A THERMOPILE OF BISMUTH ALLOY.[1]

BY W. W. COBLENTZ.

THE most recent investigation of Haken[2] and of Gelhoff and Neumeier[3] show that an alloy of Bi + 9 to 10 per cent. Sb gives a maximum E.M.F. which is of the order of 77 to 87 microvolts. The writer has found however that alloys containing more than 5 per cent. of antimony are too brittle for thermopiles. Moreover, different samples of this alloy supposed to contain the same amount of antimony did not give the same E.M.F., which varied from 61 to 85 microvolts. Apparently the physical structure has an influence upon the E.M.F. This alloy was therefore discarded, and pure bismuth was employed as in previous thermopiles. The best bismuth wire against silver gives an E.M.F. of 81 microvolts.

Tests showed that an alloy of bismuth containing 5 to 6 per cent. of tin gave a uniform (for different melts) value of 44 to 45 microvolts. A thermoelement consisting of the best bismuth and an alloy of Bi + 5 to 6 per cent. tin gives an E.M.F. of 125 to 127 microvolts per degree.

The bismuth (and in the near future, bismuth-tin alloy) may be obtained from Hartmann and Braun in fine pliable wire from 0.06 to .10 mm. diameter. This may be further reduced in size by cutting the wire in short lengths and pressing it flat between plates of glass. These flat pieces are then cut into narrow strips of the desired width.

The wire of bismuth-tin alloy is not yet on the market. It is made by spattering the molten metal, by allowing it to drop from a height upon a smooth perfectly clean glass plate.[4] Pfund[5] goes a step further, and by hurling the molten metal over a glass plate produces much longer filaments. The spattered material is quite pliable. The wide strips increase the emissivity, so that for the same resistance of the round as compared with the flat material, the best width to balance emissivity and conductivity must be found by experiment.

A thermopile was constructed as shown in Fig. 1. The receivers are of platinum 0.005 mm. in thickness and 1.8 by 3.0 mm. in area. The bismuth wire is 0.1 mm. diameter; the alloy was selected and estimated of a slightly greater area of cross-section. The thermopile is constructed by melting a globule of pure tin (0.05 mm. diameter) to the receiver by means of soldering solution. The receivers are then glued upon a piece of cardboard; properly spaced as shown in Fig. 1. The bismuth wire (joined to the silver wire by means of tin as described in previous publications) is joined to the tin on the receivers. The wires of bismuth-tin alloy are then placed on the receivers (see Fig. 1) and secured with Wood's alloy, care being taken that the fusible alloy does not affect the bismuth wire, thus producing a brittle juncture. The cardboard

[1] Abstract of a paper presented at the Chicago meeting of the Physical Society,

[2] Haken Vesh, Phys. Gesell., 12, p. 229, 1910.

[3] Gelhoff and Neumeier, Phys. Gesell., 15, p. 876, 1913.

[4] Coblentz, Bull. Bur. Standards, 7, p. 248, 1910.

[5] Pfund, PHYS. REV., 34, p. 228, 1912.

is then placed over the holder, the end-wires are attached to the binding posts by means of Wood's alloy and the card is removed by soaking in water. The front side of the receivers is painted with a mixture of lamp black and chemically precipitated platinum black, as previously described.[1]

The wires are joined in series-parallel thus reducing the resistance by one fourth from what would be obtained by joining all the elements in series. The silver or copper end-wire is used for three purposes: (1) to maintain a low resistance, (2) to maintain symmetry by having all the E.M.F. junctions close together, freely in contact with the air, (3) greater strength. The bismuth

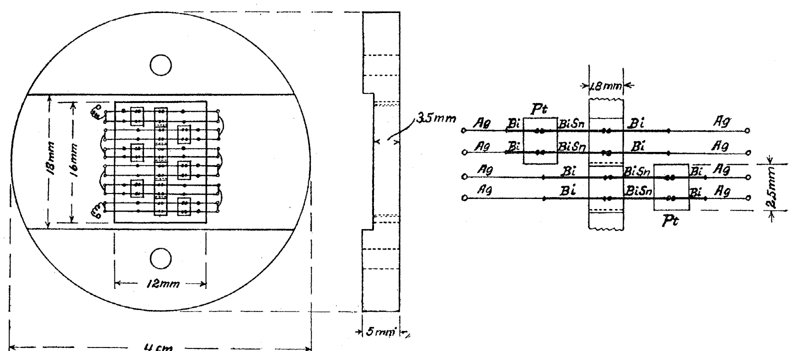

Fig. 1.

wire cannot be easily attached to binding posts, and although pliable it is not advisable to subject it to torsional strains. The additional length of wire (of negligible resistance) at the ends of the bismuth adds pliability which is needed in a commercial instrument, subjected to rough usage. No shellac is used except for covering the silver wire and for insulation at the overlapping edges of the central line of receivers. This produces a very quick acting instrument.

The radiation sensitivity of this thermopile was not quite as high as was hoped to attain. However, as a first attempt at this design, the knowledge gained indicates where improvements may be made. The resistance was 3.8 ohms. The thermal sensitivity was about 55 per cent. greater than the bismuth silver thermopile. The radiation sensitivity was 30 to 31 per cent. greater than the average sensitivity of a number of bismuth-silver thermopiles. For some researches it will therefore be of advantage to construct a thermopile of bismuth and of bismuth-tin alloy.

The efficiency of these thermopiles is such that one microwatt of radiant energy produces a rise in temperature of 15 to 16 $\times$ 10^{-5} degree in the receiver. The E.M.F. developed depends upon the number of junctions attached to the receiver and their manner of connection; whether all in series or in series-parallel as in this design. The voltage test was made with a Leeds and Northrup "type K" potentiometer, having a 100th shunt so that one division on the slide wire represents one microvolt, the standard lamp being at a distance of two meters. From this it may be seen that this type of thermopile may be

[1] Coblentz, Bull. Bur. Standards, 9, p. 7, 1912.

used in photometric and other investigations with rather insensitive auxiliary apparatus.

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An Attempt at an Electromagnetic Emission Theory of Light.[1]

By Jacob Kunz.

THE phenomena of light in discussion are explained by means of the following fundamental assumptions:

1. Light arises from oscillating electric charges. Each charge is connected with its own electromagnetic field, which has a material physical existence. These atomic fields carry mass, momentum and energy with them.
2. Maxwell's equations hold for these fields.
3. The velocity of light is always $-$ C.
4. Only relative motions can be defined and detected.

A Modified Method of Measuring e/m and v for Cathode Rays.[1]

By L. T. Jones.

THE method used is the result of an attempt to eliminate as nearly as possible the errors that accompany the experimental determination of e/m by the usual method of electrostatic and magnetic deflections. The tube through which the rays are passed is made by drawing a scratch on a slip of iron and pressing it against the upper of the two electrostatic plates. The undeflected beam thus passes at grazing incidence to this plate. The upper electrostatic plate has a piece of soft iron, of the same dimensions as that on which the scratch is drawn, inlaid in it so that the cathode beam while passing through the tube is wholly surrounded by iron.

This method differs from those ordinarily employed in the position of the photographic plate. This is placed flat on the lower electrostatic plate. Sufficient potential is applied to deflect the beam downward to strike it. The electrostatic deflection is thus constant and may be determined accurately. With the distance between the electrostatic plates small in comparison with their linear dimensions the deflected beam may be made to fall wholly within a uniform electrostatic field.

The magnetic field is furnished by a solenoid with its axis perpendicular to the surfaces of the electrostatic plates. The solenoid encloses the whole apparatus and is of such length that the field is uniform and its strength may be calculated.

The cathode beam when deflected by the electrostatic field alone produces a straight line parallel to the undeflected beam. When the magnetic field is applied this line is displaced to the right or left according to the direction of the magnetic field and takes the form of the arc of a circle.

The measurements taken from the photographic plate are the horizontal distance of travel of the electron and its corresponding magnetic displacement.

[1] Abstract of a paper presented at the Chicago meeting of the Physical Society,