Suppose now F to be so large, positive or negative, as to make v so great that V may be neglected in comparison with it, then we may think of the cups as whirled round in quiescent air in the positive or usual direction when F is negative, in the negative direction when F is greater than F_1. When F is sufficiently large the resistance may be taken to vary as v^2. For equal velocities v it is much greater when the concave side goes foremost than when the rotation is the other way. For air impinging perpendicularly on a hemispherical cup Dr. Robinson found that the resistance was as nearly as possible four times as great when the concave side was directed to the wind as when the convex side was turned in that direction (*Transactions* of the Royal Irish Academy, vol. xxii. p. 163). When the air is at rest and the cups are whirled round, some little difference may be made by the wake of each cup affecting the one that follows. Still we cannot be very far wrong by supposing the same proportion, 4 to 1, to hold good in this case. When F is large enough and negative, F may be taken to vary as v^2, say to be equal to $-Lv^2$. Similarly, when F is large enough and positive, F may be taken equal to $L'v^2$, where in accordance with the experiment referred to, L′ must be about equal to 4 L. Hence we must have nearly—

$\eta = -L\xi^2$, when ξ is positive and very large;
$\eta = 4L\xi^2$, ,, negative ,, ,,

Hence if we draw the semi-parabola O A B corresponding to the equation $\eta = 4L\xi^2$ in the quadrant $\eta\, O - \xi$, and the semi-parabola O C D with a latus lectum four times as great in the quadrant $\xi\, O - \eta$, our curve at a great distance from the origin must nearly follow the parabola O A B in the quadrant $\eta\, O - \xi$, and the parabola O C D in the quadrant $\xi\, O - \eta$, and between the two it will have some flowing form such as P N M K. There must be a point of inflection somewhere between P and K, not improbably within the positive quadrant $\xi\, O\, \eta$. In the neighbourhood of this point the curve N M would hardly differ from a straight line. Perhaps this may be the reason why Dr. Robinson's experiments in the paper published in the *Phil. Trans.* for 1878 were so nearly represented by a straight line.

FELLOWSHIPS AT OWENS COLLEGE, MANCHESTER

A SCHEME of Science and Literature Fellowships, modelled very closely after the pattern of the Fellowship Scheme of the Johns Hopkins University, Baltimore, has been organised in Owens College, Manchester. The Council propose, early in October next, to appoint to five Fellowships on the terms and conditions following:—1. The appointment will be made by the Council, after receiving a report from the Senate, not on the results of examination, but after consideration of documentary or other evidence furnished to them. 2. Application by persons desiring to hold these fellowships must be made, in writing, on or before October 1. In his application the candidate should indicate the course of his previous reading and study, and his general purposes with reference to future work. 3. The candidate must give evidence of having received a sound and systematic education either in literature or in science, such as the possession of a degree of an English University, or a certificate from the authorities of an English School of Medicine or Science, of good repute, showing that he has passed through his curriculum with distinction, or, in default thereof, such other evidence as shall be satisfactory to the Council that he is qualified to prosecute some special study or investigation in the manner indicated in § 6. Finally, he should produce a satisfactory testimonial of character and conduct, and should give the names of not more than three persons from whom further information may be sought. 4. In the award of the Fellowships regard will be had to the pecuniary circumstances of the candidates. 5. The value of each Fellowship will be 100*l.* for the academical year 1881-82. In case of resignation or other withdrawal from the Fellowship, payment will be made for the time during which the Fellowship may have been actually held. 6. Every holder of a Fellowship will be expected to devote his time to the prosecution of some special study, with the approval of the Council after receiving a report from the Senate; and before the close of the year to give evidence of progress by the preparation of a thesis, the delivery of a lecture, the completion of some research, or in some other method. He will study under the direction of the Professor of the subject in which he is appointed, and will be required to pay such fees as the Council shall in each case determine. 7. He may be called on by the Council, after report from the Senate, to render some service to the College, either as an occasional examiner or by giving instruction in lectures or otherwise, to students in the College—provided always that he shall not, during his tenure of the Fellowship, hold any regular or salaried post as Assistant Lecturer or Demonstrator in the College—but he may not engage in teaching elsewhere. 8. He must reside in Manchester during the academical year. 9. He may be re-appointed at the end of the Session for a second and, in like manner, for a third year. 10. Candidates are invited to apply for appointment in any one of the following nine departments:—(1) Classics; (2) English Language and Literature; (3) History; (4) Philosophy; (5) Pure Mathematics; (6) Applied Mathematics (including Engineering); (7) Physics; (8) Chemistry; (9) Biology (including Physiology)

SOCIETIES AND ACADEMIES

LONDON

Royal Society, June 16.—"On Stratified Discharges. VI. Shadows of Striæ," by William Spottiswoode, P.R.S., and J. Fletcher Moulton, F.R.S.

One of the most interesting questions connected with the subject of stratified discharges is this: What is the physical, as distinguished from the electrical, nature of the striæ themselves? Are they, in fact, to be regarded as aggregations of matter possessing greater density than the gas present in the dark spaces, or are they to be considered as indicating merely special local electrical conditions? The fact of their having a definite configuration, especially on the side which is turned towards the negative terminal of the tube, that of their temperature being higher than that of the dark spaces, the manner in which they are affected by solid bodies, and other considerations, all tend to give support to the view that the striæ are loci of greater density than the dark spaces. Still it can hardly be said that as yet any experimental proof of this has been given sufficiently decisive to decide the question conclusively. And it is in the hope of contributing something towards the solution of this question that the following experiments are submitted to the notice of the Royal Society.

The two terminals of a Holtz machine were connected in the usual way with the two terminals of the tube, so as to produce a stratified discharge. A narrow strip of tin-foil, or a wire, was stretched along the tube opposite the column of striæ. The positive terminal of a second Holtz machine (in practice we used for this purpose a Töppler machine) was connected with the tin-foil, and the negative terminal with one (either) terminal of the tube. An air-spark, or interval across which sparks could pass, was interposed in the part of the circuit between the machine and the tin-foil. The effect of this arrangement was this: In the interval between two sparks the tin-foil and tube became charged like a Leyden jar; the tin-foil being the outer coating, charged positively, and the gas inside serving as the inner coating, charged negatively. When the spark passed across the interval mentioned above, the jar (*i.e.* the tube) became discharged, and the electricity previously held bound on the two coatings was set free.

When the first (say the "internal") machine was not working, or when it was disconnected, *i.e.*, when no regular discharge was passing through the tube, then, whenever a spark passed at the second (or "external") machine, a negative discharge with its accompanying Crookes' radiation took place from the inside of the tube next the tin-foil, and the opposite side of the tube became covered with a sheet of green phosphorescence (the tube being of German glass).

When, however, other things remaining as before, a discharge from the internal machine was sent through the tube, and a good stratified column was produced, it was found that the green phosphorescence was entirely cut off from the parts of the tube opposite to the striæ, while on the parts opposite to the dark spaces it remained, in the form of phosphorescent rings, as brilliant as before. The experiment was repeated with various tubes with various degrees of strength of current, and with various densities of gas (produced by heating a chamber of potash in connection with the tube). It may be added that when, as is sometimes the case, through greater exhaustion, the striæ became feebler in illumination and less compact in appearance, the shadows cast by them lost proportionally in sharpness of definition and in completeness of extinction of the phosphorescent light.

The brilliancy and definition of the phosphorescent rings may be increased by inserting a small Leyden jar in the circuit, care being taken that the jar shall discharge itself completely each time. If this is not the case the main discharge is followed by

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subsidiary discharges, which tend to blur the effect. The angle of dispersion may be increased, or rather supplemented, by placing more than one strip on the tube, distant from one another by an angle of 90° or 120°. By this means the rings may be made to comprise the entire circumference of the tube.

It thus appears that the striæ are competent to cast shadows in the radiant showers issuing from the inside of the tube adjacent to the tin-foil, which part acts as a negative terminal. Many experiments have contributed to show that these radiant showers, although accompaniments of the discharge, are not carriers of the discharge; and that, having once issued from their source, they continue their own course irrespective of that of the discharge proper. They are in fact material showers, and, although not improbably charged with electricity, yet their ulterior course does not appear to depend on their electrical condition. Under these circumstances the simplest explanation appears to be that they have been arrested by a material obstacle, and consequently the phenomena above described may be considered as furnishing an experimental proof that the striæ represent local aggregations of matter, and not merely special electrical conditions of the gas.

June 16.—"On Stratified Discharges. VII. Multiple Radiations from the Negative Terminal." By William Spottiswoode, P.R.S., and J. Fletcher Moulton, F.R.S.

On examining the image of a negative terminal as traced out in tubes of great exhaustion, by the phosphorescence due to Crookes' radiations, we have often noticed that the image was not a simple figure, but that more than one outline of the contour of the terminal might be traced. From the fact of the double contour having been first remarked when the terminal was of a conical form, it was at first supposed that the second image might be due to internal reflection, or to some property appertaining to the edge of the cone. But this supposition led to no satisfactory explanation of the phenomenon.

It was however thought that, inasmuch as the two images implied different systems of radiation, a magnet suitably disposed might affect them in different degrees, and thereby throw some light on their origin. For this purpose we used a large electro-magnet with its coils so coupled up as to give the two poles similar polarity. By bringing the two poles together, inclined at a moderate angle, a single pole and a field of great magnetic strength was produced.

The tube was then placed in the plane containing the axis of the two poles, and in the direction of a line bisecting their directions. The tubes first used were of great exhaustion, and were placed sometimes with the positive, sometimes with the negative terminal towards the magnet. When the tube was placed in a comparatively weak part of the field the two images of the cone were seen in their usual positions relatively to each other, except that they were slightly more separated. But as the tube was brought gradually into a stronger part of the field the two images became further separated, and by degrees a third, a fourth, and even more images were brought out on the side of the tube. In one tube of very high exhaustion, for which we are indebted to Mr. Crookes, as many as eight images became visible.

We have then, as an experimental fact, a series of images, each formed by a system of rays issuing from the surface of the negative terminal. The images being distinct, the system of rays must be distinct also. Now, as it seems hardly possible to imagine that, from every point of a surface, there can issue at one and the same instant of time a variety of systems of radiations, each system ranging over a finite angular distance, and each differently directed in space, we are driven to the conclusion that these radiations must have issued successively and not simultaneously from the terminal. In other words, the various images are formed in succession. Now, the entire series of images are present whenever a discharge passes through the tube; and when a "continuous" discharge (such as that from a Holtz machine) is passing, they are all as steady and as persistent as are any other features of the discharge. From this it follows that the radiations are not a continuous phenomenon, but that they are composed of a recurrent series of discharges, each having its own angular range, and its own direction in space; and as the electricity, which is the motive power, and the metallic terminal, which is the directing machinery, are the same in kind for each image, we are led to the conclusion that the positions of the images are determined by the force with which the radiations are projected. In fact, we understand that the various images are due to a succession of discrete discharges of successively diminishing strength.

The phenomenon of multiple images of the negative terminal as explained above has an important bearing on the nature of electrical discharges in vacuum tubes. For, if the phosphorising radiation consists of a recurring series of discrete discharges, the radiation in each series, and *à fortiori* the radiation as a whole, is discontinuous; and consequently the electrical discharge, to which it is due, must itself be discontinuous or "disruptive." We appear, therefore, in these phenomena to have an experimental proof, independent of and in addition to those adduced by Mr. De La Rue and others, of a fundamental point in the theory of these discharges, namely, their disruptive character.

Geological Society, June 8.—R. Etheridge, F.R.S., president, in the chair.—The meeting was made a special general meeting for the election of a Member of the Council in the room of the late Sir P. de Malpas Grey-Egerton, Bart., M.P., F.R.S., F.G.S.—The President announced that the late Sir Philip Egerton had bequeathed to the Society all the original drawings made from specimens in his collection for the illustration of Prof. Agassiz's works on Fossil Fishes. The Society had long possessed the drawings made for the same purpose from the Earl of Ellesmere's collection, and some years ago the Earl of Enniskillen presented those which had been prepared from specimens in his possession. Sir Philip Egerton's kind bequest would complete this interesting series.—Sir John Lubbock, Bart., M.P., F.R.S., was elected a new Member of Council. Messrs. Grenville A. J. Cole and J. L. Roberti were elected Fellows, and Il Commendatore Quintino Sella of Rome a Foreign Member of the Society.—The following communications were read:—The reptile-fauna of the Gosau formation, preserved in the Geological Museum of the University of Vienna, by Prof. H. G. Seeley, F.R.S., with a note on the geological horizon of the fossils, by Edward Suess, F.M.G.S. The collection of reptiles described in this paper was obtained at Neue Welt, near Wiener Neustadt, by tunnelling into the freshwater deposits which there yield coal. A part of the collection was described by Dr. Bunzel in 1871; but the author's interpretation of the fossils rendered a re-examination of the whole collection necessary. All the species hitherto discovered are new, and, with the exception of those referred to *Crocodilus*, *Megalosaurus*, *Ornithochirus*, and *Emys*, are placed in new genera. Nearly all the bones are more or less imperfect. The *Iguanodon Suessii*, of Bunzel, was referred to a new genus, *Mochlodon*, characterised by the straight anterior end of the ramus of the lower jaw and by the vertical bar in the middle of the teeth of the lower jaw. There appear to be two teeth in the ramus. The tooth referred to the upper jaw has several uniform parallel vertical bars. A small parietal bone, referred by Bunzel to a lizard, is considered by the author to belong probably to the same species, and, with some doubt, he associated with it the articular end of a small scapula. Bunzel's *Struthiosaurus Austriacus* was re-described by the author, who indicated that the bones of the base of the brain-case, regarded by Bunzel as the quadrate bones, really belong to the occipital region, which necessitates a different interpretation. The foramina along the base of the skull were also described as presenting one of the characteristics of the Dinosaurian order. The base of the skull of *Acanthopholis horridus* was described to show its relation to the above type, with the view of demonstrating its Scelidosaurian affinities. The greater part of the remains were referred by the author to a new genus, *Cratæomus*; some of these had been figured by Bunzel as "Crocodili ambigui," and others as belonging to *Scelidosaurus*, and to a new Lacertilian genus, *Danubiosaurus*. To *Cratæomus* he referred mandibles, teeth, vertebræ from all parts of the column except the sacrum, dermal armour, and the chief bones of the limbs. Two species were distinguished, *C. Paulowitschii* and *C. lepidophorus*. The former, which is much the larger, was named in honour of M. Paulowitsch, who voluntarily superintended the work at the Neue Welt. The author stated that he regarded these animals as carnivorous, and that, unlike the typical Wealden Dinosaurs, they were not kangaroo-like in habit, but had strongly developed fore limbs, as indicated in the proposed generic name. Two teeth belonging to *Megalosaurus* were described as representing a new species, *M. Pannoniensis*, characterised by the crown being shorter and broader than in previously described forms. A fragment, regarded by Bunzel as the thoracic rib of a lizard, was interpreted as the distal end of the femur of a Dinosaur, and named *Ornithomerus gracilis*. The lower jaw, described by Bunzel as *Crocodilus carcharidens*, of which a maxillary bone also occurs, was made the basis of a new genus, *Doratodon*,

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probably Dinosaurian, judging from the lateral position of the apertures of the skull and the characters of the teeth. The genus *Rhadinosaurus* was founded upon the humerus and femur, the latter having been regarded by Bunzel as the dorsal rib of a crocodile; the species was named *R. alcimus*. *Oligosaurus adelus* was described as presenting Lacertilian characters in combination with some Dinosaurian peculiarities. The remains include the humerus, femur and scapula, and two vertebræ, which were regarded by Bunzel as fœtal vertebræ of a Dinosaur. The genus *Hoplosaurus* was founded on some vertebræ, fragments of limb-bones, and dermal armour; it shows, with distinctive peculiarities, a certain resemblance to *Hylæosaurus*. A procœlian crocodile was represented by many parts of the skeleton; some figured by Bunzel as Lacertilian, others as Crocodilian. It is remarkable for having a buttress supporting the transverse process in the lumbar region. The author calls it *Crocodilus proavus*. The specimen figured by Bunzel as the ilium of his *Danubiosaurus anceps*, was stated by the author to be a costal plate of a large Chelonian, in which, apparently, the margins of these plates remained separate through life. Skull bones, believed to belong to the same animal, are strongly sculptured; the author named the species *Pleuropeltus lissus*. Three or four species of Emydians were said to be indicated by isolated plates, the largest of which was named *Emys Neumayri*. The only specimen referable with certainty to a lizard is a small vertebra of elongated form, regarded as indicating a new genus and species, named *Spondylosaurus gracilis*. Of Pterodactyls there are but few remains; but these certainly represent two genera. The author only describes one species, to which he gives the name of *Ornithochirus Bunzeli*. There are, in all, probably ten genera of Dinosaurs, and five genera of other groups, making fifteen in all. The paper was supplemented by a note by Prof. Suess on the geological relations of the beds at Wiener Neustadt to those of the Gosau Valley, in which he comes to the conclusion that they are older than the true Turonian deposits, and especially older than the zone of *Hippurites cornu vaccinum*.—On the basement-beds of the Cambrian in Anglesey, by Prof. T. McKenny Hughes, M.A., F.G.S. In this paper the author first pointed out that there was in Anglesey:—(1) An upper slaty group, in which he had fixed two live zones, which showed that the series belonged to the Silurian (Sedgwick's classification), and (2) a lower group of slates and sandstones in which Arenig fossils had been found in several localities, and Tremadoc had been less clearly recognised, while by the correction of the determination of a species of *Orthis*, there was now a suspicion of even Menevian forms. These all rested upon the basement-beds of the Cambrian, of which the paper chiefly treated. They were made up of conglomerates, grits, and sandstones, with Annelids and Fucoids. The basement-beds varied in thickness and character according to the drift of currents along the pre-Cambrian shore and the material of the underlying rocks. Near Penlon, where they rested on a quartz-felspar rock, they consisted chiefly of a quartz-grit and conglomerate, almost exactly like that of Twt Hill. Near Llanerchymedd, where there was a mass of greenish schistose rock succeeding the Dimetian, the Cambrian basement-bed contained a large number of fragments of that rock, certain bands being chiefly composed of it. Near Bryngwallen, where the underlying Archæan consisted of gneissic rocks, the Cambrian basement-beds were made up of quartz conglomerate. Tracing it still further to the south-west he found bosses of conglomerate among the sand dunes of Cymmeran Bay, full of fragments of green schistose rock like that of Bangor, and telling of the further development of Pebidian at the south-west end of the Anglesey axis. In several localities these conglomerates were associated with and passed into fossiliferous grits and sandstones. He exhibited slices of the more important rocks, which he showed confirmed the results arrived at from other evidence. He pointed out that the observations now made confirmed the views he had expressed on a former occasion with regard to the basement-beds of the Cambrian between Caernarvon and Bangor, where the deposits which rested upon the granitoid rocks of Twt Hill were either a kind of arkose or chiefly composed of quartz with a few pieces of mica-schist and jasper; but as he followed them a few miles to the north-east he found that the quartz had got pounded into smaller grains, and the larger pebbles were chiefly of felsite, which here formed the shore, while further towards Bangor fragments of the still higher Bangor volcanic series helped to make up the Cambrian shingle-beach.—Description and correlation of the Bournemouth beds. Part II. Lower or freshwater series, by J. S. Gardner, F.G.S. This was in continuation of a former paper by the author (*Q.J.G.S.* vol. xxxv. p. 209). The beds described are exposed east and west of Bournemouth and near Poole harbour, over a distance of about four miles. The author referred them to the Middle Bagshot, and stated that they are distinguished from the Lower Bagshot by the absence of the extensive pipe-clay deposits and the presence of brick-earths, and from the overlying beds by the absence of flints. They reach their extreme limit in the western area of the London basin, and are represented by the lignitic beds 19-24 of Prof. Prestwich's section. Lignites can be traced partly across the bay. The cliffs present an oblique section across a delta divisible roughly into four masses, one of which, from its confused bedding and want of fossils, is supposed to have been formed by the silting up of the main channel. The total thickness of the series was estimated at 600 to 700 feet. The inferences drawn by the author were as follows:—(1) From the beds cut through showing a steep side to the west, that the river flowed from that direction; (2) from the absence of boulders or coarse sediment, that the area was flat; (3) from the absence of lignite, that there were catchment basins; (4) from the absence of flint, and the quartzose nature of the beds, that no chalk escarpments were cut through, and that the deposits came from a granitic area; and (5) from the presence of wood bored by *Teredo* that the beds belong to the lower part of the river in proximity to tidal water. The flora was stated to be confined to local patches of clay. Those at the western end of the section are very rich, and distinguished from the rest by absence of palms and rarity of ferns. The beds near Bournemouth are still richer and very distinct; those east of Bournemouth are characterised by *Eucalypti*, Aroids, and *Araucariæ*; and those at the western end of the section by abundant Polypodiaceæ. It is remarkable that nearly every patch contains a flora almost peculiar to it; but the flora as a whole seems to pass upward to the Oligocene, but not down to the Lower Bagshot.

Sanitary Institute of Great Britain, June 21.—Dr. A. Carpenter in the chair.—A paper was read by Prof. W. H. Corfield, M.A., M.D., on the present state of the sewage question. In the discussion which followed Mr. W. C. Sillar, Mr. E. F. Bailey Denton, Mr. Douglas Onslow, Mr. R. W. P. Birch, Mr. G. B. Jerram, and Mr. Wilson Grindle took part. The Chairman made a few remarks relative to the successful working of the sewage farm at Croydon, and Prof. Corfield replied briefly to some of the points raised in the discussion.

CONTENTS

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