the energy given out by the batteries over that spent in heat. Thus

$$dW = E_1\gamma_1 dt + E_2\gamma_2 dt - R_1\gamma_1^2 dt - R_2\gamma_2^2 dt - \partial T;$$

and this is the work done in virtue of changes of the currents. This quantity must be a perfect differential, since its integral vanishes for a closed cycle of changes. The condition which must hold for this enables the values of A, B, C to be identified with $-L_1$, $-M$, $-L_2$.

Maxwell's introduction of Lagrange's dynamical method into electro-magnetism is, as has been already stated, regarded by Poincaré as of great importance, and as he says "nous touchons ici à la vraie pensée de Maxwell." After finding by this method the inductive electromotive forces, and the electro-magnetic forces, he proceeds to discuss Maxwell's theorems of the electro-magnetic field, and their crowning generalization, the electro-magnetic theory of light. Except here and there, the treatment differs only in points of detail from that of Maxwell.

With regard to the equations of currents,

$$u = CP + \frac{K}{4\pi}\frac{\partial P}{\partial t},$$
$$\&c., \quad \&c.,$$

a difficulty is pointed out as to the specific inductive capacity of a conducting substance. For such a substance the first term must preponderate, and so K must be small; whereas K is generally regarded as very great in the case of a conductor. It is worth noticing that this is really only a conventional means of explaining the impossibility of charging a condenser the space between the plates of which is filled with conducting substance; the true explanation is, no doubt, very different.

The discussion of the experimental verifications of the electro-magnetic theory of light contains references to several lately-established experimental facts (apart from Hertz's experiments, which are reserved for special treatment) which bear on the theory. For example, it has been shown by Curie that dielectrics, when tabulated in the order of increasing conductivity, are on the whole arranged (as obviously they should be) in the order of diminishing diathermancy. Further, ebonite, which is opaque to light, is very permeable to dark radiations of longer period, which agrees with its high transparency to electrical waves.

Again, it is remarked that the results of the electro-magnetic theory with regard to reflections from the surface of glass and of metals lend a general support to the theory, while the disagreement in the values of the numerical constants as regards the want of magnetic permeability is referred to the frequency of the vibrations and the fact that the magnetization of the medium is not instantaneously produced.

A marked feature of M. Poincaré's treatise is the chapter on rotatory polarization, in which he discusses the phenomena of rotation of the plane of polarized light by the action of a magnetic field. Although the essential difference between this effect and the apparently similar action of quartz, sugar solutions, &c., is pointed out, the author does not appear to lay stress on it as throwing light on the difference between their causes. For example, after giving Airy's differential equations, for the propagation of the two rectangular component displacements, ξ, η, of a circularly polarized wave travelling along the axis of z, in the form

$$\rho\frac{\partial^2\xi}{\partial t^2} = \frac{\partial^2\xi}{\partial z^2} + a\frac{\partial^3\eta}{\partial z^2\partial t},$$
$$\rho\frac{\partial^2\eta}{\partial t^2} = \frac{\partial^2\eta}{\partial z^2} - a\frac{\partial^3\xi}{\partial z^2\partial t},$$

from which a formula for the rotation of the plane of polarization of plane-polarized light in a magnetic field can be obtained, which agrees with experiment; and after comparing the results of these equations with those of other proposed equations, he says:—

"Mais si le concordance de la formule avec l'expérience justifie l'introduction des derivées $+\partial^3\eta/\partial z^2\partial t$, $-\partial^3\xi/\partial z^2\partial t$ dans les secondes membres des équations du mouvement d'une molécule d'éther, aucune considération théorique ne préside au choix de ces dérivées à l'exclusion des autres; on ne possédait donc pas encore de théorie de la polarisation rotatoire magnétique."

This certainly seems rather too strong a statement in the face of Thomson's dynamical theory outlined in his "Electrostatics and Magnetism," and further elaborated in Maxwell's treatise.

Thomson's views on this subject are of the most fundamental importance, as they point to motion of, or in, the medium occupying the magnetic field as the cause of the magneto-optic effect discovered by Faraday, and to a certain structure of the substance as producing the phenomena shown by quartz, syrup, &c. One of the most interesting passages of his lectures on molecular dynamics, delivered at Baltimore in 1885, is that in which he accounts for the observed results by the presence of rotating particles, "gyrostatic molecules," in the medium.

It is obviously suggested by the gyrostatic investigation that it ought to be possible to explain the magneto-optic rotation in the electro-magnetic theory of light as a consequence of the presence of small magnets embedded in the vibrating medium with their axes in the direction of the ray; and therefore producing a component of magnetization in that direction. It is stated by M. Poincaré that a theory of this kind has been proposed by M. Potier, and published in the *Comptes Rendus*. The theory itself is not given, but the differential equations obtained are quoted, and are of the required form, and lead to the known experimental result.[1]

Maxwell's molecular vortices theory is, however, given, and certain difficulties which it involves discussed. The theoretical results of Hall's experiment are also given in this connection, and Kerr's experiment proving the production of elliptic polarization by the reflection of plane-polarized light from the pole of a magnet is cited, but without any statement of the theory of the effect which has been worked out, principally by Fitzgerald. With regard to the explanation of the Hall effect by strain of the conducting film produced by the magnetic field, it has always seemed to me that it ought to be possible with proper appliances to decide the question, by experimenting with a sufficiently powerful and uniform magnetic field.

The work, it ought to be stated, concludes with an interesting chapter by the editor, M. Blondin, on experimental verifications of the theories of Maxwell. This comprises the chief determinations of specific inductive capacity, Kerr's classical researches, and lastly, the interesting investigation made by M. Röntgen of the electro-magnetic action of currents of displacement.

Of Prof. Poincaré's second treatise on the experiments of Hertz, &c., I hope shortly to give an account as a sequel to the present article. A. GRAY.

THE ORIGIN OF THE FLORA OF GREENLAND.

HOW the present flora of Greenland originated, is a question of great interest to British botanists and geologists, for the answer will probably help to solve the difficult problem, What was the origin of the recent flora of Britain? The flora of Greenland is so poor in species and has been so well studied that its relationship to the floras of Europe and America ought not to admit of much

[1] M. Poincaré's reference has suggested to me a mode of investigating the action of these magnets on the electro-magnetic theory. This is discussed in a separate article, which contains for the sake of comparison an account of the gyrostatic theory.

debate; yet we find that an active discussion is now going on among Scandinavian botanists as to its eastern or western affinities. Sir J. D. Hooker, in his "Outlines of the Distribution of Arctic Plants,"[1] made a careful analysis of the species found in Greenland, and came to the conclusion that the relationship was more European than American, and this view seems to have been generally adopted by botanists. In a recent official report, contained in the valuable series of memoirs published by the Commission for the Exploration of Greenland,[2] Prof. E. Warming, however, has tried to show that the flora is American; and as this author has had access to fuller materials than were formerly available, his opinion will carry considerable weight. Prof. A. G. Nathorst, a botanist especially competent to speak on questions relating to the botany of the Arctic regions and on the relation of the recent Arctic flora to the Glacial epoch, objects altogether to Prof. Warming's conclusions, and, although dealing with the same materials, maintains the accuracy of the generally accepted view as to the European relationship of the vegetation.[3] He also critically examines the flora in a way that has never been done before, and points to its dependence on bygone conditions. To certain of Prof. Nathorst's observations and conclusions I should like to draw attention.

The principal result arrived at by Prof. Warming was that the boundary between the American and the European provinces is formed by the Denmark Strait (the strait between Greenland and America), and not by Davis Strait as botanists have generally thought. This conclusion Prof. Nathorst critically examines, and so many curious and suggestive facts relating to geographical distribution come out in this examination that I may be excused for referring to certain of them somewhat in detail. The flowering plants of Greenland include 386 species, none of which are confined to that country. Leaving out of account circumpolar forms, Prof. Warming finds in the list 36 characteristic western against 42 eastern species, but suggests that when the flora of Arctic America is better known the balance will probably be in favour of the western forms. Prof. Warming, however, includes among the eastern plants only those now living in Europe, the Asiatic-American species being classed as western on the ground that they must have entered Greenland from the west rather than from the east—a somewhat unsafe line of reasoning when we take into account former changes of climate and the local extinction of many plants.

Prof. Nathorst analyzes the list differently, and gives most suggestive tables and a map of the local distribution of the eastern and western plants in Greenland. From these we find that the coast nearest to Iceland contains European forms alone, the southern extremity contains European forms in a majority, while the part of the west coast nearest to America yields principally western species; but taking Greenland as a whole the flora is more European than American. Another curious fact noticed by Prof. Nathorst is that the American element of the flora of Greenland is not entirely cut off by the Denmark Strait, but extends eastward as far as Iceland.

Prof. Warming considers that the nucleus of the present flora of Greenland represents part of the original flora, which was able to live through the Glacial epoch on the non-glaciated areas; but Prof. Nathorst points out that the few non-glaciated mountain-tops must have been far too high for any phanerogams to exist on them, and all the lowlands were then covered with ice and snow. We must therefore consider that both eastern and western elements of the present flora of Greenland entered the country in post-glacial times. The tables of distribution show at what points a large number of the plants entered—they came from the nearest land, whether European or American. Whether in post-glacial times there was any complete land-connection between Greenland and either North America or Iceland is very doubtful, but the straits may well have been narrower. The ice-foot, also, which collects in winter beneath the sea-cliffs is placed in the best possible position to receive any seeds or masses of soil which may fall during the winter. This shore-ice is drifted away in the spring, and may easily discharge its burden on some far-distant shore uninjured, and the seeds just ready to germinate. Winds, migrating birds, and migrating mammals would all help to transport seeds across the straits.

Turning now to the British Isles, we know that a prolific temperate flora inhabited this country in pre-glacial times. We know also that this flora disappeared and was replaced by a thoroughly Arctic one, at least as far south as Norfolk, where its relics are found beneath the moraines. Then came a period when Britain north of the Thames was covered with ice and snow, and only an occasional hill-top—or "*nunatak*," as it would be called in Greenland—rose above. When the ice retreated, the Arctic phanerogams again spread over the country, for we find *Salix polaris*, *S. herbacea*, *S. reticulata*, *Betula nana*, and *Loiseleuria procumbens* in lacustrine deposits immediately above the boulder clay near Edinburgh; we have also a similar flora, with *Salix polaris*, *S. myrsinites*, and *Betula nana*, in Suffolk; and even in Devonshire the dwarf birch has been found. This stage, though its flora is still imperfectly known, apparently corresponds closely with the present condition of Greenland.

In Britain, however, we have now reached a later stage in the amelioration of the climate and re-settlement of the country, for the Arctic plants have either disappeared entirely or have retreated to our mountain-tops, and in their place on the lowlands we find a temperate flora now living. The British flora, like that of Greenland, varies according to the botanical character of the nearest land, though, as with Greenland, there is no reason, except the supposed impossibility of the migration of the animals and plants without a bridge, to imagine that during post-glacial times there has been any direct connection with the Continent, save perhaps at the Straits of Dover. The distribution of plants in Britain is so peculiar that I may be forgiven for pointing out to non-botanical readers that we have a southern flora opposite France, a Germanic flora on the east coast, a Lusitanian flora in the south-west, and on the extreme west there are two American plants unknown elsewhere in Europe. In the Britain of the present day I believe that we may study the re-peopling of a country over which everything has been exterminated; and until we have fuller direct evidence of the stages of the process, we may safely accept Greenland and Britain as illustrating the way in which Nature works to fill gaps in the fauna and flora, whether these are caused by changes of climate, by volcanic agency, or the submergence and reappearance of islands.

CLEMENT REID.

[1] Trans. Linn. Soc. vol. xxiii., pp. 251-348 (1861); partly reprinted (with additions) in the "Manual of the Natural History . . . of Greenland," &c. (1875).

[2] "Om Grønlands Vegetation: Meddelelser om Grønland," Part 12 (1888).

[3] *Engler's botanischen Jahrbüch*, 1891, p. 183.

THE SUN'S CORONA.

SOME little time ago Dr. Schaeberle, of the Lick Observatory, was good enough to send me the following letter:—

Allow me to call your special attention to a note of mine in the forthcoming number of the A.S.P. Publications, entitled "Some Physical Phenomena involved in the Mechanical Theory of the Corona." I wish to say that, as far as the connection of this theory with the sun-spot period is concerned, there was not, at any time, any effort on my part to make an agreement with other theories, but the conclusions reached are the legitimate and inevitable results of tracing certain observed phenomena to unexpected explanations. As you will see, the logical outcome