January 19, 1860.

Sir BENJAMIN C. BRODIE, Bart., President, in the Chair.

The following communications were read :—

I. "Abstract of a series of Papers and Notes concerning the Electric Discharge through Rarefied Gases and Vapours." By Professor Plücker, of Bonn, For. Memb. R.S. Received December 6, 1859.

I. *Action of the magnet on electric currents transmitted through tubes of any form.*

The action exerted by a magnet on the luminous electric discharge, passing through a tube or any vessel of glass which contains residual traces of any gas or vapour, may be *generally* explained, if we regard the discharge as a bundle of elementary currents, which, under the influence of the magnet, change their form, as well as their position within the tube, *according to the well-known laws of electro-magnetic action.*

The concentration of the discharge into one free arch only takes place *if the arch be allowed to constitute a part of a line of magnetic force.* [According to theory, there is no electro-magnetic action at all exerted on any element of a linear electric current which proceeds along such a line.] This condition, for instance, is fulfilled in the case of an exhausted sphere of glass, through which the discharge is sent by means of two small apertures, if the sphere be put on the iron pieces of an electro-magnet in such a way that the two apertures coincide with any two points of a line of magnetic force.

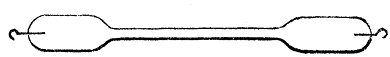
There is another case of electro-magnetic equilibrium, which takes place *if the current proceed along an "epibolic curve," i. e.* along a curve, falling within the interior surface of the vessel, whose elements, regarded as elements of an electric current, are perpendicular to the direction of the electro-magnetic force and impelled by this force towards the surface. An exhausted cylindrical tube, when equatorially placed on the iron pieces of the electro-magnet, presents the simplest instance of this case. All elementary currents are concentrated by the magnet along one straight line, which, according to the direction of the discharge and to the magnetic polarity, occupies

either the highest or the lowest position within the tube. When the axis of the tube makes an angle of 45° both with the axial and equatorial direction, the epibolic curve is found to be a fine spiral.

If neither of the two conditions mentioned above can be fulfilled, *i. e.* if the current cannot proceed either along a free magnetic or an epibolic curve, *no voltaic arch will be obtained*; *the current will be disturbed, and its light diffused.* This, for instance, is the case when the above-mentioned cylindrical tube is placed axially on the two poles of the magnet: there will be seen above each of these poles a luminous epibolic straight line, lying within the horizontal plane which passes through the axis of the tube, one on each side of this axis; but there exists neither a line of magnetic force nor an epibolic curve, joining the extremities of the two epibolic straight lines between the poles; hence diffusion of light.

There are other classes of phenomena not at all indicated and explained by the laws of electro-magnetism. In many cases *the magnet extinguishes the light of the current, without altering its intensity.* I sent the discharge of Ruhmkorff's apparatus at once through two exhausted tubes, communicating by a copper wire. The first tube, about eight inches long and highly exhausted, was brought over the iron pieces of the electro-magnet into an equatorial position, while the second one was placed at some distance from the poles. Whilst the magnet was not excited, both tubes became luminous by the transmitted current; when it was excited, the light of the first tube entirely disappeared, while the appearance of the second did not undergo the least change. Hence we conclude that the disappearance of the light does not prove the extinction of the current.

Similar results are obtained when a tube having the shape of the annexed drawing is brought with its narrow middle part between the



two iron pieces. In this case the light disappears where the magnetic action is greatest, but not in the other parts of the apparatus. Sometimes before the light disappears, its colour is entirely changed, while in other cases, the magnetic force being less strong, only the change of colour takes place. The violet colour of sulphurous acid and of vapour of bromine is thus transformed into a fine green, and the blue of chloride of tin becomes a beautiful colour of pure gold.

If the magnet be strong enough, a phenomenon of the same kind is obtained when in the above-mentioned experiment the larger tube is put equatorially on the iron pieces, and the current concentrated in the lowest part of the tube. Then, where the magnetic action is greatest, the illuminated epibolic straight line is interrupted, terminating in *two* cusps, which in the case of sulphurous acid show a green colour. Waving light goes from one cusp to the other. In a room quite dark, highly diffused light is seen moving from one pole to the other, along lines of magnetic force.

When the sphere previously mentioned is placed on the iron pieces so that the two opposite apertures fall within the equatorial plane, the transmitted current will be concentrated along an epibolic curve, which in this case is one of the two arcs of the great circle within the equatorial plane, supplementary to each other, and joining the two apertures. If it be the lower arc, turned towards the magnet, the epibolic current starting from the positive wire terminates in a cusp, where the action of the magnetic force, supposed generally to be strong, is greatest, while from the opposite side waving light enters the sphere. In this case there is only *one* cusp.

II. *The light of the negative wire bent by the magnet into curves and surfaces.*

In order to render the new class of phenomena most brilliant and well defined, larger tubes of a cylindrical shape, into which long wires enter at both ends, are to be selected. The light surrounding the negative wire must be as bright as possible, and the well-known dark space by which it is bounded must be very broad. The magnet acts on this light in a peculiar way, having no analogy with phenomena hitherto observed. I easily discovered the law giving in all cases the exact description of the phenomenon.

The light emanating from any not isolated point of the negative wire, and diverging in all directions towards the interior surface of the surrounding tube, *is bent by the action of the magnet into the magnetic curve, which passes through this point.* According to the law already mentioned, such a curve is the only one along which an electric current can move without being disturbed by the magnet. It equally represents the form which a chain of infinitely small iron needles, absolutely flexible and not subjected to gravity, would

assume, if attached with one of its points in the point of the negative wire. It is well known that a magnetic curve is completely determined by a single one of its points. Therefore the whole light, starting from all the different points of the negative wire, *will be concentrated within a surface generated by a variable magnetic curve.* The form of this "magnetic surface" varies according to the form of the negative wire, and its position with regard to the poles of the electro-magnet. When the negative wire lies within the equatorial plane, the magnetic surface assumes the shape of a vault; when the wire lies within the axial plane, the whole surface is contained within the same plane, and generally bounded by very well defined magnetic curves.

The negative light partly depends upon the substance of the wire. Particles of it, either pure or combined with the included gas, are carried off to the interior surface of the tube, which, when platina wires are used, consequently is blackened. If not acted upon by the magnet, all the part of the surface surrounding the platina wire becomes black; if acted upon, only that line along which the surface of the tube is intersected by the magnetic surface is blackened. *In this case, therefore, the particles separated from the wire move along magnetic curves.*

I think it most probable that the luminous electric currents in question are double currents,—going from the wire to the glass, and returning from the glass to the wire.

The importance of the use of magnetic curves, or lines of magnetic force, in experimental researches, has been shown by several philosophers, especially by Mr. Faraday. Hitherto only filings of iron enabled us to give in peculiar cases an imperfect image of these curves. We may now *trace through space such a curve in the most distinct way and illuminate it with bright electric light.*

III. *The light of the positive wire and its spirals under the magnetic action.*

The origin of the current takes place at the positive wire. If the negative wire is not too far from the positive, most striking phenomena are obtained when the magnet is acting on the formation of the electric current. In these experiments I made use principally of highly exhausted spheres, about two inches in diameter, through

which two platina wires, either parallel or perpendicular to each other, were conducted, whose shortest distance was about 0·8 of an inch.

When, for instance, the sphere with *parallel* wires is put on the iron pieces of the electro-magnet so that both wires fall within the equatorial plane and are vertical, the whole circular section of the sphere passing through the negative wire is almost uniformly illuminated by violet light, while the light of the positive electrode appears at one of its extremities, whence it moves, along an epibolic curve, to the corresponding extremity of the negative wire. On reversing the polarity of the magnet, the illuminated epibolic curve passes from one extremity of the positive wire to the other, while the appearance of the negative light, after the reversion, is not at all altered.

When the positive wire terminates within the sphere, we get, according to the magnetic polarity, either an epibolic curve, or diffused light, starting from the free extremity of the positive wire towards the surface of the circle illuminated by the negative light.

When the sphere with *crossed* wires is put on the iron pieces so that the negative wire becomes vertical, the positive one horizontal and equatorial,—the whole surface of the axial circle passing through the vertical wire is illuminated, except the lower part, which is bounded by the magnetic curve starting from the lower extremity of this wire. There is no light seen on the positive wire, which is intersected by the magnetic circular surface. On this surface the shadow of the positive wire is most distinctly traced. [Shadows of this description are, in the general case, produced by beams of light starting from all points of the surface of the negative electrode, and moving along the corresponding magnetic curves. Not even the positive wire deviates such beams of light from their curved paths.] Nothing at all is changed by a change of magnetic polarity.

When the sphere is turned round its vertical diameter till the horizontal and positive wire passes from the equatorial direction into the axial, the whole surface of the axial circle passing through the negative wire is filled with illuminated magnetic curves. The positive light starts from the middle of the horizontal wire, and moves round it, within the equatorial plane, towards the negative wire without interfering with the light emanating from this wire. It constitutes

a fine spiral, separated by a dark space from the positive wire, taking its origin in a cusp, and expanding more and more when it approaches to the negative wire. In changing the polarity of the magnet, instead of the single spiral starting from the middle of the wire, we obtain two such spirals starting from the two extremities of the wire, impelled against the glass of the tube and revolving in the opposite sense.

The phenomena just described and all the various phenomena of the same class may be fully explained by the laws of electro-magnetic action. For this purpose, we admit that the first element of each elementary current starting from any point of the positive wire is directed towards the negative wire. This supposition follows from the observed fact, that the positive wire, if parallel to the negative, becomes luminous along its whole length on that side which is turned towards the negative wire. When acted upon by the magnet, these first elements, bound to the positive wire, are allowed to move freely along this wire. The single point, or the system of points, where all the first elements meet before leaving the wire, may easily be determined. The following elements, subjected to the same force, are entirely at liberty to obey it. This action may generally be defined thus :—Imagine an element of the elementary electric current starting from any point of a magnetic curve, which connects both poles; imagine also the molecular currents (as assumed by Ampère) within the magnet continued round this magnetic curve. Then, if the element be perpendicular to the magnetic curve, the full action of the magnet turns it round the curve in a direction opposite to the direction of Ampère's molecular currents. If it be not perpendicular, this action is to be decomposed along the normal to the magnetic curve within the osculating plane.

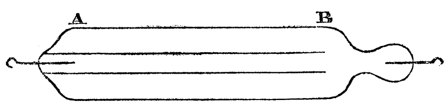
I think it worthy of notice, that the same electro-magnetic laws, applied to magnetic action on an already formed electric current, either bound to the conducting wire or free to move in space, equally hold in determining the path of the current when acted upon by the magnet during its formation between the two electrodes. Thus a moving electric particle, under magnetic action and tending towards the negative electrode, may be regarded as describing a curve, in an analogous way as a projected material point does—acted upon by gravity.

IV. *Electric currents returning on their own path.*

When only one of the wires of Ruhmkorff's apparatus is in contact with one of the electrodes of a long and large exhausted tube, while the second wire is isolated, or, what is preferable, communicates with the earth, an electric current is obtained entering the tube and returning on its own path. The existence of the two currents is most evidently proved by the magnet, which, acting differently on both, divides the double current into two of the same intensity. This intensity is much increased by touching the tube with the hand at any distance from the electrode which communicates with Ruhmkorff's apparatus.

A double current of exactly the same description is obtained in a narrow tube, which may be one foot long, communicating with a larger tube, both electrodes of which are connected with the wires of Ruhmkorff's apparatus. When the extremity of the narrow tube is touched with the hand, a current starting from the principal tube enters the narrow one, proceeds to its extremity, and finally returns to the principal tube: which is proved by the magnet.

When, through a tube whose shape is represented by the drawing,



the discharge was sent from A to B, the current, passing from the narrow tube into the surrounding larger one, was, when it arrived at the extremity of the narrow tube, partly branched off in an opposite direction towards A, and then, changing its course again, moved towards B.

There is another case where returning currents are obtained. When the discharge on its way through a highly exhausted tube passes from a large space into a narrow channel, a part of the current is reflected, and returns on its own path within the larger space: which is again proved by the magnet.

Mr. Gassiot first observed and described what he calls "reciprocating currents," and the separation of such currents by the magnet. That celebrated philosopher had the kindness himself to show me his experiment, and even enabled me to repeat it, by obliging me with one of his fine Torricellian-vacuum tubes. I do not exactly know his

opinion on the nature of those currents; for my part, I think they are induced currents returning on their own path. This opinion was supported by the subsequent experiments.

I got a hollow and highly exhausted sphere of glass about 2 inches in diameter, into which no wire entered, and placed it on the iron pieces of the electro-magnet. On touching the sphere with one of the wires of Ruhmkorff's apparatus, diffused light was spread through it. By the excited electro-magnet this diffused light was concentrated into a luminous stream, which moved along the magnetic curve determined by the point touched, from this point to another one in which the interior surface of the sphere is intersected a second time by that curve, and evidently returned in the same curve from the second point to the first. When the point where the sphere is touched by the wire falls within the equatorial plane, no part of the magnetic curve in question, which in this case is a tangent to the sphere, enters it. In this peculiar case, the phenomenon is entirely changed, the light of the induced current constitutes an ascending or descending stream proceeding along the epibolic curve within the equatorial plane. In reversing either the polarity of the magnet or the direction of the discharge, the ascending stream is transformed into a descending one, or *vice versâ*. But there is no change of the appearance in the general case.

When the sphere is simultaneously touched by the two wires of Ruhmkorff's apparatus in two different points, we get within it two independent luminous currents showing no reciprocal action on each other; and it is only when both points belong either to the same magnetic curve or to the epibolic one, that there is but one luminous arch along that magnetic or the epibolic curve.

All this shows that Gassiot's induced streams are subject to the same laws as the direct currents are, formerly observed by myself.

In all experiments mentioned in this section, the discharge of Ruhmkorff's apparatus may be replaced by a spark taken from the conductor of an electrical machine.

V. *Fluorescence produced by the electric discharge.*

Glass shows in sunlight scarcely any kind of fluorescence. A glass tube, including residual traces of a proper gas, becomes highly fluorescent when the electric discharge is sent through it: a fine green

colour appears in the case of common German glass, a fine blue if the glass contain lead. Hitherto I have tried in vain to get specimens of a different and well-determined chemical composition, which, without doubt, would offer new and curious cases of fluorescence*. A beautiful fluorescence is obtained by surrounding suitable exhausted tubes, through which the discharge is passing, with a solution of æsculine, of fraxine, of sulphate of quinine, &c. If the tubes include residual traces of hydrogen, scarcely any fluorescing light is seen; if they contain traces of nitrogen, on the other hand, the fluorescence is very intense. All depends upon the nature and the density of the gas. In certain cases, a very faint electric light, scarcely seen by the eye, produces a brilliant fluorescence, especially when the light, if belonging to the negative wire, is concentrated by the magnet. M. Geissler, in constructing his tubes, first observed (about eighteen months ago) the fluorescence of gases, which even continue luminous some seconds after the interruption of the current: further researches will explain this curious phenomenon.

VI. *The spectra of the electric current in rarefied gases and vapours.*

The light of the electric discharge through large tubes is rather too much diffused to give a distinct spectrum. I made trial, therefore, of sending the discharge through a capillary tube, and fully succeeded. I got a brilliant luminous line within the tube, of which a beautiful spectrum was obtained by replacing the distant illuminated slit, which Fraunhofer used in his observations, by the self-luminous line. Afterwards I employed Babinet's goniometer. The slit of this instrument was illuminated by the current within the capillary tube, which was placed before it at a distance of about 0·4 of an inch. The aperture of the slit could be changed; but where it is not particularly mentioned, it was seen under a constant angle of 3′. After having interposed the prism of heavy flint glass, *the refracted image of the slit, in the general case, was found to be divided into a less or greater number of differently coloured bands, appearing each under the just-mentioned constant angle of three minutes.* Hence it follows that the analysed electric light is *com-*

* From the beautiful experiments recently made by E. Becquerel, we may deduce a satisfactory explanation of these phenomena.

posed of a certain number of rays, whose refrangibility is a discontinuous one. The refraction of each ray is determined by the angle between the middle lines of the image of the slit, seen directly, and of the corresponding refracted band. This angle is independent of the aperture of the slit, and remains the same if the slit be reduced to a physical straight line.

There cannot exist a deflected band smaller than 3′; *i. e.* no such band appears under an angle less than the angle under which the aperture is seen directly, without the interference of the prism. This law holds through all my numerous observations of electric spectra. [I find difficulty in applying it to the case of the common solar spectrum.] There are, in many instances, bands observed which are seen under an angle greater than 3′; but generally such bands are resolved into two or more bands of single breadth. In some instances where the angle in question does not reach the double of 3′, there appears in the middle part of the band a *bright* line; larger bands are generally divided by small, well-defined, *dark lines.*

In order to distinguish the rays of different refrangibility in the different gases, I denoted such a ray by adding to the symbol belonging to the gas the Greek letters α, β, γ, indicating the succession of the corresponding bands in each spectrum. Accordingly, for instance, the band $N\gamma$, appearing under an angle of 6′, is divided by a dark line into two; the bands $N\delta$ and $N\theta$, having each a breadth of 10′, are divided by two dark lines into three single bands. The bands $Hg\alpha$ and $Sn\,Cl_2\gamma$, 5′ broad, show a bright middle line.

The space between two bright bands is either absolutely black, or of a greyish tint, or of a faint tint of that colour which is indicated by the position of the space within the spectrum. With regard to these faint tints, the eye, by the effect of contrast, is commonly a very bad judge of colour, and there may easily be a deception, admitting a succession of colours in the spectrum which in reality does not exist.

I cannot enter here into the details by which I obtained exact measures of the minimum refraction of the different rays. All measures were taken without deranging the adjustment of the goniometer; for ascertaining its constancy, each spectrum was compared with the spectrum of hydrogen. From the angles of refraction, I deduced the indices of refraction, and hence the corresponding lengths

of waves expressed in millionths of a millimetre in order to get absolute numbers immediately comparable with those of others.

The discharge through a capillary tube containing residual traces of pure hydrogen is of a deep red colour ; the spectrum obtained from it consists of only three bright bands :—of a most splendid red one, $H\alpha$; of a bluish-green one, $H\beta$, nearly as bright; and of a fainter violet one, $H\gamma$. The following table contains the angle of refraction ϕ, the index of refraction μ, and the length of the wave λ, corresponding to each of the three rays $H\alpha$, $H\beta$, $H\gamma$, as well as of the dark lines of Fraunhofer, C, F, G, in order to compare their reciprocal position :—

	ϕ		
$H\alpha$....	57° 10′·5	C....	57° 8′·5
$H\beta$....	59 55·5	F....	59 55·5
$H\gamma$....	61 43	G....	61 55·5

	μ		
$H\alpha$....	1·7080	C......	1·7077
$H\beta$....	1·73255	F......	1·73255
$H\gamma$....	1·7481	G......	1·7498

	λ		
$H\alpha$....	653·3	C......	656·4
$H\beta$....	484·3	F......	484·3
$H\gamma$....	433·9	G......	429·1

From this table it results that $H\beta$ exactly coincides with F, while $H\alpha$ and $H\gamma$ approach very near C and G.

The spectrum of pure oxygen was only obtained after several unsuccessful trials to procure proper tubes, the gas being in most cases absorbed by the electrode during the passage of the current.

The spectrum of nitrogen is one of the richest in colours. Its less refrangible part is of a peculiar nature, having, from the exterior red to the limit of the yellow, seventeen equidistant small dark bands.

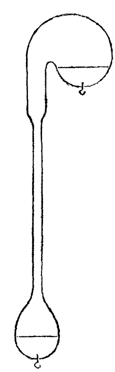
Most characteristic are the spectra of carbonic acid (oxide of carbon), iodine, bromium, chlorine, chloride of silicium, chloride of phosphorus, chloride of tin. The spectrum of the last-mentioned substance is one of the most remarkable. The colour of the gas within the larger parts of the tube through which Ruhmkorff's

apparatus is discharged, is a dark blue, in the capillary part of the same tube the finest gold-colour, while the light surrounding the negative wire is of a fawn-colour. [The finest appearance is obtained with a larger tube containing residual traces of the vapour of this salt, put on the iron-pieces of a powerful electro-magnet; within the blue light of the discharge numerous golden flashes are produced, and variously directed by the magnetic force.]

A piece of metallic sodium within an atmosphere of rarefied hydrogen does not alter the spectrum of this gas when at the ordinary temperature; but when it is heated, a single brilliant yellow band is added to the three original bands of hydrogen. The middle of the new band exactly coincides with Fraunhofer's dark line D. The vapours of the metal are condensed in the cooler parts of the apparatus.

Phosphorus, when treated in the same way, instead of adding new bands to those of hydrogen, at a certain temperature even extinguished the spectrum of the gas.

In the case of mercury, I gave to the tube the shape of the annexed drawing. The electrodes merely entered the two flask-shaped ends of the tube, where they were covered about half an inch with mercury. Peculiar bands were obtained without heating the mercury; when it was heated, the spectrum became most brilliant.



When traces of two gases, not acting on each other, are mixed within a spectrum-tube, the spectra of both are simultaneously obtained.

A result of some importance, following from the researches of which I have here given an abstract, is, that in all such dioptrical researches, where Fraunhofer's dark lines were used in order to get exact measures, these dark lines may with great advantage be replaced by the middle lines of the new brilliant bands of the gas spectra. To these bands the most convenient breadth may be given in each particular case by regulating the aperture of the apparatus. A spectrum-tube of hydrogen, exhibiting three well-defined bright bands, is well suited for this purpose. During a whole year I made use of such a tube, which remained absolutely unaltered.

Every gas being characterized by its spectrum (even by one of the

bands of the spectrum, the position of which is measured), we get a new kind of chemical analysis. In this way only we may ascertain the residual contents of the exhausted tubes, and the changes they undergo, either suddenly by the discharge, or gradually afterwards. Thus, for instance, a spectrum-tube in which traces of vapour of sulphuretted carbon were enclosed, presented most unexpectedly the combined spectra of hydrogen and oxide of carbon. Hence we conclude that there remained also within the tube some traces of vapour of water, which was decomposed as well as the sulphuretted carbon. Traces of sulphur were deposited on the interior surface of the tube, while oxide of carbon and hydrogen remained within it.

Nearly all examined combinations of hydrogen with metals, with chlorine, &c., were almost instantly decomposed. The spectrum of hydrochloric acid was found to be the combined one of hydrogen and chlorine. Sulphur and arsenic were deposited from their combinations with hydrogen, the former constituting fine dendrites, the latter well-defined large bands: the spectrum in both cases was that of pure hydrogen. Seleniated hydrogen showed within the capillary tube a fine yellow tint, but this tint was converted during the passage of the discharge into a brilliant red one; the change of colour started from one of the extremities of the capillary tube, and reached the other one after a few seconds. The spectrum observed during this change of colour was in the first moment a most distinct one, showing, for instance, between $H\beta$ and $H\gamma$ two similar systems of two brilliant blue bands separated by a black one about double as large; but this spectrum entirely disappeared, as in dissolving views, being by and by replaced by the spectrum of hydrogen. A few minutes after the discharge was stopped the red colour turned again into the primitive yellow one, the gas decomposed by the discharge having been recomposed again. Thus the same experiment could be repeated any number of times.

[Similar chemical effects were ascertained in a different way in the case of sulphurous acid, which, if included within a larger tube, shows a fine stratification of narrow violet bands. When the discharge passes during several minutes, the stratification is altogether changed, the narrow violet bands being transformed into the large clouds of the best Torricellian vacuum tubes. The primitive condition of the gas is restored by heating the electrodes; but in every

new experiment the phenomena became less distinct than they were before.]

I think it most probable that, properly speaking, *electric light does not exist*; *the light which we see belongs to the gas, rendered incandescent by the thermal action of the current.* Accordingly, in our case, the colour of the appearing light depends upon the nature of the gas and the concentration of the current. This opinion is strongly supported by the observed fact, that the temperature of the capillary tube increases considerably in some instances. Considering that this increase of temperature has its source in the heat of the residual gas, which is too small in amount to be indicated by the balance, this heat being produced by the electric current, and communicated to the heavy substance of the tube; we have scarcely an idea of the *enormous* temperature of the gaseous electrode included in the capillary channel*.

II. "On the Interruption of the Voltaic Discharge in Vacuo by Magnetic Force." By J. P. Gassiot, Esq., F.R.S. Received December 6, 1859.

The late Professor Daniell, in his Fifth Letter on Voltaic Combinations (Phil. Trans. 1839, part 1), describes some experiments made with seventy series of his constant battery, and states (page 93) "that the arc of flame between the electrodes was found to be attracted and repelled by the poles of a magnet, according as one or the other pole was held over or below it, as was first ascertained by Sir H. Davy; and the repulsion was at times so great as to extinguish the flame."

In the Philosophical Magazine of July 1858, Mr. Grove has described an experiment made by him with one of my vacuum-tubes, 2 feet 9 inches long, in which he ascertained that the discharge of a Ruhmkorff's induction coil could be stopped by bringing a magnet near the positive terminal wire, but that this effect was not obtained when the magnet was made to approach the negative. The mercurial vacuum-tube in which Mr. Grove observed this phenomenon was

* In some peculiar cases my primitive theoretical views were modified, reformed, or extended by subsequent experiments. The abstract now given refers only to what I think *at present* to be the state of the question.