY, 1841-1940  
(Total frequency: 4,950)

values has a fairly high degree of skewness with a standard deviation of  $3.41^\circ\text{F}$ . The curved line in Fig. 1 shows the normal curve with a standard deviation of  $3.41\sqrt{2} = 4.82^\circ\text{F}$ . In spite of the skewness of the original distribution, the agreement is good.

To find the range to be expected between the highest and lowest values in any series of length  $n$ , we need to find the value which has an even chance of being exceeded once in  $n(n-1)/2$  trials, i.e. which has a probability of  $1/[n(n-1)]$ . These values were found for a number of series selected at random with the results, (Range)/(standard deviation) shown in Table I. The agreement between observation and theory is reasonably good. Table II gives the expected range, in terms of the standard deviation of the original series, for

TABLE I

| Station        | Position     | Element             | Month   | Period       | (range)/ $\sigma$ |          |
|----------------|--------------|---------------------|---------|--------------|-------------------|----------|
|                |              |                     |         |              | Observed          | Computed |
|                |              | <i>Daily Mean</i>   |         | <i>years</i> |                   |          |
| Bukit Jeram    | 3°N. 101°E.  | Pressure            | { Jan.  | 7            | 2·8               | 2·8      |
|                |              |                     | { July  | 7            | 2·8               | 2·8      |
|                |              | Minimum temperature | { Feb.  | 9            | 3·9               | 3·1      |
|                |              |                     | { Aug.  | 9            | 3·3               | 3·1      |
| Malacca        | 2°N. 102°E.  | Maximum temperature | { Feb.  | 9            | 3·3               | 3·1      |
|                |              |                     | { Aug.  | 9            | 2·7               | 3·1      |
| Bukit Jeram    | 3°N. 101°E.  | Maximum temperature | { Mar.  | 10           | 3·0               | 3·2      |
|                |              |                     | { Sept. | 10           | 3·3               | 3·2      |
| Suva, Fiji     | 18°S. 178°E. | Pressure            | { Jan.  | 12           | 3·1               | 3·4      |
|                |              |                     | { July  | 12           | 3·3               | 3·4      |
|                |              | Maximum temperature | { Jan.  | 14           | 3·7               | 3·6      |
|                |              |                     | { July  | 14           | 3·8               | 3·6      |
| Apia, Samoa    | 14°S. 172°W. | Minimum temperature | { Jan.  | 14           | 3·3               | 3·6      |
|                |              |                     | { July  | 14           | 3·2               | 3·6      |
|                |              | Pressure            | { Oct.  | 21           | 4·1               | 4·0      |
|                |              |                     |         |              |                   |          |
| Cumberland Bay | 54°S. 36½°W. | Maximum temperature | { Feb.  | 21           | 3·7               | 4·0      |
|                |              |                     | { Aug.  | 23           | 4·0               | 4·1      |
| Malacca        | 2°N. 102°E.  | Maximum temperature | Jan.    | 22           | 4·3               | 4·0      |
|                |              |                     |         |              |                   |          |
|                |              | Pressure            | { Jan.  | 25           | 3·5               | 4·1      |
|                |              |                     | { July  | 25           | 4·4               | 4·1      |
| Iba            | 15°N. 120°E. | Mean temperature    | { Jan.  | 25           | 4·1               | 4·1      |
|                |              |                     | { July  | 25           | 4·3               | 4·1      |

TABLE II—RATIO OF EXTREME RANGE TO STANDARD DEVIATION  
Series of  $n$  independent observations

| No. of years | (range)/ $\sigma$ | No. of years | (range)/ $\sigma$ | No. of years | (range)/ $\sigma$ |
|--------------|-------------------|--------------|-------------------|--------------|-------------------|
| 7            | 2·80              | 18           | 3·85              | 50           | 4·74              |
| 8            | 2·97              | 20           | 3·95              | 60           | 4·88              |
| 9            | 3·11              | 25           | 4·15              | 70           | 5·00              |
| 10           | 3·24              | 30           | 4·31              | 80           | 5·10              |
| 12           | 3·43              | 35           | 4·44              | 90           | 5·18              |
| 14           | 3·59              | 40           | 4·55              | 100          | 5·25              |
| 16           | 3·73              | 45           | 4·65              |              |                   |

periods of different lengths. It should be noted that Table II is not applicable to daily values since these are not independent; a continuous set of  $n$  daily maximum temperatures in this country may be taken to be roughly equivalent to  $n/3$  independent observations, but the interdependence of daily minima appears to vary in different seasons, and that of other elements has not been examined.

C. E. P. BROOKS

N. CARRUTHERS

## OBITUARY

*Dr. Ellsworth Huntington.* We regret to record the death in October, at the age of 71, of Dr. Ellsworth Huntington, well known for his books on the influence of climate on human affairs. Dr. Huntington was educated as a geographer and spent the years 1900 to 1906 exploring in Asia, where he was impressed by the evidence for former considerable population in areas which are now waterless. In "The pulse of Asia" he developed the theory that these migrations were due to large-scale climatic pulsations. In "Civilization and climate" he maintained that the ideal climate for human progress was found in the storm belts of temperate regions, and this idea was expanded in a long series of readable books, ending with "Mainsprings of civilization" in 1945.

## NEWS IN BRIEF

The L.G. Groves Memorial Prize for Meteorology has been won this year by Mr. J. S. Sawyer, Senior Scientific Officer in the Meteorological Office. The prize is to be awarded annually on July 1, beginning in 1947, for the most important contribution made during the past year either to the science of meteorology or to the application of meteorology to aviation.

The L.G. Groves Memorial Award for Meteorological Air Observers has been won this year by Warrant Officer P. G. Rackliff, R.A.F.V.R. Meteorological Assistant. The award is to be given annually on July 1, beginning in 1947, to an officer employed on flying duties or a member of aircrew who, in either case, has been employed on meteorological air observer duties for meritorious work or devotion to duty.

Miss A. Tobitt, Meteorological Assistant at Dunstable, has been awarded the Henry van den Burgh Prize for commercial geography in the London Chamber of Commerce examinations in which she gained the highest number of marks for the whole country.

## REVIEWS

*Science from shipboard.* Prepared under the guidance of the Boston-Cambridge Branch of the American Association of Scientific Workers. Size:  $7\frac{1}{4}$  in.  $\times$   $4\frac{1}{2}$  in. pp. 268. *Illus.* Science Service, Washington, 1943.

A long voyage by sea may suggest to many a dull monotony of sea and sky. Both, however, are frequently changing and the waves, the clouds, the stars and the various forms of sea life are interesting things if only one knows what to observe. "Science from Shipboard" was prepared to provide such knowledge. It describes itself as "a simple manual of information and instruction" and, indeed, the elements of meteorology, astronomy, zoology, technology and physiology all find a place in this pocket-size volume. The style is friendly but concise; the 138 illustrations, mainly diagrammatic, are clear and, in places, amusing.

The largest section, "Waves, Wind and Weather" is contributed by the well-known climatologist, Dr. Charles F. Brooks. This includes an explanation of the main climatic regions of the world; gives homely devices for estimating direction and velocity of wind, cloud heights and temperature from on board ship; describes the weather changes in the path of a storm; and shows how

storm warnings may be seen "written" in the waves as well as in the sky. The section concludes with descriptions of climatic changes to be encountered on four of the main transport routes from the United States.

In the sections on astronomy are included short notes on the solar system with a monthly guide to the positions of the brighter planets, comprehensive star charts (for use in southerly as well as in northerly latitudes), and simple details of time measurement and of navigation. Other sections deal with sea life, oceanic birds and the constitution and changing nature of coast-line and islands. The volume concludes with "Your Ship", a description of the structure of a ship, and the working of its engines, and "Yourself", an attempt to explain the sensations one experiences on shipboard.

N. CARRUTHERS

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*A hőmérséklet napi ingadozása, mint bioklimatikus tényező* (Daily range of temperature as a bioclimatic factor), by V. Grubich. *Időjárás, Budapest*, 51, 1947, pp. 84-90. (English summary, p. 103.)

Starting from the hypothesis that temperature in itself can be regarded only as a "static" factor having no stimulating effect on the human body, Dr. Grubich has proceeded in this paper to the logical assumption that the daily range is the temperature condition exercising the greatest biological control. Because the average daily range, whilst following the yearly trend of temperature, is yet greater in summer than in winter, the author concludes that the former season has more stimulating conditions and is therefore the time most favourable for violent exercise. Furthermore, he shows that higher altitudes have a smaller daily range than do the lowlands, and so advances the opinion that the climate of the lowlands has the greater stimulating effect on human beings.

Temperature range is in fact a measure of climatic stimulation. Thus a mild climate, characterised by higher average temperatures and a lower temperature range, is far less stimulating to human beings than is a climate in which the reverse conditions operate. The difference between the temperature and temperature range when comparing the above climatic extremes is not apparent however when yearly means are considered. It is necessary to compare the monthly mean values in order to differentiate between the two differing temperature régimes. This seems such an obvious necessity that one wonders why Dr. Grubich bothered to mention the yearly values which can mean very little anyway.

Several graphs are included in the paper showing the percentage distribution of daily temperature range and these do help to build up a more detailed idea of the climatic differences which are the subject of the paper.

After considering the differing effects, from a biological point of view, of increasing and decreasing temperatures the author goes on to talk of the abruptness of the temperature transition from winter to spring in March and from summer to autumn in September. This is more marked during the latter transition period, especially in the true continental climates, when the fall in temperature can be very abrupt and may, as the author suggests, be connected with the prevalence of colds during this period. He concludes, however, by conceding that other factors such as changes in atmospheric humidity may be of importance in this case.

We feel too that he might well have added the same proviso to his statements regarding temperature range and human stimulation since it is certain that humidity changes can, in many cases, play a part of equal importance with that of temperature changes in influencing human exertions.

L. G. CAMERON

### WEATHER OF SEPTEMBER, 1947

At the beginning of the month a belt of high pressure extended from mid Atlantic north-eastwards to Norway. The eastern end of this belt gradually moved southwards and by the 10th the belt ran almost west to east from south of the Azores to northern Italy. This persisted until the 16th, when a depression north of Scotland, which gave the only considerable rainfall of the month in London on the 17th, split it into two parts. A deep depression passed north of Scotland on the 23rd after which anticyclonic conditions again spread over Great Britain, with a temporary break on the 28th-29th. The average pressure for the month shows an anticyclonic belt extending from the Great Lakes of America across the Azores and central Europe, exceeding 1023 mb. in mid Atlantic, with a depression (1003 mb.) from Denmark Strait to Spitsbergen. Pressure was above normal from the Great Lakes to Russia, the excess reaching 5 mb. east of Newfoundland, and below normal over the Arctic, the deficiency exceeding -5 mb. between north-east Greenland and Bear Island; pressure was also slightly below normal in the western Mediterranean.

In the British Isles the weather was unsettled and wet in the north-west and dry in the east and south. In England and Wales it was unusually warm; as far as can be estimated mean temperature was, with two exceptions namely 1929 and 1933, the highest for September since before 1901; in 1929 the mean temperature was higher than in 1947 but in 1933 it was about the same. Rainfall exceeded the average in western, northern and central districts of Scotland, over most of north-west England, in the Tees valley and in an inland area in south Devon. On the other hand less than half the average occurred over some parts of England and less than a quarter at Lowestoft. Rain occurred very frequently in the north-west and north, measurable rain being reported on 27 days at a number of stations in north-west Scotland. The long drought which occurred throughout most of August was not terminated in parts of England until the 11th or even the 17th; at Wye, Kent, there was no measurable rainfall from July 29 to September 16 inclusive, a period of 50 days. Sunshine exceeded the average in the Shetland Isles and in the eastern and Midland districts of England but was below the average in the west of the British Isles.

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

|                     | AIR TEMPERATURE |             |  | RAINFALL                         |   | SUNSHINE                         |   |
|---------------------|-----------------|-------------|--|----------------------------------|---|----------------------------------|---|
|                     | High-<br>est    | Low-<br>est | Difference<br>from<br>average<br>daily<br>mean | Per-<br>centage<br>of<br>average | No. of<br>days<br>difference<br>from<br>average | Per-<br>centage<br>of<br>average | Per-<br>centage<br>of<br>possible<br>duration |
|                     | °F.             | °F.         | °F.  | %                                |   | %                                | %   |
| England and Wales   | 88              | 30          | + 3.1  | 78                               | - 1   | 106                              | 41  |
| Scotland .. ..      | 78              | 26          | + 1.6  | 135                              | + 3   | 93                               | 29  |
| Northern Ireland .. | 76              | 39          | + 2.0  | 110                              | + 3   | 78                               | 25  |

# RAINFALL OF SEPTEMBER, 1947

## Great Britain and Northern Ireland

| County          | Station                  | In.  | Per cent of Av. | County             | Station                  | In.   | Per cent of Av. |
|-----------------|--------------------------|------|-----------------|--------------------|--------------------------|-------|-----------------|
| <i>London</i>   | Camden Square ..         | 1·40 | 77              | <i>Glam.</i>       | Cardiff, Penylan ..      | 2·27  | 74              |
| <i>Kent</i>     | Folkestone, Cherry Gdns. | 1·37 | 58              | <i>Pemb.</i>       | St. Ann's Head ..        | 1·98  | 69              |
| "               | Edenbridge, Falconhurst  | 1·68 | 74              | <i>Card.</i>       | Aberystwyth ..           | 2·29  | 80              |
| <i>Sussex</i>   | Compton, Compton Ho.     | 2·15 | 77              | <i>Radnor</i>      | Bir. W. W., Tyrmynydd    | 3·12  | 81              |
| "               | Worthing, Beach Ho. Pk.  | 1·54 | 72              | <i>Mont.</i>       | Lake Vyrnwy ..           | 2·97  | 79              |
| <i>Hants.</i>   | Ventnor, Roy. Nat. Hos.  | 1·42 | 57              | <i>Mer.</i>        | Blaenau Festiniog ..     | 8·19  | 104             |
| "               | Fordingbridge, Oaklands  | 1·24 | 58              | <i>Carn.</i>       | Llandudno ..             | 1·87  | 88              |
| "               | Sherborne St. John ..    | 1·10 | 54              | <i>Angl.</i>       | Llanerchymedd ..         | 3·56  | 121             |
| <i>Herts.</i>   | Royston, Therfield Rec.  | 1·15 | 61              | <i>I. Man.</i>     | Douglas, Boro' Cem. ..   | 2·77  | 85              |
| <i>Bucks.</i>   | Slough, Upton ..         | 1·15 | 65              | <i>Wigtown</i>     | Pt. William, Monreith .. | 4·09  | 140             |
| <i>Oxford</i>   | Oxford, Radcliffe ..     | 1·15 | 67              | <i>Dumf.</i>       | Dumfries, Crichton R.I.  | 2·79  | 103             |
| <i>N'hant</i>   | Wellingboro', Swanspool  | 1·30 | 72              | "                  | Eskdalemuir Obsy. ..     | 4·61  | 125             |
| <i>Essex</i>    | Shoeburyness ..          | 1·41 | 84              | <i>Roxb.</i>       | Kelso, Floors ..         | 1·28  | 67              |
| <i>Suffolk</i>  | Campsea Ashe, High Ho.   | ·86  | 45              | <i>Peebles.</i>    | Stobo Castle ..          | 2·40  | 95              |
| "               | Lowestoft Sec. School .. | ·41  | 21              | <i>Berwick</i>     | Marchmont House ..       | 1·33  | 55              |
| "               | Bury St. Ed., Westley H. | 1·12 | 56              | <i>E. Loth.</i>    | North Berwick Res. ..    | 1·08  | 52              |
| <i>Norfolk</i>  | Sandringham Ho. Gdns.    | 1·08 | 52              | <i>Midl'n.</i>     | Edinburgh, Blackf'd. H.  | 1·27  | 62              |
| <i>Wilts.</i>   | Bishops Cannings ..      | 1·36 | 62              | <i>Lanark</i>      | Hamilton W. W., T'nhill  | 4·16  | 155             |
| <i>Dorset</i>   | Creech Grange ..         | 1·79 | 65              | <i>Ayr</i>         | Colmonell, Knockdolian   | 3·84  | 111             |
| "               | Beamminster, East St. .. | 1·67 | 65              | "                  | Glen Afton, Ayr San. ..  | 6·16  | 158             |
| <i>Devon</i>    | Teignmouth, Den Gdns.    | 2·16 | 110             | <i>Bute</i>        | Rothsay, Ardenraig ..    | 4·93  | 122             |
| "               | Cullompton ..            | 2·19 | 97              | <i>Argyll</i>      | Loch Sunart, G'dale ..   | 9·08  | 145             |
| "               | Barnstaple, N. Dev. Ath. | 1·45 | 54              | "                  | Poltalloch ..            | —     | —               |
| "               | Okehampton, Uplands      | 3·33 | 103             | "                  | Inveraray Castle ..      | 10·77 | 168             |
| <i>Cornwall</i> | Bude School House ..     | 1·71 | 69              | "                  | Islay, Eallabus ..       | 5·98  | 143             |
| "               | Penzance, Morrab Gdns.   | 1·47 | 50              | "                  | Tiree ..                 | 5·12  | 138             |
| "               | St. Austell, Trevarna .. | 2·00 | 63              | <i>Kinross</i>     | Loch Leven Sluice ..     | 3·05  | 119             |
| "               | Scilly, Tresco Abbey ..  | 1·51 | 59              | <i>Fife</i>        | Leuchars Airfield ..     | 2·02  | 105             |
| <i>Glos.</i>    | Cirencester ..           | 1·77 | 80              | <i>Perth</i>       | Loch Dhu ..              | 8·60  | 150             |
| <i>Salop</i>    | Church Stretton ..       | 1·53 | 73              | "                  | Crieff, Strathearn Hyd.  | 4·52  | 158             |
| "               | Cheswardine Hall ..      | 1·42 | 70              | "                  | Blair Castle Gardens ..  | 4·27  | 180             |
| <i>Staffs.</i>  | Leek, Wall Grange, P.S.  | 1·53 | 61              | <i>Angus</i>       | Montrose, Sunnyside ..   | 1·77  | 89              |
| <i>Worcs.</i>   | Malvern, Free Library    | ·86  | 45              | <i>Aberd.</i>      | Balmoral Castle Gdns. .. | 2·60  | 108             |
| <i>Warwick</i>  | Birmingham, Edgbaston    | 1·59 | 89              | "                  | Aberdeen Observatory     | 1·67  | 75              |
| <i>Leics.</i>   | Thornton Reservoir ..    | 1·00 | 55              | "                  | Fyvie Castle ..          | 3·12  | 120             |
| <i>Lincs.</i>   | Boston, Skirbeck ..      | 1·29 | 73              | <i>Moray</i>       | Gordon Castle ..         | 3·50  | 140             |
| "               | Skegness, Marine Gdns.   | 1·02 | 56              | <i>Nairn</i>       | Nairn, Achareidh ..      | 3·25  | 154             |
| <i>Notts.</i>   | Mansfield, Carr Bank ..  | 1·47 | 80              | <i>Inv's</i>       | Loch Ness, Foyers ..     | 4·94  | 168             |
| <i>Ches.</i>    | Bidston Observatory ..   | 2·23 | 93              | "                  | Glenquoich ..            | 12·90 | 149             |
| <i>Lancs.</i>   | Manchester, Whit. Park   | 2·11 | 89              | "                  | F. William, Teviot ..    | 9·32  | 146             |
| "               | Stonyhurst College ..    | 4·73 | 124             | "                  | Skye, Duntuilim ..       | 7·85  | 171             |
| "               | Blackpool ..             | 4·03 | 141             | <i>R. &amp; C.</i> | Ullapool ..              | 5·80  | 160             |
| <i>Yorks.</i>   | Wakefield, Clarence Pk.  | 1·04 | 65              | "                  | Applecross Gardens ..    | 6·81  | 136             |
| "               | Hull, Pearson Park ..    | ·94  | 55              | "                  | Achnashellach ..         | 10·08 | 147             |
| "               | Felixkirk, Mt. St. John  | 1·56 | 86              | "                  | Stornoway Airfield ..    | 6·72  | 179             |
| "               | York Museum ..           | 1·96 | 120             | <i>Suth.</i>       | Lairg ..                 | 6·02  | 213             |
| "               | Scarborough ..           | 1·34 | 75              | "                  | Loch More, Achfary ..    | 13·58 | 236             |
| "               | Middlesbrough ..         | 2·29 | 138             | <i>Caith.</i>      | Wick Airfield ..         | 3·89  | 156             |
| "               | Baldersdale, Hury Res.   | 3·40 | 136             | <i>Shet.</i>       | Lerwick Observatory ..   | 4·89  | 162             |
| <i>Nor'ld</i>   | Newcastle, Leazes Pk.    | 1·68 | 85              | <i>Ferm.</i>       | Crom Castle ..           | 2·85  | 102             |
| "               | Bellingham, High Green   | 1·68 | 70              | <i>Armagh</i>      | Armagh Observatory ..    | 2·68  | 109             |
| "               | Lilburn, Tower Gdns. ..  | 1·14 | 48              | <i>Down</i>        | Seaforde ..              | 2·66  | 97              |
| <i>Cumb.</i>    | Geltsdale ..             | 3·23 | 115             | <i>Antrim</i>      | Aldergrove Airfield ..   | 2·86  | 115             |
| "               | Keswick, High Hill ..    | 5·24 | 124             | "                  | Ballymena, Harryville    | 3·77  | 121             |
| "               | Ravensglass, The Grove   | 3·51 | 104             | <i>Lon.</i>        | Garvaghy, Moneydig ..    | 2·87  | 97              |
| <i>Mon.</i>     | Abergavenny, Larchfield  | 1·39 | 59              | "                  | Londonderry, Creggan     | 3·99  | 121             |
| <i>Glam.</i>    | Ystaefera, Wern Ho ..    | 2·77 | 63              | <i>Tyrone</i>      | Omagh, Edenfel ..        | 3·63  | 119             |



CLIMATOLOGICAL TABLE FOR THE BRITISH COMMONWEALTH, MAY, 1947

| STATIONS                | PRESSURE                 |                         | TEMPERATURES |      |                     |                         |             |      | REL-<br>ATIVE<br>HUM-<br>IDITY | MEAN<br>CLOUD<br>AMOUNT | PRECIPITATION |                         |      | BRIGHT SUNSHINE |                                   |
|-------------------------|--------------------------|-------------------------|--------------|------|---------------------|-------------------------|-------------|------|--------------------------------|-------------------------|---------------|-------------------------|------|-----------------|-----------------------------------|
|                         | Mean<br>of day<br>M.S.L. | Diff.<br>from<br>normal | Absolute     |      | Mean values         |                         |             |      |                                |                         | Total         | Diff.<br>from<br>normal | Days | Daily<br>Mean   | Per-<br>centage<br>of<br>possible |
|                         |                          |                         | Max.         | Min. | Max.<br>1<br>2 Min. | Diff.<br>from<br>normal | Wet<br>bulb |      |                                |                         |               |                         |      |                 |                                   |
|                         |                          |                         |              |      |                     |                         |             | °F.  |                                |                         |               |                         |      |                 |                                   |
| London, Kew Observatory | mb.                      | mb.                     | °F.          | °F.  | °F.                 | °F.                     | °F.         | °F.  | %                              | tenths                  | ins.          | ins.                    | 15   | hrs.            | %                                 |
| Gibraltar               | 1015.6                   | 0.0                     | 86           | 39   | 66.0                | 48.6                    | 57.3        | +2.6 | 71                             | 7.4                     | 1.35          | -0.37                   | 8    | 5.2             | 34                                |
| Malta                   | 1014.2                   | -1.9                    | 82           | 47   | 72.5                | 58.7                    | 65.6        | +0.1 | 75                             | 5.8                     | 0.83          | —                       | 2    | 9.9             | 71                                |
| St. Helena              | 1013.9                   | -0.6                    | 79           | 54   | 72.7                | 59.7                    | 66.2        | +0.3 | 59                             | 3.9                     | 0.02          | —                       | 19   | 6.6             | 53                                |
| Freetown, Sierra Leone  | 1015.9                   | -2.3                    | 80           | 57   | 68.1                | 59.2                    | 63.7        | +1.4 | 97                             | 8.5                     | 4.35          | +1.67                   | 7    | —               | —                                 |
|                         | 1011.1                   | +1.5                    | 90           | 70   | 85.0                | 77.0                    | 81.0        | +0.5 | 81                             | 7.2                     | 4.23          | -7.24                   | 15   | —               | —                                 |
| Lagos, Nigeria          | 1010.9                   | +0.8                    | 92           | 70   | 87.9                | 72.3                    | 80.1        | -1.7 | 89                             | 7.4                     | 9.30          | —                       | 16   | 4.5             | 36                                |
| Kaduna, Nigeria         | 1008.8                   | —                       | 99           | 63   | 91.2                | 71.1                    | 81.1        | +1.2 | 72                             | 7.6                     | 6.40          | +0.63                   | 15   | 8.5             | 67                                |
| Chileka, Nyasaland      |                          |                         |              |      |                     |                         |             |      |                                |                         |               |                         |      |                 |                                   |
| Salisbury, Rhodesia     |                          |                         |              |      |                     |                         |             |      |                                |                         |               |                         |      |                 |                                   |
| Cape Town               | 1018.7                   | +0.6                    | 89           | 37   | 67.6                | 50.7                    | 59.1        | +0.2 | 85                             | 6.0                     | 3.47          | -0.28                   | 16   | —               | —                                 |
| Germiston, South Africa | 1023.0                   | —                       | 73           | 33   | 66.9                | 42.4                    | 54.7        | —    | 56                             | 1.2                     | 0.02          | —                       | 2    | 9.7             | 90                                |
| Mauritius               | 1016.6                   | +0.3                    | 84           | 61   | 80.1                | 66.7                    | 73.4        | +0.8 | 78                             | 3.4                     | 1.30          | -2.62                   | 13   | 8.7             | 78                                |
| Calcutta, Alipore Obsy. | 1003.5                   | -0.1                    | 103          | 73   | 97.0                | 80.4                    | 88.7        | +2.6 | 79                             | 5.3                     | 5.83          | +0.27                   | 9    | 8.1             | 61                                |
| Bombay                  | 1007.2                   | -0.2                    | 93           | 76   | 91.1                | 80.1                    | 85.6        | -0.2 | 77                             | 3.8                     | 0.00          | -0.55                   | 0    | 9.9             | 76                                |
| Madras                  | 1006.0                   | +0.6                    | 107          | 79   | 99.0                | 81.9                    | 90.5        | +0.7 | 69                             | 3.7                     | 0.02          | -1.82                   | 1    | 11.0            | 87                                |
| Colombo, Ceylon         | 1009.1                   | +0.7                    | 89           | 73   | 88.0                | 77.0                    | 82.5        | -0.3 | 86                             | 7.0                     | 18.02         | +7.08                   | 21   | 8.5             | 69                                |
| Singapore               | 1008.6                   | -0.1                    | 91           | 72   | 88.4                | 75.6                    | 82.0        | 0.0  | 88                             | —                       | 5.24          | -1.40                   | 14   | —               | —                                 |
| Hongkong                | 1009.8                   | +0.7                    | 88           | 69   | 81.9                | 73.6                    | 77.7        | +0.3 | 90                             | —                       | 7.30          | -4.77                   | 16   | 4.2             | 32                                |
| Sydney, N.S.W.          | 1023.3                   | +4.7                    | 82           | 48   | 69.5                | 54.7                    | 62.1        | +3.3 | 75                             | 5.7                     | 4.54          | -0.64                   | 10   | 5.9             | 57                                |
| Melbourne               | 1022.1                   | +2.9                    | 76           | 35   | 67.1                | 48.3                    | 57.7        | +3.6 | 73                             | 6.3                     | 0.47          | -1.69                   | 7    | 4.8             | 47                                |
| Adelaide                | 1023.0                   | +2.8                    | 81           | 42   | 70.6                | 51.7                    | 61.1        | +3.1 | 63                             | 5.8                     | 1.12          | -1.60                   | 12   | 6.5             | 61                                |
| Perth, W. Australia     | 1018.5                   | +0.1                    | 80           | 40   | 67.7                | 51.6                    | 59.7        | -1.0 | 69                             | 5.6                     | 9.90          | +4.93                   | 16   | 5.7             | 55                                |
| Coolgardie              | 1020.2                   | +1.1                    | 88           | 36   | 70.2                | 49.4                    | 59.8        | +2.1 | 64                             | 3.4                     | 1.30          | -0.93                   | 6    | —               | —                                 |
| Brisbane                | 1022.1                   | +3.5                    | 80           | 46   | 73.5                | 57.7                    | 65.6        | +1.0 | 71                             | 4.7                     | 2.18          | -0.63                   | 17   | 6.9             | 64                                |
| Hobart, Tasmania        | 1017.9                   | +2.6                    | 76           | 37   | 62.0                | 47.6                    | 54.8        | +4.3 | 67                             | 7.0                     | 3.44          | +1.54                   | 11   | 4.5             | 46                                |
| Wellington, N.Z.        | 1020.9                   | +5.3                    | 68           | 39   | 58.0                | 46.5                    | 52.3        | +0.9 | 80                             | 6.1                     | 2.36          | -2.32                   | 10   | 5.3             | 54                                |
| Suva, Fiji              | 1011.9                   | -0.8                    | 87           | 64   | 81.7                | 71.8                    | 76.7        | +0.2 | 81                             | 7.3                     | 13.59         | +3.52                   | 20   | 4.7             | 42                                |
| Apia, Samoa             | 1010.5                   | -0.6                    | 90           | 69   | 87.0                | 74.2                    | 80.6        | +2.2 | 80                             | 5.9                     | 10.26         | +4.19                   | 16   | 7.1             | 62                                |
| Kingston, Jamaica       | 1014.6                   | +1.5                    | 91           | 71   | 88.4                | 73.5                    | 80.9        | +1.2 | 72                             | 3.5                     | 1.94          | -2.45                   | 6    | 9.1             | 70                                |
| Grenada, W. Indies      | 1013.8                   | +1.2                    | 87           | 74   | 85.5                | 77.3                    | 81.4        | +1.7 | 82                             | 7.7                     | 0.82          | -3.37                   | 15   | —               | —                                 |
| Toronto                 | 1011.9                   | -3.0                    | 80           | 30   | 61.5                | 42.9                    | 52.2        | -1.6 | 77                             | 6.9                     | 3.37          | +0.58                   | 18   | 5.5             | 37                                |
| Winnipeg                | 1013.3                   | -0.5                    | 74           | 20   | 57.4                | 35.0                    | 46.2        | -5.8 | 81                             | 6.6                     | 0.85          | -1.15                   | 13   | 7.6             | 49                                |
| St. John, N.B.          | 1013.2                   | -0.7                    | 72           | 30   | 57.7                | 41.4                    | 49.5        | +1.8 | 80                             | 7.1                     | 6.98          | +3.27                   | 20   | 5.8             | 39                                |
| Victoria, B.C.          | 1016.2                   | -0.5                    | 85           | 36   | 66.1                | 44.8                    | 55.5        | +2.5 | 93                             | 4.9                     | 0.45          | -0.68                   | 5    | 9.4             | 62                                |

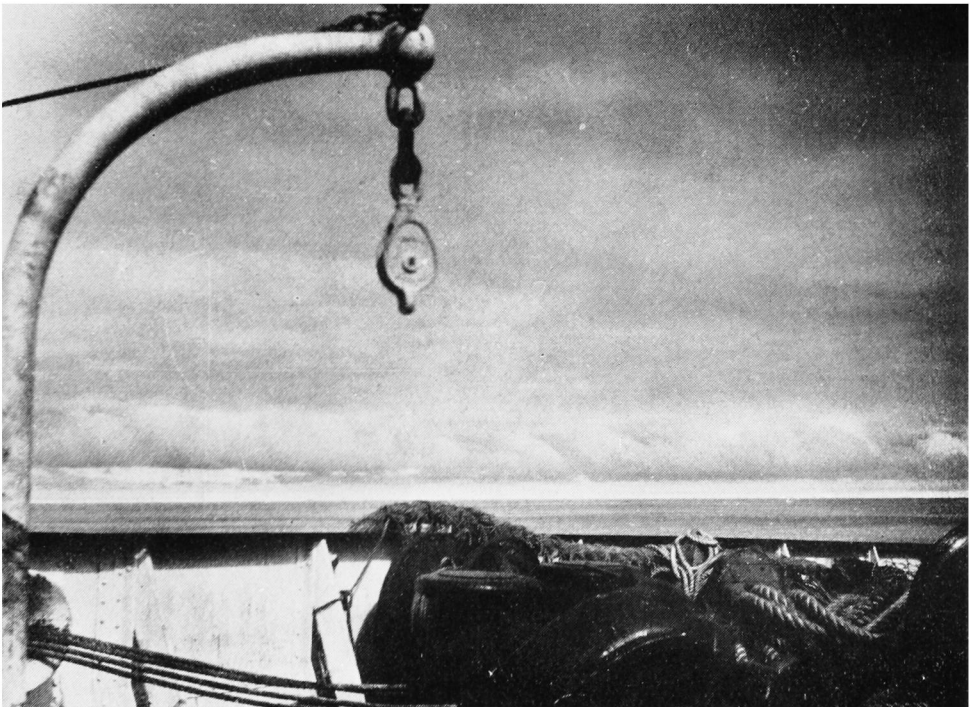


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**FINE DAWN OVER THE ICE FRINGE, SOUTHERN OCEAN**

The water is 2,500 fathoms deep here, but the still surface mirrors the pale blue and gold light of the sky and is almost as bright. Against this background the ice looks dark and the impression is of coastal shallows.

[0230 L.T., November 26, 1946, at 57°S. 55°E.]



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**MOST TYPICAL CLOUD STRUCTURE IN ANTARCTIC WATERS**

Cumulus penetrating a layer of stratus or stratocumulus at no great height above it. The cumulus is often concentrated along a line, as here, which may represent the vestiges of a decaying front.

[1200 L.T., January 26, 1947, at 63°S. 98°E.]



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#### CUMULONIMBUS ANVIL CLOUD

A somewhat rare occurrence, but actually observed on about 23 per cent. of the days of the season in Antarctic waters. The top of this anvil was estimated to be at 12,000 to 15,000 ft.

[1100 L.T., April 5, 1947, at 63°S. 84°E.]



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#### CHARACTERISTIC EDGE LINE OF A FRONTAL CLOUD SHEET

The frontal cloud consists of altostratus, and altocumulus at about 12,000 ft., which advanced from the east leaving clear only the western horizon, towards which the picture is taken.

[1900 L.T., January 11, 1947, at 63°S. 89°E.]