the corona, or at different heights; further, they most frequently do not correspond to elements known upon the earth.

Special interest attaches to the investigation of the rotation of the corona by observing or photographing the displacement of lines in the spectrum at some distance from the limb on each side of the equator. No photographic impression was secured with the fourth order spectrum of a diffraction grating, adjusted for H and K, and, although the eclipse occurred at a maximum of sun-spots, 1474 K was too feeble in the second order spectrum to permit any trustworthy measures to be made visually. A successful photograph of the H and K lines was obtained, however, with a 3-prism spectroscope attached to a 6-inch refractor, one half of the slit being exposed on the west and the other on the east side of the corona. The measured velocity of 6·8 km. per sec. has led M. Deslandres to conclude that the equatorial part of the corona moves very nearly with the same angular velocity as the photosphere. This result must be received with caution until confirmed by further researches, as the photographs taken at the same moment by Mr. Fowler give no indications of the presence of H and K in the true coronal spectrum. It is pointed out that this research may be simplified in future by making only one exposure, placing the slit radially, so that the velocities may be determined from the inclination of the lines, as in the recent researches on Saturn's rings.

In the last chapter of the report, various hypotheses as to the nature of the solar atmosphere are reviewed, and an electrical theory is propounded. It is pointed out that, notwithstanding the diversity of appearances, there is really a great similarity between the solar and terrestrial atmospheres, and the report ends as follows: "Terrestrial meteorology and solar physics, which are separated by the necessity for the division of work, are in reality connected sciences, which, by the nature of things, ought to be studied together."

THE RÖNTGEN RAYS.[1]

PROF. RÖNTGEN, of Wurzburg, at the end of last year published an account of a discovery which has excited an interest unparalleled in the history of physical science. In his paper read before the Wurzburg Physical Society, he announced the existence of an agent which is able to affect a photographic plate placed behind substances, such as wood or aluminium, which are opaque to ordinary light. This agent, though able to pass with considerable freedom through light substances, such as wood or flesh, is stopped to a much greater extent by heavy ones, such as the heavy metals and the bones; hence, if the hand, or a wooden box containing metal objects, is placed between the source of the Röntgen rays and a photographic plate, photographs such as those now thrown on the screen are obtained. This discovery, as you see, appeals strongly to one of the most powerful passions of human nature, curiosity, and it is not surprising that it attracted an amount of attention quite disproportionate to that usually given to questions of physical science. Though appearing at a time of great political excitement, the accounts of it occupied the most prominent parts of the newspapers, and within a few weeks of its discovery it received a practical application in the pages of *Punch*. The interest this discovery aroused in men of science was equal to that shown by the general public. Reports of experiments on the Röntgen rays have poured in from almost every country in the world, and quite a voluminous literature on the subject has already sprung up.

In view of the general interest taken in this subject, I thought that the Röntgen rays might not be an unsuitable subject for the Rede Lecture.

Before discussing these rays themselves, I think it may perhaps make matters clearer if I call your attention to one or two of the phenomena which accompany the discharge of electricity through gas at a low pressure. I have here a bulb from which the air has been taken until the pressure has been reduced to about 1/10000 part of the atmospheric pressure. When the electric discharge passes through this bulb you see that there is considerable luminosity in the gas in the bulb, except in a region round this terminal—the negative one; this region, where the luminosity is so deficient, is called the negative dark space. In this bulb there is no phosphorescence on the glass, and I may say no emission of Röntgen rays. If I were still further to reduce the pressure of the gas in this bulb, this dark space would expand and encroach on the luminous part of the discharge, and would, when the pressure got very low, reach the walls of the tube; the expansion of the dark space diminishes the luminosity in the gas, but we find that where the dark space reaches the glass of the tube the glass itself becomes luminous, until finally at very low pressures we get to the state of things shown by this tube, where the luminosity is all on the glass, and little or none is to be observed in the gas. Röntgen rays are produced by this bulb, though not by the other.

There is one feature in this tube to which I must call your attention: you see that there is a shadow on part of the tube; this shadow is thrown by a mica cross fixed between the negative electrode and the wall of the tube, and if we observe the shape of the shadow we see that any point of the tube is in shadow if the line joining that point to the negative electrode passes through the mica cross. We thus conclude that we have something starting from the negative electrode, travelling in straight lines, and producing phosphorescence when it reaches the glass, and, further, that this something is stopped by the mica cross. This something which travels in straight lines from the kathode is called the kathode rays: these rays are of great interest in relation to the subject of this lecture, for the kathode rays seem to be the parents of the Röntgen rays. Let me call your attention to the effect produced by a magnet on these rays: you see that when the magnet is brought near, the shadow of the cross is displaced; this shows that the direction of the rays casting the shadow have been deflected by the magnet, thus the kathode rays are deflected by a magnet. We shall see later on that the Röntgen rays, on the other hand, are not so affected. This is one of the most striking differences between the parent—the kathode rays—and the child, the Röntgen rays. The effects of the kathode rays inside the tube were discovered more than twenty years ago by Crookes and Goldstein; it is only quite recently, however, that any effects produced by these rays outside the tube have been observed. In 1894 Lenard, using a tube of the kind shown in the diagram (Fig. 1), where the kathode rays struck against a window made of very thin aluminium, found that if he placed outside the tube in front of the window a screen covered with a phosphorescent substance, pentadecaparatolyketon, it became phosphorescent; he found, further, that a photographic plate placed behind the window was affected—nay, that this plate was affected even though he placed in front of it a plate of aluminium or a thin quartz plate—in fact, he took a photograph through aluminium and quartz; he thus obtained two of the most prominent phenomena shown by the Röntgen rays. In fact, we know from the researches of Röntgen that the Röntgen rays must have been present and played a part in these experiments. Lenard himself ascribed the effects he observed to kathode rays which had penetrated the aluminium window, and indeed it would seem that something in addition to the Röntgen rays must have been present, as Lenard found that the position of the phosphorescent patch was affected by a magnet, while the Röntgen rays themselves are, as we shall see, not influenced by such an agent.

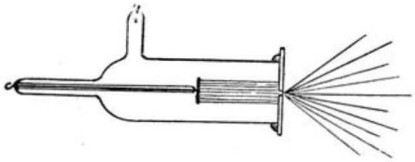

FIG. 1.

I now come to the consideration of the Röntgen rays themselves, and shall endeavour to repeat some of the experiments by which Röntgen established their existence. The apparatus consists of a tube exhausted to such a low pressure, that when the electric discharge passes through it there is an abundant supply of kathode rays; these rays strike against a metal plate in the bulb. This metal plate is not essential for the production of the rays, and was not present in the bulbs used by Röntgen; it, however, considerably increases the efficiency of the bulb.

When the electric discharge passes through this bulb, the region round it is the seat of some very remarkable phenomena. I have here a screen coated with a phosphorescent substance,

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[1] The Rede Lecture, given at the University of Cambridge, on June 10, by Prof. J. J. Thomson, F.R.S.

potassium platinocyanide; though this screen is opaque to ordinary light, you will see that it phosphoresces when placed in the neighbourhood of the bulb. This phosphorescence is due to something radiating from the bulb, because when I place this piece of metal between the bulb and the screen, a sharp shadow of the metal is thrown on the screen. The metal is opaque to these radiations. If, however, I place a piece of wood, about an inch thick, between the bulb and the screen, you will hardly be able to see a shadow; so that this board, though opaque to ordinary light, allows those rays to pass through with considerable freedom. The lighter the substance the more easily is it penetrated by these rays; thus the very light metal aluminium is very transparent, as you will see by the poor shadow it casts upon the screen. This property has been used to detect real gems from paste, as the diamond, consisting of the light element carbon, is much more transparent than an artificial one made of heavy silicates. Since light objects are, roughly speaking, transparent, while the heavy ones are opaque, if we have a mixture of heavy and light objects between the screen and the bulb, the heavy ones will throw a shadow, the lighter ones will not. We can thus detect dense objects even when surrounded by opaque ones, provided the latter are light. [Experiments throwing shadows of jewellery in cases, hands, &c., upon the screen.] Prof. Lodge has in this way been able to see through a yard of timber. We seem here to have the realisation of Sam Weller's aspiration after an optical arrangement which would enable one to see through "a flight of stairs and a deal door."

I will now endeavour to show that in order to have Röntgen rays you must have kathode rays to start with. I will produce in the bulb, which I have used for the production of the Röntgen rays, a discharge of another kind, viz. an electrodeless discharge in which the discharge, instead of travelling between metallic terminals in the gas, travels round a closed circuit in the gas. In this way we have no kathode and no kathode rays; you see that though a bright discharge passes through the bulb, far brighter than in the previous case, no luminosity is produced on the screen.

One very remarkable property discovered by Röntgen of these rays, is that they are not bent when they pass from one medium to another. We can show this in the following way. I place in front of the bulb this thick plate of metal, in which a vertical slit has been cut; the metal stops the rays, so that we get on the screen a bright luminous vertical band. Now I place between the slit and the screen this wooden prism, which covers up the lower, but not the upper, half of the slit; if the rays which came through the slit were refracted, then the lower part of the bright band would no longer be in the same straight line as the upper part. You see, however, that the two halves still remain on the same line; the only effect produced by the wooden prism has been to make the lower half somewhat dimmer than it was before.

Again, these rays are not deflected by a magnet; to prove this, we throw the shadow of two brass tubes on the screen, and observe the shadows before and after a horse-shoe magnet has been introduced into the tubes; you see that no appreciable effect is produced by the introduction of the magnet.

The absence of refraction leads us to expect that there would be little regular reflection of the Röntgen rays, and this conclusion has been confirmed by numerous experiments. At grazing insistence, however, Joly of Dublin has been able to detect a small amount of regular reflection. Though there is but little regular reflection there is an appreciable amount of what, to avoid any speculation as to its nature, has been called by Sir George Stokes "diffuse return" of the rays; this was discovered by Röntgen himself, and is rendered very evident by an experiment of Lord Blythswood. We do not know yet, however, whether the rays coming off from the metal plate are of the same kind as those which fall upon it, or whether they are slightly different. If they are of the same kind, then the effect would resemble the diffuse reflection from a piece of ground glass; if they are different, it would indicate that the piece of metal illuminated by these rays became itself a source of rays not quite of the same kind as those which fall upon it, just as when a solution of quinine is exposed to the invisible ultra-violet light it emits not ultra-violet light like that which fell upon it, but visible blue light. This point might be settled by measurements of the rates of absorption of the incident and "diffusely returned" light.

That the Röntgen rays are not all of the same kind, has been shown in several ways, of which, however, I have only time to mention one. Mr. McClelland, working in the Cavendish Laboratory, found that if he took a plate of tinfoil and a layer of water, and adjusted the thicknesses so that they exerted the same absorption on the Röntgen rays given out from one bulb, they did not necessarily produce the same absorption in the rays from another bulb, showing that the rays from the one bulb were not the same as those from the other.

Röntgen discovered that the rays not only made certain substances phosphorescent, but that they affected a photographic plate; so that if we replaced the phosphorescent screen in our experiment by a photographic plate, we should get a permanent impression of the picture, which would be thrown on a phosphorescent screen placed in the position of the photographic plate. To obtain these photographs all that is necessary is to protect a photographic plate from ordinary light by thick cardboard or aluminium, and place the object to be photographed between the bulb and the plate; after an exposure varying with the nature of the object and the state of the bulb, photographs of the kind which are now so well known can be obtained.

One very marked feature of these photographs is the sharpness of the detail; this shows that the origin of the rays must be confined to a comparatively small region. If these rays came from an area comparable with that occupied by the phosphorescence on the walls of the bulb used to produce the rays, the luminosity from one part of the screen would throw one pattern on the screen, while the rays from another portion would throw another pattern; the superposition of these patterns would produce a blurred image. To illustrate this point, I have here two photographs of the same thing—one taken by the Röntgen rays, the other taken by an incandescent lamp with walls of frosted glass, of about the same size as the bulb used to produce the Röntgen rays, and placed in the same position; you see that the photograph taken by the Röntgen rays is quite sharp, while that taken by the electric lamp is much blurred. This shows that the Röntgen rays do not come from an area nearly so extended as the phosphorescent part of the glass. We can investigate the place of origin of these rays in various ways, by observing the law of diminution with the distance of the effects due to these rays, by taking pin-hole photographs, by observing the direction of the shadows cast by a series of opaque bodies; the result of such observations shows that Röntgen rays are produced when the kathode rays strike against a solid obstacle. Cases have been observed by Lord Blythswood and by Rowland, which seem to show that this is not the only source of these rays.

The experiments made on these ray have not led to any result absolutely decisive as to their nature, but we can profitably discuss the question whether the facts known about these rays oblige us to regard them as due to a new form of energy, or whether they are consistent with these rays being a variety of some form of energy already known to us; before calling in a new form, we ought to be quite sure that it is necessary to abandon the old. The rectilinear propagation of these rays, their powers of producing phosphorescence and of affecting a photographic plate, their insensibility to a magnet, suggest that of the old forms of energy light is the one to which these rays are most closely allied. We are acquainted with so many varieties of light (by light I mean transverse vibrations propagated with a definite velocity) with such widely different properties, that we can well contemplate the existence of other kinds with still different properties. We know, for example, the ultra-violet light of very small wave-length, the subject of classical researches by Sir George Stokes, which, though it affects a photographic plate, does not affect the retina, and passes through bodies with such difficulty that the most ultra-violet kind is quenched after passing through a few millimetres of air; then we have the visible light able to affect the retina, and able to pass through great lengths of some substances which are opaque to the ultra-violet rays though stopped by very small thicknesses of others; then we have the longer waves of radiant heat given out by a hot body below the temperature at which it becomes luminous. These are not visible, have but little effect on a photographic plate, and are able to traverse substances opaque to both ultra-violet and visible light. Then we have the waves emitted by vibrating electrical systems, which neither affect the retina nor a photographic plate, which, as Mr. Rutherford has shown, are able to traverse the walls of the houses and the bodies of the inhabitants of about three-quarters of a mile of a densely populated part of Cambridge, and which are so different in properties from ordinary light that it required the genius of Clerk-Maxwell to recognise them as light at all. I shall have to call your attention to another kind of light, discovered lately by Becquerel. It will doubtless be urged that widely as these kinds of light differ from each other in some respects, they all are bent when they pass from one substance to another, while the Röntgen rays, as we have seen, are not refracted. This objection to the possibility of the Röntgen rays being a kind of light, formidable as it appears at first sight, loses all its force when more closely examined. We know cases in which light passes through substances without being refracted; thus Kundt found that certain rays could pass through gold without being refracted, while other rays were bent the wrong way. Stenger has lately found that certain blue rays can pass through fuchsin, and other slightly different ones through Hofmann's violet, without being bent. Perhaps, however, the most striking testimony to there being nothing inconsistent in the idea of a kind of light which is not refracted, is afforded by one of the last investigations undertaken by von Helmholtz, and published about three years ago. Von Helmholtz investigated what, on the electromagnetic theory of light, would be the bending experienced by light of different frequencies passing through an ideally simple substance, one whose spectrum consists of only one line. The result of his investigation is shown in this curve (Fig. 2), where the abscissæ represent the frequency of the light, the ordinates the refractive index. On the part of the curve from *f* to *g*, you see that the refractive index increases as the frequency increases; this corresponds to the normal spectrum where the blue rays are more refracted than the red. After passing *b* the curve dips down; this means that the greater the frequency the less the bending, in other words, the blue rays tend to be bent more than the red. We know many instances of this, it is called anomalous dispersion. Then we get to the part of the curve about *i*, where the refractive index is less than 1; that is, where the rays are bent the wrong way. We have examples of this, as Kundt has shown, in the case of gold, silver and copper; but the most interesting part of the curve for our purpose is the last part, where, after dipping below the line of no-bending for a short distance, it approaches it and practically coincides with it for all frequencies greater than *a h*; so that, on this theory there would practically be no bending for all waves whose frequency exceeds a certain value. Thus, so far from the absence of bending being a proof that the Röntgen rays are not light, this absence of bending is exactly what we should expect if these rays were light of very great frequency.

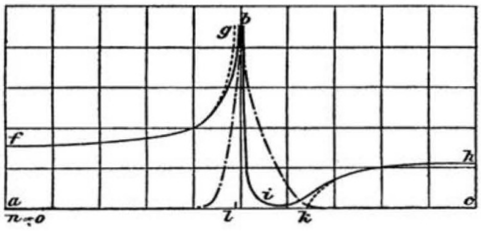

FIG. 2.

A characteristic feature of all varieties of light is the existence of polarisation, and polarisation is indisputable evidence of transversal vibration; hence, many experiments have been made to see whether any polarisation of these rays could be detected. All these experiments have practically been confined to seeing whether the Röntgen rays could traverse two plates of tourmaline more freely when the axes of the two plates are parallel than when they are crossed; there is a great difference in the transparency to ordinary light in the two cases. The results of these experiments are somewhat conflicting. Prince Galitzine and M. de Karnojitsky are of opinion that they have succeeded in detecting a slightly greater absorption of the rays when the axes are crossed than when they are parallel; on the other hand, Becquerel, Mayer, and I were not able to detect any appreciable difference in the two cases. If the result of Prince Galitzine should be confirmed, it would prove beyond cavil that these Röngten rays were light; but even if the presence of polarisation is not definitely established in this case, it does not follow that these rays can not be polarised—the methods for polarising one kind of light may not be successful when used for another. For example, a wire bird-cage will polarise the long electrical waves, but will not affect the shorter waves of radiant heat, much less those of visible light. By winding exceedingly thin wires close together on a framework, Rubens and Du Bois were able to polarise the waves of radiant heat, the wave-lengths of which are long compared with those of light. This arrangement, however, is much too coarse to polarise visible light, much less ultra-violet light. And it is possible, and indeed likely, that the structure of the tourmaline, though fine enough to polarise ordinary light, may not be fine enough to polarise the Röntgen rays.

So far, I have confined myself to showing that there is nothing in the effects known to be due to these rays inconsistent with their being a variety of light. I must now pass on to some evidence of a more positive character. Since the discovery of the Röntgen rays, Becquerel has discovered a new kind of light, which in its properties resembles the Röntgen rays more closely than any kind of light hitherto known. Becquerel found that certain uranium salts emitted, after being exposed to the sunlight, radiations which, like the Röntgen rays, could pass through plates of aluminium or of cardboard, and affect a photographic plate behind. I have here a photograph of a perforated piece of zinc, which has been taken by Becquerel's method by simply scattering over the zinc plate powdered uranium nitrate, and placing it over a photographic plate well protected from ordinary light. After a long exposure of from twenty to forty hours, the photograph now on the screen was taken. Becquerel has shown that the radiation from the uranium salts can be polarised, so that it is undoubtedly light; it can also be refracted. It forms a link between the Röntgen rays and ordinary light, it resembles the Röntgen rays in its photographic action in power of penetrating substances opaque to ordinary light, and in the characteristic electrical effect, while it resembles ordinary light in its capacity for polarisation, in its liability to refraction. The persistence of the radiation is very remarkable. Becquerel found that the potassium-platinum compound of uranium went on emitting these radiations with nearly undiminished zeal for fifteen days after it had been exposed to the sunlight. It would seem that under the influence of sunlight some change in the chemical or physical nature of the substance occurred, and that after the sunlight was cut off, the substance gradually went back to its original state, and that while doing so it emitted this peculiar radiation. The radiation from the uranium salts is of especial interest from another point of view. Sir George Stokes has shown that in the case of phosphorescence caused by sunlight or the arc lamp, the light emitted by the phosphorescent body is of longer wave-length than the light causing the phosphorescence; in the case, however, of the phosphorescence discovered by Becquerel, the light emitted is of a shorter wave-length than the incident light. The case resembles that called calorescence by Tyndall, when the body placed in a focus of dark radiant heat becomes luminous and gives out the shorter luminous waves.

From this discovery of Becquerel, we may conclude that besides the vibrations emitted by luminous bodies with which we have hitherto been acquainted, there are others having a much greater frequency and, it may be, arising in a different way.

To sum up, we may say that though there is no direct evidence that the Röntgen rays are a kind of light, there is no known property of these rays which is not possessed by one or other of the forms of light.

One of the most remarkable phenomena connected with these rays is the way in which the absorption depends upon the density of the body; if we measure the transparency of a series of bodies, we find that the order of opacity is the same as the order of their density. No other factor in the constitution of the body seems comparable in importance with density. In this respect, the relation between the opacity and the other properties of a body in the case of the Röntgen rays is simpler than that for luminous waves or electric waves. There seems no simple relation between the density of a body and its transparency to visible radiation or electrical vibration; in the case of the Röntgen rays, however, it seems the greater the density the greater the opacity. This appears to favour Prout's idea that the different elements are compounds of some primordial element, and that the density of a substance is proportional to the number of the primordial atoms; for if each of these primordial atoms did its share in stopping the Röntgen rays, we should have that intimate connection between density and opacity which is so marked a feature for these rays.

I now pass from the consideration of the rays themselves to some of the effects they produce on bodies through which they pass.

There seems considerable evidence that the energy associated with these waves is small. I am not acquainted with any effects produced by them which involve the expenditure of an amount of energy comparable with that emitted in a second by a candle. They do not produce any appreciable rise in temperature when they fall on the thin metallic strips of a bolometer. Mr. Skinner has found that they exert no appreciable effect on the combination of hydrogen and chlorine, though this is a good test of the intensity of very faint light; and, what is more unfortunate, they do not exert any of those deleterious effects on bacteria which are fortunately associated with ultra-violet light. Some of the other effects exerted by ultra-violet light seem to be associated with these rays; thus some observers who have had undue curiosity about their bones, and have in consequence exposed their hands frequently to these rays, have found that the hand so exposed became sunburnt. There seems considerable evidence, too, that these rays are not good for the eyes, though it is difficult to disentangle any distinctly injurious effect due to the rays from the bad effect that may be produced by the straining of the eye in the endeavour to see only a faintly luminous object.

There is one property of substances which seems peculiarly suitable for testing if these rays affect the substance through which they pass; it is the property of transmitting electricity.

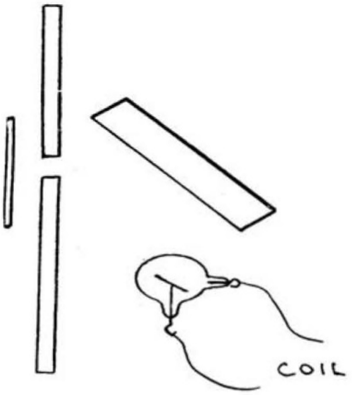

FIG. 3.

When we investigate the effect of the Röntgen rays on this property, we find the remarkable result that bodies which, when shielded from these rays, insulate to all appearance, perfectly allow electricity to pass through them when exposed to the action of these rays. I will, first of all, show an experiment illustrating this property in the case of gases which in their normal state are of all substances the most perfect insulators. The details of the experiment are shown in the diagram (Fig. 3). The coil and bulb are placed in this box, lined inside with tin-plate, and covered over the top with sheet-lead. A hole is cut in the box just over the bulb, and this hole is covered with a plate of aluminium, which is transparent to these rays. The air space between the electrodes is placed over this hole. One electrode is connected to one pair of quadrants of the electrometer, the other electrode is connected to one terminal of a battery, the other terminal of which is to earth; the two pairs of quadrants of the electrometer are connected together and with the earth, and the connection between them broken. If there is no leakage across the air space, the needle of the electrometer will remain at rest. You see it does so when the coil is not in action. As soon, however, as the coil is turned on, the spot of light moves rapidly across the scale, showing that electricity is passing across the air space. The rapidity of movement of the spot of light is a measure of the rate of leak. Now the electrical leakage produced by these rays depends on the nature of the gas. The gas I have just used was air. I will now replace the air by another gas—chlorine. Again you see the leak, but it is now much faster than before. Mr. McClelland and I have investigated the rate of leak in different gases, and we find that they can be arranged in the following order: hydrogen, coal gas, ammonia gas, air, carbonic acid gas, sulphuretted hydrogen, chlorine, mercury vapour.

That the gas itself is put into a peculiar state by the passage through it of these rays—a state which it attains for an appreciable time—is shown by the following experiment, which I described some time ago in NATURE. I have here an electrode shielded from the direct action of these rays. I charge it to a high potential, and even though the rays are on, it does not leak. I now blow some of the air through which the rays have passed on to the electrode, and you see at once we get a rapid leak. The rate at which electricity passes through the gas deper[illegible]ver the leak. Mr. McClelland and I found that for an air space of about 1 cm. the rate of leak over a considerable range of pressure varies as the square root of the pressure. In some experiments recently made by Mr. Rutherford and myself, we found that using a constant potential difference the rate of leak was smaller across a very thin plate of air than across a thicker one; it thus appears that the process of conduction through a gas is one that requires a considerable amount of room.

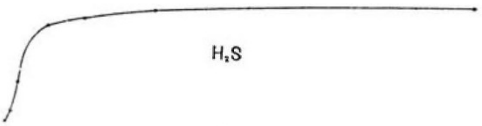

FIG. 4.

Another very interesting point about the rate of leak is the connection between the rate of leak and the electromotive force. This can, perhaps, be most easily understood by means of a curve (Fig. 4). The ordinate represents the rate of leak, the abscissa the electromotive force. At first, when the E.M.F. is small, the curve is a straight line, showing that the current is proportional to the electromotive force; in other words, that the conduction of electricity through the gas, like the conduction through metals and electrolytes, obeys Ohm's law. But it is only wh[illegible]ght. We soon get to a stage where the current increases more rapidly than the E.M.F.; beyond this, again, we reach a part of the curve where the current increases but slowly as the electromotive force increases, and we finally reach a stage where the current seems independent of the E.M.F., and is, to borrow a term from magnetism, "saturated." I have here a diagram (Fig. 5) of three curves taken for the same gas, but at different distances from the bulb. You see that the first ascent is much steeper near to the bulb—that is, when the rays are strong than when it is far away and the rays are weak, and practical saturation is attained sooner when the rays are strong than when they are weak. These curves bear a remarkable resemblance to those which represent the relation between the magnetisation of a piece of iron and the magnetic force acting upon it. When the rays are strong, the curve is like that of soft iron; when the rays are weak, it is like steel.

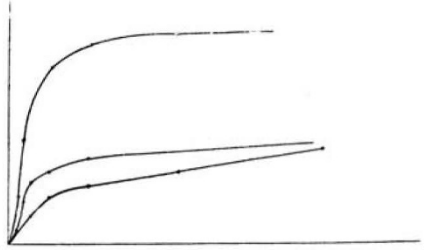

FIG. 5.

Gases are not the only substances that conduct when transmitting these rays; solids also conduct, though the conductivity obeys different laws and only lasts for a short time. The conduction through solids very closely resembles the phenomenon called "electric absorption," a well-known example of which is the residual charge of a Leyden jar.

I have here some experiments which illustrate the effect of the Röntgen rays on solids. In the first of these we have a lead cylinder with a thin base made of aluminium. At the bottom of the cylinder there is a thin layer of solid paraffin; on the top of this, and sticking to it, there is a large leaden disc, over which paraffin has been poured, so that the disc is entirely embedded in the paraffin (Fig. 6). This cylinder rests on the aluminium window in the iron chest containing the coil and the tube, this window being very much smaller than the lead plate in the paraffin. I now connect the lead plate to one pair of quadrants of a highly charged electrometer, and then connect the two pairs of quadrants together and with one of the poles of a battery of 200 small storage cells, the other pole of which is connected with the iron chest, and so with the earth. I now disconnect the quadrants from the battery, and then the quadrants from each other. There is now very little movement of the spot of light reflected from the mirror of the electrometer. When we turn on the Röntgen rays, however, the spot of light begins to move, and though the movement is small compared with that which occurred in the experiment with air, it is quite decided. The rapidity with which the spot of light moves soon, however, begins to decrease, and after a short time becomes almost inappreciable. I now discharge the lead plate by connecting it and both pairs of quadrants of the electrometer to earth for a short time, then keeping one pair of quadrants connected with the earth, and leaving the other connected with the lead plate, we see that when the rays are off there is a very slight movement of the spot of light in the opposite direction to the original deflection; this is due to the leaking out of the "residual charge." This movement is, however, greatly increased as soon as the rays are turned on, and continues until we get quite a large deflection; "the residual charge," or polarisation in the paraffin, has then been enormously increased by the rays. The conductivity of the paraffin under these rays resembles in its properties that of the insulating sheath of a telegraph cable. In testing the resistance of such a sheath, the current passing through it does not remain constant, it rapidly falls off in intensity; and if after the electromotive force has been applied for some time it is removed, and the inside and outside of the sheath connected with the terminals of a high-resistance galvanometer, a current flows through the galvanometer, and this current is in the opposite direction to that which originally flowed through the sheath.

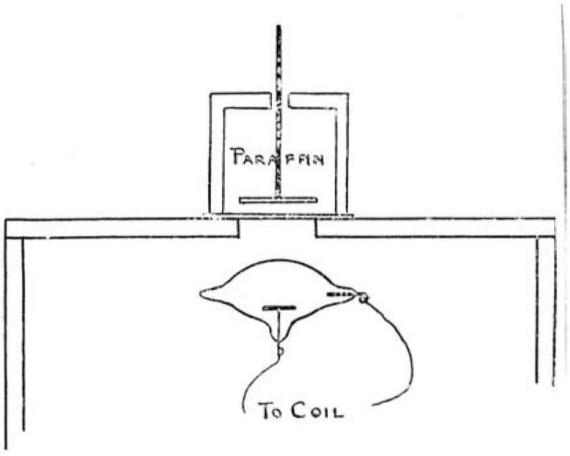

FIG. 6.

Ebonite shows the effect of the Röntgen rays in increasing the conductivity even better than paraffin. I have here a plate of ebonite about 1 mm. thick, coated on both sides with tinfoil. I put this on the aluminium window, and on the top of the ebonite plate I place a lead disc, which is much larger than the aluminium window; the object of this disc is to prevent the Röntgen rays from striking against the wire connected with the disc, and so discharging the disc through the air. That it is effectual in doing this, is proved by there being no leak when the rays are on, and the wire (raised to a high potential) disconnected from the disc. If we now repeat with this plate of ebonite the experiments we previously tried with the paraffin, we get similar but decidedly larger results. I may mention that different specimens of ebonite vary considerably in the magnitude of this effect. There is one variation of the preceding experiments which is of some interest. I will charge up the ebonite plate without putting the Röntgen rays on at all; on discharging, you see that the electrometer indicates that the "residual charge" is coming out. I keep discharging the disc until the residual charge is almost inappreciable. I now for the first time put on the rays, and you see that the residual charge or polarisation, which could not previously be detected, now becomes quite marked. These experiments show how greatly the properties of bodies are modified by the Röntgen rays, and show that by their discovery physical science has received an agent which promises to be of the greatest service in investigating some of the properties of bodies which are now most urgently pressing for explanation.

LONDON UNIVERSITY COMMISSION BILL.

THE second reading of the London University Commission Bill was agreed to by the House of Lords on Thursday last. A full report of the debate upon the Bill was given in the *Times* of Friday, and the following abridgement of it will show the favourable feeling that exists for the appointment of the Statutory Commission to deal with the reconstitution of the University.

The Duke of Devonshire moved the second reading of this Bill. He said: As I made a short statement of the circumstances that have led to the introduction of this Bill when I moved for leave to introduce it, it will not be necessary for me to detain your lordships for any long time on this occasion. The opposition to the Bill, of which I indicated the possibility, has manifested itself in the form of a statement purporting to proceed from two bodies entitled respectively the University Defence Committee and the Gresham Commissioners' Scheme Amendment Committee. It is not stated how those committees are composed, and whilst I have no doubt that they fairly represent those parties who are known to be opposed to legislation on those lines, I do not think it will be contended that the body of opinion which is represented by those committees can be compared for a moment, either in weight or as regards scientific or educational experience, with that body of opinion which in various ways has given expression to its adoption of the principles upon which this Bill is founded. I think that in moving the second reading it may be sufficient if I say that, in my opinion, the arguments which are brought forward in this case do not establish any reason why the Bill should not be read a second time. There may be some points which are referred to in that case which may be worthy of attention in Committee, and I think that some of the statements may be eminently deserving of the attention of the Statutory Commission if it should be appointed under this Bill. Lord Davey has expressed his willingness to accept the position of chairman of this Commission if it should be appointed, and I trust that before the Bill leaves your lordships' House, or at all events as soon as there appears to be any possibility or probability of its being passed through the other House, I shall be in a position, in conjunction with him, to state the names of those gentlemen who it is proposed shall form the entire Commission. With this explanation I beg to move that this Bill be read a second time.

Lord Herschell: As I have the honour to be Chancellor of the University of London, it is only natural that I should desire to say a few words on the present occasion. The objections to the measure may, I think, be put under two heads. It is alleged that the scheme of the Commission of which Lord Cowper was chairman, even when subjected to the scrutiny and modification of the proposed Statutory Commission, would involve two consequences—that it would lower or tend to lower the standard of the degrees, and that it would be unfair or tend to unfairness towards those students who sought to obtain a degree without having been connected with any college or collegiate instruction. The opponents to the scheme, both in the statement they have