NOTE ON ARTICLE BY H. M. DADOURIAN ON "SOFT X-RAYS."

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SYNOPSIS.

Soft X-Rays, (1) Criticism of Use of Electrostatic Trap to Avoid Methodical Errors of Observation.—Unless the field is fully symmetrical one kind of ions or of rays will get through, and light is not thus trapped.

(2) *Criticism of Measurements of Photoelectron Velocities.*—The beforementioned sources of error are present, and the use of a secondary field renders uncertain the value of the supposed retarding field.

(3) *Criticism of the Values Given for Variation of Intensity of Radiation with Voltage, and for Absorption in Celloidin Films.*—Errors as in (1) persist. Experiments are described exhibiting similar variations the incorrectness of which is shown by a comparison of the photoelectric and ionization currents, and by observations with the apparatus further denuded of gas. A *discussion* is given of the use of the term soft X-rays, and the *suggestion* is made that the intensity of radiation in this region from a solid produced by the impact of cathode rays of less than 200 volts velocity is small.

IN the recent article by Dr. Dadourian[1] on "Soft X-Rays" he uses the term "to denote roughly that region of general radiation which falls between the shortest known ultra-violet rays and the longest waves of characteristic X-radiation studied to date" and claims to have produced such radiation by cathode rays of from 20 volt velocity up. I should like to question the nature of his proof.

The apparatus used, in so far as it consisted of three parts, a discharge tube, an electrostatic trap, and a measuring chamber, is essentially the same as that described earlier by me,[2] the differences being that my early discharge tube was of glass, and that the field applied in the middle chamber was a radial one. Dadourian's first proof of the correctness of his results is that after a certain value of the field between his plates P and P', Fig. 1 (L.C.) is reached, the effect measured becomes constant as shown by the horizontal parts of the curves in his Fig. 3. In spite of this there might yet be ions, positive rays, and light entering his measuring chamber. No statement is made as to the vacuum obtained with the apparatus, but with the curve at 80 volts, for example, the putting on of a 10-volt field in his trap reduces the effect measured by

[1] H. M. Dadourian, PHYS. REV. (2), 14, 234, 1919.

[2] E. R. Laird, Ann. der Phys., 46, 605, 1915.

95 per cent., and by almost as much when a celloidin screen is used. This indicates a plentiful supply of ions in the apparatus, and as the field is increased the original ions may produce fresh ions in the field, some of which will pass on through the next opening. The sign of these would depend on the sign of the potential applied to the plate P, as the field is evidently not symmetrical, P' being connected to the case and the partition in which occurs the opening to the measuring chamber. Nothing is said as to whether the field was reversed. If P were $+ ve$, then fast-moving positive ions would naturally go from the anticathode to the opening S into the trap and some almost certainly on into the final chamber. I have already described a case where such positives after passing a thin collodion window not quite airtight will charge an electrode already positive. The more serious point in this case is probably that with a brass discharge tube, and a platinum anticathode, and vacuum as indicated, there would be present light of wave-length greater than 1,000 Å. capable of producing a photoelectric effect, which of course would not be diminished by the application of an electric field.

Dadourian's second argument rests on his attempts to measure the velocity of his photoelectrons. In Fig. 4 he shows a curve obtained by the retarded field method at 390 volts on the discharge tube. At this potential the presence of an X-radiation is not doubted, though it may be accompanied by light and other effects. I have previously shown a curve[1] (Fig. 6, Curve II.) at 550 volts not intersecting the axis until 20 volts retarding potential is reached, as compared with his 5 volts. My apparatus was evidently more favorable as the airtight window kept out ions or positive rays. I obtained also the negative saturation part of the curve, and an increase in the retarding potential by use of a secondary gauze. The slow rise to saturation of his curves would be explained by the presence of some fast moving positive ions which as previously suggested are probably present. In his Fig. 5, for 60 volts, where the attempt is made to demonstrate the presence of photoelectrons of velocities greater than 10 volts, the so-called retarding field was made up of two gauzes fairly close together, of 1 mm. mesh, to the inner one of which the negative potentials were applied, while the outer was at + 200 volts. It would be difficult to say what the field between plate and first gauze is under such circumstances.[2] Van der Bijl has shown that an electron current may pass through a gauze to a positive plate even though the gauze be at a negative potential, since the potential of the plate causes a stray field to act through the openings of the gauze.

[1] L. c., p. 616.

[2] Van der Bijl, PHYSICAL REVIEW, 12, 171, 1918.

The magnitude of the factor involved depends on the mesh and the nearness of the plate. Since in Dadourian's experiments + 5 volts sufficed to hold back the great majority of photoelectrons, the use of + 200 on the second gauze makes it highly probably that the effect of this was to counteract the assumed retarding field. The difference between the effects observed with and without blackening the walls of the chamber holds equally for light.

The other data shown, Fig. 7, are for 200 volts. To Curve I. the same criticism regarding the use of + 200 volts on the outer gauze applies. For Curve II. there is nothing to show that this effect would not be produced by light with or without the presence of some ions. In my former article[1] I referred to having made experiments at 200 volts, where without gauzes effects up to 4 volts retarding field were obtained but later I found that 60 per cent. of the radiation was transmitted by fluorite, so that it was concluded that the effect was due to ultra-violet light.

In Part III., Dadourian gives curves showing the relation between the potential on the discharge tube and the effect measured, and indicating the amount transmitted by thin celloidin. Although by his results the transmission of celloidin does not vary greatly between 200 and 800 volts, the form of these curves differs so markedly from those obtained by me[2] with an airtight celluloid window that some explanation should be expected. In Fig. 1, a curve is shown which was obtained with a brass anticathode and with an aluminum plate in vacuum in the measuring chamber, pressure .001 while the discharge was going in the discharge tube. It shows a peak at above 400 volts, and no increase in intensity at 600, also a peak at below 200 volts. That the irregularities were due to the effect of light of wave-length greater than 1,200 Å. was shown by the facts that (*a*) previously a number of tests had shown that a large part of whatever effect was obtained below 200 volts would go through fluorite, (*b*) that if a small amount of air was admitted to the measuring chamber no ionization was found below 200 volts and the photoelectric effect was diminished, (*c*) that above 400 volts where the other irregularities occurred, they practically vanished when air was admitted to the measuring chamber, as the ionization current totally overshadowed any small remaining effect. Curve 2 shows an ionization curve obtained on the same day as the curve I. of Fig. 1. But if these peaks indicated characteristic radiation occurring at this voltage, this radiation should produce ionization and the peaks should be magnified

[1] L. c., p. 617.
[2] L. c.

instead of suppressed. Further with greater effort to rid the apparatus of gas, they are suppressed even in the vacuum measurements.

The very slow rise in Dadourian's curves above 400 volts of itself suggests that the effect measured is largely due to light or to positive rays which become a fairly constant proportion of the original current. It may be noted that the curves of Fig. 3 show apparently a greater proportion of the effect measured transmitted by celloidin at 80 volts

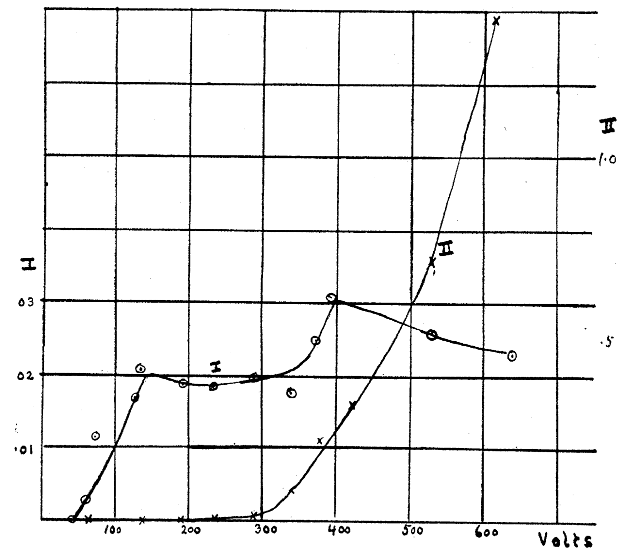

Fig. 1.

than at 380. Contrary to what is given in Fig. 8. Quite evidently as the voltage diminishes towards zero, below some value still to be determined, the absorption in these films would diminish, and not increase.

It is a well-known fact that the impact of electrons of 5 volts velocity and less on the molecules of certain vapors produces a radiation, and that velocities of 10 volts are sufficient to produce ionization in air which in turn would be accompanied by radiation, so that it is not questioned that electrons of less than 200 volts velocity produce radiation by impact, but there appears as yet no proof that such radiation lies in the region designated as belonging to soft X-rays. The properties of "entladungsstrablen" differ somewhat from those of the radiation produced by cathode rays above 300 volts, in a way to suggest longer wave-lengths and more marked absorption changes than found by Dadourian. But while it is not to be doubted that the impact of electrons on a solid will produce under the right conditions a radiation of the desired wave-length, it may be in such small amount as to make the distinguishing between it and other effects very difficult.