

XXXVIII. The expansion of mercury between 0° C. and -39° C

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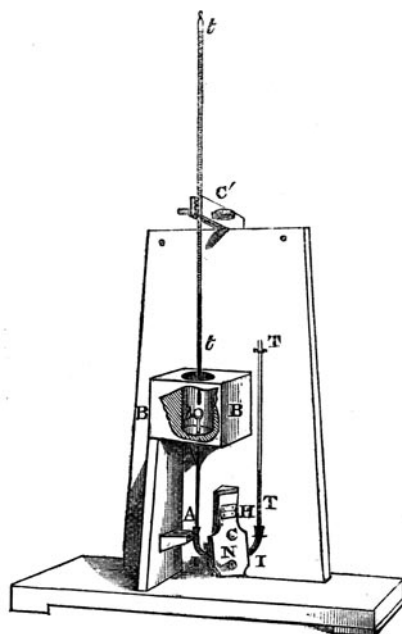
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XXXVIII. *The Expansion of Mercury between 0° C. and -39° C.* By Professors W. E. AYRTON, *F.R.S.*, and JOHN PERRY, *F.R.S.**

AT a meeting of the Physical Society in November 1885, Mr. G. Whipple gave the Society the results of the examination of thermometers down to the melting-point of mercury. There was, however, no evidence as to whether the contraction of the mercury was uniform, as the thermometers were only compared with mercurial ones, and as, in addition, we were not able to find the results of any experiments made on the expansion of mercury between 0° and -39° C., its temperature of solidification, we thought it desirable to make a series of comparisons of a mercury-thermometer, the stem of which had been accurately subdivided into equal volumes, with an air-thermometer, both immersed in a bath of frozen mercury which was allowed to gradually become warm. For this purpose we borrowed a mercury-thermometer from Mr. Whipple, which he was so kind as to lend us, and one of our assistants (Mr. Mather) constructed a very simple form of constant-volume air-thermometer, shown in the diagram.



B B is a wooden box, at the bottom of which is a hole closed

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by an india-rubber stopper through which passes tightly the glass stem of an air-thermometer, A A. The bottom of the air-thermometer is attached by a piece of india-rubber tubing, I I, to a vertical glass tube, T T; and the thermometer being filled with dry air, some mercury is introduced into the tube so as to stand at about the same height in the two limbs when the air in the bulb *b* is at atmospheric pressure. The height of the level of the mercury can be varied by turning the nut, N, which causes the clamp, C, turning on the hinge H, to squeeze the india-rubber tube more or less tightly, and so to alter its internal capacity; and in this way the level of the mercury in the left-hand tube can be kept quite fixed, and therefore the volume of air in the bulb *b* quite constant, while its temperature is altered, the corresponding pressure being of course measured by the difference between the levels of the mercury columns in the two limbs.

To perform the experiment, the box B B was first filled with mercury and frozen by stirring carbonic-acid snow and ether up with it; and when sufficient of the mercury was frozen, the bulb of the mercurial thermometer, *tt*, was introduced into the pasty mercury, and the thermometer fixed in position by means of the clamp, C'. The nut N was now turned by one observer until the level of the mercury in the left-hand limb came opposite a *fixed* mark on the tube which is only just below the bottom of the box, when the height of the mercury in the right-hand tube was read by a cathetometer made by the Cambridge Instrument Company, and the position of the mercury in the mercury-thermometer was read by a third observer. In this way several series of simultaneous observations were taken, during the course of some weeks, of the pressure to which the air in the air-thermometer had to be subjected to keep its volume constant, as the mercury in the box B B varied in temperature from about -39° C. to 0° C. Plotting these results, it was found that they lay in so nearly a straight line that we may conclude that mercury expands regularly below 0° C. as it is known to do above 0° C.; and that there is no critical point for mercury, as there is for water, above the freezing-point.

When the mercury freezes it contracts still further, as may be seen from the following extract from page 6 of the second volume of Nordenskiöld's '*Voyage of the Vega*,' which Mr. Whipple has kindly looked up for us:—

"When mercury freezes in a common thermometer, it contracts so much that the column of mercury suddenly sinks in the tube, or, if it is short, goes wholly into the ball. The position of the column is therefore no measure of the actual degree of cold when the freezing takes place."

We have to express our thanks to Messrs. Chatterton, Humphrey, and Martin, three of the students of the Central Institution, for assistance rendered in the carrying out of this experiment.

XXXIX. *On the Expansion produced by Amalgamation.* By Professors W.E. AYRTON, F.R.S., and JOHN PERRY, F.R.S.*

ON amalgamating the edge of a brass bar, nearly three quarters of an inch thick and about a foot long, for the purpose of enabling the edge to make good electric contact with a plate, we were surprised to find that the bar rapidly curved, the amalgamated edge becoming convex, exactly as happens when one side of a piece of paper is wetted. On hammering the bar to straighten it, the curvature became instead greater. Seeing that to bend a short brass bar more than half an inch in thickness to the extent produced by the amalgamation of the edge requires the exertion of very considerable stresses, it follows that very great forces must be produced by amalgamation.

We think it possible that this bending by amalgamation may be an important cause in the production of the Japanese "magic mirrors," the reflecting surface of which is polished with a mercury amalgam. Japanese mirrors are made of bronze and have a raised pattern cast on their backs; and although the eye can detect no trace of the pattern on looking at the polished reflecting surface, yet when certain of these mirrors are used to reflect a divergent beam on to a screen, the pattern at the back can be seen as a bright image on a dark ground. In a paper communicated, some years ago, to the Royal Society, we showed that this peculiar effect arose from the fact that, while the reflecting surface was generally convex, the portions corresponding with the pattern or thicker parts were less convex (that is, more concave) than the rest; and this conclusion we verified by finding that when a convergent, instead of a divergent, beam of light was allowed to fall on the mirror the image on the screen was reversed; that is, the pattern was seen as a dark image on a bright ground.

This inequality of curvature we considered at that time was due partly to the pressure of the "distorting-rod" used to make the surface convex, and partly to the pressure exercised on the subsequent polishing; but we now think that, in addition, the action of the mercury-amalgam employed by the polisher may assist in making the thin portions of the mirror more concave than the thicker.

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