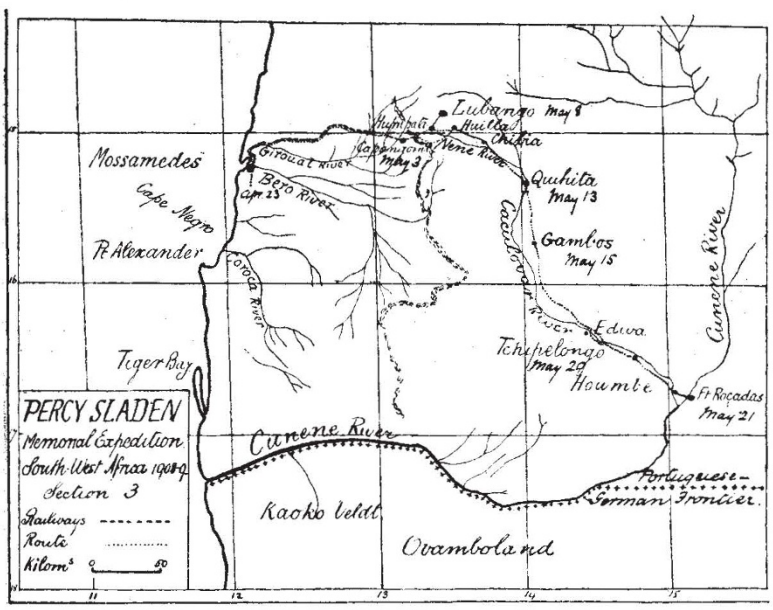
slopes of the Chella Range. The railhead is situated in an open forest of stunted trees, among which Acacias, a Bauhinia and the Baobab are prominent, with wide, grass-covered glades. This formation extends to the lower slopes of the Chella Range becoming denser as it ascends until, near the summit, it effects a junction with a Savannah, the characteristic species of which include a number of Proteaceæ and other southern forms. The western face of the Chella Range rises sheer to some 3000 feet from the forest which clothes its base, above which the bedding planes of its grey, lichen-covered sandstone are plainly visible. Except for its great extent, the whole range bears a striking resemblance to Table Mountain as seen from Table Bay. Opposite Capangombe there is a gap, the entrance to a kloof up which winds a steep footpath to the top through an increasingly dense, dripping forest, with a magnificent undergrowth of maiden-hair and other ferns. Near the summit a tall Euphorbia with the habit of *E. grandidens* occurs in great abundance.

Leaving the Boer village of Humpata (6000 feet) on May 10, we approached the Cunene along the now well-known track down the valley of the Caculovar. On descending the eastern slopes, which are less steep than the western, we passed through the same changes of flora, in the reverse order, as those already observed on the other side. Passing the Huilla Mission—the scene of the botanical labours of Fathers Antunes and Dekindt—we arrived on May 13 at Chibia (4500 feet), where the proteaceous flora thins out and gives place again to the open, dry forest, in which the Bauhinia and Acacias in turn predominate. Henceforward the surface, frequently broken by tumbled heaps of gneiss and ironstone, 50 feet to 500 feet high, slopes gently down to the Cunene. From Gambos (4100 feet) the water-supply, after the end of the rainy season (April), is meagre and its quality bad, and the whole district is fever-stricken. The temperature becomes very high after mid-day, and whirlwinds of great violence spring up very suddenly, and carry columns of dust and other light objects to great heights. Three hours by waggon from Houmbe brought us to the Cunene marshes, which are here confined to the right bank of the river. Owing to the unusually late rains they were still nearly two miles wide, and it was with great difficulty that a crossing to Fort Roçadas on the opposite bank was effected. This stronghold is placed upon the high calcareous cliff forming the left bank of the river. Its neighbourhood, the scene during recent years of many engagements between the Portuguese and the trans-Cunene Ovambo tribes, has become so extremely unhealthy that it will in future be manned entirely by native troops. The country at its foot is thickly studded with small Baobabs and away to the east the open Acacia and Bauhinia forest again prevails, and undoubtedly merges farther south into the thorn-bush of Ovamboland and the Acacia park-formation which extends far to the south of Okahandya and Windhuk.



I take this opportunity of acknowledging the effective support which has been very kindly given to the objects of the expedition by Their Excellencies Sr. Capt. H. de Paiva Couceiro, Acting Governor-General of Angola; Herr Regierungsrath Dr. Hintrager, Acting Governor of German South-West Africa; and the Hon. W. F. Hely-Hutchinson, G.C.M.G., Governor of Cape Colony.

H. H. W. PEARSON.

MODERN METHODS OF ILLUMINATION.[1]

A GREAT change has come over the methods of lighting within the last few years. We have now at our disposal means of lighting which would have seemed incredible a few years ago. Step by step with these developments has taken place the progress of education and the increase of printed matter, with the result that we use our eyes to-day far more than in the past. Our main object, therefore, should be to consider the subject of illumination from the point of view of the impression received through the eye. After emphasising this aspect of illumination, Mr. Gaster proceeds with a summary of recent developments in electric lighting.

Electric Glow-lamps.

It has long been known that a carbon filament glow-lamp could be made to yield more efficient results by bringing it to a higher temperature, *i.e.* running it at a pressure higher than that ordinarily utilised, but such a gain in efficiency has only been found possible at the expense of life and durability.

Within the last few years we have seen the development of lamps with filaments made of other and more refractory materials, such as the Nernst lamp, and the various metallic filaments, such as osmium, iridium, tantalum and tungsten, &c. The two last-named lamps, of course, now play a great *rôle* in electric lighting.

In addition, attempts have been made to improve carbon filaments in the United States by the graphitising process of Mr. Howell, by the aid of which a consumption of 2·5 watts to 3 watts per candle was attained. Another interesting attempt in this direction is the Hopfelt lamp, in which the carbon filament burns in an atmosphere of mercury vapour, with, it is stated, a consumption near 1·5 watts per candle. The Helion lamp, again, is believed to utilise a filament mainly composed of silicon; it is claimed to run for 1000 hours at 1 watt per candle, and even in the open air, without requiring to be enclosed in an evacuated globe; but it has not yet come upon the market. Perhaps the best known metallic filament lamps in use at the present day are those utilising the metal tantalum and those described by various names, but generally believed to contain as the main constituent the metal tungsten. Tungsten lamps are burned at a consumption approaching 1 watt per candle-power, and are generally stated to have a life, under good conditions, of 1000 burning hours. One great difficulty, however, has been the manufacture of lamps of moderate candle-power for high voltages, and capable of being used in any position; very recently, however, lamps having as low a candle-power as 25 or 30, and for pressures extending to 200 volts to 260

[1] Abstract of a series of four Cantor lectures delivered by Mr. Leon Gaster before the Royal Society of Arts and published in the Journal of the Society for August 6, 13, 20, 27; September 3, 10.

volts, have been produced; one company has even professed to manufacture a 200-volt 16-candle-power 25-watt lamp.

Attention may also be directed to the cooperation between the lamp-makers and the electrical supply companies characteristic of the United States, and to the work of the National Electric Lamp Association in that country. A large number of lamp-makers belong to this association, determine standard prices, and support a laboratory for the purpose of carrying out common tests on lamps for their mutual benefit. In addition, the cooperation between lamp-maker and supply company is naturally very beneficial to both parties in pushing the sale of lamps in desired directions.

Electric Arc-lamps and Vapour-lamps.

The most marked development in arc-lamps of late years has been the introduction of flame carbons, that is, carbons such that the light comes from a bridge of incandescent vapour instead of the tips of the electrodes. By this means consumptions so low as 0·2 watt to 0·3 watt per mean spherical candle-power are said to have been obtained. Flame carbons, however, burn away very quickly, and in order to extend their life lamps in which a succession of carbons is automatically used have therefore been introduced. Another development, the enclosed regenerative lamp, involves methods enabling the access of air to the carbons to be restricted, so that a high efficiency, and yet a fairly long life, is obtained. Mention must also be made of the new Blondel flame carbons, yielding a very white light, which have been stated to yield a polar curve of light-distribution specially well adapted for street lighting, and are burned vertically one above the other.

Another direction of progress has been the improvement of small candle-power enclosed arc-lamps, which formerly served to bridge the gap between high candle-power flame arcs and glow-lamps. By securing more complete exclusion of the air from the globe, the Regina Arc Lamp Company claims to manufacture a lamp consuming only 0·8 watt per candle, and lasting for 250 hours without recarboning. High candle-power metallic filament incandescent lamps, which are manufactured up to 1000 candle-power, now also serve to fill this gap.

The chief drawback of mercury-vapour lamps is, of course, the peculiar colour of their light, there being practically no red rays. It has, therefore, been proposed to mix certain salts with the mercury, to use fluorescent materials, &c., in order to improve the spectrum, but few such devices have come to a practical issue. A recent advance has, however, been achieved by Dr. Küch, of Germany, by the use of a tube composed of special quartz-glass, which can stand a very high temperature. By this means a consumption of only 0·27 watt per mean spherical candle-power is said to have been obtained; an incidental advantage is that the luminescence in the tube seems to be partially replaced by temperature radiation, and therefore the light contains a distinct red element, the spectrum broadening out into a more or less continuous band instead of consisting of isolated lines.

In addition, quartz-glass allows ultra-violet light to pass through with special ease, and the lamp is therefore believed to have special uses for the destruction of bacteria, photographic purposes, &c. For ordinary illuminating purposes a special absorbing glass envelope restricting these rays is used. The Moore tube utilises gases in a rarefied condition and subjected to a high-tension alternating discharge. The essential feature of this arrangement is the use of a valve which automatically keeps the condition of the gas within the tube constant.

Gas Lighting.

Great advances have been made in the efficiency of gas burners since the early flat-flame burners yielding only about 3 candle-power per cubic foot. The most recent figure is furnished by the Keith high-pressure light, for which 60 to 70 candles per cubic foot have been found by some observers.

Improvements have been made in the incandescent mantle both in the direction of the colour of the light and through durability. Even so, manufacturers in England have stated that, as a rule, mantles require renewing every 200 hours.

A new departure was introduced some years ago by the Plaissetty soft mantle, and more recently the Cerofrim Company is stated to have made advances in the same direction. For such mantles it is claimed that their softness renders them convenient for package, and that they naturally burn into the shape of the flame, and are thus used under the most efficient conditions. The introduction of the inverted mantle has, of course, also been a great advance, although only two years ago there were many who doubted its commercial possibilities.

At the same time, steady improvements in the design of inverted burners have proceeded. Many types on the market are specially designed to avoid discoloration of the fitting through heat, to secure all the conditions most favourable to complete combustion. Whittaker and Litle in the United States, and, more recently, Lebeis in Germany, have described thermostatical methods of automatically regulating the access of air to the burner, which frequently requires adjustment, as the burner after lighting gradually becomes heated.

Perhaps the greatest advance has been in the direction of *high-pressure* gas lighting, which serves to promote an intimate mixture of gas and air, favouring complete combustion. To this end gas at high pressure may be used, or air at high pressure led into the burner, or a mixture of gas and air at high pressure. In any case, however, special external arrangements are needed with an existing low-pressure installation. Self-contained, highly efficient lamps, which can be run off the ordinary low-pressure supply, have therefore been designed. For instance, the Lucas lamp employs a small fan driven by an electric motor, which receives current from a thermopile near the mantle. In the Chipperfield lamp, a small hot-air engine placed above the burner automatically pumps air under pressure into the burner.

An important field in gas lighting is the use of automatic ignition devices. These may consist of electric sparking apparatus, of clock-work arranged to turn on and off the gas by means of a bye-pass at specified hours, or automatic devices of the same type manipulated by a rise or fall in pressure. Clock-work systems are very trustworthy, but, of course, do not take account of peculiar atmospheric conditions, such as fog. Apparatus of the last type can be controlled from the station, and lamps can be lighted up or extinguished as the engineer desires.

Mention must also be made of the special Norwich system for interior lighting and of the pneumatic methods; these, too, involve the use of the pilot flame.

The subject of street lighting formed the object of study of a deputation to the Continent recently appointed by the Corporation of London, and was subsequently investigated by the lecturer in a visit to Germany. A novelty of considerable interest, with which experiments are being made at Stuttgart, consists in slinging gas lamps on wires spanning the street, just as is done in the case of electric arc-lamps in Cannon Street at present. Lastly, in this section of the subject, the lecturer refers to the recognition of the importance of the heating power of gas, which is now regarded as more vital than its "illuminating power," according to the prescribed tests with flame-burners, for modern methods of lighting, and discusses the suggestion of a calorific standard in the future.

Gas, Oil, Acetylene, and other Self-contained Methods of Lighting.

The simple method of lighting by petroleum lamps, the author points out, should not be neglected. It is used, for instance, in the Church of St. Sophia of Constantinople, where it is preserved on account of its decorative value and because of religious tradition. In addition, petroleum lamps are still used in the country, and give good results when properly handled; in this connection the researches of Mr. Guiselin, who has demonstrated the advisability of keeping the reservoir in oil lamps well filled, are of interest. For instance, the illuminating power was found to be improved by 20 per cent. when 700 cubic centimetres instead of 500 were retained in the reservoir.

Recently many methods of incandescent oil lighting, that is, the use of vaporised fuel with an incandescent mantle, have been devised. The Kitson system and the Empire light are stated to be very efficient for lighthouse work and for the illumination of large outdoor areas in remote

localities. Other types of lamps are the Blanchard, the Petrolite, &c., which are described in detail.

A special account is also given of petrol air-gas lighting, three typical systems, the Machine Gas Syndicate (Cox's system), the Aërogen, and the National Air Gas, being exhibited. This system of lighting has attracted great attention recently for the lighting of private houses in districts where gas or electricity are not available. A mixture of a small percentage of petrol vapour with air is generated outside the building, and passed through pipes to the burner in the usual way.

The method of lighting by alcohol lamps is worth consideration in agricultural districts where petroleum may not be available, but alcohol is readily manufactured. There are also a number of liquid-gas systems in which gas is stored under pressure in liquid form, and has been effectively used for railway-carriage lighting, &c.

Acetylene Lighting.

Mr. Gaster deals briefly with the historical development of acetylene lighting, and describes the modern form of generator and several types of portable acetylene lamps; these are frequently used in mines, for motor-cars, &c.

Acetylene, like petrol-air gas, finds its main application where gas and electricity are not available. A recent development of considerable interest is the method of dissolving acetylene in acetone, which, at a pressure of ten atmospheres, absorbs about 240 times its own volume of acetylene, but liberates it when the pressure is released. Tubes of dissolved acetylene have been widely used for portable lighting, on motor-cars, railway trains, and even in emergencies for interior lighting. Perhaps one of their most successful applications, however, is for the lighting of buoys and beacons in remote localities.

There are several types of ingenious valves which are very effective in saving the consumption of acetylene in the above circumstances. For instance, the Dalen solar valve automatically cuts off the main supply of acetylene in daylight, leaving only the bye-pass burning, and re-kindles it at night.

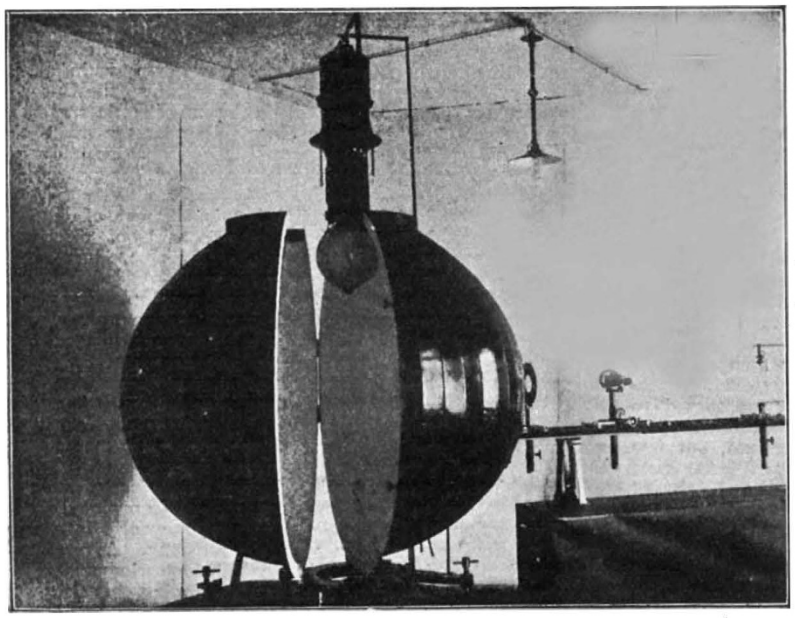
General Problems in Illumination.

In the last of these four lectures Mr. Gaster discusses the question of illumination in general terms. He again directs attention to the increasing brilliancy of modern illumination, and points out that the eye must have developed mainly in compliance with daylight conditions, and therefore we ought not to utilise artificial methods of lighting differing too widely from diffused daylight. The importance of providing for proper access of daylight in the design of buildings, particularly schools, is insisted upon. In this connection, the choice of wall-papers and the scheme of decoration are of considerable importance.

It is pointed out, too, that the intrinsic brilliancy of illumination has gradually increased of recent years. The effect of gazing directly upon such bright sources is very fatiguing and distressing to the eyes, and the author suggests that the time is now ripe for Governmental recommendations on this point.

In order to reduce the intrinsic brilliancy of light sources, suitable shades may be employed, and special reference is made to the Holophane diffusing globes and reflectors, which enable the light to be distributed and concentrated in any desired direction.

Some particulars are given of recent progress in photometry. The line of development of special consequence has been the introduction of so-called illumination photometers, which measure, not the actual intensity of the source, but the actual illumination on the pavements or at the desk at which we read. Sir William Preece so long ago as 1883 emphasised the value of such measurements. Another interesting development is the Globe photometer, an example of which is shown in the accompanying illustration.



The Ulbricht globe photometer, by the aid of which the mean spherical candle-power of a source can be determined by a single measurement.

Perhaps an exceptionally important development during the last year has been the establishment of the international unit of light between England, France, and the United States, and the recognition of a simple relation connecting this unit with the value in use in Germany. The success of co-operation in this direction in this country is felt to be largely due to the fact that representatives of the gas industry and the gas referees were invited to act with those connected with electricity on the commission studying this subject.

Turning next to some practical examples of illumination, the author insists upon the importance of adequate school lighting, quoting many authorities to show that the evesight of school children deteriorates during school life; he suggests that tests of the children's condition should be accompanied by the preservation of data relating to the methods of illumination employed in such schools, as this is believed to have a very vital influence on the health of the child.

In the same way the lighting of factories, hospitals, libraries, &c., should receive very careful study, for good illumination is as much a necessity as the provision of adequate sanitation and good ventilation; it is hoped that in the future, conditions of illumination, like the matters referred to above, will become the subject of Government inspection and recommendation. In addition, it is pointed out that even from the point of view of expediency employers would do well to pay attention to this matter, as a relatively small expense involved in securing good lighting is more than counterbalanced by the improvement in the quality and output of work. In hospitals it is obvious that the lighting should be exceptionally perfect, since people in an invalid condition are specially liable to feel the effect of bad methods of lighting.

Libraries, again, are frequented by people engaged in strenuous work and taxing their eyes severely; it is therefore suggested that in this case also no pains should be spared to make the methods of lighting convenient to the workers, and that when great expense is incurred in collecting valuable books and housing them in handsome buildings, the provision for the necessary illumination by the aid of which the books alone can be read should not be grudged.

A subject on which cooperation between different authori-

ties is badly needed is street lighting. It is pointed out that there is room for the establishment of some central testing department where thoroughly trustworthy and impartial tests could be carried out and used for the common benefit of those interested. In particular, it is suggested that it cannot be decided by the mere personal impression of a non-technical body of observers whether the lighting of the street is good or bad. This must be determined by the aid of precise scientific tests, carried out by impartial experts, who have made a thorough study of the subject, and can provide records by which experiences can be checked and subsequently repeated.

Other instances of problems in illumination in which there is great field for scientific treatment are shop-window lighting, stage lighting, and light-house illumination; in the two former fields, in particular, there is ample scope for the ingenuity of those who are up-to-date in their knowledge of the different illuminants, and possess, in addition, the requisite taste.

In the next section of this lecture Mr. Gaster deals with the scientific basis of light production, pointing out how the nature of the radiation from an illuminant depends in general upon its temperature, and indicating some of the possible lines of future development. The figures of authorities in this matter differ very greatly, but it is generally considered that the percentage of energy radiated in the form of light is very small indeed. The problem of light production is complicated by the fact that some invisible kinds of radiation seem to exert a prejudicial effect on the eye. The author describes some experiments showing the nature of the ultra-violet rays, which some authorities consider to be injurious.

In conclusion, Mr. Gaster points out that the problem of illumination is a complex subject which deserves special consideration by itself. There is a need for men who are not connected with any particular illuminant and who are able to take a wide view of the different aspects of the matter, so as to deal with modern problems of lighting. In order to focus interest in this subject and to bring into contact the engineers, architects, oculists, and others interested in illumination, a society has been formed this year which will, it is hoped, gradually lead to the solution of the important questions on which further exact data are felt to be desirable; this is termed the Illuminating Engineering Society. The first president of the society is Prof. S. P. Thompson, and the opening session will commence in November.

ANNUAL METEOROLOGICAL REPORTS.

THE Deutsche Seewarte has issued part xvii. of its over-sea meteorological observations for 1907, containing very carefully prepared summaries, and in some cases individual readings, at some thirty stations. The principal localities include Labrador, Morocco, Shantung, German East Africa, and some islands in the Pacific Ocean; there are also some isolated stations, including one recently established at Babylon. Scientific investigators will be grateful to the Seewarte for references which are given in all cases to the periodicals in which previous observations and results have been published.

The annual report of the Philippine Weather Bureau for 1907, part i., contains hourly readings at the Manila Observatory, together with means deduced therefrom. The tables also show the extreme values recorded, and the departures of the monthly and yearly means from the average. The mean temperature of the year, 79·5°, was practically normal; the absolute extremes were 98·1° in April and 59·0° in January. The rainfall, 72·5 inches, was 3·3 inches below the average; of this amount 64 inches fell from June to October inclusive (the period of the south-west monsoon). An appendix shows the greatest daily and hourly rainfall registered at the observatory in past years; the greatest daily falls were 13·3 inches and 12·1 inches, on September 24 and 25, 1867.

The report of the Liverpool Observatory for the year 1908 has been received from Mr. W. E. Plummer. This useful establishment is maintained by the Mersey Docks and Harbour Board in the interest of shipping, and is well provided with meteorological and astronomical instruments. In addition to the continuous use of the transit instrument for the determination of time, observations of selected stars and of comets visible from the observatory formed the chief astronomical work of the year. A Milne seismograph for the registration of tremors in the earth is kept steadily at work; during the Messina earthquake (December 28) the duration of disturbance was 1h. 41m., and the amplitude (half the complete range of maximum motion) was 15 mm. The meteorological results are very complete, *e.g.* the wind observations show the maximum velocity for each day recorded by Dines's apparatus, the extreme pressure on the square foot by Osler's anemometer, the horizontal motion by Robinson's anemometer, and the number of hours that the wind blew from different points of the compass. The mean temperature of the year (49·2°) was practically normal, and the rainfall (28·9 inches) slightly above the average.

The annual report of the United States Weather Bureau for the fiscal year ended June 30, 1908, shows that the research work at Mount Weather Observatory has been carried on without material curtailment, notwithstanding the destruction by fire of the administration building in October, 1907. Investigation of the upper air by means of kites and captive balloons is made daily (except Sundays), and the data are telegraphed to Washington for the use of the forecast division. The work on solar physics includes the measurement of solar radiation and the degree of absorption by the atmosphere. Considerable discrepancies exist in the values of the solar constant, even computed from observations on the same day at Mount Weather and at Washington; in most cases these are traceable to the unsteadiness of the atmosphere. Great activity exists in the divisions dealing with land and ocean meteorology; the number of climatological stations now exceeds 3700, and more than 1600 vessels cooperated with the Bureau during the year. All data referring to the Indian Ocean are lent to the Indian Meteorological Department, where they are copied and returned. In the forecast division isobaric charts are prepared from daily telegraphic reports from selected stations throughout the northern hemisphere, and forecasts for about a week in advance were published during the last three months of the year. The library now consists of about 28,000 books and pamphlets. In addition, meteorological articles contained in periodicals and transactions are catalogued under both author and subject; this bibliography is said to be more frequently consulted than the catalogue of books.

The Survey Department of Egypt has published its meteorological report for 1907, containing hourly readings at Helwan and climatological tables at thirty-five stations of the second and third order; the monthly tables give tri-daily readings in the form adopted by the International Meteorological Committee, and also include the daily amount of evaporation, as that element is of considerable importance in Egypt and the Sudan. Additional tables include hourly observations by Dines's pressure anemometer at Alexandria, rainfall and wind direction for a number of stations, and river-gauge observations. In compliance with a desire expressed by the International Meteorological Committee in 1907, tables of normal values are also given. Rainfall was in excess in Egypt and in North Sudan, but in considerable defect throughout the rest of the Sudan, and, as we have previously stated, the Nile flood was worse than any recorded during the past fifty years.

The meteorological year-book of the Bremen Observatory for 1908 has been received. From small beginnings this institution, under the superintendence of the late Dr. P. Bergholz, has attained a position of considerable importance; the observations, which include hourly readings and means, with monthly and yearly summaries, have been reduced by Prof. Grosse in the same thorough manner as heretofore, with the addition of hourly tabulations of sunshine records and monthly means of earth temperatures. The valuable materials, which now extend over many years, await a general scientific discussion; this desideratum is urgently pointed out by Dr. Grosse, but under present arrangements, while the director has to divide his energies between the observatory and other official duties, this important work has to be postponed.