Thus by plotting Δ against L a family of curves is obtained which has as an envelope a straight line passing through the origin. If the light intensity is kept constant and the electron emission from A is increased from 0 to a large value, Δ increases at first with the emission (with the 1.6*th* power of it in one set of experiments) and then becomes constant when Δ/L has reached its limiting value.

These relationships are in many ways analogous to those in electron tubes where the current is in general limited either by emission from the cathode or by space charge, depending upon which limit has the lower value. Similarly, we may assume that the photo-electric reflection may be limited either by the number of electrons that strike the electrode, or by the amount of light reaching the electrode.

Although all the characteristics of this effect are not yet understood, it seems safe to assume that the effect is caused by an activation of an adsorbed caesium film by light, the atoms in this film being brought to such a state that they cause the impinging electrons to make elastic collisions.

The effect disappears if the voltage of either B or C is brought to zero. When the voltage E_C is less than E_B the normal photo-electric effect reverses in direction, but Δ does not do so. The limiting value of Δ for sufficiently high values of L, which we may call Δ_L, is greatest when E_C is considerably larger than E_B. Thus with $E_C = 100$, $E_B = 60$, and $I_A = 26$, Δ_L had a value 2.9, while for $E_C = 20$, $E_A = 100$, and $I_A = 47$, Δ_L was 0.07. The fact that the effect still existed under the latter conditions proves that several per cent. of the electrons which are reflected from B lose not more than 20 per cent. of their energy.

With E_B kept at 20 volts, Δ_L was 1.4 for $E_C = 20$, and it steadily increased as E_C was lowered below this point, until, at $E = 5$ volts, there was a sharp maximum ($\Delta_L = 3.3$). Another even greater maximum of $\Delta_L = 4.2$ occurred at $E_C = 1.1$ volt. At $E_C = 0.5$ volt the effect fell abruptly to zero.

A sharp distinction between the new photo effect, measured by Δ, and the normal effect I_N, is that the new effect disappears entirely if a piece of red glass is interposed in front of the light source, Δ falling at least to 1/1000th of its original value, whereas the normal effect decreases only to about one tenth.. It is probable that the effect is mainly due to light having a wave length of about 5300 A° (blue-green).

A similar activation of a nickel surface causing electron reflection has also been found in connection with some measurements of the distribution of velocities of electrons in the positive column of the mercury arc, by a method like that described recently for measuring positive ion currents. (Langmuir, SCIENCE, *58,* 290 (1923)). By introducing high speed electrons (40 volts) into the mercury arc by means of a heated negatively charged tungsten filament, it was found that the ability of a small collecting electrode (1 sq. cm area) to take up low speed electrons was greatly impaired.

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THE ABNORMAL REFLECTION OF X-RAYS BY CRYSTALS

IN recent papers[1] we have described experiments which show that under certain conditions a crystal of potassium iodide deflects x-rays in a way that does not obey the ordinary laws of x-ray reflection. The discovery and extensive study of these abnormal reflections, called x-peaks, were made by means of ionization spectrometers. A number of experiments demonstrated that the x-peak reflections vanished when the voltage fell below the critical voltage required to produce the K series lines of iodine. From this we conclude that the abnormally reflected rays consisted of the characteristic line spectrum excited by the primary x-radiation in the iodine atoms of the reflecting crystal itself. The angle of reflection from the crystal depended in a complicated way upon the angle of incidence of the primary rays, and the phenomenon can not be regarded as ordinary reflection from any single set of crystal planes. We took special care to prevent rays regularly reflected by the various sets of planes from entering the ionization chamber.

We published in the *Journal* of the Optical Society (*l.c.*) the reproduction of a photograph taken in such a way as to show the x-rays defracted by the crystal of potassium iodide. The primary x-rays in this case passed through the crystal parallel to an axis. Four spots, in addition to that due to the direct beam of x-rays, appeared on the photograph in positions corresponding with the data obtained for the x-peaks by the ionization spectrometer. Thus the existence of the x-peak reflection was confirmed by the photographic method.

A letter from the Geophysical Laboratory has appeared in SCIENCE recently (July 20, p. 52) written by Mr. R. W. G. Wyckoff, in which he briefly describes experiments with a potassium iodide crystal and a photographic plate. The very excellent copies of these photographs, which he has been kind enough to send us, show no spots that can be attributed to the abnormal x-peak reflection. We thought it best to delay comment on this letter until we could make

[1] *Proc.* Nat. Acad. Sci., 8, 90 (1922); 9, 131 (1923); *Jour.* Optical Soc., 7, 455 (1923).

an effort to ascertain what the important differences really are between Wyckoff's experiments and our own. This we have not been able to do until very recently, because we did not wish to interrupt other researches already in progress.

We have reinvestigated the x-peak phenomenon both with the ionization spectrometer and by means of photographs, and the results completely confirm our previous conclusions. At least one of these photographs with a detailed description of the apparatus will be sent for publication in a future paper. The photographs show a large number of Laue spots reflected in the ordinary way from the various crystal planes together with the four well-defined spots that can not be reflected from any conceivable planes in the crystal and which correspond exactly in position with the x-peak reflections. On one of these photographs no spots except the central image are more strongly marked than those representing the x-peak reflections. There can be no doubt as to the reality of these abnormal reflections of the rays by the potassium iodide crystal.

Mr. Wyckoff's experiments are similar to the original experiments of Laue, Freidrich and Knipping, performed eleven years ago. These have been repeated over and over again by many scientists. It is not likely that such experiments would bring out the abnormal x-peak reflections in any reasonable length of time, for, if they did, the abnormal reflections probably would have been discovered long ago. The first experiments that we, ourselves, performed with photographic plates were more or less of the same kind, and in these we did not get evidence for the x-peak reflection. It was only by modifying the experiments that we succeeded in getting this photographic evidence after many hours of exposure.

As the x-rays deflected by the crystal can be detected and measured easily in a few seconds of time by their ionizing effects, this indicates the very great analyzing power of the ionization method as compared with the photographic for certain purposes.

The important differences between our experiments and the ordinary Laue photographic experiments appear to be as follows:

(*a*) Mr. Wyckoff applied to the x-ray tube an alternating voltage with a peak value of approximately 50,000 volts. It required at least 33,000 volts to produce the characteristic radiation of iodine. In our experiments we employed a voltage of 75,000 volts, more than twice as far above the critical voltage of iodine as that used by Wyckoff. Further, our voltage was constant, and did not fluctuate with the time. The fact that the voltage remained at 75,000 all the time means that our primary x-ray beam was far richer in short x-rays, the kind of rays that produce the iodine line spectrum most effectively, than was the alternating voltage employed by Wyckoff. The difference in power of producing the characteristic radiation of iodine between a constant voltage of 75,000 volts and an alternating voltage of 50,000 volts is very great.

(*b*) In the experiment which gave us our best photographs we used a single pin hole in a lead sheet to define the beam of x-rays incident on the crystal. Thus, the cross-section of this beam was determined by the area of the pin hole and that of the focal spot on the target of the x-ray tube. Further, the target of the x-ray tube was so placed that the rays passing through the pin hole almost grazed the target's surface on leaving it. This arrangement greatly increases the intensity of the x-radiation passing through a small opening. We have also made experiments with two pin holes to define the incident beam, the arrangement ordinarily used in taking Laue photographs and the arrangement which Mr. Wyckoff employed. We found that the intensities of all the spots on the photographic plate were somewhat reduced by inserting this second sheet of lead with a pin hole in it, but the intensities of the spots representing the x-peak radiation were reduced in a very much greater ratio than the others, so that employing two pin holes to define the beam decreases the photographic effect of the x-peak radiation as compared with that of the ordinary reflection. This phenomenon is quite marked. It undoubtedly is due to the fact which we have mentioned several times, namely, that the characteristic reflection of x-rays is not as accurate a phenomenon as the ordinary reflection of x-rays. In the case of the ordinary reflection only those rays of given wave-length that are practically parallel to a given line are reflected by a given set of planes. In the case of the reflection of the characteristic rays, the direction of the incident beam does not have to be so accurately parallel to the given line.

(*c*) We used a somewhat thicker crystal of potassium iodide than that employed by Wyckoff. As the characteristic wave-lengths of iodine lie in the portion of the spectrum for which iodine is most transparent, this means that our crystal let through a larger proportion of characteristic rays as compared with other rays than was the case in Mr. Wyckoff's experiments.

As stated in our papers, we have observed other anomalous deflections of x-rays by a crystal much weaker than the x-peak reflections. Dickinson[2] has recently detected similar anomalous deflections by the photographic method. He explains his results by assuming that they are due to reflections by "small crystals individually perfect but with their axes slightly inclined to those of the main crystal." This hypothesis does not explain the strong x-peak reflec-

[2] *Physical Review*, Aug., 1923, p. 199.

tions, for one can not deduce from it the observed characteristics of the x-peak phenomena—such, for instance, as the way in which the angle of reflection depends upon the angle of incidence of the primary beam, the appearance of only one x-peak in each quadrant and the fact that the critical voltage is always about equal to that of the K series of iodine. The influence of the critical absorption of the chemical elements in the crystal has been indicated on many of our published diagrams.

It is evident from the above-mentioned experiments that all the possible reflections of x-rays by a crystal such as potassium iodide have not yet been thoroughly examined. The possibility of abnormal reflections has a direct bearing upon the analysis of crystals by means of x-rays, especially upon those methods of analysis which require the taking of Laue photographs. For a completely satisfactory analysis of crystals by such a method it would be necessary to determine what the wave-length of the various deflected beams are. Probably no mistakes would be made in analyzing crystals of simple forms, such as cubic crystals, but in the more complicated cases the fact that abnormal reflections occur must always be borne in mind and in case of doubt the wave-lengths of the deflected beams should be determined. It would be difficult to measure the critical voltages for these deflected rays by the photographic method, but they could be easily determined by an ionization spectrometer.

HARVARD UNIVERSITY

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

MEETING OF THE EXECUTIVE COMMITTEE

THE meeting was called to order in the board room of the Cosmos Club, Washington, at three o'clock on the afternoon of October 14 with the following members present: Cattell, Fairchild, Howard, Humphreys, Livingston, Osborn, Walcott, Ward. The following were absent: Flexner, MacDougal, Noyes. President Walcott was elected chairman. The minutes of the last meeting were approved as previously circulated. The following interim minute of action by mail was approved: September 17, 1923. On nomination of the section committee of Section M, Mr. John T. Faig was elected to be vice-president for Section M and chairman of the section for the current year.

The permanent secretary's report on the affairs of the association was presented in mimeographed form, and was accepted. The permanent secretary's annual financial report (of September 30, 1923) was presented and accepted, and it was ordered to be audited and presented to the council at the next annual meeting.

The treasurer's report was presented by Mr. John L. Wirt, who was present by invitation. It was accepted and ordered to be audited and brought before the council at the next annual meeting.

An appropriation of $4,500 was voted for grants, including the recent Newcomb Cleveland gift of $500.

The permanent secretary reported that the project of starting a quarterly publication, to include the preliminary announcement of the annual meeting, has been postponed for the present on account of uncertainty as to funds.

The permanent secretary reported that the special committee on the philological sciences is active and that a program on this subject will be presented at the approaching Cincinnati meeting.

The appointment of Dr. Charles A. Shull, of the University of Chicago, to be assistant secretary of the association in the place of Dr. Sam F. Trelease, resigned, was approved. This appointment is for the period from September 1, 1923, to the end of the Cincinnati meeting.

The sponsorship, by the association, of the project on the standardization of engineering and scientific abbreviations and symbols was approved. The association becomes sponsor, along with the U. S. Bureau of Standards and the Society for the Promotion of Engineering Education, for the preparation of a system of standardized symbols, etc., without any financial obligations on the part of the association. The association reserves the right to pass upon the recommendations of the joint committee, when finally made, and, for its own part, to approve or disapprove, in whole or in part. The special committee which represents the association in this work consists of Dr. Henry N. Russell, of Princeton University, chairman; Dr. Augustus Trowbridge, of Princeton University, and Dr. E. W. Washburn, of the National Research Council.

The question of further publicity for the resolution on Pueblo Indian lands (adopted April 22, 1923) was left to the general and permanent secretaries, with power. The resolution has been widely published and a supply of printed copies is available at the permanent secretary's office.

One hundred and twenty-six fellows were elected, distributed among the sections as follows: Section D, 1; Section M, 12; Section O, 112; Section Q, 1.

It was voted that the permanent secretary call a meeting of the executive committee on the evening of Wednesday, December 26, at Cincinnati, if, in his judgment, there are matters for consideration that may not be cared for satisfactorily at the forenoon meeting on the following day.

After the reading of communications from the