hand we have been able to show that the specific precipitable material of the tuberculin, like that of the yeast, is resistant to the action of proteolytic enzymes, and Heidleberger and Avery have demonstrated the same fact for their pneumococcus preparations.

Work on both these fractions is being continued in our laboratory to the end of clearing up their chemical nature and arriving at an understanding of the part each plays in the disease processes.

ON SCATTERED RADIATION DUE TO X-RAYS FROM MOLYBDENUM AND TUNGSTEN TARGETS

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In notes recently published in these PROCEEDINGS experiments performed in our laboratory have been described in which the spectra of secondary x-radiation have been examined by an ionization x-ray spectrometer. The curves representing the ionization currents as functions of the glancing angles of incidence of the rays on the calcite reflecting crystal contained sharply marked peaks representing scattered radiation from the secondary radiator having wave-lengths equal to those of the primary rays to within the limits of error of the measurements, but no *peaks* appeared indicating radiation comparable in intensity with the above scattered radiation and having wave-lengths corresponding with Professor A. H. Compton's interesting and important theory of single electron scattering.

Recently we have repeated some of these experiments with two important modifications in the apparatus and have found evidence of radiation agreeing very well with the equation

$$\Delta\lambda = 0.024 \ (1 - \cos\theta), \tag{1}$$

which Professor Compton deduced from his theory.

Figure 1 on page 381 of the September number of the *Proceedings of the National Academy of Sciences* represents the general arrangement of the apparatus. No large masses lay near the secondary radiator and x-ray tube except the unavoidable lead plate fastened against the brick wall. The most important changes in the spectrometer are as follows: (*a*) Instead of employing a water-cooled molybdenum target tube with a large bulb blown in it, we used in some experiments a water-cooled molybdenum target sealed into a glass tube of approximately uniform diameter throughout. This tube was about 3 cm. in diameter and its walls were made somewhat thinner opposite the target than elsewhere in order to reduce the absorption of the rays by the glass. Professsor A. H. Compton described a similar x-ray tube in his papers and it seems admirably adapted to the investigation of the spectra of secondary radiation, not only on account of its thin walls but also because the secondary radiator can be placed much closer to the target than with a commerical x-ray tube. (*b*) We constructed a Soller[2] multiple slit system by placing a number of straight, very thin steel springs parallel to each other so as to form fourteen different slits side by side. The breadth of each slit amounted to about 0.7 mm. and the length to 50 cm. In order to reflect the rays coming through all of the slits at the small glancing angles of incidence $(6° - 7°)$ we had to use a calcite crystal more than 9 cm. long. The x-ray tube of small diameter and the multiple slit system very greatly increased the intensity of the secondary radiation. This has two distinct advantages. Firstly: the spectrometer possesses a much better resolving power and secondly, we could use much smaller secondary radiators. The latter proved to be of considerable importance in investigating the Compton effect for if the secondary radiator has a large volume the rays from the target strike different parts of it at different angles and according to the preceding equation (1) the shifted radiation coming from different points of the radiator and passing through the slit system will have different wave-lengths. All the points of the secondary radiator contribute to the unshifted rays producing intense radiation that lies in a relatively narrow portion of the spectrum. The shifted radiation, however, having a great variety of wave-lengths is drawn out into a broad band. The relative intensity at any point in this band is much smaller than it would be if the secondary radiator had a very small volume and all the secondary rays examined made very nearly the same angle with the primary rays.

With this apparatus, we have examined the secondary radiation coming from a large number of secondary radiators composed of different chemical elements (lithium and elements of higher atomic weight). We placed these radiators in different positions near the tube, sometimes so that only a very narrow beam of primary rays struck them and sometimes so that the primary rays made a great variety of angles with the secondary radiation. In every case narrow peaks appeared on the curves representing scattered radiation with unshifted wave-lengths. The intensity and distribution of the radiation having somewhat longer wave-lengths than the primary depended upon the size and exact position of the secondary radiator. If this radiator was placed so that only a narrow beam of primary rays produced the secondary rays, a well-marked peak somewhat broader than the unshifted peak appeared and this peak changed its position in the spectrum in substantial agreement with the preceding equation (1). If the secondary radiator was so placed as to utilize a large number of primary rays coming at different angles to the secondary the curves showed a sharp peak corresponding to the unshifted radiation with a broad shelf alongside of it, similar to some of the curves already published representing previous experiments. The fact that the radiation of shifted wave-lengths depends so much upon exact experimental conditions should not be taken to mean that the Compton Effect itself is very variable. It furnishes rather excellent confirmation of equation (1), for, in those cases in which we did not observe a shifted peak but a broad shelf, this equation indicates that the radiation should be drawn out into a broad band, no part of which is very intense as compared with the unshifted radiation.

In general the peaks representing radiation of shifted wave-length appear to be somewhat broader than would be expected from the relative positions, etc., of the secondary radiator and the x-ray rube. Further, some evidence was obtained for weak radiation between the shifted and unshifted peaks. The general or continuous spectrum radiation, also, appears to be somewhat more intense, relative to the line spectra than is the case with the primary radiation. These points have been mentioned by Professor Compton in some of his papers. The relative intensity of the shifted to the unshifted radiation appears to be greater for tungsten than for molybdenum.

With this apparatus we have not observed sharp peaks on the curves that correspond to tertiary radiation, although in certain cases some radiation exists at wave-lengths longer than that represented by equation (1).

The results that we have obtained so far indicate that equation (1) deduced by Professor Compton from his theory of single electron scattering represents the wave-lengths of a large part of the secondary radiation due to primary rays in the K series spectra of molybdenum and tungsten. The molybdenum spectra are in close agreement with the results obtained by Professor Compton and Mr. Woo[3] using an ionization spectrometer with a Soller slit system and small x-ray tube. They also agree substantially with the excellent photographs obtained by Professor Ross[4] with a spectrometer giving very high dispersion and with the photograph and accurate photometer curves published by Dr. Becker.[5] In addition, they show changes in the position of the shifted line (indicated by equation (1) for different values of θ) in the secondary radiation from chemical elements other than carbon, and also a marked diminution in intensity, when the shifted line is drawn out into a band.

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[2] W. Soller, *Phys. Rev.*, **23**, 272 (1924).

[3] A. H. Compton and Y. K. Woo, these PROCEEDINGS, June, 1924, p. 271.

[4] P. A. Ross, these PROCEEDINGS, July, 1923, p. 246; and July, 1924, p. 304.

[5] J. A. Becker, these PROCEEDINGS, August, 1924, p. 342.