III. "On the alleged Expansion in Volume of various Substances in passing by Refrigeration from the state of Liquid Fusion to that of Solidification." By Robert Mallet, C.E., F.R.S. Received April 28, 1874.

(Abstract.)

Since the time of Réaumur it has been stated, with very various degrees of evidence, that certain metals expand in volume at or near their points of consolidation from fusion. Bismuth, cast iron, antimony, silver, copper, and gold are amongst the number, and to these have recently been added certain iron furnace-slags. Considerable physical interest attaches to this subject from the analogy of the alleged facts to the well-known one that water expands between 39° F. and 32°, at which it becomes ice; and a more extended interest has been given to it quite recently by Messrs. Nasmyth and Carpenter having made the supposed facts, more especially those relative to cast iron and to slags, the foundation of their peculiar theory of lunar volcanic action as developed in their work, 'The Moon as a Planet, as a World, and a Satellite' (4to, London, 1874). There is considerable ground for believing that bismuth does expand in volume at or near consolidation; but with respect to all the other substances supposed to do likewise, it is the object of this paper to show that the evidence is insufficient, and that with respect to cast iron and to the basic silicates constituting iron slags, the allegation of their expansion in volume, and therefore that their density when molten is greater than when solid, is wholly erroneous. The determination of the specific gravity, in the liquid state, of a body having so high a fusing temperature as cast iron is attended with many difficulties. By an indirect method, however, and operating upon a sufficiently large scale, the author has been enabled to make the determination with considerable accuracy. A conical vessel of wrought iron of about 2 feet in depth and 1·5 foot diameter of base, and with an open neck of 6 inches in diameter, being formed, was accurately weighed empty, and also when filled with water level to the brim; the weight of its contents in water, reduced to the specific gravity of distilled water at 60° F., was thus obtained. The vessel being dried was now filled to the brim with molten grey cast iron, additions of molten metal being made to maintain the vessel full until it had attained its maximum temperature (yellow heat in daylight) and maximum capacity. The vessel and its content of cast iron when cold were weighed again, and thus the weight of the cast iron obtained. The capacity of the vessel when at a maximum was calculated by applying to its dimensions at 60° the expansion calculated from the coefficient of linear dilatation, as given by Laplace, Riemann, and others, and from its range of increased temperature; and the weight of distilled water held by the vessel thus ex-

panded was calculated from the weight of its contents when the vessel and water were at 60° F.

We have now, after applying some small corrections, the elements necessary for determining the specific gravity of the cast iron which filled the vessel when in the molten state, having the absolute weights of equal volumes of distilled water at 60° and of molten iron. The mean specific gravity of the cast iron which filled the vessel was then determined by the usual methods. The final result is that, whereas the specific gravity of the cast iron at 60° F. was 7·170, it was only 6·650 when in the molten condition; cast iron, therefore, is less dense in the molten than in the solid state. Nor does it expand in volume at the instant of consolidation, as was conclusively proved by another experiment. Two similar 10-inch spherical shells, 1·5 inch in thickness, were heated to nearly the same high temperature in an oven, one being permitted to cool empty as a measure of any permanent dilatation which both might sustain by mere heating and cooling again, a fact well known to occur. The other shell, when at a bright red heat, was filled with molten cast iron and permitted to cool, its dimensions being taken by accurate instruments at intervals of 30 minutes, until it had returned to the temperature of the atmosphere (53° F.), when, after applying various corrections, rendered necessary by the somewhat complicated conditions of a spherical mass of cast iron losing heat from its exterior, it was found that the dimensions of the shell, whose interior surface was in perfect contact with that of the solid ball which filled it, were, within the limit of experimental error, those of the empty shell when that also was cold (53° F.), the proof being conclusive that no expansion in volume of the contents of the shell had taken place. The central portion was much less dense than the exterior, the opposite of what must have occurred had expansion in volume on cooling taken place.

It is a fact, notwithstanding what precedes, and is well known to iron-founders, that certain pieces of cold cast iron do float on molten cast iron of the same quality, though they cannot do so through their buoyancy. As various sorts of cast iron vary in specific gravity at 60° F., from nearly 7·700 down to 6·300, and vary also in dilatability, some cast irons may thus float or sink in molten cast iron of different qualities from themselves through buoyancy or negative buoyancy alone; but where the cold cast iron floats upon molten cast iron of less specific gravity than itself, the author shows that some other force, the nature of which yet remains to be investigated, keeps it floating; this the author has provisionally called the repellent force, and has shown that its amount is, *cæteris paribus*, dependent upon the relation that subsists between the volume and "effective" surface of the floating piece. By "effective" surface is meant all such part of the immersed solid as is in a horizontal plane or can be reduced to one. The repellent force has also relations to the difference in temperature between the solid and the molten metal on which it floats.

The author then extends his experiments to lead, a metal known to contract greatly in solidifying, and, with respect to which, no one has suggested that it expands at the moment of consolidation. He finds that pieces of lead having a specific gravity of 11·361, and being at 70° F., float or sink upon molten lead of the same quality, whose calculated specific gravity was 11·07, according to the relation that subsists between the volume and the "effective" surface of the solid piece, thin pieces with large surface always floating, and *vice versâ*. An explanation is offered of the true cause of the ascending and descending currents observed in very large "ladles" of liquid cast iron, as stated by Messrs. Nasmyth and Carpenter. The facts are shown to be in accordance with those above mentioned, and when rightly interpreted to be at variance with the views of these authors.

Lastly, the author proceeds to examine the statements made by these writers, as to the floating of lumps of solidified iron furnace-slag upon the same when in a molten state; he examines the conditions of the alleged facts, and refers to his own experiments upon the total contraction of such slags, made at Barrow Iron-works (a full account of which he has given in his paper on "The true Nature and Origin of Volcanic Heat and Energy," printed in Phil. Trans. 1873), as conclusively proving that such slags are not denser in the molten than in the solid state, and that the floating referred to is due to other causes. The author returns thanks to several persons for facilities liberally afforded him in making these experiments.

IV. "Note on the Excitation of the Surface of the Cerebral Hemispheres by Induced Currents." By J. Burdon Sanderson, M.D., F.R.S., Professor of Practical Physiology in University College, London. Received April 30, 1874.

In a paper recently communicated to the Royal Society by Dr. Ferrier (Proceedings, No. 151) it is shown that when two ends of copper wire distant from each other not more than a couple of millimetres, and in metallic communication with the terminals of the secondary coil of a Du Bois's induction-apparatus in action, are applied to certain spots of the surface of either hemisphere, and great intensity is given to the induced currents thereby directed through the living tissue, by previously bringing the secondary coil into such a position that it is very close to the primary coil or even partially covers it, characteristic combined movements of the opposite side of the body are produced.

With reference to these effects, it was observed by Dr. Ferrier (1) that excitation of the same spot always produces the same movement in the same animal, (2) that the area of excitability for any given movement (or, as it may be called for shortness, *the active spot*) is extremely small and admits of very accurate definition, and (3) that in different animals