abstract science. Such men recognised the value of certain metals and alloys for definite uses, they investigated their mechanical properties, and proclaimed their merits to engineers. The intervener then disappeared, leaving behind some coefficient or constant bearing his name by which he was gratefully remembered. As an instance, Galileo's estimation of the tensile strength of copper cylinders, and Young's determination of the rigidity of steel (which had resulted in Young's modulus) were cited.

It was not easy to fix the period in industrial history at which the metallurgist began to give the engineer material assistance. If in this country Stonehenge were taken as a starting point, the architect-engineer who designed that crowning example of Neolithic art could not have received any assistance from the metallurgist. That stately structure arose from the plain at a time when bronze tools were known but were not in general use, and this period had recently been fixed by Mr. Gowland at about 2000 B C. In another phase of engineering work it was known that Rome, in the days of her occupation of this country, trusted to the metallurgists of our island to supply the lead which was so extensively used in the Eternal City. The fourth-century wrought-iron column, discovered in India, and the girders and beams of the Orissa temples, rendered it necessary to exercise great caution as to the period at which iron was used in construction. Such magnificent efforts as those given were, however, not maintained, and no widespread or continuous records of the metallurgists' contributions to early constructive work could be presented. On the other hand, the civil engineer had, to quote the charter of the institution, "advanced mechanical science and directed the great sources of power in Nature for the use and convenience of man," for ages before the metallurgists rendered more than incidental service. As examples of great engineering works into the construction of which no metal entered, the lecturer referred to, and gave illustrations of, the primitive cantilever bridges of pine trees used to cross mountain torrents in Savoy. The interesting thirteenth century cantilever bridge made up of 20-foot beams given in the note-book of Villars de Honnecourt was also shown, as was a bascule bridge of the middle ages. The dome of Milan Cathedral, as designed by Leonardo da Vinci, the great Tuscan painter, engineer and architect, was also referred to as an example of a structure in which metal was not used. The employment of cast iron from the time of Queen Elizabeth to the present day was then dealt with, and the proposed cast-iron bridge of 600-foot single span, by Telford and Douglas, was referred to, and it was pointed out that in the nineteenth century metallurgists, by creating the age of steel, more than atoned for their somewhat tardy and intermittent efforts to supply engineers with suitable materials.

As regarded the use of cast iron and malleable iron, the influence of Watt in developing the steam-engine was traced, and it was admitted that the necessity for pumping water out of mines was the main factor in the evolution of the steam-engine, and, in turn, the development of British metallurgy of iron and steel dated from the time when the steam-engine of Watt enabled air to be readily pumped into the blast-furnace employed for the production of cast iron. It was then pointed out that more than half of the last century had elapsed before the "age of steel" began, and that towards the end of the century great attention was devoted to considerations connected with the molecular structure and properties of steel, and to enforcing the action of carbon, the element which gave steel its properties, by the addition of other elements than carbon in very small proportions. With regard to the slow growth of confidence in the qualities of steel, the opinion of successive presidents of the Institution, as expressed in their addresses, was quoted; Sir John Hawkshaw, Sir John Fowler, Sir Frederick Bramwell, Mr. W. H. Barlow, Lord Armstrong and Sir George Bruce being specially alluded to. In 1887, when Sir George Bruce delivered his address, the merits of steel had at last received recognition, and, as regards the crowning triumph of the age of steel—the Forth Bridge—Sir George exultingly exclaimed:—"At the Menai Bridge, the total quantity of iron was 11,468 tons; at the Forth Bridge, there will be 50,000 tons of steel and iron." No one had done more than Sir Benjamin Baker to insist on the importance of phenomena which engineers used to consider "mysterious" in connection with the behaviour of steel, and his warnings and example were at last being regarded and followed. The lecturer pointed out that when metallurgists gave engineers mild steel, they provided a cinder-free *solid solution* of iron and carbon. All subsequent advance had been due to the recognition of this fact, and to the gradual studies of the properties of metallic *solid* solutions. Sir John Hawkshaw, in his presidential address to the Institution, delivered in 1862, had said that if the strength of iron could be doubled, the advantages might be equal to the discovery of a new metal more valuable than iron had ever been. The lecturer contended that this was exactly what metallurgists had done with regard to steel. By suitable thermal treatment, and by suitable additions of comparatively rare metals, they had doubled the strength of steel as it was known in its early days. The nature of solid solutions was then explained, and the importance of allotropic modifications of iron was dwelt upon, this portion of the subject being illustrated by some difficult experiments. The question was then asked, could the past molecular history of a mass of steel be traced by microscopic examination of the solid metal? Some very beautiful experiments by M. Osmond, Mr. Stead, and others, were appealed to in evidence of the possibility of this. It was then demonstrated that solid metals might even reveal, by their structure, the vibrations to which they had been subjected, and Sir Benjamin Baker had constantly insisted on the importance of such vibrations. In making this clear, Vincent's experiments on the beautiful wave-structure that might be imparted to the surface of mercury by the aid of a vibrating tuning fork were then exhibited, and it was demonstrated that the surface of *solid* lead which had been subjected to similar vibrations possessed a similar structure to the vibrating surface of mercury.

Finally, with regard to the efforts metallurgists were making to study the influence of rare metals on iron and other metals, the reducing power of aluminium on metallic oxides was shown. Very high temperatures of 3000° C. and above were attained, and brilliant light was produced during the reduction of chromium, cobalt, nickel and other metals from their oxides.

In conclusion, the lecturer appealed to the new Alexander III. Bridge at Paris as showing the need for the careful measurement of high temperatures in connection with the treatment of large masses of steel. In the construction of the bridge, 2200 tons of *cast* steel had been employed, and a peculiar molecular structure was imparted to the steel by rapidly cooling it in air from a temperature of 1000° C. to 600° C.; this gave the metal certain mechanical properties which it would not otherwise have possessed. With reference to the aid given by metallurgists to engineers in connection with ordnance, reference was made to the address delivered by Mr. T. Hawksley, the father of the president, in 1872. He said that "In no way" other than by the study of such questions "could the Institution" of Civil Engineers "serve its country better, or better promote, in the interests of peace, the advancement of practical Science, and its application, if events should order, to the purposes of protective warfare." The use of copper, aluminium and other metals in electrical engineering was referred to, and the lecture ended with an appeal for the more extended study of the physical properties of metals.

THE GLACIERS OF KANGCHENJUNGA.

MR. DOUGLAS W. FRESHFIELD publishes, in the April number of the *Geographical Journal*, an account of his expedition to Kangchenjunga during the autumn of 1899. The Kangchenjunga group is cut off from the mountains of Nepal by the Khosi Valley on the west, and from the mountains of Bhotan by the Teesta Valley on the east. By crossing the lofty spur which unites it to the Thibetan highlands, it is just possible to get round the mountain without trenching on territory officially recognised as Thibetan. Mr. Freshfield's object was to make this high-level tour round Kangchenjunga, passing as near as possible to the great mountain, and, further, to obtain some accurate idea of the glacial features of the group. Progress was greatly interfered with during the earlier part of the journey by the storm which caused so much damage at Darjiling and by the lowering of the snow-line which resulted from it; but the tour was successfully accomplished, and from the head of the valley of the Kangchen, in Nepal, Europeans looked for the first time on the north-west face of Kangchenjunga, "not a sheer cliff like the three other aspects of the peak, but a superb pile of rock buttresses, terraces of snow and staircases of ice, through whose labyrinthine complexities the future conquerors of the mountain will have to find the least hazardous way to the

summit." Concerning the Kangchenjunga glaciers, Mr. Freshfield says, "Four glaciers radiate from the peak, pointing roughly to the north-east, south-east, north-west and south-west. Those are the Zemu Glacier, eighteen miles long, and the Talung Glacier, both draining to the Teesta, the Kangchen Glacier, fifteen miles long, and Yalung Glacier, both draining to the Arun and the Khosi. The forked spurs that protrude south and west from Kangchenjunga, dominated respectively by Kabru and Jannu, enclose in the first case the Alukthang glaciers, united not long ago in a single stream and now divided by little more than their moraines, and the southern glaciers of Kabru, which fall into a separate glen; in the second case, three considerable ice-streams, one of which almost meets the Kangchen Glacier at its lower extremity, the second builds across the valley, out of the rockfalls of the tremendous cliffs of Jannu which encompass its source, a remarkable wall of moraine stuff, similar to those of the Allalein, or the Brenva in the Alps, and extent of the cliffs surrounding the head of the glacier. The glacier is now in retreat; the ice has sunk somewhat and the lateral moraines appear above it.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE installation of the Prince of Wales as Chancellor of the University of Wales will take place at the University College, Bangor, on May 9.

LORD ROSEBERY has been formally nominated as Chancellor of the University of London, in succession to the late Lord Kimberley. As no other nomination has been made, he will be elected by Convocation at the meeting to be held on May 13.

THE London School Board, and the School Boards of most large towns, have for same years provided special schools where their pupil teachers receive instruction at specified times. It has now been decided that these schools are illegal. Mr. Cockerton, the Local Government auditor, has formally notified the London School Board that it has no authority in law to spend the rates in providing and maintaining special schools for the instruction of pupil teachers.

IN the House of Lords on Monday, in reply to a question by Lord Reay, referring to the new Regulations for Evening Schools, the Duke of Devonshire said:—"It is intended that all local expenditure—by which is meant expenditure on evening schools other than that which is provided by Government grants—shall in future be provided by local authorities under the Technical Instruction Acts. As to whether the funds at the disposal of the local authorities will be sufficient for that purpose, the existing local authorities under the Technical Instruction Acts have by no means exhausted the funds at their disposal

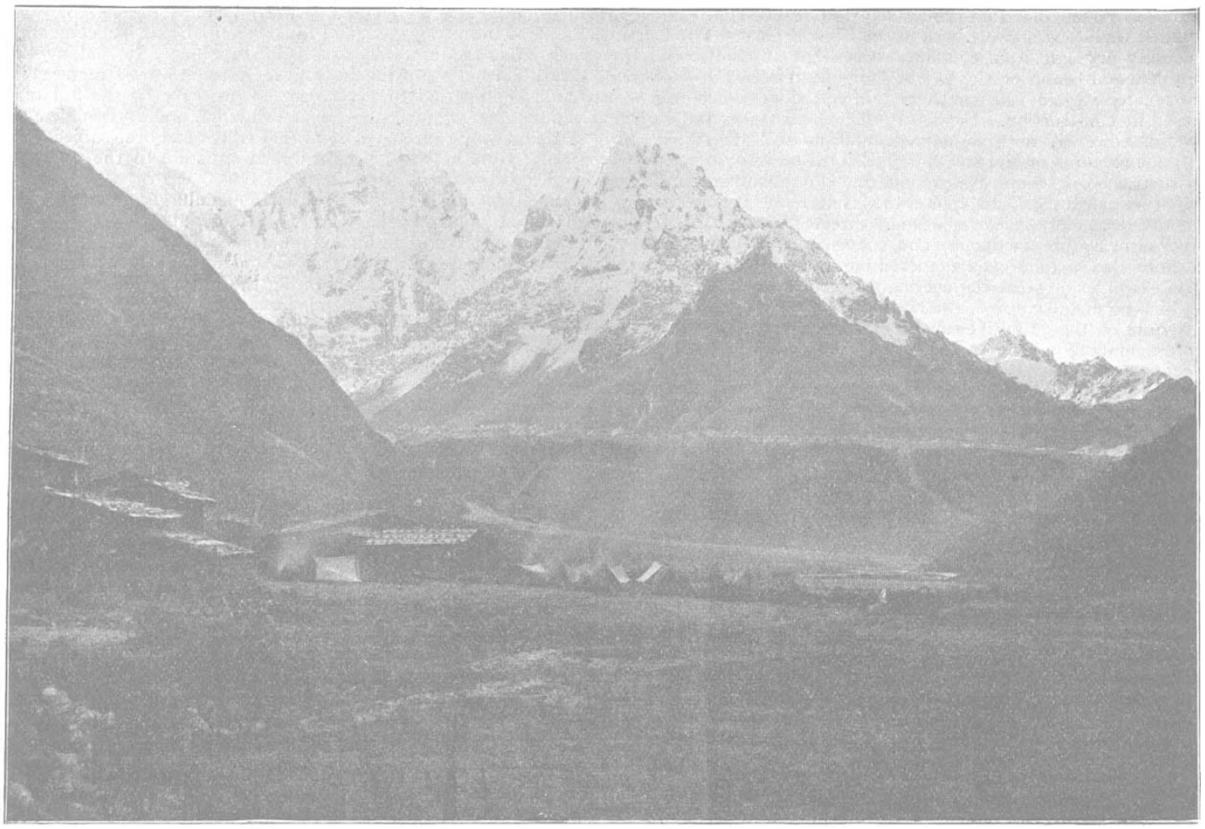

FIG. 1.—Kanbachen in Nepal, with Jannu and the Dyke of the Jannu Glacier. (From the *Geographical Journal*.)

while a third fills a glen the stream from which joins the Kangchen torrent at Khunza."

Mr. Freshfield was accompanied by Prof. Garwood, Signor Vittorio Sella and his brother, and Mr. Dover, now road inspector at Sikhim, with an Alpine guide. Prof. Garwood devoted much labour to the compilation of a photo-topographic map of the region, which is to be published in an early number of the *Geographical Journal*, and is described by Mr. Freshfield as a "specimen of the right method to delineate glaciers." The paper is illustrated by a number of photographs taken by Prof. Garwood and Signor Sella. The specimen we reproduce represents Jannu and the dyke of the Jannu Glacier as seen from Kanbachen. The ice crosses the valley at right-angles, over a great dyke of moraine débris, and the torrent from the higher valleys is squeezed against the western hill. There was at one time a lake above the moraine dyke. The cause of the exceptionally large amount of moraine material is the great height