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BISMUTH BLACK AND ITS APPLICATIONS

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BISMUTH BLACK AND ITS APPLICATIONS.

By A. H. Pfund

It is demanded of radiometric devices such as thermopiles, radiometers and the like that they reach a maximum deflection in a few seconds. This cannot be accomplished if the heat capacity of the receiving element be large. So as to reduce this quantity to a minimum it is essential that the mass of the black material, employed to absorb the incident radiation, be kept as small as possible. Absorbing films of platinum and nickel "black" are perhaps the most satisfactory in so far as performance goes—yet, deposition by electrolysis on delicate surfaces is difficult. Without discussing the various methods now in use, it is proposed to describe a new procedure which not only yields extremely thin and intensely black films—but which subjects the delicate curface to be coated to no risk of being harmed during the process of deposition.

If a bit of bismuth be evaporated from a hot tungsten spiral at a very low pressure, the metal is deposited as a bright, metallic layer. If, on the other hand, the pressure be raised to about 0.25 mm the bismuth comes down as an intensely black film, termed "bismuth-black". The actual form of the heating element is shown in Fig. 1. Here, *A* is a bell jar through whose neck a tapered and ground tube *B* is inserted.

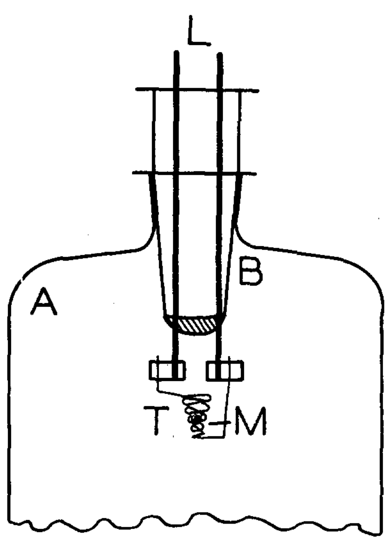

Fig. 1.

Attached to the lower end of the leads *L* are a pair of small brass blocks which serve as connectors for the conical tungsten spiral T. The latter is made of No. 30 wire and serves to hold the bit of metal M. The surfaces to be coated are mounted below the spiral at a distance of from 3–4 cm. After the required pressure of about 0.25 mm has been reached the tungsten spiral is raised to yellow heat and the deposition occurs speedily.

The value set down for the correct pressure was arrived at by noting that, if the pressure be too low, the film of bismuth is partially reflecting. If, however, the pressure be too high, the film is greyish.

A film of bismuth-black which was quite opaque to visible light, was tested for its absorption in the infrared by means of a rock-salt spectrometer. The film was deposited on a polished plate of rock-salt so that both transmission and reflection could be investigated. It was found that, at normal incidence, neither transmission or reflection was as large as 1% in the spectral range from 0.5μ to 13μ. This is a very close approach to a "black-body." Photometric measurements of the surface brightness were carried out by projecting upon the black surface the filament-image of an auto headlight lamp and by determining the brightness of this image for red light by means of an optical pyrometer. Taking a fumed surface of MgO as a standard (brightness 98%) the results found were: Camphor soot, 2%; bismuth-black, 0.3%. The relative surface brightness for camphor soot, bismuth-black and black velvet in daylight are shown in the accompanying photograph (Fig.2).

Due to the extreme fineness of the particles of bismuth black it is

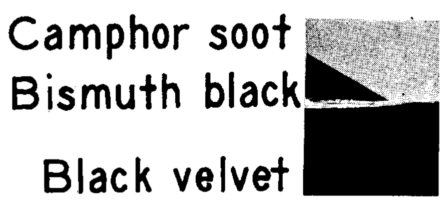

FIG. 2.

found that, if a film be deposited on plate glass, specular reflection is observed at grazing incidence. Since it is desired to prepare a receiving surface that is rough at all angles of incidence, the following experiment was performed: the piece of glass was held over burning camphor sufficiently long to allow a faintly greyish film of soot to be deposited. Next, this film was wiped off over a central strip; finally bismuth black was distilled over the entire surface. It was found that the partially transparent bismuth was most opaque over the central strip. Examined by reflection it was observed that the central strip showed specular reflection at grazing incidence, whereas the rest of the area was very rough at all angles of incidence. This state of affairs can be accounted for on the assumption that the particles of camphor soot act as centers of consensation for the bismuth which is piled up in the form of minute pyramids. This procedure of depositing first, a thin film of soot is to be recommended for the production of a rough, black surface of bismuth-black.

The general mode of procedure preciously outlined lends itself to the production of a surface bolometer. A thin sheet of brass 2.5×2.5 cm is provided with a central clear space 1×1 cm. This frame is cut in two and then is put together again: the two parts being insulated from one another. A film of nitrocellulose so thin as to show first order Newton colors is spread over the square, central opening. This system is then placed under a bell-jar and a thin, highly reflecting and electrically conducting film of bismuth is distilled on the nitrocellulose at a pressure of about 10^{-5} mm of Hg. Terminals attached to the frame may be taken out to a Wheatstone bridge so that the bismuth deposition may be terminated at any desired resistance of the film. Next, the pressure is raised to 0.25 mm and the absorbing film of bismuth-black is deposited on the conducting film of bismuth. No change in resistance of such a surface bolometer having a resistance of 250 ohms was noted when the black film was thrown down.

The formation of these two types of films may, possibly, be explained on the assumption that, in a high vacuum, the evaporated bismuth particles remain clean during the time of their passage from the molten bead to the receiving surface. As a result, these particles align themselves upon those already present so as to form a regular crystal lattice —which is a good conductor of electricity. However, upon admitting air to a pressure of 0.25 mm the bismuth particles become contaminated to such a degree that a regular alignment no longer takes place. The result is a loosely packed, non-conducting film of bismuth-black.

While this entire discussion deals with bismuth, it is by no means to be inferred that bismuth alone yields black films. As a matter of fact the first black films were made from an alloy of gold and silver. The reason for choosing bismuth is that, since it distils rapidly at a comparitively low temperature, the danger of harming the surface to be coated is reduced to a minimum.

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