AUSTRALIAN STANDARDS.

BY

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Member.

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AUSTRALIAN STANDARDS.

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(*Read before Sydney Division.*)

The object of this paper is to present to members of this Institution a statement of the position to-day in regard to physical standards and their maintenance ; also to compare the position of Australia and its States with that of other countries, and to offer some suggestions in regard to methods which could be adopted with advantage in securing for Australia a means of maintaining National Standards of physical quantities, not only economically and efficiently but also in such a way that their copies could be transferred readily and made available so as to aid in the development of national industry. The march of civilisation has brought with it an ever increasing need for greater accuracy in measurement and correspondingly higher precision in the determination of physical units. The question of weights and measures is intimately related with that of coinage, so much so that under the Constitution of the United States, Article 1, Congress is given power " to coin money, regulate the value thereof, and of foreign coin, and to fix the standard of weights and measures." It requires very little consideration to see that the control of weights and measures is just as important as the control of coinage, and that the difficulties which will obviously arise from lack of control in regard to the latter must arise also in the case of the former. In fact, all that money can have to do with is inseparably associated with the results of weighing and measuring in some form or other.

It is a matter of considerable importance to Australia that a simple basis should be provided for securing uniformity in the standards of measurement used throughout the British Empire. In other countries divergencies have led in course of time to serious difficulty which it is hoped may be avoided within the Empire and within the Commonwealth.

Uniformity in standards and in standard specification of materials and apparatus should be looked to as one of the best means of developing trade within the Empire.

In the modern processes of manufacture, in order to obtain interchangeability of parts, the greatest possible accuracy is required in measuring instruments, gauges, etc., and the resources of even the best-equipped testing laboratories are called upon to provide the means for obtaining this accuracy.

This position has been realised particularly since the War and in the older countries large sums have been, and are still being, spent in the development of such institutions and every possible effort is being made to promote close relationship between these departments and industrial undertakings. Such countries as Japan and Czecho-Slovakia are taking a very active part in similar developments and all the more progressive nations have established departments for Scientific and Industrial research which they have subsidised liberally. One important part of the work of all such departments is that of the maintenance of standards and the carrying out of investigations and researches connected therewith.

The Commonwealth of Australia has established a Council for Scientific and Industrial Research and under the 1926 Commonwealth Act this Council is provided with powers and functions which enable it to carry out "The testing and standardisation of scientific apparatus and instruments, and the carrying out of scientific investigations connected with standardisation of apparatus, machinery, materials and instruments used in industry," and also "the establishment of a Bureau of Information for the collection and dissemination of information relating to scientific and technical matters."

A committee of this Council is at present preparing recommendations in regard to matters affecting standards and their maintenance.

The Munitions Department of the Federal Government found that it was necessary before it could proceed with the manufacture of munitions in Australia to instal gauges and measuring apparatus of the highest precision and has established the nucleus of a valuable Metrology Section at Maribyrnong, in Victoria. Its equipment is, of course, designed particularly to meet the special requirements of the department but could be extended with advantage and co-ordinated with the work of other institutions.

Throughout Australia many of the State Departments and the larger industrial undertakings have installed, and are constantly using, testing equipment of high precision which, from time to time, requires careful calibration against legalised

standards. The Engineering and Scientific Departments of the various Universities have also taken some part in similar development.

Standard Specifications.

In recent years the need has been felt for finding some means of expressing the quality and performance of apparatus in precise terms, and Engineers have combined in the preparation of what are known as standard specifications. This work, particularly, as applied to electrical apparatus and machinery, is now in active progress in Australia, Austria, Canada, Czecho-Slovakia, France, Germany, Holland, Italy, Japan, Norway, Poland, Roumania, Russia, Sweden, Switzerland and the United States of America. This complex problem can only be solved by some form of expression finally in terms of standard quantities and units.

As an example, in the specification of annealed copper for electrical apparatus, we rely ultimately upon the following standards :—Length, area, volume, mass, density, temperature, and resistance ; while in the specification of electrical machinery we become involved in the use of a still greater number of terms.

As any such expression of quality or performance must be made in terms of our physical standards or of quantities which can be expressed in terms of such physical units, it becomes essential that each country using such specifications should possess the means of determining whether apparatus comes within the specification or not. The only way in which this can be done is to make available legalised copies of the standards of the quantities involved, and to provide the ways and means by which the comparisons can be made with the standards.

This last point must not be passed over lightly as, in practice, it is frequently found that the auxiliary apparatus and equipment necessary in carrying out a comparison may be far more costly than the standards themselves. Without proper means for comparison the standards are, of course, of very little value.

An attempt is being made to obtain as far as possible international uniformity in these specifications and with that object in view the International Electrotechnical Commission, upon which are representatives of all countries concerned, is proceeding to adjust by discussion and compromise the dif-

ferences which exist in the individual specifications of the different countries.

Although it is improbable that universal agreement will ever be arrived at in regard to much of the detail associated with specifications, nevertheless there is every prospect of arriving at uniformity in regard to the more fundamental and important points. In this connection it is becoming more and more evident that a serious attempt should be made to co-ordinate the work of the British Dominions so that we may have at least a common set of British Empire Specifications.

Historical.

Actual record of the existence of standards dates back to 1000 B.C., when in Egypt the *cubit* of 20.63 inches was adopted as a standard of length; the *hon*, approximately 29.2 cubic inches, as the standard of volume, and the *kat*, between 138 and 155 grains, as the standard of weight. From that date we have records of the legal regulation of measures, most of the States having preserved official standards—usually in temples under priestly custody. The Hebrew "shekel of the Sanctuary" is familiar. In Athens, beside the standard weight, 12 copies for public comparison were kept in the city. In Rome, the standards were kept in the Capitol and weights also in the Temple of Hercules. In England, the Saxon standards were kept at Winchester before A.D. 950 and copies were legally compared and stamped. The Normans removed them to Westminster to the custody of the king's chamberlains at the Exchequer, and they were preserved in the cript of Edward the Confessor while remaining royal property. The oldest English standards remaining were those of Henry the Second.

In more recent times the British system was based upon the yard, pound, second, while the Continental system adopted the centimetre, gramme, second, and the need for other derived units has led to the extension of both these systems. The relationship between the corresponding units in these two systems is known with great accuracy, and in some countries both systems are accepted as legal measures.

The development and realisation of the electrical units has been given much attention during the last century, being carried out in the scientific departments of many Universities and in national standardising and testing laboratories.

Means are now available for reproducing most units of physical quantities and their multiples and sub-multiples with extremely high degrees of accuracy.

Realization of Units.

The definition of Standards is an important function of the legislature of a country. Most Acts refer to these matters by custom as "Weights and Measures" and if the term measures be taken in its broad sense it will cover measures of all the Physical quantities with which we are concerned in Science and Industry. Under British legislation the term measuring instrument is specifically defined as including any instrument for the measurement of length, capacity, volume, temperature, pressure or gravity, superficial area, counting and for the measurement and determination of electrical quantities. In terms of the fundamental quantitites, Length, Mass and Time, we can derive theoretically most of the other physical quantities, and we shall refer to these units hereafter as derived units. However, in some cases practical difficulties arise which make it necessary or advisable to specify units of some quantities arbitrarily. This applies to such units as Temperature, Candle-power, Radium Standard and the Electrical Units. It is probable, however, that before long the present Internationally-accepted Electrical Units will be replaced by the absolute units expressed in terms of the Centimetre, gramme, and second. At the present time sufficient tolerance is allowed to enable the International Electrical Units to be accepted as the equivalent of the Units prescribed by the British Acts.

A further practical difficulty arises in regard to many derived units in that not only is great difficulty often experienced in making precise absolute determination of their values, but further difficulties arise in the design of apparatus which will maintain constant values, be independent of temperature, humidity, age, etc., and be capable of being transported from one place to another without change in values. This applies to such apparatus as standard condensers, inductances, cells, and, to some extent, to practically all the electrical standards.

A further difficulty arises from the fact that the form in which the legal standard is expressed is not always that which is best suited for practical use.

For example, it is the general practice to define the yard or metre as the distance between two lines suitably marked

upon some standard bar. The development of modern industrial practice has, however, brought about the necessity of expression of length in terms of what are known as end standards in which the measurement is defined as the distance between the end surfaces of a bar. It is now possible to grind the two end surfaces of a standard bar so that they are parallel to a very high degree of accuracy and such bars lend themselves much better to the determination of gauge measurements than do the line standards.

The transfer from legal line standards to end standards is a matter of great importance and of considerable difficulty but has been satisfactorily accomplished.

The auxiliary apparatus required in the form of comparators is of different design dependent upon whether it is to be used for inter-comparison of line standards or of end standards.

In the case of the unit of Candle-power this at present can only be fixed arbitrarily. The greatest difficulty has been found, of course, in comparing the intensities of lights of different colours and the present position is that we require a different arbitrary standard for the measurement of each different quality of light. In practice to-day we require one standard for light of quality corresponding to that given by the carbon lamp, one for light corresponding to the metal filament lamp and a third for light as given by the modern gas-filled lamp.

The question of standards and their maintenance is, therefore, by no means the simple matter which it is sometimes thought to be. It is not sufficient to merely procure standards or their copies and deposit them securely in some form of vault. In the first place, if these standards are to serve a useful purpose provision must be made for comparing with them from time to time sub-standards with which in turn working copies may be compared and corrected. To do such work requires proper facilities, and in many cases it will be found that the auxiliary equipment which is necessary will be many times more expensive than the standards themselves.

Again, it is known that standards of most units are liable to change, more so in some cases than in others. For example, the United States Government found in 1830 that considerable variation existed in the standard yards which were held by the different States, and it became necessary to withdraw these and to fix the standards of weights and measures to be uniformly used in every State of the Union by Federal enactment.

Much work has been done on the question of suitability of material for the construction of standard bars. The material used in the earlier days was a bronze mixture known as Bailey's metal; but it has been found that nickel, nickel alloys and quartz are much more satisfactory materials from which to construct such standards on account of their smaller temperature co-efficients and smaller variations due to structural change within the material. At present investigations which are in progress in the different laboratories indicate the possibility of using the wave length of the red cadmium line as a universal standard of reference, and lengths of the order of four inches can now be expressed with the necessary accuracy in terms of this quantity. It is to be anticipated that before very long we shall be in a position to express the yard and the metre sufficiently accurately in terms of the wave length of the red cadmium line to make it possible to adopt this as a universal unit. Such a unit would have the advantage that it could be independently and directly determined in any country. The yard and metre would then be used as fixed multiples of this primary unit.

Again, in the case of electrical units, although these can be produced with a high degree of precision, very careful attention is required in the maintenance of their copies. For example, if one were to compare all the cadmium cells which are at present in Australia some striking variations are to be expected depending upon their age and the conditions under which they have been maintained or used. Comparing twelve standard cells of ages extending over a period of ten years, I have recently found differences of the order of five parts in 1000, and this is in the case of cells which have been kept under lock and key and used only for comparison purposes. With the modern 0.1 normal acid cells, the unit of voltage, as realised by cells made in America and Great Britain, has been fixed by actual comparison to a value of one part in 100,000.

Again, in the case of resistance, mechanical changes due to alterations in temperature may, in the case of high resistance coils, cause serious changes and the possibility of gradual corrosion at the terminals can produce similar effects. In the case of heavy current-carrying resistances, not only has one to look for changes in structure, but as most of these resistances are immersed in oil it is essential that such oil should be perfectly acid-free and contain no ingredient which may affect the manganim. It is by no means easy to realise this condition, and it is only recently that investigations carried out, both by the N.P.L. and the Bureau of Standards, shewed that it is

possible to procure suitable oil for this purpose which does not produce any appreciable effect within two years. As a result, if standards are to be of any practical value, they must be continually checked, and for this purpose proper facilities must be provided. Such work is of a highly specialised nature and it would obviously be much more economical and satisfactory to maintain one set of Federal Standrads in accordance with British Standards by careful intercomparisons with the N.P.L. than to have six independent State bodies attempting to do the same work or for departmental bodies within the States to be still further multiplying the work of intercomparison abroad.

Legislation: It is of some interest to compare briefly the position in regard to standards and their maintenance, and the laws relating to these matters in Great Britain, Canada, America, Japan and Australia.

In Great Britain the position is defined under the Weights and Measures Acts of 1878-1889-1897, 1904 and 1926 and Special Orders in Council which deal with the Electrical Units.

The Imperial yard and pound, together with the second, are adopted as the fundamental units, the gallon and bushel being also defined in these Acts.

The Metric System is Legalised in Great Britain and centimetre and gramme standards are expressed as fractions of the yard and pound respectively.

The Electrical Units defined are the Ohm, Ampere and Volt and the tolerances allowed in the definitions of these quantities are sufficient to allow of the use of the present International values of these quantities being used as legal measure. The Board of Trade in conjunction with the National Physical Laboratory are responsible for the maintenance of the units.

Canada: In Canada the weights and measures service, also that of gas and electricity inspection, is a Federal service operating under Federal legislation—Weights and Measures Acts, Ch. 52 and 75. The standards of weights and measures are set down and defined in the Act and are copies of the Imperial Standard Yard, Pound, Gallon, and Troy Ounce.

The metric system is legal.

It is interesting to note that three sets of Dominion Standards were obtained from England in 1874, one set being placed in the custody of the Minister of Trade and Commerce;

one each in the custody of the Speaker of the Senate and Commons. (The Commons' set has been lost, presumably in the fire that destroyed Parliament buildings in February, 1916.) The Provincial Governments have nothing to do with weights and measures and possess no standards.

For administration purposes the Dominion is divided into eighteen districts, with a District Inspector in charge of a suitable staff and, of course, equipped with local and working standards.

A certain amount of scientific research work is carried on in the various departments of the Government in the interests of the development of natural resources and industrial research. Departments such as the Mines, Forestry, Agricultural, Dominion Observatory and its Boundary Survey Department, also the Topographical Survey Department and the Public Works carry on a certain amount of work in connection with the standards which they employ.

At present the National Research Council of Canada is considering the establishment of a Dominion Bureau of Standards to co-ordinate the various branches of the Government service engaged on any scientific, technical and research work under it, with the intention of developing on similar lines to that of the Department of Scientific and Industrial Research of Great Britain.

The United States: Notwithstanding the fact that under Constitution U.S., Article 1, 1787, Congress was given power to coin money, regulate the value thereof, and of foreign coin and to fix the standard of weights and measures, and notwithstanding that the importance of the subject was repeatedly urged by such men as Washington, Adams and Jefferson, no general legislation has been enacted by Congress in regard to weights and measures. At the time of the American Revolution the weights and measures in common use were supposed to be identical with those in use in Great Britain, and it was not until 1830 that, as a result of an investigation which showed that variations existed in standards of the same denomination, that a Federal enactment was passed fixing the standards of weights and measures to be uniformly used in every State of the Union. Further action was taken in 1836 when the different States were provided with copies of the Federal Standards. It is stated as a matter of regret that at least one State by local legislative act established a standard of its own differing from the National Standard.

In 1866 the use of the metric system was legalised in the United States of America. The fundamental standards of the customary system, the yard, pound, gallon and bushel, are, in general, uniform throughout the Union. Practice, however, in regard to the use of the two units last mentioned, differs materially. In some States the gallon of certain commodities is defined as a definite number of pounds. For example, 11 lbs. of sorghum molasses is a legal gallon in Indiana and Mississippi; 12 lbs. in North Carolina, South Carolina and Tennessee; while $6\frac{1}{2}$ lbs. of kerosene in Kansas and $7\frac{1}{2}$ lbs. of linseed oil in Ohio constitute a legal gallon. The ton of coal is fixed in some States as 2000 pounds, while two or three specify 2400 lbs.

In regard to the bushel, considerable variation exists, it being legally established in some States as 2748 cubic inches, while in others it has values of 2500, 2571 and 2688. So much confusion has arisen through the diversity illustrated above that there is now a growing tendency to discontinue the use of the bushel and to sell commodities commonly sold by this unit by weight.

In 1893 the British Imperial yard and pound were replaced by the international metre and kilogram as the fundamental standards of the United States. The yard was defined as a certain fraction of the metre and the pound as a certain fraction of the kilogram. This action did not, of course, affect the values of the customary weights and measures, but fixed them in terms of standards which were assumed to represent the highest development of metrology.

In 1894 the legal units of electrical measure were defined by Congress. They included the Ohm, as the unit of resistance, the Ampere, as the unit of current, the Volt, as the unit of electromotive force; the coulomb, farad, joule, watt and henry. These are in accordance with international values.

In 1901 the National Bureau of Standards was established at Washington and its functions are very much the same as those of the N.P.L. of Great Britain.

The present position in the United States is that, although the Federal Government has power to control all matters of weights and measures, it has been content to merely define certain of the units and has left it entirely to the States to devise their own regulations controlling questions of weights and measures generally. The Bureau of Standards has faced the difficult task of attempting to co-ordinate the work of the States with the object of obtaining uniformity and has apparently met with a certain amount of success. However, to-day, through variations in legislation and regulations in the many different States, the position has become very complex, and it is being urged in many quarters that decisions with regard to such matters, at least, as suitable types of weighing and measuring apparatus should be treated as a Federal function and controlled by the Bureau of Standards. Speaking generally there appears to be a considerable amount of overlapping and lack of uniformity throughout the States which is very difficult to counteract under the system which has been allowed to grow up.

Japan: Some idea of the position in Japan can be gained from an article recently published by the Director of the Engineering and Industrial research division of the National Research Council, U.S.A. It is stated therein that thirty thousand engineers are enrolled in the membership of Japan's national engineering societies. Ninety research institutions are listed by the Department of Commerce and Industry all conducting laboratories.

In general the national organisation of research in Japan follows the German system in that the leading institutions in the representative fields of science and industry are directly subsidised or otherwise supported by the Imperial Government. Of the 90 research institutions listed, 23 are supported by the national treasury, and, in addition, there are such national institutions as the Research Institutes of the Army, Naval Fuel Bureau, Imperial Railways and Government Institutions. The most important national institutions are the Tokyo and Osaka Industrial Research Institutes which are working in close co-operation with the industries on general research problems arising in these important centres. Although the work carried out by these institutions is much more than is necessitated by standards and their maintenance, nevertheless the work of each institution is dependent primarily upon the accuracy of its copies of the national legal standards.

Australia: In Australia the Federal Government has power under the Constitution to control matters relating to weights and measures, but it is remarkable that to date it is the one power which the Government has not exercised.

The Acts (Weights and Measures) of the different States are all similar in that they adopt the fundamental British units. The derived units, and particularly the Electrical units, have not so far as I can find been dealt with under any of these Acts.

Queensland is remarkable in that it is the only State to legalise the gramme, its multiples and sub-multiples, but, strange to say, it does not similarly include the metre.

Otherwise throughout the Commonwealth States the Metric System is not legalised—this is all the more remarkable since Great Britain, Canada and America recognise this important system.

In the Queensland Act the weight denominated by a ton is defined as 2240 lbs. except in the case where it applies to bran, pollard or flour, when it is defined as 2000 lbs. I understand that this practice also holds in the other States.

The Federal Government has established a Council for Scientific and Industrial Research modelled upon the British plan and has provided for this Council controlling such work as would be carried out by a National Physical Laboratory if such were established.

The National Physical Laboratory : To give some idea of the work carried out by the great national testing and standardising Laboratories a brief account of the work of the National Physical Laboratory of England will be helpful.

The National Physical Laboratory, founded in 1900, occupies a site of 23 acres at Teddington, ten miles from London, now includes ten large and some smaller buildings and employs a staff of over 500. Originally controlled by the Royal Society, in 1918 the Laboratory was made a part of the Department of Scientific and Industrial Research and is now under the direction of Sir Joseph Petavel, formerly Professor of Engineering at Manchester University.

The National Physical Laboratory is responsible for all experimental work required in connection with the British fundamental standards of measurement.

The Imperial yard and pound and the British copies of the International Metre and Kilogram are in the custody of the Board of Trade; the Superintendent of the Metrology Department of the Laboratory is also Dep. Warden of Standards under the Board of Trade, and the periodical intercomparisons of the Board of Trade Standards are made at the Laboratory. The Electrical Standards formerly in the custody of the Board of Trade are now deposited at the Laboratory and are held by the Director on behalf of the Minister of Transport to whom by Order of Council of January, 1920, the powers and duties of the Board of Trade in relation to electrical

standards were transferred. Other standards maintained by the Laboratory include those which determine the measurement of all other derived quantities as well as of arbitrary units.

The Laboratory maintains close relations with the Bureau International des Poids et Mesures at Sevres, Paris, where the international metric units of length and mass are preserved and with the principal National Standardising Laboratories.

Working standards are circulated from time to time between the several laboratories and agreement is secured on the values adopted for international units and standards.

In addition to the work in connection with Standards a large field of research work is covered and important investigations are carried out on behalf of State Departments—Admiralty, Wireless Board, Fuel Research, Air Ministry, and also on behalf of a large number of manufacturing companies.

The following departments are constituted :—

(1) Physics.
(2) Electricity.
(3) Metrology.
(4) Engineering.
(5) Metallurgy.
(6) Aerodynamics.
(7) William Froude National Tank.

Physics Department—

(1) General Physics and Heat.
(2) Radiology.
(3) Sound.
(4) Optics.

Electricity Dept.

(1) Electrical Standards and Measurements.
(2) Electrotechnics.
(3) Wireless Work.
(4) Photometry.

Metrology Dept.

(1) Pure Measurements.
(2) Standard Gauges and Gauge Testing.
(3) Physical Instruments.
(4) Glassware and Hydrometers.
(5) Drawing Office and Workshop.

Engineering Dept.

(1) General Research.
(2) Lubrication Research Committee.
(3) Ordnance Committee.
(4) Aeronautical Research.
(5) Engineering Co-ordinating Research Board.
(6) Building Research Board.

Australian Laboratories: Considering Australia's position from the International and Imperial aspects, we have, in the first place, the Bureau International des Poids et Mesures which is responsible for the development of international units and the inter-comparison of such copies as are held by the testing and standardising laboratories of the nations which support the Bureau. Next we have the National Physical Laboratory of Great Britain working in close co-operation with the International Bureau, well organised and subsidised by the Imperial Government, and capable of acting on behalf and in the interests of all parts of the British Empire, including Australia.

The development of an Imperial chain of Dominion Testing and Standardising Laboraties becomes the next step in the extension of this work, and for that purpose it becomes necessary that there should be some authoritative Australian body entrusted with the maintenance of Australian Standards and the comparison and checking of such standards with those of Great Britain by means of close co-operation with the N.P.L.; and entrusted further with the continual calibration and checking of all Australian State copies of the Federal Standards.

To link up with industry in such a way that convenient access may be obtained to standards requires next the formation of some form of State institution responsible for holding the State copies of Federal Standards and provided with means for carrying out the checking and calibration of the various measuring devices—mechanical and electrical—which are used by commercial undertakings.

Finally, we come to the Testing Laboratories which most of our State Departments and larger industrial concerns have found it necessary to develop in order to ensure the necessary degrees of accuracy in the work under their control. Such laboratories are absolutely essential to the proper development of modern industry, and if means were provided by such a scheme so that they could have easy access to the checking of their working standards and instruments, it would be an incentive to further development in scientific investigation along those lines which particularly affect the departments concerned.

It may seem that the cost involved in developing Federal and State Laboratories is prohibitive. The cost of a Centralised Federal Laboratory would, undoubtedly be very great and it is questionable whether at present it is warranted. On the other hand, we have in Australia University Scientific

Departments, Observatories and such Departments as that of Munitions, which between them possess a very large proportion of the requirements necessary for carrying out the work involved in the maintenance of standards. I feel sure that a proper co-ordination of the work of such Departments would make it possible to undertake, even now, at very small additional cost an efficient and economical control of the necessary standards. Ultimately, as the needs and resources of the country develop, it will probably be found advisable to develop a Federal Standardising and Testing Laboratory along the lines adopted by the older countries, and there is no reason why the work done in the meantime should not be arranged in such a way that its results and the equipment installed could be readily transferred to such an institution when the necessity arose.

Again, in each of the States we find a number of similar institutions which, to some extent, are beginning to overlap, and it is possible to co-ordinate the work of these State bodies in such a way that an effective and efficient means could be devised for controlling copies of standards and units within the States and maintaining proper calibration of measuring instruments and apparatus used in the commerce and industry of each State.

Further, if we are to arrive at a simple and well-defined solution of the problem, it is essential that the Federal Government should make use of its powers under the Constitution and authoritatively define the Australian physical units. It is necessary, in the first place, to have a Federal Weights and Measures Act dealing, at least, with that portion which is common to all weights and measures acts, *viz.*, the definition of standards.

After comparing the conditions in the United States of America and in Canada, I feel that our conditions in Australia could further best be met by Federal Regulations drafted under such an act, and that the necessary authority for the enforcement of such regulations could, with advantage, be delegated to the individual States. Such a system would remove practically all the disadvantages which exist under the present arrangements in the United States and, at the same time, would not interfere with the organisations which have already developed in the individual States for the carrying out of such work. If, for any reason, later on it was found that Canada's system offered greater advantages, there would be no greater difficulty in effecting the change than there would be under the conditions existing to-day in Australia.

I feel confident, however, that the system suggested would meet the really essential needs and would be of very great advantage, not only in simplifying procedure but in avoiding the difficulties which are already developing and which the example of America has shown must be anticipated if we are content to let things remain as they are.

Finally, although the scheme suggested is intended to deal primarily with the question of Standards and their maintenance it provides also an organisation capable of being extended so as to include scientific investigation and research into more general problems affecting industrial development. The one thing more than any other which is to be learnt from the experience of other countries is that in the present-day struggle for industrial supremacy the closest co-operation is necessary between industry and science. We have already become involved seriously in Australia in industrial development, and we can not afford to delay in providing the means for this essential co-operation with science. Our Governments are appreciating the necessity for such action and the engineering profession should be prepared to give the matter earnest consideration with the object of providing a scheme which, while being efficient and economical, should be capable of meeting the growing needs of the country. At the same time it is unreasonable to expect that Australia can meet the position to-day with legislation which, more than half a century ago, was found to be ineffective in the United States of America, and our Federal Government should be urged to take immediate action in this important matter.

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