THE CASE-HARDENING OF STEEL.

THE autumn meeting of the Iron and Steel Institute was to have taken place in Turin, but unfortunate circumstances rendered this impossible. None the less, a series of important papers by Italian authors were presented—and taken as read—at the meeting held recently in London. Most of these papers were of the nature often met with at foreign meetings of this institute—*i.e.* records of metallurgical resources and achievements of the country. On this occasion, however, two Italian papers of a different character were laid before the institute. These deal with the case-hardening of steel, and are both from the pen of the well-known Turin metallographer Prof. F. Giollitti, whose name proclaims his close relationship to the present Prime Minister of Italy.

The two papers in question are entitled "On Case-hardening by Means of Compressed Gases" and on a "New Industrial Process for the Case-hardening of Steel." The striking fact brought out by these papers is that the Italian metallographers who have worked on this subject have evolved order out of chaos by treating the whole question as one of physico-chemical equilibrium between the various solids and gases present during the process. It is to be regretted that Prof. Giollitti did not carry out his avowed original intention of giving a detailed summary of the more important researches on this subject conducted by him and his collaborators at Turin, but the mere bibliography of some fifteen memoirs is sufficiently impressive. The results of these researches are, however, summed up by the author in his present paper in a series of conclusions which are very definitely laid down. If we may accept Prof. Giollitti's statement that his views are fully established, the fundamental facts of case-hardening are as follows:—

(1) Solid carburising agents, without the intervention of gases, have only a slight action.

(2) The specific effect of nitrogen is very weak, and only in the presence of cyanides, ferrocyanides, &c., does the effect of volatile nitrogen compounds become marked.

(3) The specific carburising effect of carbon monoxide is enormously greater than that of any solid cementing agent. Pure carbon monoxide carburises iron at all temperatures between 700° C. and 1300° C., and it produces a greater depth of carburisation in a given time than any other carburising agent. Both the depth and intensity of the cementation can be accurately regulated, as they are governed by equilibrium conditions, which can be definitely ascertained and adhered to.

(4) The use of carbon monoxide as the principal cementing agent makes it possible to obtain softer and better graded cementation than is obtainable by other means.

The new industrial process which Prof. Giollitti bases on his experimental results is, in effect, a specially mechanically arranged furnace, which makes it possible to charge and discharge a vertical muffle with the articles to be case-hardened in a very short time. So soon as the muffle is charged with the steel, which is introduced at a red heat, the remaining free space of the muffle is filled with hot granulated carbon, which, the author tells us, flows into the interstices like a liquid. Then a current of carbon monoxide or of dioxide is passed in at a measured rate for a definite time and at a measured temperature, and any desired degree of hardening can be obtained. The effect of the direct contact of the steel with the solid granular carbon appears to be the production of a thin outer skin of very highly carburised steel, while the effect of the gases gives a less highly carburised region extending for some depth into the metal. In the Giollitti muffle it is possible to withdraw the solid granulated carbon at any desired stage, and to continue the cementation with the gas alone, merely leaving enough carbon in the muffle to secure equilibrium of the gases (CO and CO_2) with solid carbon. Tables of analyses are given which show that the result of such treatment is somewhat to lower the carbon concentration of the extreme outside layer and to reduce the carbon concentration gradient inwards to almost any desired extent. This treatment, therefore, removes the risk of cracking and shelling which arises from the rapid changes in carbon content which occur in articles case-hardened in the ordinary way, and more especially by the use of cyanides or ferrocyanides. By the new method it is claimed that cementation of very great depth can be safely obtained, even with special alloy steels, which tend to become "rotten" on the surface when cased by other means. Whether the Giollitti muffle and method will realise all these expectations practical experience alone can show, but there is no doubt that these Italian investigators have thrown a flood of new light into a formerly obscure region of steel metallurgy.

The character of this new light is perhaps more clearly shown, so far as the scientific point of view is concerned, in the paper by Giollitti and Carenvali on case-hardening in compressed gases. The work described in this paper is based on the researches of Schenk on the equilibrium of the systems consisting of Fe, C, CO, and CO_2; Fe, Fe_3C, CO, CO_2; Fe, FeO, CO, CO_2, and other systems consisting of the mutual compounds of the elements iron, carbon, and oxygen at various temperatures and pressures. The experiments of the present authors were conducted by means of a small electric resistance furnace placed inside a steel cylinder, and partially filled with both granular carbon and steel specimens, into which compressed carbon dioxide was fed at known rates. The authors found, in general, that the rate of cementation increased with the pressure employed, but they also found that when certain pressures were exceeded, in spite of their intimate contact with incandescent solid carbon, the surfaces of the steel specimens became thickly coated with oxide, although vigorous cementation had taken place in the metal immediately beneath the oxide layer. Thus they show the photomicrographs which are reproduced in Figs. 1 and 2; in No. 1 we see the section of the region of a carbon steel close to the surface, which was covered with a thick layer of oxide, and the highly carburised nature of the steel close to this surface is at once evident. In No. 2 we see the section of an alloy steel (in this case a nickel-chrome steel) which exhibits an altered, highly carburised layer close to a deeply oxidised surface; the magnification in both cases is 65 diameters.

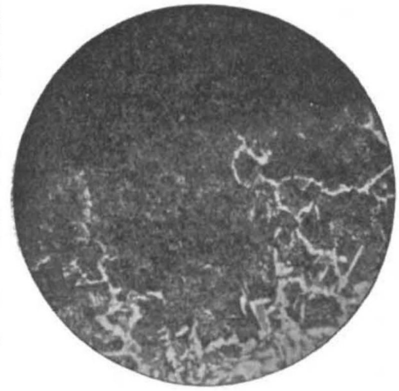

Fig. 1.

Fig. 2.

In the case of chrome-steels such a paradoxical result had already been observed by Charpy, who expressed his results by stating that apparently in the action of carbon-monoxide on iron-chromium alloys the two metals behaved independently, the iron becoming carburised, while the chromium is oxidised. The present authors show that such an opinion is not justified; the explanation of the apparent paradox lies in the equilibrium conditions of the systems referred to above. For every temperature and concentration there is a critical pressure above which oxide, as well as carbide, of iron is present in equilibrium with CO, CO_2, and C. The addition to iron of a baser metal, such as chromium or manganese, lowers this critical pressure until—in certain alloys—it falls below the ordinary atmospheric pressure, and oxidation as well as cementation takes place. On the other hand, the addition of a "nobler" metal, such as nickel, raises the critical pressure and allows of the use of gases under higher pressures for cementation without risk of spoiling the articles by surface oxidation. Two interesting conclusions are drawn by the authors. The first is that for a given steel there is a limiting pressure for cementation, by means of carbon-carbon-monoxide mixtures, beyond which surface oxidation sets in. The second is that in the case of chromium alloy steels the pressure of CO and CO_2 must be diminished below atmospheric to allow of cementation without oxidation. Since it is only the partial pressure of these gases, however, which comes into effect, this diminution below atmospheric pressure can be produced by simple dilution. It follows, and the authors describe an experimental verification, that in these circumstances oxidation can be avoided by diluting the stream of "cementing" gases (CO and CO_2) with air. The oxygen, of course, combines with the granulated carbon in the furnace to form CO and CO_2 in the proportions required by the equilibrium conditions, while the remaining nitrogen acts as a diluent and produces the desired effect.

We have here a series of remarkable deductions and experimental verifications of facts which appear almost incredible to any steel-worker not conversant with the theory of physico-chemical equilibria; indeed, the practical man will probably find it difficult to believe them until he has tried for himself. None the less, there is here a basis for the rational and scientific conduct and control of a process hitherto largely based on "rule of thumb."

W. ROSENHAIN.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.[1]

THE annual volume of the Transactions of the Institution of Engineers and Shipbuilders in Scotland, which at the close of the session 1908–9 had 1650 members upon its roll, contains several valuable papers. The president, Mr. C. P. Hogg, in his address, after passing in rapid review some of the outstanding developments in engineering during the past 100 years, directed attention to some of the problems of the future; in his opinion the nineteenth century demonstrated how to utilise the forces of nature, while the problem of the twentieth century will be how to do so efficiently.

Mr. C. A. Ablett in a paper on electrically driven reversing rolling mills described in detail the Ilgner system, in which the power, supplied under very economical conditions by a steam turbine or a gas engine, is applied to drive a reversing mill. The mill motor is a direct-current shunt-wound machine; interposed between it and the source of power supply is a fly-wheel converter set in order to provide a system by which the mill motor may be started, stopped, reversed, and kept under control in regard to speed without loss of energy, and at the same time to enable a control apparatus of reasonable dimensions to be employed. The electrical equipment of a 36-inch cogging mill at Osnabrück was described as an example of this system, and the paper was illustrated by a series of drawings and photographs of the plant; especial attention was given to the flexible coupling between the fly-wheel and the electrical machines of the converter set.

In the discussion on this paper Mr. T. B. Mackenzie expressed the opinion that German steel makers were able in many cases, owing to their skilful utilisation of waste energy, to roll their steel at lower rates for power than usually obtained in this country; he believed that in the steel works of the future there would be no reciprocating steam engines employed—the whole of the power needed would be generated by gas engines in a central station and distributed electrically to the various mills.

In a paper by Mr. A. Melville, the "Simplex" method of concrete pile foundations was described; the essential principle of this system was the driving into the ground of a 16-inch diameter steel tube closed at the lower end either by a loose point or a pair of hinged jaws, which open when the tube is eventually withdrawn and permit concrete, either plain or reinforced, to be passed through, filling up the entire space originally occupied by the tube simultaneously with the withdrawal of the latter from the ground. This system has now been extensively employed in the United States, and is rapidly coming into use in this country; the cost was stated to be about 2*s*. 6*d*. per cubic foot of pile when no reinforcement was used.

The important problem of the design of surface condensers, more important than ever since the introduction of the exhaust steam turbine, was dealt with in a paper by Mr. R. M. Neilson, who stated that empirical methods must be abandoned, and the area of cooling surface calculated in a rational manner so as to allow a given vacuum to be guaranteed under given conditions. The author proceeded to work out a scheme for the design of condensers, allowing for the varying conditions found in practice, and then offered a series of valuable suggestions as to the most profitable lines on which experimental research might in the future be conducted. In the discussion Prof. Mellanby directed attention to Dr. Stanton's researches into this problem, and Mr. Weir pointed out that in a condenser for a turbine-propelled torpedo-boat he was able with a vacuum of 28·7 inches to secure a condensation of 27 lb. per square foot of cooling surface.

Other papers published in this volume are steamship repairs by electric and autogenous welding, by Mr. H. S. Younger, descriptive of processes by which repairs can be carried out either by electric welding or by means of the oxy-acetylene process on damaged material so as to make it serviceable again; some tests on board ship to ascertain the water consumption of engine-room and deck auxiliaries, by Mr. C. F. A. Fyfe; and Prof. Mellanby's description of a new experimental steam engine at the Glasgow and West of Scotland Technical College.

T. H. B.

[1] Transactions of the Institution of Engineers and Shipbuilders in Scotland. Vol. liii. Fifty-third session, 1909–10. Edited by the Secretary. Pp. xxxii+429 (Glasgow: The Institution, 1910.)

TICKS.[1]

THE rapid advance that has been made in recent years in scientific and medical knowledge with regard to diseases caused by parasitic Protozoa and other microscopic organisms has had the secondary result of directing attention to the insects or other invertebrate animals which are often the agents in the dissemination of the disease-causing parasites. Mosquitoes, tsetses, and other biting flies, fleas, and other ectoparasites are now being collected eagerly and studied earnestly in all parts of the world, less perhaps by professed zoologists than by medical men and others, to whom the practical importance of these pests is a greater stimulus to investigation than the purely scientific interest which the creatures may possess in themselves. Hence special attention has been directed to the various groups of blood-sucking arthropods so soon as their connection with particular diseases has been made known. Mosquitoes were the first to come into prominence when their connection with malaria was discovered; then biting flies, and especially tsetse-flies, when their *rôle* in disseminating trypanosomiases of animals and human beings was made known; and next fleas have been the subject of close study, when their relation to the spread of plague became apparent. There remain three important groups of ectoparasites: ticks, lice, and bugs. It is well known that ticks play a considerable part in spreading diseases. In human beings, African relapsing fever is caused by a spirochæte transmitted by a tick; hence its popular name of "tick-fever." In animals, various deadly diseases, known collectively as "piroplasmoses," because caused by a minute blood-parasite belonging to the genus Piroplasma, or allied genera, are known to be transmitted by various species of ticks; such are the "red-water" or "Texas-fever" of cattle, and similar diseases of horses,

[1] "Ticks, a Monograph of the Ixodoidea." By G. H. F. Nuttall, C. Warburton, W. F. Cooper, and L. E. Robinson. Part i., Bibliography of the Ixodoidea, by G. H. F. Nuttall, L. E. Robinson, and W. F. Cooper. Price 6*s*. net. Part ii., by G. H. F. Nuttall and C. Warburton. Price 12*s*. net. (Cambridge University Press, 1911.)