The entertainment and hospitality meted out to the Association by the Mayor and Corporation of Swansea and the leading citizens were of a most lavish and thoroughly enjoyable character, and the local arrangements were carried out by Mr. W. Grant Murray with a smoothness and precision which have never been surpassed.

The Association, at its business meeting, elected a distinguished worker on the art side—Mr. E. Rimbault Dibdin—to be president for 1914–15.

THE HARDENING OF STEEL.

AT the May meeting of the Iron and Steel Institute two papers were read and discussed dealing with the theory of the hardening of steel; they gave rise to one of the most interesting discussions of the meeting. While it is, of course, obvious that the more "practical" members of the institute take no interest in these discussions, it must be borne in mind that the theories of to-day become the foundations of the practice of to-morrow, and that therefore the "practical" man cannot in the least afford to despise or ignore what he likes to dismiss as "mere theory."

The two papers on hardening presented to the institute both put forward fairly definite theories, and at first sight these differ entirely from one another and still more from the older purely "allotropic" theory of hardening. It was interesting to find, however, that during the discussion not a single advocate of the other older theory—that of the so-called "carbonists"—came forward. When the views put forward by Profs. Edwards and Carpenter and by Mr. McCance are carefully compared, however, it will be found that they do not really differ very vitally either from one another or from the older allotropic view. All three theories agree in supposing that when carbon steel is cooled rapidly an essentially unstable transition product is formed which is itself intrinsically hard. The allotropic theory called this intermediate hard product "beta iron," and identified it with the beta iron which has a limited range of stable existence in pure iron and in low-carbon steels; Messrs. Edwards and Carpenter and the writer now identify it with the "hard amorphous phase" of Beilby, while Mr. McCance invents a new word and calls it "interstrained" iron. The real difference of opinion seems to centre on the question how this intermediate substance comes into existence.

Profs. Edwards and Carpenter approach the subject from the point of view of an analogy between the hardening by quenching of steel and of alloys of copper containing from 10 to 13 per cent. of aluminium. These latter are somewhat hardened by quenching, and there is a corresponding similarity, on broad lines, between the respective constitutional diagrams; by quenching, both kinds of alloys are caused to pass rapidly through a transformation range. The resulting micro-structures also show a certain similarity, the aluminium-copper alloys exhibiting an acicular structure having some resemblance to the coarser kinds of martensite seen in hardened steels. The authors then endeavour to show that the structures of both quenched aluminium-copper alloys and of quenched steel arise from an identical cause, viz., highly multiplied twinning, which they believe to occur during quenching as a result of the internal strains caused during rapid cooling. The evidence that the martensite of steel is really equivalent to highly twinned austenite is, however, very weak, and it has yet to be proved or even shown to be likely that quenching can produce multiple twinning. In the discussion of this paper, the writer pointed out that to produce notable strain-hardening of a plastic metal by deformation needed the application of really large deformations, while, on the contrary, the amount of deformation (*strain* in contradistinction to internal *stress*) which could be caused in steel by quenching must be very small. It is further a very open question whether strain really ever produces direct twinning in a metal. Finally, it has yet to be shown that a twinned constituent is really materially harder than in the untwinned condition; the softness and ductility of such materials as rolled and annealed copper or brass, which are one mass of twinned crystals, points in the opposite direction. The idea put forward by Edwards and Carpenter that amorphous layers are formed on the twin boundaries in the process of twinning was well refuted by Mr. Humfrey in the discussion, as he showed by means of models that twinning could and did occur without disarrangement of the space-lattice at the boundary. As a result of the whole discussion it appeared that the authors had attached altogether too much weight to the process of twinning, but that the formation of amorphous metal during the quenching process might well be looked upon as the real cause of hardening—a view which the late F. Osmond had put forward quite clearly a year or so before his death.

Mr. McCance's paper began a thoughtful consideration of the whole subject by a review of existing theories. Both in regard to the existence or otherwise of beta iron as an independent allotropic modification, and in regard to the amorphous theory, however, the author made the mistake of considering that the objections which he raised can settle the point and dispose of these theories in half a dozen words. The question as to the extent and nature of the differences between alpha and beta iron is still being closely discussed, and even if Weiss's magneton theory finds ultimate acceptance, it is still a question whether the magnetic transformations do not really constitute one type of allotropy, nor is it yet certain that they may not be associated with far-reaching changes in other properties. Again, as regards the amorphous theory, Mr. McCance's objections are based on a simple misunderstanding, coupled with an assumption, based on the magneton theory, which has yet to be justified. This assumption amounts to the view that only crystalline solids can be ferro-magnetic, and that consequently amorphous iron would necessarily be non-magnetic. Facts are, however, against this view, for colloidal suspensions of iron are strongly ferro-magnetic, and so are a number of oxides and salts of iron, some of the latter even in a state of solution.

Of much greater value are Mr. McCance's experimental studies of hardening in carbon steel, which lead him, finally, to put forward a theory of the hardening of steel by "interstrain," which is practically a translation of Osmond's view ascribing the hardness of quenched steel to the presence in it of "le fer alpha écroui.' It is only Mr. McCance's account of the nature of "interstrained" iron which it is difficult to accept. Declining to accept the views of Beilby and of Rosenhain as to the hardening of strained metals by the formation of layers of the amorphous phase, the author uses the word "interstrain" to denote a condition in which the regular crystalline arrangement is broken up generally, leaving a mass of irregularly arranged crystal fragments. It may well be asked what it is that holds these irregular and ill-fitting fragments together, and why an aggregate of such fragments should be harder than the aggregate of the larger pieces of crystal which constitute the ordinary soft metal? But beyond this

there is the experimental evidence; both strain-hardened metal and quenched steel on etching exhibit the well-defined oriented lustre of a crystalline aggregate, thus clearly showing that the crystals are not disarranged into minute irregular fragments. It would seem, therefore, that Mr. McCance's conclusions must be narrowed down to this, that the hardness of quenched steel is due to the same cause as the hardness of strain-hardened iron, and this—but for a difference as to mode of origin—is also the view of Edwards and Carpenter. In this narrowed conclusion, however, there is a distinct step forward, since we have a definite "explanation "of the hardening of steel in the sense that this phenomenon is correlated with the much larger class of phenomena which occur when any soft or ductile metal is hardened by plastic strain. If we accept the possible existence of the amorphous phase, it is easy to express both classes of facts in a single and simple formula, and this in itself constitutes another argument in support of the amorphous theory. Whatever view one may take of these admittedly hypothetical matters, it seems that a definite advance has at last been made in our knowledge of the hardening of metals.

W. ROSENHAIN.

SCHOOLS AND EMPLOYERS IN THE UNITED STATES.[1]

MISS WINEFRID JEVONS gives in the report before us an interesting account of the history and present position of the relations between the schools and industrial employment in the United States.

The most important lesson to be learnt from the report is, perhaps, that in the United States employers and trade unions have realised, to a much greater extent than in this country, the necessity for part-time day classes for persons engaged in industry and commerce. Not only does the American Confederation of Labour take this view, but the National Association of Manufacturers also favours it. Indeed, the latter body went so far in 1912 as to recommend compulsory continuation classes, until the seventeenth or eighteenth year, one half-day a week, without loss of wages.

In this country there are some firms (comparatively few in number) who have had the wisdom to see that it is not only in the interest of the people they employ but also in their own interest to liberate young persons a certain number of hours a week, in order that they may in the daytime receive proper part-time instruction directed to make them more efficient in their respective industries; but we are still far from so wide and generous a belief in the value of education as the resolutions of the National Association of Manufacturers show to be prevalent in the United States.

The existence of such a wholesome state of public opinion accounts for the large amount of voluntary and compulsory part-time instruction which is to be found throughout the States; many instances of this are given in the report. In Massachusetts, a law has been enacted which enables local authorities to open day continuation classes for the education of children between fourteen and sixteen who are in regular employment, and to compel attendance at these classes in the daytime for not fewer than four hours a week; the time spent in the school is counted as a part of the number of hours that the child is permitted by law to work. The State provides half of the cost of the maintenance of the classes.

In the States of Ohio and Wisconsin, compulsory day continuation classes are in existence; in the latter State, apprentices may not be employed for more than 55 hours a week, and the employer must liberate the apprentice five of these 55 hours a week in order that he may attend a day continuation school.

J. W.

[1] Board of Education. Special Reports on Educational Subjects, vol. xxviii.

SEISMOMETRY AND ENGINEERING.[1]

IN the memoir before us we have a gratifying proof that practical engineers realise the importance of the application of the principles of instrumental seismometry to building construction. The immediate object in the present investigation is the vibration set up in a large masonry bounding wall of a reservoir in Queistal, Schleswig. This wall stretches between rocks across a narrow valley, and the overflow of water, estimated at 100 cubic metres a second, falls about 40 metres. Thus an enormous amount of vibrational energy is set up.

The destructive action of vibration on a structure is probably determined by the maximum acceleration experienced, and thus short-period vibrations are often more serious than long-period vibrations of larger amplitude. Prof. Grunmach first describes and discusses an apparatus designed to give the maximum acceleration, and then goes on to describe the arrangements for investigating the period and amplitude. These are really seismographs for measuring the horizontal and vertical components of motion. They are based on precisely the principle of electromagnetic registration introduced by Prince Galitzin for earthquake recording. The apparatus differs from Galitzin's in detail considerably, since the periods and amplitudes to be measured are very different from those experienced by the passage of earthquake waves. Continuous registration was made, and excellent diagrams of the results are given. It appears that the periods ranged from about 0·03 sec. to 0·003 sec., and the amplitude from 0·001 mm. to 0·00005 mm.

The theoretical discussion of electromagnetic registration given appears somewhat inadequate. The author adopts what may be called an equilibrium theory instead of a dynamical one. It is possible that this may be accurate enough in the case considered, but one would like a demonstration that this is so.

The memoir will no doubt be appreciated by engineers and seismologists alike.

G. W. W.

[1] "Experimentaluntersuchung zur Messung von Erderschütterungen. By Prof. L. Grunmach. Pp. 102. (Berlin: Leonhard Simion Nf., 1913.

RECENT BOTANICAL WORK IN DENMARK.

AT the general meeting of the Danish Botanical Society in 1912 it was decided to publish in the future two distinct journals. One of these is the *Botanisk Tidsskrift*, the society's old periodical, which has reached its thirty-third volume, and contains chiefly papers on the Danish flora, besides articles on subjects of more general botanical interest. This will continue on its former lines, being written mostly in Danish, though occasionally—much too rarely, it may be said, for non-Danish readers—with abstracts in English, French, or German. The second journal is a new venture, the *Dansk Botanisk Arkiv*, published at indefinite periods, and containing monographs and other special articles in either of the four languages mentioned. Both journals are sent post free to members of the society, membership being open to all on payment of 10 kronen (11*s*.) a year; the subscription for the *Botanisk Tidsskrift* alone is 6 kronen, and the numbers of the *Arkiv* may be pur-