action $Mn + FeO = Fe + MnO$ to take place, and the oxides so formed, if uncombined, further form inclusions. The reduction, however, is never complete. Inclusions of this type contain invariably between 60 and 70 per cent. of MnO and from 21 to 28 per cent. of FeO, and this is an expression of the equilibrium relations between the two oxides. Silicon and aluminium also act strongly on ferrous oxide, and to an enhanced degree as compared with manganese. The ferrous manganous oxide complex passes, if sufficient silica is present, into a silicate, and ultimately into manganese silicate only. In the author's words, therefore, ferrous oxide "is an influence for evil in every class of steel, for when it is not removed it is the cause of blow-hole formation, and when it is removed from solution it leaves as a non-metallic inclusion a record of its previous existence."

It would appear, therefore, that in the manufacture of steel the chief desideratum, if inclusions are to be kept down to a minimum, is to finish with a bath containing the minimum of ferrous oxide. This is achieved in practice by working at as high a temperature as possible, which produces not merely less oxide in the steel, but also less iron in the slag, *i.e.* a more silicious slag, and the theoretical justification for it is clearly shown in the paper. H. C. H. C.

EDUCATION, SCIENCE, AND LEADERSHIP.[1]

SINCE the last annual meeting of the guild all questions of education have been under discussion, and we now know better where our weakness lies and the extent and nature of our needs. In the number of our institutions providing higher education America alone stands ahead of us. Sir Robert Hadfield has pointed out that Great Britain and Ireland have one university per 2½ millions of population as compared with one million in America. In the Dominions, on the other hand, where the population is relatively sparse and the distances great, the proportion is one university to two-thirds of a million of people. This numerical comparison is, however, misleading, except that it indicates educational centres capable of extending their activities. The true criticism is the number of students who undergo a complete course of training. Of full-time students only 4400 entered our universities in 1913–14, and of them several hundred were foreigners who would later leave this country. Putting the output of university and technically trained men and women in another way, it appears that per 10,000 of population there were sixteen full-time students in Scotland, thirteen in Germany, ten in the United States, six in Ireland, five in England, and five in Wales. The figure given for the United States includes only students at universities and technical schools of recognised standing. If all students taking four-year courses at these institutions were included, the rate per 10,000 of population would be doubled. It is impossible not to believe that these figures help to account for the high standard of intelligence in Scotland and America, and for the success of the Scottish and American peoples in many spheres of activity, while the relative backwardness of England, Ireland, and Wales must exercise an influence in public life.

The financial test shows a deplorable inferiority to the United States and Germany, and must indicate roughly the relative importance attached to higher education in these countries and our own. Thus the total income of State-aided modern universities and university colleges in England and Wales is about 700,000*l.*, of which 34 per cent. is derived from Parliamentary grants. The corresponding figures for Germany are nearly 2,000,000*l.* and 80 per cent., and the University of Berlin alone receives from the State an annual grant nearly equal to that given to all our universities and university colleges. The annual income of the American universities and colleges is 20,000,000*l.*, of which 7,000,000*l.* is at the disposal of the colleges of agriculture and mechanical arts. Private benefactions towards higher education in the United States amount to more than 5,000,000*l.* a year. With us they do not reach one-twentieth part of this sum.

The only possible inference from these figures is that, as compared with the United States and Germany, our higher education is lamentably inferior in quantity. We are not producing trained leadership sufficient for our needs, and the diffusion of knowledge is pitifully inadequate to the requirements of a modern State. If an analysis of the kind of training received by our governing classes were possible, it would be found that scientific knowledge was exceedingly rare and even non-existent in some quarters where it is essential. Sir Robert Hadfield states that in one important Government institution devoted to educational work about 90 per cent. of the principal officials have received a classical training, and only 5 per cent. have been educated in science. Mistakes and inertia in the direction of public policy and in administration are thus explained. There is not enough knowledge of the right kind in Governments, departments of State, or Parliaments, while, in the world of industry, a sufficient supply of trained research workers cannot at present be obtained. Until this requirement is fulfilled the development of new industries on a large scale must be impracticable.

The excellent report of Sir Joseph Thomson's Committee on the position of natural science in education throws a flood of light on our national deficiencies, and points the way to educational reconstruction. The Committee justly claims for sound science teaching that "it quickens and cultivates directly the faculty of observation. It teaches the learner to reason from facts which come to his notice. By it the power of rapid and accurate generalisation is strengthened. Without it there is real danger of the mental habit of method and arrangement being never acquired."

All thoughtful students of our public affairs must admit that, alike in peace and in war, our leaders in all classes have shown a certain lack of the qualities which science training can impart, and that national interests have suffered grievously for this reason. The power of reasoning from facts and of "rapid and accurate generalisation," combined with the habit of "method and arrangement," is the best possible qualification for Cabinet Ministers as well as for all leadership on lower planes; and the British Science Guild has persistently urged that science should take a prominent place in the education of our public servants.

The Committee recalls the fact that the neglect of science was noted by a Royal Commission on the public schools more than half a century ago. The position of scientific instruction in the United Kingdom was also surveyed in detail in 1870–75 by a Royal Commission, of which the seventh Duke of Devonshire was president and Sir Norman Lockyer, the founder of this guild, secretary. But although there has been advance in recent years, it has required the shock of a world-war to make us wide awake to our shortcomings. The champions of classical learning are now moderate in their claims. The Council for

[1] From the presidential address delivered at the annual meeting of the British Science Guild, June 19, by the Right Hon. Lord Sydenham, G.C.S.I., F.R.S.

Humanistic Studies declares that the future citizen should possess knowledge, not only of the physical structure of the world, but also of "the deeper interests and problems of politics, thought, and human life," and that he needs "scientific method and a belief in knowledge even more than physical science." This marks a change of attitude, and the advocates of the dominance of science in education would agree with the proviso that applications of science unknown to the ancients determine the conditions of health and of economic stability in modern life, and that a "belief in knowledge" and method in pursuing it are best inculcated by the study of law in the natural world.

The great merit of Sir Joseph Thomson's report is that it discloses the present causes of the weakness of science in our education. The universities as a whole now show a bias in favour of science teaching, but there is a deplorable lack of students, due partly to weakness in the schools, and partly to the influence of scholarship examinations in which classics predominate. Thus the old universities, by their scholarship systems, tend to discourage science teaching in the public schools, and the public schools react upon the preparatory schools. It follows that many of the most intelligent boys are deterred from entering upon a scientific career. It is also possible that some class prejudice, based upon long tradition, dating back to the Renaissance, may still operate against science training. The recommendations of the Committee are wise and far-reaching, but I can give only the barest indication of their objects and scope. Nature-study in primary schools up to the age of twelve is to be the foundation, and instruction in science up to the age of sixteen is enjoined upon all secondary schools, physics and chemistry to be taught, because all other sciences, to which they should be treated as passports, require some knowledge of them Mathematics should be connected with science at an early period. The general aims of a science course at school age are defined with the view of securing two educational objects of primary importance:—

(1) To train the mind to reason about things the boy observes himself, and to develop powers of weighing and interpreting evidence.

(2) To develop acquaintance with broad scientific principles and their application in the lives of men and women.

No better foundation for the training alike of the statesman, the leader of commerce and industry, and the manual worker can be laid down. The Committee was strongly impressed with the importance of manual work at school-age, and, speaking from personal experience, I am certain that I owe much to the handling of the file and the lathe before I entered the Army, although mechanical pursuits at one time caused me to neglect other studies. I believe that if all classes underwent some manual training there would be a better understanding of the dignity of labour. Rightly distrusting examination tests of the conventional type, the Committee recommends the inspection of all schools

Higher standards of teaching power, co-ordinated training from the primary school to the university and to the post-graduate stage, with a lowering of fees and a liberal allocation of scholarships to be awarded for "intellectual merit and promise," and not in accordance with the results of set examinations—such are the educational ideals which are set before the country. By these means we may hope in time to develop intelligence now wasted, as the Committee points out, to supply our present deficiency of experts in all branches of science, and to secure more orderly methods of administration and a higher average of leadership.

SCIENTIFIC RESEARCH AND INDUSTRIAL DEVELOPMENT.[1]

AT the request of my friend, Lord Sydenham, I am pleased to support the work which has been so ably carried on by the British Science Guild, now under his leadership. I do so principally for two reasons: First, because of the importance of the work; secondly, because I believe that an erroneous impression exists in many quarters as to the attitude of the producing interests of this country to this work, and I wish to endeavour to remove this impression.

There has been, I fear, a tendency in certain quarters to misjudge the attitude of manufacturers upon this subject. The impression seems to prevail that they are not fully alive to the necessity for research work in connection with their industries. This may be true in some quarters, but, speaking generally, I think there is no body of men more keenly alive to the necessity for a very great development in the application of science to industry.

Among employers there are comparatively few who have studied science or taken degrees in science before entering a business career, but the number of those who have done so has been steadily growing, and is certain to have a great influence upon the future of industry. Further, there is a large number, chiefly of the smaller manufacturers, who have grown up to the practice of "rule of thumb" methods, and will probably never depart from them.

There is, however, a large number, and they are chiefly of the most enterprising and intelligent kind, who have a keen appreciation of what science has done, and may yet do, for their industries, and are alive to the necessity of employing men of scientific attainments, and of encouraging others to undergo a training in science. In my industry I believe there are very few firms which do not employ chemists for the purpose of their business. Mine has never been without them for many years, and has found the value of their services.

I think we cannot absolve Parliament from a share—and that a large one—of the responsibility for our deficiency in scientific research as compared with some other countries. Not only has it been most niggardly in the provision that it has made for the study of science: it has persistently ignored, time after time, the claims of business men for legislation that would enable the application of scientific discoveries to take place, and encourage the application of these discoveries for business purposes. The most familiar illustration of this is the trade in aniline dyes. I maintain that the blame for the unfortunate position of this industry at the beginning of the war rests chiefly upon Parliament. Many times the demand was made by the dye producers that alcohol should be allowed free of duty for dye-making; but requests were refused, and the advantage of free alcohol was enjoyed by the German producers, which rendered economic production here, in competition with them, impossible Further, year after year we went to the Board of Trade to give us a patent law that would be fair and reasonable, and not protect the foreigner and his inventions without reciprocal treatment in his country, but until Mr. Lloyd George became President in 1906 nothing was done. These, in my opinion, are the two chief causes why the aniline dye trade was virtually lost to this country, and the blame for it rests upon the Government and upon Parliament, and not upon the business man.

The principle that trade must be left severely alone

[1] From an address by Sir Algernon F. Firth, Bart., read at the annual meeting of the British Science Guild held at the Mansion House on June 19