

Some Experiments with Röntgen's Rays

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XXIII. *Some Experiments with Röntgen's Rays.*

By SILVANUS P. THOMPSON, *D.Sc., F.R.S.**

THE following is a brief narration of points observed by me during the past three months, and which are now brought before the Physical Society.

1. Many experiments have been made to observe polarization of x -rays, but no trace has been found. Tourmalines of several colours, and thicknesses varying from 0.1 millim. to 6 millim., have been used. Andalusite, mica, calc-spar cut in slices parallel to the axis, epidote, and ripidolite have been tried without result. The method pursued has chiefly been to cut the slice of crystal into three parts, laying two of them upon the third, one of the upper parts having its axis parallel to the axis of the under part, while the other had its axis laid at right angles. In this way equal thicknesses of crystal were compared side by side. Thinking that results might be obtained from dichroic crystals containing a metal of considerable atomic weight, slices were tried of crystals of sulphate of nickel, sulphate of nickel and potassium, sulphate of cobalt and potassium, sulphate of cobalt and ammonium, fluosilicate of cobalt, and fluosilicate of nickel, but no trace of polarization was seen.

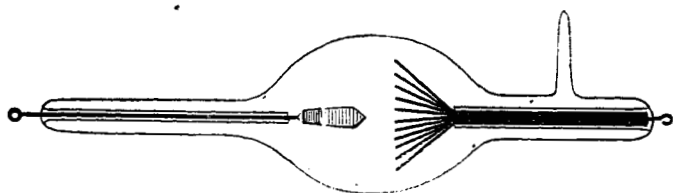
Another method consisted in comparing the opacity of tourmaline in a direction parallel to the axis with that of an equal thickness in a direction at right angles to the axis. Not the slightest difference was observed either in the photographic shadows or with the use of a luminescent screen of barium platinocyanide.

2. For several weeks in the months of February and March experiments were made with many different forms of bulb to determine the source of the x -rays and the form of tube most favourable to their production. In common with the conclusions of so many other observers, it was found that the effective source was in every case a surface against which the cathodic discharge was directed. A form of tube which gave results superior to those of any Crookes tube at the time in

* Read June 12, 1896.

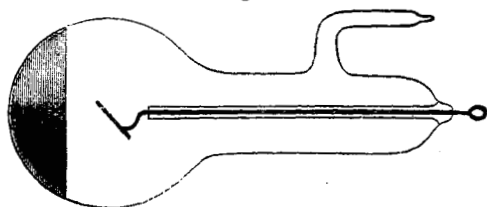
the market is shown in fig. 1, in which the kathode consisted of a number of iron wires spread out from a centre, and the antikathode, which also served as anode, was a spade-shaped piece of iron or platinum. Another form of which many

Fig. 1.



bulbs were tried was provided with an external kathode of foil, and an internal anode projecting to about the centre, terminating in a small spade of platinum-foil as antikathode (fig. 2). This also gave good results, but was liable to be pierced

Fig. 2.



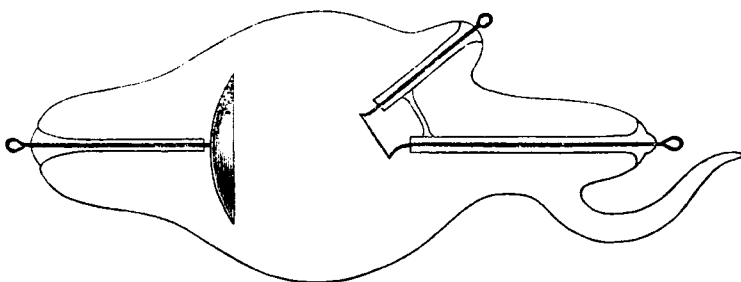
at high stages of exhaustion. With this form various experiments were tried as to the influence of the material of the antikathodic surface. Glass was found to work quite well, but to be more troublesome than metal. A phosphorescent enamel made by fusing together two parts of a soft lead-glass with one part of Balmain's luminous paint was also tried. The result of these experiments was to show that, contrary to the opinion then current that the presence of much phosphorescence or fluorescence was promotive of the production of the x -rays, the x -rays were most freely emitted when the conditions were such as to waste as little as possible of their energy in internal fluorescent effects: that in fact a metal surface was preferable to a surface of glass, enamel, or porcelain for receiving the impact of the cathodic discharge.

At about this time Mr. Jackson's perfected form of focus-

tube was brought out, a tube which for photographic purposes was found superior to any other form, and has not yet been surpassed.

3. Observing in some of these experiments that the metal spade used as antikathode became red-hot, a special tube was constructed for me by Mr. Gardiner to test the question whether the high temperature of the antikathode was, or was not, prejudicial to the emission of x -rays. This special tube (fig. 3) was furnished with an antikathode of platinum-foil mounted so that while serving both as antikathode and as anode it could be heated by passing a current through it from an auxiliary battery. Observing the activity of the tube by means of a luminescent screen of platinocyanide of potassium, it was found that the heating of the antikathode, so far from being disadvantageous, decidedly promoted the emission of x -rays, and increased the continuity and brilliancy of the luminescence. Various amounts of current were sent

Fig. 3.

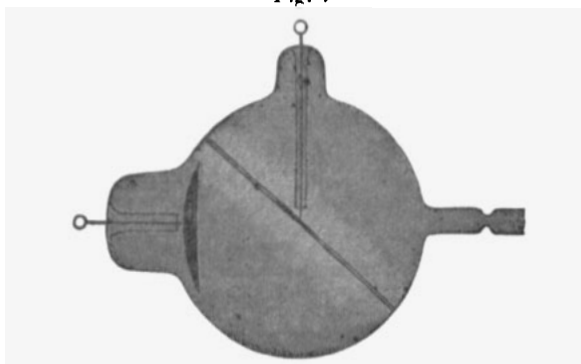


through the platinum, the most effective result being obtained by currents which heated the surface to visible redness. Whether the effect is a direct one or an indirect owing to the driving out of occluded gases is not yet determined.

4. When watching with the luminescent screen the emission of x -rays within bulbs connected with the pump, some observations were made of direct importance with regard to the state of exhaustion that is best. The degree of vacuum which suffices for the production of cathodic shadows is known not to be sufficient for the production of x -rays. It is also known that when evacuation is pushed very far the internal resistance of the bulbs rises very high, so that they

become almost non-conductive. If a bulb is exhausted, and heated during exhaustion, and the vacuum pushed almost to non-conductivity, and if a little air is again admitted and the tube again exhausted, the high degree of vacuum is again very soon reached, probably because during the first exhaustion the gases absorbed upon the walls of the bulb were mostly removed. After three or four repetitions of this process the transition from the low state of vacuum to the high state is exceedingly rapid. If a bulb in such a condition is examined by the luminescent screen while the pump is at work, scarcely any trace of x -rays can be noticed so long as the vacuum is such that the resistance is low. A pair of discharging-points arranged as a shunt to the tube serves as an approximate gauge. Kathodic shadows can be seen when the resistance is so low that the discharge-points do not spark even when placed 3 millimetres apart. When the resistance rises so that the spark-points must be put 20 or 30 millimetres apart x -rays begin to be given off; and are given off both from the back and from the front of the antikathode. The bulb, as seen upon the adjacent screen, shows two pale luminous regions divided by a fine oblique black line which is in the plane of the antikathode (fig. 4). If the pump goes on

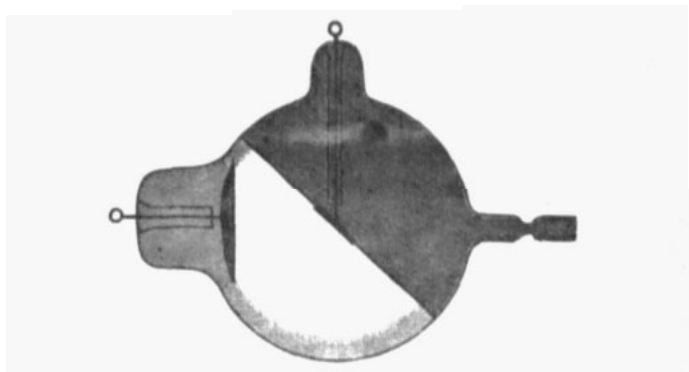
Fig. 4



working, in two or three seconds, or while only a few cubic centimetres of mercury pass through the pump, the phenomenon changes. The luminosity behind the antikathode dies out, and that in front of the antikathode increases; so that there is seen simply a bright anterior region ending at the

oblique plane of the antikathode, beyond which all is dark (fig. 5). This oblique delimitation can also be seen in the yellow phosphorescence upon the walls of the bulb. This sudden transition occurs after the resistance of the bulb has passed its minimum. The brightest luminescence occurs

Fig. 5



when the spark-length exceeds 40-50 millimetres. The luminosity does not fall off much even at very small angles to the plane of the antikathode, proving that the emission of x -rays does not follow Lambert's law of the cosine by any means. Experiments on this point are still in progress.

5. The phenomenon of diselectrification by x -rays is very readily demonstrated. For this purpose I have found a very convenient instrument to be an electroscope consisting of two strips of aluminium leaf (which is lighter than gold leaf) suspended in a thin-glass jar entirely covered with a fine metal gauze. It is charged with a dry pile, and a metal cap is then placed over the charging knob, so that it is entirely electrostatically screened from external electrical influences. Positive and negative electrifications are both readily discharged, even at the distance of several feet from the bulb.

6. On the first announcement of the diselectrifying properties of x -rays, I attempted to obtain electric dust-figures as shadows of metallic objects by applying the x -rays to discharge electrified surfaces of glass or ebonite upon which mixed powders of red lead and sulphur were then dusted.

These were obtained almost at the first trial; but to produce them satisfactorily requires a little care.

The object whose shadow is to be obtained—a pair of scissors, for example—is laid upon a thin sheet of aluminium placed to stand on four feet at the height of about 20 millim. over the sheet of ebonite or varnished glass upon which the shadow is to be thrown. This sheet of ebonite is first carefully diselectrified by passing it over an alcohol flame, and then laid upon an earthed sheet of foil upon the table. The aluminium tray with the scissors upon it is placed over the ebonite. A guard-box of lead with a rectangular hole in its top is placed over all. Then the aluminium tray is charged electrically by a small influence-machine which has one pole put to earth and the other connected to the aluminium tray. In this state of things the ebonite plate lies in an electro-static field, but is not electrified upon its upper surface. The x -rays are now caused to fall upon the aluminium tray, through which they pass save when obstructed by the metallic object, and, discharging the tray, virtually carry down the electrification upon the surface of the ebonite in straight lines, leaving the shadowed portions unelectrified. The influence-machine is disconnected, the aluminium tray removed, the sheet of ebonite lifted off the table, and the mixed powders are forthwith dusted over its surface, revealing the shadow. Both positive and negative shadows can be obtained. Several alternate dispositions are possible.

These observations were made early in February before the announcement by M. Righi of some similar cases of production of shadows by x -rays.

7. I have also made some observations upon the reflexion of x -rays. The production of diffuse reflexion by solid bodies is very easily observed; but hitherto I have no clear evidence of specular reflexion. Air unfortunately itself sets up diffusion, behaving as a semi-opaque fluid. If ordinary experiments on the reflexion of light had to be carried on in dense smoke or in milky water, a similar diffusion would interfere with specular reflexion. In one set of experiments a V-tube made of lead pipes set at right angles, and open at the bottom, was used, the x -ray source being made to shine down one limb, while a shielded photographic plate was placed at the

upper end of the other. The surfaces to reflect x -rays were placed at the open lower ends at 45° to the lines of incidence and of presumed reflexion. Reflexion of a sort was indeed obtained when surfaces of metal and of glass were placed across the bottom of the tubes. But an effect was also obtained even when nothing was placed across the open bottom. It seems exceedingly doubtful whether true specular reflexion has been observed in any case.

DISCUSSION.

Prof. DU BOIS said that Galitzine had found that Röntgen rays were polarised by tourmaline, a special form of developer being employed. The behaviour of tourmaline to light-waves presents some curious features; for if the wave-length is increased, a point is at length reached where the ordinary and extraordinary rays are equally absorbed. For greater wave-lengths the ordinary conditions are reversed. If the Röntgen rays are not homogeneous, the contradictory results obtained by different observers might be due to the fact that they were working with rays which were differently absorbed by tourmaline.

Mr. SWINTON said he had tried the effect of heating the kathode, and had obtained results similar to those which were obtained by the author. Mr. Swinton further said that he had found that the blue luminescence sometimes observed depended on the size of the kathode. With tubes in which the kathode was almost a complete hemisphere, it was impossible to eliminate this blue luminescence.

Mr. APPELYARD suggested the performance of the experiments under the surface of a dielectric.

Prof. GRAY said he had obtained some indication of regular reflection, but nothing definite.

The AUTHOR, in his reply, said that it had been found that if the Röntgen rays are reflected from a surface of sodium *in vacuo* the amount reflected is a minimum for normal incidence, and increases at oblique incidence. Comparing this behaviour with that of ultra-violet light, it supports the idea that the Röntgen rays consist of transverse vibrations.
