SUSPECTED RELATIONS BETWEEN THE SUN AND THE EARTH[1]

II.

IN my last article I endeavoured to show that as a matter of fact there is an intimate connection between the physical state of the sun's surface and the diurnal

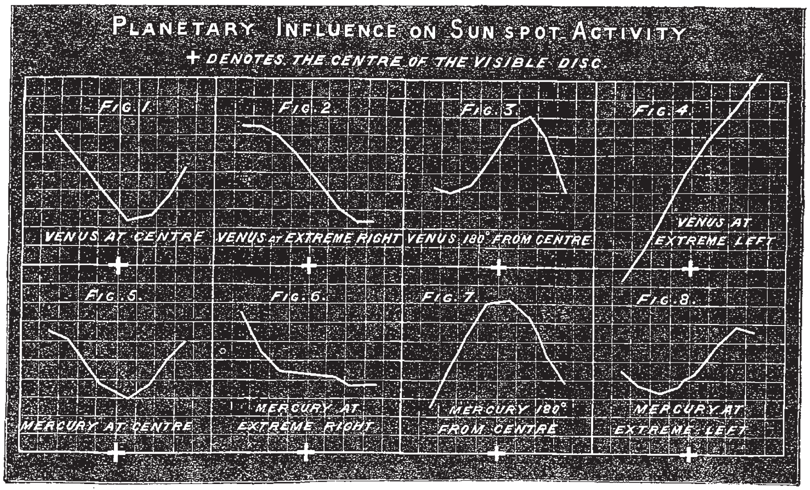

DIAGRAM C.

range of the magnet freely suspended at the Kew Observatory. It was suggested that this relation might

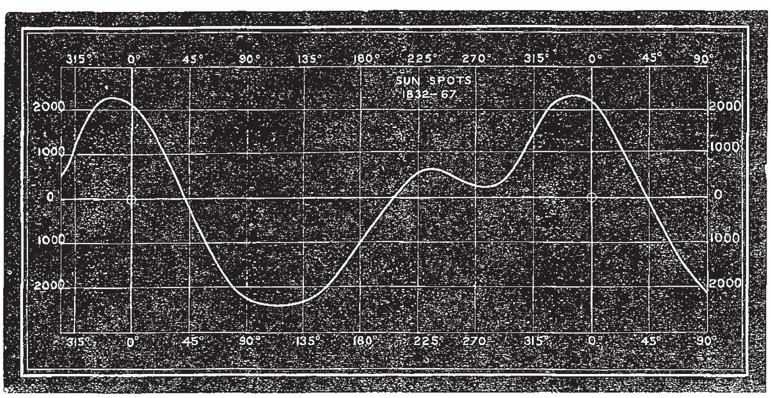

DIAGRAM D.

be that of cause and effect, inasmuch as the variations of spotted area exhibited in Diagram B invari-

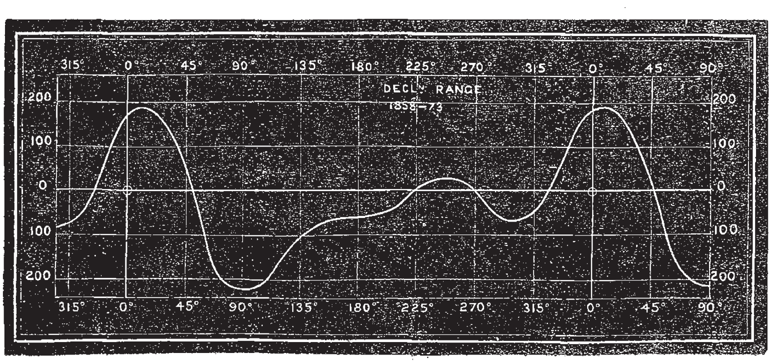

DIAGRAM E.

ably precede the corresponding variations of magnetic range.

[1] Continued from p. 11.

It cannot, however, with propriety be said that sun spots are the cause of magnetic oscillations, for it has been pointed out by Mr. J. A. Broun that even when there are no spots on the solar surface the magnet has yet a very considerable range in its daily oscillations. Then, on the other hand, the spectroscopic researches of Mr. J. N. Lockyer and others leave us little room for doubting that there may be vast solar activity without sun-spots, while, however, spots will probably make their appearance when the disturbance of the sun's surface is very great.

In fine, sun-spots will probably only afford us a rough means of estimating solar activity just as rainfall might give us a rough means of estimating the meteorological activity of a district of the earth. Is it not possible that sun-spots are in truth a species of celestial rainfall?

Be this as it may, it is evident that, inasmuch as sun-spots exhibit a recurring period, we are entitled to say there is a period of this kind in the meteorology of the sun. The interesting question then arises, What can be the possible cause of such a period? This question has been discussed by Mr. Warren De La Rue and those associated with him in his solar researches.

The theory propounded by these observers is that the planets are in some unknown way concerned in the production of spots. In their paper, which will be found in the *Proceedings* of the Royal Society for March, 1872, they make the following remark :—

"It might be said, 'How can a comparatively small body like one of the planets so far away from the sun cause such enormous disturbances of the sun's surface as we know sun-spots to be?' It ought, however, we think, to be borne in mind that in sun-spots we have, *as a matter of fact*, a set of phenomena curiously restricted to certain solar latitudes, within which, however, they vary according to some complicated periodical law, and presenting also periodical variations in their frequency of a strangely complicated nature. Now these phenomena must either be caused by something within the sun's surface, or by something without it. But if we cannot easily imagine bodies so distant as the planets to produce such large effects, we have equal difficulty in imagining anything beneath the sun's surface that could give rise to phenomena of such a complicated periodicity. Nevertheless, as we have remarked, sun-spots do exist, and obey complicated laws, whether they be caused by something within or something without the sun. Under these circumstances, it does not appear to us unphilosophical to see whether as a matter of fact the behaviour of sun-spots has any reference to planetary positions. There likewise appears to be this advantage in establishing a connection of any kind between the behaviour of sun-spots and the positions of some one prominent planet, that we at once expect a similar result in the case of another planet of nearly equal prominence, and are thus led to use our idea as a working hypothesis."

Proceeding upon this principle, these observers measured every sun-spot recorded by Mr. Carrington from the beginning of 1854 to the end of 1860, as well as every one photographed at the Kew Observatory from the beginning of 1862 to the beginning of 1867, and the results of all these measurements are recorded in Diagram C.

In this diagram each curved line is supposed to represent the behaviour, as regards size, of the various groups of spots as they pass across the disc of the sun by solar rotation from left to right. If, for instance, a spot were always to retain the same magnitude, its path would be represented by a horizontal line, but if it were to become smaller at the middle of its course than at either extremity, then we should have it represented as in the first figure. Now, from this diagram, we find that whenever either Venus or Mercury is between or nearly between our earth and the centre of the sun, the sun-spots behave as in the first figure; that is to say, as they are carried round by rotation nearer to the planet, they become less, and as they are carried away from the planet they become greater. Secondly, when Venus or Mercury is at the extreme right of the sun the spots diminish in size all the way across. Thirdly, when Venus or Mercury is on the other side of the sun, exactly opposite the earth, the spots have their maximum in the centre; and, finally, if Venus or Mercury be at the extreme left, the spots augment in size all the way across; in fine, they are always least in the immediate neighbourhood of Venus or Mercury, and greatest when that portion of the sun to which they are attached is carried by rotation to the position farthest from the influential planet.

If there be any truth in this evidence it would seem to follow as a corollary that when two influential planets are together on one side of the sun, their peculiar spot-producing action should be conspicuously great, and hence there should be a greater than usual amount of spots when such conjunctions take place.

On the other hand, when one influential planet is on one side of the sun and another on the other side, they might be supposed to counteract each other, and hence the spotted area would be conspicuously small. In a memoir which will be found in the *Transactions* of the Royal Society for 1870 the Kew observers have

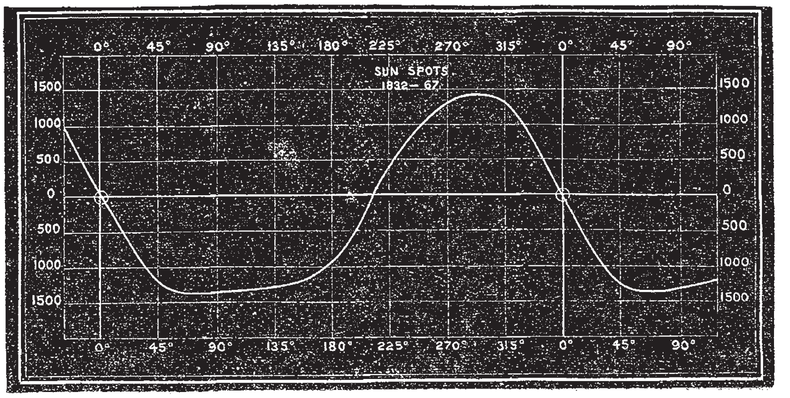

DIAGRAM F.

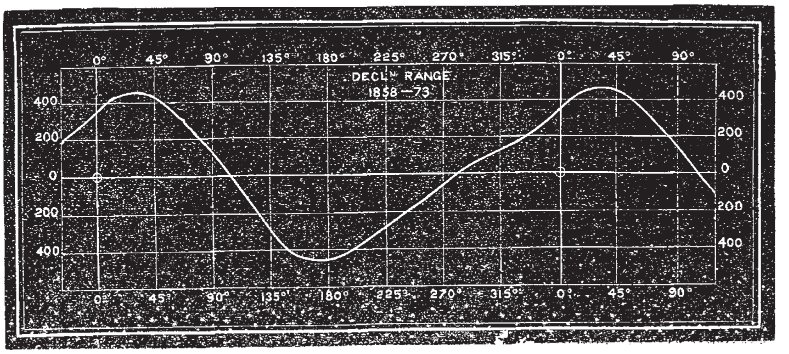

DIAGRAM G

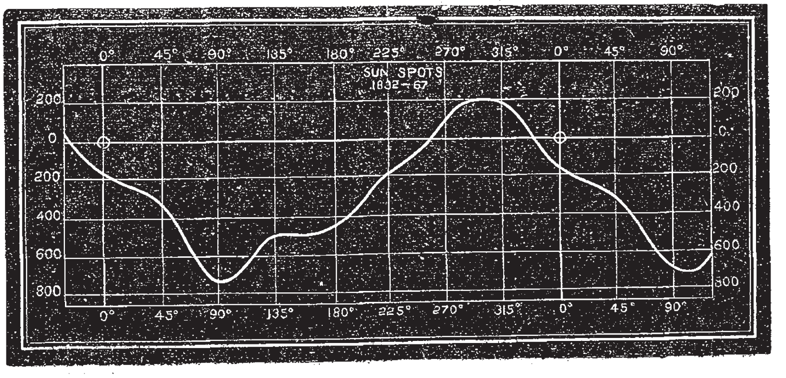

DIAGRAM H.

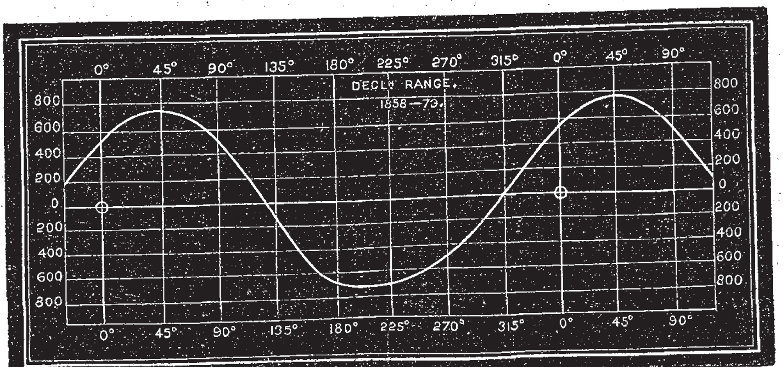

DIAGRAM I.

investigated this point also, and they appear to have found sun-spot inequalities depending on the relative positions of the various influential planets.

For instance, there is a greater than usual amount of sun-spots when Venus and Jupiter are together; there is the same a little before the time when either Venus and Mercury or Mercury and Jupiter are together, and finally, there is the same a little before the time when Mercury is nearest the sun.

These results of strictly solar observation are capable of being verified in quite a different manner. If the planets have an influence on the sun and if the state of the sun's surface affects terrestrial magnetism, it might be expected that we should have magnetic inequalities depending upon the positions of the planets.

By this it is not meant that the planets influence the magnetism of the earth directly, but rather through their effect upon the solar surface.

Again, it was shown in the last article that terrestrial magnetic effects at Kew lag behind corresponding states of the solar surface. This lagging behind ought therefore to be exhibited in any comparison which we make between sun-spot inequalities depending on the planets and magnetic inequalities at Kew depending on the same cause *if the latter inequalities are caused indirectly through the medium of the sun*.

A comparison of this kind has recently been made by the writer, using for this purpose those inequalities of short period that were most likely to be exhibited in the limited series of magnetic observations at his disposal for the purpose.

The results are embodied in the preceding diagrams. Diagram D represents the sun-spot, and diagram E the magnetic inequality due to the relative positions of Mercury and Venus (0° denoting conjunction). Diagram F represents the sun-spot, and diagram G the magnetic inequality due to the varying distance of Mercury from the sun (0° denoting perihelion). Diagram H represents the sun-spot, and diagram I the magnetic inequality due to the relative positions of Mercury and Jupiter (0° denoting conjunction). From all these it will be seen that there is a striking likeness in character between the planetary sun-spot inequalities, and the planetary magnetic inequalities derived from the records of the Kew Observatory—the latter, however, lagging behind the former in point of time, as might have been expected.

It is unquestionably a very strange and striking conclusion that the daily range of the magnet freely suspended in a vault of the Kew Observatory, should be sensibly greater about the times when Venus and Mercury, or Venus and Jupiter come together in position, and also about the times when Mercury is nearest the sun.

Perhaps it is not too much to say that the facts described in the last article go to show that the sun influences the earth, and possibly also the other planets in some unaccountable manner, while the facts of this article go to show that (shall we say in return) the most conspicuous planets of the system, and possibly also the earth, are not without an influence upon the state of the solar surface. I may be permitted, in conclusion, to transcribe a paragraph from a former essay on this subject (Owens College essays). "At first sight we are startled by the supposition that a planet like Venus, which comes nearer to the earth than it ever does to the sun, should in any way be accountable for such enormous manifestations of energy as those which occur over the sun's surface. But the wonder will disappear if we bear in mind that there may be two kinds of causes or antecedents. Thus we may say that the blacksmith is the cause of the blow with which his hammer strikes the anvil, and here the strength of the blow depends upon the strength of the smith. But we may likewise say that the man who pulls the trigger of a gun or cannon is the cause of the motion of the ball, and here there is no relation between the strength of the effect and that of its cause.

"Now, in whatever mysterious way Venus and Mercury affect the sun, we may be sure it is not after the fashion of the blacksmith—they do not deal him a violent blow producing all this enormous effect, but they rather pull the trigger, and immediately a very great change takes place."

BALFOUR STEWART

(*To be continued.*)

THE NEW ZOOLOGICAL GARDENS AT CALCUTTA

THE propriety of establishing Zoological Gardens at Calcutta, has, as those who are acquainted with the proceedings of the Asiatic Society of Bengal are well aware, been before the public and the Indian Government for these last fifty years. It is, however, only within a very recent period that anything has been practically effected, and the first report on the progress made in the development of the new institution during the first year of its existence has only just reached us. Before alluding to its contents, a few words on the origin of the present scheme may be acceptable to those who take an interest in the subject.

Many previous plans for the institution of Zoological Gardens in Calcutta, including that proposed by Sir Joseph Fayrer in 1867, having come to nothing, Mr. L. Schwendler, of the Indian Telegraph Department, brought the subject again to the notice of the Council of the Asiatic Society in March, 1873. Mr. Schwendler proposed that the necessary capital should be raised by subscription, but that the Government of Bengal should grant the site and give a contribution towards the annual expenditure. This scheme, although taken up with interest by the Asiatic and Agricultural Societies and supported by the press, would have ended, like its predecessors, in failure, had not the energy of Mr. Schwendler led him to adopt a different course of action. Having a fine private collection of living animals of his own, Mr. Schwendler was able to prove to the Viceroy of India (then Lord Northbrook), who honoured him with a visit, how easy it was to maintain such an establishment in a climate so well adapted to animal and vegetable life as that of Calcutta. Instead of the large and expensive houses necessary in these inclement climes simple sheds suffice as a protection for the animals against the weather, and the luxuriant vegetation is ever springing up to contribute to their shelter and retirement. In fact, if only space is provided, and sufficient fencing is put up, animals can be kept almost in the same state as in their native wilds, and buildings may be dispensed with. So practical was Mr. Schwendler's illustration of how easily zoological gardens might be established in Calcutta by showing his own grounds fitted up for the purpose, that the Viceroy was convinced at once, and quickly brought the excellent Lieutenant-Governor of Bengal to a similar state of mind. Having taken up the matter, Sir Richard Temple set to work at it with his usual energy, and by a minute of September 24, 1875, granted a large site for the purpose on the road leading from Surat Bridge to the Governor's official residence at Belvedere. Shortly afterwards an honorary managing committee was appointed, with Lord Ullick Browne as president; Mr. Schwendler and Dr. King and Mr. Watson as members, and Mr. C. Buckland, private secretary to the Lieutenant-Governor, as honorary secretary. The objects of the new institution, besides the general instruction and recreation of the community, were specified to be to facilitate scientific observations on the habits of animals, to encourage their acclimatisation, and generally to promote the science of zoology. Upon the starting of the new institution, Mr. Schwendler immediately hastened to present to it his whole collection of living animals, and the Governor-General