LETTERS TO THE EDITOR.

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The Recent Radium Controversy.

I SHALL be obliged by your making the following correction on an accidental misstatement of mine, quoted by Mr. Soddy (p. 517, line 3 from foot of column one) in his very interesting article on "The Recent Controversy on Radium," in your issue of September 20 (p. 516). In a letter to the *Times*, from which the quotation is correctly made by Mr. Soddy, I had written accidentally *four* instead of *five*. The corrected statement is that Prof. Rutherford had suggested that radium might be a compound of one atom of lead and five of helium. This is a suggestion wholly in harmony with chemical science. Rutherford is scientifically cautious in naming lead as possibly one of the ingredients of radium, but he names helium as demonstrated experimentally to be an ingredient, and considers five atoms as rendered somewhat probable by elaborate and important experimental investigations, of which he gives careful descriptions and very complete references in his book on "Radio-activity."

Netherhall, Largs, September 21.

KELVIN.

Stress in Magnetised Iron.

IN NATURE, August 2 (p. 317), I observe under the above title a letter from Dr. Shelford Bidwell re-opening a question discussed in your columns ten years ago. As the originator of the discussion I feel indisposed to let Dr. Bidwell's letter pass unnoticed.

In my first letter (NATURE, vol. liii., 1896, p. 269) I directed attention to the fact that certain writers, including Dr. Bidwell, Dr. J. A. Ewing, and Dr. More, had stated explicitly or implicitly that the material of a magnet is subjected to a longitudinal compressive stress approximating to $B^2/8\pi$ when H/B is small, whilst other authorities, including Kirchhoff and Prof. J. J. Thomson, postulated a *tensional* stress of like amount. I remarked on the apparent inconsistency, and explained the reasons which led me to regard the last-mentioned view as the more plausible. My letter led to others. Dr. Ewing explained that he had changed his views. He left it, however, uncertain whether he believed that no such stress as $B^2/8\pi$ exists in iron, or whether he took the view that tensional and compressive stresses both exist, but in adjacent portions of the magnet. The latter view seems indicated by the illustration he advanced, viz. that of a man sitting in a clothes basket and pulling the handles. The medium in this case is obviously not free from stress, having a tensile stress in his arms and a corresponding compressive stress elsewhere. Prof. E. Taylor Jones wrote favouring a tensile stress, and referring to work by himself and Prof. Nagaoka on the subject. Prof. L. R. Wilberforce dwelt on the fact that the stress $B^2/8\pi$ most properly associated with Maxwell's name has its seat in a hypothetical ethereal medium, not in the material iron. Dr. Bidwell did not then give his views to the public, so far as I am aware. From his late letter I infer that they have remained unaltered since 1896.

Dr. Bidwell advances illustrations to explain his ideas. His arguments, however, seem really to amount only to this, that if *two* masses of iron, whether bars or spheres, close to one another be capable of *bodily* movement (e.g. if they rest on a smooth table or be suspended by long threads), and have between them some compressible non-magnetic medium (e.g. a finger), this interposed material will be squeezed if the iron becomes suddenly magnetic. This result is, however, equally consistent with either of the above theories; also it throws no light on the nature of the stress in the iron.

If, however, we suppose—as Dr. Bidwell ostensibly does—the two hypothetical masses of iron to be consecutive members of an infinitely long series, which seems the only hypothesis likely to represent the interior of a magnet,

and suppose them to be separated by air or by a non-magnetic solid, there is obviously no reason why their centres should approach one another when the masses all become longitudinally magnetised. Number n mass is urged to the right, say, by the attraction of mass $n+1$, but to the left by the equal attraction of mass $n-1$, and there is no reason to move bodily one way rather than the other. If we regard the centres of the masses as fixed, then it is obvious if air gaps separate the mass n when unmagnetised from the masses $n-1$ and $n+1$, that after magnetisation it will—whether of extensible or highly inextensible material—suffer a *tensional stress* in consequence of the attractions exerted by its two next neighbours. If the intervals between n and its neighbours be filled by, say, lead, the lead will suffer no compression unless the mass n lengthens when magnetised. If the mass n lengthens, the lead will suffer compression; but the longitudinal stress in n , though less than if the lead were non-existent, will still be a tension. If we suppose that the poles of the hypothetical elementary magnets are not quite at their ends, and that the elements lengthen when magnetised, so that adjacent ends either meet across an air gap or else exert pressure on an interposed non-magnetic layer, then a compressive stress might be looked for, not merely in the layer, but also in the short terminal parts between the poles and the ends; tensional stress would, however, exist throughout the longer central portions. Whether these various hypothetical cases will do more than serve to show the inconclusiveness of Dr. Bidwell's illustrations is, I realise, very doubtful.

In practice there are usually complications from free ends and want of symmetry. We may, at least theoretically, avoid such complications by taking some endless solid, the simplest being an anchor ring, preferably of small section but large aperture. Is there a "hoop" stress in such a ring when magnetised which did not exist prior to magnetisation, and, if so, what is its sign? If there is a "hoop" tension, then the case is so far analogous to that presented by a ring rotating about an axis through its centre perpendicular to the plane of its aperture. If we imagine a short element of the rotating ring bounded by planes through the axis, the *tensions* across the end faces will give an *inwardly* directed radial resultant which is balanced by the "centrifugal force." A stationary Saturn ring of continuous material, under the attraction of a planet at its centre, similarly gives a case of a compressive "hoop" stress; the *pressures* over terminal faces of an element give an *outwardly* directed resultant, balanced by the planet's attraction and that of the ring on itself. In the Saturnian as in the rotating ring (when reduced to a statical problem), the hoop stresses are really excited by a radial action. Is there anything equivalent to this in the magnetic problem? If there is no radial action there will naturally be a change of aperture, unless, like Dr. Bidwell, we suppose the magnetic material absolutely "rigid." With change of aperture there will be change in the intermolecular distances, and so in the intermolecular forces. It would obviously be difficult to distinguish between the stresses due directly and those due indirectly to magnetisation.

I might add that Dr. Bidwell's remarks on the "uniformly magnetised rod" divided transversely seem to me to confuse tensile with compressive stress. He deduces a stress from iron to air gap, which seems really a tension on the iron. If he supposes the two fragments of iron held so as to prevent them doing more than just touch, he will, I think, realise this. Again, his remarks in reference to his spherical model do not seem to draw a sufficiently clear distinction between stress and strain. A "rigid" body, if such an entity could be realised, might be under stress though exhibiting no strain. On the other hand, in an elastic body the signs even of the stress and strain in a given direction may differ.

During the ten years that have elapsed since the controversy began I have been too busily engaged in other matters to follow the developments of magnetic and electrical theory. I hope that the recognised leaders in these developments will not turn a deaf ear to Dr. Bidwell's appeals for further light.

C. CHREE.

September 15.