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WORLD METEOROLOGICAL ORGANIZATION

There are eight Technical Commissions of the World Meteorological Organization, each responsible, in its own sphere, for "(a) keeping abreast of and promoting meteorological developments; (b) standardizing methods, procedures and techniques". Each Commission must meet at least once every four years; all eight will have met during the 20 months July 1952 to February 1954—six of them during the five months July 1953 to November 1953.

Combined Meeting of the Commissions for Instruments and Methods of Observation and for Aerology

The Commission for Aerology and the Commission for Instruments and Methods of Observation met at the same time, in Toronto, from August 10 to September 5, 1953—and experienced the hottest August for 50 years. Both meetings were held in the Economics Building of the University of Toronto, and, as far as practicable, it was arranged that sessions of the two Commissions did not clash. This was quite important because of the 18 countries represented six were represented on both Commissions by only one man.

The British representatives on the Commission for Aerology were Dr. R. C. Sutcliffe, Miss E. E. Austin and Prof. P. A. Sheppard; and on the Commission for Instruments and Methods of Observation, Dr. D. N. Harrison, Dr. R. Frith and Capt. S. W. C. Pack.

The subjects discussed by the Commission for Instruments and Methods of Observation ranged over a very wide field and a great many Recommendations and Resolutions were made. The vast majority of these were concerned with "keeping abreast of and promoting meteorological developments", only three or four being concerned with the "standardization of methods, procedures and techniques". The most important of these were: Technical Regulations; Barometer Conventions; Comparison of radio-sondes.

In the Technical Regulations are those rules, governing the performance of instruments and methods of observation, which must be observed by all Member States to ensure that the observations from all countries are strictly comparable (e.g. that surface wind reports refer to the same height above the ground and to the wind averaged over the same length of time—which is by no means the case at present).

The new Barometer Conventions are intended to tidy up the present confusion, whereby millibar barometers are adjusted to read correctly at 12°C. in England, at 0°C. in Europe, and at 54°F. in Canada; and inch barometers are made to read correctly at 32°F. for one purpose and at 62°F. for another. There is similar confusion in the "standard" gravity values used. Under the new Conventions all mercury barometers will read correctly when the temperature is 0°C. and the value of gravity is 980·665 cm./sec.[2]

It is difficult to assess the absolute accuracy of radio-sonde data. It is therefore all the more important that any differences in the readings obtained from different types of radio-sondes, especially between those types used in neighbouring countries, should be known. To investigate these differences one series of comparison trials has already been held in Switzerland; it is now planned to carry out a second, and later a third, series of trials.

The Commission for Aerology is more closely connected with research than the other Commissions, and among the most important of its recommendations were those aimed at lightening the task of assembling data for research, by ensuring that all aerological data are made available in the form of daily values, monthly means and long-period averages, and by drawing up specimen forms to secure as much uniformity as possible in the method of presentation.

The subjects for study during the international geophysical year were also carefully considered, the selection being based on the principle that attention should be given first to problems of world-wide significance. Special importance was attached to obtaining cross-sections of the upper air from pole to pole along certain meridians, and to additional sections in tropical regions in view of the special need for a comprehensive study of tropical meteorology and its bearing on the general circulation.

Another important part of the work of the Commission was that dealing with the study of atmospherics. Many recommendations were put forward for extending the network of stations, comparing techniques, and standardizing terminology.

The Commission for Aerology was concerned also with more theoretical subjects such as the definitions of various physical quantities (thermodynamic wet-bulb temperature, relative humidity, etc.) and the details of aerological diagrams and tables; important recommendations on these subjects were put forward.

The increasing interest in the higher levels of the atmosphere was reflected in the Recommendation that 150 mb. and 100 mb. should be added to the list of standard isobaric surfaces, and that new definitions of the tropopause should be brought into use on an experimental basis in order to provide for reports of a double tropopause.

In order to help the Commission for Aerology in its task of keeping abreast of meteorological development, nine scientific lectures were arranged outside the plenary meetings; these were well attended by members of both Commissions, and gave rise to interesting discussions.

The members of both Commissions were impressed by the difficulty of saying precisely the same thing in two or more languages; and by the confusion which can be caused by an incorrect translation.

Delegates were entertained to dinner by the Government of Canada, and, as guests of the Hydroelectric Power Commission, paid a most enjoyable visit to Niagara, where they saw not only the Falls but also something of the enormous new hydroelectric project now being developed.

At the close of the meetings M. Perlat (France) was elected President (in succession to Dr. J. Patterson who had retired), and M. Malet (Belgium) Vice-President of the Commission for Instruments and Methods of Observation. Prof. van Miegham (Belgium) was re-elected President and Dr. Sutcliffe (United Kingdom) elected Vice-President of the Commission for Aerology.

Commission for Agricultural Meteorology

There was a good attendance at the first session of the Commission for Agricultural Meteorology which was held in Paris from November 3 to November 20, 1953. Some 30 delegates representing 22 member States were present, together with several observers and representatives of such organizations as the Food and Agriculture Organization and the United Nations Educational, Scientific and Cultural Organization.

Mr. L. P. Smith represented the United Kingdom at this session.

As meteorology has a bearing on every aspect of agriculture, horticulture and forestry, the discussions ranged over a wide field of pure and applied research. It was the need of agricultural science in general, and food production in particular, for help from all branches of meteorology that prompted the Conference to reject a proposal for a merger with the Climatological Commission; it was considered that only about a third of the work of an agricultural meteorologist was concerned with climatology.

Co-operation was planned with important internal bodies such as the Food and Agriculture Organization and with the work being done by the United Nations Educational, Scientific and Cultural Organization on Arid Zone Research. It was clearly realized that advance could best be made by collaboration with other agricultural scientists, and many of the recommendations and choices of working parties stressed this important point. The fight against pests and diseases, such as locusts and the diseases of potatoes, cereals and vines for example, demands considerable meteorological aid to the entomologists, pathologists and mycologists to ensure adequate protection of plants and animals.

The problems of altering the weather, either by erecting shelter, using frost-protection methods, or attempting to create artificial rain were discussed in considerable detail. The importance of the exchange of ideas and the dissemination to other scientists and the agricultural industry of the results of pure and operational research was not lost sight of, and the most promising impression of the meeting was the practical attitude to the problems of many of the delegates.

During the three weeks, visits were made to the Station Centrale de Bioclimatologie et de Physique Agricole at Versailles and to the Bergerie Nationale at Rambouillet.

At the conclusion of the session, Prof. J. J. Burgos of the Argentine was re-elected President and Dr. H. Geslin of Versailles was elected Vice-President.

Commission for Bibliography and Publications

The Commission for Bibliography and Publications of the World Meteorological Organization held its first session in Paris from November 24 to December 12, 1953, under the chairmanship of its President, M. Mézin of *La Météorologie Nationale de France.*

Mr. G. A. Bull represented the United Kingdom at this session.

The Commission is responsible for the preparation of a lexicon of meteorological terminology with definitions and of a multi-lingual dictionary of equivalent terms, for the revision of systems of classifying meteorological subjects, and for recommending the general methods in which meteorological publications should be compiled, catalogued, preserved, reproduced, and exchanged.

The first matter dealt with at the meeting was the bringing up to date of the meteorology section, 551.5, of the Universal Decimal Classification. The section was discussed in detail and a number of changes were recommended. These changes need to be agreed between the World Meteorological Organization and the International Federation of Documentation, which is the central co-ordinating body of the Universal Decimal Classification, before they can be published. The major changes proposed are in 551.509 (Weather forecasting and other applications), 551.511 (Mechanics and thermodynamics of the atmosphere), and 551.551 (Wind, structure, microvariations, gustiness, turbulence).

The meeting considered a draft "Guide to meteorological library practice" which had been written some years ago by Dr. C. E. P. Brooks in conformity with a decision of the International Meteorological Organization Commission for Bibliography and Publications taken at its meeting at Toronto in 1947, and prepared a revised text which it is hoped will eventually be published by the World Meteorological Organization. This work gives general guidance on methods of classifying, cataloguing and preserving meteorological documents.

A draft lexicon of meteorological terminology with definitions and a polyglot dictionary of equivalents were submitted to the meeting by the French delegation, and an international working group was established to examine these important works and to act as a standing group to consider questions of the definitions of meteorological words as they arise.

Other matters considered at the meeting were the preparation of a periodic world meteorological bibliography of new literature and the exchange of meteorological publications between members.

At the close of the meeting M. Mézin was re-elected President of the Commission, and Mr. Bull (United Kingdom) was elected Vice-President.

MEAN MAXIMUM AND MEAN MINIMUM TEMPERATURES AS CRITERIA OF TEMPERATURE CHARACTERISTICS OF A MONTH

By W. A. L. MARSHALL

Cool days and warm nights of June–July 1953.—Low day-time temperatures and relatively warm nights were notable features of the weather in London during the months of June and July 1953. At Kew Observatory the mean maximum temperature in June was 1·8°F. below average and the mean minimum 1·1°F. above average, giving a mean temperature deficiency over the whole month of 0·4°F. In July the mean monthly deficiency of 1·5°F. was brought about entirely by the cool days, the mean maximum value being 3·1°F. below average while the mean minimum figure was in exact agreement with the long-period July average. Apart from a week or so at the end of June and a few isolated warm days at other times, day maximum temperatures were consistently below average. In contrast, the nights were predominantly warmer than usual from June 11 onwards. Daily values are shown in Fig. 1 in which the maximum temperature and minimum temperature for each day are given by the top of the black column or the bottom of the hatched column in their respective diagrams. The average maximum and minimum values used for Fig. 1, and throughout this note, are those for the 30-yr. period 1906–35.

It is clear from Fig. 1 that for most purposes the difference of the mean maximum temperature from the average gives a better representation of the temperature characteristics of June and July 1953 than any other single value. Night-time temperatures are not of popular interest during the summer. The object of this investigation is to ascertain with what frequency the orthodox mean monthly temperature is substantially unrepresentative of conditions by day and by night, and to discuss the usefulness of the mean maximum and mean minimum as bases for comparing one particular month with the same month in other years in respect of temperature.

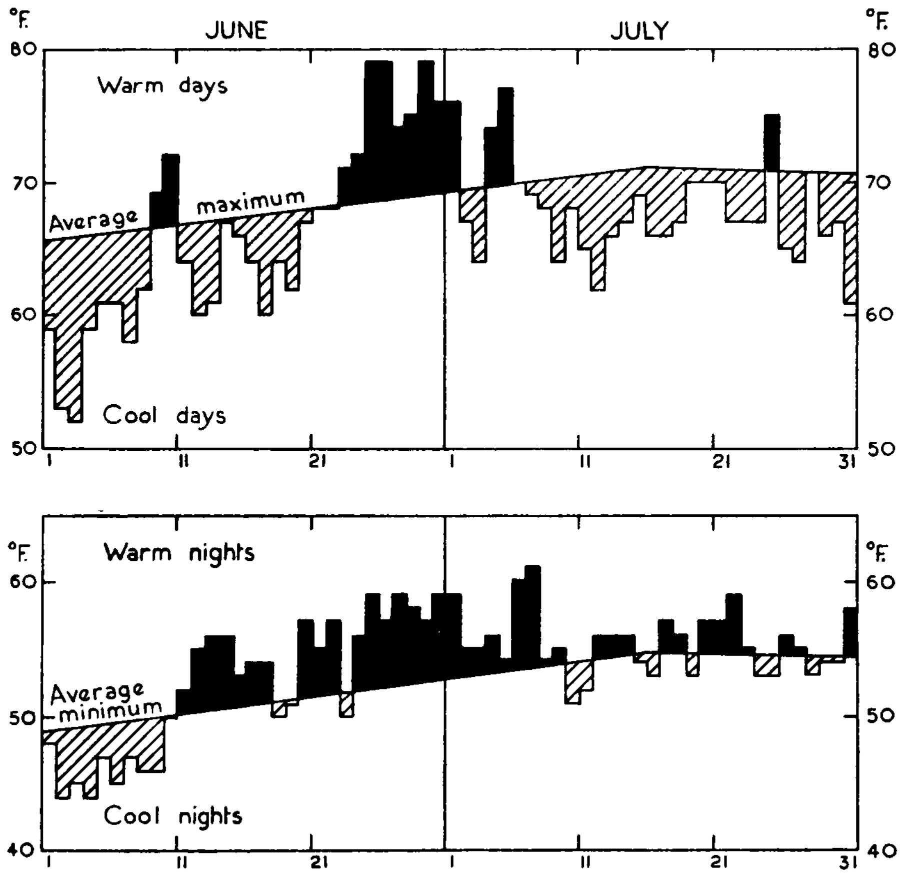

FIG. 1—DAILY READINGS OF MAXIMUM AND MINIMUM TEMPERATURE AT KEW OBSERVATORY, JUNE AND JULY 1953

Readings above average are given by the top of the black column, readings below average by the bottom of the hatched column.

Mean maximum, minimum and monthly temperatures.—Mean maximum, mean minimum and mean monthly temperatures are published in Table III of the *Monthly Weather Report* of the Meteorological Office, although departures from the average are given only for mean monthly values. The differences from their respective averages of the mean maximum (T_x), mean minimum (T_n) and mean monthly (T_m) temperatures at Kew Observatory

TABLE I

T_x = Difference of monthly mean maximum temperature from average maximum temperature.
T_n = Difference of monthly mean minimum temperature from average minimum temperature.
T_m = Difference of monthly mean temperature from average temperature.

	January			February			March			April			May			June		
	T_x	T_n	T_m	T_x	T_n	T_m	T_x	T_n	T_m	T_x	T_n	T_m	T_x	T_n	T_m	T_x	T_n	T_m
	degrees Fahrenheit																	
1928	+2·4	+0·1	+1·2	+4·5	+2·0	+3·2	+1·2	+2·3	+1·8	+0·7	+1·0	+0·9	−2·3	−1·3	−1·8	−2·0	−1·8	−2·0
1929	−6·1	−4·2	−5·2	−7·6	−8·1	−7·9	**+3·9**	*−3·8*	0·0	−2·2	−2·9	−2·5	0·0	−1·4	−0·6	−1·1	−1·3	−1·2
1930	+3·8	+2·8	+3·2	−3·1	−0·5	−1·8	+0·3	0·0	+0·2	−1·3	+1·0	−0·1	−2·7	+0·2	−1·2	+2·7	+2·1	+2·4
1931	−1·4	−1·8	−1·6	−0·7	−1·4	−1·1	−1·7	−2·5	−2·1	**−2·4**	*+0·8*	−0·8	−1·0	+0·5	−0·2	+0·9	+2·0	+1·4
1932	+3·5	+2·8	+3·1	−3·4	−2·0	−2·8	−1·3	−2·9	−2·1	−2·2	−0·1	−1·1	**−3·4**	*−0·2*	−1·8	−0·3	−0·2	−0·3
1933	−3·4	−2·9	−3·2	+0·2	+0·4	+0·2	**+5·0**	*+1·2*	+3·1	+3·1	+1·2	+2·2	+1·1	+1·1	+1·2	+3·1	+1·6	+2·3
1934	−0·5	−1·3	−1·0	−1·6	−3·8	−2·8	−0·6	−0·9	−0·8	+1·3	+1·6	+1·5	+0·8	−0·2	+0·4	+2·7	+1·2	+1·9
1935	+0·1	+1·1	+0·6	+2·7	+3·6	+3·1	+1·6	+1·8	+1·7	−0·5	+1·4	+0·5	−3·6	−2·3	−2·9	+1·8	+3·0	+2·4
1936	+0·1	+0·7	+0·4	−3·1	−2·7	−3·0	+2·3	+3·6	+3·0	−3·6	−1·5	−2·5	−0·3	−0·4	−0·3	+1·5	+2·9	+2·2
1937	+2·0	+1·9	+1·9	+2·3	+3·4	+2·8	−4·2	−2·2	−3·2	+1·8	+3·7	+2·8	+0·6	+2·0	+1·4	+1·1	+1·2	+1·1
1938	+3·5	+2·8	+3·1	+0·5	+1·6	+1·0	**+8·8**	*+3·6*	+6·2	−0·4	−1·1	−0·7	−2·8	−1·6	−2·2	+1·8	+2·0	+1·8
1939	+0·6	+2·3	+1·4	+2·3	+1·6	+1·9	−0·9	+1·6	+0·4	+1·3	+1·6	+1·5	−2·1	−1·4	−1·7	−1·2	+0·5	−0·4
1940	−9·1	−9·0	−9·1	−3·8	−1·6	−2·8	+0·5	+1·2	+0·8	+1·4	+2·3	+1·9	+2·6	+0·7	+1·7	+4·3	+3·6	+3·9
1941	−7·1	−4·2	−5·7	−1·6	−0·4	−1·0	−1·1	−0·6	−0·8	−3·6	−0·8	−2·2	−6·3	−4·5	−5·4	+2·0	+2·0	+2·0
1942	−6·8	−6·3	−6·6	−8·8	−6·5	−7·7	−1·5	−0·7	−1·1	+2·0	+3·4	+2·8	−1·4	−0·2	−0·8	+2·4	+0·3	+1·3
1943	+1·0	+2·1	+1·5	+2·5	+1·1	+1·8	+2·8	+1·4	+2·1	+5·8	+5·7	+5·8	+0·9	+1·8	+1·4	−0·5	+1·4	+0·4
1944	+3·1	+3·7	+3·4	−2·7	−0·4	−1·6	−0·8	−1·6	−1·2	+4·5	+4·8	+4·7	+1·1	−1·8	−0·4	−2·5	+0·2	−1·2
1945	−7·3	−6·0	−6·7	+5·0	+5·0	+5·0	+4·8	+3·4	+4·1	+5·2	+3·7	+4·6	+1·5	+2·0	+1·8	−0·9	+2·0	+0·5
1946	−2·8	−1·3	−2·0	+2·7	+4·0	+3·3	−2·2	−0·7	−1·4	+5·2	+2·6	+4·0	−2·8	−1·6	−2·2	**−3·8**	*+0·2*	−1·8
1947	−4·4	−4·9	−4·7	**−12·8**	*−8·5*	−10·7	−3·6	−0·7	−2·2	+1·8	+1·9	+1·9	+2·9	+2·2	+2·6	+2·4	+3·0	+2·6
1948	+3·3	+3·2	+3·2	+0·3	+1·1	+0·6	+6·1	+3·6	+4·8	+3·8	+2·5	+3·2	+0·4	−0·7	−0·1	−2·0	+0·9	−0·6
1949	+2·2	+1·4	+1·8	**+3·0**	*−0·7*	+1·1	−1·5	−0·6	−1·0	+4·9	+4·4	+4·7	−1·4	−1·3	−1·3	+2·5	+1·4	+1·9
1950	−0·3	+1·0	+0·3	+3·4	+2·3	+2·8	+3·7	+3·2	+3·4	−0·2	+1·0	+0·4	−1·6	+0·2	−0·6	+4·3	+3·8	+4·0
1951	−0·3	+0·9	+0·2	−1·5	−0·5	−1·0	−2·9	−0·6	−1·7	−1·2	−1·1	−1·1	**−4·5**	−1·4	−2·9	−0·3	−0·4	−0·4
1952	−1·4	−1·3	−1·4	−1·6	−2·0	−1·8	+0·7	+3·0	+1·9	+4·3	+3·2	+3·8	+3·3	+3·2	+3·3	+1·5	+1·1	+1·3

	July			August			September			October			November			December		
	T_x	T_n	T_m	T_x	T_n	T_m	T_x	T_n	T_m	T_x	T_n	T_m	T_x	T_n	T_m	T_x	T_n	T_m
	degrees Fahrenheit																	
1928	+3·7	+0·9	+2·3	−0·8	−0·3	−0·5	**+0·3**	*−3·3*	−1·4	+0·8	−0·1	+0·3	+3·4	+3·4	+3·4	−2·2	−3·4	−2·8
1929	+2·5	−0·4	+1·1	+0·4	−0·3	+0·1	**+7·8**	*+3·9*	+5·9	−0·8	−1·3	−1·1	+2·0	+0·5	+1·3	+2·5	+1·7	+2·0
1930	−1·8	−0·4	−1·1	+0·8	+0·4	+0·6	**−0·4**	+2·6	+1·2	+1·0	+1·4	+1·2	+1·5	+0·5	+1·0	−0·7	−1·2	−1·0
1931	−1·7	+0·3	−0·7	−3·4	−0·5	−1·9	**−4·9**	−1·7	−3·2	−1·6	−2·8	−2·2	+2·5	+2·3	+2·4	+0·5	+1·1	+0·8
1932	−0·8	+0·3	−0·3	+5·1	+3·6	+4·3	−0·6	+1·2	+0·4	−2·1	−1·5	−1·8	+0·2	+1·8	+1·0	+1·1	+1·3	+1·2
1933	+4·8	+3·2	+4·0	**+6·0**	*+2·5*	+4·3	+3·7	+3·9	+3·8	+0·4	+1·4	+0·9	−1·4	0·0	−0·7	−7·2	−5·2	−6·2
1934	+5·7	+2·8	+4·3	−0·1	−0·5	−0·3	+3·7	+1·5	+2·6	+0·6	+2·4	+1·5	−0·7	+1·4	+0·3	+5·2	+7·0	+6·0
1935	+3·9	+2·7	+3·3	+3·1	+0·2	+1·7	+0·5	+1·5	+1·0	−1·0	+0·3	−0·3	+1·5	+1·9	+1·7	−2·7	−1·4	−2·1
1936	−2·6	*+0·5*	−1·1	+1·1	+0·4	+0·7	**+0·5**	+3·7	+2·2	−1·4	−1·7	−1·5	−0·5	+0·3	−0·1	+1·1	+0·7	+0·8
1937	−0·4	+1·9	+0·7	+4·0	+2·9	+3·5	+0·1	−0·4	−0·1	+0·8	+2·1	+1·5	−2·0	−1·5	−1·7	−3·1	−2·5	−2·8
1938	−1·1	+0·1	−0·5	+1·7	+1·6	+1·7	+1·0	+1·4	+1·2	−0·3	+0·8	+0·3	+5·6	+6·3	+5·9	−1·3	−2·0	−1·7
1939	**−3·6**	*+0·3*	−1·7	+0·6	+1·8	+1·2	+1·0	+3·5	+2·3	−3·5	−0·8	−2·1	+4·0	+5·9	+4·9	−4·0	−3·2	−3·6
1940	−2·9	−1·1	−2·0	+0·8	−0·3	+0·3	+0·1	−1·0	−0·4	−1·6	+0·1	−0·7	+1·8	+0·9	+1·3	−1·6	−1·8	−1·8
1941	+3·2	+2·5	+2·9	**−4·3**	*−0·3*	−2·3	+0·8	+3·2	+2·0	−0·1	+1·2	+0·5	+0·7	+1·0	+0·9	+0·7	+0·7	+0·6
1942	−2·4	+0·3	−1·1	+0·4	+2·0	+1·2	−0·1	+2·4	+1·2	+0·8	+2·1	+1·5	−2·0	−1·1	−1·5	+2·3	+3·4	+2·8
1943	+0·7	+1·2	+0·9	+0·2	+0·9	+0·5	−0·8	+0·5	−0·1	+1·0	+2·1	+1·5	−0·3	−0·8	−0·5	−1·8	−1·8	−1·8
1944	**−1·1**	*+2·1*	+0·5	+3·1	+3·8	+3·5	−2·8	−0·3	−1·5	−2·8	*+0·3*	−1·3	0·0	+1·0	+0·5	−2·9	−3·0	−3·0
1945	+0·9	+1·6	+1·3	−1·0	+0·9	−0·1	**−0·8**	*+4·2*	+1·8	+2·8	+2·8	+2·8	+1·5	+3·9	+2·7	+0·5	+0·2	+0·3
1946	+0·3	+0·3	+0·3	−3·4	−0·7	−2·1	**−1·7**	*+2·4*	+0·4	−1·0	+1·5	+0·3	+2·5	+4·8	+3·7	−3·8	−4·7	−4·3
1947	+1·6	+3·6	+2·6	+7·4	+4·4	+5·9	+3·7	+2·6	+3·2	+2·0	−1·0	+0·5	+1·9	+3·8	+2·9	+0·3	+1·1	+0·6
1948	−1·5	+0·1	−0·7	−2·1	0·0	−1·1	−0·1	+1·7	+0·8	−0·3	−1·2	−0·7	+1·6	+1·6	+1·6	+2·3	+2·4	+2·3
1949	+4·5	+2·5	+3·5	+3·7	+1·8	+2·7	+6·6	+7·1	+6·9	+4·0	+3·2	+3·6	+0·2	0·0	+0·1	+2·3	+2·0	+2·1
1950	−0·9	+1·4	+0·3	−0·5	+0·7	+0·1	**−2·8**	*+1·7*	−0·5	−1·0	+0·5	−0·3	−0·3	+1·4	+0·5	−6·7	−4·3	−5·6
1951	+1·2	+1·2	+1·2	−2·8	0·0	−1·4	+0·3	+2·6	+1·5	−0·1	−0·8	−0·4	+4·2	+5·0	+4·6	+2·0	+1·8	+1·9
1952	+1·6	+1·8	+1·7	−0·1	+2·2	+1·1	−4·9	−2·8	−3·8	−2·6	−0·4	−1·5	−3·2	−2·7	−2·9	−3·3	−3·6	−3·5

over the past 25 yr. are given in Table I. Cases in which $T_x \sim T_m$ amounted to more than 1·5°F. are printed in bold figures and cases in which $T_n \sim T_m$ exceeded the same amount are printed in italics.

Usefulness of the mean maximum.—Taking day-time temperatures first, the number of occasions on which the mean maximum departure in Table I differed from the monthly mean departure by specified amounts is given in Table II.

The two values were in fairly close agreement in late autumn and winter. As a first approximation therefore the mean maximum temperature had no obvious advantage over the monthly mean as a standard on which to judge the

TABLE II

Difference $T_x \sim T_m$	Frequency in 25-yr. period 1928–52 Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
°F.	*Number of occasions*											
0·0–0·5	17	12	10	12	11	13	7	10	7	11	17	20
0·6–1·0	6	6	7	7	10	7	9	7	3	9	6	4
1·1–1·5	2	5	5	5	2	4	7	6	7	5	2	1
1·6–2·0	...	1	1	1	2	1	2	2	5	...	...	...
2·1–2·5	...	1	...	...	...	...	...	...	2	...	...	...
2·6–3·0	...	...	1	...	...	...	...	...	1	...	...	...
3·1–3·5	...	...	...	...	...	...	...	...	...	...	...	...
3·6–4·0	...	...	1	...	...	...	...	...	...	...	...	...

broad day-time temperature characteristics from October to January. But over the remainder of the year, and especially in the equinoctial months of March and September, the mean monthly values sometimes differed by large amounts, and on those occasions the mean maximum temperature would be preferable to the monthly mean as a brief expression of day-time temperature. March 1929 was an outstanding example. Mean temperature over the month as a whole agreed exactly with the long-period average, but frequent warm days during that month resulted in the mean maximum value being 3·9°F. above average. The reverse position obtained in September 1946. Cool days until the 23rd of the month resulted in a mean maximum temperature 1·7°F. below average, yet the mean temperature over the month as a whole was above average. July 1944 and September 1928, 1930 and 1945 are further instances of differences of sign between T_x and T_m.

Monthly range of day maxima.—The mean maximum, in common with any other single mean temperature value in the British Isles, frequently masks large changes. The magnitude of the monthly range of daily maxima at Kew Observatory during the period dealt with in this investigation is summarized in Table III.

TABLE III

	Range of day maximum temperatures in 25-yr. period 1928–52 Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	degrees Fahrenheit											
Largest	25	29	31	33	37	33	36	26	27	28	26	30
Smallest	13	10	13	12	14	14	10	13	13	11	13	11
Average	19	17	21	22	25	23	20	19	18	19	18	19

Temperature characteristics by day.—Despite these fluctuations the curves of daily maximum temperature at Kew Observatory usually fall into one of ten main types and the classification of each month in the 25 yr. 1928–52 is shown in Table IV. There were some months for which none of these classifications was strictly appropriate. In such cases the figure selected was to a certain extent a matter of personal choice.

Use of the maximum-temperature index figure.—The index figure in Table IV amplifies the overall picture of day-time temperature given in Table I by making it possible to visualize the temperature changes which are included in the mean maximum value. From the information given in Table I alone the Januaries of 1931 and 1952 might appear to have had closely similar day-time temperature characteristics. In fact, the two months were very different. January 1931 began with cold weather and then became much milder, while mild weather in the first half of January 1952 gave way to a cold spell later in the month. Taking

TABLE IV—CLASSIFICATION OF MONTHS BY CONSIDERATION OF MAXIMUM TEMPERATURE

Index Number	Description	Characteristic relation of daily readings to average*
0	Average.	Often ±2°F.
1	Rather warm.†	Mainly 3–5°F. above average.
2	Rather cold.†	Mainly 3–5°F. below average.
3	Warm.	Often 6–9°F. or more above average.
4	Cold.	Often 6–9°F. or more below average.
5	Brief cold periods.	Mainly above average but colder interludes.
6	Brief warm periods.	Mainly below average but warmer interludes.
7	Warm then colder.	Two well defined and contrasting temperature régimes.
8	Cold then warmer.	(as for 7)
9	Changeable.	Alternating warm and cold periods.

Kew Observatory Period: 1928–52

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1928	1	3	9	9	6	6	5	6	7	5	5	6
1929	4	6	5	6	8	6	5	8	3	0	5	5
1930	1	2	9	8	6	9	7	6	0	9	9	6
1931	8	6	8	6	9	5	6	2	6	7	5	9
1932	5	6	8	6	9	9	9	3	7	2	6	9
1933	7	7	3	5	9	9	3	3	3	7	6	4
1934	9	9	0	9	5	5	3	9	5	0	0	3
1935	9	9	8	6	9	8	3	9	0	6	7	8
1936	9	6	8	8	9	8	6	8	7	8	7	9
1937	5	5	6	5	8	9	9	5	7	0	9	6
1938	8	9	3	6	9	5	8	7	9	0	3	7
1939	5	8	9	9	6	7	6	8	7	7	5	6
1940	4	8	9	8	1	3	2	9	7	2	9	6
1941	4	9	9	6	4	6	5	4	5	7	9	9
1942	6	4	9	5	6	9	2	9	7	0	6	5
1943	8	5	1	3	8	9	6	0	7	0	6	2
1944	1	7	8	3	9	2	6	5	6	2	6	6
1945	4	3	3	5	9	8	9	9	6	1	0	5
1946	9	7	8	3	2	2	9	4	8	9	0	6
1947	4	4	8	9	9	7	8	3	1	7	9	1
1948	9	7	3	1	9	9	8	2	9	7	9	7
1949	1	3	8	3	9	5	9	3	3	7	9	1
1950	7	3	3	9	9	3	2	9	2	9	2	4
1951	9	2	6	6	4	9	9	2	9	9	1	5
1952	7	8	7	9	5	9	9	9	4	2	7	6

* The average for this purpose is the value obtained from a smooth curve joining the average monthly values when these are plotted to the 15th of the month.

† The terms warm and cold are used in the broad sense, "warm" becomes "mild" in winter, for instance.

a summer month it would be reasonable to deduce from Table I that the month of June 1930 was similar to June 1934, but the index figure in Table IV shows that apart from the final mean maximum value there was little similarity between the temperatures experienced in the two months. June 1930 was a month of frequent and often large temperature variations, amounting to 10°F. or more from one day to the next on several occasions. Maximum temperatures in June 1934, on the other hand, were above average on most days, the mean value being brought down to the same level as that of 1930 by some short but markedly colder interludes.

Usefulness of the mean minimum.—The shortcomings of the monthly mean as an expression of day-time temperatures apply equally to its suitability as an indication of temperatures at night. The amateur gardener is no less interested in night-time temperatures during the spring and autumn than the professional horticulturist, yet it is just at those times that the monthly mean can be seriously misleading. The figure for March 1929 given in Table I suggests an average month at Kew Observatory. In fact, the nights were exceptionally cold with air frosts on 13 nights. Mean temperature over the month of October 1944 as a whole was below average, yet the nights were rather mild with slight air frost on only one night.

The number of occasions on which the mean minimum departure in Table I differed by specified amounts from the mean monthly departure is given in Table V.

TABLE V

Difference $T_n \sim T_m$	Frequency in 25-yr. period 1928–52 Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
°F.	*Number of occasions*											
0·0–0·5	16	11	11	11	8	13	6	8	5	11	16	19
0·6–1·0	7	7	6	10	13	9	10	9	6	9	6	5
1·1–1·5	2	5	5	3	3	2	6	6	9	4	3	1
1·6–2·0	...	1	1	1	1	1	3	2	3	1	...	...
2·1–2·5	...	1	...	...	...	...	...	...	2	...	...	...
2·6–3·0	...	...	1	...	...	...	...	...	...	...	...	...
3·1–3·5	...	...	...	...	...	...	...	...	...	...	...	...
3·6–4·0	...	...	1	...	...	...	...	...	...	...	...	...

The mean minimum temperature, as in the case of the mean maximum, differed most from the monthly mean in spring and early autumn and least in the winter months. Noteworthy instances in which the differences of the mean minimum and mean monthly temperatures from their respective averages were of opposite signs were February 1949, April 1931, June 1946, July 1936 and September 1950. In most of these cases the mean minimum temperature was above average and the mean monthly temperature below average. The mean minimum is therefore frequently preferable to the monthly mean as a brief representation of temperatures at night during the period to which the mean value refers.

Monthly range of night minima.—The mean minimum and the mean maximum are alike in occasionally concealing large temperature ranges. The figures given below show that the monthly range of night minima at Kew in the period examined was usually greater in late autumn, winter and early spring than at other times of the year.

TABLE VI

	Range of night minimum temperatures in 25-yr. period 1928–52 Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	degrees Fahrenheit											
Largest	37	32	30	25	30	23	21	19	23	30	34	33
Smallest	13	10	14	9	6	8	9	11	14	16	14	13
Average	22	20	20	16	18	15	13	14	18	23	20	21

Temperature characteristics at night.—It is difficult to devise a straightforward scale of classification as a means of amplifying the mean minimum temperature analagous to that used in Table IV to supplement the mean maximum. Any such scale should take into account the occurrence of frosts and their severity, in addition to giving an indication of the general characteristics of the monthly curve of night minimum temperature readings in relation to the average for the time of year. The scale adopted for the present purpose and the monthly classifications for Kew Observatory over the past 25 yr. are given in Table VII.

Use of the minimum-temperature index figure.—The index figures in Table VII enable a truer appreciation to be made of the bare mean minimum values given in Table I. Taking a spring month as an example, mean minimum temperatures in the Aprils of 1937 and 1945 were both 3·7°F. above average, but the details of the night-time temperatures in these two months were dissimilar in many respects. Nights were cold in early April 1937 with air frost on one night, but warmer weather later in the month offset the initial coldness. April 1945 on the other hand had consistently warm nights for the first three weeks, and although colder weather set in during the last week of the month there were no air frosts at Kew Observatory. The Septembers of 1948 and 1950, too, had identical

TABLE VII—CLASSIFICATION OF MONTHS BY CONSIDERATION OF MINIMUM TEMPERATURE

Index Number	Description	Intensity of air frost: May–September	Intensity of air frost: October–April
0	Mainly above average.	None.	Slight or keen.
1	Mainly above average.	Slight or keen.	Hard or severe.
2	Above average then colder.	None.	Slight or keen.
3	Above average then colder.	Slight or keen.	Hard or severe.
4	Below average then warmer.	None.	Slight or keen.
5	Below average then warmer.	Slight or keen.	Hard or severe.
6	Changeable.	None.	Slight or keen.
7	Changeable.	Slight or keen.	Hard or severe.
8	Mainly below average.	None.	Slight or keen.
9	Mainly below average.	Slight or keen.	Hard or severe.

An index figure, 0, 2, 4, 6 or 8, in brackets indicates "ground frost but no air frost" in the months May–September and "no air frost" in the months October–April.

Kew Observatory Period: 1928–52

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1928	6	6	6	6	(8)	(8)	6	6	(8)	4	4	8
1929	9	9	5	8	9	6	6	4	0	6	4	6
1930	0	8	6	(6)	(0)	0	6	6	0	6	6	6
1931	4	8	7	(0)	(0)	0	6	6	6	2	0	7
1932	1	8	5	(6)	(6)	6	6	0	2	(6)	0	4
1933	3	2	6	6	0	0	0	0	0	2	6	8
1934	7	9	6	4	(6)	0	0	6	6	6	6	(0)
1935	6	0	0	(0)	7	0	0	0	(6)	6	6	4
1936	7	9	6	6	(6)	4	0	6	2	(4)	2	6
1937	6	0	8	4	(0)	0	0	0	6	(0)	2	6
1938	(0)	6	0	8	9	0	4	2	4	(2)	0	3
1939	6	6	6	6	(8)	6	9	4	(0)	(2)	0	3
1940	9	7	6	6	(0)	0	9	6	(2)	6	6	8
1941	5	7	6	6	(8)	4	0	6	0	(6)	4	2
1942	9	9	6	(0)	(6)	(6)	6	4	0	(6)	8	0
1943	4	6	6	(0)	(0)	0	0	6	(2)	(6)	8	6
1944	0	8	6	(0)	(8)	(0)	0	0	(6)	0	6	7
1945	9	0	0	(2)	(0)	0	0	4	(2)	(0)	0	6
1946	7	3	4	6	(8)	(0)	6	6	0	(2)	(0)	9
1947	7	9	5	0	(0)	0	0	0	(0)	6	7	1
1948	6	3	(0)	(0)	(6)	0	4	6	(6)	6	6	3
1949	0	5	4	0	(6)	6	6	0	0	2	6	0
1950	3	0	0	6	(0)	0	0	0	0	2	6	8
1951	6	6	6	(8)	(8)	(4)	0	6	0	6	(0)	6
1952	3	8	0	0	0	6	0	0	(8)	4	2	5

mean minimum temperature values, but while the September of 1948 consisted of alternating warm and cold periods with some ground frosts, night minima in September 1950 were fairly consistently above average for the time of year and the month was completely free from ground frosts.

Summary.—The long-established climatological importance of the mean monthly temperature is unquestioned. Nevertheless, the mean value over the month as a whole is sometimes unrepresentative and occasionally misleading, both as a measure of the day-time or night-time temperatures of which it is composed and as a basis for comparing one particular month with the same month in other years. The mean maximum and mean minimum temperatures, together with their respective differences from the average, are much better criteria of the temperature characteristics of a month than the monthly mean, while index figures summarizing the changes in the monthly curve of day maximum and night minimum readings give considerable assistance in the interpretation of the mean values.

BUOYANT MOTIONS AND THE OPEN PARCEL

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Summary.—The model of the open parcel, in which a moving parcel of air is subject to continuous mixing of heat and momentum with its environment, is put forward to formalize the close connexion between turbulent and convective phenomena. The device is of considerable power, and the results of some of its applications to problems in convection and turbulent heat transfer are indicated.

Introduction.—*Closed parcel.*—In a recent review[1], where turbulence was regarded primarily as a process of interaction between motions at different scales, attention was drawn to the importance not so much of what was different, but of what was common, between the many problems in turbulent transfer which arise in meteorology. A similar outlook will be applied here to the closely related class of problems which concern atmospheric motions in which buoyancy is the dominant motive influence. These range in scale from the complex multi-cellular motions in cumulonimbus clouds, many miles in extent, through single-cell convection bubbles, down to the problem of heat conduction from ground to air on a sunny day when the path of an individual element may be measured in centimetres.

Great though their differences, until the last few years these problems have all been attacked by means of the same conceptual device. This device has become most widely familiar to meteorologists through the work of Sir Charles Normand on the parcel model of convection. The parcel was conceived as a uniform mass of air, of unspecified size, which was displaced from its original level and then moved through the medium without undergoing any mixing with the environment. Because of this latter feature, the device will be referred to here as the closed parcel. A subsequent development, the slice method, did not represent any fundamental change in outlook, for, as Normand himself pointed out[2], the slice method added no information to that provided by a large number of parcels moving both up and down.

From this last point it is only a short step to realize that the basic tool for study of turbulent heat transfer, the mixing-length theory, is in effect a statistical counterpart of the same device, the individual element of the turbulence being conceived with the same properties as the closed parcel of convection theory. Thus it may be claimed that a unified concept at one time underlay the whole structure of studies of buoyant motions at all scales. Despite, or perhaps because of, the great simplicity of the concept it was immensely fruitful, allowing us for example to understand and identify the different forms of instability which arise in convection problems, and estimate the vertical velocities generated, and, in the turbulent field, providing the very backbone of a whole complex subject.

In recent years in all these problems, from the thunderstorm to the small-scale turbulence, advances have been made and added complexities brought to light with which the closed-parcel device has appeared inadequate to deal. Modern research has tended to underline the peculiar nature of each of the separate problems, and to stress the importance of the new features (though in convection theory, in particular, there appears a strong cleavage of opinion as to which of these features are the important ones). The attacks on the different problems are tending to diverge more and more widely, and the general meteorologist, who is not a specialist in any one of them, is robbed of the unifying idea which is so helpful towards an understanding of the whole. Inevitable as these tendencies are, the task of science is to synthesize as well as to analyse, and it is equally important to look for features in common and see whether some new unified idea can be found to take the place of the closed parcel. Such an idea properly formalized, though inclined to represent an over-simplification in special cases, might nevertheless make some positive contribution to each; and would at any rate serve as a root stock on to which the cuttings from the detailed problems may be grafted.

Open parcel.—With this specific unifying need in mind, the formal concept is put forward of what will here be called the open parcel. Like the closed parcel, the open parcel is regarded as having a level of origin where its physical properties (and motion) can be given any assigned value but which will usually be taken as those of its environment; as it moves, however, it is subject to continuous bombardment by turbulent motions on a smaller scale, and so to continuous mixing of its properties with those of the surrounding air. Thus whereas a closed parcel of dry air, displaced vertically, will change its temperature at the adiabatic rate, the rate for the open parcel will depend on the rate of mixing and on the lapse rate of the environment. The open parcel is composed of a changing set of fluid particles, and its motion at any instant is defined as the mean motion of the fluid parcels which comprise it at that instant. To complete the specification of the body of air which is under consideration, we are free to define the manner in which the parcel changes its size as it moves, and to achieve the simplest mathematical formulation we elect that the size shall remain constant. It is clear from the definition that the treatment will have much in common with the American treatment of entrainment[3], save that the latter deals with the whole of the buoyant mass as it grows, and the present treatment, on the other hand, with a fixed volume thereof. The equations which govern the mean vertical velocity w and mean temperature T of the parcel may then be taken in their simplest form as (Priestley[4])

$$\frac{dw}{dt} = \frac{g}{T_e}(T - T_e) - kw \qquad \ldots\ldots (1)$$

$$\frac{dT}{dt} = -w\Gamma - k(T - T_e) \qquad \ldots\ldots (2)$$

where T_e is the temperature of the environment, Γ is the dry adiabatic lapse rate, and k is the mixing rate; k is allied to the turbulent interchange coefficient K between parcel and surroundings, for it has the form K/R^2 where R is representative of the linear dimensions of the parcel. From the work of Richardson[5] and also the more modern ideas on turbulence, k will be large for a small parcel and small for a large one; following an individual parcel (which remains of constant size) it is treated as a constant.

In problems where changes in water phase are important, e.g. in saturated ascent, a third equation must be added for the mixing of water content, but though this complicates the analysis it does not affect it fundamentally.

The problem is now the mathematical one of the solution of these simultaneous equations in a known environment. The condition for a steady environment is

$$\frac{dT_e}{dt} = w\frac{\partial T_e}{\partial z} \qquad \ldots\ldots (3)$$

which allows $T - T_e$ (or alternatively w) to be eliminated from the equations, leaving for example a single equation of motion in the form

$$\frac{d^2w}{dt^2} + 2k\frac{dw}{dt} + \left[\frac{g}{T_e}\left(\frac{\partial T_e}{\partial z} + \Gamma\right) + k^2\right]w = 0 \qquad \ldots\ldots (4)$$

where $(T - T_e)/T_e$ has been neglected as small, as it always is in nature. No restriction whatever has been placed on the possible magnitude of w.

Basic modes of single-cell convection.—In a layer of constant lapse rate, equation (4) takes the form familiar as the equation of damped motion with a disturbing or restoring force proportional to displacement. There emerge* three basic modes of behaviour: asymptotic motion, where the parcel eventually approaches an equilibrium level at an exponentially decreasing rate, oscillatory motion, where it executes damped oscillations about the equilibrium level, and absolute buoyancy, where w eventually increases exponentially with time. $T - T_e$ behaves in a similar fashion. The first mode probably occurs most frequently in convection, though it is the one which the closed parcel fails to indicate. The criteria determining the type of motion can readily be obtained and will not be reproduced here, but they must clearly be entirely in terms of the coefficients in equation (4). That is to say, the question of which type of motion will occur is decided entirely by the lapse rate and k (the size of parcel and level of small-scale turbulence), and is independent of the initial temperature and velocity of the parcel on entering the layer. The scale of the motion, on the other hand, does depend on these initial conditions.

Each of these types of motion is actually observed in single-cell convection, and from the derivation it is seen that the motion occurring at a given level at a given moment must belong to one of these three basic types, or to certain transitional modes (i.e. those which occur for particular combinations of values of k and lapse rate which separate the ranges of values where the basic

*In the space available it is not possible to provide full details of certain derivations, but these either have appeared or will appear elsewhere[4,6].

modes apply). The three therefore form a useful and complete set for describing single-parcel convection. Absolute buoyancy requires that the lapse rate be superadiabatic, and so will occur in practice only in layers of limited vertical extent. On the other hand, a superadiabatic lapse rate does not necessarily imply absolute buoyancy, for the solution is seen to be asymptotic for parcels below a certain critical size (k large): an element of sufficiently small size which is at rest will experience no tendency to move, so that the description "unstable", as applied to superadiabatic lapse rates, is true only for parcels above a certain limiting size.

To provide illustrations of the basic modes of motion, the curves of Fig. 1 show the upward velocity as a function of time for an element which enters a layer of constant lapse rate with $w = +100$ cm./sec. and $T' = +1$°C., g/T_e being taken as $3 \cdot 3$ cm./sec.^{2} °A. Values of k and lapse rate were chosen as follows:—

I $k = \frac{1}{3}$ min.$^{-1}$, $\quad \frac{\partial T_e}{\partial z} + \Gamma = +10^{-4}$ °C./cm. (isothermal)

II $k = \frac{1}{3}$ min.$^{-1}$, $\quad \frac{\partial T_e}{\partial z} + \Gamma = 0$ (adiabatic)

III $k = \frac{1}{3}$ min.$^{-1}$, $\quad \frac{\partial T_e}{\partial z} + \Gamma = -0 \cdot 94 \times 10^{-5}$ °C./cm.

IV $k = \frac{1}{4}$ min.$^{-1}$, $\quad \frac{\partial T_e}{\partial z} + \Gamma = -0 \cdot 94 \times 10^{-5}$ °C./cm.

V $k = \frac{1}{2}$ min.$^{-1}$, $\quad \frac{\partial T_e}{\partial z} + \Gamma = -0 \cdot 94 \times 10^{-5}$ °C./cm.

Those in II and III are such as to give transitional conditions between oscillatory and asymptotic, and asymptotic and absolutely buoyant respectively. All the curves have been calculated directly from the appropriate solutions of equation (4); the temperature behaviour may thence readily be obtained from equation (1).

Scorer and Ludlam[7] have drawn attention to the apparent frequency of a mode of motion in which the velocity rises to a maximum value and then remains steady, as for instance with III of Fig. 1. In explanation, however, they appeal to equation (1) while ignoring equation (2); this is not acceptable, since turbulent mixing of momentum must be accompanied by mixing of other properties. It is more satisfactory to use both equations, whence it is seen from equation (4) that a solution of the form

$$w = w_\infty - Ce^{-2kt} \qquad \ldots\ldots (5)$$

occurs under the special condition that

$$k^2 = -\frac{g}{T_e}\left(\frac{\partial T_e}{\partial z} + \Gamma\right) \qquad \ldots\ldots (6)$$

which implies that, in a given environment, the parcels must be of a specified size. This condition occurs at the transition from asymptotic motion to absolute buoyancy, and the empirically-based relation similar to equation (5) given by Scorer and Ludlam turns out to be a transitional rather than a principal form of solution. The frequent observation of this special case may be explained by combining the present theory with the picture that Scorer and Ludlam have themselves drawn. Small bubbles will rise to an equilibrium level but leave a

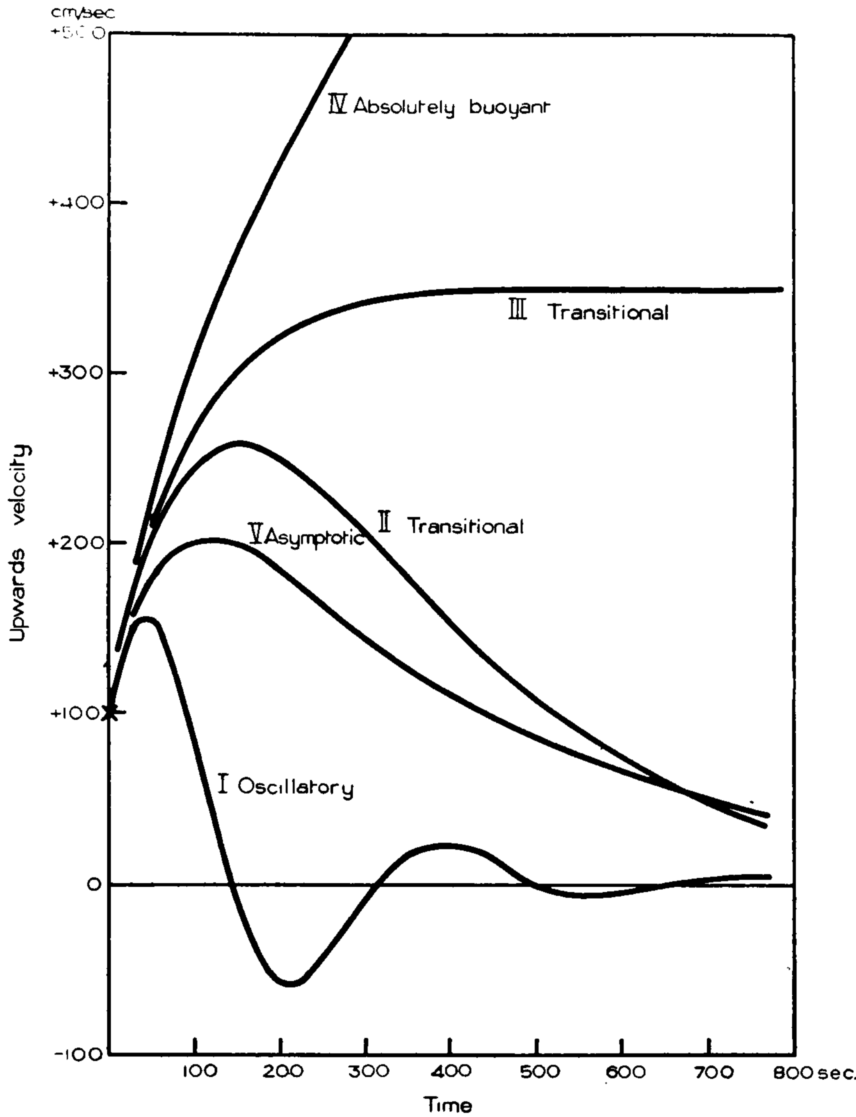


FIG. I—MODES OF CONVECTION FOR AN OPEN PARCEL

residual wake, and repetitions of the process will leave successively larger wakes until the critical size for absolute buoyancy is just realized. The parcel will then penetrate, and there is little tendency for growth beyond this size; whilst smaller parcels in the asymptotic mode will be abundant they are less easy to observe. Thus from a programme of visual observations of cloud behaviour in a super-adiabatic* layer, motions close to the transitional mode may be expected to stand out.

The oscillatory mode is of damped harmonic form, with an interval of exactly

$$\frac{\pi}{\sqrt{\left\{\frac{g}{T_e}\left(\frac{\partial T_e}{\partial z} + \Gamma\right)\right\}}}$$

between successive zeros of w and approximately the same between successive turning points*. Oscillations of cloud tops have been observed and their periods

*In these two applications, Γ of course refers to the saturated adiabatic lapse rate.

measured by Dr. E. G. Bowen and his colleagues near Sydney, and the latter agree with the formula within the limits of experimental accuracy. For sufficiently large clouds (k small) the damping becomes negligible, and we recover the formula for simple-harmonic gravity oscillations which was given many years ago by Brunt[8], but which does not appear to have been invoked in discussion of cloud behaviour.

Heat flux and temperature profile near the ground.—Application of the open parcel to the problem of heat transfer from ground to air on sunny days can be illustrated by Fig. 2. It is recognized that the profile under these

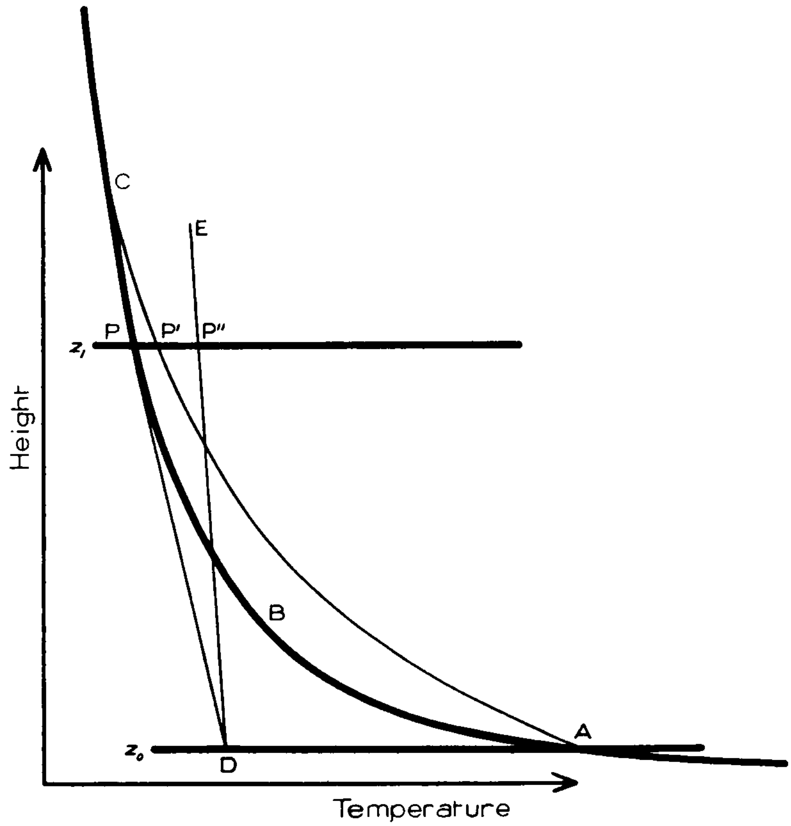


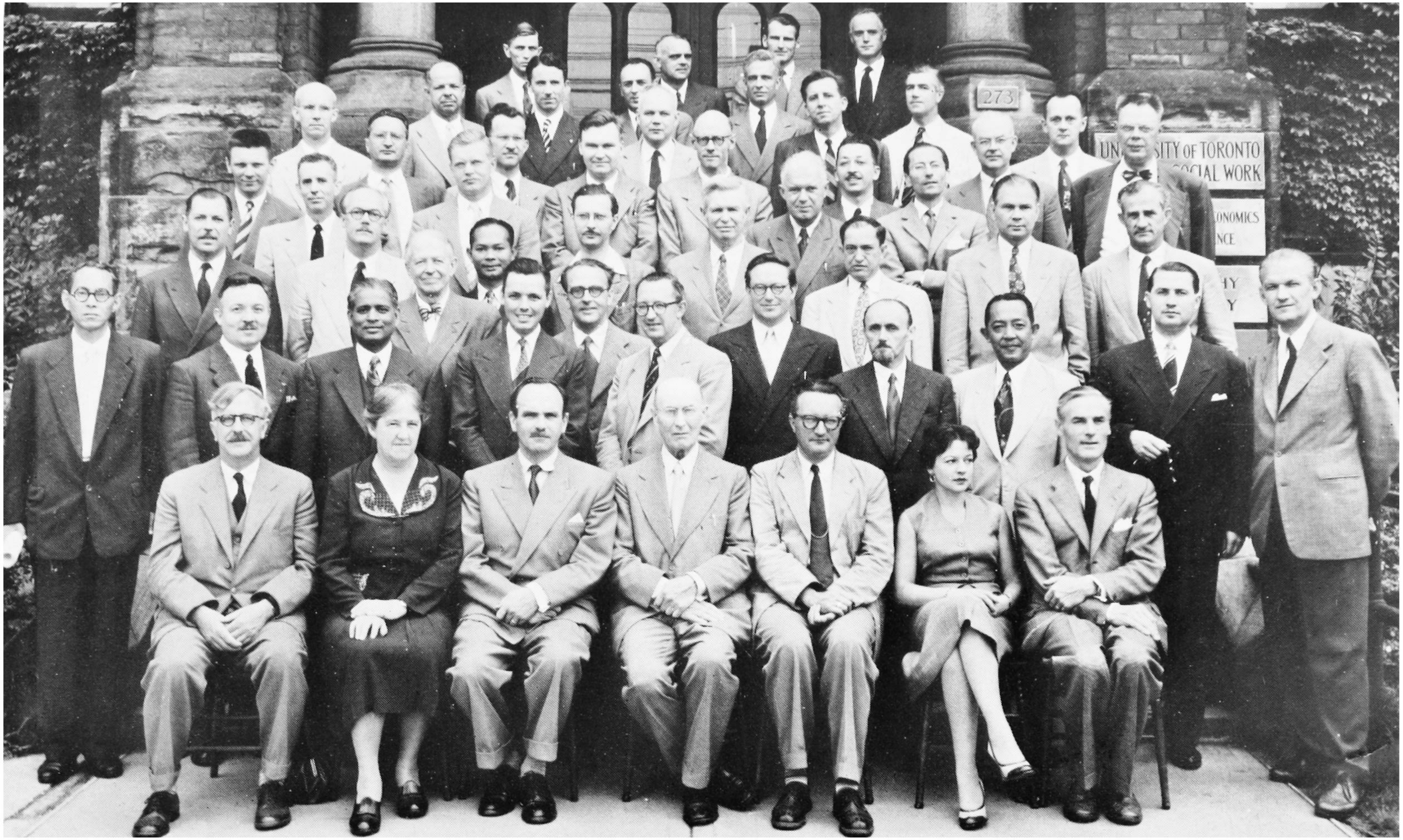
FIG. 2—DIFFERENCE BETWEEN MIXING-LENGTH AND OPEN-PARCEL THEORIES

conditions is strongly curved, and it is assumed to be represented by the equation

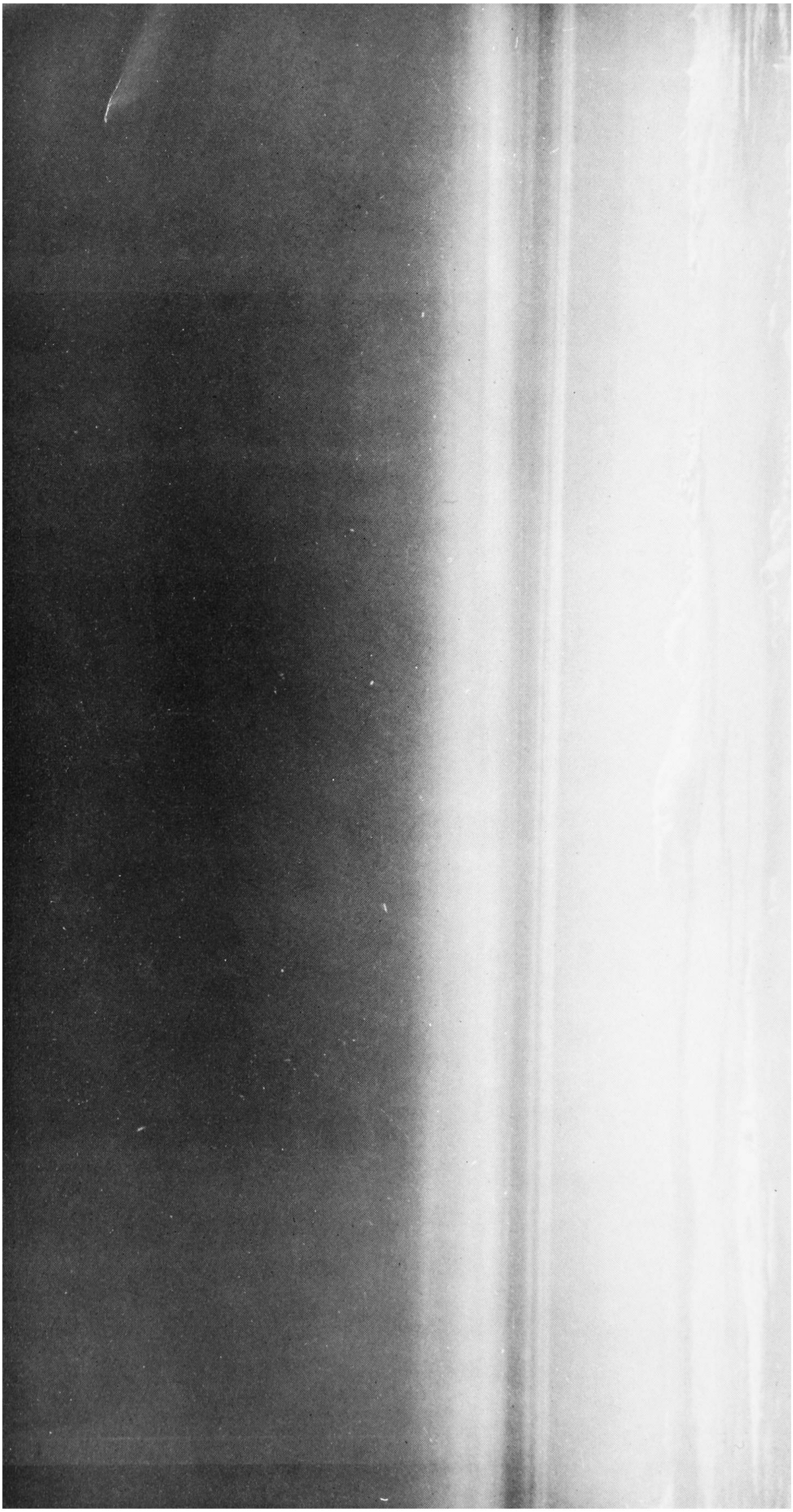
$$\frac{g}{T_e}\left(\frac{\partial T_e}{\partial z} + \Gamma\right) = -Cz^{-\delta} \qquad \ldots\ldots (7)$$

where δ characterizes the shape of the profile and C the general intensity of lapse rate. Such a profile is shown by the thick curve ABPC. The temperature behaviour of an individual element may then be calculated from equations (1) and (2), a typical result being indicated by the thin curve AP′C, and PP′ will then measure the excess temperature at level z_1 of an element starting from z_0. To derive the temperature excess PP″ given by the classical model (mixing-length theory) one would construct the tangent at P and, through the point D where this cuts the level z_0, draw a line DP″E of lapse rate Γ. It is evident that the present model is the more realistic, since the classical approach allows neither for the curvature of the profile nor for the mixing of the element.

[To face p. 112



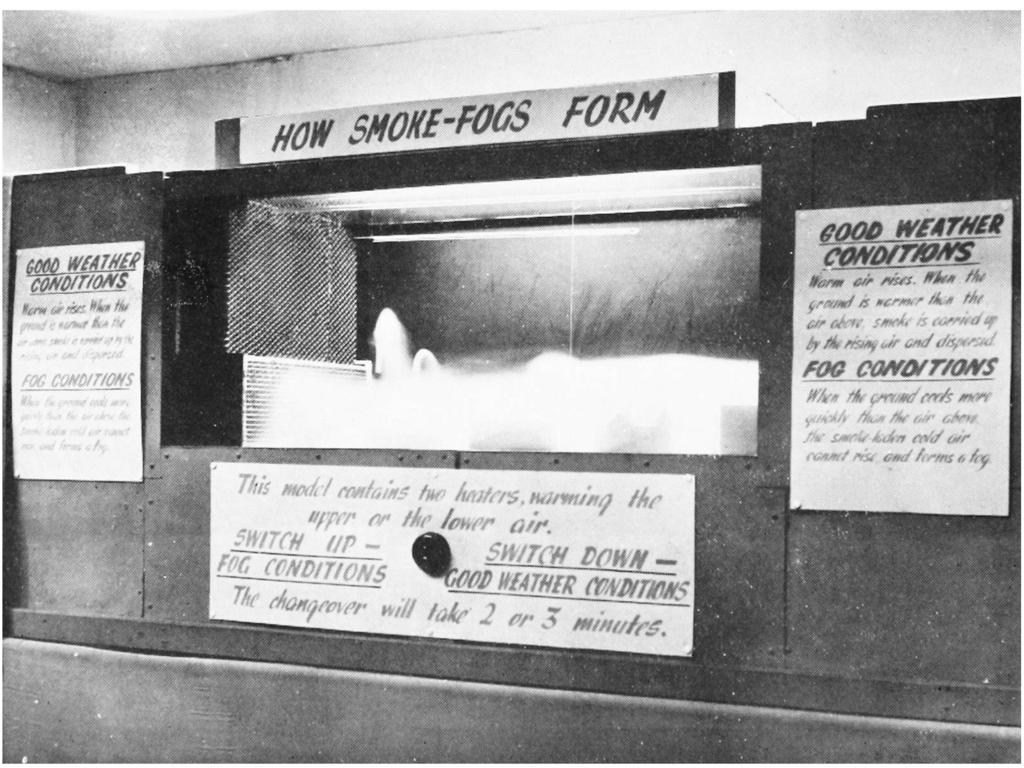
COMBINED MEETING OF THE COMMISSIONS FOR INSTRUMENTS AND METHODS OF OBSERVATION AND FOR AEROLOGY, TORONTO, AUGUST–SEPTEMBER 1953 (see p. 97)



DUST CLOUD AT ABOUT 49,500 FT.

These two photographs are selected from a special series taken over Defford, near Worcester, on July 30, 1953, between 1500 and 1510 G.M.T., at about the same height as the cloud.
(see p. 115)

Lapse conditions



Inversion conditions

MODEL TO ILLUSTRATE THE FORMATION OF SMOKE FOG

(see p. 114)

When equation (7) is substituted in equation (4) the form of the solution for w for a given value of k can be found*, and hence the solution for $(T - T_e)$ from equation (1). The heat flux through the level z_1 is then obtained by suitably averaging the product of these solutions over all possible values of k and of starting levels z_0. The mathematical treatment becomes rather involved, but there emerge three quite simple results (Priestley[6]): (i) that δ must in practice be close to $\frac{4}{3}$ and equal to it under steady conditions, except in layers where radiational heating is large, where δ will be smaller; (ii) that the rate of heat loss varies as $C^{3/2}$; and (iii) that the root-mean-square temperature fluctuations are proportional to $Cz^{-1/3}$.

A number of measurements of these last two quantities have been made by the writer's colleagues, and the agreement is most encouraging. In view also of the clear-cut prediction concerning the shape of the temperature profile, the large amount of published evidence on lapse profiles has been examined. Here the agreement is, from most sites, as good as the accuracy of the data permits. The discrepant profiles come from sites where the nature of the surface round the instrument is markedly different from that of the surrounding country, or where the exposure is otherwise impaired. At such sites, since wind and hence advection effects are rarely completely absent, one in effect measures, at different heights, samples of profiles typical of different conditions of ground cover, and no unified theory could be expected to provide satisfactory predictions.

Hot spots in a stable layer.—All the above results follow from the simple model of the open parcel, and suggest that the device is of some power and worthy of further application. Another novel result which may be mentioned in conclusion may be of practical importance to both scales of phenomena discussed above. Imagine a layer at a stable lapse rate in which a number of "hot spots" are created by some external agency, e.g. from heated ground or by penetration from an unstable layer below. The buoyant motions of the hot parcels will bring about an upward flow of heat through the layer. Small hot parcels will soon mix, and the heat flux due to them will be slight; large hot parcels will execute large oscillations approaching the simple harmonic in form with w and $T - T_e$ exactly $\pi/2$ out of phase, and the heat flux will again be slight. In between there will be an optimum size of parcel which, for a given intensity of temperature disturbance, will maximize the heat flux. The condition for the optimum has been found to be*

$$k^2 = \frac{1}{3}\frac{g}{T_e}\left(\frac{\partial T_e}{\partial z} + \Gamma\right),$$

and the upper limit to the heat flux given in terms of the root-mean-square temperature fluctuation σ_T by

$$F_H = \frac{\rho c_p \sigma_T^{\,2}}{\sqrt{\left\{\frac{3T_e}{g}\left(\frac{\partial T_e}{\partial z} + \Gamma\right)\right\}}}$$

where ρ is the density and c_p the specific heat at constant pressure of the air. The last formula shows that very considerable upward flows of heat may occur in stable layers in the free atmosphere when these are penetrated by cumulus tops.

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* see footnote on p. 109.

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MODEL TO ILLUSTRATE THE FORMATION OF SMOKE FOG

By K. H. STEWART, Ph.D.

The Royal Sanitary Institute held an exhibition on "Atmospheric pollution—causes, effects, prevention" from November 9 to December 5, 1953. The Meteorological Office contributed a working model (illustrated facing p. 113) intended to show how weather conditions affect smoke from factories and houses.

The model is in the form of a small wind tunnel. A fan at the right-hand end draws air through the tunnel at a mean speed of about ½ ft./sec. At the left-hand end two electric heaters are arranged so that one of them can heat the upper layers of air or the other the lower layers. A switch in the centre of the front panel is used to change from one heater to the other. Smoke is let into the model through chimneys near the left-hand end. When the upper heater is on the model simulates foggy, inversion conditions and the smoke forms a dense flat-topped layer near the floor. When the lower heater is on the smoke is carried aloft in convection currents, as on a clear day with steep lapse conditions.

At first sight the simplest way of making the model would have been to have used a closed box with heaters on the floor and ceiling for lapse and inversion conditions respectively. This does simulate inversion conditions well, but in lapse conditions the whole model fills with smoke unless there is a fairly strong air current to extract the smoke. It was felt that it would be too unrealistic to change the mean air speed between lapse and inversion conditions, but that a steady flow must be maintained.

With air flowing through the model, a ceiling heater could no longer be used to give an inversion because the heat would be conducted downwards so slowly as to warm only a very shallow layer. Instead, a wire-asbestos "mat" heater had to be used near the intake end, with the air flowing through it. Various arrangements of the heater were tried. Most of them produced strong convective circulations inside the model instead of the desired flat-topped inversion; in the final arrangement an extension was fitted to the intake end, with the air inlet aperture in its roof and the heater wires fixed over this aperture. This arrangement gave a smooth inflow of hot air which automatically confined itself to the upper part of the model. The air in the lower part was found to remain relatively cool and to move more slowly than the upper air, thus giving a realistic representation of inversion conditions. The wind shear was further increased by putting model buildings on the floor of the model and baffles in the lower part of the outlet end.

For lapse conditions, heating of the floor was not found to be very effective; convection currents were certainly set up, but owing to the restricted size of the model they merely served to mix the smoke throughout the model rather than to disperse it. Better results were obtained from a single heater at the bottom left-hand end of the model. This produced a simple convection system with one main current rising across the model to the outlet end, carrying most of the smoke with it.

To show the temperature conditions inside the model, two thermometers are suspended horizontally near the top and bottom, with their bulbs near the intake end. In inversion conditions the upper layers reach about 100°F. and the lower layers 75°F.; in lapse conditions the values are about 80°F. and 90°F. respectively.

The smoke is produced by burning sawdust (in a small tin can) with a regulated air supply. The smoke is passed through a 2-ft. metal tube before reaching the model, to cool it towards room temperature. This smoke generator runs for one or two hours without attention, but does require refuelling and cleaning too often to be really satisfactory. Various chemical methods of making smoke are available, but none gives a smoke sufficiently non-poisonous to be used for long periods without elaborate ventilating arrangements.

When properly adjusted the model gives a realistic demonstration of the difference between lapse and inversion conditions. It is difficult to use it to demonstrate or investigate more detailed points, such as the effect of variations of wind speed or small changes in lapse rate, because changes in wind speed affect both the temperature rise produced by the heaters and the turbulence structure in the model, and because the behaviour of the smoke depends rather critically on its temperature and speed of emission in relation to the air temperature and speed in the model.

The model was constructed at Kew Observatory. The work of the workshop staff and of Mr. A. J. Lander, who supervised the making of the model and contributed much to its development, is gratefully acknowledged.

DUST CLOUD IN THE STRATOSPHERE

By L. JACOBS, M.A., M.Sc.

On the morning of July 27, 1953, a Defford (near Worcester) pilot, Flt-Lt Munday, flying in a Canberra aircraft over the Peterborough area at 40,000 ft. was very surprised to find that there was a thin broken sheet of roll-type cloud well above him. He estimated that the cloud was at about 45,000 ft. and stretched from the Manchester area to the Pennines; it did not have the usual crystalline appearance of cirrus and was well defined on the eastern edge. (The height of the tropopause at this time and place was deduced from radiosonde ascents—about 28,000 ft.) When this report was received at Gloucester, from whence it was transmitted to the Central Forecasting Office for general distribution on the teleprinter network, it was suspected that the high cloud might well be the residual dust cloud from a volcanic eruption over Alaska on July 9, a message on the meteorological teleprinter network on July 11, 1953 having read "Information has been received that dust cloud from a volcanic eruption from Alaska on July 9 expected to cross north-east United States beginning July 11. Atlantic weather ships are to be asked to note particulars including time leading edge of cloud arrives overhead and any associated optical phenomena."

While weather (or other) ships did not observe this dust cloud (the Marine Branch of the Meteorological Office made a search later through all available logbooks) high-level cloud was observed from the meteorological office at Lichfield on the evening of July 27, the observer noting "its first appearance was at 1930 G.M.T. as streaks of white light, having an unusual appearance and not being readily explainable. It became apparent that the sun had been illuminating the underside of a layer of dust or haze for, as the sun gradually sank, the white streaks took on a dirtier appearance. At the point of sunset it became unquestionably evident that there was a layer of haze, and its underside exhibited a roll form reminiscent of stratocumulus cloud, the orientation of the rolls being roughly north–south. For a time shortly after sunset the haze layer could have been confused with cirrus or cirrostratus, had it not been kept under continuous observation."

On receipt of a further report of very high cloud from a Defford pilot on July 29, a request was made to all stations on the British meteorological teleprinter network to look out for such cloud. This request yielded many aircraft reports both for that day, the next day and also two for the previous day (i.e. for July 28–30). No further reports were received of very high cloud till Lichfield meteorological office reported some on the evening of August 4.

With the co-operation of the Superintendent at Defford a special flight was arranged on July 30 to obtain the exact height and thickness of the cloud and to take photographs. It was found that the cloud was quite thin, the base varying between 49,000 and 49,250 ft. and the top varying between 49,500 and 49,650 ft. Two of the photographs taken of the cloud are reproduced in the centre of this magazine. The following details are summarized from the observer's account: "While the high cloud could be seen from the ground owing to reflected light it could not be seen between 2,000 and 20,000 ft. but it was clearly visible from above 20,000 ft. It was not until the aircraft had reached 40,000 ft. (above some pre-frontal cirrus, base 35,000 ft., top 37,000 ft.) that it was possible to see how extensive the cloud was, with long drawn-out streaks in every direction for about 100–200 miles. The cloud was, however, only visible obliquely or from a distance. The photographs were taken between 49,500 and 50,000 ft. so that the top layer of cloud had a wider span in proportion to its thickness than the cirrus (top 37,000 ft.) or the cumulus (top 12,000 ft.). The photographs were taken about 30–40 miles away from each patch because the high cloud layer seemed to disappear whenever the aircraft entered it."

The high cloud reports were all from aircraft flying at 40,000 ft. or above, apart from the Lichfield surface reports mentioned above, and reports from the meteorological office at Waterbeach of very high cloud seen from ground level on the evening of July 27 and again at 1200 G.M.T. on July 30. Pilots' estimates of the base of the cloud, which, except in one case, was above the aircraft, varied from 46,000 to 55,000 ft. The only other aircraft, apart from the above-mentioned special Defford flight, reaching the cloud base was in the Wyton area at 1430–1500 on July 29, when the pilot reported thin layers of cirrostratus with base at 48,000 ft. and temperature there −56°F.

The first report from the Defford pilot on the morning of July 27 of very high cloud, having a sharp eastern edge over the Pennines, and that of a Wyton pilot, of a complete sheet of cirrostratus estimated 5,000–10,000 ft. above his aircraft when flying at 45,000 ft. over the route Wyton–Stuttgart–Frankfurt–Wildenrath–Wyton, 0530 to 0900 on July 28, is consistent with the same cloud sheet being observed, the upper wind at about 50,000 ft. being around 30 kt. From all the reports it appears that this thin, very high, cloud was extensive over England, Wales and southern Scotland from about the evening of July 27 till it was reported, at 1300–1400 on July 30, to be thinning slightly to the west of Wales and over north-west England. The cloud seen from Lichfield on August 4 might have been the last of this thinning cloud but is more likely to have been a separate later portion—it was first noticed at 1930 as a very high layer of rather close-grained stratocumulus-roll-type appearance above a band of definite cirrus; the high layer could only be seen towards the setting sun at an elevation of 20–40° and vanished by 2036.

Nearly all observers stated that the cloud did not look like ordinary cirrus, had a non-crystalline appearance and a streaky, hazy nature. There was general comment that the cloud base appeared to be wavy, rather like strato-cumulus cloud, and that if it was not looked at obliquely it could not be seen, the latter point being consistent with the thinness of the cloud; all pilots reported smooth flying conditions.

Synoptic situation.—From July 27 to 29 the British Isles remained under the influence of an upper cold pool which had been dominant in the area since July 14. Winds were westerly. On July 27 there were scattered showers with some thunderstorms; in the Defford area a pilot reported cumulonimbus tops with a pronounced anvil at 30,000 ft. with patches of anvil cirrus to 32,000 ft. (this cloud thus extending well above the tropopause) but the air became more stable in the south at night as a wave depression passed over northern France. On the 28th the weather was fair over the British Isles with a slack westerly gradient wind. In the same slack gradient wind a weak occlusion crossed Wales overnight, July 28–29, and England during the 29th, giving only occasional slight rain. On the 29th an upper warm ridge was spreading eastwards on the Atlantic in association with a shallow surface depression. Ahead of this system was a north-westerly jet stream. By 1500 G.M.T. on the 30th the jet stream (maximum speed 118 kt. at 300 mb., speed at 50,000 ft. 30 kt.) had reached the Liverpool area; the rain of the depression reached west Wales by 1800. It was the cirrus cloud of this depression that was observed by the Defford pilot at 1500 below the very high cloud. This depression, moving eastwards, cleared the east coast of England soon after midday on the 31st. It was followed by a developing ridge bringing fine warm weather over the British Isles which lasted till further Atlantic fronts moved eastwards on August 4, a cold front clearing Lichfield, where the last of the very high cloud was observed that evening soon after 1800 that day. The tropopause height at Defford rose steadily during the period July 27–30, the 1500 daily values being respectively 28,000, 32,000, 34,000 and 35,000 ft. The tropopause height at Lichfield on the evening of August 4 was about 39,000 ft.

Conclusion.—The present type of high dust cloud may have been mixed with thin ice-crystal cloud such as was observed at around 47,000 ft. on August 10, 1951[1] and discussed by Farquharson[2] since some observations described it as cirrus or cirrostratus. No optical phenomena or colouration of sun or moon were reported—unlike the high, very thick, dust cloud (base 31,000 ft., top about 40,000 ft.) of September 26, 1950, which gave a blue appearance to sun and moon[3]. Discontinuities in the tephigrams in the present case were rather minor and irregular and may well have been due to the minor fluctuations discussed by Sawyer[4].

Although the pilot who found the cloud on August 10, 1951 stated "I have never before seen cloud above 42,000 ft. in this country whilst flight-testing to altitudes of 50,000 ft. over the last three years" yet Farquharson[2] reports a further observation on August 25, 1952, and following discussions after the present series of reports had been received, further aircraft reports of cloud above 40,000 ft. were obtained for August 12 and 18, 1953 and for October 2, 1953. Murgatroyd and Goldsmith[5] in an account of cirrus cloud over southern England, based on reports by the Meteorological Research Flight, Farnborough, from January 1949 to August 1953, mention that cirrus cloud above 40,000 ft. was observed on May 4 and 5, 1953 and August 7, 1953 as well as on the days, July 27, 29 and 30, mentioned in the present account. It may well be that thin and very high ice-crystal or dust cloud is more common than is thought at present.

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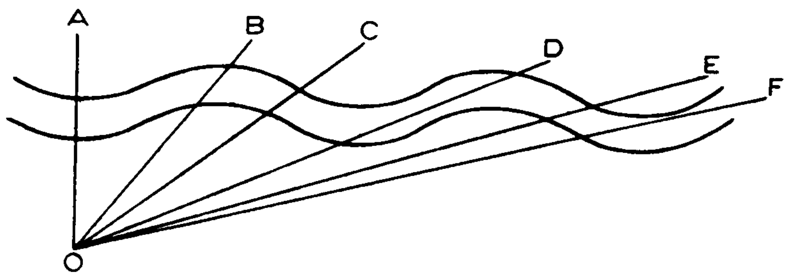
[Mr. D. H. Johnson, who examined all reports and studied the original 100-mb. charts at the Central Forecasting Office, comments: The air at 100 mb. over Wyton on July 29 probably entered the North Atlantic area from the north or north-west over the Denmark Strait on July 25 or 26 (assuming no vertical motion) and subsequently flowed south and south-east, later turning east to cross the British Isles. The air at 100 mb. over Defford on July 27 and 28 and over Stuttgart at about 0900 G.M.T. on July 28 was probably almost stagnant above a cold pool near ocean weather station INDIA from July 24 to 26, subsequently moving south-east and later east. It is just possible, however, that at 50,000 ft., allowing for the wind speed being 8–10 kt. greater than at 100 mb. (about 54,000 ft. on this occasion) that the Defford and Stuttgart cloud came from the north or north-west to the west of this cold pool during July 25 and 26. It may be significant that the ship at INDIA reported only anvil cirrus at the main hours from July 24 to 26. Very high cloud was apparently not observed.

In the absence of definite reports of the phenomenon from ships on the Atlantic or North American or Greenland stations it will, of course, be out of the question to attempt to track the haze or cloud back to its suggested source in Alaska.

Not the least interesting feature of the observations is the reference in every report to the cloud having a wave or roll form. Since most of the reports stress that the cloud was only visible when observed obliquely, it is just conceivable that it consisted of a series of discrete "rolls" of dust, the clear lines between the rolls consisting of clear air brought up or down from some neighbouring dust-free level. However, the Wyton report (July 28) mentions that the sheet of "cirrostratus" was visible above the aircraft over the whole route. There were shallow waves observed in the cirrostratus base when observed obliquely.

Also when observed obliquely there were apparent lanes but these were not seen when viewed vertically. This last observation strongly suggests that the "roll form" and the clear lanes mentioned in several reports may have been to some extent an optical illusion there being in fact a continuous, though waved, sheet of dust. None of the reports gives an estimate of the wave-length, but it seems reasonable to assume that it was long compared with the 500-ft. and 1,000-ft. thicknesses mentioned. A cross-section through the cloud would then look like this



An observer at O looking along OA, OB, OC or OE would be looking through a thin layer of haze; along OD or OF he would be looking at a much greater thickness of cloud. Hence the apparent "lanes" and "rolls".]

METEOROLOGICAL RESEARCH COMMITTEE

The Physical Sub-Committee met on November 12, 1953, and the Main Committee on November 26, 1953.

At the meeting on November 12 the Physical Sub-Committee considered a paper by Mr. Goldsmith[1] which discussed some aircraft and surface observations made at Khartoum in July 1952, the aircraft observations of frost point being the first of their kind to be made in the tropics, and a paper by Mr. Blackwell[2] which discussed five years' continuous recording of daylight illumination at Kew Observatory. Methods of forecasting the length, density and persistence of contrails were also considered.

The 66th meeting of the Meteorological Research Committee was held on November 26. The Committee reviewed the progress made during the past six months, and Dr. Sutcliffe gave a brief summary of the work on numerical forecasting which was being done within the Meteorological Office.

ABSTRACTS

1. GOLDSMITH, P.; Some aircraft and surface meteorological observations made at Khartoum in July 1952. *Met. Res. Pap., London,* No. 789, S.C. III/147, 1953.

Part I describes aircraft measurements of temperature and frost point between 20,000 and 39,000 ft. on 3 flights. Tephigrams are drawn. Frost points about −80°F. were found near 38,000 ft. with air temperature about −60°F. It was found that the Dobson-Brewer frost-point hygrometer can be operated in the tropics. In Part II ground measurements of direct solar radiation, reflected short-wave, atmospheric and ground long-wave radiation are briefly summarized.

2. BLACKWELL, M. J.; Five years continuous recording of daylight illumination at Kew Observatory. *Met. Res. Pap., London,* No. 831, S.C. III/162, 1953.

The paper discusses autographic measurements of illumination on a horizontal surface since 1947, including standardization, sources of error and their correction. Variation is tabulated by 10-day and hourly means. The greatest values (up to 200 kilolux/hr. for 1–2 min.) are given by clouds near but not obstructing the sun. Diurnal variation is shown for all and for cloudless days. Luminous efficiency (lumens/watt), daylight/radiation intensity, varied from 112 in December to 137 in September (year 128·5), showing a rough linear relation to water-vapour content of the atmosphere.

OFFICIAL PUBLICATION

The following publication has recently been issued:—

PROFESSIONAL NOTES

No. 108—Comparison of wind recorded by anemometer with the geostrophic wind. By W. A. L. Marshall

The commonly accepted forecasting rule that the surface wind speed is one third of the geostrophic wind inland and two thirds of the geostrophic wind at sea is broadly valid over the whole range of synoptic conditions met with in the British Isles. Similarly, wind direction near the surface is usually backed from the mean-sea-level isobars by about 30° inland and by about 10° at sea. But this general connexion between wind and pressure distribution is by no means invariable. The wind measured at four anemograph stations has been compared with the estimated geostrophic wind at six-hourly intervals over the year 1946. Abnormalities of wind speed and direction are discussed in relation to the existing synoptic situation, the temperature lapse rate, the exposure of the anemograph and the time of day.

LETTERS TO THE EDITOR

Oscillations of barometric pressure

I should like to suggest with reference to the article entitled "Recurrence tendencies in Kew surface pressure" in the October 1953 number of the *Meteorological Magazine* that the negative conclusion arrived at by the authors is perhaps attributable to the fact that Kew Observatory may lie on an amphidrome or line of nodes. According to the theoretical investigations of Margules the pattern at any time on the earth's surface of a pressure oscillation in the atmosphere consists of a number of adjacent high-pressure and low-pressure regions separated by lines of zero amplitude. The lines of zero amplitude may also intersect each other.

The theoretical results of Margules, which are naturally limited by his initial assumptions such as absence of vertical motion, relatively small amplitude of pressure variation and isothermal changes, have nevertheless found some practical confirmation—at least, so it is claimed—in the work of Lettau on a 36-day period in pressure oscillation in north-west Europe and of Mäde on an oscillation of a 20-day period of almost world-wide extent.

The nodal character of the littoral region of north-west Europe relative to the annual oscillation of pressure is well shown by a chart constructed by Stumpff. He finds that the amplitudes of the annual pressure oscillation are greatest over the Continent and over the Atlantic Ocean near Iceland, where they are respectively in opposite phase, and they are small in the coastal regions, where the lines of like phases are crowded together.

J. WADSWORTH

London, October 30, 1953

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4. STUMPFF, K.; Die Periodenforschung in der Geophysik. *Zbl. Geophys., Berlin*, **4**, 1939, p. 145.

Science and forecasting

Mr. B. C. V. Oddie has recently given an interesting review of the Pope Memorial Lecture on the subject "The scientist's place in the Services"*. Having quoted a statement by Dr. Wansbrough-Jones that the scientist "will never commit himself to an answer until he is at least nearly sure that he is right", Mr. Oddie concludes that the weather forecaster "is in a special category, and, perhaps, needs his own philosophy of science".

In reaching this conclusion, I think Mr. Oddie is interpreting science in too narrow a sense. The whole vast range of natural and social phenomena (inanimate matter, living organisms, human society) can be studied in a scientific manner. The essence of the scientific method is to collect and analyse the factual data in such a way as to reveal and define the relations between events, concepts or processes. Defined relations can then be used to predict future events. However, only in a very restricted field of knowledge (the so-called exact sciences) is it possible to plan future events or to make precise forecasts. In synoptic meteorology, as in many other fields of natural and social science, on account of the inadequacy of the data and the complexity of the relations between events, concepts or processes, sound scientific judgement demands that predictions be made in terms of trends, probabilities, approximations.

Nevertheless such predictions can often be useful as guides to action, and I do not think it is an exaggeration to say that the weather forecaster who on the basis of a careful scientific analysis of a complex changing synoptic situation issues a forecast for the next 24 hours qualified by such words as "may", "perhaps", "probable", is just as worthy of the proud title of scientist as the astronomer who predicts months ahead that a total eclipse of the moon will begin at 0050 G.M.T. and end at 0414 G.M.T. on January 19, 1954. Both are behaving in a manner consistent with "the general philosophy of science".

Preston, December 31, 1953 F. E. LUMB

[I did not intend to suggest that a synoptic meteorologist is not a scientist, and still less that he is useless. But he does occupy an unusual (though not unique) position, because he is often compelled to bet heavily on mere probabilities. This arises from the nature of his audience rather than of his science—above all things, he must be comprehensible. Therefore he says "Tomorrow will be . . . ". It would be much more truly "scientific" to give a table of probabilities, but it would not endear him to the B.B.C. Obviously this kind of thing—and every forecaster can think of other examples—presents the meteorologist with a special kind of ethical problem.—B. C. V. ODDIE]

Cleveland Abbe

I heard recently from Dr. Truman Abbe that he had completed and sent to the publisher the biography of his father Cleveland Abbe.

All English-speaking meteorologists owe a debt, direct or indirect, to Cleveland Abbe for his collections of classical papers on the mechanics of the earth's atmosphere, and the story of his efforts to raise the standard of meteorological science in the second half of the nineteenth century should be a notable contribution to meteorological literature. E. GOLD

8 Hurst Close, London, N.W.11, December 21, 1953

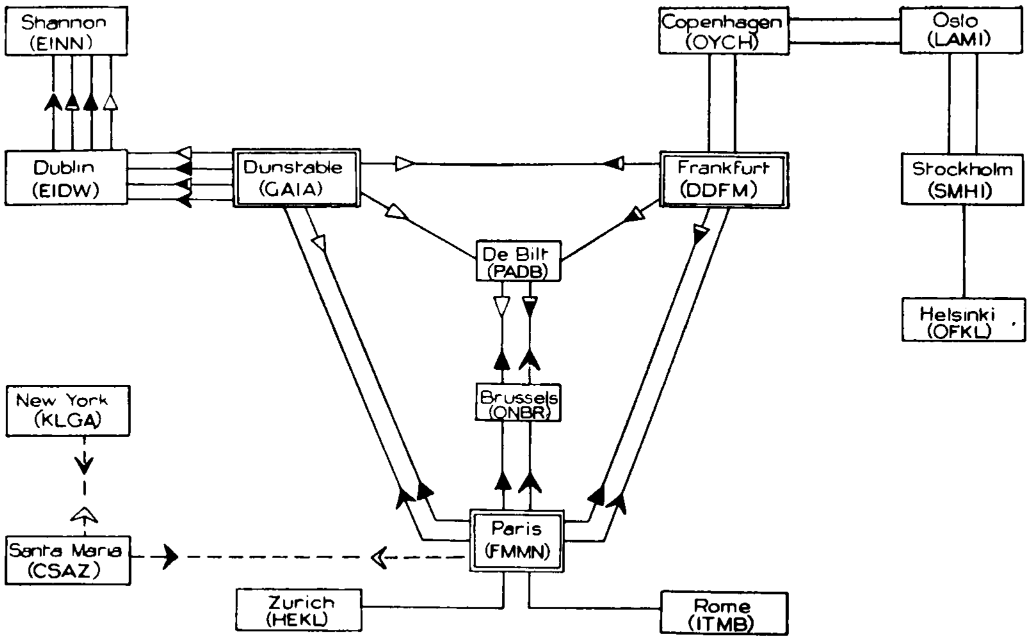
*ODDIE, B. C. V.; Royal Sociey of Arts. *Met. Mag., London,* **82,** 1953, p. 312.

NOTES AND NEWS

A new international meteorological communications centre at Frankfurt

In earlier days of synoptic meteorology, as in fact in many countries today, dependence upon radio communication with its uncertainties resulted in forecasters not being at all sure whether a particular station report would be available for plotting on charts. In the United Kingdom we have become so accustomed to the regular and accurate receipt of six-hourly, three-hourly and hourly reports by teleprinter from a very dense network of stations in western Europe that we tend to take for granted the complex telecommunications organization which exists to ensure that the exchange of basic information shall be as complete and perfect as possible. The engineering of circuits and operation of terminal equipment has to be arranged in such a way as to fit in with the framework of the meteorological network, and much ingenuity, planning and collaboration with various telecommunications authorities is required to accomplish this with the utmost economy and efficiency. The exchange of data must go on continuously throughout the 24 hours for 365 days of the year, and arrangements must be made for reserve routings to be provided and brought into operation at a moment's notice in the event of a break-down in a channel normally used. From time to time a major reorganization is called for. One example was the switch-over of the "hub" of the United Kingdom teleprinter network from Birmingham to Dunstable in the early days of the last war. The transfer involved much preparatory work which led to such a smooth change-over that comparatively few recipients of the broadcasts were aware of it. Another example is the reorganization of circuits forming the western European teleprinter network which has recently been effected. This network was built up by international co-operation after the last war, and was based upon exchange centres at Dunstable, Paris and the Headquarters of the British and United States Forces in the Occupied Zones of Germany as described in World Meteorological Organization Publication 9, Fascicule III. Each of the four centres originated a broadcast of about 30,000 five-figure groups a day comprising data collected from its own "area of responsibility". At noon on January 4, 1954, the basic network, which had been termed a "ring" or "quadrilateral", became a triangle with Frankfurt, Paris and Dunstable as its apexes, the Frankfurt centre (DDFM) being operated by the Federal German Meteorological Service.

The change-over was accomplished without any hitch or break in the supply of data, and completely revised schedules which had been carefully prepared and agreed beforehand were introduced to accord with the changed "areas of responsibility" assigned to the centres. The international network includes two sub-centres at De Bilt and Brussels, and the smoothness with which the machinery of reorganization worked was the result of close co-operation between six national services with the World Meteorological Organization Regional Association VI, Working Group for Weather Transmissions, co-ordinating the overall planning. One result has been the speeding-up of North American information which is now rediffused from the Paris centre by tape-relay uninterrupted by the inclusion of any European data which are now carried by an independent broadcast. Reports exchanged on the basic triangle are, of course, "fed" by land-line to many other western European countries



——— Land-line teleprinter circuit.
- - - - - - Radio-teleprinter circuit.
DUNSTABLE BROADCAST: United Kingdom, Ireland, Iceland, Greenland, Netherlands, U.S.S.R. in Europe, eastern Mediterranean, Ships' reports.
FRANKFURT BROADCAST: Austria, Bulgaria, Czechoslovakia, Denmark, Faeroes, Greenland, Federal German Republic, Eastern Germany, Finland, Greece, Hungary, Norway, Poland, Romania, Siberia, Sweden, Yugoslavia, Ships' reports.
PARIS BROADCAST: Belgium, France, Italy, north Africa, Portugal and Azores, Spain, Switzerland, Ships' reports.
North American data to Europe.
European data to North America.
Circuits not annotated carry selected data.

WESTERN EUROPEAN METEOROLOGICAL TELEPRINTER NETWORK

including the Irish Republic, Denmark, Finland, Norway, Sweden, Switzerland and Italy. Several other countries are at present developing internal national networks so that in the next few years it is expected that the great majority of western European countries will be in a position to receive data for the compilation of synoptic charts covering a wide area by land-line at the teleprinter speed of working, instead of having to intercept many morse-radio broadcasts which have to be made at a speed of only 18–20 five-figure groups a minute.

C. V. OCKENDEN

United Nations technical assistance in meteorology

British meteorologists and the Meteorological Office figure prominently in the latest announcements about the administration by the World Meteorological Organization of the United Nations scheme of technical assistance in meteorology to under-developed countries.

Dr. C. A. Lea, Director of the Meteorological Service of Malaya, appointed United Nations technical assistance expert to advise the Government of Libya on the organization of a meteorological service, took up his duties in November 1953.

Mr. J. Cochemé has been nominated to advise the Government of Jordan on the organization of a meteorological service with special reference to agricultural meteorology.

Three members of the Israeli Meteorological Service are to study in the Meteorological Office under the scheme; one will study meteorological instruments, and two synoptic meteorology and forecasting.

REVIEW

Linkes Meteorologisches Taschenbuch. Edited by F. Baur. $8\frac{1}{2}$ in. $\times$ 6 in., pp. Bd I viii + 360, Bd II xvi + 724, *Illus.*, Akademische Verlagsgesellschaft Geest & Portig K.-G., Leipzig, 1953. Price: *DM* 30, *DM* 38.

The publication of a new edition of Linke's "Meteorologisches Taschenbuch" is very welcome. The new edition is in two volumes.

The seven sections of the first volume cover:—

I. Weather reporting (synoptic codes, symbols, W/T transmitters).

II. A table of equivalents of meteorological words in German, English, French, Italian, Spanish and Russian apparently unchanged from the pre-war edition.

III. The International Meteorological Organization (as at 1949).

IV. Monthly and annual means of pressure and temperature for 207 stations.

V. The cloud classification of the "International cloud atlas" (1932).

VI. The meteorology section of the Universal Decimal Classification.

VII. A summary of meteorological history.

The value of the section on codes, transmitters, etc. in a publication of this kind is rather doubtful. Such information changes rapidly, and it is always necessary to refer to the current World Meteorological Organization, or national, publications which are kept up to date by amendment notices. A brief statement inserted in proof points out that Section III is obsolete, and gives the principal officers and a list of Commissions of the World Meteorological Organization.

The second volume contains six sections:—

I. List of symbols for quantities occurring in meteorological literature according to the system of the German organization for units and symbols.

II. Mathematics and methods of calculation for the meteorologist. This section is a summary of higher mathematics including integral equations, the calculus of variations, vector and tensor calculus, interpolation, harmonic analysis, probability, and mathematical statistics.

III. Practically applicable equations of dynamical meteorology. A summary of the mechanics and thermodynamics of the atmosphere in general including the theory of turbulence.

IV. The evaluation of aerological measurements. This section covers the subject briefly from the correction of radiation errors of radio-sondes to the use of the various aerological diagrams, construction of upper air contour and thickness charts, isentropic analysis, construction of cross-sections, and has an appendix on methods of observation with high-altitude rockets.

V. Climatological meridional cross-sections of the free air. Mean cross-sections for January and July for the northern hemisphere along the 75°W. and 120°W. meridians giving mean isopleths of temperature, potential temperature, zonal wind and tropopause.

VI. Tables divided into eleven sets.

A. Astronomy and geodesy.

B. General physics and geophysics.

C. Atmospheric statics and pressure (barometer reduction etc.).

D. Atmospheric thermodynamics, humidity, cloud physics.

E. Atmospheric dynamics.

F. Radiation and atmospheric optics.

G. Atmospheric electricity.

H. Ionosphere.

J. Long-period series of observations. A miscellaneous collection including a table showing whether the synoptic situation over Germany was cyclonic or anticyclonic on every day from 1881 to 1950 and information on sunspots from 1749 to 1951.

K. Mathematical tables.

L. Conversion tables.

The mathematical summary of section II would be very useful to any meteorologist who can read German, but much of the section on methods of evaluation of aerological methods necessarily has a limited value to meteorologists of other countries.

A reviewer naturally compares the splendid collection of tables in section VI with the recently published 6th edition of the "Smithsonian meteorological tables". Each has something that the other has not got. The latest Smithsonian tables are more complete in purely meteorological tables; they have, for example, tables for gradient (as distinct from geostrophic) wind and for humidity mixing ratio which are not in the latest Linke. On the other hand Linke has tables on subjects, such as atmospheric electricity, not touched by the Smithsonian tables and provides also general physical and mathematical tables. Neither the Smithsonian nor Linke's tables are complete in themselves; the meteorologist who has both will not often need to search outside them.

The price of nearly £3 for the second volume is not excessive as prices for German books go.

G. A. BULL

BOOKS RECEIVED

Schweizerisches Forschungsinstitut für Hochgebirgsklima und Tuberkulose in Davos. Tätigkeitsbericht für die Betriebsjahre 1949–51 and 1952. Schweiz. med. Wschr., Basel, **82,** Nr. 46 and 48, 1952, and **83,** Nr. 6, 1953.

Kennzeichen und Beurteilung des Hochgebirgsklimas. By Dr. W. Mörikofer. *Medizinische*, **9,** Nr. 19, Physikalisch-Meteorologischen Observatorium, Davos, 1953.

METEOROLOGICAL OFFICE NEWS

Retirements.—Mr. M. T. Spence, Senior Principal Scientific Officer, retired on February 28, 1954. He joined the Office in 1912 and was attached to the Statistical Branch. During more than 40 years' service Mr. Spence has worked both at Headquarters and aviation outstations as well as at Valentia Observatory and the Branch Office, Edinburgh. During the Second World War he was Senior Meteorological Officer at Headquarters No. 2 Group and later Chief Meteorological Officer to Bomber Command. In 1946 he was posted to the Personnel and General Services Branch at Headquarters and from 1948 until the time of his retirement was Assistant Director responsible for Personnel matters, Meteorological Training and General Services. During the First World War Mr. Spence served in the Royal Naval Volunteer Reserve. He was awarded the O.B.E. (Civil) in 1943. At a meeting in the Conference Room at Victory House on February 26, Dr. Stagg presented Mr. Spence with a cheque subscribed by his colleagues and this he intends to use towards the purchase of a television set. In expressing his thanks Mr. Spence recounted some interesting recollections of the people and events with which he had been connected. Mr. Spence has accepted a temporary appointment in the Meteorological Office.

With reference to the announcement in the March number of the retirement of Mr. R. A. Watson, a present in the form of field glasses, bought with donations from many of those with whom he had been associated was handed to Mr. Watson at Edinburgh on February 27. At the presentation he expressed his thanks to all who had contributed to the gift of his choice.

WEATHER OF FEBRUARY 1954

Mean pressure was above normal over Scandinavia and also over the North Atlantic between 40°N. and 50°N. Mean pressure was below normal in the region extending from Iceland south-eastward to Europe and the Mediterranean; mean pressure was also below normal over the eastern half of North America. The mean pressure reached 1027 mb. in Finland where it was 14 mb. above normal; the mean pressure at the Azores, 1026 mb., was 3 mb. above normal. The mean pressure in the central Mediterranean fell to 1008 mb. and was 9 mb. below normal in places.

Mean temperature was below normal over the whole of Europe, as much as 10°F. in the east; in the Mediterranean region the mean temperature was generally 2°F. below normal. Most of the United States had mean temperatures above the normal.

In the British Isles the very cold north-easterly winds experienced at the end of January persisted over England and Wales during the first few days of February and were followed by a ridge of high pressure moving south. From the 6th–7th onwards changeable, predominantly cyclonic, conditions prevailed.

An anticyclone situated over southern Scandinavia on the 1st was joined on the 2nd by another westward of Ireland and subsequently the whole belt of high pressure moved slowly south. Very cold weather prevailed with some snow, mainly slight, and temperature remained continuously at 32°F. or below locally in the south from the evening of January 29 to the morning of February 7. Very low screen minimum temperatures were registered during this spell; for example 7°F. at Thetford, Norfolk, on the 1st, −4°F. at Welshpool, Montgomeryshire, 0°F. at Hawarden Bridge, Flintshire, 3°F. at Moor House, Westmorland, 5°F. at Kielder Castle, Northumberland, and 6°F. at Alston on the 2nd, 3°F. at Moor House and 8°F. at Houghall, County Durham, Kielder Castle and Welshpool on the 6th. The snowfall of late January still lay on the ground and the fresh north-easterly winds in the south caused deep drifts in places; roads were blocked and villages isolated, particularly in Kent; at Throwley, a village four miles south-west of Faversham, Kent, there were drifts up to 7 ft. on the 1st. Rivers, canals and lakes were frozen or partly frozen. On the 6th–7th a deep depression was centred north of Scotland and an occlusion crossed the British Isles giving rain in the south and extreme west but snow in many northern districts and in Lincolnshire. Further depressions brought more snow to northern and eastern areas on the 8th–10th and smaller falls in south-eastern and Midland areas. Keen frost occurred in northern districts on the 8th and 9th; 9°F. was registered in the screen at Houghall and 10°F. at Moor House on the 8th and 10°F. at Kielder Castle on the 9th. On the 10th a depression off the west of Ireland moved south-east giving precipitation in most places; there was a temporary rise in temperature over much of England, Wales and Ireland, 50°F. being reached at a number of places in the south and west, but fog kept temperature below 40°F. locally, for example at West Raynham, Norfolk and at Watnall, near Nottingham. Further depressions moved south-east over our south-west districts during the next few days giving rather cold easterly winds over much of the country with some precipitation; a good deal of fog occurred in eastern districts. On the 15th and 16th a ridge of high pressure moved south-east over the British Isles, with more fog in eastern and Midland districts. From the 17th to the 19th small wave depressions moved east-north-east over southern England bringing widespread rain. Subsequently a changeable, rather mild, south-westerly type of weather prevailed, with temperature reaching or somewhat exceeding 50°F. locally at times; for example, 55°F. at Aldergrove on the 21st and 56°F. at Mildenhall on the 22nd. Rainfall was fairly heavy at times in the north (2·06 in. at Patterdale, Westmorland on the 24th). Between the 25th and 27th a complex, deep depression moved from south of Iceland to the North Sea. Strong winds and gales occurred in England, Wales and Ireland on the 26th, with gusts of 68 kt. at Bidston and 66 kt. at Speke. Showery weather, with snow or sleet in many places, prevailed in the colder air coming round the rear of the depression, particularly in the northerly current on the 28th.

The general character of the weather is shown by the following provisional figures.

	AIR TEMPERATURE			RAINFALL		SUNSHINE
	Highest	Lowest	Difference from average daily mean	Percentage of average	No. of days difference from average	Percentage of average
	°F.	°F.	°F.	%		%
England and Wales ...	58	−4	−3·1	131	+3	88
Scotland	56	0	−2·7	98	+2	82
Northern Ireland ...	56	18	−2·1	149	+4	65

RAINFALL OF FEBRUARY 1954

Great Britain and Northern Ireland

County	Station	In.	Per cent. of Av.	County	Station	In.	Per cent. of Av.
London	Camden Square ...	2·22	133	*Glam.*	Cardiff, Penylan ...	4·30	146
Kent	Dover	2·81	146	*Pemb.*	Tenby, The Priory ...	5·58	192
,,	Edenbridge, Falconhurst	2·08	94	*Radnor*	Tyrmynydd	5·67	108
Sussex	Compton, Compton Ho.	3·87	147	*Mont.*	Lake Vyrnwy	5·50	121
,,	Worthing, Beach Ho. Pk.	2·34	118	*Mer.*	Blaenau Festiniog ...	9·68	118
Hants.	Ventnor Cemetery ...	3·59	166	,,	Aberdovey	3·91	131
,,	Southampton, East Pk.	3·19	139	*Carn.*	Llandudno	2·33	119
,,	South Farnborough ...	2·77	147	*Angl.*	Llanerchymedd ...	3·83	151
Herts.	Royston, Therfield Rec.	1·74	113	*I. Man*	Douglas, Borough Cem.	5·17	162
Bucks.	Slough, Upton... ...	2·24	132	*Wigtown*	Newton Stewart ...	4·51	120
Oxford	Oxford, Radcliffe ...	2·34	143	*Dumf.*	Dumfries, Crichton R.I.	4·18	128
N'hants.	Wellingboro' Swanspool	2·03	126	,,	Eskdalemuir Obsy. ...	4·33	87
Essex	Shoeburyness	1·72	140	*Roxb.*	Crailing	1·28	69
,,	Dovercourt	1·89	149	*Peebles*	Stobo Castle	2·85	103
Suffolk	Lowestoft Sec. School...	1·81	129	*Berwick*	Marchmont House ...	2·18	105
,,	Bury St. Ed., Westley H.	2·01	134	*E. Loth.*	North Berwick Res. ...	1·52	97
Norfolk	Sandringham Ho. Gdns.	2·68	162	*Midl'n.*	Edinburgh, Blackf'd. H.	1·54	93
Wilts.	Aldbourne	3·02	140	*Lanark*	Hamilton W. W., T'nhill	3·31	114
Dorset	Creech Grange... ...	3·64	127	*Ayr*	Colmonell, Knockdolian	4·13	107
,,	Beaminster, East St. ...	3·79	125	,,	Glen Afton, Ayr San. ...	4·43	101
Devon	Teignmouth, Den Gdns.	3·08	116	*Renfrew*	Greenock, Prospect Hill	6·36	120
,,	Ilfracombe	4·84	175	*Bute*	Rothesay, Ardencraig...	3·93	98
,,	Princetown	8·67	115	*Argyll*	Morven (Drimnin) ...	5·60	106
Cornwall	Bude, School House ...	4·10	164	,,	Poltalloch	3·70	86
,,	Penzance, Morrab Gdns.	5·88	176	,,	Inveraray Castle ...	5·40	80
,,	St. Austell	5·65	147	,,	Islay, Eallabus... ...	5·15	123
,,	Scilly, Tresco Abbey ...	4·43	159	,,	Tiree	3·73	108
Somerset	Taunton	2·18	105	*Kinross*	Loch Leven Sluice ...	2·96	105
Glos.	Cirencester	3·07	136	*Fife*	Leuchars Airfield ...	2·31	132
Salop	Church Stretton ...	3·06	131	*Perth*	Loch Dhu	7·86	106
,,	Shrewsbury, Monksmore	2·15	137	,,	Crieff, Strathearn Hyd.	4·53	129
Worcs.	Malvern, Free Library...	2·19	122	,,	Pitlochry, Fincastle ...	3·09	105
Warwick	Birmingham, Edgbaston	2·70	160	*Angus*	Montrose, Sunnyside ...	2·03	110
Leics.	Thornton Reservoir ...	2·41	144	*Aberd.*	Braemar	3·01	106
Lincs.	Boston, Skirbeck ...	2·17	149	,,	Dyce, Craibstone ...	2·81	123
,,	Skegness, Marine Gdns.	2·33	152	,,	New Deer School House	3·02	142
Notts.	Mansfield, Carr Bank...	2·30	119	*Moray*	Gordon Castle	1·47	77
Derby	Buxton, Terrace Slopes	4·31	115	*Nairn*	Nairn, Achareidh ...	0·94	58
Ches.	Bidston Observatory ...	2·46	146	*Inverness*	Loch Ness, Garthbeg ...	2·47	72
,,	Manchester, Ringway...	2·69	142	,,	Glenquoich	...	...
Lancs.	Stonyhurst College ...	2·79	83	,,	Fort William, Teviot ...	4·77	64
,,	Squires Gate	2·95	139	,,	Skye, Broadford ...	4·80	74
Yorks.	Wakefield, Clarence Pk.	2·20	129	,,	Skye, Duntuilm ...	4·50	98
,,	Hull, Pearson Park ...	2·10	127	*R. & C.*	Tain (Mayfield) ...	1·77	77
,,	Felixkirk, Mt. St. John...	2·43	144	,,	Inverbroom, Glackour...	3·11	61
,,	York Museum	2·16	143	,,	Achnashellach	5·21	76
,,	Scarborough	1·84	110	*Suth.*	Lochinver, Bank Ho. ...	3·27	82
,,	Middlesbrough... ...	1·28	98	*Caith.*	Wick Airfield	1·88	83
,,	Baldersdale, Hury Res.	1·93	66	*Shetland*	Lerwick Observatory ...	5·43	172
Norl'd.	Newcastle, Leazes Pk....	1·65	108	*Ferm.*	Crom Castle	4·71	160
,,	Bellingham, High Green	1·80	71	*Armagh*	Armagh Observatory ...	3·68	166
,,	Lilburn Tower Gdns. ...	2·47	124	*Down*	Seaforde	4·88	160
Cumb.	Geltsdale	1·69	65	*Antrim*	Aldergrove Airfield ...	3·95	164
,,	Keswick, High Hill ...	4·77	97	,,	Ballymena, Harryville...	4·13	127
,,	Ravenglass, The Grove	4·30	140	*L'derry*	Garvagh, Moneydig ...	4·21	135
Mon.	A'gavenny, Plâs Derwen	4·23	121	,,	Londonderry, Creggan	3·85	121
Glam.	Ystalyfera, Wern House	7·97	155	*Tyrone*	Omagh, Edenfel ...	4·75	159

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