The fact cannot be concealed, however, that the eruptive apparatus of this last upheaval has been left in a state which furnishes a constant menace to the neighboring villages. On account of the sudden cessation of action, the secondary phenomena have not taken place, by which nature usually brings about a permanent end to these parasitic craters. It is, then, among the possibilities of the near future, that another eruption may take place on the same spot where the late one has proved abortive.

## *MAGNETO-MOTIVE FORCE.*

"Faraday compared a magnet to a voltaic battery immersed in water;[1] and he established by experiment the principal analogies on which this comparison is founded." Mr. R. H. M. Bosanquet, from whom the above is quoted,[2] thinks that too little has been made of this analogy, which seems to him to furnish the only sound view of magnetism. He would speak of a permanent magnet as possessing a certain 'magneto-motive force,' which, acting through a circuit made up of the magnet and the bodies or medium surrounding the magnet, produces throughout this circuit a total magnetic induction, equal to the quotient of the magneto-motive force by the 'magnetic resistance.' So-called magnetic substances are those in which the *magnetic conductivity* is great; and bodies of this sort, when brought near a magnet, become parts of the magnetic circuit, whose resistance they lessen, just as masses of metal placed in the water forming part of an electric circuit would lessen the total electrical resistance of such a circuit.

Moreover, a new distribution of the lines of magnetic induction is brought about by the entrance of the magnetic body into the field; this body receiving and transmitting a larger proportion of the lines of magnetic induction than the space it now occupies received and transmitted when filled by air. The body is now said, in ordinary terms, to be magnetized. At the same time, the lines of magnetic induction, being deflected from their most direct course, and bunched together where they approach the magnetic body to enter it, encounter in that region an increased air-resistance. A like condition of things exists in the air-region where they are departing from the magnetic body; and the effect of these increased air-resistances is to make the number of lines of magnetic induction through the body less than it would otherwise be. This air-resistance near the surface has for its equivalent in the ordinary theory the 'demagnetizing' action which the induced magnetism of a body exerts upon the interior particles of the body itself.[3] In the case of a very thin disk, magnetized by induction in a direction normal to its surface, the ordinary theory says that the demagnetizing action of the free magnetism of the surfaces almost neutralizes within the disk the effect of the external magnetizing forces, so that the magnetic induction in the disk is scarcely more intense than that in the air about it. The other theory explains the fact by saying that the superior magnetic conductivity of the disk is not able, acting for so short a distance, to seriously affect the course of the lines of induction in its neighborhood by making it advantageous for these lines to bend from their normal course in order to pass through the disk.

[1] Exp. res., iii. § 3276. [2] Phil. mag., March, 1883.
[3] Faraday, Exp. res., iii., § 3289; Maxwell, arts. 426 and 438, old edition.

Mr. Bosanquet's article is an attempt to prepare Faraday's theory for use in numerical calculations by furnishing it with exact quantitative definitions, and to show by the results of experiment that the theory is fitted for such work. In doing this he thinks it necessary to make essential changes in well-known and widely received formulas.

Mr. Bosanquet states the ordinary theory thus: "Now, the fundamental hypothesis at the base of the ordinary mathematical theory of magnetism is, that there are magnetizing forces $\mathfrak{H}$ which are of the dimensions of the magnetic induction $\mathfrak{B}$ which they produce, and that the magnetizing force permeates every medium, and produces in magnetic media magnetic induction proportional to the force and to a co-efficient of permeability $\mu$, quite independently of the existence of any magnetic circuit." To this Mr. Bosanquet objects; one of his objections being, that "we have to suppose that the magnetizing force $\mathfrak{H}$ within a magnetic body has the power of remaining separate and distinct from the magnetic induction as a whole, though the two are quantities of the same nature." In his theory "the quantity $\mathfrak{H}$ becomes merely the magnetic induction in vacant space, and $\mathfrak{B}$ that in magnetic matter. $\mathfrak{B}$ replaces $\mathfrak{H}$, and is not supposed to include it as before."

Instead of remaining

$$\mathfrak{B} = \mathfrak{H} + 4\pi\mathfrak{I}, \text{ or } \mu = 1 + 4\pi\kappa,$$ [1]

"our fundamental equation becomes

$$\mu = 4\pi\kappa, \text{ or } \mathfrak{B} = 4\pi\mathfrak{I}."$$

The formula

$$\mathfrak{B} = \mathfrak{H} + 4\pi\mathfrak{I}, \text{ or } \mu = 1 + 4\pi\kappa,$$

adopted by Maxwell and others, might, according to Mr. Bosanquet, lead to serious errors. Thus in a sphere of infinite magnetic permeability, magnetized by induction, Stefan, he says, has shown that "the ratio of the number of lines of force through its equatorial section to the number through the same section in air" is 3. Practically the same result is obtained from one of Thomson's papers, and Mr. Bosanquet confirms these results by a calculation in accordance with the views he is advocating.

He attempts now to show that Maxwell, using the formulas above, would make this ratio 4 instead of 3. A similar error would, he thinks, occur in calculating, according to Maxwell, the corresponding ratio for the case of a disk of infinite conductivity.

However interesting and suggestive certain parts of Mr. Bosanquet's paper may be, there is little doubt that he has here met the usual fate of those who attempt to convict Maxwell of error in reasoning. It is easy to show that Maxwell's formulas are in complete accord with the result above obtained from Stefan and Thomson. Thus (p. 66, vol. ii., old edition) Maxwell says that "in the case of a sphere the ratio of the magnetization to the magnetizing force is . . ., and if $\kappa$ were infinite the ratio would be as 1 to 4.19," etc. This result Mr. Bosanquet quotes, but from that point he goes wrong. On the next page of Maxwell, where he is discussing the demagnetizing forces which the poles of a magnetized body exert upon the 'interior particles' of the body itself, we read, "If the magnet were a sphere the demagnetizing force would be $\frac{4}{3}\pi I$." The symbol I here, like $\mathfrak{I}$ in the formula above, means the intensity of magnetization.

Now, according to Maxwell, $\mathfrak{H}$[2] is not merely the original magnetizing force, which we will call $\mathfrak{F}$. It is this minus the *demagnetizing* force, which in this case is $\frac{4}{3}\pi I$. We have, therefore, from Maxwell,

[1] Maxwell, art. 428. [2] Maxwell, arts. 398 and 426.

$$\mathfrak{B} = \mathfrak{H} + 4\pi\mathfrak{I},\ \mathfrak{H} = \mathfrak{F} - \tfrac{4}{3}\pi\mathfrak{I},\ \text{and}\ \mathfrak{I} = \frac{\mathfrak{F}}{4.19};$$

whence

$$\mathfrak{H} = 4.19\,\mathfrak{I} - \tfrac{4}{3}\pi\,\mathfrak{I} = 0,$$

and

$$\mathfrak{B} = 4\pi\mathfrak{I} = 4\pi \times \frac{\mathfrak{F}}{4.19} = 3\,\mathfrak{F},$$

which is the result reached by Stefan and Thomson.

A precisely similar line of reasoning applies in case of the disk; the fact that $\mathfrak{H}$ in both the sphere and the disk becomes 0 explaining how it happens that $\mathfrak{I}\,[=\kappa\mathfrak{H}]$ remains finite, though $\kappa$ is supposed infinite.

The fact seems to be, that Mr. Bosanquet does not understand the full meaning of Maxwell's $\mathfrak{H}$. He apparently supposes that it is the magnetizing force arising from external sources,[1] just what has been denoted above by $\mathfrak{F}$. Having, therefore, found that his own formula, $\mathfrak{B} = 4\pi\mathfrak{I}$, gives, in the case of the sphere of infinite conductivity, $\mathfrak{B} = 3\mathfrak{F}$, he naturally concludes that Maxwell would obtain $\mathfrak{B} = \mathfrak{F} + 3\mathfrak{F} = 4\mathfrak{F}$.

The two above-mentioned cases, then, are of interest, not as showing the inaccuracy of the ordinary formulas, but as instances in which Mr. Bosanquet's formulas hold good. In any medium possessing finite magnetic conductivity only, i.e., in any known medium, Mr. Bosanquet's formulas will evidently lead to results different from those given by Maxwell's; and it remains to be shown, I think, that Maxwell is in error.

Indeed, it is by no means evident that Maxwell's formulas need be essentially changed in order to be in accordance with the requirements of the theory Mr. Bosanquet is advocating; for, though Maxwell preferred to speak of magnetization as an induction phenomenon, he was, of course, perfectly well aware of its analogy to conduction, as might be shown by numerous quotations from his treatise, of which only one need be given.

"In many parts of physical science, equations of the same form are found applicable to phenomena which are certainly of quite different natures, as, for instance, electric induction through dielectrics, conduction through conductors, and magnetic induction. In all these cases the relation between the force and the effect produced is expressed by a set of equations of the same kind, so that when a problem in one of these subjects is solved, the problem and its solution may be translated into the language of the other subjects and the results in their new form will still be true."[2] E. H. HALL.

Cambridge, Mass., April 19, 1883.

[1] Maxwell does, in art. 437, use $\mathfrak{H}$ in this sense; but he does not use it thus in his formulas.

[2] Art. 62, new edition.

## THE SMALL PLANETS.

THE following statement of the condition of the prize question of the Royal Danish society of sciences appears in *Copernicus* for March, 1883: —

The number of small planets between the orbits of Mars and Jupiter has by degrees become so large, that it is not to be expected that it will in future be possible to compute, in advance, the motion of every single one. And it will even be less possible to compute their influence singly on the motions of the large planets or of comets. Fortunately, however, the masses of the small planets are so trifling that the perturbation caused by any one separately may be left out of consideration; but it is very doubtful whether their collective influence might not be traced in the motion of the nearer planets or comets. In order that researches on this point should give a reliable result, it is necessary first to know the form and position of the ring formed by all the small planets, and the distribution of the masses in this ring.

No degree of accuracy can be attempted in the statistical description of the ring; and, with very few exceptions, the systems of elements already deduced for each planet may be adopted; the more so, as it will be of no importance whereabouts in its orbit a planet is at any time. As to the single masses, it is, of course, necessary to draw conclusions from the apparent brightness; but the number is so considerable that a fairly reliable result may be hoped for. In the statistical researches hitherto made, the separate elements only have been discussed, apart from their connection with the other elements; but this cannot be considered satisfactory. Thus the fact that the planets, arranged according to their mean distances, are divided into a number of distinct groups, does not, by any means, prove that the ring formed by them around the sun is dissolved into a number of fairly concentric rings.

The Royal Danish society of sciences, therefore, offers its gold medal (value 320 crowns, equal to nearly ninety dollars) for a statistical investigation of the orbits of the small planets considered as parts of a ring around the sun. The form, position, and relative distribution of mass, should, if possible, be stated with at least so much accuracy as is judged necessary for computing its perturbing influence on planets and comets.

The memoirs should be written either in Latin, French, English, German, Swedish, or Danish, and must be sent before the end of October, 1884, to the secretary of the society, Dr. H. G. Zeuthen, Copenhagen. They should not bear the author's name, but only a motto, while the name should be enclosed in a sealed envelope.

## RESEARCHES ON THE DICYEMIDAE.

DR. C. O. WHITMAN has published an article[1] on these puzzling and imperfectly known parasites of the cephalopods. The number of genera is reduced to two, — Dicyema, with eight cells around the anterior end of the body; and Dicyemennea, with nine. The number of species is increased to ten, all of which are carefully described. Three are new.

As these animals have been taken by Ed. van Beneden as the type of a new division of the animal kingdom, and as they have been the subject of much discussion, we reproduce Whitman's summary. The dicyemids may be divided, according to the share they take in the work of reproduction, into monogenic and diphygenic individuals. The first produce only vermiform, the latter, first infusoriform, and then vermiform embryos. It is doubtful whether the two kinds of individuals are heterogeneous forms; for they are alike in origin, development, and adult form and structure; but their germ-cells, for unknown reasons, pursue different courses of development. There is a relation, the meaning of which is unknown, between the age of the host and the condition of the parasites; the nematogens predominating in the young, the rhombogens in the adult cephalopods. The rhombogens alone have a plurinucleate axial cell, which then contains, first, its own large nucleus; second, bodies, probably correspond-

[1] Mittheil. zool. stat. Neapel, iv. 1.