

scheme could be readily worked out. The following is a scheme which, from my experience as Director of the Charters Towers School of Mines and Principal of the Ballarat School of Mines, I am satisfied would give beneficial results and extend the usefulness of both Technical Colleges and Universities, viz., recognition should be given to Colleges or Branches that are properly equipped and have a competent teaching staff. There is no difficulty beyond expense in obtaining equipment, and high-class lecturers are now readily obtained. There are many cases in which College Lecturers have become University Lecturers, and at least two cases in which they have become Professors. The syllabus of work at the Colleges could be so drawn up that one or more stages or grades are recognised as at least equal to a definite grade at the University; students to matriculate before passing to the University; students to be allowed to take as few subjects per year as they find necessary or expedient, provided such subjects are taken in a more or less definite natural order.

The scheme would have the following advantages: It would enable students living in country centres, engaged as engineering apprentices, or of necessity earning their living, to complete a large portion of a University Course before devoting the whole of their time, with its heavy expense at the University. The whole of the mathematics and pure science to at least "pass" standard of the University Course could be cleared up before going to the University, thus leaving the student free to attend advanced subjects and laboratory work.

Widespread facilities for giving instruction in pure and applied science, usually organised into useful associate and certificate courses, are essential in providing technical officers for the expansion of old and the establishment of new industries.

Instruction comparable at least in efficiency and range to that given at Ballarat, Bendigo, Charters Towers, Kalgoorlie, etc., should be obtainable at industrial centres such as Newcastle, Maitland, Lithgow, Broken Hill, Wollongong, etc. The instruction at each centre should be carefully drawn up to meet the requirements of the industries of the district, e.g., at Newcastle there should be Coal Mining, Metallurgy, Mechanical Engineering, Electrical Engineering, Industrial Chemistry, Chemical Engineering, etc. A liberal system of scholarships should also be established to enable the most promising and ambitious students to proceed to the University to continue their studies to the full extent available in the State. The systematic establishment of this branch of Technical Education will be expensive, and the visible beneficial results may be slow in appearing; but undoubtedly they will be of great and increasing value in a few years to our industries.

The First University Engineering Degree Course was that established in Melbourne, followed by a similar course in Sydney. Every State in the Commonwealth now has a University, each with its Engineering School.

The entrance qualification is the Matriculation Examination, usually with special extra subjects, such as Mechanics and a general paper in English and Geography. The Institution of Civil Engineers recognises Engineering Courses as giving exemption from their membership examinations, provided the entrance examination and course of work come up to their requirements. The Engineering School of the Sydney University is one of these recognised schools for its entrance examination and some of its courses.

The Engineering Matriculation has of recent years been greatly modified and made a more suitable preparation for engineering courses.

In the Sydney and Melbourne Universities there are three courses, Civil Engineering, a combined course in Mechanical and Electrical Engineering, and a combined course in Mining Engineering and Metallurgy. In Adelaide there is no Civil Engineering Course, but separate courses in Mechanical Engineering, Electrical Engineering, Mining Engineering and in Metallurgy. Each of the four last-mentioned subjects is now much too wide to be properly taken with another. Separate curricula enable the essentially professional subjects to be treated to a much-to-be-desired greater fullness than is possible in combined courses. This more detailed treatment can with advantage be taken to a further degree, viz., that after a good generalised course up to the third year, students should have the option of greater specialisation in their fourth year, e.g., in Civil Engineering they could be given the option of two out of, say, the following groups: Railway Engineering, Municipal Engineering, Hydraulic Engineering, Sanitary Engineering, Steel Structures, Irrigation Engineering.

Two other courses could with advantage be added, viz., Architecture and Chemical Engineering. Industries are springing up requiring men who must be good Chemists, but at the same time have a good knowledge of mechanical and electrical machinery. Portion of their instruction would require to be chemical and engineering courses, specially drawn up to meet their cases. No doubt this specialisation would necessitate present lecturers giving extra courses, and also in the appointment of special lectures. This, however, must be faced in the near future if the Universities are to beneficially and efficiently carry out their duties. Such specialisation has been carried out in some Associate Courses with very gratifying results.

The time is now ripe for our Alma Mater to avail itself with advantage of the services of its own or other graduates who have reached pre-eminent positions in some branch of Engineering. Such men could give a course of specialised lectures to third or fourth year students, or even to graduates. I make this suggestion with every confidence, because I know that I have the approval of a number of prominent graduates, and that such association with the work of our Engineering School would rightly be considered an honour. There should be no great difficulty in arranging such lectures, as in a similar manner men with busy positions or practices are assisting in the work of the Medical and Law Courses.

The curriculum for each course should be most carefully drawn up as to the subjects included, the syllabus of each subject, and the general balance of the Course. Students usually have but a limited time (three or four years) at their disposal for their technical education. The fullest advantage should therefore be taken of the time. The instruction at the Universities should be more seriously treated as training for a profession than as academical culture of an applied science nature. A thoroughly sound professional training is compatible with the undoubted advantage of the refinement of a University education.

Professors and Lecturers in science subjects are still seen at Universities who openly or in practice abhor work of a professedly utilitarian nature. Curricula are frequently out of balance, owing in part to Professors of pure science subjects obtaining an undue allotment of time for their work, to the detriment of professional subjects, the lectures of some of which are given by outside lecturers.

If the instruction in an Engineering School is to be fully effective, it is necessary that the various Professors and Lecturers, besides being highly technically trained, must have had intimate personal experience in, and should still be closely associated with, the practice of their subject. As one of numerous examples, I may mention Mr. Elwood Mead, who was formerly Professor of the Institution and Practice of Irrigation at the University of California. While occupying this position, he was in very intimate association with irrigation work in U.S.A. He relinquished this position to become Chairman of the Commission for Rivers and Water Supply in Victoria. The University of California offered him very great inducement to return to his former position.

Some Universities, including our own, have a written or equally effective unwritten rule that no one will be appointed to a Professorial Chair who has passed the age of 35, or in some cases 40 years. Such a course may have real advantages

in the case of some chairs, and also in reference to superannuation or similar funds; but it has grave disadvantages in connection with the appointment to Professional Chairs. This system favours a young brilliant man who may be of wholly, or almost wholly, academical training with very little professional experience, in preference to older men of wide and sound training and experience, and who would more efficiently handle a professional subject. On the other hand, the best man in training and experience up to an age of 50 to 55 is selected to fill a position of Lecturer. The anomalous position may arise of a brilliant academical Professor of small professional experience assisted by Lecturers of sound training and experience. Unfortunately cases also arise of some of the lecturers also being brilliant academical men of little professional experience. It is desirable for the whole of the professional staff to be of sound training and experience, and I consider it is absolutely essential that the professional head or heads should be such.

In Australian Universities, Engineering Professors and Lecturers may, on approval, undertake consulting work. Non-University Institutions usually prohibit such work. In America it is the custom that they may not only undertake, but are expected to undertake, such work, and are consequently paid lower salaries. If they do not keenly undertake such work it is considered that they are not keeping in sufficient touch with their work.

The control of technical teaching institutions varies very much in Australasia, but may be divided into two main groups:

(a).—Free from State Administration or Control.

These include the technical branches of the various Universities and the Adelaide School of Mines. These institutions are reasonably similar in their control, receiving financial assistance directly or indirectly from their respective States; their governing bodies usually contained State representatives; but the State does not exercise through any of its departments any control over the internal administration, curricula, examinations, degrees or diplomas.

The work of these schools comes under the immediate supervision of the heads of departments and under the general supervision of a Faculty. The work of an Engineering School such as that of our own (Sydney) University, has grown to such large dimensions, and should in the future grow to still larger dimensions, that it should come under a Faculty of Engineering, and not merely be one branch among an ever-increasing number in a general Faculty of Science, where for many

reasons it is desired to limit the personnel to keep it from becoming unwieldy. A separate Faculty would enable it to devote its undivided attention to Engineering matters, and it would enable each Department to be properly represented.

University Faculties, Boards of Study, Syllabus Committees, should contain scientifically trained professional men of wide practical experience, who personally know what is essential or desirable in the training of young Engineers or Metallurgists to enable them to efficiently carry out their duties.

The influence of such men may be seen in the radical modifications and extensions made a few years ago in the curricula of the Royal School of Mines. A faculty composed entirely of members of the teaching staff and ex-officio members of the Senate is apt to become too academic, and to get out of touch with the great body of the profession.

(b).—Partially or wholly under State Control.

Here are found an extraordinary diversity of types. The Schools of Mines at Charters Towers and Kalgoorlie came directly under the control of the Mines Department of their respective States. These Schools are under the supervision of Directors, each of whom is responsible to the Minister and Under Secretary for Mines for the administration, discipline, standard and scope of work and teaching efficiency. The examining body is composed of the lecturers and outsiders acting conjointly. In Victoria the Schools of Mines have local governing Councils subsidised by the State, the teaching staff having little or no voice in the administration. The syllabus of subjects is set by the Department of Education usually acting on the advice of special committees composed of instructors, examiners and outside experts. The syllabus of subjects in Diploma courses are usually of a high order. The Department conducts the examinations and issues the certificates. Several of the older and larger institutions, such as the Schools of Mines at Ballarat and Bendigo, draw up their own diploma courses and issue diplomas, but the Department conducts the examination of most of the individual subjects. The individuality of these old institutions is thus maintained. In New South Wales the Sydney Technical College and its numerous branches is a Branch of the Education Department. It is under the control of a Superintendent responsible to the Director and Minister for Education. The College controls its courses, syllabus of work, examinations and certificates. There are special committees for each group of subjects which advise on the syllabus of work and the equipment of classes. These Committees very rightly have no voice in the administration.

In Queensland the Central Technical College in Brisbane is under the Department of Education, but in the country centres the local administration, control of syllabus and examinations are somewhat similar to that in Victoria. In South Australia the Schools of Mines in country centres have been largely independent of outside control, but are now to be brought under the State. The details of the scheme have not yet been worked out.

The system adopted at Charters Towers and Kalgoorlie was more suited to a single institution than a group. It gave excellent results in the hands of capable men, but would be disastrous under incompetent control. The Councils at provincial schools are usually too large, and are mostly composed of men whose only recommendation is their willingness to act. These large Councils should be replaced by small bodies of about five to seven specially selected members, of whom the Principal should be one. The Council should have control of any funds placed at its disposal, visit the school and confer with the Principal and heads of departments, and advise the central authority as to new classes, further class equipment, new buildings, etc., that might be required; but the Council should not have any voice in the internal administration of the School.

The Principal should be one in reality, responsible for the efficiency of work and the discipline of staff and students. It was worthy of note that in the past the most efficient institutions were those that were free from Department of Education control, or, as in the past, it should be more correctly termed "interference." This at first sight was surprising, until it is remembered that the chief experience and function of Departments of Education, especially in the past, was primary education, and, despite their pretensions, they really understood very little of technical education. The technical branch of every Department of Education should be placed under the responsible control of technical men of wide training and experience.

The training of Engineers has given rise to a very large amount of discussion during the past quarter century. For many years the recognised system was by articles apprenticeship in Engineering Works, or articulated pupilage in an Engineer's Office. Scientific Technical Training given at Engineering Schools has gradually crept until it is now recognised as essential, but for many years was not officially recognised by the Institution of Civil Engineers.

It is now almost universally accepted that Engineers should have a good general education, followed by special training, consisting of two parts, viz., scientific education at an

Engineering School and practical training. The period of special training should extend over a period of five or six years.

There is still a great difference of opinion as to when, where and how this practical training is to be obtained. Many eminent authorities are of opinion that the scientific training should follow immediately upon the school education; others that it is preferable for a young man to have twelve months' Works experience before going into an Engineering School; and this is the custom in Germany. There is no doubt that initial practical work enables a student to take a more intelligent and keener interest in his scientific training. The "sandwich system" also has many notable advocates. Under this system the lecture courses are confined to a consecutive six months in each year, the rest of the year being taken in the shops or on works. This system gives admirable results if it can be arranged. There is still another method, viz., the concurrent, i.e., the student is regularly engaged on his work, and takes his class in the evening, or by special arrangement during the day. It is, however, difficult to obtain full laboratory and class experimental work. This method has been systematically arranged in connection with the apprentices at the Railway Workshops at Newport. Special arrangements are made for them to attend lectures, instruction in design, laboratory work, etc., during portion of several forenoons per week at the Workingman's College. All practical or trade instruction is, however, given at the Newport Workshop. If an apprentice does not avail himself of this opportunity and fails to make satisfactory progress with his studies, he cannot rise above the grade of ordinary mechanic. The system is giving excellent results, and has already been the means of bringing forward into prominent positions several very able young men.

I have also applied this system to Mining Education at the Charters Towers School of Mines, where it gave good results. It takes much longer to complete an associate course, viz., four to six years. Underground work is arduous. Those who qualify under this system are usually the best type of young man, and they have universally turned out well. It is a test of a strong, sound constitution, determination, grit and ability.

It is necessary for an Engineering Graduate of an approved Institution to have had the following practical training in various classes of work before he can qualify for Associate Membership in Institution of Civil Engineers, viz., a minimum of two years, one year of which must be in the drawing office and one year in or upon Engineering Works. The period of practical work is much longer for those who

have not an approved degree. They must also pass a comprehensive examination in Engineering, Science and Mathematics.

An essential feature in all classes of technical institutions should be the possession of Engineering, etc., laboratories well equipped with suitable apparatus. The primary objective of these should be teaching purposes. Students should work singly or in groups in experimentally working out problems involving fundamental principles and processes. Original research was very valuable for both staff and post graduate students, but where only limited funds were available, special plant and apparatus for research should not be installed to the curtailment of teaching plant.

Special courses of lectures should be drawn up to meet the requirements of each class of students, instead of loose wide courses of lectures to classes composed of students in different courses of study.

The training received in an Engineering Course is largely general. Students should, however, receive very full practical instruction in work they are likely to be called upon to undertake in their early outside employment. They should be so trained as to be of material value to their first employers. This is an aspect that is largely overlooked, especially in University Engineering Schools. It was an unfortunate fact that too many graduates, who, despite their sound scientific training, were for a considerable time practically helpless because they were ignorant of the minor usages and routine of their work, placing them in an unnecessarily humiliating position, and casting ridicule upon their Alma Mater.

Instruction in the principles of organisation should form a part of the curriculum of all Engineering Schools. An Engineer who devoted all his student days to the problems of design is poorly fitted for his career. The need of instruction in the principles that underlie organisation and management does not at first make itself apparent, but as industry has become a greater factor in our national life there has been an increasing demand for technically trained men who know something of the commercial side of industry and who can organise and manage industrial properties. Statistics show that a very large proportion of the graduates of technical institutions go into the commercial and managerial side of industry. The demand, therefore, for the inclusion in the contents of the curriculum of some instruction in the principles of industrial organisation and management is perfectly logical. All Engineers should receive instruction in the elementary principles of industrial organisation, cost finding, wages systems, time and motion study, and the general economies of manufacturing.

The curricula of the Royal School of Mines was reorganised a few years ago largely under the influence of past graduates who had obtained eminence and wide experience in the mineral industry. An extensive course of lectures and demonstration on Business Transactions was included in the new courses.

The Institution of Civil Engineers held a Conference in 1911 on the Education and Training of Engineers. Many prominent Engineers emphasised the necessity of a knowledge of business being included in the training of Engineers.

Special lectures should also be given in the law of contracts, industrial laws, electrical and machinery regulations, etc. It is not advocated that an Engineer should be his own lawyer, but he should have a sound knowledge of the legal requirements surrounding his work. He would also know the advisableness of obtaining expert legal advice when the occasion arises.

Suitable lectures should be given in all courses in general sanitation and hygiene.

One of the difficulties which confront graduates is the great uncertainty that they will be able to find suitable employment at a reasonable remuneration. During the early days of the Engineering School certain branches of the Public Works Department readily availed themselves of our graduates and offered reasonable salaries. The men who entered then now occupy prominent positions. At a later date the Public Service Board was established, and that body very unwisely decided that graduates should enter the Professional Service as Probationers on the same footing as boys direct from school. Very few graduates entered under these conditions. It is now possible for graduates to enter on favourable and encouraging terms.

There is one important State Department, viz., the professional service of the Railway Commissioners, that is still indifferent, if not passively hostile. This service does not encourage the entrance of Engineering Graduates, nor does it take any effective measures for properly training its apprentices, as is done both in Victoria and Queensland. It is therefore not surprising that it is found necessary from time to time to introduce leading men for the locomotive service. The great want of technical training among men in the Locomotive Service of the British Railway Companies was commented on at the Conference on Engineering Education held by the Institution of Civil Engineers in 1911.

About 40 per cent. of our graduates have left the State. It would be highly beneficial to the community for our State and public bodies to offer more liberal inducement for highly

trained technical graduates to enter and continue in their service. American Corporations find that it pays them handsomely to offer encouragement; in fact, in many cases a young man must be a graduate before he will be accepted for Professional Service.

It would be of great value to Engineers if more publicity were given to the results of tests of materials, etc., and of research which is undertaken in the Engineering School. The results could with advantage be issued as bulletins from time to time by the School, as is frequently done in similar American Institutions. It would also be the means of inviting the interest of the outside Engineers and the public in the work of the School.

