Meteorological Influences of the Sun and the Atlantic.[1]

By PROF. J. W. GREGORY, F.R.S.

THE prospects of long-period weather forecasting and the explanation of major variations of climate appear to rest on two lines of investigation. The effort of the first is to connect changes in the weather with those in oceanic circulation; the second attributes the changes to variations in the heat supply of the sun acting through the atmospheric circulation. Each theory has its own *a priori* probability. The oceanic control of climate has the attraction that each ocean is a potential refrigerator, since it is a reservoir of almost ice-cold water, which, if raised to the surface, must chill the air, disturb the winds, and enable polar ice to drift further into the temperate seas. Hence Meinardus, for example, connected the range of ice in the Icelandic seas and harvests in Germany with variations in the surface waters of the North Atlantic. The alternative theory has the recommendation that, since the earth receives its heat supply from the sun, variation in solar activity is the natural cause of climatic change.

The oceanic theory must be true in part. The abnormal character of some coastal climates is clearly due to the upwelling of cold water under the influence of off-shore winds. Moreover, unusual spells of weather on some of the coasts and islands of the Atlantic follow changes in the quality of its surface water, as proved by Dr. H. N. Dickson for North-western Europe, and by Prof. H. H. Hildebrandsson's demonstration that for fifteen years there has been constant coincidence between rainfall in British Columbia and the weather in the following autumn in the Azores. The alternative theory that the main factor in controlling the temperature of the earth is the varying heat from the sun acting through changes of wind and atmospheric pressure has been mainly advanced by the work of Sir Norman and Dr. W. J. S. Lockyer and of Prof. Frank Bigelow; they are now strongly reinforced by Dr. B. Helland-Hansen, the director of the biological station at Bergen, and Dr. Nansen, who remark that these views have hitherto received but little support.

The important memoir by these Norwegian oceanographers is based on a detailed study of variations in the temperatures of the air and surface waters along the steamer route from the English Channel to New York. Their detailed discussion of the results and associated problems is accompanied by a valuable series of temperature charts of the North Atlantic for the months of February and March from 1898 to 1910. The data are often uncertain and the inconvenience of the Centigrade thermometer with its zero at freezing point is illustrated by records of water temperature of $-3°$ C. and $-4°$ C., which have to be rejected. Drs. Helland-Hansen and Nansen, after discussion of the theory of oceanic control, reject it as quite inadequate. Thus the chilling effect of the drift of ice into the North Atlantic they estimate as "vanishingly small" in comparison with the heat transported by the air, or even by ocean currents. They consider that, though not yet fully established, the variations of the air temperature preceded, and were therefore not the result of, those of the water temperature. They hold that the variations of temperature require some much greater and more general cause than oceanic variations.

Faith in the meteorological influence of oceanic circulation was greatly favoured by the exaggerated estimates attached to what the authors refer to as "the so-called Gulf Stream." Thus the warmth of the water off the Norwegian coast was attributed to that current even by Pettersson and Meinardus; this conclusion the authors describe as surprising because the evidence of salinity shows that the Norwegian waters are coastal and quite different from those of the mid-Atlantic. This sound criticism of the Swedish and Münster oceanographers renders it the more remarkable that there is no reference, either in the long historical discussion or in the bibliography, to the pioneer work on this subject in the earlier papers by Dr. H. N. Dickson, or to his observations as to the seasonal entrance of the Atlantic water into the North Sea. The authors agree with Schott in terminating the Gulf Stream west of Newfoundland, and calling the current off Western Europe the "Atlantic current," for which Dickson's name of "European current" is more descriptive and definite. The Atlantic is a large mass, and has a whole system of currents, of which the so-called Atlantic current is by no means the largest.

Drs. Helland-Hansen and Nansen, after rejecting the oceanic theory, accept as firmly established the dependence of variations in the earth's temperatures on the solar variations proved by sunspots, the numbers of solar prominences, and terrestrial magnetic disturbances. They point out that the influence of the sun on the weather of any area on the earth depends upon so complex a series of factors that the results at first sight appear inconsistent. The crude expectation that an increase of heat supply from the sun would raise the temperature of the whole earth was early dismissed, for the greater evaporation would lower the temperature on the coastlands by increased clouds, rain, and snow. Blanford pointed out, for example, the see-saw of oceanic and continental conditions; but, though his view has not been fully confirmed, his principle is supported by the proof that regions are oppositely affected by changes in the heat supply from the sun. Bigelow has divided the world into three groups of regions: in the "direct" group the temperature conditions vary directly with the sun; in the

[1] Björn Helland-Hansen and Fridtjof Nansen, "Temperature Variations in the North Atlantic Ocean and in the Atmosphere." Introductory Studies on the Cause of Climatological Variations. Smithsonian Miscellaneous Collections, vol. lxx., Publication 2537. 1920. Pp. viii+408+48 plates.

"indirect" group the variations agree in time, but are opposite in character; in the third, the "indifferent" group, there is no regular correspondence. Sir Norman and Dr. W. J. S. Lockyer have shown that a region may for years belong to the "direct" group, then suddenly become "indirect," and later return to the "direct" group. Drs. Helland-Hansen and Nansen accept this frequent inversion, and also their explanation of the phenomenon.

The authors' instructive study of North Atlantic temperatures therefore strengthens the case for solar variations acting through the atmospheric circulation as the main cause of meteorological changes. To what extent the ocean helps by regulating the air temperature and circulation the authors do not discuss in the present memoir; that and other questions are to be dealt with after further investigations in a series of memoirs to which the present is introductory. The usefulness of the promised memoirs would be increased (should they have as many appendices and supplementary notes as the present) if each were provided with an index.

The Thermionic Valve in Wireless Telegraphy and Telephony.[1]

By PROF. J. A. FLEMING, F.R.S.

THE thermionic valve is an invention which has vastly increased the powers and range of wireless telegraphy. Like many other inventions, the telephone, for instance, it is simple in its essential construction. It consists of a little electric lamp comprising a glass bulb, very highly exhausted of its air, containing a filament of carbon, or better tungsten, which can be rendered incandescent by an electric current. Within the bulb and around the filament are fixed certain metal plates or cylinders, and, it may be, spirals of wire or metal networks called the grid. To explain its origin in its simplest form I shall have to take you back in thought to the days when the physical effects taking place in incandescent electric lamps were first beginning to be considered carefully. In 1883 Mr. Edison for some purpose placed in the glass bulb of one of his carbon filament lamps a metal plate which was carried on a platinum wire sealed through the glass. When the filament was rendered incandescent by a current from a battery, he found that if the plate was connected by a wire, external to the lamp, with the positive terminal of the filament, a small electric current flowed through it, but if connected to the negative terminal no current, or at most a very feeble current, flowed. This new and interesting effect became known as the "Edison effect" in glow lamps, but Mr. Edison gave no explanation of it, and made no practical application of it.

Edison supplied some lamps with plates in the bulb to the late Sir William Preece, and the latter found that the current called the Edison effect current increased very rapidly as the filament was heated to higher and higher temperatures, and that the collecting plate could be placed a long way from the filament, even at the end of a side tube, without altogether causing it to vanish. At a little later date I took up the subject, and one of the first things discovered was that the Edison effect was greatly reduced if that side of the carbon loop filament in connection with the negative pole of the battery was enclosed in a glass or metal tube, or if a sheet of mica was interposed between the filament and the collecting plate. This seemed to indicate that the effect was due to some material emission from the hot filament.

Another fact I observed very soon was that the filament was giving off torrents of negative electricity, and could discharge a positively electrified conductor connected to the plate, but not one negatively charged. Furthermore, I found that the vacuous space between the filament and the plate possessed a curious unilateral electric conductivity for low-voltage direct electric currents, and that even a single cell of a battery could pass a current from the hot filament to the collecting plate if the negative pole of the battery was in connection with the hot filament, but not in the opposite direction. This fact had, however, been previously noticed in another manner by W. Hittorf. These experiments were made in 1888 or 1889, and at that time were not satisfactorily explained.

It was not until nearly ten years later that your distinguished professor of natural philosophy, Sir Joseph Thomson, published accounts of his epoch-making and important researches, in which he proved that the agency we call negative electricity is atomic in structure, and exists in indivisible units now named electrons, which carry a certain electric charge and have a certain mass. These negative electrons are constituents of all chemical atoms. An electrically neutral atom which has lost one or more electrons is called a positive ion, and neutral atoms which have lost or gained electrons are said to be ionised. There are arguments in favour of the view that the majority of the atoms in metals and other good conductors of electricity are in a state of intermittent ionisation, and that intermingled with the atoms or positive ions, say in a wire of copper, tungsten, or carbon, there are electrons which are jumping from atom to atom with great velocity. If we apply to the wire an electromotive force, this causes a drift of these electrons at the instant they are free in the opposite direction to the force (on usual conventions), and this drift or unidirectional motion is superimposed on the irregular motion, and constitutes an electric current. The drift velocity may be very slow compared with the velocity of the irregular motion. The drift motion of the electrons superimposed on the irregular

[1] From a discourse delivered at the Royal Institution on Friday, May 21.