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SECOND CONGRESS OF THE WORLD METEOROLOGICAL ORGANIZATION

By J. DURWARD, M.A.

The Second Congress of the World Meteorological Organization was held in Geneva from April 14, 1955 to May 13, 1955, inclusive, under the Chairmanship of Dr. F. W. Reichelderfer, President of the Organization. It was attended by representatives of 83 member countries or territories, 7 non-member countries and 11 international organizations. The total number of persons present in the capacity of delegates, advisers or observers was about 215. The United Kingdom delegation was led by Sir Graham Sutton, Director of the Meteorological Office.

In the *Meteorological Magazine* for June 1951 a short account is given of the first Congress of the World Meteorological Organization describing how the semi-official International Meteorological Organization was replaced by the World Meteorological Organization and the problems which had to be faced by the First Congress. Naturally the problems of the Second Congress were different. It was now not necessary to create measures to ensure the smooth functioning of the Organization but more necessary to improve upon the procedures which had already been tried out over the first financial period. The review of the basic administrative procedures was made by the Administrative Committee and the Legal Committee. In addition the technical programme for the second financial period was handled by the Programme Committee.

It would be impossible to set out all the matters discussed and results achieved within the compass of a short article. Attention will therefore be confined to items likely to be of most interest to readers of this Magazine.

Officers of the Organization.—The following were elected to hold office until the Third Congress: President, Mr. A. Viaut (France); First Vice-President, Dr. Barnett (New Zealand); Second Vice-President, Prof. Ferreira (Portugal).

Executive Committee.—Dr. Reichelderfer was elected unanimously and with acclamation. Voting for the other five vacancies for elected members resulted in the following appointments: Mr. A. A. Solotoukhine (U.S.S.R.), Sir Graham Sutton (United Kingdom), Mr. L. de Ascarraga (Spain), Dr. A. Nyberg (Sweden), Mr. M. F. Taha (Egypt).

Secretariat.—Mr. D. A. Davies, Director of the British East Africa Meteorological Service, was elected as Secretary-General of the Organization. Other changes approved for the Secretariat were: increases in salary for the Secretary-General and Deputy Secretary-General; increases in the number of persons employed; a rise in grade of the professional officers employed; the addition to the staff of a radio technologist; and the employment when necessary of a legal expert as a consultant.

Work of the Legal Committee.—One of the main tasks of this Committee was to review the general regulations of the organizations and make the necessary amendments, additions or deletions to make the regulations as clear as possible. It will be appreciated that one source of difficulty is that of language—translation too often alters the sense. In no language have words the same delicate shades of meaning as in English.

Work of the Administrative Committee.—*Contributions.*—Naturally a great deal of the time of the Administrative Committee was taken up in discussing a basis for contributions to the Organization. The proposals ranged from (*a*) adoption of the present scale, (*b*) adoption of the United Nations scale, (*c*) adoption of the International Telecommunications Union scale or a compromise between (*a*) and (*b*). The compromise ultimately adopted was to take 75 per cent. of the existing scale and 25 per cent. of the United Nations scale—a solution which resulted in the United Kingdom's contribution being reduced by one unit.

Budget.—The total budget of the Organization for the next four yearly period was fixed at $1,700,000. This is somewhat less than the maximum figure to which the United Kingdom was prepared to go and resulted in a curtailment of the technical programme.

International Meteorological Organization funds.—It was decided to invest $50,000 of the surplus funds of the International Meteorological Organization, and to devote part of the income from this investment to the award of an International Meteorological Organization Prize for outstanding work in the field of meteorology. The first award is to be made to Dr Hesselberg who is retiring shortly from his appointment as Director of the Meteorological Service of Norway.

Assistance by Secretariat during and between sessions of constituent bodies.—A sum was included in the budget for the second financial period to cover assistance to constituent bodies during and between sessions. This sum included travelling expenses of Secretariat staff at meetings of Regional Associations and Technical Commissions and of Presidents of Technical Commissions; also it included partial financing of meetings of working groups.

New Headquarters building.—No decision was reached regarding the provision of a new Headquarters building for the World Meteorological Organization, but a sum was included in the budget to allow for the renting of accommodation additional to that already occupied.

Work of the Programme Committee.—*Adoption of technical regulations.*—There was a great deal of controversy about the adoption of technical regulations. In particular the registering with the Organization of "deviations" from a standard practice was not favoured by some delegates on the grounds that such a procedure savoured too much of "rack and screw methods".

It was decided that Chapter XII of "Technical regulations" which deals with "Meteorological service for international air navigation" should be published separately, and come into force on January 1, 1956; Chapters I–XI will come into force six months later.

Programme for the second financial period.—Twenty-two items for inclusion in the programme were listed in a Congress resolution. Some of the more important of these are meteorological telecommunications, World Meteorological Organization participation in the International Geophysical Year, preparation of meteorological guides and technical notes and comparison of instruments, in particular of radio-sondes and barometers.

Technical assistance.—There was criticism of the manner in which the benefits of the United Nations Expanded Programme of Technical Assistance were distributed. It was felt that the World Meteorological Organization, through its regional associations and Executive Committee, ought to play a greater part in deciding which countries should be assisted and which projects supported. The difficulty is that the country and not an outside body must ask for assistance in various fields and allot priorities to the various projects. It was left that the existing arrangements be continued, modified in the light of experience and development.

There was discussion as to whether the World Meteorological Organization should operate a regular Technical Assistance programme with funds under its own control. Objection was taken to the title of such a programme, and to avoid confusion and possible competition with the expanded programme, it was decided to recommend that the World Meteorological Organization include in its budget provision for the creation of an "Operational and Technical Development Fund"—a fund which would be devoted to remedying deficiencies in the pattern of world-wide and regional meteorology by encouraging the development of reliable meteorological services in areas of meteorological importance.

Items on the technical programme for the second financial period.—There was detailed discussion on some of the 22 items which were left on the technical programme for the second financial period—the arid zone, humid tropics and water-resource development projects of other specialized agencies, the preparation of a world climatological atlas, of a world meteorological bibliography, international meteorological guides and the formation of a film lending library.

As regards the International Geophysical Year, Congress decided that the World Meteorological Organization should accept the responsibility of becoming the collecting centre for essential meteorological records of the International Geophysical Year, and should prepare standard forms for the recording of meteorological data.

There was a good deal of discussion on the terms of reference of the Technical Commissions. It was generally agreed that some radical changes in the existing structure would have to be made in the interests of efficiency, but there was insufficient time during Congress to formulate the problem clearly. The existing Commission structure will therefore remain during the next financial period and plans for re-organization will be submitted to the next Congress.

CONFERENCE OF COMMONWEALTH METEOROLOGISTS, MAY 1955

By J. DURWARD, M.A.

The fifth Conference of Commonwealth Meteorologists was held in the Air Ministry, Whitehall Gardens, from May 23 to 26, 1955. The Conference was attended by delegates from all Commonwealth territories, by an observer (Dr. Doporto) from the Republic of Ireland, by representatives of the Naval

Weather Service, Colonial Office, Commonwealth Relations Office, and, for certain items on the agenda, by representatives of the Royal Society (Sir David Brunt), Ministry of Transport and Civil Aviation, and Ministry of Supply, in addition to various members of the staff of the Meteorological Office.

The Conference was opened by Lord De L'Isle and Dudley, V.C., Secretary of State for Air, who, in the absence of Sir Graham Sutton, because of illness, was introduced by Dr. J. M. Stagg. In his remarks the Secretary of State referred to the contributions made by Commonwealth meteorologists in the advancement of their science. He welcomed the appointment of Mr. D. A. Davies as Secretary-General of the World Meteorological Organization and Dr. Barnett of New Zealand as its first Vice-President. He continued, "As with rapidity of communications in the modern world, so we need rapidity in the exchange of ideas if we are to keep pace in meteorology with advances in other branches of science and knowledge. I believe that you will have this in the forefront of your minds as you meet in Conference." In lighter vein, he referred to some words from the voyage to Laputa by Jonathan Swift, " 'He had been eight years upon a project for extracting sunbeams from cucumbers which were to be put into vials, hermetically sealed and let out to warm the air in raw inclement summers.' But I recognize that your task like that of Socrates in his basket is with 'higher things' ".

Dr. J. M. Stagg was elected Chairman, and, before beginning the business of the meeting, he suggested that a message should be sent to Dr. J. Patterson former Controller of the Canadian Meteorological Service in view of his association with the Commonwealth Conferences over the years. The following telegram was accordingly despatched to Dr. Patterson.

"Weather Toronto for Patterson. At the opening session of the fifth Conference of Directors of Commonwealth Meteorological Services it was unanimously agreed to send greetings to you Dr. Patterson in recognition of your long and valued association with Commonwealth Meteorology and your work in connexion with earlier Conferences. The assembled Directors wish you continued good health and strength in the future and all success in your present work."

The formal business of the session consisted either in the examination of certain papers which had been prepared as congress documents or of an opening statement by an expert from the Meteorological Office.

Review of the resolutions of the 1946 Conference.—Many of these resolutions have by now been implemented and are in the main only of historical interest. Reference was, however, made to the paucity of ships' reports from certain areas. This shortage arises in many cases from the failure of the receiving country to disseminate the reports as quickly as possible.

It was also considered necessary to confirm a resolution of the 1946 Conference regarding the "Interchange of meteorologists between Commonwealth countries".

Dr. Sutcliffe, having stressed the desirability of frost-point hygrometer observations by aircraft at high levels, was asked to circulate information to Canada, Australia and New Zealand on the fitting of such instruments to aircraft. This action might enable those countries to overcome the difficulties of making such observations.

Discussion on marine meteorology (opener: Cmdr Frankcom).—The most important question discussed was the improvement of the network of voluntary observing ships. The Commonwealth with 23 per cent. of the world's tonnage provide 34 per cent. of the "selected" ships. There was thus ample justification for the members of the Commonwealth planning their programme so that they benefit themselves in the first instance. An offer was made by Mr. Thomson (Canada) proposing to have on the Canadian "selected" ships' list, ships of British registry not on the British list. A general resolution to this effect was adopted.

Recruitment and training in the Meteorological Office (opener: Mr. H. L. Wright).—The main points brought out were the difficulty in getting recruits, the unattractiveness of forecasting as a career, difficulties in overseas territories of getting staff on "approved terms" and the added difficulty in some colonies because of impermanence of employment.

A resolution was finally adopted emphasizing the importance of co-operation between Commonwealth territories in training meteorologists and recommending that full use should be made by the smaller territories of the training facilities available in the larger territories.

Meteorology and aviation (opener: Dr. A. C. Best).—The discussion on Dr. Best's opening remarks was centred mainly on the accuracy and availability of aircraft reports, the best methods of using the observational data for the construction of upper air charts, the need for speeding up the collection of data and the need for increased accuracy in aerodrome forecasts.

Reference was made to the panel set up by the Institute of Navigation to discuss the problem of improving navigational techniques so that more accurate estimates of the wind could be made.

The construction of contour charts came in for some criticism especially from the representatives from tropical territories who rightly represented that the contour-chart technique was of no value in these areas, and thought that the only possible way of estimating upper winds was the statistical method weighted as necessary by any actual recent measurement available.

Mr. Ockenden remarked that the use of facsimile transmissions would help considerably for distributing processed data but not basic data. Mr. Thomson (Canada) described the coast-to-coast wire and radio facsimile network established in Canada which was working well.

As regards accuracy of aerodrome forecasts, Mr. Sellick thought that it was quite unrealistic to express cloud heights and visibilities to any high degree of accuracy 12 hr. or more in advance—a point of view shared by many others.

Gusts and turbulence (opener: Mr. J. K. Bannon).—This subject was included at the request of the Commonwealth Air Research Council. Mr. Grimes of the Ministry of Supply said that what was wanted was information on the maximum gust likely to be encountered, the shape of gusts and the frequency of occurrence.

It was decided that the prime responsibility was on aircraft pilots to report occurrences of severe turbulence so that Meteorological Services could make synoptic investigations into the really outstanding cases.

Numerical forecasting (opener: Mr. J. S. Sawyer).—Mr. Sawyer's opening statement, which was illustrated by lantern slides, evoked a great deal of interest, and the ensuing discussion was mostly in the form of questions to the opener: How long did the complete process take? Was any smoothing of the data required? Were more than two parameters necessary? Could one improve on the geostrophic relation? What hope was there for tropical regions where the geostrophic relation did not hold?

Dr. Sutcliffe summed up the tropical problem by saying that before numerical forecasting could be thought of in these regions, one had to know a great deal more of the tropical weather systems. There did not seem to be much real knowledge about this except that, according to Mr. Sellick, few systems (except some cyclones) extend to any great height.

Meteorological research including artificial control of rain (opener: Dr. R. C. Sutcliffe).—Dr. Sutcliffe described the main research activities of the Meteorological Office under the main branches, climatological, forecasting, physical, instrument development and special investigations. In answer to Mr. Thomson (Canada) he described how the research and operational staff were brought together by colloquia at Dunstable and Harrow and by discussions in London. Co-ordination between the Office and the universities was effected largely through membership of the Meteorological Research Committee.

A desire was expressed that progress reports on research projects should be circulated amongst Commonwealth Meteorological Services. It was not enough to see only the finished product.

Dr. Schumann (South Africa) made a strong plea for the publication of world maps of temperature and wind at different levels for each month of the year. He regarded this as a project of the utmost importance.

On the problem of artificial control of rain, the principal speakers were Dr. Sutcliffe, Mr. Thomson (Canada), Dr. Naqvi (Pakistan), Mr. Davies (East Africa) and Dr. Basu (India). Mr. Thomson said that seeding by means of silver iodide generators had, according to a statistical analysis, caused a decrease of 14 per cent. of rain over the target area, a result which Dr. Naqvi explained might be because silver iodide discharged from the ground had lost its effectiveness as a nucleating agent before it had reached the freezing level. Dr. Basu stressed the importance of carrying out experimental work over several years. An increase of 15 per cent. in one year of the rainfall in an area of very low rainfall was of no significance.

Current methods of forecasting (opener: Mr. S. P. Peters).—Mr. Peters described the data now available, and how it was handled. The main "products" of the forecasters' skill were prebaratics and forecast thickness isopleths. The great problem, however, remains that the derivation of a forecast from a prebaratic does not lend itself to computation and increased accuracy is hard to come by.

Mr. Sellick spoke to a paper he had submitted as a conference document on forecasting in Rhodesia and Nyasaland. The subsequent discussion showed that it was difficult to make any progress with the problem of tropical forecasting until the nature of the weather system had been established. A pattern was required to which the Services could work. Some Services had tried to work on waves in the easterlies or on the intertropical convergence zone but with little success. It was felt that the drawing of and forecasting the movement of stream lines were very important but they would necessitate a good network of radar wind stations.

There was discussion on the setting up of an institute of tropical meteorology. The idea was abandoned, but a resolution was agreed for the setting up of a small research team working in a tropical Commonwealth territory, but looked after by the Meteorological Service of one of the major Commonwealth countries. The United Kingdom was regarded as the best sponsor for such a project.

Commonwealth participation in the International Geophysical Year (opener: Mr. H. W. L. Absalom).—Sir David Brunt, on behalf of the Royal Society, attended the meeting at which the programme was discussed. Most territories indicated the extent of their programme, some suggesting additional items such as measurements of hygroscopic nuclei and others indicating that in low latitudes the number of radio-sonde observations could very well be reduced from four a day.

It was reported by several Colonial delegates that they were not being kept in the picture regarding the International Geophysical Year, and Sir David Brunt agreed to raise the matter at the next meeting of the National Committee for the International Geophysical Year.

Meteorological instruments and instrument supply (opener: Dr. F. J. Scrase).—Dr. Barnett (New Zealand) also spoke to the document submitted by him on the M.E.7 (radar wind equipment). The general discussion is summed up in the resolution passed that

The Conference, considering the desirability of

(i) lowering the cost of meteorological instruments through steps towards standardization,

(ii) reduction in the number of designs required for particular requirements,

(iii) stating the specifications of particular instruments so as to cover as wide a field of requirements as is practicable,

resolved that the Meteorological Services of the British Commonwealth should co-operate in the development of standardized instruments by exchanging promptly all specifications which they develop and inviting comment on the principles or details of the design.

The detailed discussion centred around the development of

a simple radar wind-measuring equipment
a replacement for the Dines anemograph
a low-level (2,000–5,000 ft.) radio-sonde balloon
an instrument to give a measure of the evaporation from a free surface
precision aneroids.

On the social side the Conference enjoyed the hospitality of the Air Council, The Royal Meteorological Society and Messrs Muirhead, Messrs Decca Radar and Messrs Mullard.

The Conference was a great success owing to the able chairmanship, to the friendly atmosphere, the eagerness of delegates to learn about the latest developments and to ventilate the problems peculiar to their own territory. There is no doubt that the opportunity to get together in this way and get to know one another's personal characteristics is of a definite personal and official advantage.

SOME EFFECTS OF SHELTER-BELTS AND WIND-BREAKS*

By R. W. GLOYNE, B.Sc.

Introduction.—Considerable information is available concerning the physical and biological effects of wind-breaks and shelter-belts, although, owing to the difficulties inherent in field work and to the complexities of the interactions involved, the accuracy and reliability of this information varies widely.

Most of the pioneer work has been carried out in hot arid regions of the world, and this, together with the fact that the action of a given belt is decisively affected by its physiographical and climatic setting, makes necessary a very critical examination of the conditions under which any results were obtained before they can be applied to the British Isles.

Physical effects of shelter-belts and wind-breaks.—A barrier will alter the air flow (mean flow, and vertical and horizontal gradients of flow) and the flux of radiation (direct and diffuse) towards and from surfaces within the "zone of influence" of the barrier.

These basic changes, acting singly or in combination and in conjunction with the properties of the surface (slope, aspect, roughness etc.), will effect consequential changes in:—

(i) Air and soil temperature—absolute values, vertical and horizontal gradients (in practice we are also concerned with the temperature of exposed surfaces).

(ii) Heat balance and exchange—heat changes, at natural and artificial surfaces (both wet and dry), by forced and free convection and by radiation.

(iii) Moisture content of the air—absolute and relative values, horizontal and vertical gradients.

(iv) Evaporation (i.e. water loss)—from open water surfaces, soil, evaporimeters, and through the plant (i.e. by transpiration).

(v) Erosion, transport and deposition of small particles—generally soil or snow, but also insects, spores, bacteria and pollution.

(vi) Properties of the soil—affecting the soil moisture by the influence on the amount of precipitation reaching the ground and on the subsequent loss by evaporation, run-off and percolation; affecting the soil freezing through the influence on snow-cover and shading; and affecting the mechanical properties related to cultivation and "trafficability".

An essential prerequisite for an estimate of the effects due to a barrier in any given case, is an adequate appreciation of the interaction between the sheltering from the wind and the shading from sun and sky. The data which follow have been selected as being appropriate to conditions in the British Isles. Consequently relatively recent work from Denmark, Holland, Germany and Switzerland has been drawn upon, in preference to the older and more widely known results obtained in Russia, the United States and elsewhere.

When considering the results of field work in this subject, it is particularly important to consider critically the instruments used and techniques adopted for the measurement and analysis of the meteorological factors. The limitations so revealed have been given due weight in the presentation of the results to follow.

*This paper is based upon one presented to the Committee on Hedgerow and Farm Timber of the Forestry Commission, and is published with their permission.

Reduction in mean speed of the wind.—For convenience barriers may be classified into open barriers (density or "blockage-ratio" less than 40 per cent.), medium dense barriers (density 40–80 per cent.), and dense barriers (density 80–100 per cent.). It is assumed that the density is uniform over the face of the barrier.

Wind speeds in the protected area are normally expressed as a percentage of the simultaneous wind speed in the "open", the measurements being made at some convenient reference height less than the height of the barrier and generally between 4 and 6 ft. (see Table I). If, in addition, horizontal distances are measured in terms of the height *h* of the barrier, scale effects are, for practical purposes, eliminated. Although some effects can be detected certainly at 60*h*, and possibly to greater distances, for most purposes effects beyond 30*h* or 40*h* may be ignored. These percentage figures are valid for "free" wind speeds of between about 5 and 20 m.p.h., and for many purposes hold sufficiently well for higher speeds, say 25 m.p.h.

TABLE I—TYPICAL VALUES OF THE HORIZONTAL WIND SPEED EXPERIENCED BEHIND BARRIERS OF DIFFERENT DENSITIES

Down-wind distances measured in terms of the height *h* of the barrier

Type of barrier	Wind speed at distance down wind of								
	0*h*	2*h*	5*h*	10*h*	15*h*	20*h*	25*h*	30*h*	40*h*
	percentage of "free" wind speed								
Open (density about 30%)	90	80	70	75	85	90	95	100	100
Medium dense (density about 50%) ...	40	25	20	25	50	60	75	90	100
Dense (density about 100%)	0	20	40	65	80	85	95	100	100

Typically, the dense barrier gives rise to a region of still air immediately to its lee, followed by a rapid recovery in speed, giving but little reduction beyond 20*h*.

The medium dense barrier (a barrier of density 60 per cent. is found to give the best results) allows air to filter through, thus avoiding complete stagnation, and producing a minimum speed equal to about 20 per cent. of the "free" speed at 3*h*–5*h* down wind with a relatively slow recovery to 60 per cent. at 20*h*, and to about 100 per cent. at 40*h*.

With a very open barrier (such as is presented by close-mesh wire fencing) the wind speed is reduced to perhaps 70 per cent. of the free value at 5*h*, but usually beyond 10*h* there is hardly any reduction. The absolute height of the barrier, the wind speed and the stability of the air modify the results, but not to an extent sufficient to prejudice the general applicability of the figures quoted.

It is generally agreed that straightforward cumulative effects do not arise with a succession of simple barriers set 40*h* or more apart.

Eddies and turbulence.—Eddies form in an air stream when a barrier is encountered, and behind an impermeable barrier such eddies cause damage to crops. Indeed, the benefit to certain easily bruised crops (e.g. tulips, citrus fruits), expected from the reduction in wind speed caused by an impermeable barrier, may be completely cancelled out by the damage caused by eddies.

It is found that an eddying type of flow is mainly confined to a zone 10*h* or 15*h* down wind from the barrier, and the motion in the remainder of the wake (recognizable at any rate to 40*h*) can in practice be regarded as a mean horizontal flow with relatively small-scale turbulence superimposed upon it.

An eddying region can be identified until the density of the barrier becomes as low as 20–30 per cent., although little damage to crops appears to occur with barriers of density less than 50 or 60 per cent. (this is the density of the most efficient barrier regarded from the point of view of evenness of wind reduction over a wide strip).

Modifications in air flow induced by barriers of limited cross-wind length and of considerable thickness.—Even if the wind approaches a barrier at right angles, it will "cut-in" around the ends so reducing the area effectively protected, and when the wind blows obliquely to the barrier, the protected area is further reduced. It must be remembered that only at particular sites will the wind always approach from one or two very limited ranges of direction, and only in special circumstances will it be winds from only one direction against which protection is desirable. To obtain the full benefit from a barrier of height *h* it must have sufficient cross-wind length—one of length about 20*h* is hardly sufficient.

The protective effect of a dense barrier formed by a thick belt of trees (at least 40–60 yd. thick) is much as is given in Table I, but the vigorous eddying inseparable from a narrow dense barrier seems to be much reduced with a wide barrier such as that formed by a plantation of trees whose canopy presents an extensive and very rough surface to the air stream. If the tree belt is very deep (of the order of miles) then the protective effect in the lee margins exceeds the values quoted in Table I (e.g. 100 per cent. at 60*h*–70*h* instead of 40*h*)[16].

Although, as mentioned earlier, there is no indisputably convincing evidence of a cumulative influence exerted by a succession of narrow barriers set 40*h* or more apart, a succession of large plantations does appear to exert such an effect. This, however, is as likely to be due to a progressive reduction of the general wind (which reduction is very difficult to determine in such circumstances), as to a straightforward cumulative shelter effect. There is evidence, however, that the decrease of protected area due to "end-effects" is reduced by a succession of parallel barriers, and indeed that the protected zone extends laterally to a further 7*h*–12*h*, and in this sense some cumulative protection is achieved[34].

Shading.—The extent of the shadow will depend on the orientation of the barrier, but its importance will depend upon the amount of sunshine—especially in the six months October–March—and near a dense belt the loss of light is quite sufficient to depress growth in the spring.

As well as the direct effect upon illumination, the shading will affect soil and air temperatures (including the extent and intensity of freezing), water loss and soil moisture.

Little investigational work has been done on the influence of various types of barrier upon illumination reaching the surface. Bates's work[18] almost stands alone, but his results are not directly applicable to conditions in the British Isles as he was working in the presence of continuous, rather than intermittent, sunshine.

Soil temperature.—Temperature at or near the ground surface fluctuates markedly in response to sunshine and to direct shading, but the contrast between temperatures in shaded and unshaded areas decreases with depth.

The Dutch workers Van der Linde and Woudenberg[31] report an occasion when temperatures at a depth of 4 in. in parts of a wind-sheltered area exceeded those in the open by up to 6°F.; such an excess was transitory and rather greater than the values reported by other workers. In the immediate shadow the corresponding temperatures were at times 2–4°F. lower than in the open. Differences tend to disappear at night, in overcast weather, or when winds are strong.

Air temperature.—In conditions of light wind, temperature in the protected area exceeds that in the open during those parts of the day when there is a net gain of radiation at the surface, and falls below it when the surface is, on balance, losing heat[20]. In regions subject to long spells of clear skies the mean temperature over a 24-hr. period differs little between sheltered and unsheltered areas. In our conditions of intermittent sunshine there is a small net gain over the 24 hr. unless the barrier is so sited as to form a frost "pocket" on still nights, when the net effect may be negative[31].

In the Dutch investigations the highest day temperature occurred in the protected zone just beyond the limit of the shadow[31]. The largest temperature increases were of the order of 2–3°F. at 4 ft. from the ground and about twice that amount at 4 in.; these differences occurred within a strip $5h$ or less from the barrier. At night the position of the minimum temperature appeared to be closely linked with that of the minimum wind (a secondary minimum was also identified immediately behind a live barrier[31]). At 1–2 ft. above the surface, minimum temperatures were of the order of 1°F. lower in the sheltered than in the unsheltered areas, little difference being reported at 4 ft. The same workers[31] report anomalously high maximum temperatures in unshaded but sheltered margins.

Recently Kreutz[25] has published results showing an increase of 4½°F. in maximum and a decrease of 2½°F. in minimum temperatures a foot or so from the surface within the close network of artificial and natural screens.

With "free" wind speeds between about 5 and 12 m.p.h. temperature differences become insignificant beyond about $10h$; with stronger winds both the temperature differences and the area affected decrease.

Heat balance.—The heat exchange of a body exposed to the elements, besides being a function of the physical and geometrical properties of the body, is affected by wind, humidity, direct and diffuse radiation as well as by the air temperature measured in the meteorological screen.

These considerations are particularly important with livestock, and, in practice, every case must be considered on its merits. The potential benefits of a shelter-belt to livestock must not be judged with respect to the changes caused in air temperature alone.

As regards buildings it is reported[34] that the heat loss from a house is about doubled with an increase of wind from 5 to 20 m.p.h., and that in the central regions of the United States the fuel bill can be reduced by up to 40 per cent. by exploiting the protective effect of shelter-belts.

Humidity.—Within a zone extending down wind for about $10h$ to $15h$ from the shelter, absolute and relative humidities in the middle of the day are generally higher than in the open. The differences are, however, small beyond about $5h$. Within the narrower zone, typical values[31] for the increases a foot or two from the surface are 5–10 per cent. for relative humidity and 1–3 mb. for absolute humidity in conditions when the general level is about 10–16 mb.

In the very disturbed eddying flow behind a dense barrier both absolute and relative humidity may be lower than in the open due to the increased loss of water vapour by eddy diffusion. In the high-temperature zone adjacent to an unshaded but sheltered margin, similar differences occur[31].

Dew-fall is higher in the protected zone, being appreciably greater near to the belt[25]; this effect extends down wind to 5*h* or 10*h*.

Evaporation.—Practically all investigators, and especially the earlier ones, attach great importance to the ability of a shelter-belt to decrease evaporation (or more strictly the water loss from various types of evaporimeters). Evaporation is very difficult to measure in a way free from serious criticism, but there is sufficient qualitative agreement between the various measurements, and ample biological confirmation, that the "evaporative potential" imposed upon the ground and upon plants is reduced by the interposition of a barrier. Results from some recent work[25] at the agricultural-meteorological station at Giessen, Germany, are given in Table II; it is not clear what type of evaporimeter was used. The similarity in trend of the results is of interest. No explanation is given by the author for the rather anomalous result at 2·8*h*—variability of that order is not uncommon in field studies however.

TABLE II—WIND SPEED AND EVAPORATION AT DIFFERENT DISTANCES FROM A HEDGE

April 5, 1949

	Value at distance from hedge of:					
	0·4*h*	1·6*h*	2·8*h*	4·0*h*	5·2*h*	6·4*h*
	percentage of "open" value					
Wind speed ...	52	59	63	61	74	80
Evaporation ...	70	80	84	80	86	95

Reviewing the mass of the data available it would appear that the effect of a barrier upon water loss:—

(i) is similar in pattern to that for wind speed but less marked in extent

(ii) extends to 5*h* or 10*h* and exceptionally to 20*h*

(iii) is strongly modified by direct shading

(iv) is a function of the absolute speed of the wind.

Snow cover, soil moisture.—Snow will tend to accumulate within, or be confined to, those regions adjacent to a barrier where eddying takes place. The region to leeward extends to about 12*h*–15*h* from a permeable barrier and rather less from a dense barrier, although in the latter case the maximum vertical extent of the region is greater[17].

Particularly if the snow falls before the ground is frozen, the soil will become saturated under the drifts. Surfaces clear of snow are more liable to freeze.

The differential supply of water to the soil is not, however, regarded as likely to be of importance in the British Isles, where, certainly in the hill areas, the soil in all parts is almost invariably at "field capacity" in the early spring. Under such conditions differences in soil moisture in the summer should be related to evaporation from the surface, or transpiration from plants. There appears, however, to be no suitable numerical data to quote, and the possible higher moisture content of the soil in sheltered areas can only be inferred from the behaviour of crops and the state of the soil surface. The soil will dry out less readily in sheltered areas which, from an agricultural point of view, may be a disadvantage.

Erosion, transport and deposition of small particles.—Wind erosion is a phenomenon of only a few well defined areas in the British Isles. Experience elsewhere[33] has show the immense value of barriers of all kinds, from forest-like plantations to slat fences and stubble, for stabilizing the soil.

Judging from the behaviour of snow there is a tendency for airborne material to be deposited in the shelter of a barrier. If such material consists of insects, spores and bacteria, the agricultural implications are obvious.

Some biological consequences of shelter-belts and wind-breaks.—In semi-arid regions shelter-belts are valued mainly for their ability to reduce the blowing of soil, and to mitigate the effect of strong drying winds; it is to this latter effect that the large increases in the yield of crops are attributed. In the British Isles, however, the areas where blowing is of consequence are limited in extent, and prolonged severe dessicating winds do not often occur. The benefit derived by crops from shelter in these islands is at least as much to be attributed to the reduction in physical damage and to other effects, as directly to the reduction in water loss. With livestock the main benefits can be traced to the reduction in heat loss. It would be out of place in this present survey to consider biological effects to any extent, but sufficient information will be given to enable the reader to judge of the importance of the subject in agricultural meteorology.

Shelter-belts are known to influence the growth, development, activity and productivity of plants and animals. Amongst the effects noted by various observers are the following:—

(i) Increase in yield of crops—linked with the reduced water loss, reduced physical bruising, slightly higher temperature and humidity in the protected zone. Often, however, shading is detrimental and the root competition from any trees or shrubs forming the barrier is usually disadvantageous.

(ii) Earlier crops—frequently the direct consequence of protection from the cold dry E. and NE. winds of early spring. An "early bite" of grass can be induced by the use of shelter-belts.

(iii) Better-quality produce—particularly of the leafy delicate crops and of fruit and flowers readily bruised by the wind.

(iv) Livestock benefit in many ways from protection afforded by barriers against cold winds (especially when in association with rain), against hot sunshine, and indirectly through the better herbage frequently to be found near shelter-belts.

(v) The balance of pests and predators is often altered by the interposition of a barrier (whether live or artificial) and this may or may not be an advantage. One advantage is the greater activity of pollinating insects when protected from boisterous conditions.

(vi) With fruit trees, benefit is claimed from the protection during blossoming time against cold winds with or without precipitation, and from the reduced risk of "windfalls" just prior to harvest. Protection against unseasonally warm winds in early spring (when the soil is cold and moisture uptake inhibited) is also beneficial.

(vii) The partial or complete stilling of the air by a shelter-belt can, however, give rise to a damp stagnant atmosphere and damp cold soil which can be detrimental, particularly by virtue of the encouragement to certain diseases of plants and animals.

Amongst the data of relevance to the British Isles, that contained in two important publications from Germany and Denmark by Kreutz[25] and Andersen[33] respectively, may be mentioned. Broadly speaking crop yields are increased by 10–20 per cent., and in certain circumstances by 50 per cent. or even more, within a strip extending $10h$–$12h$ down wind. Leafy and delicate crops gain more than do, for example, cereals which are detrimentally affected by shading. There is also risk of a softer growth in the sheltered area which is more vulnerable to insect or disease attack.

Kreutz reports that in the dry and warm season of 1949 there were increases of 57 per cent. in the yield of beans and 18 per cent. in the yield of fodder beet when grown in "cells" 18 m. × 12 m., having barriers of 1·8 m. high along the shorter sides and maize bordering the longer sides.

Andersen reports from Denmark a progressive decrease in average yield of apples (1922–31) from 627 Kg./hectare in a 36-m.-wide strip beginning at 14 m. from a shelter-belt, to 483 Kg./hectare in a similar strip some 200 m. from the protective belt. On the whole Denmark has a rather windier climate than the British Isles, and equally striking results may not be usual here, although there certainly are areas in the British Isles (e.g. the higher parts of Cornwall) where some shelter from the wind is essential before any reasonable commercial crop of vegetables or flowers can be grown.

In a current series of investigations on the effect of shelter, which are being carried out jointly by the Meteorological Office and the experimental horticultural stations of the Ministry of Agriculture, results of a type confirming the experience on the Continent are being obtained.

The effects on pests and diseases have yet to be studied properly, but some information is given by Schrodter[41]. On balance, in the British Isles, it is thought that the tendency for shelter to increase losses from disease and pests may be a major fact limiting its usefulness.

Notes on the effects of certain types of natural barriers.—*Isolated trees.*—These will present to the wind a narrow impermeable barrier for the first few feet, and above, a large semi-permeable canopy. We expect to find, therefore,

(i) some very limited protection from winds from every direction

(ii) a localized increase in wind speed around the sides of the trunk

(iii) vigorous eddying in the lee

(iv) a relatively large shaded area compared with the limited obstruction to wind near the ground.

That vigorous eddying does occur is confirmed by the frequent observations of "laid" crops near impermeable barriers and around isolated trees. The denser the canopy and, within limits, the nearer it is to the ground the more vigorous the eddies.

In respect of (ii) Geiger[21] reproduces some observations of Woelfle indicating regions where the wind speed reached 135 per cent. of the "free" wind adjacent to an isolated trunk rather less than a metre in diameter. These areas were displaced slightly down wind and approximately $1\frac{1}{2}$ m. from the centre of the trunk. In the same paper he quotes an instance[26] in which two rows of poplars bordered a roadway, the trees being 5 m. apart within the rows. Local increases of wind speed up to 120 per cent. of the "free" wind speed were recorded between the trees. The associated eddies would be detrimental on the whole to crops, but the shading provided by the spreading canopy could be of assistance to stock in hot weather. The competition for moisture and plant nutrients between the trees and the surrounding crop may be detrimental to the crop.

Copses and Spinneys.—The compact shape of these plantations will give shelter from winds from any direction, but the comparatively small cross-wind dimensions will lead to relatively large losses of shelter due to end effects.

The shelter from a square block 5 acres in area would, however, be appreciable, and such a plantation, even if the trees were widely spaced within it, could not fail to present an efficient barrier against the wind. The shading would be adequate for a large herd of cattle, but allowance must be made for the tendency of cattle to sterilize the area by their droppings.

Often plantations of trees will be used to supplement the protection obtained by farm buildings, in which case the benefit to livestock farming will be much greater than the limited acreage devoted to trees would suggest[36].

Roadside trees in belts up to 20-yd. wide.—This produces the "basic" type of shelter-belt, and if it can be maintained so as to give a medium dense barrier, and particularly if supplemented by a reasonably dense hedge, the effects listed earlier in this paper will be manifest in the most typical form. Even a belt of two or three staggered rows of trees, if properly maintained and accompanied by the shrub layer, can present an adequate barrier to the wind.

Problems of shelter plantations in hilly areas.—In hilly and particularly in mountainous areas the climate, the topography, and the characteristics of the soil will often dictate what trees to plant and where this can be done; the lack of choice, in effect, simplifies the problem. In most other respects, however, the problems are rendered more complicated than those encountered when considering the provision of shelter in flat areas.

In the first place a system of hills will control the air flow in a way not yet fully understood, and a realistic estimate of the effectiveness of any given belt demands a knowledge of the relationship between the actual wind experienced and the large-scale wind system. Whilst air flow alone might be studied with profit as an aerodynamic problem in the wind tunnel, no similar technique is available for the investigation of other features of the climate, which must therefore be undertaken in the field. Indeed it should be clear that in any practical case all factors involved and their interactions must be considered, and this will imply that a full appreciation of the broad climatic and topographical features is as essential as is the estimate of the local and microclimatic effects which the shelter-belt is expected to produce.

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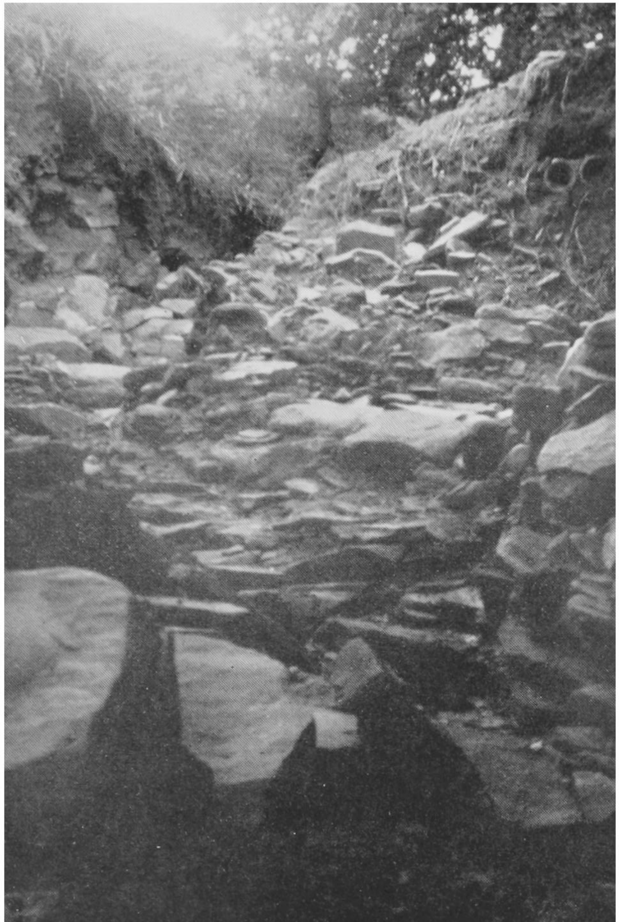
TORNADO SEEN AT LUTON AIRPORT, JUNE 8, 1955
(see p. 289)

COURSE OF THE TORRENT THROUGH THE WHEATFIELD
The ravine is 150 ft. long, 8 ft. wide and 5–6 ft. deep.

VIEW INSIDE THE RAVINE
The stones are slabs of Pennant grit.

RAVINE CUT THROUGH A WHEATFIELD

The torrent came down the mountain slopes shown in the background from a small valley behind the large tree on the right of the farm buildings (Gelli-hir Farm). The back of one of these buildings was smashed in by hundreds of tons of boulders (see p. 281).



VIEW IN TORRENT BED BEHIND GELLI-HIR FARM

The torrent scoured a channel 4–5 ft. deep in stratified grits.

GULLY ERODED IN ROAD TO TOR-Y-FRON FARM

The road had a macadamized surface over consolidated ash.

MORE FLOOD DAMAGE NEAR GELLI-HIR FARM

(see p. 281)

FLOOD DAMAGE IN FORMER MOUNTAIN STREAM BED BEHIND GELLI-HIR FARM
(see opposite)

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A SOUTH WALES THUNDERSTORM

By G. MELVYN HOWE

The thunderstorm which raged over a portion of the Llynfi Valley in mid Glamorgan during the afternoon of August 22, 1954 was undoubtedly the worst in living memory. It was of exceptional severity and the extensive flooding of roads and basements of houses and shops in the Garth district of Maesteg, together with the havoc caused by swollen torrents at the nearby Gelli-hir farm made the occasion unique and worthy of investigation. Fortunately such phenomena are relatively rare in any one area, though they are familiar from press reports. When they occur they invariably cause damage and considerable inconvenience; in this respect the Maesteg thunderstorm was no exception. Largely as a result of culvert blockage the drainage system failed to take the sudden rush of storm water and the inevitable flooding which followed led to traffic dislocation and considerable damage to roads and property.

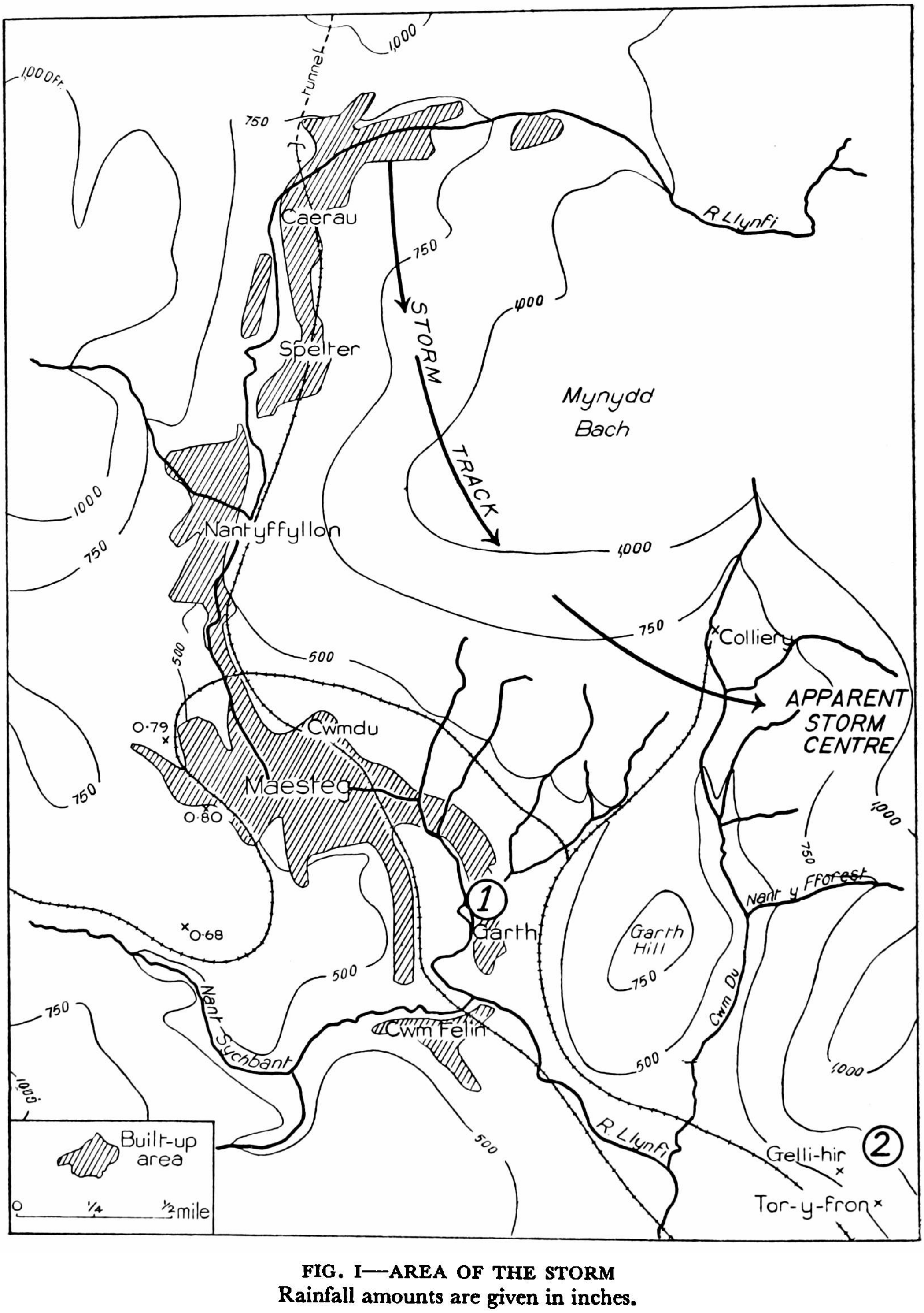

FIG. I—AREA OF THE STORM
Rainfall amounts are given in inches.

The storm.—On August 22, 1954 the convergence of unstable air in a trough of low pressure provided the explosive situation which was touched off by day-time heating. Thunderstorms were widespread, but that at Maesteg would appear to have been the most violent and spectacular. This storm developed near the head of the Llynfi Valley at Caerau at approximately 3.45 p.m., from whence it followed a half-mile wide track south-eastward (Fig. 1). It skirted Mynydd Bach (1,421 ft.), and then seemed to impinge on the amphitheatre-like area near the St. John's Colliery one mile north-east of Maesteg, and also over the watershed between the Llynfi Valley and the Garw Valley to the east. Here it remained for some 90 min. during which time the district was enshrouded in a dull red pall of cloud. The rainfall, which reached tropical intensity, was preceded by a particularly heavy fall of hailstones, the whole being accompanied by violent thunder and lightning.

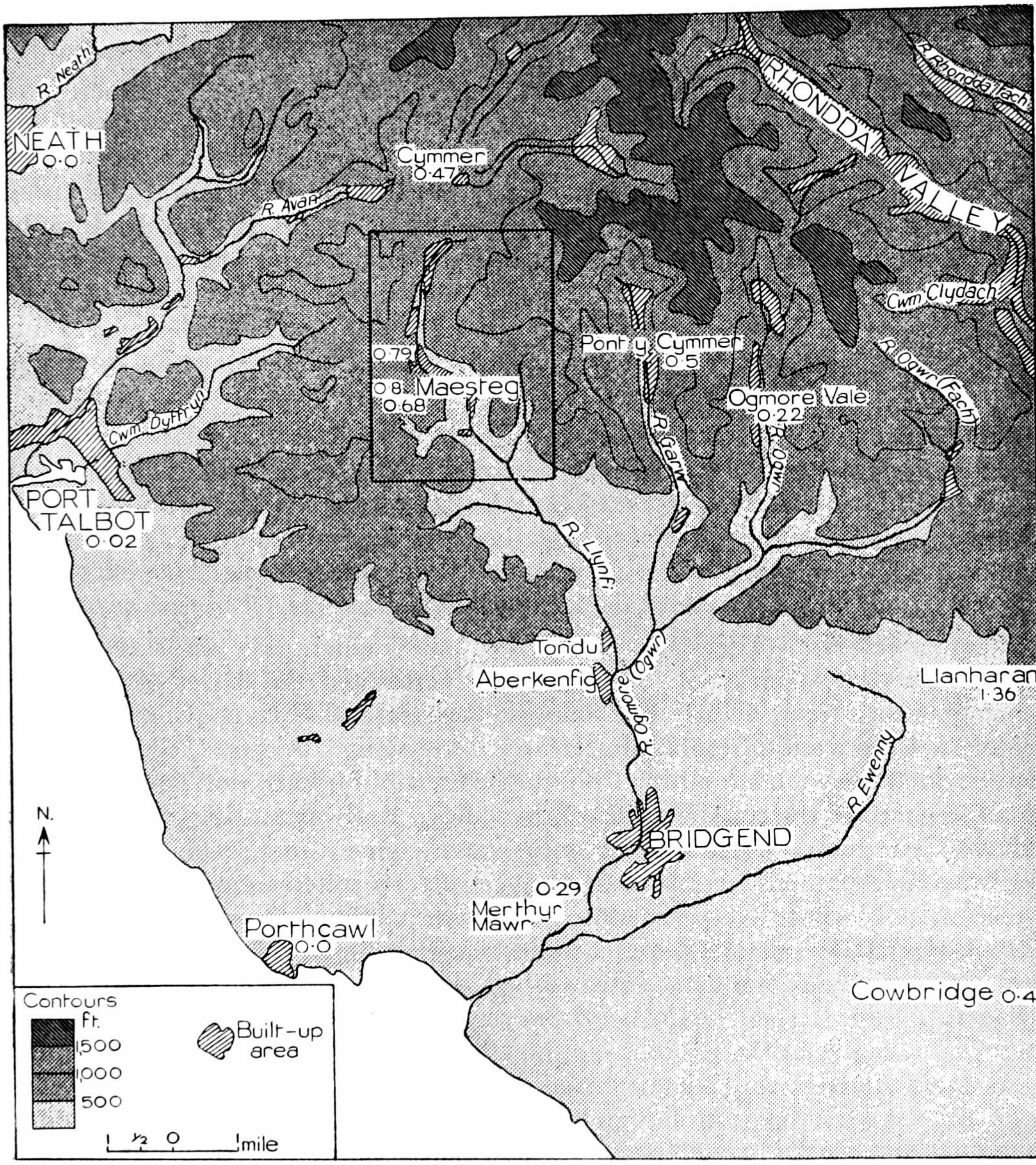

FIG. 2—MID GLAMORGANSHIRE
The area covered by Fig. 1 is indicated by the rectangle. Rainfall amounts are given in inches.

It is unfortunate that there was no rainfall recording station in the area which experienced the full effects of the storm, while a rain recorder sited in the Welfare Park at Maesteg, on the edge of the storm, was blocked by hailstones and consequently failed to register. A rain-gauge alongside the recorder and two other gauges, all sited on the western side of the valley and on the very fringe of the storm, gave the not unusual falls of 0·79, 0·80 and 0·68 in. respectively. Such falls would not even qualify for the "noteworthy" category[1] even though they occurred in the short space of 90 min. but it is the general opinion of numerous observers, borne out by the spectacular evidence of changes wrought in the land surface, that the rainfall was very much heavier on the eastern side of the valley. National press and B.B.C. reports stated that "nearly 4 in." of rain fell in the area during the storm period of 90 min. Such a fall in so short a time would appear highly improbable, and the claim probably arose from a local press report saying that "it would be no exaggeration to suggest that the rainfall over the Cwmdu (east) side of Maesteg was five times that experienced on the Hospital (west) side" (see Fig. 1). However, ten miles south-east of Maesteg at the village of Llanharan (see Fig. 2), where there was another, though much less severe, cloudburst, a "noteworthy" fall of 1·36 in. in 80 or 90 min. was recorded. Just how much rain and hail actually fell in the centre of the Maesteg thunderstorm during that terrifying and disastrous one-and-a-half hours will never be known, but it probably substantially exceeded 2·5 in. and most likely approximated to 3·0 in. In any case it easily qualified for the "very rare" category which is taken as a minimum of 2·52 in. in 90 min.

Little rain fell on the south Glamorgan coast (see Fig. 2). No rain fell at Porthcawl, 0·02 in. at Port Talbot and 0·28 in. at Rhoose (west of Barry). Inland at Schwyll, near Merthyr Mawr, and at Pwllwy, Aberthin, near Cowbridge, only 0·29 and 0·40 in. respectively were recorded. In the valleys eastward of the Llynfi, Pont-y-Cymmer in the Garw Valley received 0·50 in. and Ogmore Vale in the Ogwr Valley received 0·22 in. from the same storm. These aggregates spread over 24 hr. give only reasonably wet days and are not unusual in these parts. They also confirm the extremely localized nature of the downpour.

Storm effects.—The initial fall was of hail* which gave the surrounding hillsides a coat of unseasonable white and perforated the leaves of rhubarb, cabbage and trees. This was followed by torrential rain which rapidly converted the tranquil mountain streams into raging torrents. To these latter were added the waters resulting from the heavy and rapid run-off from artificial road surfaces on the eastern slopes of the valley. Railway cuttings on the slopes above Cwmdu were transformed into water courses and several sections of railway embankment were washed away. Culverts suited to more normal flow were soon blocked by storm water, and the narrow, though swift-flowing, Llynfi river failed to take the greatly increased volume of water. Tons of silt, pebbles and huge boulders were washed down the west side of Garth Hill (849 ft.), colliery spoil heaps were severely gullied and large amounts of soil were removed from the gardens of a new housing estate. The drainage system was unable to cope with the torrential rain and hillside torrents, and the covers of manholes were thrown feet high by the pressure of the exceptional and sudden

*It was thought that the covering of storm-water traps by up to 10-in. depth of hail was a contributory factor in the serious flooding that occurred in Maesteg, Tondu and Aberkenfig. Hailstones of up to 1 in. in diameter were observed.

rush of water. Considerable flooding followed, but fortunately, though numerous domestic pets were drowned, no human lives were lost (Area 1 on Fig. 1). On the east side of Garth Hill where the bulk of the storm water was conveyed to the Llynfi via the Cwm Du, the absence of houses meant that the greatly enlarged stream caused no serious damage.

A mile to the south-east of Maesteg at the hill farm known as Gelli-hir (Area 2 on Fig. 1), turbulent storm waters followed the former course of a mountain stream which has been piped away in another direction. The previously shallow and dry water course of gradient 1 : 4 to 1 :5 was filled to overflowing, and scoured to a depth of 4–5 ft. in stratified grits (see photographs in the centre of this Magazine). Yet this exceptional erosion and transportation of rock waste only occurred between about 500 ft. and 700 ft. above sea level. Above that height and towards the source of the dry stream bed and where the gradient was less steep (1 : 6) evidence of abnormal stream flow was completely lacking. Huge angular blocks of grit were dislodged from the stream bed and transported down the mountain side to crash into certain farm outbuildings. It was estimated that 1,000 tons of waste were deposited on and around these demolished buildings, some of the rocks being heavier than four men could lift. Two bullocks were engulfed in the torrent and crushed to death.

Below the farm buildings and further down the mountain side the turbulent waters scoured a trench through a field of wheat 150 ft. long, up to 8 ft. wide and 6 ft. deep. A typical vertical section in this trench showed 18 in. of top soil and the remainder subsoil derived from the underlying grits. The road leading to a neighbouring farm (Tor-y-fron) built of one foot of consolidated ash overlying heavy clay was scoured by a 2 ft. wide trench to a depth of 2–4 ft. (see photographs in the centre of this Magazine).

Conclusions.—The steep side of the Llynfi valley, so typical of all mining valleys in south Wales, undoubtedly aggravated the speed and volume of run-off after this exceptional storm. At the Llynfi power station, for example, down stream from Maesteg, the river was observed to rise 7 ft. within 45 min. while the larger Ogwr River, into which the Llynfi flows, rose 5 ft. at Bridgend. A gauging scheme for the mid-Glamorgan rivers has yet to be introduced, and so volumes of discharge for the various streams and rivers are not available. It has been estimated however that, at the peak of the flood, discharge in the Ogwr at Bridgend was of the order of 7,000 cusecs; it would be very difficult to hazard even a guess for the Llynfi discharge.

The effects of the cloudburst on the landscape have been briefly outlined, and from them one is led to agree with what Prof. Austin Miller wrote in connexion with a 1944 cloudburst in the Mawddach Valley in north-west Wales, "The conclusions justify the belief that rivers do their geological work in sudden spurts; one great flood can achieve more erosion and transportation of rock waste than centuries of normal behaviour"[2]. On the other hand one cannot but speculate on what the human effects would have been had the circumstances been but slightly different. In the first instance the fact that the rain fell in a local thunderstorm was important, for it meant that the downpour was limited in its effects. Had the torrential rainfall been more widespread within this densely populated area or occurred further up the Llynfi Valley in the vicinity of Caerau, or even been displaced slightly to the east or west over the neighbouring and densely populated valleys (see built-up areas in Fig. 2), the effects of the storm would have been catastrophic. Instead, and unique among the mid and east Glamorgan valleys, the Llynfi Valley opens out into a fairly wide strath below Maesteg. The collieries and close settlement of the narrow, trench-like valley up stream of Maesteg are replaced by a few scattered farms in a typically rural setting. Consequently, when the storm impinged over the mountain side south-east of Maesteg and resulted in an exceptional downpour in a limited area, the greatly enlarged Llynfi overflowed its banks in a relatively sparsely-populated area, and acres of meadowland rather than streets of houses were inundated. Equally significant was the fact that the Ogmore River, which is tidal to the town of Bridgend, was able to convey from the Llynfi the additional flow of storm water and discharge it into the Bristol Channel, a discharge which was possible only because the tide in the Channel during the period of the storm was on the ebb. Had the reverse been true and the incoming tide impounded the rush of flood water, the results in the large urban centre of Bridgend would have been incalculable.

Acknowledgment.—I have to acknowledge many valuable observations on the storm and its effects which were made by Mr. Lewis W. Jones, Engineer and Surveyor to the Maesteg Urban District Council, Mr. H. W. Adams, Manager and Clerk to the Mid-Glamorgan Water Board and Mr. W. E. Wright, Clerk and Engineer to the Glamorgan River Board.

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OFFICIAL PUBLICATION

The following publication has recently been issued:—

PROFESSIONAL NOTES

No. 114—A study of warm fronts. By A. G. Matthewman, M.A.

Some typical features of the structure of warm fronts with respect to temperature, humidity, wind and cloud are examined. An example of detailed analysis of a well marked warm front illustrates the large-scale and small-scale structures of the temperature, humidity and wind fields. The difficulties presented by the small-scale structure are discussed. The cloud structure is examined statistically in relation to the textbook models, and in relation to various parameters, usually or sometimes available to the forecaster. The best correlation of frontal cloud here achieved is with the difference between the speed of the surface front and the actual wind component normal to the surface front at the upper surface of the frontal zone, but this correlation coefficient is only about 0·5.

ROYAL SOCIETY

Radiative balance in the atmosphere

On Thursday, June 9, 1955, from 11 a.m. to 6 p.m. a discussion on the radiative balance in the atmosphere was held in the apartments of the Royal Society at Burlington House, London. There were 13 principal speakers; the earlier contributions were devoted to the lower atmosphere (troposphere and stratosphere) and the later ones to the region above 30 Km. All layers are meteorologically significant in that they give rise to radiative energy exchanges, one of the most important of which is the selective absorption of the incoming solar beam.

The discussion was opened with a general survey by Prof. H. S. W. Massey. To solve the problem of radiative exchange it was necessary to know, for all levels, the composition of the atmosphere, on which depend the absorption spectra and scattering phenomena. It was also necessary to know the distribution with height of one of the quantities, temperature, pressure or density, the other two being then deducible from the gas equation and the hydrostatic equation. For levels below about 30 Km. the techniques of measuring these quantities are mainly those employed in modern meteorology; above this level direct measurement using rocket-borne instruments has replaced the former indirect methods such as anomalous sound propagation and the observation of meteorites.

Dr. F. Moller considered the flux of infra-red radiation in the troposphere. In the lower and middle layers the most important factors are water vapour, clouds and haze layers. The radiative exchanges correspond to a general cooling in these layers of the order of 2°C./day. Near the tropopause absorption by carbon dioxide outweighs the emissive losses due to water vapour. Slides were presented showing the net radiative cooling at various levels with various types and amounts of cloud.

Mr. A. R. Curtis said that on the basis of reasonable physical assumptions it would be possible with an electronic computer to integrate the equations of radiative transfer with their variable absorption and emission coefficients over the necessary ranges of wave-length and height.

Dr. M. V. Migeotte described the fine structure of various absorption bands in the approximate range 3–24 μ of the solar spectrum, mostly obtained from spectroscopic observations on the Jungfraujoch. With the aid of slides he demonstrated that these bands are very complex; for example, the absorption band of ozone at $9{\cdot}6\mu$ when subjected to a high degree of resolution shows over 300 separate absorption lines.

Dr. G. D. Robinson said that recent work at Kew Observatory had been directed to estimating the atmospheric albedo from observations of the solar radiation received at the ground. This involves measuring the intensity of the direct solar beam and the diffused radiation due to scattering by cloud and other particles. These had to be balanced with the values of the solar constant and the absorption by atmospheric constituents which were known, and values of the absorption by dust and cloud particles which it was necessary to estimate. At Kew, for example, the absorption by atmospheric dust was estimated as between 5 and 10 per cent. of the incoming solar energy.

Dr. F. E. Jones, Dr. J. Yarnell and Mr. J. T. Houghton described various aspects of the work of radiation measurement in the upper air using instruments mounted in aircraft. There are numerous difficulties in instrumental technique not the least of which is to keep the spectroscope always pointed towards the sun when observations of the direct solar beam are required. One of the reasons for high-level work is to reduce the amount of carbon dioxide and water vapour between the observer and the sun, and it is found that the obscuration due to these constituents is much reduced at a height of 5 Km. Mr. Houghton described the measurement of the upward and downward components of infra-red radiation with the Houghton and Brewer radiometer mounted in a Mosquito aircraft of the Meteorological Research Flight. The upward flux of radiation was always greater than the downward but both were in reasonable agreement with the values estimated from radiation charts.

Prof. G. M. B. Dobson emphasized the importance for radiative exchanges of the distribution of water vapour and ozone in the stratosphere and upper troposphere, and he outlined the methods of measuring these quantities; both could be determined with satisfactory accuracy. In general, water vapour diffuses upwards and ozone downwards. The very low values of atmospheric water-vapour content (frost point 189° K.) found at about 15 Km. in the region of the British Isles are remarkable. It seems that they can only be explained by advection from the cold tropical stratosphere; it is suggested that this advection is an important feature of the general atmospheric circulation. It is difficult, however, to understand why the stratosphere in our latitudes does not gain water vapour by diffusion.

The remainder of the discussion, including contributions from Dr. R. M. Goody, Prof. D. R. Bates, Dr. R. L. F. Boyd, and Prof. R. W. Ditchburn, was concerned mainly with the very high levels of the atmosphere above 50 Km. and was of less direct meteorological interest. At those high levels it seems that Kirchhoff's law of radiative emission and absorption requires modification to account for the probable heat exchanges. There was reason to believe that at 200–300 Km. the temperature is of the order 700–800° K., while at the outer fringe of the atmosphere it is necessary to assume a temperature of 1,500° K. to account for the escape of helium.

LETTER TO THE EDITOR

Unusual halo phenomena

On February 5, 1955 at Wrexham there was a minor halo complex which was notable for the virtual absence of the halo of 22° and the persistence throughout the day of a brilliant arc of contact of the halo of 22°.

A period of continuous sleet in the early morning came to an end at 0845; by 0840 the low cloud had all dispersed leaving the sky uniformly covered with grey altostratus, through which the sun was visible, accompanied by a bright upper arc of contact to the halo of 22° and a sun pillar extending right up to that arc. Both these phenomena lasted practically all day afterwards, the former being particularly prominent, and one was able to watch continuously its change of shape with varying solar altitude. The sun pillar became a little shorter after 0930, but an inferior pillar of about 5° formed as well; and the upper part persisted until 1500. The arc of contact remained until 1600. The halo of 22° was seen on three occasions for a few minutes only, and was fragmentary and very faint. The left parhelion was visible from 0903 to 0920, and the right parhelion briefly at 0950. The upper part of the halo of 46° was visible for some time from 1147, and it was brighter than the halo of 22° had been.

S. E. ASHMORE

11 Percy Road, Wrexham, February 20, 1955

NOTES AND NEWS

Unusually low temperatures in Hong Kong

On the night of January 11–12, 1955 the minimum air temperature at the R.A.F. Station Sek Kong was 26·5°F. This is the lowest temperature recorded in the colony of Hong Kong since records were begun in 1884. The previous lowest was 32°F. in January 1893 at the Royal Observatory in the town of Kowloon. However, meteorological observations have been made at Sek Kong only since April 1951, and it is probable that even lower temperatures have occurred there in the more distant past.

On the morning of the 12th the aerodrome was extensively covered with hoar frost—a very rare sight in Hong Kong.. Unfortunately, no grass minimum thermometer is used at Sek Kong and the temperature near the ground was not measured. The night had been cloudless with little or no surface wind. The minimum temperature at the Royal Observatory on the same night was 41·3°F. On the previous night the minimum at Sek Kong was 35·6°F. and at the Observatory 37·6°F. The latter temperature was the lowest for 55 yr. at the Observatory.

This remarkably cold spell of weather was caused by a strong surge of the winter monsoon on the western side of a depression which had moved eastwards across Japan. Very cold air from western Manchuria swept southwards across the eastern part of China.

Sek Kong is about 30 ft. above M.S.L., situated in a narrow valley about six miles south of the Chinese border. There are hills to 1,800 ft. on its north side, to 3,000 ft. on its east side and to 1,500 ft. on its south side. There is generally low ground to the west.

The latitude of Sek Kong is 22°26′N. The highest temperature recorded there during the last 3 yr. is 96·8°F. This compares with the absolute maximum of 97°F. recorded at the Royal Observatory in 1900.

R. G. HUGHES

An exceptionally cold day in May

May 17, 1955, will find a place in meteorological history as an exceptionally cold day for the time of year in many southern and central districts of England and Wales, and also as a day of unusually late snowfall.

On May 10 there was a sharp fall of temperature of more than 10°F. over much of the country due to an influx of arctic air around the eastern side of an anticyclone near Greenland. This cold northerly air stream persisted for more than a week, but was temporarily interrupted on the 17th by a depression which moved from Scilly across southern England to the southern North Sea. Heavy rain fell in south-east England as the depression approached, but after its passage the wind reverted to a northerly direction with renewed strength, frequently reaching gale force, while the rain turned to sleet or snow in many places. There had been fairly extensive ground frost in the north during the night—the minimum air temperature fell to 32°F. at Dyce and to 35°F. at Aldergrove—and this cold surface air was quickly brought southward by the gale-force winds.

The maximum temperature during the day was only 36°F. at Aberystwyth (Llety-evan-hen), Cardinganshire, and was 39°F. or lower at a number of other places in Wales and in the Pennines from Buxton to Moor House. There were many stations where the temperature rose no higher than 40°F., but among the lower-level stations the most notable was Ross-on-Wye where 40°F. was the lowest maximum temperature recorded in May since temperature records were first taken in 1875, and 2°F. lower than the previous lowest on May 13, 1915. During this long period there were only two other days in May—May 13, 1915 and May 3, 1892—when the maximum day temperature was below 45°F.

Over a wide area in Wales, the Midlands and southern England, as the wind backed to north behind the depression and the temperature fell by several degrees, rain turned to sleet or snow. Birmingham experienced its worst May snowstorm for 60 yr.; there were 26½ hr. of continuous precipitation which included a period of 8 hr. of sleet and about 2 hr. of snow. Further north 4 in. of snow fell at Malham Tarn and several roads were blocked by snow drifts in the Peak District, one by a drift 3 ft. deep. In the evening snow and sleet were reported from many places in the south and east, including the London area; snow fell for over an hour at Bournemouth, and in east Yorkshire and the east Midlands it lay extensively to a depth of over 1 in. Parts of Wiltshire and north Dorset had the worst mid-May snowstorm in the memory of the local people; snow fell all day accompanied by a high wind, and in many places snow lay to a depth of 3 in. In south Wales 3 or 4 in. of level snow lay extensively in the Merthyr, Brecon and Neath districts. Snow had not occurred so late in the year since 1902 at Bedford.

R. E. BOOTH

Funnel cloud at Luton, June 8, 1955

We are indebted to Mr. E. Pestell for the photograph of a funnel cloud facing p. 280 which was taken from Luton Airport at about 1430 G.M.T. on June 8, 1955. Notes on the phenomenon have been provided by him and by Mr. C. V. Smith, who observed it from near the Meteorological Office, Dunstable.

The cloud appears to have been over the outskirts of Luton, and both there and at Dunstable it was raining heavily at the time, with some thunder. Mr. Pestell first noticed that about two miles away two clouds were beginning to amalgamate and rotate. Their height was estimated at 800–1,000 ft. and this was later confirmed by aircraft observations. After 3–5 min. the funnel cloud extended apparently down to the ground over a hill about two miles away west-south-west from the airport. It then seemed to Mr. Pestell to recede as quickly as it had developed, but according to Mr. Smith it took 10–15 min. to dissipate gradually from the ground upwards, during which time it travelled north-east with the main body of cloud, trailing at an angle of about 45° to the vertical. As the decaying funnel cloud passed over Luton Airport black specks which might have been leaves or birds were seen whirling around in it. It was not raining at the airport when the cloud passed overhead, but some minutes afterwards a heavy thunderstorm broke out there and lasted for about two hours.

Weather had been thundery over the southern half of England since June 4. The instability developed ahead of a cold depression which was moving eastwards into the Bay of Biscay. A weak frontal belt extended east–west and may have contributed to the development, but winds were light at all levels in this region.

Retirement of Mr. P. N. Skelton, M.B.E.

Mr. P. N. Skelton, Head of the Instrument Supply Branch of the Meteorological Office, retired on July 9, 1955, after nearly 49 years' service in the Meteorological Office. Mr. Skelton, who was born at East Molesey, Surrey, in 1890, was educated at Alleyn's School, Dulwich and in H.M.S. *Worcester.* Having obtained a Board of Trade First-Class Certificate in Seamanship he was offered an appointment with the British India Steam Navigation Company but had to refuse it because his eyesight was below the acceptable standard.

Mr. Skelton joined the Meteorological Office at 63 Victoria Street as a Probationer in 1906. During his first year he worked in the Library under R. G. K. Lempfert and T. Duncan Bell and also on the *Weekly Weather Report* under A. J. Rigby and C. W. Heinemann. In 1907 he moved into the Instruments Branch under E. Gold and R. F. Wallace, but during the mornings he helped in the "telegraph room" where the *Daily Weather Report* was reproduced by "jellygraph". For the following three years Mr. Skelton was engaged in tabulating autographic records in the "Observatories' Room" at Victoria Street under R. H. Curtis and J. Sherman. He continued on similar work for three years after the Office moved to South Kensington. From 1913 to 1919 Mr. Skelton was at Eskdalemuir Observatory, first under L. F. Richardson and later under A. Crichton-Mitchell. For the first half of this period Mr. Skelton was in charge of the meteorological observations of the Observatory and, for the second half, the magnetic observations. In 1919 he rejoined the Instrument Branch, then under R. Corless, and continued in this part of the Office for the 36 years until his retirement. When, in the reorganization of the Office in 1948, an Instruments Division of three branches was set up, Mr. Skelton was appointed Head of the Branch concerned with the supply, testing and maintenance of equipment.

Mr. Skelton has always appeared as a tower of strength to his colleagues. When he was faced with the task of transferring the Meteorological Office Stores from South Kensington to Stonehouse, Gloucestershire, at the outbreak of the Second World War, and the much bigger task of moving to Harrow after the war, he took everything in his stride, and it was largely due to his efficient organization that these major operations were carried out so smoothly. His willingness to lend a helping hand when difficulties arise is a characteristic well known to those who worked with him. His long experience in instrument work gave him an encyclopaedic knowledge which, together with his technical ability, has been of very great service to the Meteorological Office. In 1942 he was appointed a Member of the Order of the British Empire, a well deserved honour which all his colleagues applauded. He was promoted in 1952 to the first Chief Experimental Officer post created in the Office. With his nautical education it was natural that Mr. Skelton's recreations should be aquatic. He was a good oarsman, a swimming champion of H.M.S. *Worcester*, and he took a prominent part in the swimming galas which the Meteorological Office at Stonehouse was able to hold during the last war.

Colleagues throughout the Meteorological Office contributed to a gift to Mr. Skelton on his retirement, and this was presented to him by Dr. F. J. Scrase at a large gathering at Harrow on July 8. All his colleagues wish Mr. Skelton a long and happy retirement.

REVIEWS

The English climate. By C. E. P. Brooks. 8 in. × 5½ in., pp. 214, *Illus.*, English Universities Press Ltd, 1954. Price: 12*s*. 6*d*.

This book gives a fascinating account of our climate as it affects us all in our everyday lives. Sir David Brunt in his foreword rightly says that Dr. Brooks has made climatology a subject of live human interest, and points out that too often in the past have books on climatology been crammed with indigestible facts. Perhaps the outstanding feature of the book is that even though it contains a wealth of information, particularly facts about unusual weather in the past, it is written in such a way that the dry figures come alive. It thus has the merit of being both a reference book for the professional meteorologist and a popular exposition of the subject which will hold the attention of anyone who takes an interest in the weather of these islands.

In his "Introduction" Dr. Brooks sets the scene with an account of the effects on its climate of Britain's position in the world. Chapters 2–5 deal with the effects of our physical situation in more detail. Chapter 2—Winds and warmth—shows how markedly winds from different directions control our weather and describes the characteristics of the main air masses which we experience. Chapter 3—Storms and squalls—after explaining briefly the development of depressions, discusses some outstanding storms, squalls and tornadoes, including an interesting reconstruction of the pressure distribution of the storm of November 1703 which was described by Daniel Defoe. A map showing the tracks of tornadoes which have occurred in England since 1638 is of special interest. Chapter 4—Rain, snow and hail—deals with the distribution of these elements, and also that of thunder, with special reference to some of the noteworthy floods, droughts, snowstorms, etc. of the past. There are two maps which, so far as the reviewer is aware, have not appeared elsewhere; one showing the average annual number of wet days and the other the distribution of what Dr. Brooks calls "raininess"—a combination of total amount of rain and its duration. Chapter 5—Fog and soot—describes the different types of fog and refers to notable London fogs of the past and to their effects, both on materials and mortality statistics. A map of the dirtiness of London's air based on data from various sources is of special interest; it shows, for example, how the parks form comparatively clean areas. Dr. Brooks quotes the example of Pittsburgh in the United States as showing that although the fog menace is constantly extending it is by no means insuperable. Chapters 6—Local climate—and Chapter 7—Climate and fitness—are perhaps the most interesting in the book. The first deals with the effects of type of soil, exposure and aspect, trees, houses and nearby water on the general climate. The second emphasizes the importance of changes in weather on health and energy, and outlines the present position in the largely unexplored field of bioclimatology. The author discusses the qualities which make a climate "bracing" or "relaxing", and is forced to the conclusion that it would be difficult to evaluate the bracing quality of a place from its meteorological statistics. Nevertheless he includes a map of bracing and relaxing climates, based on the assessments of Dr. Hawkins published over 30 years ago, which agrees fairly well with climatological expectations. The reviewer was surprised to note that Southport, where he lived for many years and always regarded as "relaxing" at least in the summer months, is included in a "bracing" area on the map. He cannot help feeling that a place which on the average has bracing characteristics may quite often be relaxing, particularly in summer when winds on the whole are lighter, and that one which is generally relaxing can often be bracing, particularly in winter. The chapter also includes a first attempt to map what Dr. Brooks calls the "energetics" of our climate. In preparing this he has taken into account, with what appear to be reasonable weighting factors, mean temperature, variability of temperature, frequency of thunder, number of wet days, sunshine and cleanness of the air. It suggests that the best places are along the south coast while the worst are industrial Lancashire, Glasgow and the extreme west of Scotland, but the author emphasizes that the range is not large considered on a world scale. Chapter 8—Where to live; where to holiday—is a practical summary of the two preceding chapters. Chapter 9—Seasons, saints and spells of weather—introduces the controversial topic of singularities and discusses their reality and possible causes. The main results of an investigation which Dr. Brooks, with the late Dr. J. E. Belasco, conducted in 1941–42 are set out, and are discussed further in the next four chapters, where these singularities form a background against which the weather of each season is discussed with special reference to outstanding occurrences in the past. It is unfortunate that the singularity graphs, as in the original article in *Weather*, are on too small a scale for the reader to extract with confidence the value for a particular day. This difficulty is emphasized when it is found that the actual values quoted on p. 140 do not always appear to fit the graphs. The tables in Chapters 10–13 which list the outstanding events in our weather history should be of special value for quick reference. It was of special interest to note that the February cold wave from Iceland, one of the singularities dealt with in some detail in Chapter 10, was strongly reproduced in 1955, when the sequence of events corresponded remarkably well with Dr. Brooks's Fig. 21. Chapter 14—Weather cycles and other prognostics—completes the book proper with an account of various periodicities and sequences in our weather which have been found or postulated by meteorologists, but concludes that there are no known methods of forecasting for more than a few days ahead, only statistical probabilities based on past weather which may go all wrong. Summing-up, Dr. Brooks considers that in spite of its occasional ugly moods our climate is one of the best in the world, the largest item in its favour being its health-giving variety. Chapter 15—The daily weather map—appears to have been added as an afterthought and might better have been called an Appendix. It briefly describes the surface synoptic chart, the weather charts that were televised by the B.B.C. at the time the chapter was written and the televised road weather maps.

A number of minor errors and obscurities were noted in the text and these will probably be corrected in a future edition, but a few of the more important may be mentioned here. In the table on p. 14, the source of which is not quoted, the figures for Scotland add up to 345 instead of 365; the number of days with NW. winds should perhaps be 41 instead of 21. On p. 32 we are told that line-squalls was the name formerly given to fronts; this presumably refers only to cold fronts. On p. 51 it is stated that thunder is most frequent in the southern Midlands; this is in conflict with p. 59 where it is stated, more correctly, that the greatest frequency is in Nottinghamshire. The table on p. 127 lists the main monsoon period of June 18–July 6 as an anticyclonic singularity, while the larger table on pp. 130–131 contains a column headed "Number" the meaning of which, namely "Frequency at peak date", could only be discovered by reference to the original paper in *Weather*. On p. 146 mean temperature at night is referred to when minimum temperature is clearly intended. The source of the dates of maxima and minima of daily rainfall in London given on p. 169 is not stated; they are not in agreement with the Kew Observatory data 1871–1950. Also, it is unfortunate that the specimen road weather maps in Fig. 27 are inconsistent with the commentary on them on p. 211.

The book is well produced and the illustrations are generally adequate. The low price, in these days of high production costs, helps to make it very good value indeed and a "must" on every meteorologist's bookshelf.

H. C. SHELLARD

Meteor astronomy. By A. C. B. Lovell. *Int. Ser. Monogr. Phys.*, 9½ × 6 in., pp. xvi + 464. *Illus.*, Geoffrey Cumberlege, Clarendon Press, Oxford, 1954. Price: 60*s*. net.

The study of meteors has been revolutionized since 1945 by radar observations. It was suggested in 1929 that meteors might be responsible for the observed sudden increases in the ionization of the ionosphere, and correlation of the visible flight of a meteor and a burst of ionization was obtained in 1932. It was not, however, until 1945 that radio methods, using British military radar sets, were systematically applied to the study of meteors. The radar echoes from most meteors are reflections from the ionized trail behind the meteor. A few meteors also produce strong reflection from the head of the meteor. The use of radar has, in particular, revealed the existence of great day-time showers of meteors.

The author of this book, Prof. Lovell, has been a leader in the application of radar methods to the observation of meteors. The book is not however devoted to radar methods alone. It is a comprehensive treatise on the masses, speeds and directions of motion of meteors based on old and new visual observations as well as on radar.

It does not deal with the physics of meteors to which the author hopes to devote another volume. The parts of the book of particular meteorological interest are those on the mass of meteoric material entering the atmosphere, in view of the recent suggestion by E. G. Bowen that meteoric dust may produce noctilucent clouds and condensation nuclei in quantities varying sufficiently to lead to variations in rainfall, and on the zodiacal light.

There are two types of meteor, the sporadic ones which appear quite irregularly and the "shower" ones which recur annually, though with marked variations from year to year, during short fixed periods. The showers are named after the stellar constellations, e.g. Geminids from the constellation Gemini, from which they appear to emerge. Using an assumption due to the American astronomer W. F. Watson relating the luminosity and mass of a meteor it is found that the sporadic meteors with 485,000 Kg. bring annually much more meteoric material into the atmosphere than the "shower" ones which account for 130,400 Kg. Roughly 10,000 Kg. of the shower mass is attributable to four major showers of which the Arietid and Perseid showers of June contribute 41,500 Kg. Thus, though the "sporadic" mass greatly outweighs the "shower" mass over the year as a whole, during the two or three days during which major showers occur the "shower" mass markedly outweighs the average "sporadic" mass. The book concludes with a discussion of the work of van de Hulst and Öpik on the relation between meteors and the particles which, by scattering sunlight, produce the zodiacal light. Van de Hulst's theory, based on the assumption that the size distribution of the scattering particles is the same as that of meteoric matter which gives their radii as predominantly between 0·1 and 1 mm., requires a density of scattering material some 10,000 times that inferred from meteor observations unless, as that writer has suggested, the particles are moving with velocities small relative to the earth. Öpik has shown that for astronomical reasons van de Hulst's explanation cannot be correct, and has suggested that very small particles are much more numerous in the zodiacal-light particles than would be inferred from available observation of meteors. Solution of the discrepancy awaits observation of very faint meteors produced by particles less than 10^{-3} cm. in diameter.

Meteorologists will look forward to the publication of Prof. Lovell's work on the physics of meteors, because of the important connexion between that subject and the structure of the upper atmosphere.

G. A. BULL

METEOROLOGICAL OFFICE NEWS

Academic successes.—Information has reached us that the following members of the staff have been successful in recent examinations; we offer them our congratulations.

Associate of the Royal College of Science (A.R.C.S.): Second Class Honours in Physics, J. B. Andrews.

City and Guilds—Telecommunications (Principles): Grade III, J. W. O. Rowe; Grade I, M. R. G. Sea (First Class pass).

Horticultural show.—The Air Ministry Horticultural Society held their annual show at Whitehall Gardens on July 12. The staff of the Office were represented in all three sections—flowers, fruit and vegetables. Miss H. G. Chivers, in addition to gaining prizes for flowers and fruit, was awarded (for a dish of superb red currants) the prize for the "best exhibit in the show". Other prize winners were Miss D. J. Wordsworth (flowers) and Mr. H. A. Scotney (flowers and fruit).

WEATHER OF JULY 1955

Pressure and temperature were decidedly below normal over most of the polar regions. The greatest anomalies were −8 mb. and −3°C., both over Greenland, as part of an extensive cold trough stretching far south into the western Atlantic, which seems to have been the most stationary feature of the atmospheric circulation in temperate latitudes during the month. Pressure was also 5 mb. below normal in another great trough extending to quite low latitudes over eastern Asia. East of the Atlantic cold trough the Azores anticyclone extended north-eastwards in a great quasi-permanent ridge of high pressure across the British Isles to northern Scandinavia and Finland, the greatest anomalies of +7 to +8 mb. falling over northern Ireland, Scotland and central Norway. Pressure was 2–3 mb. below normal over the Mediterranean.

Temperature was a little above normal over most of Europe and 2–4°C. above normal over much of the United States east of the Rockies.

Less than half the normal July rainfall was collected over most of Britain and Scandinavia, but there was excessive rain, up to three times the July normal, over central Germany and the Alps. Appreciable rain broke the dry season over Italy, Malta and Spain. Rain also fell in the Sahara south of 25°N. Rainfall was above normal over most of North America, especially the Rocky Mountains where over twice the usual falls occurred in many places, but a belt of dryness with only 30–50 per cent. of the normal rain extended from the Arctic coast of north-west Canada across all the north-eastern half of Canada to Newfoundland.

In the British Isles, apart from the first few days of the month when depressions moved eastward across Scotland, the weather was anticyclonic, with high pressure from the Azores region to Scandinavia, practically the entire month.

On the 1st widespread rain with local thunder accompanied a depression and its associated trough as it moved eastward across the country. The following day was generally sunny in the east, but a small and deepening depression from the Atlantic reached north-west Ireland late that evening bringing heavy rain to the west; several stations at 0900 on the 3rd measured 1½ in. of rain, which had fallen in 12 hr. Behind the depression on the 4th pressure over the country rose considerably and this began a spell of fine warm anticyclonic weather, with little rain apart from thunderstorms, which lasted till the end of the month. The weather had been cool for the first five days but a brilliantly sunny day over England and Wales on the 6th, when there were over 15 hr. of sunshine in the Channel Islands and south-west England, brought temperatures into the seventies in many places. On the islands and coasts of north and west Scotland sea fog and low cloud kept temperatures in the fifties for most of the month. The highest recorded temperatures on the 6th were in eastern Scotland where Dyce recorded 80°F. For much of the month the weather followed the same pattern day after day; easterly winds brought cloud inland at night, but this cleared from most areas during the morning to give fine warm days, except on the east coast where temperature was persistently below normal. The warmest period of the month was from the 11th to the 18th when temperature at Kew and many other places in south-east England rose above 80°F. daily and on the 17th reached 88°F. at London Airport. Thunderstorms, although scattered, occurred frequently during this period, and were often of unusual severity and accompanied by torrential rain, particularly on the 14th and 18th. On the 14th 1·02 in. of rain fell at Blandford, Dorset in 15 min., and at Croydon 0·79 in. fell from 1615 to 1630. Wind rose to 50 kt. in a squall at Croydon at 1620 during this storm although the mean hourly wind speed was only about 7 kt. A "very rare" fall occurred at Gnoll Reservoir, Neath, Glamorgan, on the 18th during a severe thunderstorm when 3·37 in. was recorded in 90 min. During heavy storms in south Dorset, which caused severe flooding, Weymouth and Dorchester each registered 7½ in. during 24 hr., of which 2·5 in. fell at Weymouth from 1530 to 1700. The highest total in 24 hr. that day was recorded at Upwey, Dorset, with 9·5 in. In spite of the large rainfall amounts recorded locally, July on the whole was a remarkably dry month with a long period of drought over most of the country. Over much of the west and Midlands there was no measurable rain from the 3rd or 4th till the end of the month, and even in the east most places had at least 15 consecutive days without rain. Many places had their driest July on record and, with a total of only 0·1 in. of rain, Gorleston had the driest July since records began in 1871. Sunshine was also an outstanding feature of the month. Many places, particularly in the western part of the country, exceeded their previous best totals for July; at Southport it was the sunniest month on record since before 1896. At many places it was the warmest July since 1939.

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 ...	90	34	+1·9	37	−10	146
Scotland	87	29	+3·0	37	−12	172
Northern Ireland ...	82	40	+2·3	51	−14	184

RAINFALL OF JULY 1955

Great Britain and Northern Ireland

County	Station	In.	Per cent. of Av.	County	Station	In.	Per cent. of Av.
London	Camden Square ...	0·23	10	*Glam.*	Cardiff, Penylan ...	0·59	19
Kent	Dover	0·79	37	*Pemb.*	Tenby	0·40	13
„	Edenbridge, Falconhurst	2·37	103	*Radnor*	Tyrmynydd	1·22	30
Sussex	Compton, Compton Ho.	0·80	28	*Mont.*	Lake Vyrnwy	1·16	33
„	Worthing, Beach Ho. Pk.	0·08	4	*Mer.*	Blaenau Festiniog ...	3·70	43
Hants.	St. Catherine's L'thouse	0·36	18	„	Aberdovey	0·85	24
„	Southampton (East Pk.)	1·33	58	*Carn.*	Llandudno	0·53	22
„	South Farnborough ...	0·47	23	*Angl.*	Llanerchymedd ...	1·32	46
Herts.	Harpenden, Rothamsted	0·20	9	*I. Man*	Douglas, Borough Cem.	2·58	84
Bucks.	Slough, Upton	0·66	34	*Wigtown*	Newton Stewart ...	1·77	56
Oxford	Oxford, Radcliffe ...	0·29	12	*Dumf.*	Dumfries, Crichton R.I.	1·96	60
N'hants.	Wellingboro' Swanspool	0·15	7	„	Eskdalemuir Obsy. ...	2·56	62
Essex	Southend, W. W. ...	0·59	30	*Roxb.*	Crailing...	2·00	69
Suffolk	Felixstowe	0·14	7	*Peebles*	Stobo Castle	3·16	109
„	Lowestoft Sec. School ...	0·25	11	*Berwick*	Marchmont House ...	2·42	79
„	Bury St. Ed., Westley H.	0·00	0	*E. Loth.*	North Berwick Gas Wks.	1·87	73
Norfolk	Sandringham Ho. Gdns.	0·30	12	*Midl'n.*	Edinburgh, Blackf'd. H.	1·56	55
Wilts.	Aldbourne	0·17	7	*Lanark*	Hamilton W. W., T'nhill	1·44	50
Dorset	Creech Grange... ...	1·06	43	*Ayr*	Prestwick	1·27	52
„	Beaminster, East St. ...	4·57	176	„	Glen Afton, Ayr San. ...	2·30	55
Devon	Teignmouth, Den Gdns.	2·79	120	*Renfrew*	Greenock, Prospect Hill	1·04	28
„	Ilfracombe	1·07	42	*Bute*	Rothesay, Ardencraig ...	1·11	28
„	Princetown	1·43	27	*Argyll*	Morven, Drimnin ...	0·74	17
Cornwall	Bude, School House ...	1·64	67	„	Poltalloch	1·40	34
„	Penzance	0·12	4	„	Inveraray Castle ...	1·92	39
„	St. Austell	0·18	5	„	Islay, Eallabus	0·36	11
„	Scilly, Tresco Abbey ...	0·09	4	„	Tiree	0·39	11
Somerset	Taunton	1·48	70	*Kinross*	Loch Leven Sluice ...	1·36	47
Glos.	Cirencester	0·14	5	*Fife*	Leuchars Airfield ...	1·22	47
Salop	Church Stretton ...	0·87	33	*Perth*	Loch Dhu	1·54	32
„	Shrewsbury, Monkmore	1·31	62	„	Crieff, Strathearn Hyd.	1·14	38
Worcs.	Malvern, Free Library...	1·27	56	„	Pitlochry, Fincastle ...	0·40	15
Warwick	Birmingham, Edgbaston	0·43	17	*Angus*	Montrose, Sunnyside ...	0·66	25
Leics.	Thornton Reservoir ...	1·03	42	*Aberd.*	Braemar	0·74	29
Lincs.	Boston, Skirbeck ...	0·35	16	„	Dyce, Craibstone ...	0·83	27
„	Skegness, Marine Gdns.	0·52	24	„	New Deer School House	0·50	16
Notts.	Mansfield, Carr Bank ...	1·14	44	*Moray*	Gordon Castle	0·95	30
Derby	Buxton, Terrace Slopes	1·21	31	*Nairn*	Nairn, Achareidh ...	0·59	23
Ches.	Bidston Observatory ...	0·57	22	*Inverness*	Loch Ness, Garthbeg ...	0·54	17
„	Manchester, Ringway...	0·92	28	„	Glenquoich	...	...
Lancs.	Stonyhurst College ...	1·06	27	„	Fort William, Teviot ...	1·50	31
„	Squires Gate	1·77	64	„	Skye, Broadford ...	0·97	18
Yorks.	Wakefield, Clarence Pk.	0·57	23	„	Skye, Duntuilm ...	1·32	35
„	Hull, Pearson Park ...	0·77	33	*R. & C.*	Tain, Mayfield... ...	0·40	15
„	Felixkirk, Mt. St. John...	1·19	44	„	Inverbroom, Glackour...	0·44	12
„	York Museum	1·04	41	„	Achnashellach	1·71	35
„	Scarborough	1·17	48	*Suth.*	Lochinver, Bank Ho. ...	0·82	27
„	Middlesbrough... ...	1·15	45	*Caith.*	Wick Airfield	0·35	13
„	Baldersdale, Hury Res.	1·16	40	*Shetland*	Lerwick Observatory ...	0·83	36
Norl'd.	Newcastle, Leazes Pk....	1·01	39	*Ferm.*	Crom Castle	1·56	45
„	Bellingham, High Green	1·69	51	*Armagh*	Armagh Observatory ...	1·83	63
„	Lilburn Tower Gdns. ...	1·68	68	*Down*	Seaforde	3·65	114
Cumb.	Geltsdale	1·78	52	*Antrim*	Aldergrove Airfield ...	1·23	44
„	Keswick, High Hill ...	2·63	68	„	Ballymena, Harryville...	1·16	34
„	Ravenglass, The Grove	3·35	89	*L'derry*	Garvagh, Moneydig ...	1·09	34
Mon.	A'gavenny, Plâs Derwen	0·13	5	„	Londonderry, Creggan	1·07	29
Glam.	Ystalyfera, Wern House	2·13	46	*Tyrone*	Omagh, Edenfel ...	1·51	44

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