silver ranks high amongst the mineral productions of Peru, the increase is less marked than it would otherwise have been. The leading products are copper, 34,727 metric tons; petroleum, 363,162 metric tons; silver, 294,425 kilos.; vanadium ore, 3145 metric tons; gold, 1690 kilos; coal, 290,743 metric tons. These are the only minerals the annual value of which exceeds 200,000*l.*; all the others are far less important. The production of copper, already very important, appears to be likely to increase still further. It is also noteworthy that of the total export of copper no less than 93·85 per cent. was in the form of bars, so that practically the whole of the copper ores produced in Peru are now smelted in that country. This effect is largely due to the heavy rise in freights; before the war these were about 30*s.* to 2*l.* per ton, whereas in 1915 they rose to 5*l.* to 6*l.* per ton without taking the increased cost of insurance into account, so that for any ore or matte containing under 40 per cent. of copper the rise in freights would outweigh a rise of 10*l.* in the price of the metal. This effect would be even more marked in the case of ores of a cheaper metal like lead, so that nowadays Peru exports few ores except those of such metals as vanadium, tungsten, molybdenum, etc., which, on account of their considerable intrinsic value, are proportionately less affected by a rise in freights. It is worth noting that the production of coal has only increased from 283,860 tons in 1914 to 290,743 tons in 1915, whilst the imports have fallen from 139,312 tons to 55,662 tons, in spite of the increased development of the metallurgical industry, as just pointed out, the reason being that the use of petroleum to replace coal as a fuel is on the increase, the output of oil having risen 43·7 per cent. above that in 1914.

NATIONAL LABORATORIES AND INDUSTRIAL DEVELOPMENT.[1]

II.

A NATIONAL PROVING HOUSE AND STANDARDISING LABORATORY.

CERTAIN general principles seem to me essential to success, namely:—

(1) Standardisation and testing must, if they are to be of value, depend upon research, and be closely connected with it.

(2) While there must be the closest union between the testing authority and the trade concerned with the production of the goods to be certified, the authority should not be dependent on the trade for financial support, and while the wishes of the trade as to the standards to be attained must be fully considered, the executive of the testing institution should be an independent authority.

Testing must go hand in hand with research. For, in the first place, research is necessary in order to set up the standards required. Take, for example, our standards of length. The yard or the metre is the distance between two marks on certain standard bars very carefully preserved. They are both arbitrary standards, it is true, and it is clearly of the greatest importance that they should be invariable. Do we know that this condition is secured, and, if so, how do we know it? Materials certainly alter their dimensions with changing temperatures, and possibly also with time; for standard work we must know the temperature at which we make our comparisons, and this need leads at once to the investigation of the methods of measuring temperature and of the amounts by which various materials change in size with changes of temperature. A wide field of investigation opens directly; temperatures are measured by thermometers. How are the various kinds of thermometer connected? Do a mercury thermometer and a gas thermometer give the same results? Is the glass of which an ordinary mercury thermometer is made of importance? Or, again: To what extent is the length of a yard measure of brass or steel dependent on the temperature? Can we find a material less sensitive to temperature changes than the platinum-iridium alloy of which the standard metre is made? And so on. The investigations necessary before we can standardise our yard measure have called for much research. But, again, what security have we that even if we keep the standard with the greatest care and make our comparisons under the most favourable conditions of temperature, its length is invariable? Is the metre the same length now as when it was first deposited at the Bureau des Poids et Mesures at Sèvres? To answer this question a research of great difficulty was carried out at Sèvres by Michelson when he compared the length of the metre with the wave-length of light under certain specified conditions. There are cogent reasons for supposing that to be an invariable quantity.

At the laboratory during the past two years we have tested vast numbers of gauges and the improvement in manufacture has been very marked; this has been reached only by careful investigation into each cause of error by attention to small details, and by research into methods of measurement with a view to their simplification so that they could be used in the workshop, and to improvement in accuracy so that the results obtained were not vitiated by errors in the method of obtaining them.

A visit to the gauge-testing-room of the National Physical Laboratory will show anyone how closely research and standardisation go together, how hopeless it would be to try to run a standardising laboratory apart from research. Or, again, to take an example from another department of science. Ohms and volts and amperes are nowadays familiar words; you measure the one with a Wheatstone bridge, or more probably with an ohmeter, you read off the others in a voltmeter or an ammeter. But the definitions of these quantities are highly technical and scientific.

Do you realise what research has been required before our present practical system of making electrical measurements was evolved, and how much you owe to that research? Compare the rate of advance of the electric motor and the steam engine.

The work of the Engineering Standards Committee has been of untold advantage to the country. At every step of that work the committee has kept in close touch with scientific principles, and researches of the most varied character have been carried out, and are being carried out now, with the view of determining what standards to set up and what tests to prescribe.

Nor is it enough to say that much of this has been done and need not be carried further; the principles on which ammeters and voltmeters are made have been thoroughly investigated, the optical laws with which telescopes and lenses must comply are well known; lay down your tests and specifications, and train observers, analysts, and testers to enforce them, and you have done all.

Stagnation and death, not life and progress, lie that way. It is not our object merely to apply with rigid fairness the laws laid down, and to be pleased rather than otherwise, like the mythical examiner, when we "plough" them every one. The standards set must be reasonable, but they must tend to raise the quality of the product tested. Recurring defects must be watched and investigated, and the tests modified to prevent

[1] Abridged from two lectures delivered at the Royal Institution on February 26 and March 5 by Sir R. T. Glazebrook, C.B., F.R.S. Continued from p. 77.

them; you must gain the confidence of the manufacturer and lead him to realise you are out to help him, and that you really know something, probably more than he does, of the strength and weakness of his goods. Nearly all Englishmen are anxious to maintain the reputation of their country, and welcome fair tests which show up bad work and make for its improvement. Our statistics show the improvement that is produced by tests properly carried out.

So much, then, for my first contention, that research and standardisation must go hand in hand; the truth of the second, that the testing authority should be independent of the manufacturer, is, I think, obvious. It is necessary to give confidence.

A certificate has but little value, even if it states the truth and nothing but the truth, unless it comes from an absolutely impartial source. If I bear witness of myself, my witness is nothing. To the old customers of a well-established firm the assurance of the firm is sufficient; a stranger looks for some independent evidence before he accepts as true all the claims made by the man who desires to sell his latest production as something far superior to all else on the market.

Impartiality is the first attribute of justice, and the suspicion that the judge may be swayed by something besides the strict merits of the case is fatal. Again, it is necessary for the good of the manufacturer. False praise is dangerous to the recipient. The man who relies on the verdict of a too friendly critic may easily fail to maintain the high quality of his products and find himself outstripped by one who has been spurred to effort by fair and judicious criticism.

A testing laboratory controlled by an association of manufacturers for the advancement of their trade is of much less value, both to them and to the country, than one in which the ultimate decisions rest with an independent authority. Of course, the standards to be worked to must be determined in closest co-operation with the trade. No specification is ever adopted by the Engineering Standards Committee until it has been fully discussed at meetings at which the trade is fully represented; in no case is the decision as to whether an article comes up to the standard left to such a meeting, and this has had an important bearing on its success. At the laboratory we have advisory committees on various matters. Executive powers rest with the Executive Committee or with the director acting under the instructions of that committee. He signs all the certificates, and is responsible only to the committee, and this seems to me the proper plan.

[The lecturer then proceeded to describe and illustrate on the screen some of the principal tests now carried out at the laboratory.]

Having now dealt with the test work at the laboratory, and the method of procedure, let us turn to the future. Is the work of value? If so, what steps have been taken to make it of more value still, to increase its range, and to widen its influence? Are further steps desirable, and, if so, what should they be?

Its value is, I think, recognised; the recent growth in many branches of our work, besides that of testing gauges for engineers, is evidence of this; the proposals to establish standardising laboratories in various centres of industry point in the same direction. Engineers are coming to recognise more and more the importance of interchangeability, the advantage of working to limits, the gain in producing power—combined, I fear, with deadly dullness in much of the work—secured by the standardisation of parts.

Here, I think, a word of caution is necessary. Local standardising institutions are desirable in certain cases; local standards are most undesirable. I am not sure how many wire gauges used in the sale and purchase of wire and thin metal sheets there are In a recent list I saw enumerated some six or eight, each with its own tolerances, or in many cases with no tolerances at all; each has been introduced to fill a need, but with no thought for other needs. There is a risk, I fear, that the establishment of local testing laboratories, unless care is taken to connect them with some central institution responsible for maintaining their standards and co-ordinating their methods, may tend to perpetuate like anomalies. There is already, as many of us know, a standard inch and an "Enfield" inch; we do not want Manchester, Leeds, and Birmingham inches.

Transit is easy, and the delay involved in sending goods to a central institution need not be great; the uniformity of results secured in this manner is worth much. Where this cannot be done there should be some organisation devised to keep the standards employed in all parts of the country alike within agreed limits, and to maintain this connection with the results of research.

The increase in the number of clinical thermometers has already been mentioned. Tests on optical instruments of all kinds are growing, and steps have been taken to add to the staff and improve the facilities for handling these.

The quantity of glassware used in chemical laboratories throughout the country is enormous. In pre-war days this was almost all of German manufacture, and much came into the country with Reichsanstalt certificates. English manufacturers have taken up the question, and are now prepared to offer large supplies, and a scheme has been arranged for its standardisation and the issue of certificates. This is the outcome of discussions of a committee on which were representatives of the Department, the manufacturers, the users, and the laboratory. The limits of error for the various classes of articles have been provisionally fixed, and a schedule of fees settled which the makers think reasonable, and it is hoped will in time enable the work to be carried on without loss. For the present a house has been secured at Teddington, and is being equipped, in which the testing can for the time go on—a certain amount of this class of work has always been carried out at the laboratory. Additional buildings are to be erected, and the scheme put on a permanent footing.

The quantity of the various articles is very large, and it is not necessary that all should be tested to the same limits of accuracy, nor would it be possible to send them all to the laboratory. This difficulty will be met by having two classes of goods treated differently. For work of the highest accuracy it is necessary that the articles should be sent to Teddington and be tested individually. Those that pass the tests will constitute Class A, and receive the laboratory mark. The vast majority will be dealt with at local centres organised by the laboratory and manned, at least so far as the more responsible positions go, by members of the laboratory staff. These centres will, in some cases, be at the large works; in others it is hoped to interest the local universities or technical colleges. At the head of each will be the N.P.L. inspector, who will be free to visit the works, inspect the methods of manufacture, and select for test from each batch such articles as he thinks fit. So long as the methods remain satisfactory and the goods come up to standard, the firm will be licensed to mark the articles in some distinctive way.

A fee will be charged for each article tested at the laboratory. In the case of the articles inspected or tested in bulk, it is proposed to cover expenses by a royalty reckoned on the numbers produced, which would be charged for permission to use the trade-mark.

Such a scheme, it is clear, requires the cordial co-operation of the makers and the inspecting authority.

This we have already been promised, and while the conditions of test and the limits permissible are settled after consultation with the manufacturers, the enforcement of those conditions and the power to refuse the licence rest with an independent body. Such a plan, it seems to me, is far preferable to the alternative under which an association of the manufacturers would run its own testing laboratory.

A similar scheme is clearly applicable to other industries. For engineering work the standards of the Engineering Standards Committee are mostly adopted. The laboratory holds the standard screw gauges of the committee as well as the rail templates and other similar standards. Some organisation whereby standards employed locally for testing purposes are controlled by the laboratory and kept in close correspondence with those at Teddington ought not to be difficult to devise, and would secure much of what is needed, though with screw gauges at present identity of the method of testing rather than of the standard of comparison is what is difficult to secure.

Or, again, with electrical instruments, supply meters, ammeters, voltmeters, and the like can be, and are, sent to the laboratory, and where high accuracy is required this must be done. Very large sums depend now on the measurement of the energy supplied from central stations to big works, tramway systems, collieries, and other large installations, and very high accuracy is needed. This, too, is true in the case of acceptance tests of large machinery. The necessary accuracy can be obtained only in a properly equipped laboratory, and, indeed, in the case of meters, an individual test is always necessary, but where the type has been tested and approved the individual tests could be carried out by inspectors at the works, or at some convenient local institution. And there are many pieces of apparatus and small plant which could be dealt with in a similar manner to the chemical glassware.

The Engineering Standards Committee has specified the performance tests for motors and dynamos requisite before the term "British standard" can be applied to them. It is clearly impossible to expect that every small motor should have been put through these tests. It would be quite simple to arrange that some limited number of the type were tested out at the National Physical Laboratory, that steps were taken, by inspection and occasional tests, to secure that in subsequent production the same standard was attained; and, so long as this was done, to license the manufacturer to put the E.S.C. mark on his machine, and call it a "British standard machine."

The process can be extended to other electrical products; it has already been suggested for lamps, and four years ago I had good hopes that some action of the kind would be taken—1914 stopped it for the time. I would urge that now is the time to develop a scheme of the kind so that we may be ready when once more peace reigns on earth among men of good will.

The scheme is a large one, one that as director I cannot hope to see fully developed. It is enough perhaps for me to have indicated how the laboratory may grow, both as a National Research Laboratory and as a National Proving House and Standardising Laboratory.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

MISS PHYLLIS M. BORTHWICK, lecturer in physics at the Ladies' College, Cheltenham, has been appointed assistant-professor of physics and chemistry at the Lady Hardinge Medical College for Women, Delhi.

ON the first Saturday of each month from May to October, at 3.30 p.m., free public demonstrations on practical bee-keeping will be given in the Horniman Gardens or the Museum, Forest Hill, S.E., by Mr. W. H. Prior, of the Kent and British Bee-keepers' Associations.

M. PAUL OTLET's article in the *Revue générale des Sciences* for February last on "The Future of the International Catalogue of Scientific Literature" contains a short account of the foundation of the catalogue and some proposals for its future development. The vast experience which M. Otlet has acquired at the International Institute of Bibliography at Brussels entitles his opinion on such a subject to respect. It is, however, difficult to reconcile his statement that "before the war the German Government had decided to withdraw from the International Catalogue" with the fact that at the meeting of the International Council of the catalogue held in London on June 11 and 12, 1914, about six weeks before the war broke out, the representative of the German Government, Dr. Uhlworm, proposed the resolution:—"That the International Catalogue of Scientific Literature shall be continued during the years 1916–20," which was adopted by the council. M. Otlet would like to see the International Catalogue extended to include technology, industrial sciences, medicine, agriculture, social sciences, philology, literature, the fine arts, history, geography, philosophy, and religion. In view of such extension he thinks the work of the regional bureaux in the various co-operating countries should no longer be controlled by scientific societies, but undertaken by the authorities of the National Library in each country. M. Otlet suggests that in view of the continual increase in the number of scientific journals, authors should agree not to publish original papers in any periodical that was not included in a list drawn up by mutual agreement. In order that subscribers to the catalogue may be in possession of the latest information, M. Otlet recommends that the index-cards received at the Central Bureau should be printed and issued at once. As each volume appeared, the cards corresponding with that volume would be destroyed by the subscribers, who need keep only such cards as had not yet been published in a volume.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, March 21.—Sir J. J. Thomson, president, in the chair.—Dr. C. **Chree**: The magnetic storm of December 16–17, 1917, as recorded at Kew and Eskdalemuir Observatories. The magnetic storm of December 16–17, 1917, was of very considerable though not outstanding magnitude. It commenced between 8h. and 9h. on December 16, and had not wholly subsided before the afternoon of the following day. Attention is directed in the paper to the curves for the twenty-four hours commencing at 8h. on December 16. The most active period of disturbance was between 15h. (3 p.m.) on December 16 and 4h. on December 17. A prominent feature in the curves was a succession of oscillations of periods averaging about twenty minutes. There were also, especially at Eskdalemuir, some very large short-period oscillations. The paper compares the oscillations recorded at the two observatories, and gives estimates of the rate of change of the magnetic elements during the most rapid movements. The amplitude and rapidity of the changes proved to be much greater at the more northern station. —E. A. **Owen**: The absorption of X-rays. (1) The absorption coefficients of a number of substances for a radiation of wave-length $0{\cdot}586 \times 10^{-8}$ cm. (the α-line of palladium) have been determined, and the values