EFFECT OF X-RAYS ON THE RESISTANCE OF TIN FOIL

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Some unexpected results have been obtained recently in an experiment on the action of X-rays on a beam of electrons. In connection with this the question arose whether X-rays would affect the resistance of a metallic conductor.

The first work in this field was reported by J. W. Giltay[1] in 1896. Because of the similarity between X-rays and light he anticipated that the resistance of selenium would be altered by exposure to X-rays. Experiments confirmed the prediction. Later work has been carried to such point that this property may be applied to measurement of the intensity and of the constancy of X-rays. Giltay mentioned an incidental test on a tin bolometer which gave no indication of a change in resistance caused by the X-rays.

Selenium exhibits a change in resistance also when exposed to the action of radium and radium compounds. At first it might be supposed that the change manifested is caused by the gamma rays. However, experiments carried out by F. C. Brown and Joel Stebbins[2] indicate that the change observed is the result of bombardment of alpha and, particularly, beta particles, the gamma rays having little or no effect. The action of radium bromide on a bismuth spiral was studied by R. Paillot,[3] who reported his work in 1904. He found a change in resistance of about one part in three thousand. The description of his experimental arrangement indicates that alpha particles could not have participated in the action, but no effort was made to isolate the effects of the beta particles or the gamma rays and the work was not followed up.

In view of the lack of quantitative data on any material except selenium and the theoretical importance which a positive result would have, it was thought advisable to

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1. J. W. Giltay, Nature, V. 54, p. 109, (1896).
2. Brown and Stebbins, Phys. Rev., V. 25, p. 505 (1907); V. 26, p. 273 (1908).
3. R. Paillot, Comptes Rendus, Vol. 138, p. 139 (1904).

determine with considerable care whether an X-ray beam has any effect on the resistance of an ordinary metallic conductor. As tin foil was most convenient it was chosen for a preliminary experiment.

The foil was cut into the form of a grid so as to have a total resistance of about 13.1 ohms, not including heavy leads soldered to it. This grid was mounted with shellac on a glass plate and enclosed in a light pasteboard box for the sake of protection from air currents and rapid temperature changes. The grid was placed in a position about twenty centimeters from the target of a Coolidge tube. The current for the tube was furnished by a large Klingelfuss induction coil with a Wehnelt interrupter. The equivalent spark gap was approximately six inches.

The resistance measurements were made with a Wheat-stone bridge circuit arranged so as to be especially convenient for the detection and measurement of small changes in resistance, essentially a bolometer. The slide wire was shunted and also resistances were inserted at each end so that its equivalent length was about fifteen hundred meters. The galvanometer was a special Leeds and Northup instrument of high sensitivity and low resistance. The bridge arms were so proportioned that the galvanometer was critically damped. The use of a good telescope and a scale three meters from the mirror aided in securing high sensitivity.

The sensitiveness of the arrangement could be determined in two ways, by the deflection resulting from a given shift in the balance point and by the deflection produced when a known change of resistance occurred in the X-branch. As it was more convenient and more accurate, the latter method was employed. In series with the tin foil grid was placed a one ohm resistance which could be shunted by a resistance of ten thousand ohms. The resulting change in the resistance of the X-branch was very nearly one ten thousandth of an ohm. It produced a change of twelve millimeters in the galvanometer deflection. For resistance changes up to at least three thousandths of an ohm there was a linear relation between the resistance increment and the corresponding galvanometer deflection. During all measurements the galvanometer and the battery circuits were closed continuously so that trouble with thermoelectric effects was eliminated.

Under ordinary circumstances the galvanometer deflection exhibited a steady shift resulting from a gradual change in the X-resistance caused by its change in temperature. By reading the deflection at intervals of, for instance, fifteen seconds with the X-ray beam alternately on and off, the effect of the X-rays themselves could be isolated. The results may well be shown graphically, plotting times as abscissa and deflections as ordinate. When temperature changes are occurring, the points will lie on a smooth curve having a positive slope. If a resistance change is produced by the radiation, alternate points will be displaced vertically from the curve by a constant amount. The amount of this displacement gives a measure of the resistance change.

Some difficulty was experienced at first with leakage from the high tension circuit of the Coolidge tube. The amount of interference seemed to be dependent on the frequency of interruption of this current. Proper precautions, however, made this trouble negligible. Several series of observations were made in the manner described. The frequency of the X-rays was varied through a considerable range. Sensitivity tests before and after the measurements showed that a resistance change of one ten-thousandth ohm in the X-branch would cause a deflection of twelve millimeters. No change in resistance caused by the X-ray beam was detected.

Fluctuations in the rate of change of temperature made it impossible to take full advantage of the accuracy of which the bridge used is capable. However it may be said that any resistance change which does occur when tin is subjected to such an X-ray beam is less than one part in four hundred thousand, or less than 0.00025%.

Experiments with more adequate temperature control to permit much greater accuracy and with other elements than tin are anticipated.

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