Reviews

Polar Atmosphere Symposium, Part I, Meteorology Section, Editor, R. C. Sutcliffe, Pergamon Press, London, 1958, pp. 341, price 70 sh.

An exploratory symposium on the pressing problems of the Polar Atmosphere was held at Oslo from 2—8 July 1956 under the auspices of the Advisory Group for Aeronautical Research and Development (AGARD) of the North Atlantic Treaty Organisation (NATO). The publication under review is a collection of papers presented and discussions held at the Symposium. There are twentyone full papers and two abstracts arranged into four Sections with valuable combined discussions on the papers in each Section, besides the opening address by the Director of the AGARD and a thought provoking Introductory speech by the late Prof. Harald Sverdrup.

Section I contains four papers relating to Polar Climatology. 'Arctic Geography and Climate' gives the basic distributions of geographical parameters of the Arctic and Sub-Arctic in partial equilibrium with the existing climate. The second paper compares the Arctic and the Antarctic marine climates and points out the greater circumpolar symmetry and the smaller annual variations of the Antarctic climatic features relative to those of the Arctic, presumably due to the American and Eurasian continents. The next paper describes a significant rise in the winter temperatures of the Arctic during the years 1917—22, followed by a slow increase, the termination of this rise in the present decade and the consequences of such an improvement in the Arctic climate. The Section concludes with a brief review of the research work done (upto 1956) in Arctic meteorology with the help of available upper air soundings.

Section II contains five papers dealing with the general circulation over the Polar regions. The first two papers try to bring out the existence of anomalies in the average winter circulation patterns of the Arctic during the period 1948—55 with respect to the long-term mean, and their apparent teleconnections with the anomalies of the middle latitudes. These have an important bearing in the field of medium-range forecasting, and therefore needs careful study by all those engaged in the development of medium-range forecasting. A theoretical discussion of the maintenance of the Arctic anticyclones as a result of the influx of comparatively warm air aloft, forms the subject matter of one paper. The remaining two papers deal with winds and temperatures in the Arctic stratosphere upto the 50-mb level. A westerly Polar Night Jet Stream near the 30-km level, at the boundary between the dark and the sunlight stratosphere is discussed in some detail. There is also some discussion on the existence of stratospheric summer easterlies in the vicinity of the poles.

Section III contains five papers coming under the category of Arctic Weather Analysis and Forecasting. Based on the study of numerous vertical sections, one author emphasises the limitations in the application of methods of frontal analysis. In the opinion of one author the present network of upper air sounding stations over the Arctic appears to be adequate for numerical weather prediction over the area. One paper shows that cold lows and cold pools move according to the mean wind of the environment (300 to 500 km around the low-centre) at the 500-mb level. A few instances of the abnormal warming at the 50—100 mb level are mentioned and an opinion expressed that they may be due to a self re-enforcing process. Empirical rules for the forecasting of movement of sea level cyclones with the help of temperature and contour gradients at the 500-mb level, vertically above the sea level cyclone is given in the abstract of a paper. The Section concludes with a paper on the Quantitative Representation of Isobars and Contours of an Arctic chart using Fisher's orthogonal polynomials. Such methods are of great value in objective analysis as well as in modern synoptic climatology.

The Proceedings of the Polar Atmosphere Symposium, Part I, Meteorology Section, have also appeared as a Special Supplement to the *Journal of Atmospheric and Terrestrial Physics*, 1957

Section IV is the largest section and covers nearly half the volume. One paper deals with correlation coefficients between the ozone content at Tromso and various meteorological elements, two papers with sea ice conditions and their forecasting, two papers with different aspects of visibility and three papers with phenomena closely associated with radiation processes. One paper deals with the problem of taking meteorological observations in Polar regions. Since the most important energy transformations in the polar regions are related to processes of radiation leading to different types of stability conditions, papers dealing with radiation, inversions and allied phenomena have a special significance in a symposium on Polar Meteorology.

The results of one year's measurements of solar radiation at the Ice island T-3, 4° away from the North pole, are described in the first paper. The highest value of the solar radiation recorded there was about 890 langley/day in mid-June while the highest value recorded during the same June at Washington D.C., near 39°N was 680 langley/day. Evidence is presented to show that only a small fraction of the solar energy absorbed by the lowest air layers go to melt the ice, the rest being transmitted to the clouds through eddies.

The paper on "Long-wave Radiation and Turbulent Heat-transfer in the Antarctic Winter" contains valuable information on micrometeorology and deserves careful study by research workers in this field. The meteorological site on an ice-shelf at Maudheim, Antarctica, has apparently afforded conditions for study almost as ideal as those obtained by a physicist in his laboratory. Two of the important results are: (i) The outgoing radiation from the snow surface decreases from about 0.125—0.100 langley/min with no surface inversion, to about 0.05 langley/min with a well developed surface inversion of 20—25°C, when it becomes independent of the free air temperature above the inversion layer; and (ii) The turbulent heat transfer in langleys per minute is nearly 0.006 times the wind in metres per sec at 10 metres above the snow surface.

A paper on Lower Tropospheric Inversions at Ice island T-3, describes a new method of classifying inversion types and inversion intensities and presents a thorough analysis of 1100 ascents on such a basis. Some of the results of the analysis are: the annual mean value of the magnitude of a surface inversion is +17.6°C; the mean maximum annual inversion lapse rate for the surface inversion is 33°C per km; on occasions extreme inversions of 14.1°C in 7 mb and 17.2°C in 9 mb have been observed; and surface inversions occur even with mean winds of 12—16 metres/sec.

This collection of papers and discussions have served the double purpose of clarifying some of the meteorological problems of the polar regions and of stressing the importance of the scientific developments in those regions to the problems of middle latitudes. And if developments in Polar regions affect the middle latitudes, they are likely to affect the tropical latitudes also. Tropical meteorologists, therefore, have to keep themselves abreast of the scientific knowledge regarding atmospheric processes in the Polar regions and the volume under review is very useful for this purpose. Knowledge on Polar Meteorology is bound to increase considerably when the information collected during the International Geophysical Year is analysed and assimilated, and it is hoped that similar useful Symposia Volumes will be brought out in the near future.

P. R. PISHAROTY

Climatology: Reviews of Research, Arid Zone Research—X, Paris (UNESCO), 1958, pp. 190, price 25 sh.

At the invitation of the Government of Australia, the Arid Zone Research Council of the UNESCO organized an International Symposium at Canberra on Arid Zone Climatology with special reference to microclimatology from 17 to 20 October 1956 in collaboration with the World Meteorological Organization. The volume under review is essentially a report on the technical proceedings of the Symposium which comprised eight sessions (excluding the introductory and concluding meetings) covering a variety of topics from heat and moisture balance to animal and plant ecology with main emphasis on arid zones. In view of the diverse characteristics of the numerous papers presented at the different sessions of the Symposium, the UNESCO, for purposes of this review report, commissioned the services of experts in various fields for consolidating the entire material and contributing articles covering all the subjects that came up for dealing and discussion. Thus, the present report has eight articles, *viz.*, (1) Evaporation and the water balance by E. L. Deacon, C. H. B. Priestley and W. C. Swinbank; (2) Climatic factors in arid zone animal ecology by F. S. Bodenheimer; (3) Radiation and the thermal balance by A. J. Drummond; (4) Climates and vegetation by A. Vernet; (5) Proprioclimates of man and domestic animals by D. H. K. Lee; (6) The modification of microclimates by E. M. Fournier d'Albe; (7) The Chemical climate and saline soils in the arid zones by E. Eriksson; and (8) Climatological observational requirements in arid zones by M. Gilead and N. Rosenan.

Every article is in itself a thorough review of the present state of our knowledge in the respective field and the suggestions for further work which the authors have made at the end of each are worthy of serious examination in view of the rapid omnidirectional development of climatology. The extensive bibliography that follows individual papers is a distinguishing feature, as it was also in the previous UNESCO reviews on *Arid Zone Research.*

Apart from the immense research interest that the volume is bound to stimulate in all classes of (micro-) meteorologists, of special significance are the excellent review of evaporation and its measurement by the C.S.I.R.O. (Australia) Group, Drummond's plea for intensive studies in radiation climatology, Bodenheimer's reference to the inspiring discoveries of Rainey pertaining to aggregation and gregarization of locust populations in relation to the location of the Intertropical Convergence Zone, Vernet's praisworthy appeal for the simultaneous development of the three disciplines—climatology, pedology and botanical geography and Lee's work on physiological climatology in general and strain charts as a means for quantitatively studying an individual's reactions under different conditions of thermal stress, in particular. D'Albe's article covers those aspects of microclimate that Lee's on 'proprioclimate' does not and in this respect the two together are an exhaustive review of microclimatology with reference to plants and animals (including man), Eriksson's reference, in his paper, to the salinity investigations in the Rajasthan desert from the view-points of Holland and Christie on the one hand and Godbole and Auden on the other should be of immense interest to Indian Arid Zone scientists; his proposals for further investigations in chemical hydrology of arid zones are noteworthy. Gilead and Rosenans' paper on the observational requirements of the arid zones deserves special attention in view of the fact that it lists certain climatic parameters that are not usually observed at routine stations.

The publication thus has matter of considerable detail and importance which would not ordinarily be available to the researcher; its special virtues are its vast bibliography and valuable suggestions for new lines of work. The UNESCO deserves to be complimented for making available such an admirable and long-awaited volume which is a very welcome addition to a climatologist's library.

V. P. SUBRAHMANYAM

National Atlas of India (Preliminary Edition)—"*Bharat Rashtriya Atlas*" (Prathamik Sanskaran). Edited by S. P. Chatterjee, Director, National Atlas Organisation, printed at the Survey of India Office (H.L.O.), Calcutta: Dehradun, 1957. Price Rs. 100.00—Popular Edition.

The National Atlas Organisation deserves congratulations for compiling and processesing a huge amount of data collected from different sources and ultimately giving it a good pictorical form. The series of maps not only depicts the regional, physical and climatic features of the country, but also brings out in detail the socio-economic distributional patterns which are of great interest to people engaged in industry, trade, commerce and in planning activities. Each map has been drawn in great detail with all the latest available materials and will thus act as an extremely valuable guide not only to students but also to research workers. The loose leaf binding of the Atlas allows the maps to be extracted for special study etc.

In the 26 plates of the Atlas are given 21 maps on a scale 1:5,000,000, 16 maps on a scale 1:10,000,000 and 38 inset maps on smaller scales. There are also a number of larger scale inset maps covering smaller areas which are intended to bring out certain special features. The addition of English version of the legends and explanatory notes side by side with Hindi has been an advantage as it helps the non-Hindi knowing persons also to read and understand the maps. Very appropriately, this Atlas is the first of its kind in India in which the maps have been published using the metric system of units.

The maps in the Atlas may be grouped under the following heads, Administrative, Physical, Climatic, Economic, Demographic and Miscellaneous—Education, Health, Archaeology, Tourism.

Each group consists of a few maps explaining the different aspects of the subject. Although intended for general reference, emphasis has been laid more on the socio-economic aspect.

The Atlas has presented up-to-date information and depicted many aspects hitherto not so well known. However, a few doubtful points or inconsistencies have been noticed. Some of these are as follows:

It is not known why for depicting the flood affected areas of India in the inset map of Plate No. 5, the data for only 3 years have been taken into account. Probably a better map could have been prepared of the areas liable to floods, based on as many years data as are available.

The River Valley Projects, certainly an important item of interest, have been shown on too small a map and the project areas have been shown without the rivers actually harnessed for the purpose.

It is not known how the run off figures have been arrived at. The method followed for obtaining the run off values in different parts of India should have been indicated in the legend.

The following maps constituting the climatological series are included in Plate Nos. 6 and 7.

(i) Distribution of annual rainfall based on data upto 1940, (ii) Lowest annual rainfall expressed as a percentage of normal annual rainfall together with the frequency of famines, (iii) Highest annual rainfall expressed as a percentage of normal annual rainfall, (iv) Absolute maximum temperature, (v) Mean daily maximum temperature and wind direction (January), and (vi) Mean daily maximum temperature (May) and wind direction (July).

In the course of analysis of map No. (ii) above, it has been suggested that the occurrence of famine is frequent in areas where the rainfall in the driest year is less than 50 per cent of the normal value. It is felt that the amount of annual rainfall by itself is not necessarily such a specific criterion in this respect. It is the failure of rain during certain crucial stages of sowing and growth of the crops which is more important and is responsible for crop failure and may result in famine. Further, it is also not known whether the driest years corresponding to different regions in the map are also the famine years for those areas. Maps (v) and (vi) show the trends of the mean maximum temperature in the months. Perhaps it would have been better if the mean minimum temperature for January was shown instead of the mean maximum temperature (January) in map (v). This together with map No. (vi) would have given an idea of the average annual range of temperature. Wind direction of July presumably representing the winds in the monsoon season has been shown on the temperature chart of May; but utility of studying these two elements together is doubtful.

Plate No. 9 shows the location of working mines, mineral deposits etc., and also the distribution of workers in the mines and quarries. It may be pointed out that the two areas, *viz.*, Sikkim and Madhya Pradesh east of Katni have been shaded with colour tint V (*i.e.* 100—500 persons working in mines out of every 10,000 people), although practically no working mine or mineral deposits are shown to be located in these areas.

In Plate No. 10 the black cotton soils of the Deccan have been shown to extend much further south compared to the Trap rocks of the plateau (*vide* map No. viii). It appears to be doubtful that the weathering of gneisses and schists of the Carboniferous age along the Krishna-Tungabhadra basin has completely yielded the black cotton soil over the entire area. A definite answer to this question has to await an intensive soil survey in that area.

The Brahmaputra valley in upper Assam (Plate No. 12) is an area of good rainfall (75″—100″ per year) and is very frequently subjected to floods. The fact that the map shows a green patch suggesting that the valley area is under irrigation to the extent of 40—60 per cent seems, therefore, to require verification. The big inset map shows increase in the percentage of irrigated land during 1910—54. The Brahmaputra valley and the districts of 24 Parganas and Midnapore in West Bengal is shaded green suggesting 100—250 per cent increase in the irrigated area during the last 45 years (1910—1954). The areas in question have not taken up any major irrigation project during these years nor do they need any irrigation and as such these figures do not appear to be significant.

Plate No. 14 contains 4 maps, the one on the top left hand corner shows the growing of raw cotton and jute and their fabrication. By the use of different shades of green colour the different degree of intensity of cotton cultivation has also been indicated. Cachar valley in Assam has been shaded with green tint No. II suggesting that it stands second in importance in the intensity of cotton cultivation in India. Is this verified?

Plate No. 16 shows by colour tints the statewise per capita consumption of electric power. West Bengal consumed the highest amount, *i.e.*, more than 50 k.w.h. per capita. Next was Bombay with 40—50 k.w.h. per capita (*vide* col. 1, page 5). But in the map, Bombay has been shaded with a colour (tint VI) which indicates that the per capita consumption is only 30—40 k.w.h.—this needs correction.

The Atlas also suffers from a few other defects. The colour schemes adopted in the maps as well as the quality of the multi-coloured printing requires improvement. At places two adjacent colours are not easily distinguishable. Congestion of symbols also occur at many places thus introducing difficulty in reading the maps. The markings of latitudes and longitudes on the border of the maps are too faint and not visible at all. It is hoped that in the final edition it will be possible to improve upon some of the above features.

S. K. GHOSE

Announcement

We acknowledge, with thanks, the receipt of the paper (published as a booklet) "Meteor—Astronomical Universal Laws of Atmospherical Precipitation" by Hugo Melzer, Icaria Palace Hotel, Praia das Flechas, Niteroi, E. do Rio, Brazil. The book published in 1957 contains about 100 pages including figures, extensive tables, references, two supplements and the original version in Spanish.

We hope to publish a review of this interesting paper in the next issue of the journal.

Sir Gilbert Walker, C.S.I., Sc.D., F.R.S.

Sir Gilbert Walker died at Coulsdon, Surrey, on 4 November 1958 at the age of 90. While his scientific career falls naturally into several phases, he is best known to most of us for his work as Director General of Observatories in India during the years 1904—24. A few months before his death Sir Gilbert spoke to the present writer about his predecessors in India, mostly about Sir John Eliot, whom he knew personally, who (he said) had an outstanding flair for administration, who accomplished so much more than any single individual is normally expected to do and who finally secured for his successor the scientific assistance he had longed for himself. Sir Gilbert was anxious that the present generation should realise how much the Indian Meteorological Service owed to its founders, Blanford and Eliot. It is true that these two won for their Service a world-wide reputation. It is equally true that Sir Gilbert Walker, through his work, not only maintained but enhanced that reputation.

Gilbert Thomas Walker was born at Rochdale in Lancashire on 14 June 1868. His parents moved later to Croydon in Surrey and he went to St. Paul's School in London, where his teachers quickly recognised his remarkable gift for mathematics. In 1885 he was awarded a Mathematical Scholarship to Trinity College, Cambridge, and four years later he graduated as a Senior Wrangler or First Man of his year in the Mathematical Tripos in which the second place went to Frank Dyson, later Astronomer Royal.

Walker was appointed a Fellow of Trinity College in 1891, to which was added a University Lectureship a year or two later. This post allowed him opportunity for original work in the realms of electromagnetism and dynamics, for which an Sc.D. degree was conferred in due course. The *Indian Meteorological Department Administration Report* for 1924-25 recorded the sequence of Walker's Cambridge papers in some detail. Of his electrical papers, however, mention may be made here of an essay on *Aberration and some other Problems connected with the Electro Magnetic Field* for which the University of Cambridge awarded him an Adams Prize. It is of interest to recall also that after he went to India he gave in 1908 a series of lectures to the University of Calcutta, afterwards published in book form with the title "The Theory of Electromagnetism".

About Walker's dynamical researches at Cambridge the late Prof. E. T. Whittaker has written that it was currently believed among his friends that his dynamical interest originated during a visit to Australia where he saw boomerangs thrown by aborigines and resolved to investigate the theory of their flight. Papers on elongated projectiles, on dynamical tops and on boomerangs established him as an authority, in which the outcome was not only theoretical, for he became expert himself in designing and in throwing boomerangs and acquired at Cambridge the name of "Boomerang Walker". The editors of the massive "Encyklopadie der Math. Wissenschaften" invited him to write the article on "Spiel und Sport"; and the Royal Society of London elected him a Fellow in 1904 on the strength of the original work he had done in Cambridge.

In 1903 the Government of India invited Dr. Walker to succeed Eliot as Director General of Observatories. As meteorology was a foreign realm to him at that time he first of all visited meteorological offices in Europe and America and then, on arrival in India, spent a few months in close touch with Eliot both in Simla and on tour, before taking over charge on 1 January 1904. The early years of his directorship from 1904—09 were a most productive period both administratively and scientifically. Although a dynamical expert, Walker did not devote himself to problems in dynamical meteorology, partly because, as he has hinted to the present writer, he felt that exercises based on classical hydrodynamics would only produce answers which, however interesting in theory, would be unlikely to agree with observation. In any case he was faced with the more pressing problem of forecasting the monsoon, an annual task to which he had fallen heir, and all the more challenging because the devastating famine of 1899-1900 was still prominent in people's minds. So Walker accepted this as the main line of investigation. At the same time he allowed his scientific assistants, Field, Patterson and

Simpson to work on problems of their own choice; simultaneously at Kodaikanal Evershed was examining the spectra of the sun's surface. Field was the driving force behind all the early work on the upper air over India. Simpson studied the electricity of rain in Simla and produced his classic memoir on the theory of thunderstorms. Walker had had a say in the choice of all these men and it says much for his acumen that when he retired from India Patterson, Simpson and Field were the Directors respectively of the meteorological services in Canada, Britain and India, while Evershed, who had no University Degree to support his original appointment, had become an F.R.S.

Illness, staff changes, financial stringency each played a part in damping the rate of progress from 1910 to 1913. After a brief brighter spell the First Great War made its call on officers and the years 1916 to 1919 were for his department a period of stagnation when even the routine publications fell into arrear. In these years Walker was greatly supported by Hem Raj, whose memory of weather charts was phenomenal. Walker has often declared that Hem Raj was a martyr to duty, in that he worked on when he should have been in hospital and made no mention of his illness.

During the post-war years from 1919 onwards the flush of activity of Walker's earlier years of directorship were never quite regained. The process of overtaking arrears and a new spell of financial stringency hampered progress. However in 1922 Government did establish a Meteorological Service with a cadre of officers and uniform pay scales, at the same time deciding that it should be Indianised as far as possible. The appointment of four Indian officers in 1922 saw the beginning of the Indian Meteorological Services as they are today.

A long story could be written about Walker's scientific work in India. Here again one must refer the reader to the Administration Report 1924-25 for the fuller account. In a search for factors to use for forecasting the monsoon he began with investigations on the influence exerted by temperature and pressure in India in the pre-monsoon period, went on to examine relationships with conditions in and around the Indian Ocean and later extended his work to influences of conditions much further afield. To test relationships Walker computed the correlation coefficients and became a pioneer in their use in Meteorology. He contributed also to the theory of correlation in that he established a criterion of significance for use when the highest of a large number of C.Cs. are chosen. Within a few years Walker selected snowfall accumulation in Himalayas at the end of May, pressure at Mauritius and rainfall at Zanzibar in May, and pressure in South America in April and May as the best factors to use in a forecast of the monsoon. These were embodied in a formula by the method of multiple correlation. In later years similar formulae were drawn up for different areas in India and suggestions were put forward for forecasting seasonal rainfall in other parts of the world.

Only those who saw Walker at work could easily appreciate how critically he examined the details of his data and the inter-relationship between them before publishing a result or a recommendation. Also, he was always on the lookout for the physical causes behind relationships. For example, he correlated sunspots with pressure, temperature and rainfall in different parts of the world. His departmental memoirs on these subjects are still a standard source for the relationship between solar radiation and terrestrial weather; they proved that the sun does not directly control the weather and that the immediate source of radiation in terrestrial weather must be sought within the atmosphere itself. Finally Sir Gilbert went on to study world-weather, using quarterly means of pressure and rainfall at about 20 centres over the earth. Since these were all correlated one with another for contemporary and consecutive seasons it involved a lengthy computational programme, the execution of which was, curiously enough, aided during the first world war by the fact that normal activities had been damped down, scientific staff were either overburdened with routine or away on military duties, and work had to be found for members of the junior staff.

The results were published in two departmental memoirs and, after Sir Gilbert left India, by the Royal Meteorological Society. These memoirs are a mine of information out of which, as is now well known, emerged the familiar see-saw connection between the Azores and Iceland, also a similar connection in the North Pacific, and a more important see-saw between the Indian Ocean and the Central and South Pacific, which Walker called the Southern Oscillation. The Indian monsoon has its place in the Southern Oscillation, more however as a precursor than as the outcome of other events. In these papers Sir Gilbert revealed many important relationships that merit further attention and suggested forecasting formulae for other areas of the world as well as India. Taken altogether, the series of memoirs on seasonal weather formed a most impressive programme of research. They deserve a re-appraisal, now that the data of thirty or more years have become available to apply the searching test of performance to all those correlation coefficients and multiple correlation coefficients that appeared to be of significance in the 1920s. This is a task, which, undertaken by a competent statistician and meteorologist, will go a long way to supply us with a final verdict on the place of the correlation coefficient in meteorology and in long-range forecasting.

While world-weather was his main theme, Walker pursued many other lines of enquiry in India, for example, the question of changes of climate, the theory of musical instruments, and the soaring flight of birds. He was a keen observer of bird flight throughout his years in Simla, gave several lectures on the subject and eventually wrote the article on animal flight in the Encyclopaedia Britannica. From its beginnings he participated in the meetings of the Indian Science Congress, of which he was General President in the year 1918. He had a wide circle of friends and acquaintances and kept in touch with the mathematical and physical departments in Indian Colleges. It is appropriate to recall that he played a considerable part in the recognition of the mathematical genius of Ramanujan and in preparing the way for him to go to Cambridge.

Walker received a Knighthood on leaving India in 1924, and soon succeeded Sir Napier Shaw as Professor of Meteorology at the Imperial College, London. Here he spent another productive ten years. Of special interest was the new direction of much of his thought and the changed nature of method, because he and his pupils, including S. Mull, devised striking laboratory experiments to test the effect of varying the rate of shear in an unstable fluid. They reached highly important results, for they explained the mode of formation of various cloud forms. In 1933 Walker was President of Section A of the British Association. He was also a President of the Royal Meteorological Society and was for several years the Editor of its Journal.

From 1934 until a few years after the Second Great War Walker lived in Cambridge, nominally in retirement, but extending earlier studies of his on periodicity and on coherence and persistence in data, in connection with which he was led to criticise severely the use of the so-called "Symmetry" points in long-range forecasting, which indeed was a subject on which he was much consulted during the last Great War.

How many are there alive today who can recall the sight of Sir Gilbert performing intricate figures in orthodox English style on the ice of the skating rink at Simla or remember catching the sound of his flute or piccolo when rounding a corner in the Simla hills. He was an expert skater and had been proficient rock climber in his youth. High among his wide range of interests must be placed his love of music; and he found great joy in spending the occasional holiday out of doors with a paint brush, sketching in water colour. He was a very friendly man, sympathetic and liberal minded, one whom all ranks could admire and respect. The India Meteorological Department will ever hold his memory in high esteem.

C. W. B. NORMAND

Sir Gilbert T. Walker used to take keen interest in the scientific research carried out in the Indian Universities and year after year he would actively participate in the work of the Indian Science Congress. It was during the Science Congress Session of 1916 that I first came in contact with Sir Gilbert. In the 1920 Session of the Congress, I opened a symposium on earthquakes, over which Sir Gilbert presided. In his speech, Sir Gilbert displayed a remarkable depth of knowledge of earthquake phenomena.

In dynamics and electrodynamics, Sir Gilbert had a queer knack of solving problems. The complexity of a problem would not deter him from attacking it. For instance with consummate skill, he attacked the problem of Boomerangs. His interest in Boomerangs did not end with the analysis of their flights. In 1922—24, when we were having meteorological lessons from him in the Meteorological Office, Simla, he would in the evening take us down to the Annandale with a number of boomerangs, throw them with great skill and explain to us the different types of paths they would take. When asked to throw these boomerangs we universally found it extremely difficult to retrace the paths which he obtained with comparative ease.

Sir Gilbert's main interest in those days and for many years after his retirement was statistical analysis of meteorological data. In the application of correlation methods for forecasting of seasonal rainfall in India, he was a pioneer. His world-wide search of meteorological factors led to a selection of those which had significant correlation coefficients with the subsequent monsoon rainfall and the subsequent winter rainfall. With the introduction of Walker's test of significance, a few of the factors so selected had to be discarded. Subsequent work has not led to much improvement in the Regression Equations which he formed for the seasonal forecasts.

In 1924, he gave a course of lectures on periodogram analysis. Although these lectures were based on Schuster method (*Trans. Camb. phil. Soc.*, 1900) he brought in several new ideas of his own regarding the tests to be applied for the detection of any hidden periodicity and periodicity with breaks and the use of correlation coefficients in periodogram analysis. His method of rapid calculation of correlation coefficients has been found to be of great value by other workers. (*Quart. J. R. met. Soc.*, 1924).

At Simla he took great interest in observing the soaring flight of birds over the sun-lit side of the mountain and would speak often enthusiastically on the principles which governed the soaring and the gliding flights and the manner in which birds drew energy from the air-currents. His contributions on the subject and particularly on cloud formation and gliding give remarkable elucidation of the manner in which the different wind systems are to be used for soaring and gliding flights (*Proc. Camb. phil. Soc.*, 1922; *Royal aero. Soc.*, 1923, 1927, 1930, 1933; *Quart. J.R. met. Soc.*, 1939).

Sir Gilbert used to come daily to the forecasting room as soon as the working charts were ready for discussion. He would take the chair with all the meteorologists standing round him. In those days, weather analysis was based on the movement of depressions, pressure departures, pressure changes, cloud types and their movements and associated rainfall and changes of humidity. There was little or no upper air data. The role of fronts was recognised in well-marked cases; for instance, when the Arabian Sea monsoon current came in contact with the deflected Bay of Bengal current along the Gangetic Plain. In the discussion of the day's charts, Sir Gilbert would give in a few clear and concise sentences the action in the atmosphere which in his view would be expected to follow during the next 24 hours. Very often he would recall a past date on which the day's charts bore a close analogy and would at the same time make a remark that he had not as good a memory as Rao Bahadur Hem Raj (a retired Meteorologist of the India Meteorological Department with a remarkable memory of past charts and climatic data) had and that Rao Bahadur Hem Raj could recall not one but half a dozen analogue charts. This led Sir Gilbert to initiate classification of weather types over India—a work which has never been finished.

In 1934, when I met Sir Gilbert, then a Professor of Meteorology in the University College, London, he was busy along with a band of Indian workers on a series of laboratory experiments to explain the evolution of certain types of clouds.

Amongst the many contributions of Sir Gilbert in later years, those which figured prominently in the talks amongst meteorologists in India were the important relationships between weather in the distant parts of the earth which he obtained by correlation methods in his World Weather investigations and particularly the three big swayings or oscillations—

(a) The North Atlantic Oscillation between the Azores and the Iceland, (b) The North Pacific Oscillation between the high pressure belt and the winter depression near the Aleutian Island, and (c) The Southern Oscillation between the South Pacific and the land areas round the Indian Seas.

When I met him in Cambridge in 1946, he was still in good health and pursuing active research. He spoke to me about "persistence" and "auto-correlation" of a meteorological series and on periods and symmetry points in pressure as aids to forecasting, a subject in which his mind was engaged at the time. He mentioned the remarkable fact that the auto-correlation between successive daily readings of pressure at Kew in winter is 0.82, which means that 67 per cent of the total variance is due to pressure on the preceding day and only the remaining 33 per cent is independent. He strongly criticised the use of symmetry points for forecasting and pointed out that correlation coefficients of the order 0.5 readily arise by chance and the "waves" giving rise to the symmetry points rarely persist beyond the interval actually examined. His health slowly failed after 1949 and he wrote to me asking that the sending of publications of the India Meteorological Department to him should be discontinued as he was no longer able to give attention to them.

Sir Gilbert throughout evinced keen interest in the development of the India Meteorological Department and wrote several encouraging letters to me. I and my other colleagues who had the good fortune of working under Sir Gilbert bear to him feelings of highest esteem and consider his demise a great loss.

S. K. BANERJI

I am very sorry to learn of this passing away of a great figure in Meteorology, particularly Indian Meteorology. It was he who interviewed me in Bombay in 1921 when he was looking out for the first Indian candidates for Meteorologists' posts in the India Meteorological Department. I don't know how I impressed him in the interview, but he impressed me then as a very shrewd, astute and sportsmanlike administrator. Later, I joined in Simla in 1922 and he and I were in the same station for a couple of years until his retirement from the department in 1924. He being the head of the department, and I the youngest recruit among the officers (almost a boy), we had not much of any real familiarity or intimacy. But I know he had the new Officers' interest at heart and he certainly guided our sound training in all aspects of meteorological work. He would send us out on inspection tours for comparison of barometers and other instruments at observatories—to work just like the regular inspectors. This was good grinding for new officers. He, it was, I believe, who planned, that I should be trained well ahead for taking up the Calcutta Storm-warning Officer's post, which ultimately happened in 1926.

Though not intimate with him I used to be quite free with him. He used to advise me to take part or interest in general activities of Simla life—"don't be a recluse" he would say. He chaperoned me once at a Viceroy's Levee.

I admired and respected him. Accuracy, brevity, almost to the point of terseness and correct choice of words and punctuation, he used to like in all writing, both scientific and non-scientific. He must have liked me, otherwise he would not have given me the few momentos which he did when he left, such as a painting of an Alpine mountain scene done by himself, and 2 or 3 of his boomerangs. It is probably well known that he was the first to work out the complete mathematical theory of that queer Australian aboriginal missile, in his Cambridge days, before he came out to India.

His career and achievements both before and during his term in India (1904—1924) are so well known in meteorological circles that I need not write about them at all. His seasonal forecasting methods based on multiple correlations have become classic.

Sir Gilbert Walker was a man of many parts. He had varied interests and hobbies. He was keen on physical fitness and games and sports. He loved skating for which Simla provided facilities. For some time he was, I believe, a practical student of dietetics too.

He was literally a great 'Walker', walking long distances in mornings, afternoons, evenings or nights many many a time. For that also Simla was grand. He was fond of art and music and he practised both; the first in the form of water-colour painting on hiking trips and the second in the form of playing on the piccolo—they say he was quite an accomplished player at any odd time when the mood was on him, even some times in the seclusion of his office room. We knew him more familiarly as Dr. G. T. Walker. He was knighted only on 3 June 1924 (in the then King's Birthday Honours) and he went away from India a fortnight later.

In Gilbert Walker's passing away we lose a great figure—a figure great in brain power and in admirable intellectual achievements, great as a disciplined and firm and strong but sympathetic early twentieth-century administrator, great in his catholicity of interests and in the attainment of a rich full life, and great also as a human personality. He was a very normal human being, with none of the proverbial eccentricities of mathematicians among whom he ranked high. This normality itself is perhaps a great and likable distinction.

According to our ordinary standards Sir Gilbert Walker lived a long full life. He must have been 89 years old, or very near it, when he breathed his last. The end has to come some time to every one. Still I am sorry, very sorry, he is no more. Hereafter we can only carry his memories, and I for one cherish them very much indeed.

V. V. SOHONI

In the passing away of Prof. Gilbert T. Walker, England has lost not only one of her brilliant mathematicians and scientist of outstanding merit but also a teacher who inspired his students with the spirit of scientific research. Having had the privilege of being one of his students and having come in intimate contact with him in that capacity, I would like to pay my humble tribute to one whom I consider my "Guru" in the true sense of the word according to the best Indian traditions.

After having guided the destinies of the India Meteorological Department successfully for over 20 years as the Director General of Observatories, Sir Gilbert Walker was appointed as Professor of Meteorology in the Imperial College of Science and Technology, London, to succeed Sir Napier Shaw. During these 10 years, Sir Gilbert soon built up an active school of meteorology which was known all the world over for its high standard of teaching and research. Although as the Director General of Observatories of the India Meteorological Department, Sir Gilbert Walker concentrated his energies mainly on the solution of the problem of seasonal weather forecasting by the use of multiple correlations and made fundamental contributions in that direction, he realised the urgency of developing experimental technique for simulating weather phenomena in the laboratory for their closer study if the difficulties of theoretically interpreting the uncontrollable variations of the atmosphere were to be overcome. Keeping in view the great strides that aviation was making then, he felt the importance of organising a study of the physics of various cloud forms by means of experimental work to get an insight into the dynamics of their formation.

The experiments of E.H. Weber in 1855 and of H. Benard later had shown that in the absence of shear, polygonal patterns are set up in a vertically unstable layer of fluid. Also, the experiments of Idrac and Terada had shown that rapid shear produces vortices alternatively right and left handed with their axes parallel to the shear. As the patterns produced in the laboratory by the above workers showed resemblance to the various cloud forms obtained in nature, Sir Gilbert Walker decided to make use of their technique for this study. He, therefore, desired that not only the experiments of the previous workers for no shear and rapid shear should be repeated but that the technique should be extended to the cases of intermediate shear. Experiments were, therefore, devised in the laboratory of the Royal College of Science by the writer to study the types of motion set up in a thin layer of fluid with varying rates of shear between the top and bottom surfaces of the fluid, which is subjected to vertical instability due to density distribution. The results of these experiments were very interesting as, in addition to the patterns already obtained by the previous workers for no shear and rapid shear, rectangular patterns were obtained with intermediate shear as foreseen by Lord Rayleigh on the basis of his mathematical treatment of the subject. An application of these experimental results was made to reveal the physical processes involved in the formation of stratified clouds having similar forms; and with the help of actual measurements made in cloud layers during aeroplane ascents it was demonstrated that the breaking up of a stratum of cloud in nature was associated with vertical instability and that the pattern of the cloud produced depended upon the rate of shear between the top and bottom surfaces of the stratum.

In order to study the various patterns in greater detail, Phillips improved upon the technique employed by the writer by using a trough for his investigations and by arranging more uniform conditions of flow. His results revealed that although the transverse septa obtained with intermediate values of shear gave rise to rectangular patterns observed by the writer earlier, they did not run continuously so as to be regarded as strips at right angles to the shear. As cloud strips at right angles to the shear were frequently observed in the sky in association with longitudinal strips and other cloud forms. Sir Gilbert Walker was very keen to produce these transverse strips in the laboratory. The efforts made by Phillips in this direction by using heated liquid for his experiments however did not meet with any success. Sir Gilbert Walker, therefore, rightly decided to organise experiments in the laboratory for imitating clouds by using air instead of liquids. He considered the conducting of experiments with air all the more desirable, since the study of clouds in the laboratory by the use of liquids could hardly be expected to be fully satisfactory. Work on these lines was immediately undertaken by Phillips and later by Graham who started the study of the flow patterns with unstable air employing a small wind channel for their investigations, the motion of air being indicated by fumes of Titanium tetrachloride. By suitable increases of velocity from zero, they succeeded in producing polygons, transverse vortices, cross vortices and longitudinal vortices; their resemblance to clouds was more obvious than when liquids were used. These studies also showed that the motion at the centre of the polygonal cells produced in air was downward and not upward as with liquids. Sir Gilbert Walker and his pupils made a number of contributions to important scientific journals applying the results of the laboratory investigations to bring out the dynamics of the various cloud forms occurring in nature. The full significance and achievement of their contributions cannot be told in this brief communication. Anyone interested in cloud physics will be well advised to refer to the original papers.

Being a mathematician, Sir Gilbert Walker believed in accuracy, brevity and the correct choice of words in scientific writings. He always emphasised this aspect on his students and on others who came in contact with him.

Sir Gilbert Walker was very kind and genial by nature. He had great affection for his students and was like a friend to them. His interest in them was not only confined to the class room and the laboratory, but he was equally solicitous about their welfare outside. He would make anxious inquiries about their health if he found someone absent from his class room or laboratory. I still remember with gratitude the care he bestowed on me when once I fell ill in London during the cold wave of 1929. Like a real "Guru", he would not agree to leave me to anyone else's care except that of his family physician; he would also not consent to my paying fees to the physician on the ground that being his pupil I was just like a member of his family.

Sir Gilbert Walker was a man of many hobbies. He was very fond of music and painting, and he liked his students also to develop hobbies according to their own taste. He was very particular about his physical fitness and he wanted his pupils to be likewise by not confining their activities only to their class room and laboratory but by taking part in games and sports and other outdoor activities. I still recollect how Sir Gilbert Walker, soon after my arrival in London, personally took me to the College Boat Club and got me enrolled as its member.

Great teachers are rare enough; but those with a fund of affection and sympathy for their pupils and interested in their welfare are rarer still. Prof. Sir Gilbert Walker will be remembered by his students as a great teacher who was a source of inspiration to his pupils.

S. MULL