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WORLD METEOROLOGICAL ORGANIZATION COMMISSION FOR MARITIME METEOROLOGY—THIRD SESSION

By C. E. N. FRANKCOM, O.B.E.

The Commission for Maritime Meteorology, which was established in 1907 and which met on thirteen occasions under the auspices of the International Meteorological Organization (IMO), held its third session as a technical commission of the World Meteorological Organization (WMO) at Utrecht in August 1960. Previous conferences of this Commission have been held in London (three times), Paris, Utrecht, Zürich, Copenhagen, Hamburg, De Bilt (twice), Warsaw, Berlin and Toronto under IMO; and in London and Hamburg under WMO.

It is pertinent to recall that IMO, although controlled by the directors of the meteorological services of the member states, did not enjoy full inter-governmental status, whereas WMO is a specialized agency of the United Nations and is thus an official inter-governmental organization.

Although Utrecht is situated about thirty miles from the sea, it is, like all towns in the Netherlands, linked with the sea by canals and as it is only about three miles from De Bilt, the Headquarters of the Netherlands Meteorological Service, which has always been very active in maritime meteorology, it was not inappropriate that the Conference should be held there. The session, which lasted a fortnight, took place in the magnificent Great Hall of the 14th century University of Utrecht—with its ancient tapestries and stained glass windows.

Representatives of thirty-one member states and observers from nine international organizations attended the session, which was presided over by Dr. Helge Thomsen of Denmark. Dr. Thomsen is an oceanographer with much sea experience and a meteorologist, and he has been a member of the Commission since 1938. Other members of the Commission were seamen or oceanographers and all of them have specialized in maritime meteorology in one way or another. Four Port Meteorological Officers—one from Israel, two from the Netherlands and one from South Africa—gave the Commission much practical advice.

One of the chief functions of this Commission is to endeavour to provide an adequate network of meteorological observations in all the oceans of the world —and a major problem which was discussed at the session was that of trying to improve the network in those oceanic areas where shipping is relatively sparse. The Commission had the aid of maps prepared by the WMO Secretariat showing the number of observations received from ships throughout the world on days picked at random during the International Geophysical Year. These maps clearly showed how deficient the network is in the southern hemisphere compared with the northern hemisphere. (A copy of one of these maps is shown in Figure 1.) The Conference recommended that in certain ocean areas much improvement could be effected if Port Meteorological Officers of countries bordering those areas were more active in recruiting auxiliary ships (that is, ships which are not supplied with official instruments, and which only make very simple observations when in "sparse" areas only,) and that certain countries could usefully be more active in disseminating rapidly all the reports they receive direct by radio from ships, for the benefit of neighbouring countries so that these reports could figure on all the weather maps in the areas. Evidence was produced which seemed to indicate that much of the alleged lack of ship reports in certain areas was not because ships failed to send radio weather messages, but that these were not all being disseminated. In other areas it was appreciated that there are no regular trade routes and hence no merchant ships, and the only way of improving the network there seems to be by the use of automatic floating weather stations or by establishing floating meteorological stations similar to the ocean weather stations in the North Atlantic and North Pacific. The Executive Committee had previously drawn up a draft project indicating the positions where floating meteorological stations could most conveniently be situated for meteorological purposes and the Commission had been instructed to study this project. The Conference set up a working group to study the problem, after the session, and to consider the possibility of chartering laid-up tankers as one way of solving this problem economically—the idea being that a tanker could remain a long time (up to twelve months if necessary) at sea and a relief crew could be put aboard by tender when required. Aboard such a vessel, upper air and surface observations could be made, as aboard a weather ship. The working group was also instructed to consider alternative plans, including the possibility of further observations aboard mobile ships (merchant ships) as has been done very successfully by the United States Weather Bureau aboard certain American merchant ships. The Commission considered that such observations, if carried out at all, could only be done by professional meteorologists aboard special types of ships (for example, bulk carriers) which spend considerably more time at sea than in harbour. Evidence was given concerning successful experiments carried out by the United States Weather Bureau with marine automatic weather stations, using a special mooring, in the Caribbean and South Atlantic, moored in depths of nearly 2000 fathoms.

The Commission recommended that action be taken by WMO on an international basis to secure more co-operation by fishing vessels of various nations in the provision of radio weather messages—bearing in mind the fact that fishing vessels tend to operate in areas where merchant shipping is relatively sparse—and to educate fishermen as to the importance of doing this and the value to themselves of regular and accurate weather information.

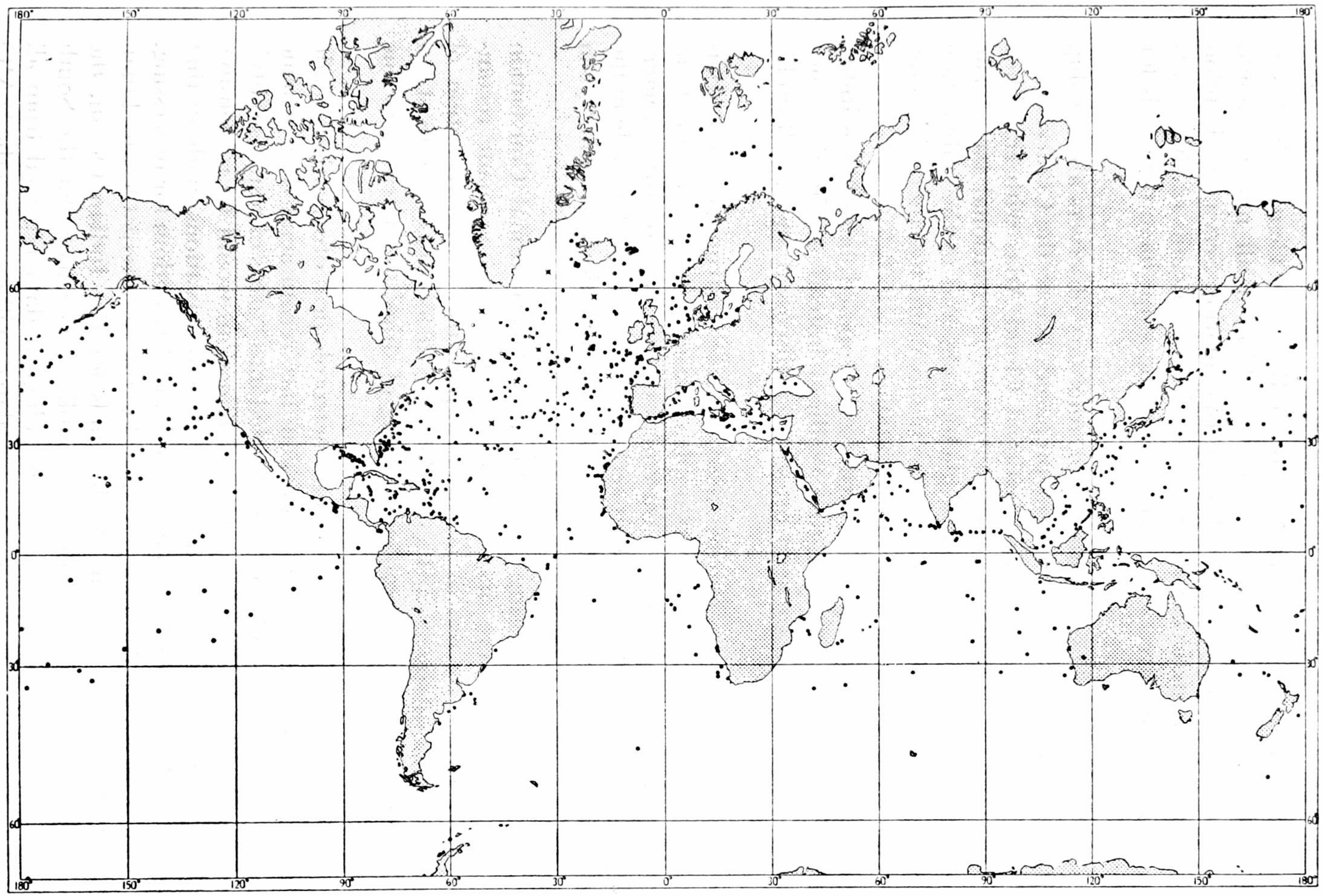

FIGURE I—DISTRIBUTION OF SHIPS MAKING METEOROLOGICAL OBSERVATIONS AT 0600 GMT, 1 NOVEMBER 1957

Weather ships are marked with a cross.

Number of ships:	Northern hemisphere	745
	Southern hemisphere	106
	World total	851

A recommendation was made with the object of obtaining the maximum number of meteorological observations from ships in the Indian Ocean during the international oceanographic expeditions in that Ocean (1960–64), which are being organized by the Special Committee of Oceanographic Research of the International Council for Scientific Unions, and of obtaining the maximum meteorological value from and of providing assistance to the ships of the expeditions themselves.

Resulting from a request from the Anti-locust Research Centre, the Commission recommended that voluntary observing ships of all nations should report direct by radio to the Desert Locust Information Service in London whenever locusts are sighted; the report would include details of the locusts seen and wind force and direction. British observing ships have done this for several years.

Cloud observations are always difficult for voluntary observers aboard ship and a working group of the Commission prepared, before the Conference, a selection of photographs from the International Cloud Atlas with simplified descriptions for issue to voluntary observers on an international basis. The Commission agreed with this selection of photographs and to the publication of an international cloud card embodying the photographs together with some guidance to observers on cloud height observation.

No drastic changes in the "ship" code form were proposed, but the possibility of recommending direct sea temperature readings instead of the difference between sea and air temperature as at present was discussed and is still under consideration.

Various problems relating to marine meteorological instruments and accuracy of observation aboard ship (for example, measurement of precipitation, sea temperature measurements and measurement of true wind by anemometer) were discussed as well as a suggestion that certain changes might be made in the wind speed equivalents of the Beaufort scale—all these questions are being given further consideration and study.

Meteorological questions arising from the 1960 International Convention for Safety of Life at Sea were discussed and the Commission made recommendations concerning the use of facsimile apparatus for the reception of weather maps and ice maps aboard ship, the issue of forecasts of state of sea and swell for shipping and the problem of icing of ships' superstructures due to frozen spray.

In order to get the maximum value from meteorological observations made aboard ships of all nations, the Commission has recommended a scheme whereby the oceans of the world would be divided into "areas of responsibility" for climatological purposes. Thus, the United Kingdom would be responsible for most of the North Atlantic, and punch cards of observations made in that ocean by ships of all nations will be sent to the United Kingdom for processing. Similarly, South Africa would be responsible for the Southern Ocean, Japan and the U.S.A. for the Pacific, the Netherlands for the Indian Ocean, the U.S.S.R. for the Arctic and the Federal Republic of Germany for the South Atlantic. The general intention is that climatological data received from all ships in the various ocean areas, after being tabulated, will be sent to the WMO Secretariat for publication in the form of monthly climatological summaries. It has not been practical to publish oceanic summaries previously except in the case of ocean weather stations, because data from the ships has never before been gathered together on an international basis. The Commission also made recommendations concerning the eventual preparation of a world climatological atlas of the oceans, for consideration by the Commission for Climatology, based upon data collected from all ships in the various ocean areas, the period selected being 1950 to 1979.

Another general subject discussed by the Commission was that of sea ice; recommendations were made about a unified code for reporting ice from aircraft, ships and shore stations, and for the publication of an international illustrated ice nomenclature.

During the Conference a series of lectures was held on the question of "methods of forecasting the state of sea on the basis of meteorological data", at which delegates from the Federal Republic of Germany, the Netherlands, the United States of America and the United Kingdom contributed. The U.S.A. and the Nertherlands have used such forecasts during recent years in connexion with the weather routing of ships with which they claim to have secured quite a lot of success. A further technical discussion was held one evening, when the subjects included activities aboard U.S.S.R.oceanographical and weather ships in the Pacific and a description of a portable radio-sonde used aboard certain U.S.A. merchant ships.

Several working groups were set up by the Commission to discuss various problems during the three years that must elapse before the next Conference. At the conclusion of the session Mr. J. A. Montijn, Head of the Marine Department of the Netherlands Meteorological Institute, was elected President in place of Dr. Thomsen who wished to resign the Presidency. Mr. Montijn previously served as a Deck Officer in the Netherlands Merchant Navy.

Utrecht is an attractive old town and, although the delegates had to work hard to cover a formidable agenda, time was found for social activities and our Netherlands hosts were very hospitable. The activities included a trip round Rotterdam Docks in a motor launch and receptions by the Burgomasters of Rotterdam and of Utrecht.

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FRONTS INVESTIGATED BY THE METEOROLOGICAL RESEARCH FLIGHT

By M. H. FREEMAN, O.B.E., M.Sc.

Introduction.—Sawyer[1] has reported on the frontal observations made by the Meteorological Research Flight in 1950–52. Another series of flights was made during the period 1953–55 and forms the subject of the present article. On each sortie observations of temperature, frost point, cloud and precipitation were made at half-minute intervals on horizontal flights at about 500 and 600 millibars and at 500-foot intervals during climbs and descents. The track was chosen so as to be approximately perpendicular to the front being investigated, and the time so as to overlap the 1400 GMT upper air observations.

Method of analysis.—Vertical cross-sections along the line of flight were drawn using both the aircraft and radio-sonde observations. The diagrams for six of the more active fronts, three warm and three cold, are shown at Figures 1 to 6. In general there was fairly good agreement between the aircraft and radio-sonde temperatures and it was possible to draw a frontal zone, as defined by the region of maximum temperature gradient, with reasonable confidence.

Figures 1(*a*) to 6(*a*) show the synoptic situation with surface fronts and isobars and the 500–1000-millibar thickness; the aircraft track is also marked. Two vertical cross-sections are presented for each front. On Figures 1(*b*) to 6(*b*) are drawn isotherms at 10°C intervals and isotachs showing the magnitude of the component of the upper winds perpendicular to the flight track, that is roughly parallel to the surface front. Figures 1(*c*) to 6(*c*) depict the cloud structure and precipitation as deduced from the aircraft observations and synoptic reports. Also on these diagrams are drawn isopleths of depression of dew/frost point. The vertical scale on the cross-sections is exaggerated 100 times.

Thermal structure of the frontal zone.—As in the previous series of flights investigated by Sawyer[1], these fronts showed a good deal of variety in their detailed thermal structure. The width of the frontal zone ranged from 25 to 180 miles. The greatest temperature gradient within the frontal zone was about 2°C in 10 miles and the least about 0·5°C in 10 miles; on one of the traverses the front appeared to be diffuse and it was not possible to define a temperature gradient. The horizontal profiles of temperature (and frost-point depression) for five of the six fronts have been published by Sawyer.[2] The slopes of the fronts also showed considerable variety, ranging from 1:30 to 1:140 for cold fronts and 1:110 to 1:200 for warm fronts.

Humidity in the vicinity of fronts.—One of the most striking things about these six frontal flights was the tongue of very dry air which was experienced near the frontal zone. Figures 1(*c*) to 5(*c*) all show a dry region (frost-point depression greater than 10°C) near the upper part of the frontal zone and orientated roughly along it. The dry air extended upwards from about 750 or 850 millibars and often reached nearly to the tropopause. The driest air was actually in the frontal zone and occurred at heights between 800 and 600 millibars. On 13 January 1955 (Figure 3(*c*)) a patch of very dry air with a frost-point depression of 25°C occurred at 8000 feet only 10 miles ahead of the frontal cloud and only 500 feet below the frontal cloud sheet above. Very large gradients of frost-point depression were not uncommon, an exceptionally large one being 13°C in 3 nautical miles as the aircraft approached the frontal cloud at 500 millibars on 13 January 1955. The greatest frost-point depression recorded was 45°C at 630 millibars on 16 September 1954. Pothecary[3] examined the front of 29 November 1954 and tracked the dry air back to a region where subsidence took place 24 to 36 hours previously. The humidity isopleths are such as would be expected from the descent of air along the upper frontal surface.

Frontal cloud structure.—The great diversity of cloud formations associated with fronts is well known and was amply exemplified by fronts investigated by the Meteorological Research Flight. Five of the six fronts illustrated in this article were well marked ones and the cloud sequences conformed moderately well with the "textbook" models. All three warm fronts were accompanied by cirrostratus, altostratus and nimbostratus, as was the slow-moving cold front of 11 January 1955 (Figures 1(*c*) to 4(*c*)). This latter was, in fact, the same front which was investigated on 13 January 1955 when it returned as a warm front. The cold front of 16 September 1954 (Figure 5(*c*)) was a good example of a "kata" front with descending air at the frontal surface and very little frontal cloud. On all these fronts the bulk of the cloud was in the warm air, and the frontal zone was in clear air except in the lowest layers.

The warm fronts and slow-moving cold front all had cloud systems, the slope of which was about twice as steep as that of the frontal zone. This important fact was noted by Sawyer and Dinsdale[1] in 1955 and is well corroborated by these flights, though the level at which the cloud intersected the warm boundary of the frontal zone was generally lower than the 600 millibars suggested by Sawyer and Dinsdale. On the three warm fronts the forward edge of the precipitation was close to the position where the frontal cloud intersected the warm boundary of the frontal zone.

Wind régime.—On all six occasions a wind speed maximum occurred just below the tropopause in the warm air above the upper end of the frontal surface. The strength of the maximum component parallel to the surface front varied between about 60 and 150 knots. A commonly quoted feature of the frontal model is that the jet stream lies approximately above the intersection of the frontal zone with the 500-millibar level. This was roughly borne out by the six fronts considered, the relevant height being 550 millibars on the average with values ranging from 430 to 630 millibars on the individual fronts.

On the four fronts where a cirrus and cirrostratus sheet was present the edge of the cloud sheet appeared to be near the core of the jet stream and a little below it. Sawyer[2] on theoretical grounds deduced the presence of upward motion on the warm side of the jet stream core and downward motion on the cold side when the jet stream was intensifying or becoming more cyclonically curved. The presence of cloud on the warm side of the jet stream would be in agreement with Sawyer's thesis.

Notes on the individual fronts follow.

Warm front of 29 November 1954

(*a*) *Synoptic situation.* A depression had persisted to the south of Iceland for several days with a series of secondaries crossing the Atlantic to the south of the main centre. On 29 November 1954 a vigorous secondary depression approached Ireland from the south-west. At 1400 GMT the position was as shown in Figure 1(*a*) with the warm front lying across Cornwall and the Cherbourg Peninsula and moving north-east at about 35 knots. The flight was in the direction 050° from Farnborough and penetrated the frontal zone four times, on the ascent and descent and on horizontal sections at 19,000 and 14,000 feet.

(*b*) *Frontal structure.* The upper frontal zone was a fairly narrow one with temperature changes of 8°C in 65 nautical miles and 7°C in 80 miles at 19,000 and 14,000 feet respectively. Below 10,000 feet the frontal zone was more diffuse with some indication of a double structure; at 6000 feet the width of the zone was about 140 miles. The slope of the warm frontal surface was about 1:150. The front reached its maximum elevation over the Heligoland Bight and farther to the north-east it descended again as the upper cold front of an occlusion. On the horizontal flights some very large gradients of frost-point depression were recorded, 25°C in 14 miles at the edge of the frontal zone and 22°C in 15 miles near the top of a cumulonimbus cloud. The precipitation encountered was all in the form of rain and all occurred below 7000 feet; on the descent the aircraft entered the main cloud layer at 7800 feet and encountered rain at 7000 feet.

Warm front of 7 October 1955

(*a*) *Synoptic situation.* This example occurred during a period of unsettled westerly type of weather. On 7 October 1955 there was a complex low over the Atlantic with a wide warm sector. The passage of the warm front across England was slowed by a small wave which moved south-eastwards along the front. At 1400 GMT this wave was near Cornwall (see Figure 2(*a*)).

On this occasion two flights were made: (i) by Hastings at 13,000 and 18,000 feet on track 070°–250° from Farnborough and (ii) by Canberra at 30,000 and 35,000 feet in direction 060°–240°. The frontal zone was entered at 13,000 feet but all the other horizontal flights were made entirely in the warm air.

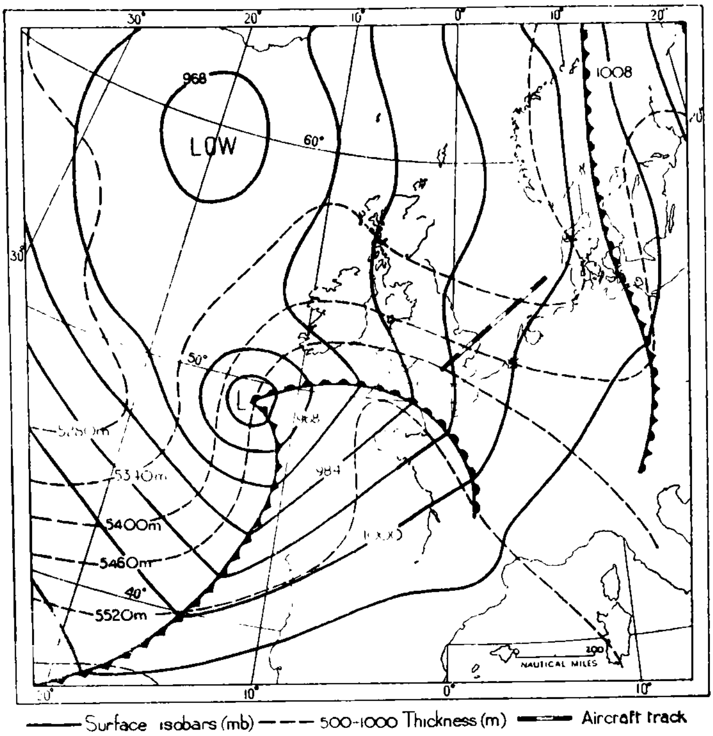
(*b*) *Frontal structure.* In the upper troposphere the frontal zone was about 50 nautical miles wide; below 15,000 feet the frontal zone was wider and a double structure was evident. This could also be detected on the surface charts, the dew-points rising in two stages, from the upper forties to about 55°F and then to 59°–60°F. The frontal surface had a slope of about 1 :110 and extended almost up to the tropopause (see Figure 2(*b*)).

The aircraft reports indicated that the cloud was in numerous layers rather than a solid mass, and the lower part of the frontal cloud (not penetrated by the aircraft) may have been more broken than indicated in Figure 2(*c*). Precipitation was not reported above 13,000 feet, but rain was found at this level, sometimes quite near the top of a cloud layer. The broken nature of the cloud system makes it difficult to assign a slope to it but on the whole the cloud has a greater slope than the frontal zone. Most of the frontal zone above 5000 feet was a region of dry air, a frost-point depression of 33°C being recorded by the aircraft at 13,000 feet.

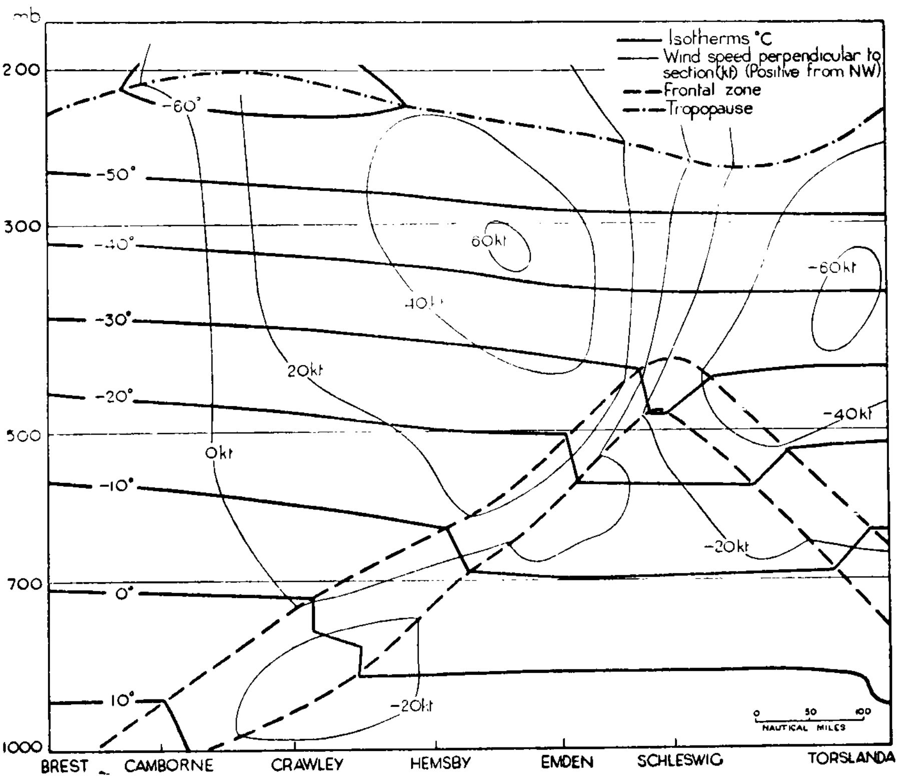
Warm front of 13 January 1955

(*a*) *Synoptic situation.* A depression over Scandinavia had brought a cold northerly airstream to all parts of the British Isles. Early on 13 January 1955 a depression broke away from the complex low in the central Atlantic and moved east in about latitude 50°N. An active warm front associated with this depression moved slowly north-north-east from the Bay of Biscay and at 1400 GMT on 13 January the position was as shown in Figure 3(*a*). Much of the flight, which took from 1150 to 1520 GMT, was made in the frontal zone (see Figure 3(*c*)).

(*b*) *Frontal structure.* The thermal structure showed a broad frontal zone with two fairly well marked regions of maximum temperature gradient. The upper frontal zone can probably be identified with an occlusion which amalgamated with the main cold front as it moved south across the British Isles three days previously, and remained in existence as a feature in the temperature field as the combined front moved back north-eastwards as a warm front. At 13,000 feet the temperature gradients measured were $5\frac{1}{2}$°C in 65 nautical miles and 2°C in 20 nautical miles in the two regions, while the total contrast between the two air masses at this level was about 14°C spread over a distance of about 300 nautical miles. The slope of the frontal surface was about 1 :200. Precipitation reached the ground as snow at the forward edge of the precipitation belt, turning to rain after about 70 miles. The 500–1000-millibar thickness at the snow belt was between 5340 and 5390 metres, which are unusually high values to be associated with snow. Murray[5] found that on only 0·4 per cent of occasions did snow occur with thickness values between 5370 and 5397 metres.

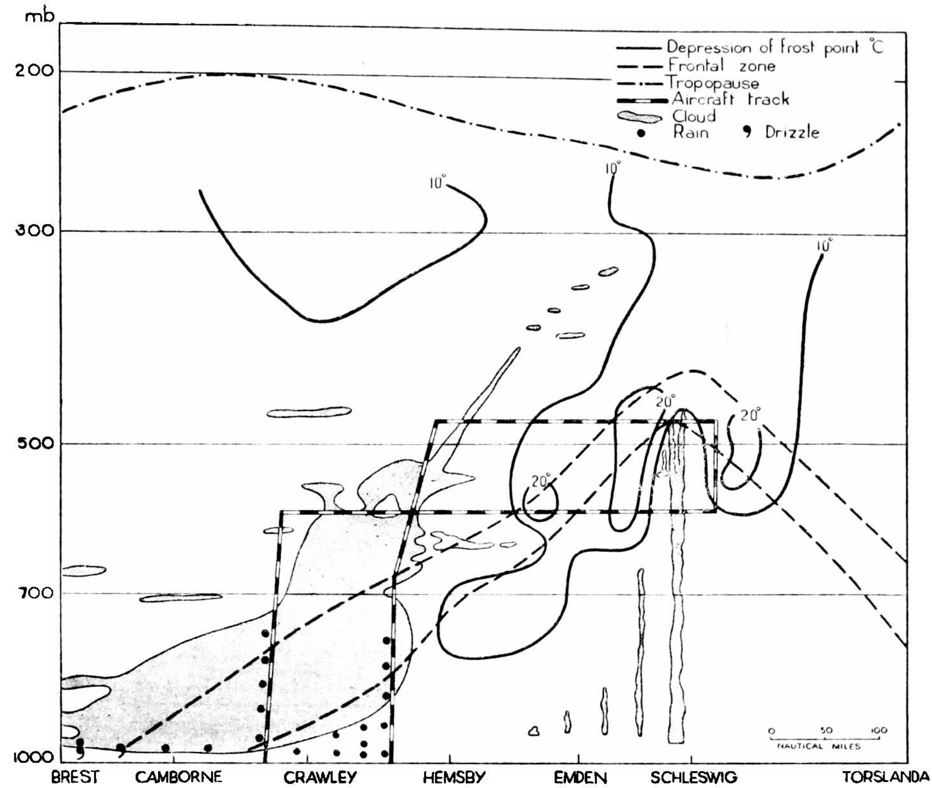


(*a*) Synoptic chart for 1400 GMT



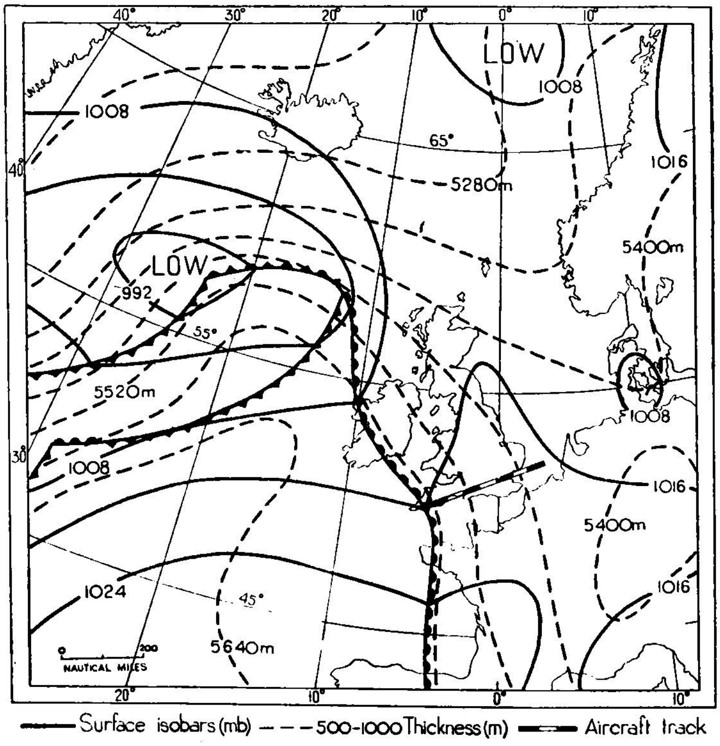
(*b*) Vertical cross-section, Brest to Torslanda, showing isotherms and isotachs

FIGURE 1—WARM FRONT OF 29 NOVEMBER 1954



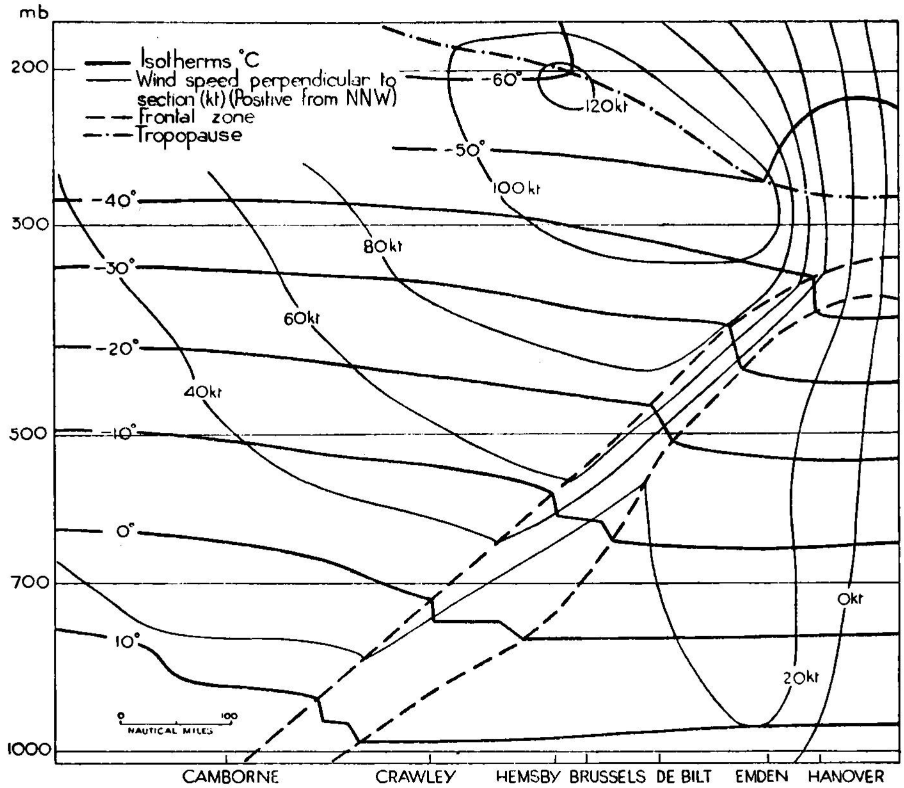
(*c*) Vertical cross-section showing humidity and cloud

FIGURE 1—WARM FRONT OF 29 NOVEMBER 1954 (*cont.*)

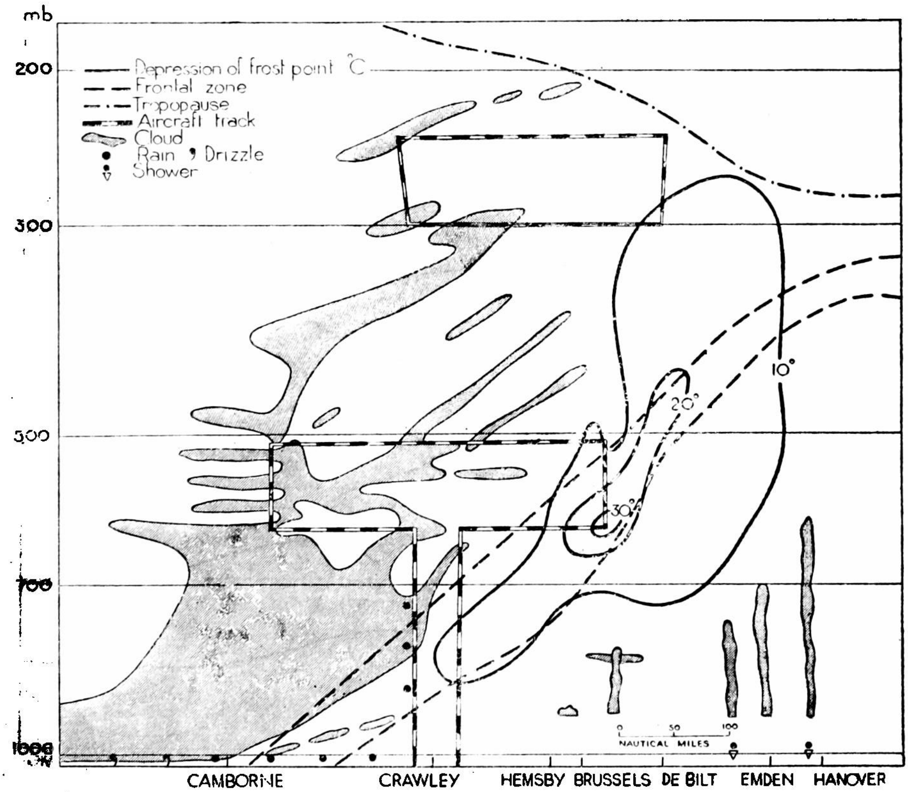


(*a*) Synoptic chart for 1400 GMT

FIGURE 2—WARM FRONT OF 7 OCTOBER 1955

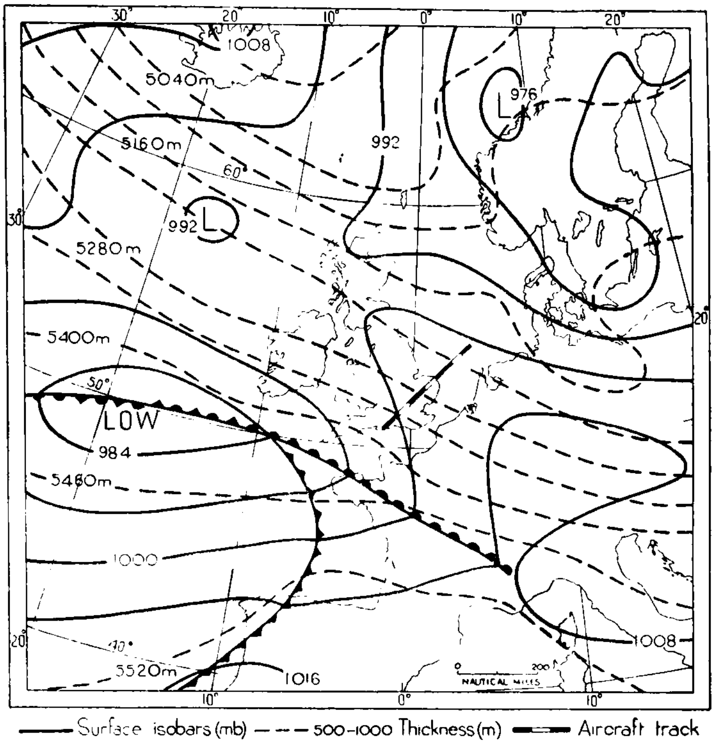


(*b*) Vertical cross-section, Camborne to Hanover, showing isotherms and isotachs

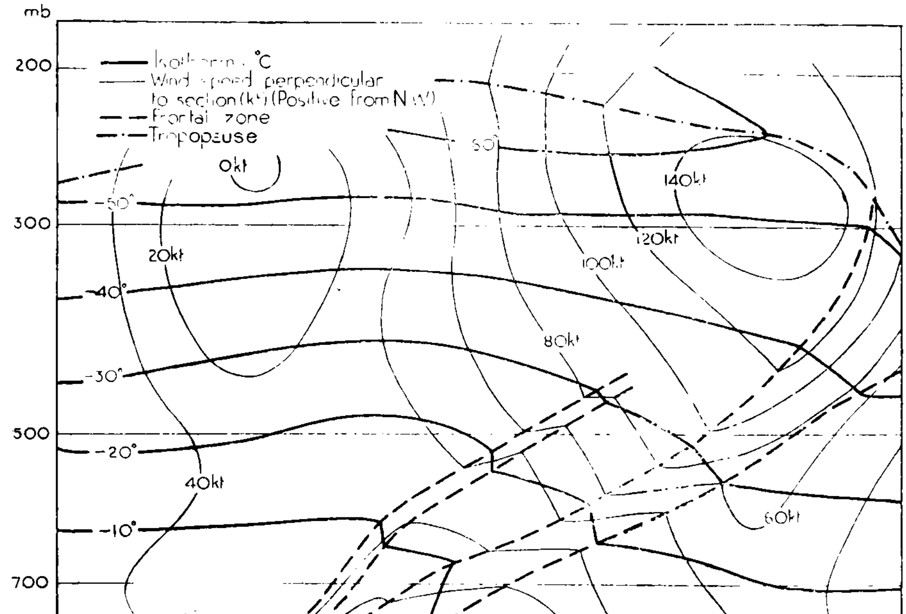


(*c*) Vertical cross-section showing humidity and cloud

FIGURE 2—WARM FRONT OF 7 OCTOBER 1955 (*cont.*)

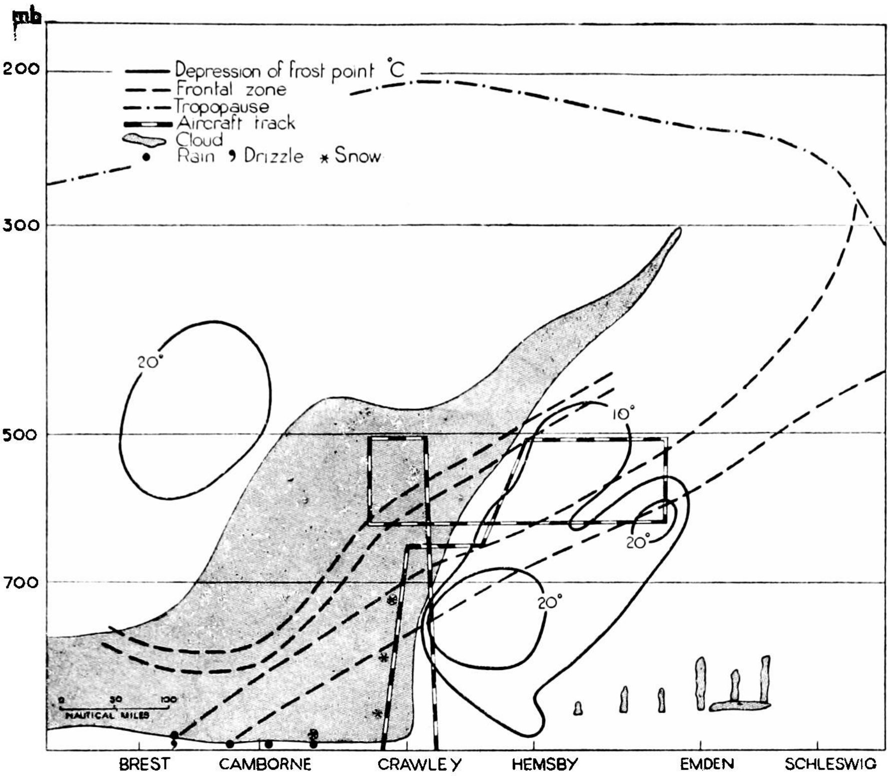


(*a*) Synoptic chart for 1400 GMT



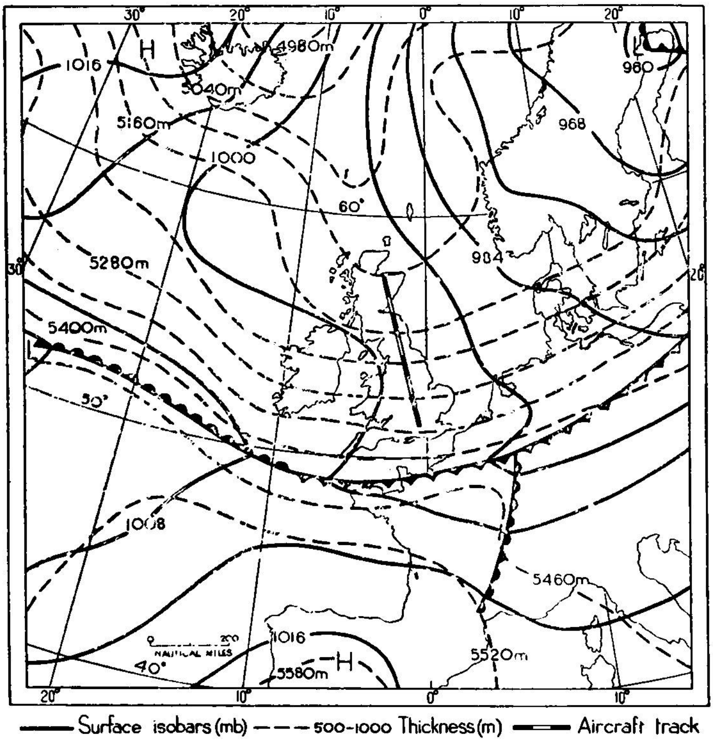
(*b*) Vertical cross-section, Brest to Schleswig, showing isotherms and isotachs

FIGURE 3—WARM FRONT OF 13 JANUARY 1955



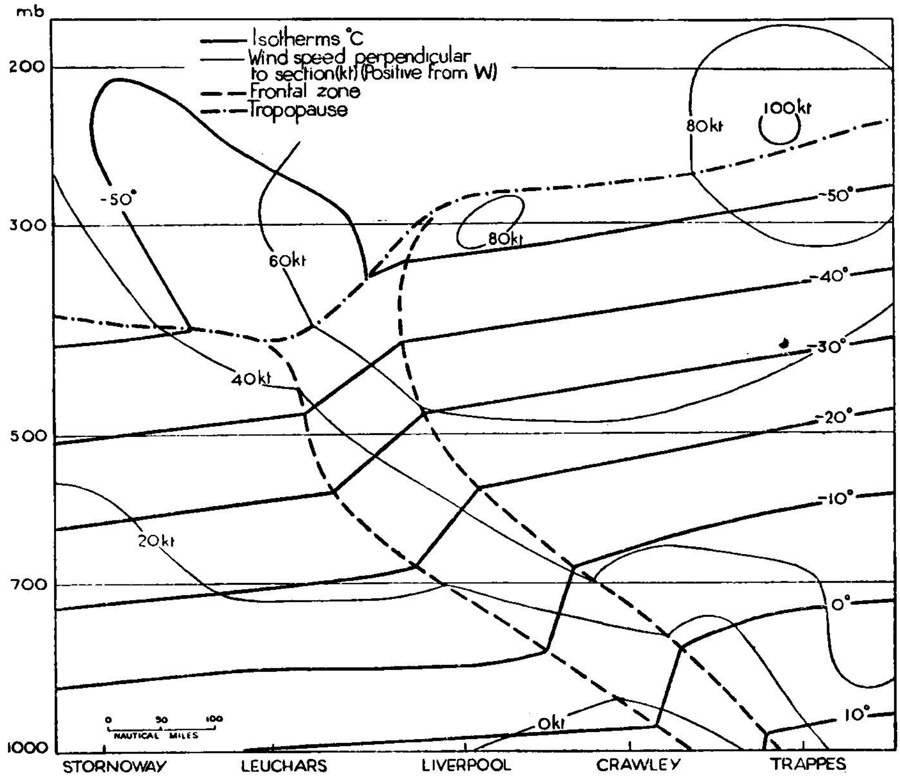
(*c*) Vertical cross-section showing humidity and cloud.

FIGURE 3—WARM FRONT OF 13 JANUARY 1955 (*cont.*)

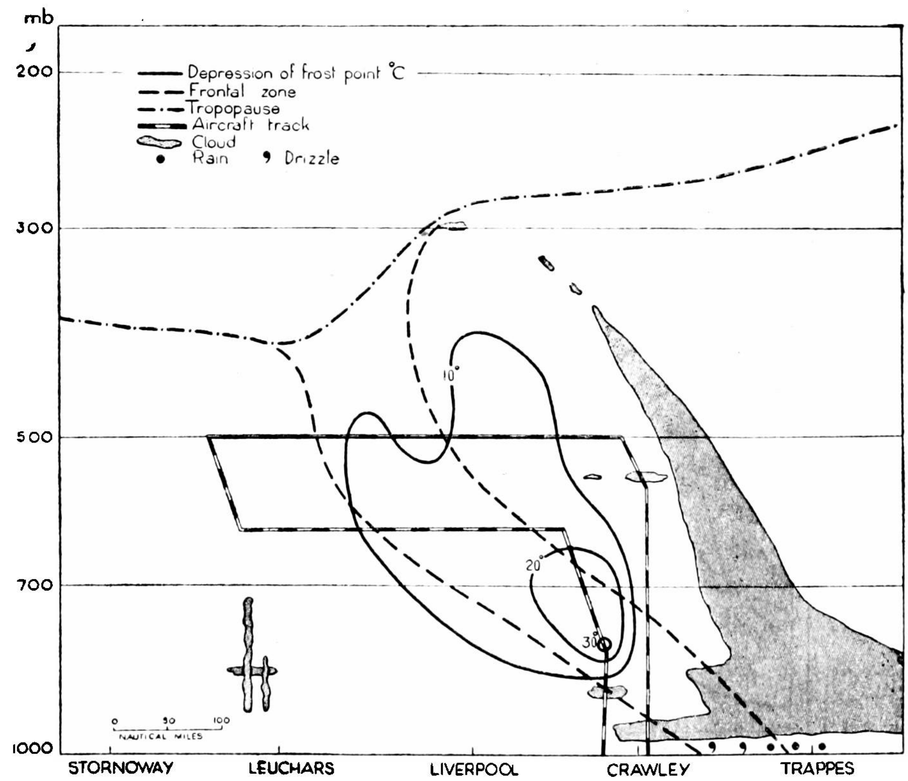


(*a*) Synoptic chart for 1400 GMT

FIGURE 4—COLD FRONT OF 11 JANUARY 1955

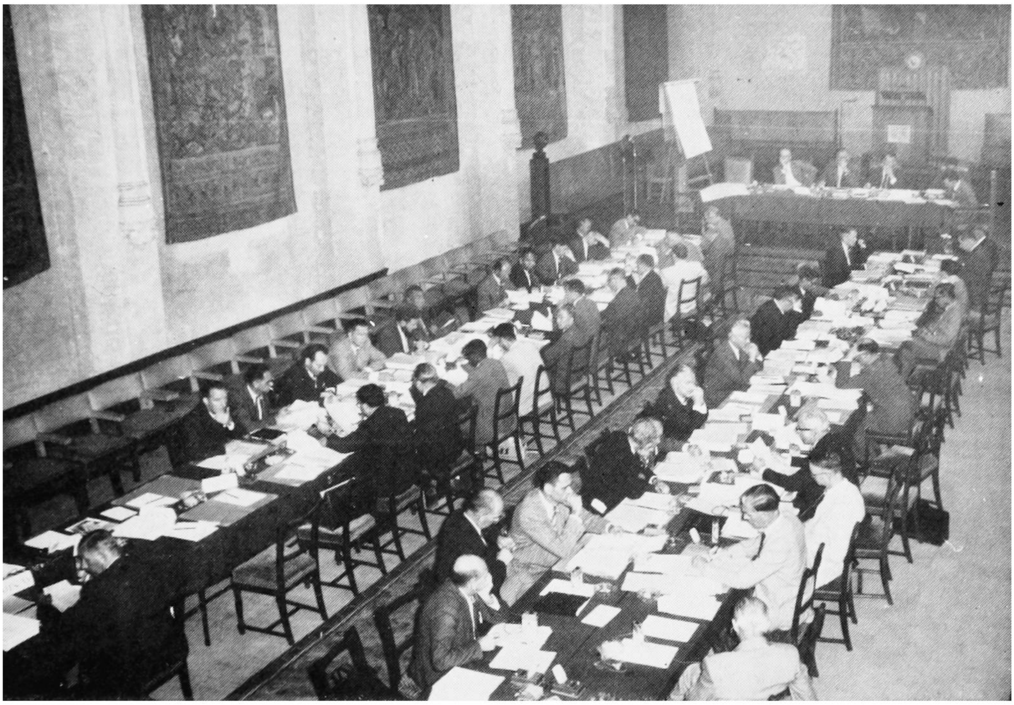


(*b*) Vertical cross-section, Stornoway to Trappes, showing isotherms and isotachs



(*c*) Vertical cross-section showing humidity and cloud

FIGURE 4—COLD FRONT OF 11 JANUARY 1955 (*cont.*)



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THIRD SESSION OF THE WORLD METEOROLOGICAL ORGANIZATION COMMISSION FOR MARITIME METEOROLOGY

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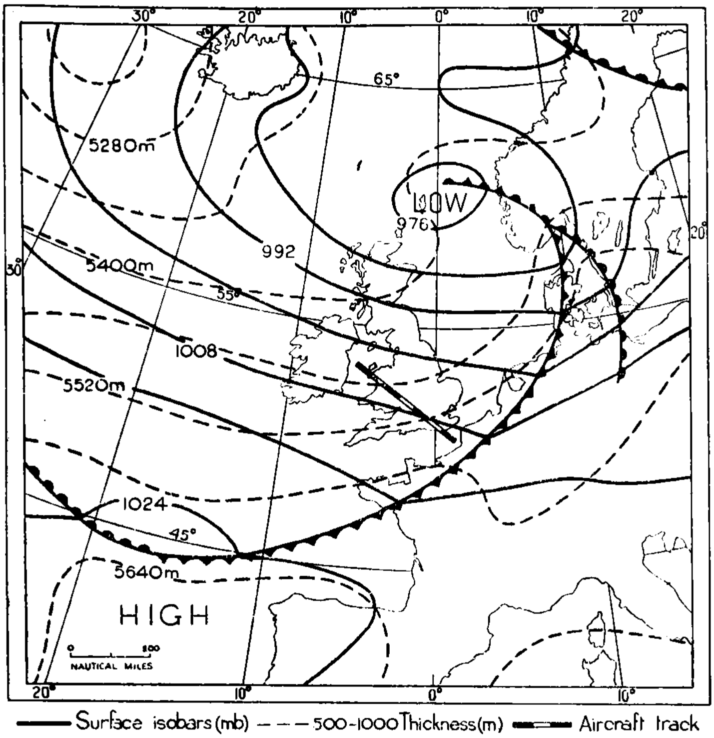
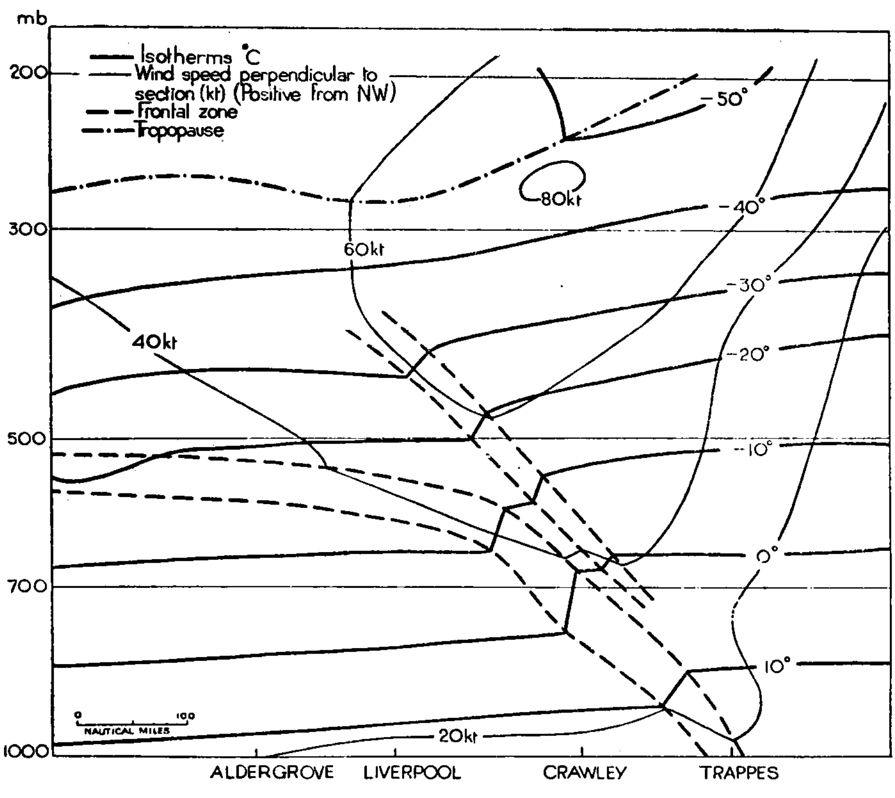
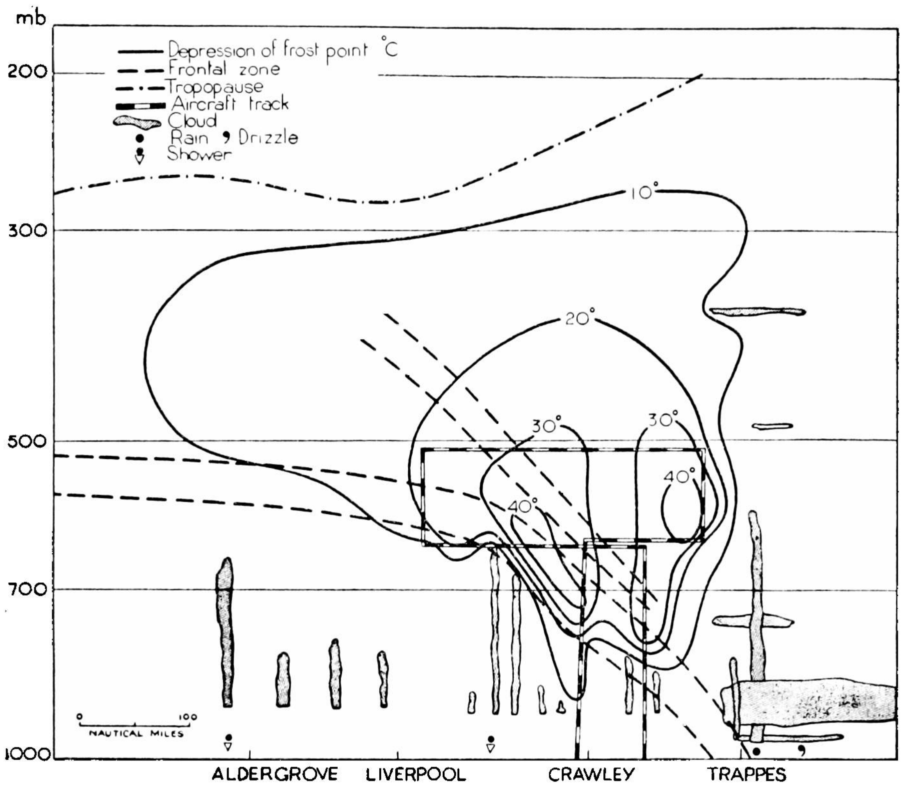


(*a*) Synoptic chart for 1400 GMT



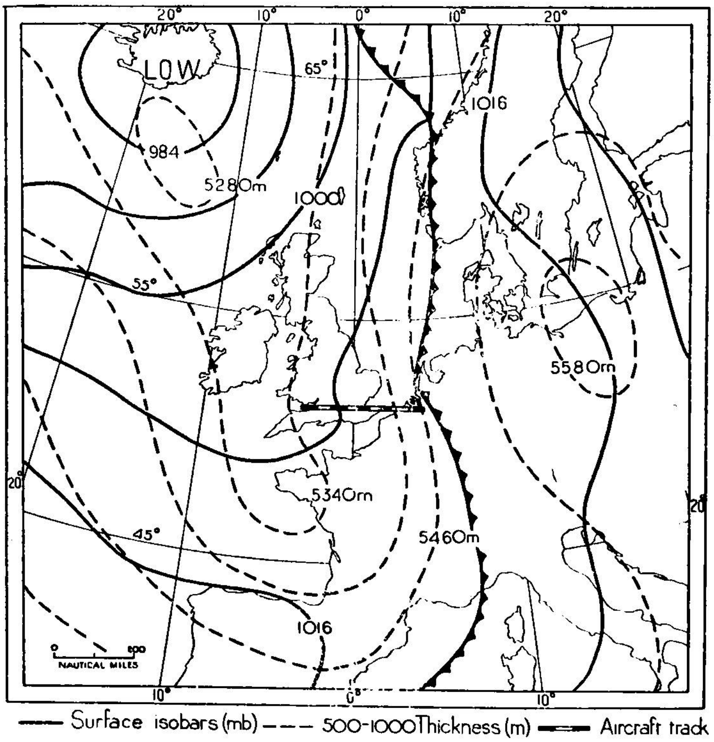
(*b*) Vertical cross-section, Aldergrove to Trappes, showing isotherms and isotachs

FIGURE 5—COLD FRONT OF 16 SEPTEMBER 1954



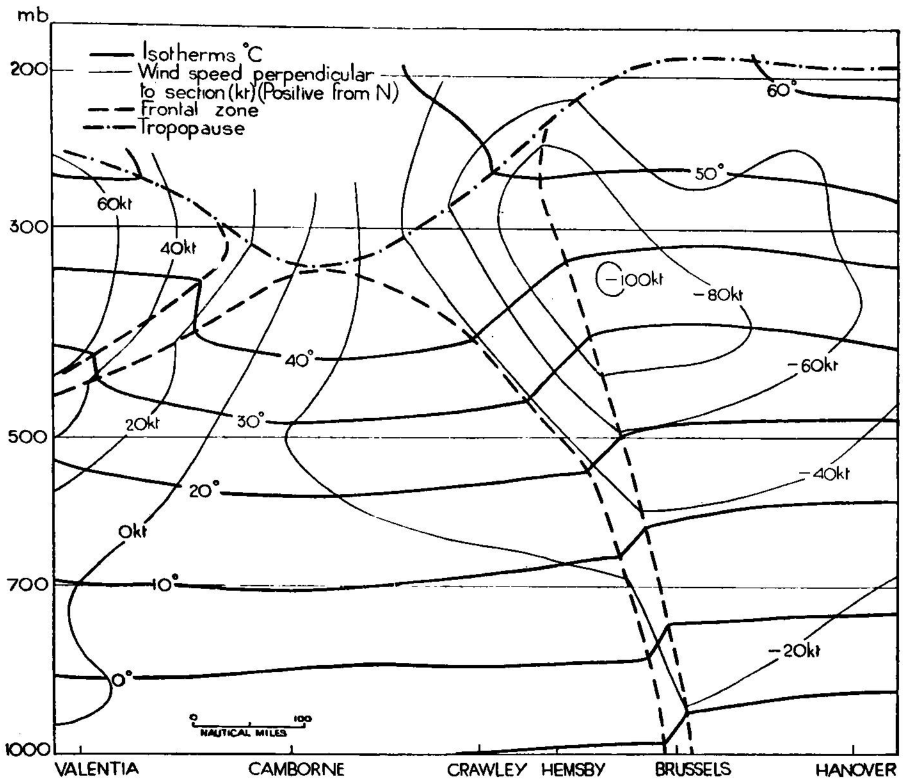
(*c*) Vertical cross-section showing humidity and cloud

FIGURE 5—COLD FRONT OF 16 SEPTEMBER 1954 (*cont.*)

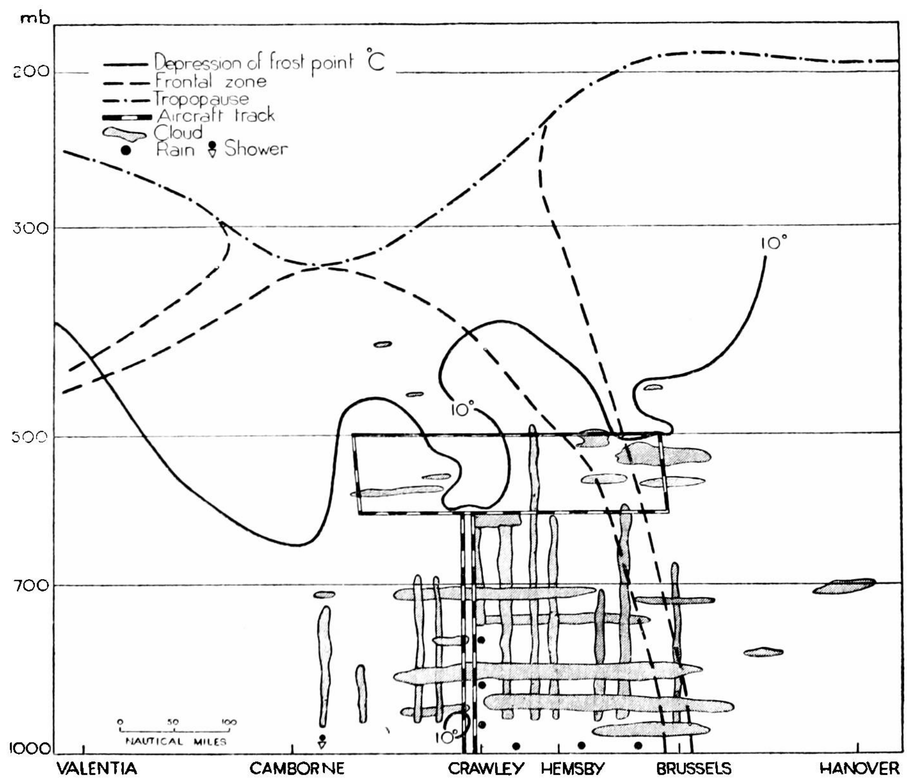


(*a*) Synoptic chart for 1400 GMT

FIGURE 6—COLD FRONT OF 20 OCTOBER 1953



(*b*) Vertical cross-section, Valentia to Hanover, showing isotherms and isotachs



(*c*) Vertical cross-section showing humidity and cloud.

FIGURE 6—COLD FRONT OF 20 OCTOBER 1953 (*cont.*)

Cold front of 11 January 1955

(*a*) *Synoptic situation.* A complex depression in mid-Atlantic had brought mild air to the southern half of the British Isles. A depression developed between Scotland and Norway and moved slowly north-east. A cold front associated with this depression moved slowly south across the British Isles and by 1400 GMT on 11 January 1955 lay along the north coast of France when it was moving south at about 12 knots (see Figure 4(*a*)). There was a surface temperature drop of some 10°F at the frontal passage and in many parts of England the post-frontal precipitation turned to sleet or snow. The flight was made on an approximately north–south track and intercepted the frontal zone on the horizontal sections at 620 and 500 millibars and on both the ascent and descent.

(*b*) *Frontal structure.* This was a good example of a slow-moving cold front with an extensive cloud sheet and broad precipitation belt behind the surface cold front. The horizontal flights at 18,000 and 13,000 feet showed a broad frontal zone about 180 nautical miles wide with a temperature drop across it of about 10°C. The slope of the front below 600 millibars was 1:140; above this level it was steeper, about 1:45. The driest air was at 6500 feet on the descent when a frost-point depression of 31°C was recorded.

Cold front on 16 September 1954

(*a*) *Synoptic situation.* During an unsettled westerly type of weather a depression moved east-north-east just to the north of Scotland. The associated cold front crossed the British Isles during the morning of 16 September 1954, moving south-east across England at 28 knots. By 1400 GMT the cold front had crossed the coasts of north France and the Low Countries and was in the position shown in Figure 5(*a*). The flight was made on a track of 310°–130° through Farnborough and intersected the frontal zone on both the horizontal sections as well as on the climb and descent. It did not, however, reach the frontal cloud which lay over France.

(*b*) *Frontal structure.* This occasion provided a good example of a "kata" cold front with descending air at the frontal surface and very little frontal cloud. The passage of the surface front was accompanied by a rapid clearance of cloud.

The frontal zone was well marked on the flight at 12,500 feet with a temperature contrast of 9°C in 50 nautical miles. At 17,500 feet the temperature difference was only 4½°C in about 35 miles. Below 12,000 feet the frontal surface was clearly defined and had a slope of about 1:110. Above 12,000 feet the original front was very weak and had a much smaller slope (about 1:400). The main temperature contrast aloft at the time of the flight lay above the old front and probably had a dynamical origin with very subsided air ahead and air which had subsided rather less forming the "cold" air.

The flight was notable for the extremely dry air encountered, a frost-point depression of 45°C being recorded in the warm air at 12,500 feet. Another very dry patch occurred at this level in the frontal zone. The whole of the flight was made in clear air, with cumulus cloud occurring in the cold air below the frontal zone. The position of the surface front was marked by a mass of cumulus and stratiform cloud with tops extending to about 14,000 feet.

Cold front of 28 October 1953

(*a*) *Synoptic situation.* A cold front associated with a depression near Iceland had moved east across the British Isles and become slow moving over the Low Countries and the North Sea. Minor waves moved north along the front and at

1400 GMT one of these was over Holland (see Figure 6(*a*)). An area of rain was affecting south-east England. The flight was made mainly in the cold air to the west of the front.

(*b*) *Frontal structure.* Although there was a large temperature contrast between the main air masses (about 11°C in 100 nautical miles in the upper troposphere), the frontal zone was somewhat diffuse. On the flight at 18,000 feet the main frontal zone was fairly well marked with a temperature change of 3½°C in about 25 miles. At 14,000 feet, however, the temperature change was more gradual and no clear-cut frontal zone was observed. Below 500 millibars the slope of the frontal surface was large, 1:35. At greater heights the front was less steep.

The cloud observed was almost all in the cold air west of the front and consisted of multilayer cloud with cumulus cells embedded in it. Much of the cloud was below 10,000 feet but various broken layers were encountered at higher levels. There appeared to be little resemblance to the texbook cloud models for a cold front. Dry air was observed in the region of the front and in the cold air behind it, the maximum frost-point depression, 17°C, occurring in the warm air near the frontal zone at 500 millibars.

Conclusion.—The series of flights through fronts here described confirms Sawyer's findings in his report on the earlier series of flights made by the Meteorological Research Flight. The most striking fact is the presence of regions of dry air in and near the frontal zone.

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551.501.45: 551.521.11: 551.524.3: 551.571.3

YEAR-TO-YEAR VARIATIONS FROM METEOROLOGICAL AVERAGES

By T. H. APPLEGATE

In a previous article Smith[1] gave an explanation of a simple method of estimating the probable deviations from average monthly rainfall in a decade by means of ten sample percentages. This method has now been applied to averages of mean monthly air temperature, mean monthly 0900h dew-point temperature and mean monthly sunshine duration.

Data used.—For the temperature investigations twelve stations were used each of which had continuous records over the fifty years 1906–55. The stations were distributed as evenly as possible over England, six were on the coast and six inland. They were Durham, Manchester, Spurn Head, Bidston, Cromer, Coventry, Woburn, Bath, Plymouth, Newquay, Kew and Eastbourne. For the sunshine investigation it was not possible to find twelve well distributed stations with such a long record. Consequently six stations were selected with fifty-year records from 1901–50, namely Newton Rigg, Scarborough, Llandudno, Oxford, Rothamsted and Penzance.

Method.—For each station and each month, fifty-year averages were found. The deviations from average were then arranged in algebraic numerical order and the means of successive groups of five deviations were computed. This gave ten sample deviations for each month and each station; these samples for each month were then averaged over the twelve (or six) stations, or over sub-groups of northern, southern, inland or coastal stations as required.

Variations in mean monthly temperature.—Table I gives the sample deviations, month by month, taking the average samples of all twelve stations. The largest deviations from average are clearly to be expected in the winter months, especially in regard to the negative deviations in February. The monthly mean temperatures in May and June vary least from the long-term average.

TABLE I—MEAN DEVIATIONS FROM TEMPERATURE AVERAGE (°F) IN A SAMPLE OF TEN YEARS

	1	2	3	4	5	6	7	8	9	10
January	−5·8	−2·8	−1·6	−0·8	−0·1	+0·6	+1·3	+2·0	+2·8	+4·5
February	−6·6	−3·1	−1·8	−0·9	−0·1	+0·8	+1·7	+2·4	+3·2	+4·4
March	−4·0	−2·7	−1·7	−1·1	−0·5	+0·3	+1·0	+1·7	+2·7	+4·3
April	−3·6	−2·2	−1·5	−0·8	−0·3	+0·1	+0·8	+1·4	+2·4	+3·7
May	−3·0	−1·9	−1·2	−0·7	−0·3	+0·3	+0·7	+1·2	+2·0	+2·9
June	−3·3	−1·8	−1·0	−0·5	−0·1	+0·3	+0·6	+1·0	+1·7	+3·0
July	−3·5	−2·2	−1·4	−0·8	−0·3	+0·2	+0·7	+1·4	+2·3	+3·7
August	−3·6	−2·0	−1·2	−0·7	−0·3	+0·2	+0·7	+1·2	+2·0	+3·8
September	−3·5	−2·0	−1·4	−0·7	−0·2	+0·3	+0·8	+1·3	+1·8	+3·6
October	−3·6	−2·0	−1·2	−0·7	−0·1	+0·3	+0·8	+1·1	+1·9	+3·7
November	−5·0	−2·5	−1·2	−0·5	−0·0	+0·5	+0·9	+1·6	+2·5	+3·7
December	−4·8	−3·0	−2·1	−1·2	−0·2	+0·7	+1·4	+2·0	+2·9	+4·3

Stations in the north tend to have larger variations than those in the south in spring and early summer; the reverse is true in early winter. There is little difference apparent in the other seasons of the year. As might be expected, inland stations always show a greater tendency to large variations from average, but the differences are not as great as might have been thought probable. These differences only become effectively apparent in the coldest or warmest years in ten, and these are summarized in Table II.

TABLE II—MEAN MONTHLY TEMPERATURE DEVIATIONS FROM AVERAGE (°F)

	Coldest period in ten				Warmest period in ten			
Period	North	South	Coastal	Inland	North	South	Coastal	Inland
March–April	−4·0	−3·6	−3·7	−4·0	+4·2	+3·8	+3·8	+4·2
May–June	−3·3	−3·0	−2·9	−3·4	+3·2	+2·8	+2·7	+3·2
July–August	−3·7	−3·4	−3·4	−3·7	+3·6	+3·9	+3·4	+4·1
September–October ...	−3·6	−3·6	−3·4	−3·7	+3·6	+3·6	+3·5	+3·7
November–December ...	−4·7	−5·2	−4·6	−5·3	+3·8	+4·2	+3·7	+4·3
January–February ...	−6·1	−6·4	−5·8	−6·6	+4·5	+4·5	+4·2	+4·8

Variations in mean monthly 0900h dew-point temperatures.—Table III gives the sample deviations, in the same form as Table I, for the mean dew-points. As in mean monthly temperature, these deviations are greatest in winter and least in summer. It is worth noting that November can have an unusually large negative deviation. Clearly it is not uncommon for dew-points in that month to be on occasion considerably below average, more so than in either October or December.

There is little difference in the distribution pattern between north and south, or between coast and inland, in spring and autumn. In summer, the north is more variable than the south; in winter this trend is decisively reversed. The difference between coastal and inland stations is not so marked. These differences are summarized in Table IV.

TABLE III—MEAN DEVIATIONS FROM DEW-POINT AVERAGE (°F) IN A SAMPLE OF TEN YEARS

	1	2	3	4	5	6	7	8	9	10
January	−5·7	−3·0	−1·8	−0·9	−0·1	+0·8	+1·4	+2·0	+2·7	+4·7
February	−6·1	−3·1	−1·9	−0·9	−0·1	+0·6	+1·4	+2·3	+3·2	+4·8
March	−4·3	−2·5	−1·8	−1·1	−0·5	+0·3	+1·1	+2·0	+2·9	+4·1
April	−4·2	−2·7	−1·6	−0·9	−0·2	+0·4	+1·0	+1·7	+2·5	+3·9
May	−3·9	−2·3	−1·5	−0·8	−0·2	+0·4	+1·1	+1·7	+2·3	+3·5
June	−3·3	−2·0	−1·3	−0·7	−0·2	+0·2	+0·7	+1·3	+1·9	+3·3
July	−3·1	−1·9	−1·2	−0·8	−0·2	+0·3	+0·8	+1·3	+1·9	+2·9
August	−3·2	−1·9	−1·2	−0·7	−0·2	+0·3	+1·7	+1·2	+1·8	+3·1
September	−3·9	−2·0	−1·3	−0·7	−0·3	+0·3	+0·9	+1·5	+2·1	+3·6
October	−4·5	−2·4	−1·4	−0·8	−0·3	+0·3	+0·9	+1·5	+2·6	+4·2
November	−5·8	−3·0	−1·3	−0·6	−0·0	+0·6	+1·1	+1·9	+2·9	+4·3
December	−5·1	−3·0	−2·2	−1·3	−0·3	+0·5	+1·2	+2·1	+3·1	+5·0

TABLE IV—MEAN MONTHLY DEW-POINTS (0900H) (DEVIATIONS FROM AVERAGE)

	Lowest period in ten				Highest period in ten			
Period	North	South	Coastal	Inland	North	South	Coastal	Inland
March–April	−4·2	−4·3	−4·1	−4·4	+4·0	+3·9	+3·9	+4·1
May–June	−3·8	−3·4	−3·3	−3·9	+3·4	+3·4	+3·0	+3·8
July–August	−3·3	−3·0	−3·2	−3·1	+3·2	+2·9	+2·9	+3·2
September–October ...	−4·1	−4·2	−4·2	−4·2	+3·9	+3·9	+4·0	+3·8
November–December ...	−5·1	−5·9	−5·5	−5·4	+4·5	+4·8	+4·5	+4·8
January–February ...	−5·6	−6·3	−5·7	−6·1	+4·3	+5·2	+4·6	+4·9

Variations in mean monthly sunshine.—Table V gives the usual sample deviations, expressed in terms of percentage of average. The variation is greatest in winter when the averages are small; the least variation is found in late spring and early summer. The coastal stations show less tendency to vary about the average than those inland; variation is usually greater in the north than in the south.

TABLE V—VARIATION IN MONTHLY SUNSHINE TOTALS (1901–50) (EXPRESSED AS PERCENTAGES OF AVERAGE)

	1	2	3	4	5	6	7	8	9	10
January	58	74½	82½	88½	93	100	109	118	128½	148
February	54	72	80½	89	95½	102½	109½	118	128½	150½
March	61½	74	82½	89	94½	100½	107	115½	125½	150
April	64½	75½	83½	89	95	100½	106	115	128	143
May	68	80	85	90	95½	101	105½	115	122	138
June	67½	81½	87	92	97	103	108	112½	119	132½
July	62½	75	82½	89	96½	102	108½	116	126½	141½
August	68	79½	85	90½	96	101½	107½	113	120½	138½
September	65	77½	83	89	95	101	108	116	124	141½
October	69	80	86	92	97	101½	106½	112½	120	135½
November	59	74	80½	87	93½	101½	109½	117½	128½	149
December	56	69½	77½	88	96	102½	109	118	129½	154
Mean	62½	76	83	89½	95½	101½	108	115½	125	143½

Extremes.—The extreme variations for each of the three elements amongst the sample stations are given in Table VI. These can in no sense be regarded as "records", because of the smallness of the sample. For example, the highest August percentage of monthly sunshine is given as 201 per cent, which was recorded at Newton Rigg in 1947, the nearest approach to this by the other five

TABLE VI—EXTREMES IN FIFTY YEARS

	Deviation from mean monthly temperature (°F) Highest	Lowest	Deviation from mean monthly dew-point (°F) Highest	Lowest	Percentage of monthly sunshine Highest	Lowest
January	+7·2	−10·9	+7·6	−11·4	206	19
February	+6·4	−12·1	+7·6	−11·2	197	22
March	+8·2	− 5·3	+6·9	− 9·5	202	36
April	+5·6	− 5·8	+7·8	− 6·2	164	49
May	+4·6	− 5·7	+6·6	− 7·3	158	37
June	+5·2	− 5·0	+6·4	− 5·8	158	55
July	+5·4	− 5·4	+5·8	− 5·4	168	41
August	+6·9	− 5·5	+5·7	− 5·1	201	36
September	+6·2	− 5·3	+6·5	− 5·7	160	46
October	+5·9	− 5·9	+6·3	− 7·3	162	57
November	+5·7	− 7·5	+7·2	− 8·9	178	38
December	+6·6	− 7·8	+7·2	− 8·3	189	34

sample stations was 156 per cent at Llandudno. There is no reason to suspect the Newton Rigg record but clearly other unexamined stations might produce similar extremes in other months. Furthermore it is by no means certain that all long-term temperature records in Britain are acceptably homogeneous, a condition which must be established before any precise deductions can be made.

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"PRESSURE JUMPS" AT MALTA

By T. H. KIRK, B.Sc.

Atmospheric wave-motion is not uncommon at Malta. Some two-dozen examples a year of well defined regular waves on the anemograms can be found and on many more occasions some evidence of irregular wave-motion can be discerned. For the most part these oscillations are accompanied by only small regular fluctuations of pressure.

Lamb[1] has drawn attention to an unusual oscillation of the wind at Malta (Figure 1), of distinctive character, accompanied by a sharp rise of pressure. A

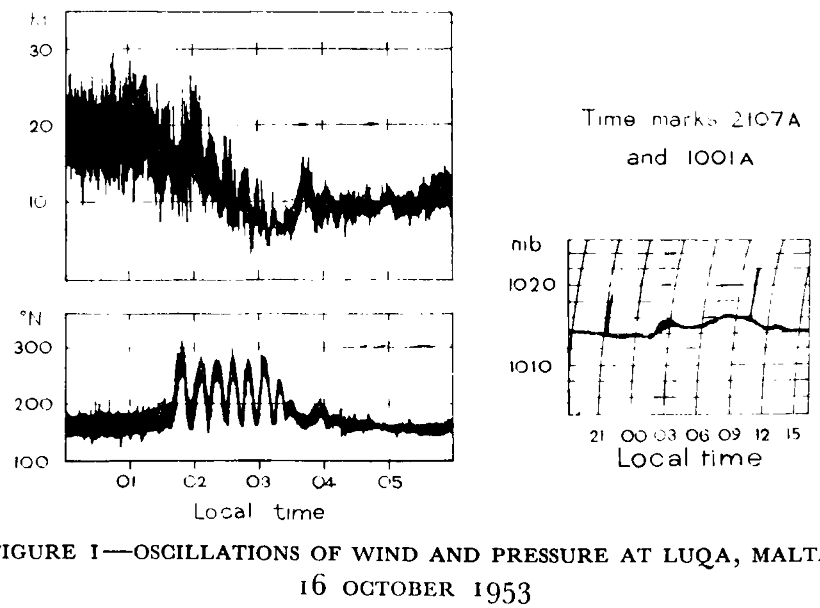

FIGURE 1—OSCILLATIONS OF WIND AND PRESSURE AT LUQA, MALTA, 16 OCTOBER 1953

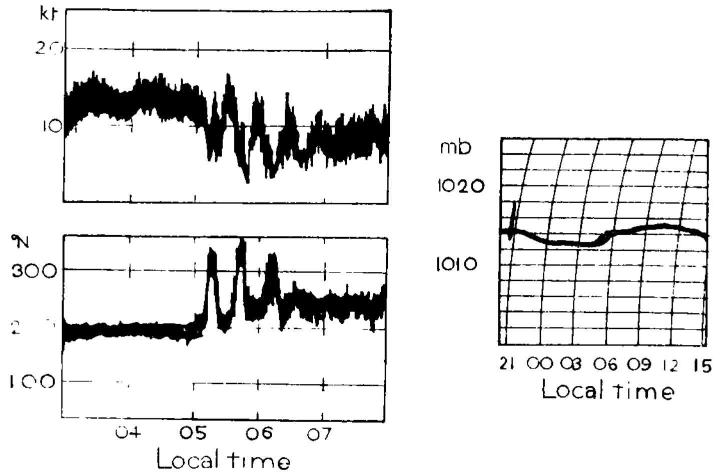

FIGURE 2—OSCILLATIONS OF WIND AND PRESSURE AT LUQA, MALTA, 9 AUGUST 1951

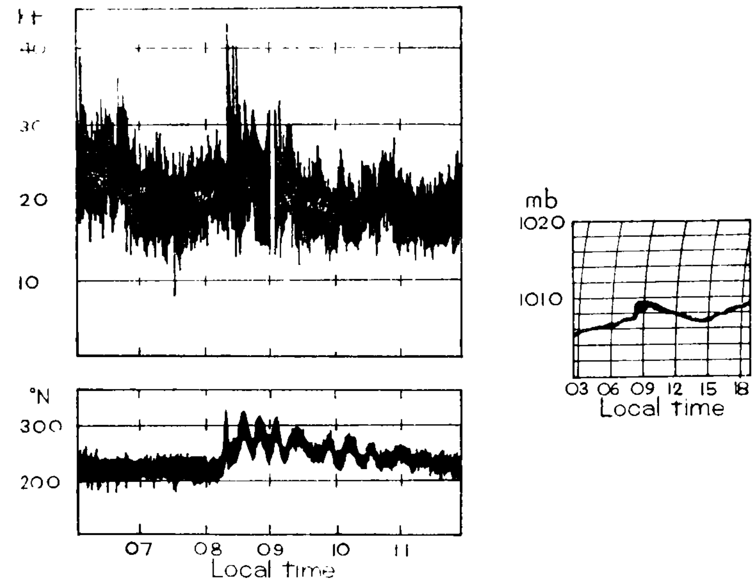

FIGURE 3—OSCILLATIONS OF WIND AND PRESSURE AT LUQA, MALTA, 30 MARCH 1952

detailed examination of wind and pressure records at Malta has led to the discovery of many more examples of the same type. Some are reproduced in Figures 2 to 5. There is evidence therefore for treating oscillations of the type illustrated as belonging to a separate class characterized by the sharp pressure rise at the time of onset of the oscillations. It is significant, too, that all the examples occurred in the presence of a temperature inversion.

It is now suggested that the major interest in this phenomenon is to be found precisely in this sharp abrupt change of pressure rather than in the wave motion, striking though this may appear at first sight. A cursory examination of the pressure changes suggests an identity with those discussed and illustrated by Tepper[2] and his term "pressure jump" may suitably be applied to them without necessarily accepting any particular theory of their formation or propagation.

Lamb attempted an explanation in terms of an old degenerate front and suggested that the wind oscillations corresponded to riplets on the degenerate

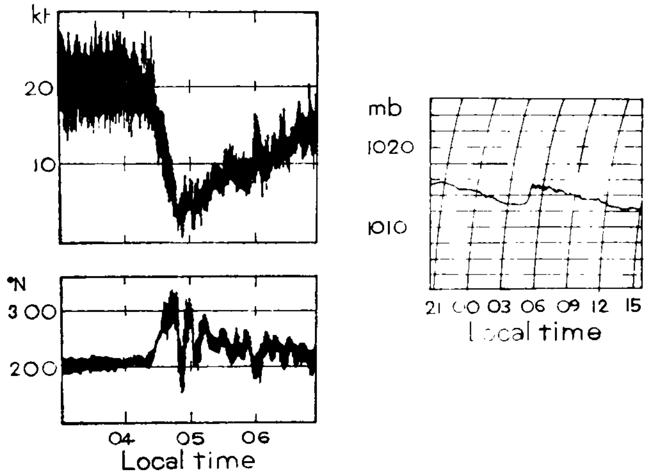

FIGURE 4—OSCILLATIONS OF WIND AND PRESSURE AT LUQA, MALTA, 19 SEPTEMBER 1952

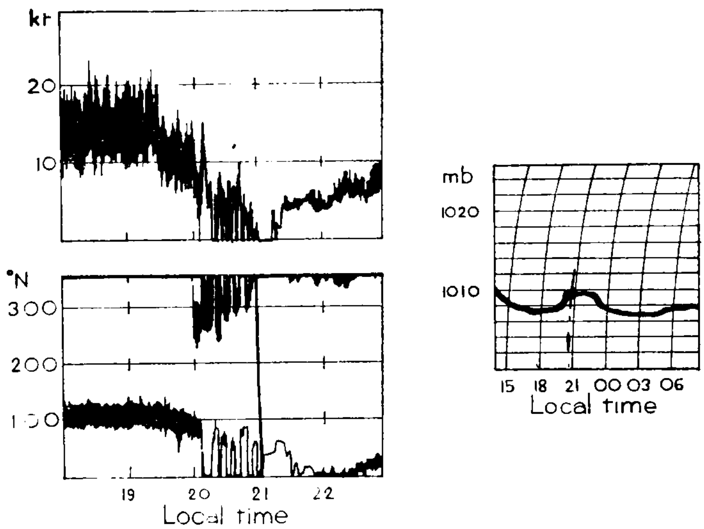

FIGURE 5—OSCILLATIONS OF WIND AND PRESSURE AT LUQA, MALTA, 4 JUNE 1951

front. The complete lack of true frontal characteristics apart from the pronounced pressure rise, which, incidentally, one would hardly expect at a "degenerate" front, suggests that an alternative explanation must exist. The probability of this is immeasurably increased by the discovery of many examples possessing the same distinctive characteristics.

We shall therefore propose that the pressure jump be considered as a discontinuity in its own right. Instead of the "degenerate front" we substitute the pressure-jump line. Perhaps it is more than a coincidence that in the example discussed by Lamb this line occurred ahead of a major cold front in much the same sort of situation for which Tepper propounded the pressure jump as a possible explanation of the "instability line".

Synoptic experience, combined with a close examination of wind and pressure records at Malta, suggests that many of the discontinuities marked as fronts on the weather charts are not true fronts but rather pressure jumps or instability lines. The realization of this may lead to greater consistency and insight in Mediterranean analysis.

Taking a broader view, the phenomenon of the pressure jump draws attention to the distinctive properties of flow under an inversion. It is the writer's opinion that a greater knowledge of these properties will do much to explain many peculiarities of weather in the Mediterranean where inversion conditions prevail for much of the year. It is hoped to assemble synoptic evidence for demonstrating the role of the pressure-jump line as a distinctive element in Mediterranean analysis.

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551.506.2(420,429)

THE GENERALLY MILD WINTER OF 1960–61 OVER ENGLAND AND WALES WITH SPECIAL REFERENCE TO AN EXCEPTIONALLY MILD FEBRUARY

By R. E. BOOTH

After an unusually wet summer and autumn in England and Wales, with more rainfall from July to November than during any corresponding period for at least two hundred years in parts of southern England, the winter of 1960–61 was generally wet and mild. Although there were some cold spells, particularly during January, it was a generally mild winter; February 1961 was exceptionally mild and ranks as one of the mildest Februaries over much of southern England since 1869.

The winter began with stormy cyclonic weather; rain was unusually heavy locally, particularly in parts of south Wales, where there was very severe flooding. During the first three days of December about seven inches of rain fell on the Brecon Beacons, some places having as much as four inches on the 3rd. At one time early in the month, floods were prevalent in forty counties.

The weather became more settled on the 4th with moderating winds allowing the floods to subside. From the 8th to the 17th a col between anticyclones centred over the Azores and over Russia lay over the country and weather was rather cold and foggy with some rain or wintry showers particularly in eastern England. Freshening northerly winds brought rain belts south-east across the country on the 18th and for the next four days disturbances moved down the North Sea on the eastern flank of an anticylone centred in the North Atlantic; precipitation was heavier in the east than in the west of the country and often of a wintry character.

A period of about three weeks of mild unsettled weather began on 23 December as the Atlantic anticyclone moved south allowing a succession of depressions or troughs to pass over or near the British Isles. Most days were dull and wet, rain being particularly heavy in north Wales and north-west England on Christmas Day and again on 12 January.

An anticyclone moving eastwards from the Atlantic was centred over the British Isles on 14 January and during the next few days very high pressure built up over northern Europe forming a block to the eastward progress of troughs from the Atlantic. For much of the remainder of the month Britain was in a marginal area between cold dry air from Europe and mild moist air from the Atlantic. Any temporary weakening of the European high pressure centre resulted in the incursion of wet weather, mainly into western districts. Eastern districts on the other hand, particularly north-east England, experienced precipitation, often wintry in character, from the North Sea. It was because of these spells of easterly winds that the mean January temperature over England and Wales was below the average.

During the last few days of January and the first two weeks of February frequent disturbances moved eastwards across the British Isles on the northern flank of a high pressure belt extending from the Azores to central Europe. Weather over southern England became progressively milder with occasional rain; during the second week of February mean temperatures in south-east England and the Midlands were as much as 4°C above normal. By the 15th the centre of high pressure had moved to eastern Europe and for a week or more a dry and exceptionally mild south to south-east airstream covered the country. In the last week there was a change to a mild and unsettled westerly type of weather, the 27th being a particularly wet day as a small depression moved eastward along the English Channel.

Table I gives monthly and seasonal deviations from the 1921–50 average temperatures in degrees Celsius for six districts of England and Wales and for the country as a whole.

TABLE I—MONTHLY AND SEASONAL DEVIATION FROM AVERAGE TEMPERATURE

	Dec. 1960 °C	Jan. 1961 °C	Feb. 1961 °C	Winter season °C
North-east England	−0·5	−0·5	+2·2	+0·4
East England	−0·1	−0·3	+2·7	+0·8
Midlands	−0·4	−0·4	+2·9	+0·7
South-east England	−0·2	−0·0	+3·0	+0·9
North-west England and north Wales	−0·8	−0·5	+2·5	+0·4
South-west England and south Wales	−1·0	−0·4	+2·7	+0·4
England and Wales	−0·5	−0·3	+2·7	+0·6

It will be noted that mean temperatures were slightly below the average during December and January but that February was outstandingly mild in all districts, especially in south-east England. On 14 February it was exceptionally warm inland, afternoon temperatures rising to 15°C at many places and reaching 18°C in the London area, the highest mid-February temperature recorded in the area this century and some 11 degrees above the normal, although 19°C was recorded at Greenwich on the last day of February as recently as 1959. At Kew Observatory the mean February temperature was 8·3°C making it the warmest February since comparable records began in 1841.

NOTES AND NEWS

The photographs between pages 198–199 were taken on 14 July 1960 from the cockpit of a Canberra aircraft during the Farnborough morning reconnaissance. The hill is Brent Knoll, 457 feet high, some five miles south of Weston-super-Mare in Somerset. Each photograph is separated by roughly three seconds with the aircraft approaching from the south at an altitude of about 2000 feet. There was no other very low cloud in the area except for a trace of similar cloud on the hills about three miles to the north-east. Cloud details as observed during the flight as a whole were as follows: 8/8 Ac base 8000 feet tops 8800 feet over south-east England gradually becoming 6/8 westwards with patches of Sc base 6000 feet, layered to tops 7500 feet. 5/8 Cu near Bristol tops 8000 feet with decayed Cu tops to 15,000 feet. 518–6/8 Cu base 2000 tops 8000 feet, in Bristol channel with slight showers. Cumulus developing in "columns" over the south coast with estimated tops 7000 feet.

The synoptic situation at the time showed a depression of 994 millibars off north-west Scotland maintaining an unstable westerly airstream, with troughs over southern England.

The surface wind in the area of Brent Knoll was westerly, 10–15 knots. No temperatures were available in the near vicinity but Filton, some twenty miles to the north-east, reported a temperature of 59·0°F and a dew-point of 57·0°F (relative humidity, 94 per cent; condensation level, 680 feet above mean sea level). The difference in the height of the condensation level is probably explained by the close proximity of the sea to Brent Knoll and other factors involving location and orographic detail. The photographs were all taken within a minute of 0800 GMT.

HONOURS

The following awards were announced in the Birthday Honours List on 10 June 1961:

C.B.

Dr. R. C. Sutcliffe, O.B.E., F.R.S., Director of Research, Meteorological Office.

I.S.O.

Mr. T. W. V. Jones, B.Sc., Assistant Director Aviation Services, Meteorological Office.

M.B.E.

Capt. H. Sobey, R.D., Master, Ocean Weather Ship *Weather Adviser.*

METEOROLOGICAL OFFICE NEWS

The announcement of the first Gassiot Fellowship was made in the May 1961 *Meteorological Magazine.* The second Gassiot Fellow appointed by the Secretary of State for Air is Dr. H. M. Iyer. Dr. Iyer is currently working at the University of California and will take up his appointment in the Meteorological Office in the autumn, when he will work from Kew Observatory on the increasingly important subject of seismology.

Retirement.—The Director-General records his appreciation of the services of:

Mr. T. H. Applegate, Experimental Officer, who retired on 2 May 1961 after 42 years' service in the Office. He began as a Probationer at Kew Observatory and on appointment as a Technical Assistant he commenced a long period of service at aviation outstations. In 1936 he was transferred to the Marine Branch at Headquarters, but in the following year he was again posted to an aviation outstation. In 1953 he returned to Headquarters in the assistant directorate for climatological services and remained there until his retirement.

Staff suggestion scheme

Mr. D. J. George, Temporary Acting Senior Assistant (Scientific), was awarded £10 for his model for teaching pilot balloon theory at the Meteorological Office Training School.

Mr. D. L. MacDonald, Technical Grade III, was awarded £5 5s. od. for his suggestions about the design of GL. III maintenance log books.

OBITUARIES

It is with deep regret that we learn of the death on 27 April 1961 of Mr. N. Lewis, Technical Grade II, and Mr. R. S. White, Senior Assistant (Scientific). Both were killed as a result of a road accident while travelling on duty.

Mr. Norman Lewis joined the thunderstorm location unit at Dunstable from the Air Ministry in December 1942. At this time the location of thunderstorms by direction-finding on atmospherics was just developing. Norman Lewis believed that the system could be made reliable and accurate and for the next 19 years he enthusiastically worked towards this end. His enthusiasm and concern for the reputation of the Sferics organization spread to many of the staff who worked with him and also to many of the forecasters with whom he came into direct contact. He gave generously of his time and experience to research workers and meteorologists who sought the help and advice of the Meteorological Office in the field of Sferics, and he will be remembered and missed by many workers in this country and elsewhere. Outside his official duties he was a useful and willing helper to the organizers of many of the social activities connected with the office at Dunstable. His regular assistance at the children's Christmas party was only one of these. He is survived by a widow and two daughters to whom the sympathy of all who knew him is extended.

Mr. Ronald Sidney White joined the Office in October 1951 as an Assistant (Scientific). For the first two years he served at aviation outstations, but in 1953 he was transferred to thunderstorm location work and he continued in this work until his death. In the Sferics organization he found work which he enjoyed and which became one of his hobbies. His enthusiasm matched that of Mr. Lewis and the two were closely associated in most of the developments and special projects undertaken in recent years. He was most generous with his time off duty returning to help with any work on hand whether of an official nature or for the benefit of one or other of the office social activities. The sympathy of all who knew him is extended to his mother.