

would be possible to get five times as much light for a sovereign as could be done now. At present electric lighting would succeed commercially where other considerations than cost had weight. Improvements in the lamps were certain, and there was a probability that these improvements might go so far as to reduce the cost to one-fifth of what it now was. He left the meeting to judge whether or not it was probable, nay, almost certain, that lighting by electricity was to be the lighting of the future.

#### HARDENING AND TEMPERING STEEL

ONE of a series of lectures to the Liverymen and Apprentices of the Company of Cutlers of London was delivered on Thursday last by Prof. W. Chandler Roberts, F.R.S., "On some Theoretical Considerations connected with Hardening and Tempering Steel."

The Master of the Company, Mr. J. Thorne, presided, and the Lecturer observed that the phenomena with which they had to deal, although admittedly as interesting and remarkable as any in the whole range of metallurgy, are but little understood.

If the fact that steel can be hardened had not been known, the whole course of our industrial and even political history would probably have been widely different, and the dagger, which occupies so prominent a place in the armorial bearings of the City of London, would have represented a survival of implements made, not of steel, but of copper hardened with tin.

It has long been known that there are extraordinary differences between the properties of wrought iron, steel, and cast iron, but our knowledge that these differences depend upon the presence or absence of carbon is only a century old, for it was not until the year 1781 that Bergman, Professor in the University of Upsala, showed that wrought iron, steel, and cast iron, when dissolved in certain acids, leave amounts of a graphitic residue, varying from  $\frac{1}{10}$  to 2½ per cent., which are essential to the constitution of these three varieties of metal. Bergman's work led many early experimenters, notably Clouet in 1796, to attempt to establish the importance of the part played by carbon, and Clouet converted pure iron into steel by contact at a high temperature with the diamond, which was the purest form of carbon he could command. Prof. Roberts said that this experiment had been repeated by many other observers with varying success, as in all the earlier work the furnace gases, which had not been excluded, might have converted the iron into steel without the intervention of the diamond. It remained for a distinguished Master of the Cutlers' Company, Mr. W. H. Pepys, to repeat Clouet's fundamental experiment under conditions which rendered the results unequivocal, by employing electricity as a source of heat. This experiment, which had been communicated to the Royal Society in 1815, was performed in the way Pepys had indicated.

It was then shown that in soft, tempered, and hardened steel respectively the carbon has a distinct "mode of existence," as is indicated by the widely different action of solvents on the metal in these three states.

The evidence as to whether carbon in steel is *combined* in the chemical sense, or is merely *dissolved*, was then considered at some length, special reference being made to the results obtained by various experimenters, from Berzelius and Karsten to Sir Frederick Abel of the War Department.

Prof. Roberts stated that the researches of Troost and Hautefeuille afforded strong evidence that in "white cast-iron" and steel the carbon is merely dissolved, a view which he adopted, as he did not consider it to be at all in opposition to the facts recently established by Sir Frederick Abel, who had shown that the carbon may be left by the slow action of solvents on soft steel as a carbide of iron.

The various physical, as distinguished from the chemical theories that had been propounded from the time of Réaumur, (1722) to that of Akerman (1879), to account for the "intimacy of the relation" of carbon and iron in hard as compared with soft steel, were then described at some length, and the remarkable experiments of Réaumur, who cooled steel slowly in a Torricellian vacuum in order to show that the absorption of gas did not take place during cooling, was illustrated.

In recent years much importance has been attached to the physical evidence as to the peculiar constitution of steel, and it has been shown that there is a remarkable relation between the amount of carbon contained in different varieties of steel and their electrical resistance. Some of the very interesting experi-

ments of Prof. Hughes on this point were then exhibited and described, and Prof. Roberts concluded by saying that the value of the early work by Bergman and Réaumur had rather been lost sight of in recent discussions, Bergman's work being specially remarkable, as he attempted, by thermometric measurement, to determine the heat equivalent of the phlogiston he believed iron and steel to contain.

The importance of the degree of carburisation of steel from the point of view of its technical application was illustrated by reference to a series of curves, and it was incidentally mentioned that, in the case of the variety of steel used for the manufacture of coinage-dies, the presence of  $\frac{1}{10}$  per cent. of carbon more or less than a certain standard quantity makes all the difference in the quality of the metal.

#### UNIVERSITY AND EDUCATIONAL INTELLIGENCE

OXFORD.—The new Board of the Faculty of Natural Science has issued its first list of lectures this term. The lectures are divided under the following heads:—Physics, Chemistry, Animal Morphology, Geology, and Botany. No lectures are scheduled this term under Mineralogy or Physiology.

In Physics Prof. Clifton lectures on "Instruments and Methods of Measurement employed in the Study of Optics." These lectures are given in the Clarendon laboratory, where practical instruction in Physics is given by the Professor, assisted by Messrs. Stocker and Heaton. At Christ Church Mr. Baynes lectures on Electrokinematics and Electrodynamics, and gives practical instruction on Electric and Magnetic Measurements. At Balliol Mr. Dixon gives a course of experimental lectures on Elementary Heat and Light.

In Chemistry Dr. Odling lectures at the Museum on the Composition of Air and Water; Mr. Fisher lectures on Inorganic Chemistry; and Dr. Watts on the Cyanogen Series. At Christ Church Mr. Harcourt has a class for Quantitative Analysis, and Mr. Dixon a class for Gas Analysis.

In Animal Morphology Prof. Moseley lectures on Comparative Anatomy, and gives practical instruction to his class after each lecture; Mr. Hickson lectures on the Development of the Chick, Mr. Hatchett Jackson on Mammalian Osteology and the Principles of Embryology, Mr. Poulton on the Distribution of Animals, and Mr. Lewis Morgan on the Vertebrate Exoskeleton and on Human Osteology.

In Botany Mr. Chapman gives practical instruction on Vegetable Morphology at the Botanic Gardens.

In Geology Prof. Prestwich will give a series of lectures on Friday afternoons on the strata and fossils to be visited on his Saturday excursions.

On June 19 an examination will be held in common by Magdalen, Merton, and Corpus Christi Colleges for electing a Scholar in Physical Science at each College. At Merton and Corpus the chief subjects will be Chemistry and Physics.

Jesus College offers a Welsh Scholarship in Natural Science. The examination will be held on June 14.

Examinations for the degree of Bachelor of Medicine (both First and Second) will be held this term. Candidates are to send in their names before May 1.

CAMBRIDGE.—Prof. Huxley's Rede Lecture at Cambridge University will be given on June 12, at 3 p.m., in the Senate House. The subject is not yet announced.

Dr. Michael Foster leaves the Lectures on Elementary Biology for this term in the hands of Dr. Vines and Mr. Sedgwick, and will hold Catechetical Classes in Physiology for the Natural Sciences Tripos.

Dr. F. Darwin will give six Demonstrations on the Physiology of Plants (Growth, Movement, &c.) at the Physiological Laboratory on Saturdays at noon, beginning April 21.

Prof. Liveing will lecture on the Chemistry of the Heavenly Bodies, beginning May 1.

LONDON.—Mr. A. H. Keane has been appointed to the Hindustani Lectureship at University College.

THE Winter Session at the College of Agriculture, Downton, near Salisbury, ended on Monday, when the certificates and prizes were presented to the successful students by Archdeacon Sanctuary. The certificate of membership, obtainable on examination after completion of the two years' course of study, was granted to Mr. Arthur Herbert Kerr, Crookham, Farnham,