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THE NATION'S DEBT TO SCIENCE.

THE noble record of the universities and schools of England in the recent war may one day come to be written. It is doubtful if anyone has realised as yet how great will be its full extent. There is one page in particular which will contain more than is grasped even by those who have had the best opportunities of doing so. It will tell of the special work of the men who have been trained in the scientific and technical laboratories.

The war has called for every ounce of scientific knowledge and effort. It could not be otherwise when great nations have been straining their utmost, and when the advantage has so often gone with the best use of every help that modern knowledge could give. The scientific battle has been fought by the laboratory men.

The mastery of the air, for example, has depended on the skill and courage of the pilot, but also, very vitally, on the perfection of his machine. The latter, in its turn, has depended on the knowledge gained with infinite care by those who have tested out each detail of design. The engine itself with its many complicated parts, the form of the struts and planes, the covering fabric and the varnish applied to it, the recording instruments, the photographic gear, the signalling apparatus, the machine-guns, the bomb-dropping arrangements, each of these has been the subject of experimental research requiring the highest technical skill. Each was improved beyond all belief during the war: by how much labour and devotion only those intimately connected with the work can tell. Some of our finest men of science lost their lives in this service. Yet on all this improvement the success of air warfare depended, for it was the last additional strength or trustworthiness, quickness of manœuvre, or power of flight that gave the pilot confidence and superiority; and the staff who carried out this work, whether at Government experimental stations or at the National Physical Laboratory, or elsewhere, were for the most part drawn from the laboratories of the universities and technical schools.

So, too, with the brigade of chemists, who did so much in the war. Professors and lecturers became senior officers in the brigade; junior officers were drawn from the students. They fought the German gas, devising the protective masks and instructing the Army in their use; they worked out the processes for manufacturing gases on a large scale for the use of our own armies. The huge industry of the manufacture of explosives required the solution of chemical problems, which they accomplished, and so saved the nation vast sums of money, and made it possible to supply the Army with all that it wanted. They produced the smoke-screens, and the special bullets that brought down Zeppelins and observation balloons. They solved innumerable problems involved in the great business of supplies; they were constantly the advisers of the Munitions Department, of the health authorities, of the Intelligence, and in a thousand-and-one ways they were indispensable to the progress of the war. The nation has indeed cause to be grateful to its chemical laboratories.

A body of keen young physicists, drawn from various universities of the Empire, developed the methods of sound-ranging until it became possible to locate with extraordinary accuracy the positions of enemy guns, even during the continuous roar of the Western front; they were responsible for a great part of the locations on which artillery work depended. The same methods applied to under-water work by the Admiralty experimental stations made it possible to locate with accuracy explosions occurring hundreds of miles from the shore, and incidentally have furnished the hydrographers with a means of shortening enormously the work of charting the seas. Much of the work of the Admiralty stations, especially that which related to anti-submarine defence, may not, of course, be discussed in public. It can only be noted that here also the universities and technical schools were largely represented on the staffs.

It is impossible even to enumerate the various branches of scientific service. There was the highly efficient and most important gauge work of the National Physical Laboratory; the work of the men who listened for and located the underground operations of the enemy miners; the wide range of most important optical work, from the submarine periscope to the aeroplane camera; the research work on wireless telegraphy, which was so immensely advanced during the war; the meteorological work which was of such great service to the air forces; the geological work of the front; the bacteriology; and so forth. It is impossible to give the barest recital of all the scientific work involved in the immense problems of the medical service. In every section of the operations by land, by sea, and in the air urgent experimental work was carried on, results were obtained which were of the highest importance, and the first-class scientific work which was required was carried out mainly by the men already mentioned, the science teachers and students of the universities and technical institutions.

The war may now be over, and these special occasions for service may no longer exist. But in the long new struggle before us the need for scientific training and method is as great as ever. Our capital is gone. We must pay our debts and earn our living, and, besides, we must amend the pre-war conditions of our workers' lives. It cannot be done except by making every use of the knowledge we have already, and by labouring to add to it: that is to say, by following scientific methods. The services of the laboratory-trained men will still be indispensable. That there is a general understanding of the position is shown by the crowding of new students into the universities, and the demand for instruction in science.

But where are the teachers and the apparatus for teaching? Even before the war the salaries, especially of the junior staff, were poor and the positions few. Many of the former teachers will not come back, for some have been lost in the war, and others are being attracted by the better prospects of research laboratories and commercial work. The universities have no funds wherewith to meet the proper increases of salaries or any increase of staff, for their grants remain unchanged, all expenses have increased, but they may not raise their fees. The number of students is growing rapidly, and, as things are, increase in numbers generally means an increase in expenditure. Most of the universities are really unable to carry on without increased aid from the State.

The sowing of the seed is the last thing that may be neglected if there is to be a harvest, and all our experience, thrown into strong relief by the war, shows that the harvest of the successful development of the work of this country, work which is to pay our debts and bring comfort to our peoples, will follow only on the application of scientific method and research, which is the seed sown in universities and technical schools.

FOUNDATIONS OF ELECTRICAL THEORY.

The Theory of Electricity. By G. H. Livens. Pp. vi+717. (Cambridge: At the University Press, 1918.) Price 30*s.* net.

ELECTRICAL theory, the most rapidly growing part of physics, has now reached such dimensions that no author can hope to produce a text-book which will deal effectively with its many aspects. A series of such books is necessary which shall take different points of view and lay especial emphasis in certain broad directions. We already have several, and notably the works of Jeans and Richardson, which are both comparatively recent. But lacunæ remain, and one of these the present author has set out to fill. We may say at the outset that he has filled it with considerable success, for the work now before us in no way constitutes a reduplication of any important part of an existing treatise. It is, moreover, one which can be recommended without reserve to a student who is anxious to obtain a clear picture of the fundamental principles underlying certain important, and often rather neglected, aspects of electromagnetic theory.

This is said advisedly, for the feature of the book which makes the strongest appeal to the reader is probably the excellent account of that much-discussed and rather chaotic subject, the energy, stress distribution, and general mechanical relations of polarised media. Matters of this kind are usually presented very imperfectly to the student, in spite of the classical foundation which exists in papers by Larmor, and the author has done good service in directing attention to them by their incorporation, in a consistent and very complete form, within the compass of a treatise of this size. If any other section of the work were selected as deserving of special mention, it should probably be that devoted to conduction of electricity by metals, with some of the small, though fundamental, phenomena which accompany it. The author has himself contributed a great deal of work to the subjects described in these sections, and is especially qualified to give an effective account of them.

The preface describes the work as largely the outcome of a course of lectures delivered ten years ago by Sir Joseph Larmor. We may express regret that such a fine compliment is so rarely paid to those who lecture by members of their audience. Although dealing with a mathematical subject, the mathematical side is kept under control by the author, who does not expound it beyond the point necessary for a real comprehension of the principles involved, and an insight into the manner in which they must be worked out in detail. References to the more complete or elaborate investigations are provided as footnotes, and, though by no means exhaustive, these are sufficiently numerous to direct the reading of those who wish to pursue special sections of the subject.

There are two main divisions of electrical theory at the present day, both extensive. In the first place, we have the original framework of Faraday and Maxwell, developed for systems in motion by Larmor, and just afterwards, with more generality, by Lorentz. Superposed on this is the more speculative side, including the principle of relativity, theories of atomic structure, photo-electricity, and other branches, together, in fact, with all the phenomena for which the quantum theory has been invoked. We call this section speculative only by comparison, in that its mathematical and logical foundations and inter-connections are of a lower order of security. It has been well developed in existing treatises, and is not seriously touched upon in the present work. The need for a comprehensive treatise on the older form of theory, satisfactory from the point of view of mathematical and physical consistency, if not always capable of including certain phenomena within its scope, has always been felt, and