est care was taken to obtain the most sensitive plates and the most powerful developer known, and that this matter gave much more trouble than the experiment just described. OGDEN N. ROOD.

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FURTHER EXPERIMENTS WITH X-RAYS.

PHOTOGRAPHS have now been obtained with several of the Crookes tubes in the cabinet of the Dartmouth Laboratory, but the one referred to in a previous communication is by far the most efficient, and it has been used in nearly all the experiments now to be described. This tube was made by Stoehrer, of Leipzig, being No. 1147 of his catalogue, where it is designated as Puluj's neue Phosphorescenz-Lampe. It contains a mica diaphragm coated with some phosphorescent substance, and gives quite a brilliant green light when in action (although this brilliancy is doubtless immaterial to the production of the X-rays).

As to the source of the X-rays developed by this tube it may be stated that a variety of experiments have shown that they originate in the diaphragm itself where exposed to the cathode rays, and not to any appreciable degree in the glass around the diaphragm. Cathode rays which pass through the diaphragm appear, however, to develop X-rays at the surface of the glass where they impinge.

The method first adopted for determining the position of the source was that of calculating its distance from the plate from the magnification of the shadows of intervening opaque objects, but this procedure brought out anomalies, as will presently be mentioned. By bringing the plate near the tube, the diaphragm could be made to cast its own shadow, and the resulting appearance leaves no doubt that the X-rays chiefly originate in a limited portion of the diaphragm. The method of using a series of parallel films leads to the same conclusion, and indicates that in this tube the rays do not proceed directly from the cathode itself.

Lenard has observed that the cathode rays are diffracted around the edges of obstacles. In case of the X-rays our experiments indicate an effect apparently somewhat the reverse of this. While the shadow of an obstacle is always magnified, and often to a degree disproportionate to the distances involved, we have obtained several plates showing the impression from an aperture in an opaque object to be slightly minified, when the plate is sufficiently near the object. This would point to an outward rather than an inward bending of the rays. In this connection attention is called to a curious phenomenon presenting to the eye the appearance of irradiation, although it is difficult to believe that any real analogy to irradiation is offered.

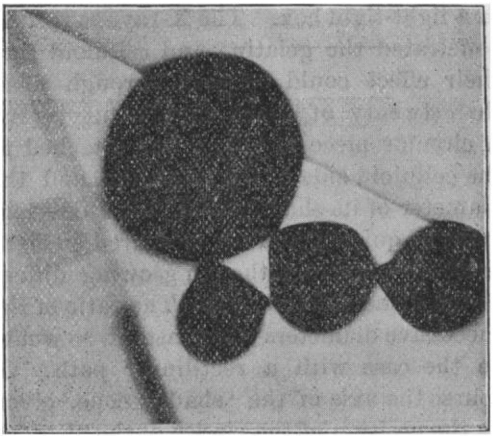

FIG. 1. DISTORTION OF COINS PHOTOGRAPHED WITH X-RAYS.

The coins shown in Fig. 1, are a silver dollar, a dime, and two nickels, in contact, all perfectly round; a glass rod (ending in a brass cap) touches the dollar, and a small piece of hard rubber prevents it from rolling. The line across the plate, through the shadow of the dollar, is the image of the mica diaphragm, the plane of which was nearly perpendicular to the plate. The tube was but 14 mm. above the coins and 17 mm. above the film. The magnification of the shadows is slight, but the distortion is almost grotesque. Plates showing this effect can be easily obtained.

It should be stated that the nearness of any conductors, as these coins, to the tube in action will produce in them a considerable static charge, as may be readily tested by a proofplane and electroscope. This may possibly have a bearing upon the cause of the distortion.

The rectilinear path of the X-rays after they have passed by an obstacle has been proved by the use of a long strip of celluloid film, as used in Kodak cameras. A framework like two parallel ladders was so made that the film could be tightly drawn across the rounds with successive portions parallel and at a distance of 10 mm. from each other, the whole being enclosed in a light-tight box. The X-rays so readily penetrated the gelatine and celluloid that their effect could be seen through more than twenty of these equidistant layers. A circular piece of silver was attached to the celluloid side of the front film, and the diameter of its shadow could after development be quite accurately measured on eight successive layers, although growing diffuse as the distance increased. The ratio of the successive diameters was constant, as would be the case with a rectilinear path. Of course the axis of the 'shadow cone,' given by the position of the circles of the shadow, passes through the source of the rays. On some of the films exposed in this way very curious markings are seen which we are as yet unable to explain.

This use of films at once suggests the need of a new kind of sensitive plate for photographing with X-rays which shall absorb them far better than does the ordinary dry plate. When a strip of film was folded up on itself, so that there was no loss of intensity by increase of distance from source, the impression was hardly less strong on the twelfth than on the first layer; and an impression could doubtless be transmitted through a hundred layers. It follows that the time of exposure necessary for X-ray photographs could be diminished in proportion as the plates are made to absorb the energy falling upon them. On account of the opacity of platinum, it occurred to me to try platinum photographic paper of the kind used for portraits, but such paper (intended for long exposures in printing in sunlight) was far too lacking in sensitiveness to produce any effect. It ought to be easily possible for our photographic chemists to produce plates which should require but one-twentieth or less of the exposure now required for X-rays with ordinary plates.

The writer has succeeded in repeating Röntgen's reflection experiment, except that a celluloid film was used instead of the less permeable glass plate. Nickel and copper disks were attached to the under side of the film, and after exposure (70 minutes) their effect in reflection was shown by the greater intensity of the dark (or negative) circles above them.

Certain plates gave anomalous results of reflection, the portion of film above the reflecting object being affected less intensely than the rest of the film ; that is, the outline of the object *beneath* the film is shown, but is lighter on the negative than the surrounding area, instead of darker, as would be expected.

On four of our plates an appearance strikingly like interference fringes can be observed, and thus far we can only account for it on the supposition of reflection from the brass spring which presses against the glass side of the plate in the holder, thus keeping the plate in place. Numerous attempts have been made to obtain interference fringes after the analogy of Newton's rings, but thus far unsuccessfully.

The difficulty found by Professor Emerson and myself in *precisely repeating* most of these experiments has doubtless been experienced by others working with the X-rays. When the conditions of an exposure seem identical with those of a previous one, the results often differ, from varying excitation of the tube, or possibly slight shifting of the source of the rays, or from numerous other causes difficult to control. A confirmation of results by other observers is therefore valuable.*

Since the last paragraph was in type I have succeeded in proving that the 'fringe' is due to the spring by the somewhat surreptitious method of placing a second Crookes tube behind the plate, and thus projecting a shadow of the spring itself upon the plate on which at the same time the spring was reflecting the fringe. Fig. 2, is from a plate obtained a fortnight ago. A silver dollar lay on the slide above the plate, directly over the spring which was behind the plate; the tube was 14 mm. above the plate and the exposure was one hour. The X-rays must have passed through the silver dollar and then have been reflected by the spring, giving the 'fringe.' Since the central bright line is much brighter than the other portions of the plate partially screened by the dollar, it would seem that this additional brightness can only result from the superposition of waves in the same phase, or, in other words, from something closely akin to interference. Similar fringes have been obtained through tinfoil instead of silver, and also where no obstacle intervened between tube and film. We hope by this method to obtian the wave-length of the X-rays.

EDWIN B. FROST.

HANOVER, N. H., March 10, 1896.

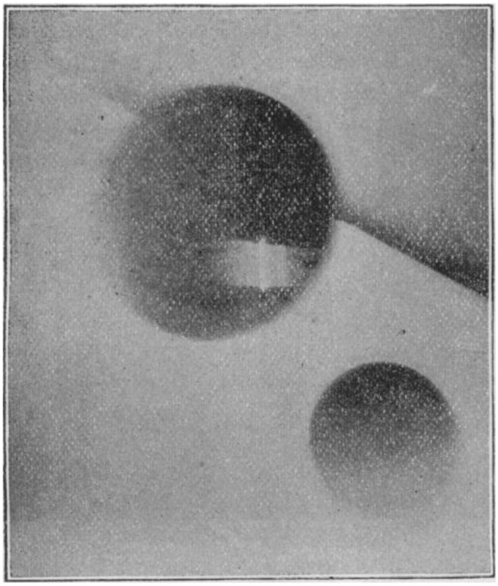

FIG. 2. SHOWING REFLECTION AND INTERFERENCE OF X-RAYS.

* In a previous communication (p. 235), a slip of the pen made me invert the order of permeability of hard rubber, glass and brass; the rubber is of course the most permeable.

THE RECEPTION OF FOREIGN STUDENTS IN FRENCH UNIVERSITIES AND SCHOOLS.

IN order to carry out effectively the plan for the reception of foreign students in the schools of France, in which there is now so much interest, the French government has formed a Committee of Patronage for the purpose of receiving new comers, giving them encouragement, and furnishing them with all necessary information in regards to their studies and facilities for life in the university towns. The object of these Committees is to make the student's stay in France agreeable as well as profitable. They also offer their friendly offices to the families of students.

THE PARIS COMMITTEE.

The Paris Committee has its headquarters at the Sorbonne, and is composed of the following members:

MM. Emile Boutmy, Member of the Institute; Director of the *École libre des sciences politiques* Michel Bréal, Member of the Institute. Xavier