On a Suggestion by Professor J. J. Thomson in Connexion with the Luminescence of Glass due to Kathode-Rays

This content has been downloaded from IOPscience. Please scroll down to see the full text.

1894 Proc. Phys. Soc. London 13 287

(<http://iopscience.iop.org/1478-7814/13/1/328>)

View [the table of contents for this issue](#), or go to the [journal homepage](#) for more

Download details:

IP Address: 155.69.4.4

This content was downloaded on 25/08/2015 at 13:27

Please note that [terms and conditions apply](#).

XXVII. *On a Suggestion by Professor J. J. Thomson in Connexion with the Luminescence of Glass due to Kathode-Rays.* By JOHN BURKE, B.A., Lecturer in Physics, Mason College, Birmingham.*

LAST August, at Oxford, I communicated a paper to the British Association on a strange luminous phenomenon which had been observed by Beccaria more than a hundred years ago. It was there pointed out that although the conclusions arrived at by the Italian physicist, if true, were likely to lead to results of an extremely interesting character, in connexion with Mr. Crookes' important researches on the luminescence of glass, &c., in vacuum-tubes, and although the mysterious nature of the phenomenon was likely to attract much attention, yet the subject was allowed to retain its obscurity. Beccaria ('Artificial Electricity,' § 766) observed that when *vacuum*-bulbs were broken in the dark a light, consisting of a faint glow, was produced in the place where the bulb lay. He attributed an electrical origin to the phenomenon, owing to the manner in which certain substances were supposed to behave in yielding the glow. He mentioned, moreover, that the mere breaking of glass did not give rise to the phenomenon, but that the presence of air was essential to its production, and that when air was allowed to rush suddenly into a vacuum by the bursting of a bladder at the mouth of a receiver, articles such as glass bottles, vessels of sealing-wax, &c., became luminous by, he supposed, the violent dashing of the external air on them; the luminosity was most conspicuous at the necks of the bottles or at the upper edges of the vessels.

As has already been remarked, Beccaria's researches appear to have been forgotten for more than a century, and not until quite recently has attention been drawn to them. This has been done by Professor J. J. Thomson, who, in his 'Recent Researches in Electricity and Magnetism,' p. 119, recalls the fact and indicates its possible close relationship to Mr. Crookes' theory of the luminescence of the glass in Geissler's tubes :

* Read November 9, 1894.

that the bombardment of the glass by the particles of gas projected from the kathode is intense enough to cause the glass to become luminous. Prof. Thomson quotes from Priestley's 'History of Electricity' :—

“Signor Beccaria observed that hollow glass vessels, of a certain thinness, exhausted of air, gave a light when they were broken in the dark. By a beautiful series of experiments, he found, at length, that the luminous appearance was not occasioned by the breaking of the glass but by the dashing of the external air against the inside when they were broke. He covered one of those exhausted vessels with a receiver, and letting the air suddenly on the outside of it observed the very same light.”

That the light observed in both cases was the same, unless the exhausted vessel, which had been covered by the receiver, was broken by the dashing of the external air against it, is a circumstance which, from considerations that shall presently be adduced, I think we may be justified in questioning.

Through the kindness of Prof. FitzGerald in extending to me the facilities afforded in the Physical Laboratory of Trinity College, Dublin, I have been enabled to experiment upon this subject. It would be impossible for me to attempt to render in detail the acknowledgment of what has been due to his invaluable advice and suggestions.

It must be mentioned at the outset that the present investigation has by no means been completed, yet, thus far, it appears that some of Beccaria's results have not been wholly of that degree of exactness which we should have hoped for. It must, however, be borne in mind that scientific appliances in his time were less perfect than they are to-day, and such imperfection may account for much inaccuracy.

A number of incandescent lamps of various sizes with broken filaments were procured. An observer who had been fifteen or twenty minutes in the dark, whose sight had become sufficiently sensitive to the faintest light, broke one of the larger of these bulbs with a hammer, at the same time protecting his face by a plate of thick glass. A faint *white* glow, which lasted but for a very small fraction of a second, was seen in the place where it was known the bulb had lain. The experiment was repeated in the presence of several persons,

who testified to the same effect. The intensity of the light seemed to depend upon the size of the bulb—the larger bulbs, about 7 or 8 centim. in diameter, giving a greater intensity than the smaller ones; whilst with bulbs of not more than 2 centim. diameter no luminous effect was perceived.

A circular plate of glass, about 7 centim. in diameter and 2 millim. thickness, was then placed on the mouth of a receiver, the opening of which was about 5 centim. in diameter, and the contact made air-tight, whilst the air in the receiver was exhausted until a vacuum of about 20 millim. had been obtained.

The plate of glass was then broken with a hammer. A beautiful stream of white light was visible throughout the whole receiver. The light, which lasted for a small fraction of a second, resembled that produced when vacuum-bulbs were broken, though it was more distinct, and consisted not merely of a uniform glow, as in that case, but was marked, in addition, by a number of luminous spots of various sizes: in fact the effect presented the appearance of a faint nebula.

On account of the extreme faintness of the light, it was found impossible to photograph it: at least any attempts in this direction have hitherto proved unsatisfactory, even with the most sensitive plates I could procure.

In some instances the luminous spots were observed to be unusually large; the fragments of glass were in such cases also found after each experiment to be of an exceptional size, often 7 or 8 square centim. in area.

This fact is especially worthy of notice, as it undoubtedly indicates that the fragments of glass themselves had become luminous, the continuous glow in all probability having been caused by the very minute fragments.

Different kinds of glass were used without giving any perceptible difference in the effects.

Thin brittle plates of cast-iron and steel were tried in the place of glass, but yielded negative results, owing, perhaps, to the fact that they did not break up into innumerable fragments as glass did readily when struck with a hammer, or because the air was not consequently permitted to enter the vacuum very suddenly and with sufficient violence.

Various gases were made to take the place of air. Fig. 1 represents the apparatus employed for this purpose. *a* is a glass receiver; the strong glass ring *b*, the opening of which was covered by a piece of thin glass *c*, rested on the mouth of the receiver *a*, and served to support a long glass tube *d*, at the upper end of which, being closed, there was an arrangement *e* by which a weight *f* was supported and allowed to fall by turning the handle *h* and thus break the glass *c* and open free communication between the gas in the tube *d* and that in the receiver *a*.

The joining between *d* and *a* was made completely air-tight so that no leakage occurred. The tube *d* was then filled with carbon dioxide or oxygen, and the air in the receiver *a* exhausted until a vacuum of about 20 millim. was obtained. The weight *f* was made to fall and break the glass *c*, so that the gas in *d* might enter violently into the vacuum. The same luminous phenomenon was observed as on previous occasions when air was employed, with no perceptible difference as regards colour, intensity, or the general appearance of the glow and luminous spots.

When the gases in both *a* and *d* were exhausted and the glass *c* broken as before, no luminosity whatsoever was observed, thereby showing that the mere breaking of glass did not suffice to produce the phenomenon; but that the presence of a gas was essential, though any gas was sufficient to produce the effect—that is, that some function performed by a gas in rushing into a vacuum was the cause or a circumstance invariably connected with the phenomenon.

The three following hypotheses seemed possible:—

(1) The violent dashing or bombardment of the molecules of air against the glass might have caused the latter to emit light.

(2) It might have been a sort of miniature meteorite phenomenon, caused by the collisions of the fragments of glass with the interior of the receiver and with each other; the

intense bombardment of the larger fragments by the minute dust particles giving rise to the luminous spots.

(3) It might have been an electrical phenomenon caused by the rubbing of air against glass ; somewhat resembling that produced by the friction of mercury against glass in a barometric tube*.

In view of testing hypothesis (1) the following experiments were made :—

A bladder was fastened to the neck of a small receiver, the air in which was then exhausted until a vacuum of about 20 millim. was obtained.

The bladder was then caused to burst, and a stream of *yellowish* light was seen to descend within. This experiment was repeated several times with receivers of various heights ; and it was found that in the case of tall receivers the light was confined to the higher portion, near the mouth of the receiver.

The intensity of the light seemed to depend upon the pressure in the vacuum, that is to say, upon the violence with which the air entered the interior of the receiver.

The general appearance of this yellowish light seemed to indicate that the luminosity in *this* case was partly, if not altogether, due to parts of the bladder taking fire, being heated by the friction of the air against them, or by being suddenly torn. Articles of various materials, such as those mentioned by Beccaria, were placed in the interior of the receiver, also a plate of glass supported horizontally so that the air on entering might impinge directly upon it.

A light in some respects, perhaps, resembling that mentioned by Beccaria was observed, but only with short receivers ; for in the case of tall ones, under precisely similar circumstances, no light was perceived in the lower region where the articles lay ; thus suggesting that in the former case the portions of burning bladder had been stopped, in their fall, by the articles within the receiver. Beccaria took no precautions to determine the part played by the bladder in the phenomenon, or rather, he entirely failed to notice that it ever became luminous.

In order to stop the bits of bladder, gauzes of various

* See Armstrong, Phil. Mag. ser. 3, vol. xviii. (1844).

materials and different thicknesses were tried ; such as should stop the pieces of bladder but permit the air to rush through without much impedance. The glass bottles beneath the gauze, however, were not seen to give rise to any luminosity.

A similar plan was made use of when air was allowed to enter a vacuum by the breaking of glass.

The apparatus employed for this purpose (see fig. 2) consisted of a cylindrical receiver, *A* ; a ring, *a*, which fitted closely into the cylinder and was supported by iron rods that were adjustable so that the ring could be moved up and down, carried the wire gauze, *b*, which was tightly fastened to it. A plate of glass, *c*, was laid on the mouth of the receiver, and the contact made air-tight ; *d* were articles

Fig. 2.

such as glass bottles &c. ; an electromagnet, *e*, supported a hammer, *f*, which fell and smashed the glass plate, *c*, when the circuit was broken at *g*. The part of the cylinder above the gauze was screened from the observer's sight.

The air in the cylinder having been exhausted, no light was seen to penetrate the gauze, neither was there any luminosity seen in the vicinity of *d*, when the external air was

allowed to enter the receiver, in the usual manner, by breaking the glass, *c*.

A bladder was then used instead of glass plates, but the results were similar.

Different gases were allowed to issue forth from bottles containing these gases in a highly compressed state, on the surface of glass, and especially on its sharp edges, but without producing any visible effect.

These results do not seem to harmonize with hypothesis (1). Let us now proceed to the consideration of hypothesis (2).

Fig. 3 shows the arrangement by which air could be allowed to enter suddenly into a vacuum without the necessity for breaking glass or bursting a bladder. *a* is the glass receiver; *b* a ring, between which and the receiver is a sheet of fine tissue-paper, *c*, on which a number of fragments of glass were placed; a plate of strong glass situated on top of the ring *b* admitted of being drawn aside, and thus allowed the air to enter the vacuum, whilst the rest of the apparatus was held fast.

A luminosity similar to that seen upon previous occasions was observed, though less distinct in some respects, perhaps, than before.

Under precisely similar circumstances, in the absence of any fragments of glass on the tissue-paper, no light was produced, whether or not there were any articles that the air could impinge upon within the receiver.

A single piece of glass cut into a definite shape was then made to take the place of the great number of fragments, some cotton-wool being placed on the plate of the air-pump in order as far as possible to prevent the piece of glass from breaking.

The following facts were noticed :—(α) Only a single spark seen. Not as on a previous occasion when a number of fragments of glass were allowed to enter the vacuum,

(β) the spark always appeared on the side of the receiver in the direction in which the plate d had been drawn aside* (see fig. 3). (γ) The piece of glass was found almost vertically under the place where the spark had taken place.

It seemed probable that the spark was caused by the collision of the piece of glass with the interior of the receiver. Two strong pieces of glass were then struck violently together, and a light similar in every respect to that previously observed was produced.

These experiments seem to justify hypothesis (2): the dust particles causing the glow by their impacts against the interior of the receiver and against each other; whilst the brightness of the luminous spots may be attributed to sparks produced by the larger fragments of glass, and to the bombardment of the dust particles against the surfaces of these larger fragments.

A large quantity of fragments of cast-iron, steel, ebonite, sealing-wax, bone, &c., were tried as well as glass, but the attempt to obtain a luminous effect by the above method proved fruitless.

If metallic dust should produce a luminous effect when made to bombard the surface of glass, and if different effects should be produced by lead glass and German glass, the theory that *solid* particles emitted from the kathode would give rise to luminescence of the glass would be justified. The above experiments, however, do not seem to throw much light on Mr. Crookes' theory of luminescence due to the emitted *particles of gas*.

In the earlier stage of the investigation hypothesis (3) appeared plausible enough. Any experiments, however, that were made in connexion with it did not lead to results of an interesting character.

Whatever may be the real value of these experiments, it cannot be doubted that the inquiry into the cause of such a phenomenon as that noticed by Beccaria must prove of the greatest interest: firstly, on account of the obscurity enveloping the subject, and, secondly, on account of the interest attached to the artificial production (though on a small scale) of meteoric phenomena in the laboratory.

* It is probable *à priori* that this should take place.