"Gay Lussac has proved by experiment that when an elastic fluid streams from one receiver into a second exhausted one of equal size, the first vessel is cooled, and the second one heated, by exactly the same number of degrees. This experiment, which is distinguished for its simplicity, and which, to other observers, has always yielded the same result, shows that a given weight and volume of an elastic fluid may expand to double, quadruple, in short, to several times its volume without experiencing, on the whole, any change of temperature; or, in other words, that for the expansion of the gas of itself (*an und für sich*), no expenditure of heat is necessary. But it is equally proved that a gas which expands *under pressure* suffers a *diminution* of temperature.

"Let a cubic inch of air at 1°, and under the pressure of 30 inches of mercury, be warmed by the quantity of heat x to 274° C., its volume being kept constant; this air, on being permitted to stream into a second exhausted vessel of the same size, will retain the temperature of 274°, and a medium surrounding the vessel will suffer no change of temperature. In another experiment, let our cubic inch of air be kept, not at constant *volume*, but under the constant *pressure* of the 30-inch mercurial column, and heated to 274°. In this case a greater quantity of heat is required; let it be $x + y$.

"In comparing these two processes, we see that in both of them the air is heated from 0° to 274°, and at the same time permitted to expand from one volume to two volumes. In the first case the quantity of heat necessary was $= x$, in the second case $= x + y$. In the first case the mechanical effect was = 0, in the second case it was equal to 15 lbs. raised one inch in height."

He then proceeds with his calculation.

Here it will be seen that Mayer was quite awake to the importance of the considerations dwelt upon by Prof. Stokes—that he knowingly chose for his determination a substance which, *an und für sich*, in expanding, consumes no heat. Hence, when by its expansion *against pressure* heat is consumed, no part of that heat is lost in producing "a change of state in the matter operated upon." The heat consumed is, therefore, the pure equivalent of the work done.

With regard to Dr. Joule, I have, to my regret, vainly endeavoured to find a mislaid document written a year ago, in which I ventured to describe his labours,* and to express the esteem I entertain for them. Supposing him to have derived his inspiration from Mayer's papers, that they had even caused him to prosecute his experiments on the mechanical equivalent of heat, he would still have rendered immortal service to science, and more than merited the honours bestowed upon him last year. For, wanting his work, the mechanical theory, however strong the presumptions, and however concurrent the evidence in its favour, could not be regarded as completely demonstrated. But Joule was not stimulated by Mayer. His work is his own, being practically contemporaneous with that of Mayer. He not only demonstrated experimentally the mechanical theory of heat, but in its completer form he was an independent creator of that theory. And so impressed was the Council of the Royal Society last year with the magnitude of his merits, that they actually added to the Rumford Medal already bestowed upon him, the final distinction of the Copley Medal. If England rated him as highly as I do, his reward would not be confined to mere scientific recognition.

As regards the latter, however, I do not think that the possibility suggested by Prof. Stokes represents any real danger. I do not imagine that the eyes of Science are in the least degree likely to be "shut to the merits of our own countryman." And I believe that the Royal Society, by stamping in two consecutive years these two men with the highest mark of its approval, will have strengthened that confidence in its impartiality which, throughout the whole scientific world, it has so long and so justly enjoyed.

JOHN TYNDALL

* Thanks to the friendly efforts of Dr. Sharpey, this document reached my hands just as the proof of this paper was being returned for pre s. With the permission of the Editor of NATURE I will publish the document, with some additional matter, next week. J. T.

AIRY ON MAGNETISM

A Treatise on Magnetism. By G. B. Airy, Astronomer Royal. (Macmillan and Co.)

THIS is a book written upon the true scientific principle expressed by Newton when he said "Hypotheses non fingo." The elementary laws of magnetism are deduced by rigorous induction from particular cases and are then applied to explain phenomena. The book contains the substance of a series of lectures delivered by the Astronomer Royal at the University of Cambridge. One great element of excellence in the book is that the mathematics employed throughout are of a simple character, so that the first principles of magnetism are thus thrown open to one who has gone no great way in mathematical reading.

Formulæ having been obtained in the early sections for the action of one magnet on another, and the law of the inverse square having been established by a comparison of calculation with experiment, the great bulk of the volume is occupied in investigations which bear more directly on terrestrial magnetism and the magnetism of iron ships. The methods of determining the values of the magnetic elements at any place are carefully explained and illustrated, and the necessary formulæ deduced from the theory established in the preceding sections. We would especially recommend to the reader's attention the articles on the theory of the dipping needle. One chapter of extreme interest is devoted to "Theories of Terrestrial Magnetism," and the beautiful theory of Gauss is sketched out. We sincerely hope that that theory which was carried by Gauss to the fourth order of approximation will be before long carried to a higher order. Data now exist for this advance, as it requires accurate determinations of only eleven more elements.

The subject of the deviation of the compass in iron ships is one upon which the Astronomer Royal is peculiarly justified in speaking or writing. All the sections relating to the disturbance of compass needles are full of most important and suggestive matter. One section is devoted to the continuous registration of small changes in terrestrial magnetism, and the concluding section just touches on the subject of the relation between galvanic currents and magnetic forces, without entering into any calculations.

The book supplies a distinct want which has hitherto existed in the list of our mathematical text-books, and is a most valuable contribution to the diffusion of physico-mathematical science.

JAMES STUART