The Photographic Action of Radium Rays

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XI. *The Photographic Action of Radium Rays.* By S. SKINNER, M.A., *University Demonstrator in Experimental Physics at the Cavendish Laboratory, Cambridge* *.

It is well known that a photographic plate by exposure to Radium rays is affected in such a way that the plate develops similarly to its development after exposure to light. The following experiments are an attempt to answer the question : Are the actions the same? As far as can be seen by eye, plates exposed to the two agents appear on development to be darkened in a similar way, and we may conclude that the final result of the actions and of the development is the same. I have attempted to obtain information of the intermediate stages, and some of the experiments described below appear to indicate that only slight differences occur in these early stages. I shall describe the experiments in the order in which they may be best understood, although this was not the order in which they were made.

A plate, inclosed in two envelopes of paper, one red and the other black, was placed under a capsule containing 10 milligrammes of radium bromide at a distance of 1 centimetre from the plate for periods of time varying from half a minute to 48 hours. A different part of the plate was presented to the radium for each period of time. It was then developed in alkaline hydroquinone for three minutes, and the intensities of the developed images were compared by means of a commercial densitometer. A similar experiment was also made with 50 milligrammes of radium bromide. For most of the experiments a red label rapid Ilford plate was used, and in a few a 'Lumière' plate.

The general result of these experiments showed that the intensity of the developed image increased rapidly to a maximum value, then decreased rapidly, and finally the intensity decreased very slowly until a stage was reached in which there was practically no dark image formed on development. The time of exposure required to reach the maximum depended on the mass of the radium bromide used,

* Read January 22, 1904.

that with 50 mgr. being earlier than with 10 mgr. In fact, after 40 hours' exposure the effect on the plate might be compared to the complete reversal of image obtained when a plate is very much over-exposed to a bright light. The following curves refer to Ilford red label rapid plates, I. exposed respectively to 50 mgr. and II. to 10 mgr. (fig. 1). With this class of plate the maximum was reached

Fig. 1.

in 15 minutes with 10 mgr. of radium bromide, and in 7 or 8 minutes with the 50 mgr. With Lumière plates the maximum was reached in about 2 hours, see fig. 2.

Fig. 2.

To verify the result that an exposure greater than a certain critical value will produce a less dense image, the following

experiment was made. A slit was cut in a thick sheet of lead and a covered photographic plate was placed below it. It was then exposed to radium rays for 10 minutes. Then the lead plate was removed, and the plate was exposed for a further period of 10 minutes. In this way the parts opposite the open slit received altogether 20 minutes' exposure, whilst the protected parts were exposed only for half that time. On development the slit appeared as a light line crossing a dark field. This result follows at once from the diagram (fig. 1), for if OA represents the 10 minutes' exposure the density will be AM, and for a time exposure OB the density is BN, a value less than AM.

Here it will be recognized that the action on the plate is like that of light, for an overexposure produces a fainter image. The action, however, is more under control as its rate is slower.

From the arrangement of the radium * I am inclined to think that the α -rays were all absorbed before reaching the plate, and that we have to consider the action as coming from the β - and γ -rays alone, these two sets of rays having much more penetrating properties than those of the α group.

The next experiments were made with the view of finding out whether a plate exposed to the light of an electric spark would undergo any reversal if it was afterwards exposed to radium rays. In fact, I tried to obtain a reversal effect similar to that got by Clayden, by exposing a plate first to electric sparks and then to faint gas-light, only I substituted radium rays for the after-exposure to faint light. Clayden showed that it was easy to reverse the images of bright sparks by exposing the plate subsequently to a gas-flame for a few seconds. In this way he explained the reversed images of lightning-flashes which are obtained when several images are taken on one plate, or when images are obtained of lightning-flashes with a bright cloud behind them.

In my experiments an Ilford plate (red label) was exposed in a camera to a series of Wimshurst machine sparks, the plate being shifted between each spark. Then the plate was placed

* The radium bromide was contained in an ebonite capsule covered with a thin mica plate. The rays passed through the mica.

in its envelopes, and a part of it was protected by a thick leaden screen. The rest of the plate was exposed to the radium. This was repeated for different periods of radium exposure. On developing these plates, it was found that in those which had been exposed to the radium for only short periods, gradually increasing in length, there was a progressive elimination of the spark image, but the density of the parts corresponding to the radium exposure was not so great as that of the parts of the plate only exposed to the spark, although the radium action had been able to obliterate completely the spark effect. On the other hand, when those plates which had been exposed longer, or had been exposed to the greater mass of radium, were developed, I found that reversed images of the sparks appeared. These images were not so wide as the spark images. In another case, with still further exposure, I observed the radium reversing its own image, and across the radium reversed part of the plate there appeared a faint dark image of the spark. This might be described as a re-reversal of the spark.

The conditions of these experiments were such that probably only the β - and γ -rays were acting. In the Philosophical Magazine for November, 1903, a paper appears by R. W. Wood, on the subject of photographic reversal, and in it he says that he has been unable to reverse a spark-image by Röntgen rays, which are supposed to be similar, if not identical with the γ radium rays. If this is the case we must ascribe the reversal, which I have described as produced by radium, to the action of the β -rays alone. This point, however, needs further investigation with screens capable of cutting off each class of rays.

In Wood's paper he gives what may be called a reversal order. It is :—Pressure-marks, x -rays, Light-shock, Lamplight. In this order each successive influence is able to reverse those before it. He also states that Becquerel rays will reverse pressure-marks, and that lamplight will reverse the effect of Becquerel rays. The Becquerel rays which he used were probably those from a compound of uranium. My experiments show that Light-shock (from an electric spark) may be reversed by Radium rays, and consequently

Radium rays may be inserted provisionally between Light-shock and Lamplight in the above order.

Conclusions.

1. The density of the image produced on a plate by exposure to radium rays (β and γ) increases to a critical value and then decreases, at first rapidly and afterwards very slowly, until a time is reached when the image is totally reversed.

2. Spark-images are at first obliterated by radium rays which do not cause such a great density as that of the spark-images obliterated.

3. With prolonged exposure radium rays reverse spark-images.

I am greatly indebted to Mr. Hayles, of the Cavendish Laboratory, for carrying out many of the experiments described in this paper.

XII. *Some New Cases of Interference and Diffraction.* By
R. W. WOOD, *Professor of Experimental Physics, Johns
Hopkins University* *.

[Plate IX.]

IN the following paper I propose to discuss certain types of the interference of light which have been known for many years, as well as some cases which, so far as I know, are quite new; the colours of mixed plates and the phenomena of interference in transparent films deposited on metallic reflectors being the cases chiefly considered. Several years ago it occurred to me that it would be worth while to try to devise some permanent film which would show Newton's colours under the most favourable conditions, and the cases cited in the present paper are, for the most part, the outgrowth of experiments made in this direction. The facts which have been brought out may be summed up as follows.

* Read January 22, 1904.