PROF. MOEBIUS ON THE EOZÖON QUESTION[1]

II.

HAVING described the Eozöon sufficiently to enable the reader to follow its comparison with foraminifera, Prof. Moebius proceeds to the description of the structure of these animals. Fig. 12 represents a longitudinal section of *Tinoporus baculatus*, magnified 150 times. This foraminiferal species occurs very frequently upon the coral reefs of the Samoan Islands in the Pacific. Its shell consists of a bi-convex middle part, from which at

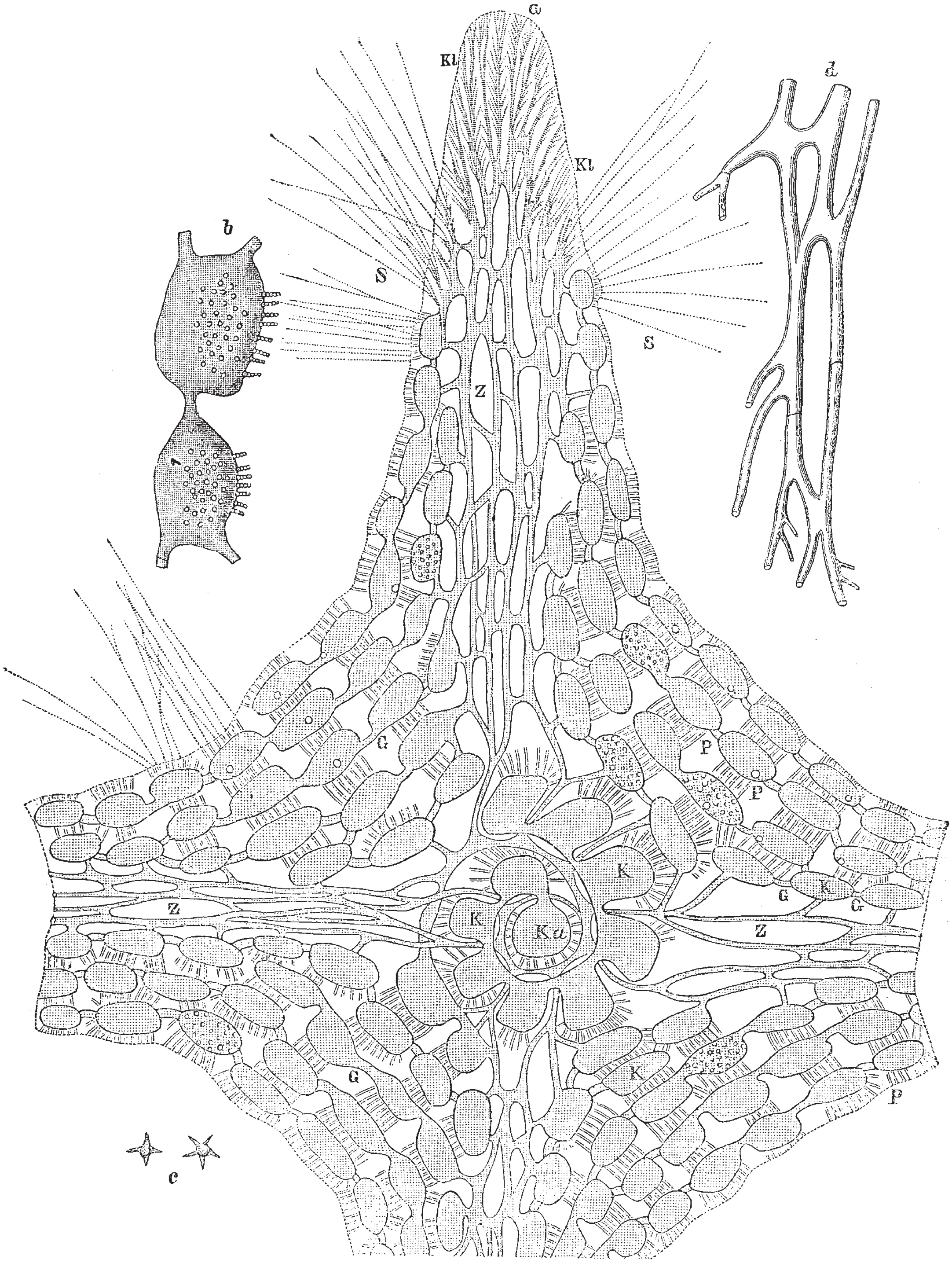

Fig. 12.

least four or five spines radiate, all of which are situated in the principal plane of the body of the shell. At C two shells of *Tinoporus* are drawn, magnified three times.

[1] Continued from p. 275.

In the centre of the larger figure we see the globular germ-chamber of the animal (K*a*) round which the next

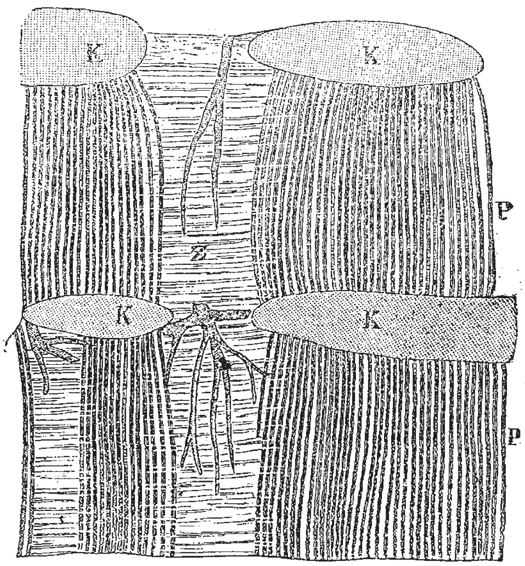

FIG. 13.

FIG. 14.

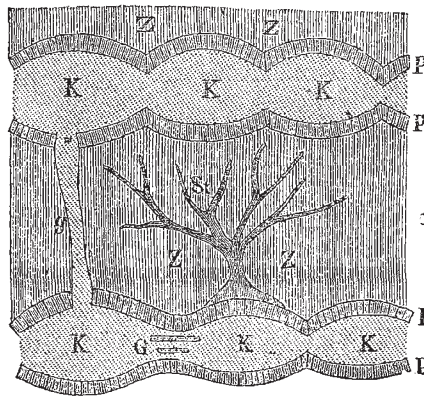

FIG. 15.

following chambers (K) are spirally arranged. Then in four directions curved rows of chambers (K) are formed, which are separated by intermediate matter (Z). The chambers communicate with each other, partly by round passages (G), partly by pore-canals (P). Through the intermediary matter (Z) a canal-system is extended, which in the long arms of the shell ends in many minute canals opening to the surface (K*l*). Through the pores of these little canals, as well as through the orifices of the peripheric pore-canals (P) of the outer rows of chambers, the sarcode, *i.e.*, the gelatinous body-substance of the animals, is in communication with the outside. In some parts protruded, granular sarcode filaments are represented (S, S); these are the so-called pseudopodia. At C we see two chitinous chamber-linings with adherent linings of pore-canals, magnified 350 times; at *d* are drawn chitinous ducts from the canal-system in the intermediary matter, also magnified 350 times, and freed from lime by treatment with dilute chromic acid. Fig. 13 represents a small part of a cross section of a tertiary *Nummulina*, magnified 220 times. K K are the chambers which were filled with sarcode. The superposed chambers communicate by means of pore-canals (P P). Between the chambers there is a deposit of poreless intermediary matter (Z), into which ramified canals are penetrating. Fig. 14 shows five pore-canals, magnified 500 times. Here it is seen distinctly that they are round tubes separated by calcareous matter. Some of them are partly filled with a dark material.

According to Dawson and Carpenter the limestone of the Eozöon represents the shell of the Eozöon animal, and the serpentine the material filling the chambers. Thus the serpentine now takes the place of the sarcode which once lived in these chambers, and which from its substance secreted the lime as a shell. The serpentine patches of the fossil Eozöon, according to this view, have the same shape and size which the separate chamber bodies of the living animal possessed when fully extended.

The separate fibres of the bands lying between the limestone and the serpentine, according to Dawson and Carpenter, are the siliceous fillings of the minute canals through which the sarcode body could send pseudopodia-filaments into the water outside of the shell. The simple

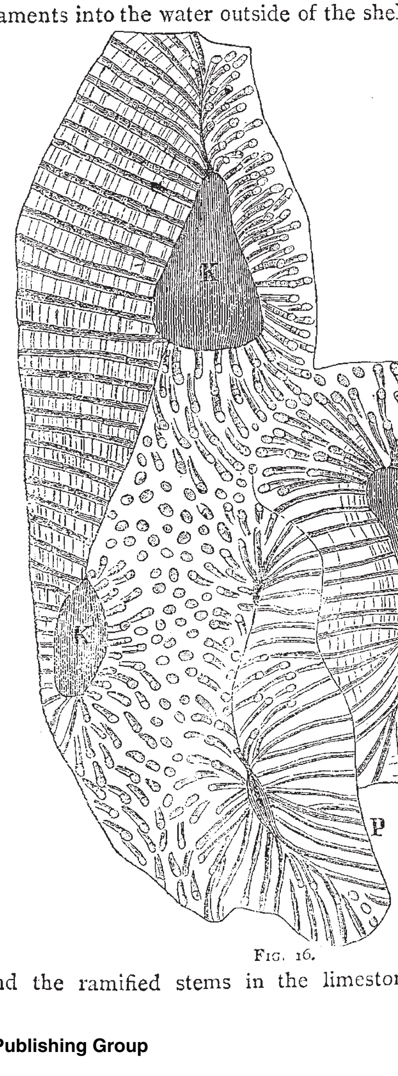

FIG. 16.

and the ramified stems in the limestone are siliceous fillings of canals in which the Eozöon sarcode extended through the calcareous intermediary matter.

Dr. Carpenter represents this view of the different parts of Eozöon by a systematic drawing, which we give in Fig. 15. K, K, K are two rows of chambers filled with serpentine. The narrow parts between the chambers correspond to the round passages of foraminifera. In the lower row of chambers, at G, the communicating passage between two chambers is divided into three narrow ducts by two plates which lie embedded here. P, P represent the walls of the chambers penetrated by the fine pore-canals, in the places of which in the real Eozöon fibres of chrysotile are now situated. Z, Z is the intermediary matter of the Eozöon shell, into which the ramified canals (St) (the present stems of the Eozöon) are protruding. Towards the left, at *g*, a chamber duct is represented, which unites two chambers of different rows or layers. Chamber ducts of this kind occur in *Tinoporus baculatus* (Fig. 12), for instance, and also in other living foraminifera.

Prof. Moebius then proceeds to compare one by one the different parts of Eozöon with those parts of foraminifera to which, according to the views of Dawson and Carpenter, they are supposed to correspond.

1. If the patches of serpentine are the filling materials of the Eozöon chambers, then they represent their cavities plastically in a similar way, as the stone kernels of echini, gasteropoda, and ammonites represent the interior cavities of the shells of these animals.

The relative sizes of the serpentine patches vary very much. The longitudinal axes of the largest ones are about thirty times as large as those of the smallest. Their absolute sizes vary from a few millimetres in length and 0·5 mm. in height, to 20-30 mm. in length and 5-10 mm. in height.

The serpentine patches of Eozöon are in form and arrangement, as well as in relative size, very unlike the chambers of most foraminifera. In their shapes none of the fundamental forms are reproduced again and again, which in all the chambers of a foraminifera species point back to one and the same law of formation. Neither the fundamental shape of a ball or lentil, nor the shape of a crescent or sickle, which occur in the different foraminifera species, form the basis of the serpentine patches of Eozöon. Yet there is a certain regularity in their shape and arrangement. Frequently they have contours similar to crystals of olivine (Fig. 10). Generally they form concavo-convex layers which are superposed and are separated by layers of limestone (Fig. 1). In many pieces an increase in size of adjacent serpentine patches in one direction may be observed. In many others ball-shaped or oval serpentine patches are arranged in such a manner that they form a spiral (Figs. 3 and 4). But this arrangement does not give the impression of a *genetic* succession, as is the case with the chambers of spiral foraminifera.

2. The fibres, forming band-like spaces between the serpentine and the limestone are supposed to be the siliceous fillings of fine pore-canals which penetrated the calcareous chamber-walls of the Eozöon shell.

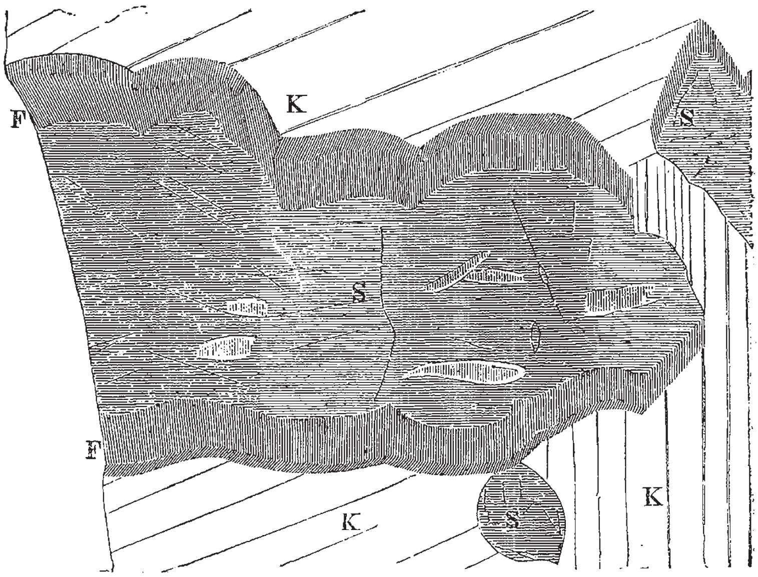

FIG. 17.

The pore-canals in the chamber-walls of foraminifera are cylindrical tubes, separated by calcareous intermediary matter. Thus every tube runs *isolated* through the chamber-wall (Figs. 12, 13, and 14). The fibres of the Eozöon, however, are prismatic needles or little plates, which are situated close together (Figs. 10 and 11), and

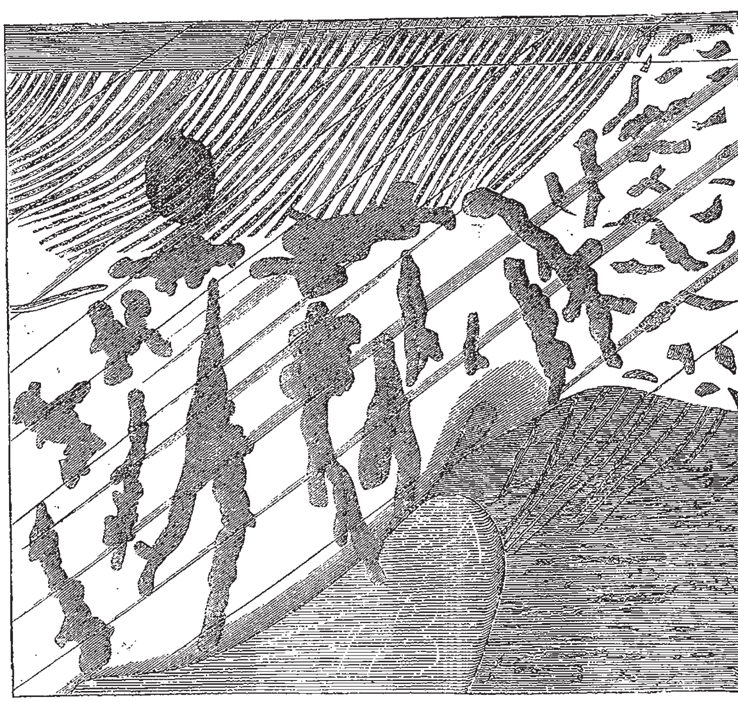

FIG. 18.

therefore they cannot represent the fillings of cylindrical tubes in another material. In no sections, neither in those which cut through them at right angles, nor in others which exhibit them obliquely, nor in those which are parallel to their axis, any traces of an intermediary substance separating the single fibres can be found. Also in polarised light the fibre bands appear altogether homogeneous and consisting only of *one* kind of material.

The pore-canals penetrate the chamber-walls of the foraminifera in such a direction that to the sarcode filaments, which, as pseudopodia are sent forth from the chambers into the water outside, they offer the shortest possible way (Figs. 12 and 13). Thus as a rule they lie at right angles to the inner and outer surfaces of their

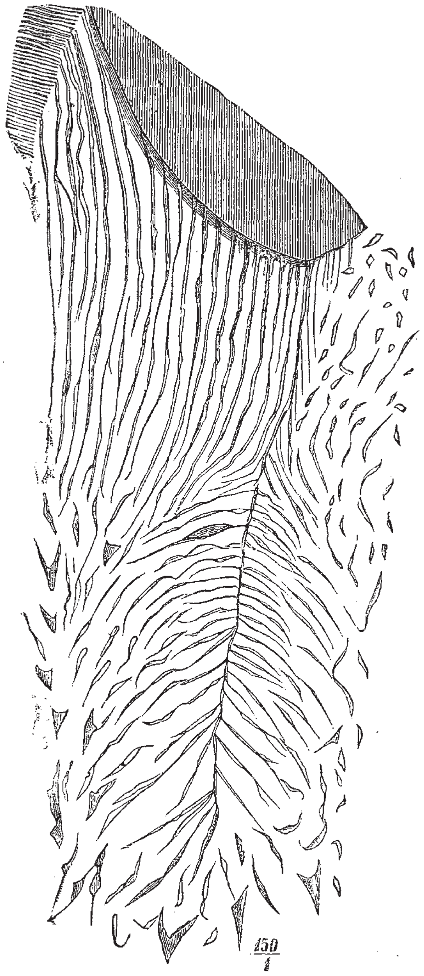

FIG. 19.

chamber-wall, as long as this continues to get uniformly thicker by the deposition of regular layers. If the thickening of the chamber-walls takes place in an irregular manner, then it often happens that the pore-canals are curved; yet even in this case the tendency of the sarcode to reach the outside water through the new thickening layers of its chamber-wall by the shortest possible way becomes apparent. This law is manifest even with the simplest forms of foraminifera, the chambers of which are not even of regular shape and arrangement. Fig. 16 illustrates this; it represents a section of *Carpenteria rhaphidodendron* magnified 120 times; K K are chambers, P P pore-canals.

In the direction of the Eozöon fibres, which are supposed to correspond to the pore-canals of foraminifera, a similar organic regularity is altogether missing. It is true that in many places they radiate from the surface of the serpentine patches, which are supposed to be the fillings of foraminifera chambers, at right angles towards the limestone; yet the direction of the fibres in these places cannot be said to represent the direction of the sarcode of a foraminifera species, because in adjacent parts the direction of the fibres does not always obey the same law, and because for great distances in the fibre bands all the fibres retain a parallel direction, no matter whether they lie at right angles, obliquely, or even tangentially to the serpentine patches. This is shown in Fig. 17, representing a section of Eozöon magnified ninety times; in the centre is a serpentine patch, S, surrounded almost on all sides by parallel chrysotile prisms; above to the right there is a smaller patch of serpentine, surrounded by chrysotile fibres of the same direction. The pseudopodia of a living sarcode mass, which once took the place of the serpentine, cannot therefore have determined the direction of the fibres; on the contrary, their parallelism points to an *inorganic* origin, because it is independent of the curvatures of the boundaries between serpentine and limestone.

3. The stems in the limestone of the Eozöon are supposed to be the siliceous fillings of ramified canals in the intermediary matter of the Eozöon shell. In good sections the stems generally look brownish in transmitted light; whitish or colourless ones are much less frequent. Their shape, size, direction, and quantity vary extremely, not only when different sections are compared, but very often already in different parts of the same section, even if this measures only a few millimetres in length and breadth. The stems may lie so close together that the spaces intervening are hardly larger than their own diameters (Fig. 18); often they are separated by wide intervals (Figs. 5 and 18). Sometimes they run parallel (Fig. 18), at other times they radiate from one or more points, or assume the shape of feathers (Fig. 19). They touch the boundaries of the limestone or are imbedded in the midst of this (Figs. 5 and 18); they are simple (Figs. 18 and 19) or ramified (Figs. 5, 9, 10, and 18), long and slender or short and broad. They terminate in fine points or in the shapes of clubs or spoons. They are straight, bent into knee shapes, curved like waves, or folded and twisted irregularly.

Their sections generally have sharp edges; round or elliptical sections, like those of the ramified canals of foraminifera, are rare amongst them. The sizes and shapes of successive sections of one and the same stem may also vary considerably.

Prof. Moebius concludes his treatise with the following characteristic sentences:—"My task was to examine Eozöon from a biological point of view. I commenced it with the expectation that I should succeed in establishing its organic origin beyond all doubt. But facts led me to the contrary. When I saw the first beautiful stem-systems in Prof. Carpenter's sections, I became at once a partisan of the view of Professors Dawson and Carpenter; but the more good sections and isolated stems I examined, the more doubtful became to my mind the organic origin of Eozöon, until at last the most magnificent 'canal-systems' taken all together and closely compared with foraminifera sections preached to me nothing but the inorganic character of Eozöon over and over again.

"In the minds of other zoologists, while showing them a series of my finest Eozöon sections, stem preparations, and foraminifera sections under the microscope, I have repeatedly in the course of an hour called forth these mental metamorphoses, which I passed through in the course of a long period of investigation.

"I am heartily sorry that, by way of thanks for the extremely kind support which Professors Dawson and Carpenter have given me in these investigations by sending me beautiful Eozöon pieces, I cannot say to them: According to my investigations also *Eozöon canadense* must be regarded as a fossil species of foraminifera. I am convinced that both, like myself, had the honest intention to represent correctly the true nature of Eozöon. But they must own that in their descriptions they did not investigate so closely nor describe so minutely the shapes nor the relative positions of the various parts, as I have done in my treatise. If they had done this then I believe that the facts would have led them to the same conclusions which they forced upon me.

"If the Eozöon pieces from the Laurentian or 'Urgneiss' formation were really remains of an undoubted foraminifera species, then we should possess in them *certain* proofs that even during the formation of the most ancient strata of the earth's crust living beings occurred, and that the first organisms belonged to the lowest animals, by which biology and geology would have gained two highly important facts. Yet by the scientifically justified elimination of Eozöon from the domain of organic beings it is not proved that during the Laurentian period no living beings existed. Perhaps the graphite of the Urgneiss formation has its origin in organic beings.

"The proof that Eozöon is not a fossil rhizopod will perhaps for many persons take away an important link from the beautiful picture of the development of organic life upon the earth, which they may have drawn up for themselves. But the object of natural research does not consist in finding reasons for attractive conceptions about nature, but in knowing nature as it really is. Because only an insight into the real condition of nature can, in the long run, satisfy the scientific mind, which gives up as errors the most attractive hypotheses regarding the essence and action of nature, if in the face of newly discovered facts they can no longer hold good, no matter whether these erroneous hypotheses may have reigned supreme for a long time previously, and may have been held to be the best conceptions of nature by the most eminent authorities."

THE BLOWPIPE CONE-SPECTRUM, AND THE DISTRIBUTION OF THE INTENSITY OF LIGHT IN THE PRISMATIC AND DIFFRACTION SPECTRA

NOW that the optical properties of the blowpipe blue cone have been so critically investigated, may I draw the attention of the readers of NATURE who are interested in the history of spectrum analysis, to what I think are the earliest experiments on that subject. They were published by me in 1848. The memoir in which they are reprinted may be found in my "Scientific Memoirs." It contains a woodcut of the five rays, adjusted to a reference solar spectrum on page 64, and another of the five images of the cone on page 69.

Let me also refer to some experiments I have recently made on the distribution of the intensity of light on the spectrum, by the aid of a new form of spectrometer, which depends on the well-known optical principle, that a light becomes invisible when it is in presence of another light about sixty-four times more brilliant.

In a memoir I am now publishing in the *American Journal of Science*, and which, I presume, will also appear in the *Philosophical Magazine*, I have described several modifications of this instrument. The following is one easily made:—

Remove from the common three-tubed spectroscope its scale-tube, and place against the aperture into which it was screwed a glass ground on both sides. In front of this arrange an ordinary gas light attached to a flexible tube, so that its distance from the ground glass may be varied at pleasure. This light I call the extinguishing light. On looking through the telescope-tube the field of view will be found uniformly illuminated, this being the use of the ground glass, the light of which is reflected from the prism. The brilliancy of the field depends on the distance of the extinguishing light from the ground glass, according to the ordinary photometric law.

Now, if another small gas flame be set before the slit of the instrument, on looking through the telescope its spectrum will be seen in the midst of a field of light. If the illumination of that field be made very brilliant, the spectrum will be extinguished; if feeble, all the coloured regions appear. By moving the extinguishing flame to proper distances, it will be found that the violet region is the first to disappear, the red the last. The yellow by no means resists longest, as it ought to do if it were the most brilliant. Hence it follows that in the prismatic spectrum, the red and not the yellow is the brightest ray.

If the cause of the increasing intensity of light in the prismatic spectrum, from the more to the less refrangible region, be the compression exercised by the prism on the coloured spaces, increasing as the refrangibility is less, we ought not to find any such peculiarity in the diffraction spectrum. In this the coloured spaces are arranged uniformly, and without compression in the order of their wave-lengths. An extinguishing light ought to obliterate them all at the same moment.

Having modified the common spectroscope by taking away its dark box, so that the slit-tube and the telescope tube could be set in any required angular position to each other, I put in the place of its prism a glass grating, inclined at 45° to rays coming in through the slit. The ruled side of the grating was presented towards the slit. Now when the extinguishing flame was properly placed before its ground glass, the plane face of the grating reflected its light down the telescope-tube. In this, as in the former case, the spectrum of a small flame before the slit was seen in the midst of a field of light, the intensity of which could be varied by varying the distance of the extinguishing flame. It was now found that as the brilliancy of the extinguishing illumination increased, all the coloured spaces disappeared at the same moment, and on diminishing the illumination all the colours came into view at the same time. As long as the red was visible the violet could be seen.

From this it follows that in the diffraction spectrum the luminous intensity is equal in all the visible regions. In the memoirs now publishing I have applied these facts to the case of the spectrum distribution of heat.

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THE NEW THERMO-ELECTRIC LIGHT BATTERY

IT appears that a difficulty which it has long been the ambition of practical electricians to overcome has at last been solved by M. Clamond. According to his statement, published in *La Lumière Electrique*, which is confirmed by the Count du Moncel, M. Clamond has succeeded in producing the electric light by means of his new thermo-electric battery. M. Sudré has also just published his design for a powerful thermo-electric battery, but we do not know whether this system has yet been put to any practical trial, whereas that of M. Clamond is now in actual use for the purpose of lighting certain factories in Paris. Full details of either system have not yet come to hand, so that it is only possible to state the general results at present obtained.

That heat could be transformed into electrical energy was first discovered by Seebeck in 1822, who found that an electric current was produced when the junction of two dissimilar metals was heated. Little use, however, was made of this discovery as a source of energy, owing to the feebleness of the current to which it gives rise, although it has been of great service since the time of Forbes and Melloni in the investigation of radiant heat.